Clouds across the Moon: A comparison of Apollo mission photographs with contemporaneous satellite images

"Methinks, that the Earth would to the people of the Moon appear to have a different face in the several seasons of the year; and to have another appearance in Winter, when there is almost nothing green in a very great part of the Earth, when there are countries all covered in snow, others, all covered with water, others, all obscured with clouds, and that for many weeks together: Another in Spring, when the forests and fields are green, another in Summer, when, whole fields are yellow etc."

Monsieur Auzout's Speculations of the changes likely to be discovered in the Earth and Moon by their respective inhabitants. Mr Auzout, Philosophical Transactions, 1665-1666, volume 1.

“Shades of blue breaking through white clouds above they’re not beneath us, yet they reach us, the blue marble”

Sagittarius, “The Blue Marble” (1969)
Acknowledgements & Disclaimer

‘Clouds Across the Moon’ was written by accident. While searching for ways to prove to stupid people that they were wrong and we did go to the Moon, it occurred to me that there had been weather satellites at the time of Apollo. After a bit of searching, I discovered a variety of sources for satellite photographs, and set about matching them with Apollo images of Earth.

This turned into a multi-year project trawling the internet for satellite photographs, video clips, newspaper photographs and any other source I could find and writing it up for every mission - including the Earth Orbit ones that genuinely didn’t go that far.

I’m not the only person this has occurred to, but this is the only place you’ll find a comprehensive analysis of each Apollo mission’s images of Earth.

The resulting document is a piece of personal and private research, and contains a wealth of information obtained from a variety of publicly available internet sources. All sources are linked (except those supplied by individuals), and all material used is the copyright of the original owner of that material. No breach of copyright is intended, nor should it be inferred. Any use of such publicly available material is considered to be fair use. The opinions contained within this document are those of the author, and do not reflect the opinions of any of organisations from which material has been sourced.

Many individuals and organisations have contributed directly or indirectly to this document: David Woods from the Apollo Flight Journal, Eric Jones from the Apollo Lunar Surface Journal and Philip Plait from the Bad Astronomy website contributed useful information and supportive comments. Jean Phillips from the University of Wisconsin very helpfully provided ATS satellite images. Mike Willmott from the Australian Bureau of Meteorology provided a useful triptych of NIMBUS 3 images. Jody Russell from NASA’s Johnson Space Centre sent high resolution images from Apollo 15. Colin MacKellar from Honeysuckle Creek sent a helpful newspaper clipping containing a contemporary weather map. Cole Smith contacted me through my site and provided useful information about the TV coverage of Apollo 16. My thanks go out to all of the aforementioned for their patient responses to random and probably very strange sounding requests.

Many thanks also to Graham, for his tireless proof-reading and numerous helpful contributions to the Discussion section.

I should acknowledge a debt of gratitude to the Apollo doubting pondlife swimming in the cesspool of conspiracy websites out there on the internet, insisting for all they are worth that 2+2=5. Without your witless idiocy, clueless gullibility, crass stupidity, blatant ignorance and proudly defiant wallowing in your poor level of education and basic lack of science knowledge this work would not have been inspired. You’re wrong, deal with it, you brainless morons, but without your nonsensical adherence to a discredited and baseless lie I would never have rediscovered the Apollo missions I witnessed as a child and the heroic age of engineering, science and exploration it represents. Thanks.


For Neil Armstrong, whose honour and integrity I defend herein.
**List of Abbreviations**

**AFJ** – The Apollo Flight Journal, which details missions before those that landed, and also covers in more detail the flight aspects of other missions. [http://history.nasa.gov/afj/](http://history.nasa.gov/afj/)

**AIA** – Apollo Image Atlas. All mission photographs, many available in high resolution. [http://www.lpi.usra.edu/resources/apollo/](http://www.lpi.usra.edu/resources/apollo/)


**AOS** – Acquisition of signal. The part of the lunar orbit when the orbiting CSM emerges from the radio blackout of the far side of the moon. APT - Automatic Picture Transmission system. A method of transmitting satellite images between receiving stations.

**ATS** – Applications Technology Satellite.

**CAPCOM** – Capsule communications. The Houston based personnel (usually astronauts) who acted as the sole voice link between mission control and the Apollo crew.

**CSM** (also CM) - Command & Service Module. The portion of the Apollo craft that stayed in lunar orbit. The Command Module (CM) portion is the only part that returned to Earth.

**DAPP** – Data Acquisition and Processing Program. Polar orbital satellites run by the US military in the 1960s, generally with higher resolution cameras. Also known as DMSP.

**DMSP** - Defense Meteorological Support Program. See DAPP.

**ESSA** – Environmental Science Services Administration. Organisation managing environmental research in the USA. Also used as a satellite name (eg ESSA 7).

**EVA** – Extra-vehicular activity. Any activity outside a spacecraft.

**GAP** – Gateway to Astronaut Photography. Useful resource of high quality images. Not all Apollo images are available in high quality. [http://eol.jsc.nasa.gov/](http://eol.jsc.nasa.gov/)

**GET** – Ground Elapsed Time. Time recorded on the ground since launch. See MET.

**HEO** – High Earth Orbit. Location for geostationary satellites around 24000 miles up.

**ITOS** – Improved TIROS Operational System.

**LEO** – Low Earth Orbit. Usually around 200-400 miles up.

**LM** – Lunar Module.

**LOS** – Loss of signal. The part of the lunar orbit where the CSM disappears behind the far side of the moon.

**LRV** – Lunar Roving Vehicle.

**MET** – Mission Elapsed Time. Time recorded since launch.

**MWL** – Mariner’s Weather Log. A monthly journal for seafarers that frequently used satellite images in its reports.

**MWR** – Monthly Weather Review. A useful source of contemporary weather data and satellite images.
NASA – National Aeronautics and Space Administration.
NOAA – National Oceanic and Atmospheric Administration. Successor to ESSA.
SIV-B – The stage of the Saturn V rocket that contained the LM before it docked with the CSM.
TEC – Trans-Earth Coast. The journey from Moon to Earth
TEI – Trans-Earth Injection. The rocket burn (usually carried out on the far side of the moon) that commenced the return to Earth from lunar orbit.
TIROS – Television Infra-Red Observational Satellites.
TLC – Trans-Lunar Coast. The journey from Earth to Moon.
TLI – Trans-Lunar Injection. The rocket burn taking the Apollo craft from Earth orbit towards the Moon.
1. Introduction

The purpose of this document is to demonstrate that any photograph featuring the Earth taken by an Apollo astronaut was taken where and when it is claimed: either en route to, walking on the surface of, or returning from, the Moon.

It will use satellite images gathered from a variety of sources and identify weather patterns in them that can also be identified in Apollo photographs. Where possible, the times of those satellite images will be identified. Software such as Stellarium, or the Earthview website, will also be used to show the relative position of observable land masses and the terminator (the dividing line between night and day) on the Earth’s surface. All Apollo missions that went to the moon and thus went beyond low Earth orbit (LEO), including the three that did not land: Apollos 8, 10 and 13, will be examined. The images chosen are the best quality available, attempt to provide as complete a coverage of the Earth’s surface as possible, and also represent key stages in each mission.

Some missions are better represented than others. Apollo astronauts’ main focus was the Moon, and images of the Earth were taken more for the ‘wow’ factor and novelty value than any attempt at serious scientific record. Possible exceptions to that are the Ultra Violet photographs of the planet taken in later missions, where matching images of Earth were taken as a comparison, and Jack Schmitt (Apollo 17’s geologist astronaut) in his effusive and detailed descriptions of the meteorological scene below him.

The number of photographs available for analysis is therefore a result of the whim of the person holding the camera. No apology is made for using many images. If there are photographs from every day of a mission, then they will be examined, because the aim is to demonstrate that for any photograph featuring the Earth it is possible to match that photograph to satellite photographs so that it can be shown beyond any doubt that the Apollo photographs are genuine.

The Earth was also not always in a position to be photographed. Like the Moon from the Earth, the Earth as viewed from the Moon has phases, and a couple of missions took place when the Earth could only be seen as a crescent. The size of this crescent can also change depending on the location of the orbiting Command and Service Module (CSM). On these occasions it is still sometimes possible to determine what weather systems are visible, but a little more detective work is required.

Images will be composited in an image editor. Other than zooming, cropping, altering of levels, and sometimes sharpening (only where appropriate to improve image quality & certainly not to deceive or confuse the reader) to make features clearer, absolutely no manipulation will be carried out on any image that materially alters their content. This point is worth emphasising again, as some critics of this approach have an immediate knee jerk response that there has been some form of fakery involved. To repeat: No content has been added to or removed from any image used here.

The observable features on both satellite and Apollo images are exactly as they have been given in their source. Any accusation that the images have been altered by the author is false, libellous, and says more about an accuser’s unwillingness to listen to reason than the quality of the evidence provided. Any critic of the technique is welcome to take the images provided (they will all be given an internet link) and perform their own analysis. If they arrive at alternative conclusions they are free to argue their case. Good luck.

These images can not, in themselves, prove beyond any doubt that the Apollo missions landed on the moon, but they represent a significant contribution to the body of evidence supporting the historical record.

Weather patterns have been identified before in individual Apollo photographs and TV broadcasts, but the analyses presented here are the first to systematically compare all the different contemporaneous sources.
The analyses provided are necessarily repetitive & to some extent formulaic. An Apollo photograph will be selected and a satellite image presented for comparison. Key weather systems will be identified on both. Where possible, images from more than one satellite will be used. Again, where possible, the time of the satellite photograph will be identified. Timelines of the Apollo missions and the journal entries given on the Apollo Flight Journal (AFJ) and Apollo Lunar Surface Journal (ALSJ) websites will be used to support suggestions as to when the Apollo images were taken.

Meteorological data will also be examined, and any other sources of information, such as TV broadcasts, newspaper reports, scientific journals and mission transcripts will be used to add further weight to the arguments presented.

Before going on to analyse the photographs, we will first look at the satellites concerned, then the cameras used by Apollo.
2. Satellite Meteorology

By the late 1960s, the use of satellites to look at the weather was increasingly common, but the technology itself was still in its infancy, and even by the end of the Apollo era there were still many experiments designed to see if the data from satellites were as reliable as those from traditional ground and atmospheric measurements.

Early satellites were launched with a lifespan of just a few months, and the images were examined on their return to Earth. These included the early Soviet Kosmos satellites as well as American efforts. Advances in communication techniques then allowed signals from an orbiting satellite to be sent back to a receiving station on Earth where they could be translated into photographic images. Although primitive by 2010's standards, the absence of modern circuit board, micro-chips and programming techniques meant that satellite developers crammed a large amount of complex, bulky, interconnected mechanical workings into a relatively small space. Ingenious solutions were arrived at to achieve simple aims, such as using electromagnets that would align with the Earth's magnetic field in order to maintain a satellite's orbital attitude.

There are two basic type of satellite orbit discussed in this work: geostationary and geosynchronous. Geostationary satellites are placed in a position above the Earth that allows them to observe the same features on the ground at all times. Geosynchronous satellites orbit in such a way that they pass over the same place on the ground at the same time each day. They are effectively always following the same path, but the rotation of the earth underneath them means that each time the return to a specific point in their orbit, they are over a different part of the planet.

Images from a number of different types of satellite are examined in this research: ATS, ESSA (and its ITOS and NOAA variations) and NIMBUS.

2.1 ATS Satellites

![ATS 3 antenna pattern test at Hughes Aircraft in 1967. Operations continue into the 1990s.](http://rammb.cira.colostate.edu/dev/hillger/geo-wx.htm)
ATS stands for Application Technology Satellite, and the satellite used in this research is predominantly the ATS-3, with some contributions from ATS-1 (sometimes seen written as ATS-I and ATS-III).

ATS-3 was launched on 05/11/67 (UK date format will be used throughout this document) and its primary aim was to investigate new ideas in satellite photography, meteorology, and communications technologies. 11 experimental functions in total were on board. It was placed in high earth orbit (HEO) at an altitude of 22300 miles in a position above the equator that allowed observation of the American, African and European continents. Although it was launched by NASA, the experiments it ran involved collaboration with a number of other countries, as well as academic institutions and private companies (NASA source).

The camera used to image the earth was developed by Dr Verner Suomi of the University of Wisconsin-Madison, Space Science and Engineering Centre, and is shown in figure 2.2.

While in orbit it span at around 120 rpm, and with each spin it scanned a small line of the Earth’s surface, each line representing 3.2 km of latitude. On the next spin it scanned a slightly lower latitude, and over 2400 revolutions it would achieve full coverage. It would take roughly 20 minutes to compose an entire image, after which the camera would reset itself and the process would start again. Most of the archives show a single image for each day, but in reality there was a very good record. As will be in seen in a later chapter this can be used to pinpoint the timing of Apollo images very precisely.

The colour image comprised a blue, green and red channel. These three channels worked for just 3 months, after which the red and blue channels ceased to function. Black & white images were still produced until the mid-70s. At the time it revolutionised satellite meteorology. The frequent transmission of images changed high altitude cloud photography from an interesting ‘after the fact’ image to almost real time imaging, so that meteorologists were able to see weather systems developing and predict more accurately where they were likely to end up. The other experiments on board the satellite allowed cloud movements to be tied in with other observations of other atmospheric conditions, as well as ground based readings, and investment in satellite technology and meteorology increased significantly.
The satellite became the first to photograph the full Earth from space in high quality colour (see figure 2.3), and this led to the first colour time lapse film of the Earth from space.

Figure 2.3: Earth from space, November 1967 (University of Wisconsin)

The first US sourced high quality full Earth black and white images (and the first satellite images to feature Earth and moon together) were done by ATS-1. The Russians, however, beat them to it in 1966. It has been argued that the first colour image was by a US DODGE satellite, but the quality is poor. The first recorded image of Earth from space is now thought to be from an American launched modified V2 rocket in 1946 (Air Space Magazine), with the first colour image credited to an Aerobee sounding rocket in 1954. This page gives a good account of the first images from space.

The image shown above in figure 2.3 has often been mis-attributed to Apollo, notably Apollo 11 by British newspaper the Daily Mail. A warning to all on the dangers of sloppy and inadequate research.

Interestingly, the satellite does have a direct link with Apollo. This NASA page reports that it provided television relay for the live Apollo 11 TV broadcasts to Radio Television Caracas, a Venezuelan broadcaster. It is important to note that it served purely as a relay for the TV signal. It took approximately half an hour for the satellite’s own camera to create a single image and reset itself, it did not have the capacity to broadcast its own images live. It would also not have been possible for Apollo 11 to send a signal direct to the satellite as it would not have been visible. The main TV signal for Apollo 11’s moon walk (Extra-Vehicular Activity, or EVA) was received by stations in Australia and transmitted by the communications satellite Intelsat to Houston after which it was relayed to the rest of the world (NASA source, Parkes Observatory).

ATS-3 stored its recorded images on magnetic tape and then broadcast its signal to Earth over VHF frequencies, where they were received on VHF antennae of the type shown in Figure 2.4.

This document describes early techniques where each strip would be printed, with characters such as '*,/,' and ')' in order used to simulate a grey scale, involving a huge amount of paper. Kinescope assemblies (A technique for recording TV images directly on still or moving film) were also used to photograph the TV images.
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Information could be recorded on tape and analysed later, but the systems were bulky and slow (figure 2.5).
Analogue signals were digitised so that different levels of brightness were assigned numerical values and these values were stored on tape. According to this NASA document, one ATS image could use an entire tape reel when digitised (4 reels for colour). Ultimately, seven track 18 inch reels were used, and these could store 70 images (roughly a day and a half’s worth of data). It took an estimated 4 hours between image transmission from the satellite to being visible on a terminal on the ground.

2.2 ESSA

The Environmental Science Services Administration launched a series of 2nd generation TIROS (Television Infrared Observation Satellites) probes through the 1960s. The satellites tended to be much shorter lived (between 1 and 3 years).

These probes were geosynchronous polar orbital satellites operating at a much lower orbital altitude of around 900 miles, taking roughly two hours to complete a single orbit, covering the entire earth’s surface in 24 hours. The satellites used on of two types of camera system, both consisting of a camera on opposite sides of the craft, and as it cartwheeled in orbit the camera facing the ground would take an image.

Advanced Vidicon Camera Systems (AVCS) recorded images on tape & transmitted them at pre-determined intervals to ground stations. Automatic Picture Transmission (APT) transmitted analogue signals immediately after acquisition. Photography actually took about 8 seconds, and transmission about 200 seconds (Google Books Source). Eventually there were around 300 APT receiving stations located around the world, and the images were therefore immediately available to anyone capable of building a receiver. This article in Radio Science, for example, describes data collected in Peru from the ATS. Amateurs could also collect images. This website for Douai Abbey describes how Benedictine monks at an English Abbey produced satellite images by recording their signals using radio receivers, although it is not clear which satellite they specifically listened to. This article describes the activities of amateur satellite trackers in the US, and some of them even made recordings, as shown here. This Pathe News report shows a British firm manufacturing the receiver stations.

On a personal note, as a student I spent some time in the late 1980s in an environmental study centre in south Wales (Ty’r Morwydd in Abergavenny, now sadly closed). Whilst I was there the centre acquired a satellite dish and the software needed to receive images from NOAA and METEOSAT satellites. I can therefore speak from personal experience and state that such images can be acquired relatively easily – as can many modern amateur trackers of satellites worldwide.
The exact coverage of each image would vary depending on the orbital height, but each image covered roughly 400000 square miles, with each line of TV transmission equalling roughly 2 nautical miles. The orbital periods are designed so that the images are recorded in daylight, effectively meaning that photographs are taken during 1 hour of each orbit. One image was taken roughly every 260 seconds, with an exposure time of around 8 seconds. It was transmitted to earth either automatically or on demand from ground stations. Images were capable of being stored on board on magnetic tape should the satellite be either out of range of a receiver station, or transmitting images whilst taking another. Figure 2.7 shows an example of the tape mechanism from this site.

Figure 2.7: TIROS magnetic tape recording mechanism.

The images were recorded on photographic film using kinescopes, and also transferred to magnetic tape, with numerical values used to represent different levels of brightness. These tapes were used in “high powered computers” (sic) to be displayed on a cathode ray computer monitor (eg, as shown here). Like APT images, they could be transmitted by fax to other agencies throughout the world.

A diagram showing the orbital paths for ESSA satellites is shown below in figure 2.8. These paths were the same for each ESSA satellite.
Figure 2.8: ESSA Satellite tracks (this diagram can be seen in most of the ESSA data catalogues catalogues, and is the same for each satellite)
2.3 NIMBUS

Figure 2.9: A Nimbus Satellite (Source)

At the same time as the ESSA program of active meteorological satellites, NIMBUS satellites were being launched as research and development tools to test out new atmospheric sensing techniques, and pioneered the AVCS & ATP techniques used in ESSA satellites. They had a secondary mission of providing useful meteorological data.

Like ESSA, they were polar orbital geosynchronous craft, and over the time of Apollo there were 3 satellites in operation. They orbited slightly lower than ESSA craft at around 700 miles, and orbits were completed in less than two hours. While ESSA used 2 cameras, NIMBUS satellites had 3, one pointing straight down and the other 2 at 35 degree angles at either side, so that despite a low orbital altitude, considerable ground coverage could be achieved (over 800000 square miles per frame). Each line of AVCS imaging equated to roughly 0.6 miles. A complete image took 6 seconds to take and successive images were taken 90 seconds apart (NASA source).

In parallel with the AVCS system, APT was also used. On NIMBUS, the APT images covered roughly 1600000 square miles, with each line of image scan representing roughly 1.5 miles. Each image was stored electrically on a plate and readings from the plate were transmitted to Earth, and the image cycle took just under 4 minutes to complete.

Figure 2.10 illustrates how the NIMBUS satellites were intended to operate in terms of data reception and transmission, collection and distribution.

As indicated in the diagram, NIMBUS images were available to anyone with a suitable decoder, and the NASA web page here: NASA source reports the uses to which European meteorological agencies put the data. As with ESSA data, amateurs could also gain access to the images. This photograph from the Baltimore Sun of May 13 1968 shows a Scottish amateur meteorologist’s set up, and the image he has received can be seen on the cylinder (figure 2.11). It’s worth comparing that with the ‘official set up of an APT receiver n figure 2.12.
Figure 2.1: Baltimore Sun image from 13/05/68 showing Scottish amateur meteorologist John B Turke’s set up for receiving NIMBUS-2 images. Original image from eBay, copyright Baltimore Sun.

Figure 2.11: Baltimore Sun image from 13/05/68 showing Scottish amateur meteorologist John B Turke’s set up for receiving NIMBUS-2 images. Original image from eBay, copyright Baltimore Sun.

Figure 2.12: APT receiving equipment. Source (bottom). Source (top).
The VHF signals sent by the satellite were received by the same type of dipolar antennae as ESSA transmissions, and were processed in the same way as ESSA signals.

Figure 2.13 shows a single orbital track's transmission from 24/05/69 (during Apollo 10).

2.4 Other Satellites

A number of additional sources of satellite images can be found in largely isolated examples across the internet. ITOS, or 'Improved TIROS Operational System', was an advancement on the previous ESSA satellites. A series of these new generation TIROS satellites were launched from 1970 onwards, and had various names attached to them as new administrative bodies were formed. The aim was to double the observing power of the satellites in operation by adding more satellites to existing polar orbital patterns.

ITOS-1 was launched in January 1970 and carried 4 improved versions of the camera technology employed by its predecessors capable of both visible and infra-red spectrum data. The satellite was deactivated in June 1971 after technical problems halted some of the on-board experiments in the preceding November, and caused problems with attitude control systems in March 1971. More information can be found here, here, and here.

The next launches in the ITOS series were christened NOAA, after the National Oceanic and Atmospheric Administration responsible for them. NOAA-1 (NOAA) was relatively short lived, launching in December 1970 but shutting down in June the following year. The only data catalogue found does not cover any of the Apollo missions.

The next satellite in the ITOS series was NOAA-2, and for the first time a satellite did not rely on TV imaging for its cloud cover data. NOAA-2 used radiometric imaging, using a combination of thermal and visible radiation measurement to produce an image of the cloud patterns below it. Despite this advancement in measurement
technique, the data were still recorded on magnetic tape and transmitted on demand. More information on NOAA-2 can be found [here](#), and links to the scanning equipment [here](#).

There do not appear to be any comprehensive data catalogues for NOAA-2, but occasional examples do show up in journals and other reports.

Perhaps the most interesting satellites available are those specifically operated by the military. The US armed forces were quick to realise the possibilities of using satellites and rocketry to observe their communist enemies - especially as their spy planes became more well known. While early efforts used straightforward 'up and down' rockets, eg those in the 'Corona' and the subsequent KH7 and KH8 GAMBIT programmes to pass cameras over the target territory and return to Earth with films for processing (there was little point in transmitting sensitive images to Earth as they could easily have been intercepted). Interestingly, the secretly developed emulsion used in the film for CORONA images was declassified so that it could be used by NASA for Apollo photography.

It soon became apparent, however, that predicting weather in Vietnam (and the USSR) would be useful, for a number of reasons. Primarily, it made sense, if you were sending a spy plane or a camera up into communist air space, to know whether or not it was cloudy there, and it also made sense to not have to ask someone if the weather over, ooh let's say Hanoi, would be cloudy tomorrow at about 09:00 just in case anyone happened to be flying overhead. It also helped to plan attacks or troop movements in those conflict arenas that were active in SE Asia, and to determine where Corona satellites should be targeted and recovered - Corona and GAMBIT were useless in cloudy weather. One report estimated that the military programme of satellite deployment paid for itself many times over by preventing unnecessary airborne reconnaissance missions and unsighted bombing runs.

At the more extreme end of usefulness, information on likely dispersal patterns for radionucleides, and the availability of long range targets was also likely to be useful. The Cold War is often dismissed as irrelevant in the world of the conspirator, and this is usually a good indicator that they didn't live through the nervy nuclear tensions that were a part of everyday life in the era before the fall of the Berlin wall.

In order to acquire this meteorological information without having to ask anyone, and according to some commentators in order to speed up development where civilian programmes didn't satisfy military needs, the military had a programme of launches of their own, for example the SAMOS satellite. It has been suggested that many of the innovations developed for this programme were later adopted in civilian designs, such as magnetic spin stabilisation. Another example is the cameras used in SAMOS, which went on to be used in the Lunar Orbiter series that mapped the Apollo landing sites ([Source](#)).

The program went under a variety of names, including the innocuous ‘Program 417’ (aimed at supporting the Corona program) and ‘Data Acquisition and Processing Program’ (DAPP), and then later on Defense System Applications Program (DSAP) and Defense Meteorological Satellites Program (DMSP). Some sources also argue that the DAPP programme was a result of frustration with the slow and overly bureaucratic process of satellite design and development within NASA. Examination of the literature suggests a co-dependence between the two, often sharing key personnel and transferring new developments between the two branches.

Another problem helping delay civilian satellites was the need to cram them with a large number of measuring devices - they had to be multi-purpose pieces of equipment, whereas the military satellites had a much narrower focus, and this specialism was what helped them develop better equipment more quickly. One area in which military satellites excelled was the development of night-time photography and targeting a camera view horizontally so that cloud heights could be determined more accurately. [This article](#) claims superior image processing and optics, and also claims double the resolution of civilian cameras thanks to being half the altitude, but its 450 mile altitude claimed is not half that of eg ESSA or NIMBUS! [This document](#) (which gives an excellent summary of the development of the military use of satellites) suggests that TIROS had a better resolution than DMSP.
That said, orbital trajectories and targeting of the cameras could be designed specifically with conflict arenas in mind, with pairs of satellites arranged to pass over their targets in the morning and evening. Of equal importance: the data could be encrypted instead of the open transmission types of their civilian counterparts.

While the early Corona images were not fully declassified until the 1990s, the DAPP/DMSP satellite data were declassified in March 1973, and images began cropping up in journals soon after. It is probably no coincidence that this declassification comes shortly after the end of the Vietnam war, which did make use of DAPP weather data. This publication describes the satellites and their operation in detail. Prior to declassification their data, and even their existence, were closely guarded secrets, with even different branches of the military denied access. The air force (to whom arguably they were of more use) jealously guarded their satellites from the other services, and very few personnel were given access to them. The army, meanwhile, continued to have to rely on field observations of notoriously changeable tropical weather in stressful and sometimes fatal battlefield conditions.

This early release means the satellite programme is well documented, but the full catalogues do not appear to be readily available online. The satellites themselves were similar in operation to their civilian counterparts, operating a sun-synchronous near polar orbit that took around 101 minutes to complete, at altitudes of around 450 nautical miles and above. The satellites had a series of developmental stages, and of particular interest to the Apollo missions are the Block 4 & 5 types with resolutions of up to 0.8 nautical miles. At least one Block 4 type was in orbit for Apollos 8-14, and least one Block 5 version was also in orbit for Apollo 12 onwards.

Meteorological data were recorded using thermal imaging and visible spectrum cameras, and they are widely reported as having better image resolutions than, for example, ESSA or NIMBUS, thanks to much better scanning equipment (giving a resolution of up to 0.3 nautical miles per scan line). Block 5 versions replaced vidicon cameras with radiometric systems in the same way that NOAA-1 evolved into NOAA-2. Whether this is true or not is a matter of debate - certainly the published records are comparable between the two. The difference is more likely to matter in the infra-red and horizontal imagery they needed for working on night-time bombing runs and reconnaissance.

The main receiving stations were restricted to a couple of bases, but the data could also be transmitted to field stations, as shown in figure 2.14.

Figure 2.14: DMSP fax receivers in the field. Source.
This [NOAA](https://www.noaa.gov) page gives brief details of one of the DAPP satellites, and this excellent history, [Cargill Hall](https://www.esa.int/esaHRD/SE/SE_D/MD/MD_H), describes the development of the satellites and the military programmes to which they contributed.

Readers might also want to look at the two USAF seminars given to trainee meteorologists covering cloud types ([part 1](https://www.esa.int/esaHRD/SE/SE_D/MD/MD_H), [part 2](https://www.esa.int/esaHRD/SE/SE_D/MD/MD_H)). The presentations make extensive use of civilian satellites, and give an insight into the contemporary understanding of how satellite data could be used in conjunction with other data. I cover these in more detail in the discussion section.

A couple of useful journals from ESSA and NOAA give more detail on how the processes worked, as well as give hints about the quality of the images. [ESSA World](https://www.esa.int/esaHRD/SE/SE_D/MD/MD_H) January 1970 and 'NOAA' January 1972 ' have articles on the modern [sic] weather forecasting service and the role of the satellite in it. These two magazines have the look and tone of 'in-house' magazines intended for members of the services concerned, and possibly other government and educational agencies. There are adverts and so on for educational material that can be bought from them, so it looks as though they had a wider distribution.

The 'Space Command' article describes how a series of commands are sent to a satellite so that it will turn on a transmitter, transmit its data, and then turn the transmitter back off. It also helps explain the administrative structure. The ATS satellites, for example, are owned by NASA, but the data acquisition process is not carried out by them. Instead it is collected by a data acquisition station and relayed to an operations centre run by NOAA (this would have been managed by ESSA prior to NOAA's creation). Figure 2.15 shows a member of 'Space Command' checking the quality of a satellite image.

![Figure 2.15: Checking satellite image quality on receipt. Source: NOAA](https://example.com/image.png)
The ESSA World article describes how the satellite images then end up with weather forecasters starting from about 06:00 local time. The strips and mosaics of photographs from the LEO satellites are “less than two hours old” by the time they get to the forecasters, although the ATS images are much newer. The interesting feature about the article is how many people are involved in the process of producing a weather forecast, and how satellite imagery was a relatively small part of that process.

Figure 2.16 shows someone from ESSA looking at a satellite image, and gives a good indication of the size of some of the printouts, and their quality.

Figure 2.16: ESSA staff examine a satellite photograph as part of preparing a weather forecast. Source: ESSA World

Another ESSA world edition provides useful information about the role of meteorological forecasters within NASA. The article, published in April 1967 and available [here](#), describes the work of the Spaceflight Meteorology Group (still in operation today: NOAA), which supported any NASA or DoD work involving orbital launches (and with missiles, sub-orbital), including the preparatory work of getting a launch vehicle to its launch platform. The link with DoD operations would prove useful during Apollo 11, as will be detailed in that section.
One interesting observation in the article confirms that the crew do have up to date information with them, at least at launch:

"One specialised service just before each launch is the preparation of a weather map for the flight crew to take with them. On the map are shown the meteorological features over which the crew will pass, as well as areas expected to be unfavourable for landing and recovery operations"

This would obviously be more useful in the much shorter Mercury and Gemini missions than the longer Apollo ones. The article also describes the development of orbital photography as an important contribution to ground forecasting, helping to compare measurements taken by conventional forecasting equipment with visual observations. This was particularly true for the Gemini missions, but as will be shown in the section on orbital missions this work continued with Apollo. The article makes one forecast that did come true:

"One expectation for the future is that Weather Bureau men will help select a smooth landing site for the first astronauts returning from a successful voyage to the moon"

This obviously happened, and the involvement of these satellites in weather forecasting for Apollo splashdowns is proudly commemorated in these first day covers for Apollo 8 and 9 (figure 2.17).

Summary

Satellites orbiting the Earth in the 1960s were engaged in data collection for meteorological agencies not just in the USA but worldwide. The operated slightly differently, but in essence they all used cameras that scanned the surface and recorded the image on magnetic tape. Data from these tapes were transmitted, either automatically or on demand, to ground stations using VHF signals. Receiver stations recorded these signals and converted them to TV images, which were photographed using kinescopes. The images could be sent over fax networks, and participating countries could record images directly.

It is also recorded that NASA used satellite imagery to work out forecasts for launch dates, and for the landing areas after re-entry. They also used them to help work out what the astronauts described from their view in space. Satellite imagery and other forecasts were supplied by ESSA, who also worked closely with other government agencies – including the DoD.

The satellite images used in this research all originate from the USA, but other countries were also launching weather satellites, including the UK, China & the then USSR. At the time of writing, images from other space and meteorological agencies are unavailable. It is hoped at some point to incorporate these other sources as further corroboration of Apollo images, as the political situation at the time means that co-operation between the US & USSR in particular was unlikely. Soviet confirmation of US data would be particularly useful.

It has also become evident that many technical journals and academic libraries contain much more information that has been gathered here. The only thing preventing access to these sources is money and proximity. If anyone is well placed in either of those respects they are encouraged to take up the mantle and expand the record further.
2.4 Modern Satellite Data reconstructions

For many years the data collected by satellites operating in the Apollo era remained buried in the journals and collections hidden in physical and online libraries.

Recently, however, a few researchers began to recognise the importance of these historic records and began to re-examine them.

Some researchers used the images as proxies for other things, for example the use of DMSP imagery to determine population growth and urbanisation. Some climate researchers, however, began to realise that the satellite data stored in archives represented an important climatic record, particularly in terms of the extent and characteristics of the Arctic and Antarctic ice sheets.

The USA’s National Snow and Ice Data Center (NSIDC) set about loading the tapes on which the original images were stored and began to process them into images, both individual tiles and composite full globe images. This youtube video describes the efforts.

The end results are a series of files available here.

The hdf format of the individual tiles requires specific viewing software available here.

Once you’ve done that, right click on the ‘brightness’ option. In the box that comes up, select the ‘Image’ radio button, then click OK. You’ll then get an image opening in the main window that you can save by clicking on the ‘Image’ text. The end result is an image file which is of considerably better quality than the compilation volumes available on line or (as in the case of the volumes I own) in print.
Once the NSIDC team had finished with the NIMBUS data they moved on to the archive of ESSA images. The archive of data covers the compilation images, rather than the individual tiles, but the way that the images have been recovered allows much more to be done with them. The files are available [here](#), and the images are in `.nc` format that are best decoded using the free ‘Panoply’ software, available [here](#).

Install the software, then click ‘File’, ‘Open’ and browse to the file of your choice. You’ll then be presented with metadata in the software.

Right click on the ‘Digitised raw brightness count’ option and choose ‘Create Maximum sized plot’. You’ll get a pop up box with the default of ‘create a georeferenced longitude-latitude plot’ selected. Click the ‘Create’ button.

You’ll then be presented with a plot window based on the image data.
The first thing to do is to choose a Map Projection, and the best one to choose is the Equirectangular one. By all means experiment with the others available. I went through and turned off various options like gridlines and overlays, and when I’d settled on a format I was happy with I set it as the default. You can also change the position of the landmasses by altering the central longitude. Once you’re happy, save the image in your preferred format.

The images are of one hemisphere, so you need two files to cover the entire globe:

Use an image editing software package to combine the two layers into a single file. Now comes the fun part.

What we have here is a single file covering the Earth in a user friendly format. We also have a range of software packages out there that will allow us to plot that file on a 3D spherical mesh and rotate it so that it can match the images of Earth used in this report.

I’ve used Blender3D to do this, and it’s much too fiddly to describe in this document. Youtube has a range of tutorials available, and this one was very useful.

What you end up with, however, is a 3D globe like this. You can even try colouring the original files in the Panoply software, as shown on the right. These images were dated 21/12/68 during Apollo 8.
The NIMBUS data can also be treated in the same way though as the whole Earth compilations tend not to include the poles a little more manipulation is required to get the projection right.

In addition to the original documents used in this report, I’ll be updating each page where appropriate to include a 3D rendered view to show how it matches the Apollo images even more clearly. There will be variations in appearance thanks to the way the software renders the images, anyone who denies that they aren’t a match is deluded beyond belief. The reason I’ve included this section is so that anyone who chooses to can verify that the files show what I claim they show.

The original data sets downloaded from NSIDC are copyright to to them, and no copyright is claimed here or should be inferred.
3. Apollo Photography

The equipment and methods used to take photographs on the Moon are well documented, particularly on the Apollo Lunar Surface Journal (ALSJ) [here](#) and [here](#), and also on the camera manufacturer's website [here](#).

The images themselves are available in a variety of locations, including the following:

- **Project Apollo Archive** and also [here](#).
- **Apollo Image Atlas**
- **ALSJ & AFJ**
- **Gateway to Astronaut Photography of Earth**

and indirectly by searching here: [http://www.archive.org/](http://www.archive.org/), a US national archive of various media. Searching by mission photograph number can reveal very high quality TIFF images (around 50Mb each), although their quality is not necessarily any greater than jpeg images a fraction of that size.

The sites listed above generally have a link to high quality versions, although this is not always the case. The Apollo Image Gallery contains the most complete record of all mission photographs, but does not necessarily always have the highest quality image scans.

The cameras used on the lunar surface were the Hasselblad EDC (figure 3.1) fitted with a high quality 80mm Zeiss lens.

This was a modified version of the EL 500 (figure 3.2) that featured a number of specific features (the EL 500 camera was used on board the command module and in Apollo 8.). Instead of loading the film directly into the camera, as would have been the case with standard film cameras of the day, the film was contained in a magazine (figure 3.3 & 3.4). The 70mm film used thinner than standard film and as a result up to 40 feet of film (sufficient for up to 200 images) could be packed into each magazine. After taking an image, an electric motor wound on the film.

![Figure 3.1: The Hasselblad EDC](source)
Later missions (e.g. Apollo 16) used cameras that had interchangeable 250mm and 500mm lenses for zooming in on distant objects, and also an adapted Nikon 35mm camera for use on the Command Module.
The film itself was a modified version of Ektachrome, which used a high strength polyester base (much stronger and more stable, which allowed it to be thinner) and a high speed emulsion to capture the image. The emulsion itself was developed for use in the top secret ‘Corona’ military satellites, but was specifically declassified to allow its use in the Apollo programme.

A Reseau plate, marked with ‘fiducial’ crosses, was built into the camera to check for image distortion and allow for the calculation of angular distances. These crosses often become obscured in over-brightened parts of scanned images, which causes much arm waving amongst the conspiracy contingent, who believe this is proof they were added afterwards. This is not true.

Also present on this back plate for lunar surface cameras (at least in later missions) were the last two digits of the camera’s serial number, which helped to identify the photographer as they were assigned to specific astronauts. Apollo 15’s were 31 and 38, Apollo 16’s were 33 and 39, and Apollo 17’s were 23 and 32. These numbers, when they are visible, have proved invaluable at identifying who took which photo, which is probably why they were introduced and also at identifying those cameras that mysteriously made their way back to Earth when they were supposed to have been discarded.

The camera’s silver body helped to reduce the thermal load on the camera, and a number of other modifications helped make the camera more suitable to the missions. Lubricants were removed, as these will perform differently in the extreme temperature environments possible on the moon, and much better electrical connections installed to improve performance and (more importantly) reduce the risk of sparks.

Weight was reduced, as was the number of moving parts, mostly by removing those components that were not needed. Viewfinders, for example, were pointless on the lunar surface because the suit helmet would have made them impossible to use. The shutter release button, f-stop and focusing levers were also modified to allow gloved hands to operate them more easily.

The cameras could be hand held or chest mounted, and a sighting ring allowed the astronaut to use them against their helmet visor. All of the cameras used on the lunar surface were left behind, and only the magazines were returned.

Astronauts were trained extensively in using the cameras. As they were unable to put the cameras to their eye to frame images correctly, they needed to be able to work out exactly what their camera was pointing out - particularly when it was chest mounted. Figure 3.4 shows astronauts in training. The astronauts also needed to be able to carry out simple repairs and diagnostics on the cameras. Apollo 10 lunar module occupants Gene Cernan and Tom Stafford) used some very direct language in their frustration at their Hasselblads experiencing a variety of problems that prevented them taking as many colour images as they wanted, and other crews describe minor repairs they undertook to the camera mechanisms.

Figure 3.4: Alan Bean and Pete Conrad working out their documentation procedures: Source
They also needed to be familiar with some basic principles of photography, particularly the relationship between aperture and exposure. At the risk of stating the obvious, unlike modern digital photography where auto settings can do a lot of the work and where a mistake is easily deleted and rectified, the crews had to have sufficient understanding of how lenses behave in order to get photographs right first time. It’s often suggested by people who haven’t examined the photographs in any great detail that they are all perfect and that this is somehow suspicious. The reality is that many of the images are over-exposed, under-exposed, badly framed or out of focus.

The key things that the crews had to work out were how to use the f-stop and exposure settings. A low f-stop means that the aperture on the lens (the part that lets the light in) is very wide, which means that a fast shutter speed can be chosen. The downside here is that the focal range is very narrow - objects near the camera may be sharply defined, but those further away much more blurred. A high f-stop means a narrow aperture, which means exposure times need to be longer, which can cause blurring if the camera (or the photograph's subject) is moved.

To get rid of one tired old chestnut immediately: the reason no stars (or at least very few) appear in Apollo images is very much related to the high shutter speeds required to take photographs of scenes lit by light reflected from bright lunar or terrestrial surfaces, as well as by the Sun. To quote Charlie Duke in a lecture I attended, ‘it was always broad daylight on the Moon’.

In fact several Apollo missions captured stars and planets, either by serendipity or as part of the low light photography program. See my website on the subject here.

The Moon’s light is sufficient to read by on Earth - imagine how bright it is up close. If you doubt it, go look at a full Moon and see how many stars you can photograph.

An additional source of lunar images is the Metric Mapping Camera, and as one set of images from Apollo 17 does feature photographs of Earth it is worth describing.

This camera was housed in the body of the CSM’s Scientific Instrument module (SIM). The view presented to the camera depended on the angle of the CSM relative to the ground, and views were usually vertical but occasionally oblique.

The 76mm lunar terrain mapping camera was complimented by a smaller stellar camera which, combined with a laser altimeter, was used to give a precise position of the CSM, and therefore of the photographs. The camera is shown in figure 3.5, and its SIM bay location in figure 3.6.

Figure 3.5: The Fairchild Metric Mapping Camera. Source
Their operation is described in detail here Fairchild Mapping Camera, here A View from Orbit, and also here Apollo Metric Photography. The data from the Apollo 17 mission that features the Earthrise image are described here: Support Data.

As the service module element of the CSM was discarded before re-entry, it was necessary to retrieve the film canisters from the SIM bay during the journey back to Earth. Figure 3.7 shows Apollo 17 astronaut Ron Evans performing the EVA to retrieve the image shown later in this document.
After splashdown, the film magazines were transferred to a technician who would inspect them for signs of damage and receive instruction from the astronauts about individual photographs that may be of significance.

The magazines were then sent by courier in temperature and humidity controlled cases (also used to transport them before launch) to the Manned Spaceflight Centre in Houston, where they were opened and inspected in the presence of senior technicians and staff. Apollo 11’s lunar surface magazines went through a decontamination process just in case something might have hitched a ride with them, but this became unnecessary once the likelihood of space-borne bacteria was found to be non-existent.

The processing equipment was thoroughly cleaned and checked before use, and the films were processed in carefully controlled environments with multiple checks on their condition before and during their development. Sample strips of each film type were sent through the development process to check their condition, and samples of the returned film (several blank frames were exposed at the start and end of each magazine) were also processed independently of the exposed images.

Each photograph is indexed according to mission, film roll, and then a unique number. Thus image AS11-40-5923 was image number 5923 on roll number 40 from Apollo 11. The numbering system has changed at least once, causing some confusion amongst die hard conspiracy lovers who claim subterfuge. The confusion is theirs alone.

The original films, once a master duplicate was taken, were committed to cold storage where they remain to this day. All versions of the Apollo images are from the duplicate copy, which itself will have been duplicated many times. There are, therefore, many different copies of the original film in circulation, which is worth bearing in mind when confronted with those who claim that there has been some interference with those images: many copies are available of the original films, and occasionally these duplicate copies (or at least part of them) can become available in auctions.

As will be discussed later, video footage also featured the Earth. The most documented video footage featuring Earth was made in a number of TV broadcasts from Apollo 11. These broadcasts were made using the Westinghouse Apollo Lunar TV Camera (figure 3.8), which had a range of standard, wide angle and telephoto zoom lenses.

Figure 3.8: The Westinghouse Apollo Lunar Camera: Source
The camera could operate at 10 or 0.625 frames per second, and could be operated from the lunar surface or from the CM. At 10 fps, each frame consisted of 320 lines.

A more general discussion of Apollo TV cameras can be found here Apollo TV (NASA), and on this website TV from the Moon by the author of a book on the subject. This interesting article discusses the role of TV in the ‘Space Race’, and includes details of scheduling, the way the programmes were made and budgets. One of the tables clearly illustrates the declining interest from US networks in the Apollo missions - 8 hours and 39 minutes of broadcast on CBS for Apollo 17, compared with over 60 hours for the considerably shorter Apollo 11.

Another source of moving pictures is the Data Acquisition Camera, or DAC.

They were mounted on the Lunar Module, and there was also a slightly different model used on the CSM to film eg docking manoeuvres. The DAC was capable of a variety of running speeds, from 1 fps to 24 fps depending on the subject. The entire Apollo 11 moonwalk was filmed using the LM’s DAC as a timelapse movie. The DAC’s were often mounted in a position that allowed them to film outside using a mirror, and quite often this means that some or all of a magazine’s contents were reversed.

One final camera to discuss could be found in the later missions, and was remarkable not just because it transmitted live TV from the moon, but also because it was operated by remote control from Earth. It’s official name was the Ground Controlled TV Assembly (GCTA) and was mounted on the Lunar Rover (LRV).

Operated by William Fendell and his team, it allowed the crew to be observed as they went about their EVA tasks and gave unparalleled views of the lunar surface as they did so. At regular intervals (usually when the astronauts were out of shot) Fendell would pan around and zoom in on Earth, and screenshots of those views will be used where they are available.

The GCTA films are a subject of controversy in the minds of the conspiracy theorist as at the end of Apollo 15, 16 and 17 they rovers were parked at a safe distance from the LM and the remote camera used to film the launch of the ascent module back to orbit. Conspiracy lovers can’t seem to comprehend that it is possible to film and track the launch of an object despite there being a 1.25 seconds delay in transmission time. This despite the hours of practice that Fendell and his team had of dealing with this delay during the missions and the exact timings of the launch sequence being known.

Figure 3.9 shows the cameras mounted on Apollo 15 & 16’s rovers, taken from the Apollo TV document linked to above, featuring images taken actually on the moon.
Using all these state of the art pieces of equipment, the astronauts were able to obtain high quality still & moving images of their journey to and from the moon, and of the lunar surface, and these images can be compared to satellite photographs obtained completely independently to verify that they were taken where they were claimed to be taken.
4. Comparisons of Apollo & Satellite images

This section will deal with each Apollo mission where the moon was at least orbited (or in the case of Apollo 13, slingshotted around).

For each mission a range of images will be selected representing different stages of the mission and showing different parts of the Earth’s surface. Wherever possible, multiple satellite sources will be used. ESSA satellite timings will be derived from the meteorological data catalogues for those satellites. Where individual ESSA, ATS or NIMBUS images are available from contemporary sources, these will used in their entirety. Download managers may be required for some links as they do not always display correctly. As the documents and other material are not hosted by the author, no guarantees can made about their permanent existence.

Where available, synoptic charts will also be used to show that weather systems visible on the satellite photographs were also present on the charts.

The most appropriate method of displaying the coincident weather systems has required some thought. A simple method of identifying cloud masses by letter has been employed by others on the internet, but it was felt that this would be potentially confusing. Instead, coloured arrows will be used to identify the same weather patterns. The use of arrows may well appear repetitive and to an extent pointless, but consistency requires their use in each image. There are also those out there who can’t see what’s in front of them even when it is described in detail, and will deny the existence of identical features. Actually pointing them out makes this more difficult for them to do.

The Apollo image will be shown in full, but for the actual analysis only the portion featuring the Earth will be used.

It is worth re-iterating that no material alteration of the photographs has been performed in any way: no weather systems have been changed on any image.

All the images are publicly available and sceptical readers are invited to look at these sources themselves to verify their accuracy.

The main aim of each analysis is to identify weather patterns that appear in satellite photographs. A secondary aim is to try and pinpoint a time that the photograph was taken, and this will be primarily done with the track records of the satellites. Additional sources, such as voice transcripts, descriptions given in the various image sources on the internet, contemporary journals and media, and where possible the photographic index from each mission (these can, in some missions, indicate the orbit concerned and the mission elapsed time). The latter will be used sparingly, as it is the evidence within the photographs themselves that is the most important factor here.
4.1 Apollo 8

Apollo 8 is of significance because the astronauts on board became the first people to see the far side of the moon, and the first to witness an Earthrise: the apparent rising of the Earth from below the Moon's horizon as the orbiting spacecraft reached Mare Smythii in its passage around the Moon. This phenomenon had, of course, already been witnessed by Soviet and US unmanned probes, but to be captured by human eyes added more significance to the event.

The mission was launched on 21/12/68, reached lunar orbit on 24/12/68, and re-entered the Earth's atmosphere on 27/12/68. During that mission, 865 images were taken on 7 film magazines. The majority of the images were used as source material for preparing future landing sites, but images of Earth are found on magazines 12-16. A number of TV broadcasts were also made, and images will also be examined from those broadcasts. Each image will be given in its original form, then compared with satellite images from the same day. The importance of the original image is mostly to demonstrate how small the Earth is in those images, despite their ability to reveal tremendous amounts of detail.

ESSA 7 images are available in this document: ESSA 7 data catalogue. I actually own a hard copy of this and confirm that the online scan is absolutely accurate. ATS-3 and ATS-1 images for at least some of the mission can be found here ATS-III data catalogue. This document has ESSA-7 images covering the north Atlantic throughout the mission and these are added where possible. We'll also be making good use of the digitally restored ESSA data (see Chapter 2.4) to produce 3D versions of the data. The full transcript of the mission can be found here: NASA link. The mission timeline is here: NASA link. The final section will look at the meteorological data available, to see how the photographic record compares with ground-based measurements of the weather at the time.

4.1.1a Apollo 8 images – on the way to the Moon

While it doesn't show the full Earth, the first images of interest to us are actually from the 16mm footage taken at the same time as the SIV-B separation (16:11 GMT). We know this as some of the SIV-B panels can be seen tumbling towards the Earth. By taking several screenshots from the video (available here) a substantial portion of the Earth's disk can be assembled into a single image. This is shown in figure 4.1.1.

Comparing this with the ESSA mosaic is a relatively straightforward business once it is realised that the film sequence used in the original video is the wrong way round - the camera was mounted so that it filmed using a mirror pointing outside.

More importantly, the Earth orbit insertion at 13:00 on the 21st was still several hours before this area was covered by the ESSA satellite. There is no ATS image for this date, but the evidence from ESSA clearly matches the Apollo video. The fact that it is a moving image, not a static photograph and complete with lumps of space hardware spinning in micro-gravity, is also an excellent refutation of the suggestion that the images were faked.

It's also worth mentioning that the TLI burn was observed from Hawaii. Separation was 25 minutes after this, and this would put the Apollo 8 ship exactly where it appears to be in the film. 15 minutes after separation we have these comments:

003:35:44 Borman: We see the Earth now, almost as a disk.
003:35:59 Lovell: We have a beautiful view of Florida now. We can see the Cape, just the point.
003:36:05 Collins: Roger.
003:36:06 Lovell: And at the same time, we can see Africa. West Africa is beautiful. I can also see Gibraltar at the same time I'm looking at Florida.

Which shows they are exactly where they should be.

A little after this we have the images of a full Earth in Hasselblad magazine number 16. This magazine is notable because it contains images from all stages of the mission from initial low earth orbit, separation of the Saturn IV-B stage, lunar orbital images, and then images of the approaching Earth on the voyage home. It was also used in the TV series 'UFO' many times between 1969-70, and in the 1972 film 'Silent Running' as the film's hero looks back to Earth through a telescope. The first image showing the entire Earth is AS08-16-2593 (figure 4.1.2), and it is compared with satellite images in figure 4.1.3.
Figure 4.1.1: Composite of several screenshots from Apollo 8 16mm footage.

Figure 4.1.2: AS08-16-2593 High resolution source
Figure 4.1.3: ESSA-7 satellite images compared with AS08-16-2593 and Stellarium estimate of time at terminator
Figure 4.1.3 (continued): AS08-16-2593 and 3D reconstruction using digitally recovered ESSA data
It is also taken very soon after separation from the Saturn IV-B rocket, as there are photographs of this event before it in the magazine. According to the timeline this occurred at 16:12 on 21/12/68. The most obvious features include the large spiral cloud system in the North Atlantic (yellow arrow), the ‘<’ shaped cloud feature off Brazil (green and magenta arrows), and lines of clouds trending south-east from Argentina (blue and cyan arrows).

It is also worth noting the shadow under the linear cloud mass near the terminator over north Africa (picked out by the green arrow). The direction of that shadow under the clouds is consistent with the sun's direction at sunset. It’s also obvious that the now moon bound craft has moved further East over the Earth’s surface, as we can now see the West coast of Africa. The 3D rendering of the digitally restored data is both spectacular and completely accurate.

We also have a 16mm still taken at around the same time, if we examine the amount of Africa visible it would appear to have been taken about 15 minutes after the still image (figure 4.1.4), and perhaps 90 minutes after the first sequence of Earth photos in magazine 16, taken shortly after TLI - changes in the position of the weather patterns over Africa, the shadows they cast, and the terminator location is very obvious when they are compared with the full disk view.

Figure 4.1.4: 16mm still, (top left) with the terminator around Africa compared with that from figure 4.1.1, and a Stellarium estimate of time at terminator. Below centre and right is AS08-16-2588 and a close up view of Africa from it rotated to match.
Stellarium (an astronomical software package used to identify the location of celestial bodies: http://stellarium.org) can be programmed with times and locations. In this case, using the lunar surface as a view and changing the date to the 21st gives a time for the Apollo image of around 17:15 and 17:30 for the 16mm still, shortly after the initial separation from the SIV-B rocket stage and the trans-lunar injection (TLI) engine burn. It's also worth noting the difference in perspective of the observer. Stellarium's Moon based view is looking 'up' with the southern Hemisphere dominating the view. Apollo's vantage point shows more of the northern hemisphere. At the time the image was taken, the transcript records a crew comment saying that:

**004:36:00 Anders:** ... it's a beautiful view with numerous cloud vortex

As well as Borman commenting that

**004:37:15 Borman:** I can still see the Cape and isthmus of Central America.

ESSA 7 data suggest that South America would have been photographed by the satellite at about 19:09, as this was when track 3 (pass number 1594) of the satellite's daily orbit over it was commenced. The time over the terminator area would be more covered by track number 1, orbit 1592, which commenced at 15:05. At the time of the Apollo image, then, it would be another 2 hours before the satellite would image the area photographed, and there would be a further few hours on top of that before all the visible Earth was covered.

The next in the series of images taken showing any significant change in the scene below them is AS08-16-2595, which is shown below in figure 4.1.5, and analysed in figure 4.1.6.

![Figure 4.1.3: AS08-16-2595 High quality version here: AFI](image)

In this image, the long shadows are cast by the clouds over the Amazon, and the yellow & purple arrows point to the same weather systems as they do in the previous figure, although only the thin tail curling away from the yellow arrow system is still visible.

Much more prominent now are a large spiral system off the north American coast and below Alaska (green arrow), and the scattered clouds over the south Pacific. There is also a prominent plume of cloud heading northwards from Antarctica (magenta arrow), and a small whirl of cloud off south America (red arrow) that are all easily found on the satellite image, along with all the other weather patterns.
Figure 4.1.6: ESSA-7 satellite image compared with AS08-16-2595 and Stellarium estimate of time at terminator
Figure 4.1.6a (Continued): AS08-16-2595 and a3D reconstruction using recovered ESSA
The Earth has rotated by a consistent amount between the first two photographs analysed, the shadows lengthen at the terminator, and the weather systems are still visible from the previous image. The bright spot showing the sun's reflection can be seen in this image, and the perspective of the photographer has changed noticeably, with much more of the Antarctic region in view.

Stellarium suggests a terminator time of around 20:45 on the 21st. The ESSA track over the terminator region was commenced at 17:00, as this was when track 2 (pass number 1593) began, as discussed for AS08-16-2593.

It’s worth mentioning again that the 3D reconstruction superbly recreates the scene, and also that as the Apollo craft is now further away the rendering process in the software has had to change to make the view match. Sticking with the original rendering would require zooming so far out of the object to reveal all the detail at the edges it would be too low a resolution to be worth including. Figure 4.1.6b illustrates the point.

![Figure 4.1.6b: Earth viewed using the same projection method in figure 4.1.4 at different virtual distances. The image on the left is from the same shot shown in the centre.](image-url)
At first glance these are the same, but a closer look shows that there is more of the Antarctic on display, and weather patterns on the western limb are more clearly in shot. This is exactly what you would expect if you were observing Earth from a real space ship moving further away from our home planet, and exactly what happens in the Apollo images.

AS08-16-2596 shows a very similar view but the Earth has rotated slightly, and there isn’t enough difference to make it worth a separate treatment. As with the previous image we also have a 16mm still equivalent, shown in figure 4.1.7.

Again, there would seem to be about a 15 minute time difference between the two. We also get a report from the transcript that:

008:24:29 Anders: ...Sure got a nice view of the Earth from here. We can see Baja California and about where San Diego ought to be.

Which is pretty much bang on the money.

The next frame in the magazine we have another view of a still more rotated Earth, and this time it has moved far enough to allow an image from ATS-1 to be included in the analysis. AS08-16-2597 is shown below in figure 4.1.8, and compared with the satellite images in figure 4.1.9.

Figure 4.1.7: Comparison of 16mm still with Apollo image from figure 4.1.5.

Figure 4.1.8: AS08-16-2597. High quality source: AFJ
Figure 4.1.9: ESSA 7 (left) and ATS-1 (right) images compared with AS08-16-2597 and Stellarium estimate of time at terminator.
Figure 4.1.9 (continued): AS08-16-2597 and 3D reconstruction using digitally restored ESSA data
Although there is no land visible in the image, it is possible to mark the position of the terminator with Stellarium by using the previous image analysis as a reference. The weather system highlighted by the green arrow is the same in figure 4.1.9 as in figure 4.1.6, which means that the terminator is just about on the west coast of the USA, which puts the time at around midnight on the 22nd. This corresponds well with the ATS-1 image, which was recorded at 00:54 on the 22nd, and it is evident from it that the eastern half of the image is in, or close to, darkness.

Stellarium also indicates that Australia should be visible on the western limb. This part of the Apollo image is a little washed out, but the magenta arrow points to a band of cloud that should lie off Australia’s east coast and that is visible in all 3 images presented here.

The presence of that green-arrowed system is another clue, if one were needed, that this is a picture that is part of a continuous sequence recording the Earth as it rotates, and not some sort of made-up on the spot fiction. As with the other images, and as will become apparent for every other image presented throughout the entirety of this report, the cloud systems on the satellite images match those of the Apollo image. The ESSA path that most represents the terminator line is track number 5, which corresponds to orbit number 1596, which commenced at 22:05 on the 21st. No specific mention of the actual time of the photograph, but the transcript does have the crew querying what settings they should be using on the camera, and stating at around 01:00 that:

012:06:27 Anders: This PTC attitude really isn't the greatest for taking pictures of the Earth.

PTC stands for 'Passive Thermal Control', or the 'barbecue roll' slow rotation that allowed the CSM to balance its temperature in direct sunlight.

As before, we have a pair of 16mms still for comparison (figure 4.1.10). While there is no apparent time difference between the first still on the left and the Hasselblad, there is a clear amount of rotation evident in the next still.

A few hours later, we have the next image of Earth showing movement, AS08-16-2599. This is shown below in figure 4.1.11, and analysed in figure 4.1.12a.
Figure 4.1.12a: ESSA-7 image compared with AS08-16-2599 and Stellarium estimate of time at terminator.
Figure 4.1.12a continued: AS08-16-2599 and 3D reconstruction using digitally restored ESSA data
The rotation of the Earth in this photograph compared with the previous one is such that the ATS image no longer has any features that are visible in it, and the only weather system identified in the previous image that is also identifiable in this one is the one picked out by the magenta arrow.

The system picked out by the blue arrow in figure 4.1.9 can still be seen on the satellite image, just as the green arrow here identifies a weather pattern that was visible on the ESSA part of figure 4.1.9, so it is obviously a continuation of the weather observations on the day. The plume of cloud extending up from Antarctica (yellow) is very easy to pick out in the Apollo image, as are the streams of west trending clouds to the west of it (purple and cyan arrows), the ‘Y’ shaped pattern near the equator (red arrow), and the Himalayan clouds (blue arrow).

Stellarium shows that the terminator is showing a time of approximately 07:00, and this can be compared with an ESSA time for the orbit nearest the terminator of 02:05 (orbit 1598, track 7).

An interesting feature of this particular Apollo 8 image is that it was taken while a US Corona satellite was in operation. Corona satellites were relatively short lived spy satellites launched to photograph enemy installations and troop movements. The film canisters were fired from the re-entering satellite and were caught by aircraft snagging trailing wires on their parachutes. Film at the time was a much better medium for detail compared with their TV picture transmitting counterparts, and the method also prevented the images being intercepted by unfriendly countries. The now declassified images are available here, and it is possible to download low quality versions of the image in a format that allows them to be superimposed on Google Earth.

One of the satellite passes is covered here in the context of showing how many passes you would need to get the same images taken by Apollo. On this image we have three areas we can examine. The first is over the coast of North Korea and China, and I’ve shown it below in figure 4.1.12b.

Figure 4.1.12b: AS08-16-2599 (top left) with area show in the Corona image (right) highlighted in red. Crop of that area in the Apollo image (centre) and Google Earth image showing the location of the Corona path (bottom left).
It’s worth pointing out a few caveats here before drawing any conclusions. We have no real idea when these images were taken other than the date, and there are very few clues available to us as to what time of day it might be. The lack of shadows on the ground suggests that the sun may well be high overhead in late morning/noon, and as the next orbital swathe available shows shadows indicative of early afternoon this doesn’t seem too far out. The Apollo image was taken at 07:00 GMT, but this translates to much later in the day in the image. The local sunset time for North Korea at this time of year is around 17:00, or 08:30 GMT, so the Apollo and Corona images could be separated by as much as 6 hours.

Another thing to consider is whether I’ve accurately worked out which location is being shown in the image given that most of the coastal area that would help us identify it precisely is under cloud. We do, however, have the ESSA satellite image that shows us coastal outlines, and this helps us to confirm that the clouds skirt around the Korean peninsula, and we do have the location correctly identified.

What the Corona image identifies is an area of clear skies off the east coast of North Korea, with a similar gap between the clouds that next to this gap and the coast to the north. The Apollo image shows a similar pattern.

A couple of orbits later and Corona begins a pass over China that ends just east of Hainan Island. Close examination under the clouds on land show shadows angled slightly towards the terminator suggestive of a photograph time of late morning/early afternoon. Figure 4.1.12c shows the details.

Figure 4.1.12c: AS08-16-2599 (top left) with area show in the Corona image (right) highlighted in red. Crop of that area in the Apollo image (centre) and Google Earth image showing the location of the Corona path (bottom left).
Again it’s worth bearing in mind the time gap between the two images, but as with the previous Corona pass the broad details are confirmed: the thick swathe of coastal cloud, some thinner bands just inland, and some lighter bands of cloud to the north.

The final pass visible in this image covers two sections stretching from Kazakhstan in the north to the Nepalese border in the south, as shown in figure 4.1.12d.

Figure 4.1.12d: AS08-16-2599 (top left) with area show in the Corona image (right) highlighted in red. Crop of that area in the Apollo image (centre) and Google Earth image showing the location of the Corona path (bottom left).

In this case the main feature in the Corona image is the large ‘C’ shaped cloud over Kazakhstan, and this feature can also be seen at the top of the Apollo image.

Also accompanying the Apollo still is a 16mm equivalent to the still image, and as with the previous image there is no apparent time difference between the two (figure 4.1.13).
A couple of images later in the magazine we have another new image of Earth, this time showing Africa as the dominant land mass in view. AS08-16-2601 is shown below in figure 4.1.14, and analysed in figure 4.1.15.

The ESSA-7 image in that analysis is dated the 22nd, and the dividing line between those orbits that started on the 22nd and finished on the 23rd can be seen to the east of Africa in the southern hemisphere, running up Arabia and across eastern Europe in the northern hemisphere, The majority of the Apollo image is west of that line.
Figure 4.1.15: ESSA-7 images compared with AS08-16-2601 and Stellarium estimate of time at terminator.
Figure 4.1.15 continued: AS08-16-2601 and 3D reconstruction of digitally restored ESSA data.
As usual, the weather patterns on the satellite images correspond exactly with those on the Apollo image, and several of the cloud systems visible in this image will be seen in later ones, not least the spectacular ‘dog-leg’ frontal mass connecting the Antarctic to south America (purple arrow), and the large frontal mass preceding a series of thin lines of cloud in the north Atlantic (green arrow, although only the main cloud front is visible in this image).

Although the Apollo image is slightly out of focus, it is still possible to pick out the thin clouds over north Africa (eg the cyan arrow), the coastal cloud banks around southern Africa, the typical frontal system off South Africa itself (yellow arrow).

The astronauts themselves describe the view to the ground at exactly the same time as this image was taken:

025:12:41 Borman: This is a mighty nice view we have down there today. A little bit more than a half-Earth. Looks like Africa and the Red Sea is visible; we’re not quite sure as there is quite a bit of cloud cover

Stellarium suggests a time of around 14:00 on the 22nd for this image. ESSA’s nearest track to the terminator is track 11. This is orbit number 1602, which is labelled as the first orbital pass on the image dated the 22nd, and was commenced at 10:05 on the 22nd. The ESSA satellite would barely cover the area around the terminator before the Apollo image was taken, never mind the rest of the photograph.

The next image in the magazine, AS08-16-2602, shows that another few hours have elapsed, and south America dominates the scene. This photograph is shown below in figure 4.1.16, and analysed in figure 4.1.17a.

![Figure 4.1.16: AS08-16-2602](https://example.com/figure4116.jpg)

Figure 4.1.16: AS08-16-2602 High quality source: AFJ
Figure 4.1.17a: ESSA-7 (left) and ATS-3 (right) images compared with AS08-16-2602 and Stellarium estimate of time at terminator.
Figure 4.1.17a continued: AS08-16-2602 and 3D reconstruction of digitally restored ESSA data
The green and purple arrows in figure 4.1.15 point to the same systems shown in figure 4.1.17, and the thin swirls of cloud discussed previously are now clearly in view (red arrow). Similar thin wispy bands of cloud can be seen off the coast of south America (south of the cyan arrow).

For the first time in this section, an ATS-3 image is usable, and this is also showing an excellent match to the Apollo picture. That image was taken at 14:58, and it is evident that the terminator is much further east in that image compared with Apollo’s.

ESSA’s orbit best matching the terminator is number 1606 (track 2) which commenced at 18:05, just 55 minutes before the Apollo photograph, which Stellarium puts at 19:00.

Ostensibly, the ATS & Apollo images seem (terminator line apart) identical, but there are subtle differences. The clouds over the always dynamic Amazon climate system, for example, are in a different formation to Apollo’s, where they are much more similar to the ESSA image taken nearer the time. There are also differences in the way the twin streams of cloud picked out in red are shaped. In ATS-3, they are much more definitely joined to the main bank of cloud (green arrow) and diverge more as they move westward. In the ESSA image, as with Apollo, the northernmost stream has broken away from the main bank of cloud, but there is a wider gap between the streams and they appear more parallel. This is a common theme throughout this research: ostensibly identical systems in fact showing small variations that are entirely consistent with the time differences between the images concerned.

Also available at this time was a TV broadcast that took place at 20:01 on the 22nd. A still from this broadcast (available here) that briefly showed Earth is available in figure 4.1.17b, and as the people on the ground state in the broadcast it’s very over-exposed and no detail can be made out. It’s shown here for consistency, along with the same scene shown on the front page of a British newspaper.

A short while after AS08-16-2602, we have AS08-16-2604. This photograph shows a very similar scene to that of 2602, but much of northern south America has passed beyond the terminator, and more of the Pacific is in view. AS08-16-2604 is shown in figure 4.1.18, and analysed in figure 4.1.19.
Figure 4.1.19: ESSA-7 (left) and ATS-3 (right) images compared with AS08-16-2604 and Stellarium estimate of time at terminator.
Figure 4.1.19 continued: AS08-16-2604 and 3D reconstruction using digitally restored ESSA data
As suggested previously, little has changed in the weather systems already shown, but it does serve to show (again) that the Earth is rotating as the CSM gets further away, and that that rotation brings into view weather systems that were previously hidden. There is no change in the ATS-3 timing, but ESSA’s most representative track for the terminator region is number three (orbit 1607), one orbit later than the preceding image, and therefore starting at 20:00.

Stellarium suggests a time for the image of 21:30, just 90 minutes after the previous one, and all of the colours for arrows to identify weather systems in figure 4.1.17 apart from the green and red ones are used again. The reader is also referred back to figure 4.1.6, which showed the same view roughly 24 hours earlier, and where magenta is used to identify the same weather pattern. Those two day’s weather patterns are compared below in figure 4.1.20.

![AS08-16-2595 (right) compared with AS08-16-2604 (left)](image)

The two days’ images show what is obviously the same weather system, but that has developed over 24 hours to extend further northwards, while a frontal band to the west moves further eastwards towards Chile.

Next up in the sequence of images is AS08-16-2605, and as will be seen shortly shows a relatively small amount of rotation since the preceding photograph on the magazine. Figure 4.1.21 shows the original Apollo image, and 4.1.22 the analysis. The degree of movement is enough to mean that there is a small amount of surface covered by both ATS-1 and ATS-3.

![AS08-16-2605. High quality](image)
Figure 4.1.22: AS08-16-2605 compared with ESSA (top & bottom left) ATS-1 (top right) and ATS-3 (bottom right) images dated 22/12/68, with Stellarium estimate of time at terminator.
Figure 4.1.22 continued: AS08-16-2605 and 3D reconstruction using digitally restored ESSA data
We’ve now moved on a couple of hours, and the Rocky mountains are beginning to disappear into night. There is no direct reference to the photograph being taken, but roughly an hour later communications issues led to Hawaii being asked to send messages, suggesting that the Pacific view in the photograph is consistent (as we would expect) with the mission narrative.

The area shown is an intermediate one between those covered by ATS-1 & 3, but the blue arrow points to the same system as is shown in figure 4.1.14. The most distinctive weather system is that off the Californian cast, where two bands of clouds separate and then rejoin in a long arc (red and green arrows).

As the time suggested by Stellarium is 23:30. The ATS-1 image was taken at 00:54 on the 22nd, so is some time before the Apollo image, but as the next ATS-1 image was taken at 22:43 on the 23rd, it falls almost exactly between the two. This time gap is enough to explain the small-scale differences, but is close enough temporally to cover the large scale similarities.

ATS-3 was taken much closer, 14:59 on the 22nd. While not identified specifically, there is good correspondence between the Apollo photograph and ATS-3 in terms of the swirl of light banded cloud off western south America. ESSA’s image is a much better match than either of the ATS satellites, as its orbital pass is much closer in time. The closest pass to the terminator is number 4, or pass 1608, which started at 21:05.

The next image of Earth is AS08-16-2606, shown below in figure 4.1.23, and analysed in figure 4.1.24, and is taken not long after the preceding one.

![Figure 4.1.23: AS08-16-2606. High quality source: AFJ](image-url)
Figure 4.1.24: ESSA-7 (left) and ATS-1 (right) compared with AS08-16-2606 and Stellarium estimate of time at terminator.
Figure 4.1.24 continued: AS08-16-2606 and 3D reconstruction of digitally restored ESSA data
The Earth has rotated sufficiently to lose the ATS-3 satellite, and the ATS-1 dated the 23rd is now nearer in time than the 22nd. ESSA’s image date is still the 22nd.

The ATS image was actually taken at 22:43 on the 23rd, over 20 hours after the Stellarium estimate of the image time, and understandably there is a much bigger difference between the Apollo image and ATS-1. However there are, as can be seen from the arrows used, still identifiable weather systems that can be seen on both those images.

Of those systems, the most striking ones are at the northern and southern ends of the planet. In the north there are the two frontal bands (green and red arrows) marking the boundaries of lighter swirls of cloud between them. To the south there are the storms heading north from the Antarctic, including the striking tight curl of cloud marked by the yellow arrow, and the long band of cloud making its way to Australia’s east coast. ESSA is a much better match for the Apollo image, and this is explained by the images being taken much closer in time to it. Orbit number 1609 (track 5) is the closest to the terminator, and commenced at 23:00 on the 22nd. The next image of Earth we have is extremely significant because it comes not from images presented after the fact but from a live TV broadcast.

As part of their journey, the Apollo 8 crew made a number of short live TV broadcasts to Earth. The first broadcast on the 22nd did show Earth but was overexposed, though photographs from it did appear in the following day’s newspapers. The most famous of the broadcasts is the Christmas Day broadcast made while rounding the moon, in which the crew took turns to read out a number of verses from Genesis. Clips from these broadcasts are viewable at the Honeysuckle Creek website.

Two clips from the Honeysuckle Creek website are of interest, as they show images of Earth. The 2nd TV transmission shown was carried out at 19:53 on December 23rd, and it is possible to capture a screenshot of the Earth from that and compare it with the ESSA 7 and ATS-3 data. The ATS-3 image was taken at 18:16 GMT – just over 90 minutes before the TV broadcast. Honeysuckle Creek have done their own image showing the orientation of the Earth at that time (figure 4.1.25).

![Figure 4.1.25: Honeysuckle Creek interpretation of terminator position during live TV broadcast](image)

The TV image is overexposed, but weather systems in both Hemispheres are easily identifiable. The broadcast of Earth from space made headline news around the world, but two interesting front pages are from the Long Beach Independent and Minneapolis Tribune of 24/12/68. Figure 4.1.27 shows these front pages, with the same weather systems in 4.1.26 identified (only one image has been arrowed for the sake of simplicity).
The newspapers were published on the 24th, and therefore can only have been taken from the TV broadcast on the 23rd. It could not have been produced from ESSA satellites imagery as the image for the 23rd would not have been completed until the 24th, by which time the newspapers would have been in production. The TV image can only have been broadcast from space on the 23rd. The ATS-3 image could, in theory, have been available, but the polar areas are missing and the angle of view, location of the terminator line, and weather systems visible on the western limb are different.

Of particular interest is the UK’s Daily Telegraph, Yorkshire Post and Daily Mirror. The UK is 5 hours ahead of east coast USA, giving them even less time before their front pages hit the news stands. The Chicago Tribune is relying on people reading it after an event has occurred.
Figure 4.1.27a:
Front pages of the Long Beach Independent (top) and Minneapolis Tribune (middle), the Daily News (bottom left) and Peoria Journal Star (bottom right).
Sources: newspaperarchive.com, blogs.pot, Facebook Apollo groups.
Apollo 8 crew first to leave Earth's gravity

While Christmas is indicated for Pueblo, Big Area

Viet Front reported quiet as Cong cease-fire starts

Commander says Communists beat Pueblo crewmen

Farm workers reject '50s or freeze' choice

Pueblo crew 'hunted and terrorized'

Moon team crosses the great divide

Earth from Apollo's Earth, as seen from the moon's TV broadcast.
Figure 4.1.27c: Press coverage from The UK Daily Mirror (top left), Philadelphia Daily News (top right), Chicago Tribune (right) and Evening Capital (left)
Figure 4.1.27d: Press coverage from The Roseburg Oregon News (ri Review (top right), the UK Daily Express (top left), and the Patriot (right).
Figure 4.1.27e: The Globe and Mail (left), Chicago Tribune (below left) and Yorkshire Post (below)
Another image is also available of the TV broadcast in the form of the image shown below (figure 4.1.28), available from the Facebook site Retro Space Images.

A zoomed and cropped image of the large monitor screen (figure 4.1.29) shows that the image on the screen (and on every monitor visible) is the same as the one on the newspaper front page, which, in turn, is an exact match of the satellite photos from the same date.

We also have TV footage of mission control during this TV broadcast (Moon Machines), and if we look carefully we can see the same TV broadcast can be seen on a monitor, with the same clouds – see figure 4.1.30a & b.
We can also include a newspaper page or two showing the scene to prove when it was done (figure 4.1.30b)

Figure 4.1.30b: Newspaper articles showing Earth on the screens at mission control

While broadcasting the view, Lovell describes the view to Capcom Michael Collins:

055:10:28 Lovell: What you're seeing, Mike, is a - Houston, what you are seeing is the Western Hemisphere. Looking at the top [left in this image] is the North Pole; in the center - just lower to the center is South America - all the way down to Cape Horn. I can see Baja California and the southwestern part of the United States. There's a big, long cloud bank going northeast, covers a lot of the Gulf of Mexico, going up to the eastern part of the United States, and it appears now that the east coast is cloudy. I can see clouds over parts of Mexico; the parts of Central America are clear. And we can also see the white, bright spot of the subsolar point on the light side of the Earth.

and

055:12:17 Lovell: Okay. For colors, the waters are all sort of a royal blue; clouds, of course, are bright white; the reflection off the Earth is - appears much greater than the Moon. The land areas are generally a brownish - sort of dark brownish to light brown in texture. Many of the vortices of clouds can be seen of the various weather cells, and a long band of - it appears cirrus clouds that extend from the entrance to the Gulf of Mexico going straight out across the Atlantic. The terminator, of course, cuts through the Atlantic Ocean right now, going from north to south. [The] southern hemisphere is almost completely clouded over, and up near the North Pole there is quite a few clouds. Southwestern Texas and southwestern United States is clear. I'd say there are some clouds up in the northwest and over in the northeast portion.

and

055:19:25 Lovell: ...I can pick out the southwest coastline of the Gulf and where Houston should be, and also the mouth of the Mississippi; I can see Baja California and that particular area. I'm using a monocular which we have aboard.

Unsurprisingly, this is an entirely accurate description of what is evident from the satellite photographs.

For the next still view of Earth we return to magazine 16. AS08-16-2607 has rotated slightly from the previous Hasselblad, but there isn't enough of a difference to make it worth examining as a separate case. Therefore the next photograph from magazine 16 to be analysed is one of the final pair from it before images of the lunar surface are found, which at the very latest puts it at before the 25th of December, and once again south America is the dominant view in the photograph. AS08-16-2608 is shown below in figure 4.1.31, and analysed in figure 4.1.32.
While Christmas day 1968 is the very latest that the picture could have been taken, the satellite record places the photograph very definitely on the 23rd, with Stellarium placing the time at 21:00 on that date. ATS-3’s image was taken at 18:16 on the 23rd, while the area around the terminator line was imaged by ESSA on orbit 1618 (track 2), which commenced at 17:05.

It’s also very obviously the same view that can be seen on the TV broadcast images, the only difference being that a substantial chunk of South America has slipped into darkness.

Looking at the Apollo photograph, they are describing accurately what they can see, and have not (as in all cases when discussing the view of Earth on any mission) been prompted in any way. The long cloud heading north-east from the Gulf is indicated by the blue arrow, and the thin cirrus clouds described from the Gulf into the Atlantic are likely to be the ones pointed out by the red arrow (although they actually extend from north to south only if coming from the Atlantic). The maroon arrow points to the same weather system off the coast of Chile identified in previous images, and the purple and yellow ones over south America itself also point to weather systems identified on the previous day by the same colours in figure 4.1.17.

The next images from Apollo 8 are from lunar orbit.
Figure 4.1.32: ESSA-7 and ATS-3 compared with AS08-16-2608 and Stellarium estimate of time at terminator.
Figure 4.1.32 continued: AS08-16-2608 and 3D reconstruction using digitally restored ESSA data
4.1.1b Apollo 8 – around the Moon

The next photographs are of much greater historical significance. As the evidence will show, the following images are not of the first Earthrise to be witnessed by human eyes, but they are the first to be photographed. As it turns out, there are three images of the first Earthrise to be photographed, and they are from three different magazines, 12, 13, and 14. Of these three, the image from magazine 13 is the one chosen as the first, and will be used in comparison with the satellite images. AS08-13-2329 is shown below in figure 4.1.33, and analysed in figure 4.1.34. Figures 4.1.35a and b show AS08-14-2383 and AS08-12-2185 respectively, together with a zoomed and cropped Earth from those images as a comparison with AS08-13-2329. 4.1.35c shows my own copy of the satellite image covering this sequence.

![Figure 4.1.33: AS08-13-2329.](image)

That the images all show the same event is obvious – the weather patterns and their distribution in each is identical. The sequence of images presented above is easy enough to determine. Magazine 13’s contribution exists in isolation, as all the images around it are of the lunar surface, while magazine 14’s image is one of a pair right at the beginning. The fact that it is clearly higher above the lunar surface than 13-2329 obviously places it later in that Earthrise. Examination of the surface in the pictures from 13 and 14 also show that different craters are evident – the photographers are moving over the surface of the Moon, and the twin craters visible in the bottom left of 14-2385 and the larger crater in the bottom right can be seen much closer to the lunar horizon in 13-2329.

Magazine 12’s contribution is also preceded entirely by lunar surface images, and as there is no lunar surface in it is obviously taken later than those from 13 and 14. While there are no lunar surface features visible to act as a comparison, a closer look at the weather system identified by the yellow arrow in figure 4.1.34 shows that it is noticeably closer to the terminator in 12-2185 than in the other two images, suggesting a time lag of around 15 minutes between them.
Figure 4.1.34: ESSA-7 image compared with AS08-13-2329 and Stellarium estimate of time at terminator.
Figure 4.1.35: Apollo images of Earth from the same orbital sequence as AS08-13-2329, together with a photograph of my hard copy of the actual satellite photograph covering this Earthrise.

a) AS08-14-2383
   (High quality source: AFJ)

b) AS08-12-2185
   (High quality source: GAP)

c) My personal hard copy of the satellite image
Figure 4.1.35d: 3D reconstruction of digitally restored ESSA data and AS08-14-2383
Determining the time of the image is also simple enough, thanks to the visibility of Africa at the terminator. In order for Africa to be on the terminator, the image must have been taken at around 16:45 GMT on either the 24th or the 25th. As by that time on the 25th Apollo 8 was well on the way back to Earth, the image must have been taken on the 24th, around 76 hours into the mission, and around 7 hours after the Lunar Orbit Insertion (LOI) burn. This should mean that there would be around 3-4 orbits before this first photograph of Earth was taken.

We have the satellite photographs to use as a basis for determining which day the image was taken, and a look at the ESSA image shows the same features as the Apollo image on the mosaic dated the 24th. The previous day’s mosaic shows that there are still two bands of clouds running from South America to the Antarctic (previously marked by purple and yellow arrows), while this Apollo image only shows one. On the following day, this band of cloud has pretty much separated from South America, rather than extending well into it. The configuration of the cloud mass off southern Africa (yellow arrow) is also different on all 3 days, and only matches exactly the one from the 24th.

The terminator on the 24th is best covered by orbit 1629 (track 13), which commenced at 14:00 on the 24th – just a couple of hours before the Apollo image was taken.

We have an additional source for this historic moment in the mission transcripts. As any conversations concerning Earthrises as they happen are not in the main transcript referred to previously (as this is the technical air to ground, or TEC, transcript), we need to turn to transcripts of the CM voice recordings, which captured the crew’s conversations as they passed over the far side after LOS.

A pdf of the document itself is available here: CM Transcript, but there is a more readable transcript of the event at the AFJ here. Joining the CM and TEC transcripts gives us a complete record of the moment. At 74:40 MET, or 15:31 on the 24th, the crew are engaged in a session of lunar photography of both planned targets and ‘targets of opportunity’, and they describe in detail which magazines have been used and how many shots have been taken on the three revolutions completed so far. The main significance of this is to set a context for what comes next – the crew didn’t suddenly decide to take photos, they were actively photographing the Moon when the Earth came in to view.

At 75:30, or 16:21, the CM starts its 4th orbit, and the lunar module pilot Bill Anders appears to be the person taking surface pictures with magazine 13 (originally labelled ‘E’), as he is the one recording the frame numbers and technical details about the photographs. At 75:46 MET, the CM pitches on command and we have the following exchange:

075:47:30: Oh, my God! Look at that picture over there! Here’s the Earth coming up. Wow, is that pretty!

075:47:37: Hey, don’t take that, it’s not scheduled. (Chuck.)

The AFJ site is more circumspect than the CM transcript, and is not specific as to who actually took the photograph, while the latter has the Anders saying the “don’t take that” line and the Borman exclaiming about the view. As Anders was the person in charge of the black & white film prior to this, it perhaps seems reasonable to assume that it was he that took this historic image.

The AFJ’s author (David Woods, also the author of How Apollo Flew to the Moon) argues that Anders was committed to the photography aspect, and would have been more likely to have been the person making the admonishment about deviating from the schedule.

A few moments later, the crew (at Anders’ prompting) scrabble for the colour film in an effort to capture the moment before finally:
Lovell: Well, I got it ri - Oh, that's a beautiful shot.
Lovell: 250 at f/11.
Anders: Okay.
Lovell: Now vary the - vary the exposure a little bit.
Anders: I did. I took two of them.

Anders, then, is definitely the person who took the colour photographs that launched a thousand environmental movements. While the debate about how took the first image is somewhat esoteric (although to this author's mind the person who took the monochrome would be the person who wanted an even better colour shot, ie Anders!), the main issue as far as this research is concerned is the timing of the images. 075:47 MET is 16:38 GMT on 24/12/68 – just a few minutes short of Stellarium's estimate for an image that matches exactly a satellite mosaic that was taken at the same time. There is no record of when magazine 12's image was taken, although Anders is exhorted to “get another one”.

The next image is AS08-12-2388, shown below in figure 4.1.36, and analysed in figure 4.1.37

![Figure 4.1.36: AS08-12-2188. High quality TIFF image source here: archive.org](image)

As before, the black and white image is matched by a colour image, in this case AS08-14-2385. The original of this image is shown in figure 4.1.38, together with the zoomed in version of the Earth on it.

The AFJ originally had the magazine 12 image timed as occurring after TEI (Trans-Earth Injection), which is an engine burn that lifts the CSM out of lunar orbit and on a trajectory towards the Earth. This usually occurs at a point on the far side of the Moon, and therefore can still show the lunar surface and an Earthrise.
Figure 4.1.37: ESSA-7 images compared with AS08-14-2385 and Stellarium estimate of time at terminator.
In terms of the weather systems, it is obvious that they are the same ones as viewed in figure 4.1.34, indeed only one arrow (the purple one) has been moved to new location. The yellow arrow, however, points to a weather system that has largely disappeared beyond the terminator, while the blue arrow shows a band of cloud much more clearly than in the previous image, again showing a perfectly consistent rotation.

We do have a small clue from the CM transcript. Orbit 5 commenced at 77:29 MET, or 18:21 on the 25th. Twenty minutes after this at about the time when the Earth would be rising, we have the following exchange between the crew members:

03 05 43 46 CMP: Bill, ... Do you know I can see the horizon? Can you see the horizon?
03 05 43 59 LMP: Pitch up?
03 05 44 00 CMP: Yes, pitch up to –
03 05 44 20 CDR: Pitch is about 50.
03 05 44 23 CMP Can you pitch up some more?
03 05 45 20 CMP No, that's about right. Let's take pictures of ...

While they aren't specific, they are evidently still taking photographs, and keen to orient the spacecraft to an angle that would allow them to take a photograph of something specific. The contention here is that it is the

Figure 4.1.38: AS08-14-2385 and zoomed Earth from it. High quality source: AJF
Earth, now showing above the horizon. The time in days, hours and minutes shown above converts to 77:45 MET, or 18:35 (which is the time used to set Stellarium). Stellarium and the photographs in magazines 12 and 14 show the same configuration of land masses, and the Apollo images show the same weather patterns as the satellite mosaic on the 24th.

The ESSA orbit for the terminator on these two images is best covered by track number 2, or orbit 1631, which commenced at 18:00.

There are no more pictures of Earth in magazine 12, but the next sequence of images in magazine 14 show another Earthrise. They could be mistaken for a continuation of the sequence just examined, but a closer look (and the fact that the first in the sequence is lower on the horizon than the previous one!) shows it is from a separate event.

The only one of these images where the Earth is completely above the horizon and fully visible is AS08-14-2393, and this is shown below in figure 4.1.39, and analysed in figure 4.1.40.

![Image](AFJ)

On the face of it this image is very different to the previous ones, but once Chile is glimpsed by the terminator it becomes evident that it is just a continuation of the previous ones, and that a couple more orbits have elapsed, allowing the Earth to rotate a little more. The purple and blue arrows point to the same weather systems as in the preceding analysis, while the remainder indicate those that have come into view as time has elapsed.

As with the previous Earthrise photographs, even if there is no direct reference to a photograph, there is a hint in the crew dialogue, and we know from the mission programme that photographs are still being taken as mission progresses. At 71:43 MET (22:34 GMT), we have the following exchange after the start of orbit 7:

03 09 43 06 CDR: Oh, brother! Look at that!
03 09 43 16 CMP: What was it?
03 09 43 18 CDR  Guess.
03 09 43 20 CMP  Tsiolkovsky? [a lunar far side crater]
03 09 43 21 CDR  No, it's the Earth coming up
Figure 4.1.40: ESSA-7 (left) and ATS-1 (right) images compared with AS08-14-2393 and Stellarium estimate of time at terminator.
Figure 4.1.40 continued: AS08-14-2393 and 3D reconstruction using digitally restored ESSA data
Stellarium has been set at 22:30 in figure 4.1.40, and it is again obvious that the land masses visible are a clear match with what can be seen on the Apollo photograph. As the Pacific is now in view, ATS-1 becomes of use, and most of the weather systems visible in the Apollo image are visible in this in one form or another. The time for the ATS image is recorded as 21:55 on the 24th. ESSA's best orbit for the terminator is track 3 (although it is slightly further west than the terminator), or orbit number 1632 which commenced at 19:05.

There are no more images from the 24th, and preparations for TEI mean that no more photographs are taken of Earth until after that burn has taken place. The next image featuring Earth is on magazine 15, and the first image on there, AS08-15-2535 is shown below in figure 4.1.41, and analysed in figure 4.1.42.

![Figure 4.1.41: AS08-15-2535. High quality version here: AFJ](image)

This view of Australia is repeated several times over the next 48 hours, and the cloud systems in it undergo subtle changes in that time, so it is worth describing what we can see.

The system to the west of Australia is like an inverted bass clef symbol (blue arrow), connected by a west-east trending cloud mass that joins the system from Antarctica. This latter system has a clear and cloudless dividing line separating it from the bass clef system, and a band of cloud runs up from Antarctica parallel with that line (green arrow) before skirting the east coast. To the north west of Australia the ocean is largely cloud free. Pakistan has a notable ‘>’ shaped cloud mass over it connected to the Himalayan clouds (magenta arrow), and there is a distinct gap between this system and a large cloud mass over SE Asia (yellow arrow).
Figure 4.1.42: ESSA-7 image compared with AS08-15-2535 and Stellarium estimate of time at terminator.
Figure 4.1.42 continued: AS08-15-2535 and 3D reconstruction using digitally restored ESSA
If the reader cares to return to figure 4.1.12, the plume of cloud extending to Australia from Antarctica is also visible there (yellow arrow), as is a 'bass clef' pattern in what could be seen as an early stage of development, identified by the cyan arrow. If the weather patterns are followed through the satellite images, it becomes evident that what is visible in figure 4.1.42 as a plume actually started out in figure 4.1.12 as a curl of cloud off the west coast, and the cloud systems visible in the images are part of a progression of weather patterns typical for the region.

The position of Australia at the terminator in the photo allows Stellarium to determine a time of 08:30 on the 25th. ESSA's image dated the 24th still applies here, and orbit number 1637 (track 8), which commenced at 05:00 on the 25th.

After this first set of three images in magazine 15, there are a further 4 that were taken some time later. These photographs are represented here by AS08-15-2538, seen below in figure 4.1.43, and analysed in figure 4.1.44.

![Image of Earth from space](https://example.com/image.png)

*Figure 4.1.43: AS08-15-2542. High quality source here: AFJ*

The view we have in this image is also one that has been featured before, and the reader is referred back to figures 4.1.3, 4.1.17, 4.1.19, 4.1.27 and 4.1.32 for similar views that show the evolution of weather patterns on Earth over several days, and not (as some conspiracy followers claim) some form of painting.
Figure 4.1.44: ESSA-7 and ATS-3 images compared with AS08-15-2538 and Stellarium estimate of time at terminator.
Figure 4.1.44 continued: AS08-15-2538 and 3D reconstruction using digitally restored ESSA data
The same broad features seen in previous photographs of south America are still visible, from the long thin band of cloud across the north Atlantic from the Gulf of Mexico (blue arrow) to the large 'dog leg' of cloud extending across from south America towards southern Africa (red arrow). The arrangement of those weather systems is, however unique to the 25th of December 1968.

Stellarium's estimate puts the time of the image at 19:00 on the 25th, and this compares with a time for the ATS-3 image of 14:33 and an ESSA-7 time for the terminator orbit of 16:09 (track 2, orbit 1643).

A little while later there is another pair of photographs, probably taken to coincide with a TV broadcast. While these show only a small rotation, they do allow the use of all 3 satellites in comparing the weather, as for once they are all available.

Figure 4.1.45 shows AS08-15-2542, and figure 4.1.46 shows the satellite comparison.

Figure 4.1.45: AS08-15-2542. High quality source here: AFJ

In the preceding photograph we have lost sight of most of the weather systems visible in the previous image, but the magenta arrow does pick out the complex cloud patterns off the south American coast that have been a consistent feature throughout photographs of the region. The most striking feature now is a long curl of cloud tightly coiled off southern Chile, a system that is common to all the satellite images in one form or another.
Figure 4.1.46: ESSA-7 (left) ATS-3 (top right) and ATS-1 (bottom right) compared with AS08-15-2542 and Stellarium estimate of time at terminator.
Figure 4.146 continued: AS08-15-2542 and 3D reconstruction using digitally restored ESSA data
The smaller weather patterns are less striking thanks to the picture being slightly out of focus, but it is still easy to make them out. The clouds over central America stretching down from the USA are very obvious (yellow arrow), and once the ESSA image's green arrowed cloud is noticed, its configuration on the actual image is readily identifiable.

As far as timings are concerned, the terminator cutting across Brazil puts the time at around 19:00 on the 25th. ATS-1's image was taken at 22:41, while ATS-3's image was taken at 14:33 on the 25th. ESSA-7's track 3 best covers the terminator region, and this was carried out by orbit number 1644 at 18:04.

A gap of several hours ensues before any more photographs are taken of Earth in magazine 15, and the next series occur after a few pictures of an increasingly distant Moon (images AS08-15-2543-7 are currently mistakenly labelled in the Apollo Image Atlas as the Earth!). The first high quality image of the sequence is AS08-15-2550 (the preceding two show the same view but are not as zoomed in). This photograph is shown in figure 4.1.47, and analysed in figure 4.1.48.

In this photograph, nearly all of the weather patterns visible in the previous picture have disappeared beyond the terminator, with the exception of the one identified by the blue arrow. In its place are the complex weather patterns dominating the south Pacific around Australia. It is fairly obvious that the long band of cloud to its north (magenta arrow) around the Hawaiian islands and those to the east (red arrow) and south (cyan arrow) are present on ESSA's image as they are in Apollo's. The cyan arrow points to a system south-west of Alaska. Alaska itself would be at around sunset at this time. By way of confirmation, at around 02:00, Michael Collins, acting as Capcom, tells them:

109:19:27 Collins: I don’t know how much detail you can see, Jim, but your sub-spacecraft point is out in the middle of the Pacific Ocean about halfway between Australia and South America.
Figure 4.1.48: ESSA-7 (top left) and ATS-1 (below left) compared with AS08-15-2550 and Stellarium estimate of time at terminator.
Figure 4.1.48 continued: AS08-15-2550 and 3D reconstruction of digitally restored ESSA data
The ATS-1 image also shows the red and magenta arrowed systems clearly, although the fact that it was taken several hours before the Apollo photograph means that there are differences in their configuration. For example the yellow arrow points to a cloud mass that is much more separated from the clouds picked out by the blue arrow in ATS than it is in Apollo. The green and cyan arrows in the ATS image point to where cloud masses are, but aren't quite as easy to see as they are on the ESSA and Apollo images.

The position of Australia is helpful in identifying time, but the cislunar view makes time estimates difficult. The sub-solar point helps to pinpoint the time at around 03:30 (see this page on my site).

As Stellarium identifies the time as being at around 04:30 on the 26th, the ATS-1’s image used is from the 25th (22:41 GMT), as this is nearer in terms of elapsed time between the satellite image and the Apollo one. ESSA’s orbit at the terminator is number 1647 (track 6) which was commenced at 00:09 on the 26th.

The next mini-sequence of images in magazine 15 is represented by AS08-15-2554, and Australia is much easier to see in this one. It can be seen below in figure 4.1.49, and analysed in figure 4.1.50.

Figure 4.1.49: AS08-15-2554. High quality source: AFJ

Australia has now come into view properly and we can see the development of the weather systems identified in AS08-15-2535. The magenta system in this image is the same one that wrapped itself more closely around the north and eastern coasts 24 hours previously, but has now moved on towards New Zealand leaving the coast clear.
Figure 4.1.50: ESSA-7 (top left) and ATS-1 (below right) images compared with AS08-15-2554 and Stellarium estimate of time at terminator.
Figure 4.1.50 continued: AS08-15-2554 and 3D reconstruction using digitally restored ESSA data
For this image, we can see that the magenta, cyan and red arrows point to systems that are visible on the same ATS-1 image (dated the 25th) as used previously. The blue and purple arrows identify systems that are just visible near the north-western horizon but were not specifically picked out in the previous figure.

The 'plume' system looks very similar, and there is still a hint of the coiled frontal 'bass clef' system to the south and west of the continent. Closer examination of the satellite images shows that in fact the plum has been joined by what was the clef, which has rotated and moved south and east. The system to the west is a new system moving eastwards from off South Africa.

ATS-1’s time has already been noted, but the ESSA orbit best matching the terminator is orbit 1648 (track 7), which commenced at 02:05.

A short while later, images are taken showing Australia’s east coast passing into darkness, as shown in AS08-15-2562 (figure 4.1.51) and analysed in figure 4.1.52. Most of the images between the previous photograph and this one consist of poorly framed images of Earth taken at the same time as AS08-15-2554.

In this latest instalment, Australia’s east coast is now well beyond the terminator, but the new frontal mass off the west coast (green arrow) is easy to make out. The purple arrow points to the long cloud bank identified by a blue arrow in the previous analysis, which joins up to landmasses over the Indian subcontinent and the Himalayas.
Figure 4.1.52: ESSA-7 image compared with AS08-15-2562 and Stellarium estimate of time at terminator.
Figure 4.1.52 continued: AS08-15-2562 and 3D reconstruction of digitally restored ESSA data
It is also easier to see in this image the transformation of the cloud marked by the cyan arrow from an elongated curl off the west coast on the previous day to the more compressed form it has on the 26th. Although not specifically labelled, it is worth noting the wide band of sub-equatorial cloud north of Australia, is it also appears in the next image showing the continent.

Stellarium puts the terminator at about 09:30 on the 26th ESSA's terminator orbit is number 1649 (track 8), which commenced at 04:00 on the 26th.

After completing their circumlunar operations, the next stop: Earth!
4.1.1c: Apollo 8 – Home again

The next image in the time sequence is a return to magazine 13. Photograph AS08-13-2369 (figure 4.1.53) is part of a small series of identical shots of Earth that appear after close-ups of the lunar surface and after pictures of a receding Moon, clearly placing it after TEI. It is analysed in figure 4.1.54.

As this photograph shows the exact region where the dividing line between days for ESSA mosaics is placed, ESSA images dated the 25th are used to discuss the areas east of that line, and dated the 26th for areas west of that line.

Describing the scene where Africa dominates is always tricky in terms of relating it to ESSA images because of the mosaic dividing line. This image does, however, show clear differences in the weather systems either side of that dividing line that helps make it simpler. It’s also worth taking a look at the 3D model, in which I’ve used the correct sections of each day’s image to produce a single globe. East of the divide, the green arrow (which is the same weather system identified with that colour in figure 4.1.50) points to clouds that show a definite difference on the image dated the 25th compared with how it looks on the image dated the 26th. Likewise the blue arrow and cyan arrows point to systems east of the divide look very different compared with the west side.

The red arrow points to a front on the western side of the divide, and if this system is compared with the one shown on the ESSA mosaic dated the 25th, he central blob of cloud shown in the latter is missing, and it is also not far enough to the east compared with the image dated the 26th. The thin line of cloud crossing the Apollo image over the southern Sahara towards Arabia (purple arrow) does not show as clearly on the ESSA mosaic dated the 25th.

The data catalogue for ESSA shows that the images dated the 25th consist of orbits 1640-1652, while the ones dated the 26th are 1652-1664, so the last orbit on the mosaic dated the 25th is the same as the first orbit on the mosaic dated the 26th (the line on the latter is clearly further east). The time for orbit 1652 is given as 10:05 on 26/12/68, which is roughly 3 hours before the Stellarium suggests the Apollo image was taken.

There is a colour image showing almost the same scene in magazine 15, AS08-15-2563, and this is shown below in figure 4.1.55, along with a zoomed and cropped image of the Earth from that image. Ostensibly this image looks identical to the one from magazine 13, but there zooming in on the terminator does show where the difference lies (figure 4.1.56).
Figure 4.1.54: ESSA-7 images dated 25/12/68 (right) and 26/12/68 (left) compared with AS08-13-2369 and Stellarium estimate of time at terminator.
Figure 4.1.54 continued: AS08-13-2369 and 3D reconstructions using digitally restored ESSA data
The weather systems are very much the same, so it is obviously taken on the same date, but it should be evident that the Arabian landmass is much closer to the terminator in the colour image compared with the black and white. The amount of rotation is consistent with a time lapse of about 15 minutes between them.

Several photographs of the same scene were taken in magazine 15, and the next photograph showing a different view in magazine 15 is AS08-15-2574. This is shown below in figure 4.1.57 and analysed in figure 4.1.58.
Figure 4.1.58: ESSA-7 image compared with AS08-15-2574 and Stellarium estimate of time at terminator.
Figure 4.1.58 continued: AS08-15-2574 and 3D reconstruction using digitally restored ESSA data
Despite Africa having moved its relative position by some distance between this photograph and the one used previously, most of the weather systems available for comparison are still visible. The magenta, purple red and yellow arrows all point to the same weather systems identified in figure 4.1.54. The time of the image is put by Stellarium at 16:00, and this time lapse has allowed the front identified by the red arrow to change its position in comparison with figure 4.1.52, and it appears much less solid than before. The ESSA orbit for the terminator here is track 12 (orbit 1653), which commenced at 12:00 on the 26th.

As with the preceding image, a different magazine shows an almost identical view. Magazine 14 has photograph AS08-14-2509, which appears after several photographs of the entire Moon through red and blue filters. This photograph is shown below in figure 4.1.59, together with a zoomed and cropped Earth from it.

Figure 4.1.59: AS08-14-2509 with zoomed and cropped Earth from it. High quality version here: AFJ

Figure 4.1.60: Libya terminator as seen in AS08-15-2574 (left) and AS08-14-2609 (right)
Of the two, it appears that AS08-14-2609 was taken slightly later than the one from magazine 15. The cloud masses over the Mediterranean to the north are clearly nearer the terminator in magazine 14’s contribution, as is the dark spot on the terminator that is Libya’s Haruj volcanic field.

It’s also with noting the shadows cast by the long clouds in central Libya between and the Tassilie n’ Aljer desert area and the Haruj, which are entirely consistent with a sunset time period. Once again we have a situation where two apparently identical photographs are not, purely because the Earth is moving while the astronauts return to it.

The next shot of Earth is a return to the 16mm footage. This time we have a pan of the Earth taken through the CSM’s sextant, and by piecing together individual frames we can get a view of the whole disk (figure 4.1.61).

![Figure 4.1.61: Montage of screenshots from 16mm footage compared with ESSA satellite mosaics dated 26/12/68, with Stellarium indication at Earth at time of filming.](image)

The weather systems are evidently those shown in the ESSA image, but how can we be certain that the image was taken at 16:55 on the 26th, particularly as the most reliable indicator of time (the terminator) is obscured? We can get an approximate timeframe for the image by comparing it with figure 4.1.59 (AS08-15-2574) has been determined as 16:00, as we can see the same weather systems identified in it.

This gives us a good start, but more reliable still is the mission report and mission transcript.
Figure 4.1.61 continued: Montage of screenshots from 16mm footage and 3D reconstruction using digitally restored ESSA data
"For this flight, a special adapter allowed the 16mm sequence camera to be attached to the command module sextant" allowing for colour filming.

"During transearth coast, sextant photographs were taken of the Moon at about 123 hours and of the Earth at 124 hours. Although the range is too great for accurate horizon analysis, the appearance of the Earth through the red tinting of the landmark line of sight should be an effective familiarisation aid for future crews."

The video footage immediately before the Earth shot is of a reddish tinted Moon, there is a reddish cast to the Earth in the montage, and the circular border would be that of the sextant. The exact timing, and the time used in the Stellarium image, is confirmed in the transcript. At 5d4h4m, or 124:04 hours MET, or 16:55, we get the following comment in response to a request from Capcom to change the CSM orientation:

124:04:16 Borman: That's fine. We are going to stay in for about two more seconds while Jim takes the pictures through the sextant for the optics people.

Is the time correct? The answer is obvious from the landmasses visible in the montage. South America is in shot on the western limb, with the Pacific ocean off Chile just discernible west of the cloud mass arrowed in green. The west coast of north Africa is just visible on the eastern edge of the picture, but the remainder of the continent (and the terminator) are hidden by the sextant’s edge.

The next views of Earth mark a return to TV.

The second TV broadcast examined here is the 6th TV transmission, which started at 20:36 on the 26th, some 3 hours after the ESSA track was taken. The ESSA image is presented with a screenshot from that broadcast in figure 4.1.62a. 4.1.62b shows wire images for the press that clearly identify the date of transmission. Figure 4.1.62c shows newspaper pages dated the following day.

Figure 4.1.62a: ESSA-7 image from 26/12/68 compared with TV broadcast from the same date.
Figure 4.1.62b: Press wire photograph from 26/12/68 showing TV image from the last TV broadcast (Image is from eBay, copyrighted Historic Images) together with my personal copy of the same image. Both images are upside down.
Figure 4.1.62c: Washington Post front page (top), New York Times (above left), and Daily News image (above right), San Antonio Express (left) dated December 27th.
The press images are centred on South America, and there is a clearly defined band of cloud along the east coast. The upper left of the image is North America, most of which is obscured by clouds.

The terminator line is just crossing Brazil, and Stellarium confirms that this is exactly where the terminator should be (figure 4.1.63).

While the TV screenshot is not as sharp as the Apollo photographs, and much of the ESSA clouds are not as clearly visible as those on Earth, it is still possible to discern unique systems that mark it out as having been taken specifically on the 26th, notably a small system off the coast of New York (identified with the blue marker) that is not there on the 25th.

The next still image in this time sequence is AS08-15-2576. It is shown below in figure 4.1.64 and analysed in figure 4.1.65.
Figure 4.1.65: ESSA-7 image compared with AS08-15-2576 and Stellarium estimate of time at terminator.
Figure 4.1.65 continued: AS08-15-2576 and 3D reconstruction using digitally restored ESSA data
Once again we have a duplicate image from magazine 14, AS08-14-2518. This image is shown below in figure 4.1.66, together with a zoomed and cropped Earth from it. On this occasion there is no obvious difference in the relationship of the various land masses and cloud patterns to the terminator, although comparisons are not helped by the out of focus nature of AS08-14-2518.

This view of south America is unique, compared with the same view from other days, and your there are no weather systems in it showing the same configuration as previous ones of south America. The time is now 21:00 in the 26th, and ESSA's orbit for the terminator would have been carried out at 17:05 (track 2, orbit 1656).

We now switch back to magazine 16 for our image sources, as no other magazines contain images after 21:00 on the 26th. The first one under consideration is AS08-16-2619, shown below in figure 4.1.67, and analysed in figure 4.1.68.
Figure 4.1.68: ESSA-7 (left) and ATS-1 (right) images compared with AS08-16-2619 and Stellarium estimate of time at terminator.
Figure 4.1.68 continued AS08-16-2619 and 3D reconstruction of digitally restored ESSA data
The Earth has rotated around to hide all but the very tip of south America in darkness, bringing the large swirl of cloud (red arrow) visible in the previous image towards the terminator. This same swirl of cloud is actually referred to in the mission transcript during a TV broadcast, when at 20:53 GMT the crew describe:

**128:02:38 Lovell: At the tip of South America, there is a great swirl of clouds down there. It looks like a great storm...And then up to the left hand side, or towards the north, we can see the light waters around the West Indies, and we can actually see Florida. I’m looking through Bill’s monocular, and I can see the various land masses, South America and the central part and southern part of the United States.**

which matches well with the suggested time for the previous image of around 21:00.

Other features visible on the previous image include the feature identified by the yellow arrow, where two streams appear to cross. This can also be seen in figure 4.1.35, where the curl of cloud is also visible, but there is less cloud between the main bands in that image.

Stellarium suggests a time for AS08-16-2619 as midnight on the 27th, and the remaining images on the magazine are a regular marking of the mission's progress towards re-entry at 15:27 GMT on that day. ESSA's terminator orbit is number 1658 (track 4), which was commenced at 21:04, while ATS' image was taken at 00:45 on the 27th.

A short while later we have AS08-16-2626, which can be seen in figure 4.1.69 below, and analysed overleaf in figure 4.1.70. There are relatively few differences between this image and AS08-16-2619, but it does at least bring those weather patterns visible in ATS-1 more clearly to the fore.

![Figure 4.1.69: AS08-16-2626. High quality source here: AFJ](image)

The blue, yellow and green arrows point to the same weather systems as they do in figure 4.1.54, although for the latter two most of the weather system they are part of are now beyond the terminator.

ATS-1's time, as before is 00:45, while ESSA's nearest terminator orbit was started at 23:09 (track 5, orbit 1659), which compares well with Stellarium's estimate of 02:00.
Figure 4.1.70: ESSA-7 (top left) and ATS-1 (bottom left) images compared with AS08-16-2626 and Stellarium estimate of time at terminator.
Figure 4.1.70 continued: AS08-16-2626 and 3D reconstruction of digitally restored ESSA data
The next images showing different views of Earth (AS08-16-2632 & 2634) show only a small change, and there is little to be gained from analysing them. For the sake of completeness they are shown below in figure 4.1.71, together with the zoomed and cropped Earths from them.

![Image showing different views of Earth](image)

Figure 4.1.71: AS08-16-2632 original and zoomed (far left and left, high quality source here: AFJ) and AS08-26-2634 original and zoomed (right and far right, high quality source here: AFJ)

The next image to be examined in detail is AS08-16-2637, shown below in figure 4.1.72, and analysed in figure 4.1.73.

![Image showing AS08-16-2637](image)

Figure 4.1.72: AS08-16-2637. High quality source here: AFJ

Stellarium estimates the terminator (based on the position of Australia) at 05:30 on the 27th, and the blue, yellow, red and purple arrows point to weather systems visible on the other images of the Pacific shown previously. The blue arrow in particular points to a swirl of cloud that can be seen progressing from west to east in figure 4.1.56. On the opposite horizon, the magenta and green arrows identify weather patterns that have been a common feature over Australia, but will be discussed in more details when the continent is more squarely in the frame.

ESSA’s orbit is somewhere between track 6 and 7 for the terminator line, which is around 01:02 for the earlier of the two (orbit 1660).
Figure 4.1.73: ESSA-7 image compared with AS08-16-2637 and Stellarium estimate of time at terminator.
Figure 4.1.73 continued: AS08-16-2637 and 3D reconstruction of digitally restored ESSA data
The next two sets of images (represented by AS08-16-2647 & 2650) show Australia gradually progressing westwards, and these are shown in figure 4.1.60 to illustrate their connection with the final image that will be analysed, where Australia occupies the same position as other images throughout the mission. AS08-16-2658 is shown in figure 4.1.74, and analysed in figure 4.1.75.

Figure 4.1.74: AS08-16-2647 original and zoomed (far left and left, high quality source here: AFJ) and AS08-26-2650 original and zoomed (right and far right, high quality source here: AFJ)

For what is probably the final photograph taken on the mission, we have the return of a familiar view, and a continuing evolution of the weather systems around Australia. The elongated curl of cloud that was west of Australia has continued its eastward progression from South Africa and now lies mostly to the south of the continent (blue arrow). The plume of cloud (cyan arrow) has also moved eastward, and what was two separate plumes is now much more consolidated.

Figure 4.1.75: AS08-16-2658. High quality source here: AFJ
Figure 4.1.76: ESSA-7 image compared with AS08-16-2658 and Stellarium estimate of time at terminator.
Figure 4.1.76 continued: AS08-16-2658 and 3d reconstruction using digitally restored ESSA data
The long, broad band of cloud above Australia (yellow arrow) still extends over the equator and still curls round to the east coast, but has now joined with a small area of cloud that was over the Melbourne area. In short, all of the images of Australia show a consistent development of weather patterns over time, and in order to assist in the reader's recollection, this development is shown below in figure 4.1.77. This development is matched by the satellite record.

Figure 4.1.77: AS08-15-2535 (left) AS08-15-2554 (centre left) AS08-15-2562 (centre right) and AS08-16-2658 (right) zoomed and cropped to Australia.

To complete this section covering still images, ESSA's orbit covering the Australia terminator is track 8, orbit number 1662, which was commenced at 05:05. This compared with Stellarium's estimate of the time for the image of around 08:00.

Start to finish for Apollo 8, with not a single image contradicting the satellite record. Let’s see how they compare with the meteorological synopses of the day.
4.1.3 Meteorological data – Apollo 8

There are a number of locations that supply general weather data for the Apollo 8 period, but relatively few show good synoptic charts. For this reason we are restricted to looking at what is available, rather than the case with satellite photos where any image of earth can be matched.

The monthly weather review (MWR) from ESSA (the organisation, not the satellite) for December (MWR) reveals (as do many newspaper headlines of the time) a very cold period with heavy snowfalls – reaching record levels in some areas.

NOAA has a facility to reproduce the weather maps of any given period here: Daily Weather Maps.

Germany kept comprehensive records and these can be found in here NOAA data, here German data, and there are documents from South Africa that also show synoptic charts with fronts marked on the: South African data. The same NOAA site has records from Pakistan here, but frontal systems are not marked.

It's important to note that at this point in history, synoptic weather charts were still mostly drawn by hand by interpolating data from weather stations, weather balloons, buoys and ships. Satellite meteorology was still in its infancy, and much research was aimed at reconciling terrestrial and non-terrestrial sources of information. It's also worth pointing out that, while a front (the point where two different air masses meet) will have a cloud mass associated with it (caused by temperature and pressure changes altering the moisture carrying capacity of the air), clouds do not always indicate the presence of a front.

A good starting point for comparing Apollo photos and synoptic charts is the first colour earthrise image examined earlier, AS08-14-2383, and the photograph taken an orbit later, AS08-12-2188, as there are a number of systems that can be seen on the chart and the photographs (see figure 4.1.78). Figure 4.1.79 shows the synoptic charts for the Northern Hemisphere on 24/12/68 as given in the German and South African data.

As already established, these photographs were taken on 24/12/68.

Clearly visible are a band of cloud in the North Atlantic, and a large weather system off South Africa. Image quality for the German synoptic chart is poor, and for this reason the weather fronts marked on the map have been highlighted in red. For orientation purposes, the bottom left of the image shows Central America.

The main front visible in the colour Apollo image in the Northern Hemisphere is the one arrows in blue above. The weather front behind it (identified by the green arrow) is the same one visible from on the Long Beach Independent’s screenshot of Apollo 8’s live TV broadcast. The red arrow points to the swirl of cloud visible off South Africa, and this same front is the one that is still visible in figure 4.1.78. A word of explanation is required for the difference in data overland compared with that over the sea. The isobars offshore represent atmospheric pressure related to the amount of mercury raised in a barometer. The lines overland represent geopotential, which takes a given atmospheric pressure and looks at the altitude you would need to be at to reach that pressure. It is a slightly different way of looking at the same information, and is where meteorologists derive the terms 'ridges' and 'troughs' when describing atmospheric conditions.

Two other images will be examined here, both of which have been looked at previously. The first is AS08-16-2595 - available here. This image was taken on the way to the moon and readers are invited to examine the satellite images in the Appendix if they wish to satisfy themselves that this is the cause. The reason this image has been chosen is that it clearly shows America, and a zoomed and cropped version of it is shown in figure 4.1.80 together with the NOAA weather charts from that day.
Figure 4.1.78: Earth as seen in AS08-14-2383 and AS08-14-2388 (sources in text)

Figure 4.1.79: German & South African Synoptic charts for 24/12/68.
Again, there is good correspondence between the Apollo photograph and ground based meteorological data.

The final image examined is AS08-16-2601, taken on the 22nd of December, and chosen here for the clear image of Southern Africa (see figure 4.1.81).

This time, as well as identifying the fronts, the area arrowed in red identifies a small lobe of high pressure air that is helping keep the skies clear over eastern South Africa.

In conclusion this section demonstrates that three satellites, a couple of TV broadcasts, video footage, synoptic data and a number of still photographs all show a degree of correspondence with each other that makes it difficult to draw any conclusion other than that the Apollo images were taken when & where it is claimed they were taken: on the way to, orbiting around and returning from the Moon.
Figure 4.1.81: South African synoptic chart compared with AS08-16-2601.
4.2 Apollo 10

Apollo 10 is an often overlooked footnote in the public memory of the moon landings, but as a full dress rehearsal for the landings proper it deserves every plaudit allowed. Without this mission, Apollo 11 would not have landed.

If Apollo 8 whetted the appetite of the general public for space in general and pictures of the Earth in particular, it seems to have motivated the astronauts even more. As a result, Apollo 10 contains possibly more images of Earth than any other mission, and transmitted colour TV pictures from space for the first time in a number of live broadcasts. This document identifies the CSM-LM docking sequence as the first ever colour TV broadcast from space.

Most of the TV footage is of inside the capsule rather than Earth (much to the evident frustration of CBS host Walter Cronkite, who fronted the live coverage of the mission on TV) and of the lunar surface, but there are some shots of Earth.

The mission launched on May 18th 1969 at 16:49 GMT, reached the moon on the 22nd, set off back to Earth on the 24th and landed back on Earth on the 26th. The timeline for the mission can be found here: Apollo 10 timeline.

In total 1463 images were taken over 9 magazines, but most of the Earth images are concentrated on magazines 27, 34 and 45. Few of the images of Earth are available automatically in high resolution format. As a result, the Apollo Image Atlas (AIA) was used to browse for images, and the Gateway to Astronaut Photography of Earth (GAP) search & image request facility was used to obtain higher quality jpgs. The search facility is freely available to anyone.

In addition to the photographs, 15 magazines of 16mm films were taken, and these can be viewed at the AFJ DAC video library. These films, taken with the Data Acquisition Camera, show the Earthrise movies as we have come to know them. The TV coverage at the time could not show Earthrise live, as the TV signal could not be transmitted to Earth until after acquisition of signal, ie until the ground based receiving stations were fully visible from the spacecraft as it rounded the far side of the moon. Three satellite sets are available here: ATS-3, ESSA 9 and NIMBUS 3.

The full ATS-3 document (including technical details of its operation) is here: ATS-3 document source, the full ESSA document is available here: ESSA-9 document source and the full NIMBUS documents can be found here: NIMBUS-3 document source 1 and here: NIMBUS-3 document source 2. The former shows the relevant orbits joined so that a day's images are presented on a single page, while the latter are the unedited film sets. A recent addition to the NIMBUS archive is from the NIMBUS data recovery project here. The project is recovering the IDCS images, and these new high quality images will be used where appropriate. Also available are high resolution scans of NIMBUS High Resolution Infra-Red (HRIR) negatives, available here, and these will also be included. Figure 4.2.00a below shows an example of one of these negatives.

![Figure 4.2.00a: Example of a HRIR NIMBUS-3 infra-red negative](image)

The same source also has scans from the ‘Medium Resolution Infra Red’ (MRIR) instrument - see figure 4.2.00b.
The quality is not as good as the HRIR version, so I won’t use these unless they capture something the HRIR image has missed thanks to, eg instrument failure.

ESSA, ATS and NIMBUS images will be used for each image wherever possible as a demonstration that three different satellites on different orbits show the same weather patterns as the Apollo images.

This publication from 1973 has strips from ATS-3 images that cover the Caribbean on the 23rd of May that can be assembled into a single image for that day, and I’ll add those as well to the ‘At the moon’ section’.

Images selected for examination are chosen to be representative of the mission and to show different parts of the Earth's surface featuring the same weather systems. In most cases, only the northern hemisphere of ESSA images are used, as relatively little of the southern hemisphere is visible in most cases.

Screenshots from the videos and TV broadcasts will also be examined.

As an example of the NIMBUS data being freely available, this study contains several examples of NIMBUS tiles used to illustrate the other uses to which the satellite could be put.

We’ll also use the restored NIMBUS and ESSA 3D models where possible and appropriate.

Let’s see how these satellite images compare with the Apollo ones!
4.2.1a - Apollo 10 Still Images – on the way to the Moon

Apollo 10, like many missions, took several photographs of Earth as soon as they were safely in Earth orbit, and these can be seen on roll 34 (Magazine M). It’s worth having a look at a pair of images taken just after the TLI burn, if only so that we can compare them with photographs taken after the LM had been extracted from the SIV-B (figure 4.2.0).

![Figure 4.2.0 - AS10-34-5009 (top) and AS10-34-5010 (bottom)](image1)

Although there aren’t many clues to timing in the first image, the second one does show clear signs of debris from the separation process, and so must have been taken at around 19:52 on the 18th. The AFJ shows separation to have occurred above a point just south of Hawaii and as will be seen this is borne out by the view we see from the departing craft. The image on the right shows the west coast of the USA.
The first full disk image of Earth is AS10-34-5013 (figure 4.2.1). This image can be seen after an image of the SIV-B after the CM has separated from it. The timeline shows that this separation occurred at 19:51 on May 18th. AS10-34-5013 must therefore have been taken after this time.

![GAP scan of AS10-34-5013](https://example.com/image1.png)

**Figure 4.2.1: GAP scan of AS10-34-5013. AFJ source**

Stellarium suggests that this image was taken at around 22:00 (figure 4.2.2), a couple of hours after separation from the SIV-B.

The weather system to the east of the USA has a distinctive shape that should be evident from satellite photographs. The high quality version of the image clearly shows the shadow cast on Baja California by the bank of light cloud to the west. Other cloud systems of note are those north of Alaska with their 'streamers' of cloud extending into the North Pacific from the Arctic.

Figure 4.2.2a shows a zoomed and cropped version of AS10-34-5013 together with the corresponding ESSA 9, ATS 3 and NIMBUS 3 image, and a Stellarium inset showing the estimate of the time at the terminator. The ATS image is in two parts in the data catalogue, and these have been merged in this figure.

The distinctive hammer shaped system off eastern USA is very much evident. What is noticeable about the satellite images is that many of the cloud systems in them are (while still recognisable) less clear than on their Apollo counterparts. This is a consistent feature throughout these three datasets. Both sets of image data provide perfect matches with the Apollo image when converted to 3D models.

The position of the weather systems suggest that the time of the Apollo image and the ESSA track over north America were very close together. North America is covered by track 3-5. The ESSA image dated the 18th of May consists of tracks 1013-1025, putting the ESSA image of North America at roughly between 18:00 and 22:00.

The orbital data for NIMBUS show that the satellite image (orbits 461-464) would have been taken between 16:22 and 21:45 on the 18th, slightly earlier than the ESSA images from the same day. The mapping method used on the photos makes placing some of the weather systems more difficult, but the 'hammer' shaped system off the east coast of the USA is still clearly identifiable, and the weather system identified by the cyan arrow is also very distinctive. That particular system was imaged a 16:37 by the IDCS on NIMBUS 3. The other distinctive one is picked out by the yellow arrow, and the westernmost part of this was photographed at 21:39.
Figure 4.2.2a: ESSA-9 (top left), ATS-3 (bottom left) & NIMBUS 3 (bottom right) mosaics from 18/05/69 compared with AS10-34-5013 and Stellarium estimate of time at terminator.
Figure 4.2.2a continued: AS10-34-5013 compared with 3D reconstructions using digitally restored ESSA (left) and NIMBUS (right) satellite data.
Also available are the high resolution infra-red passes from NIMBUS-3, combined here from 4 orbital strips into a single image (figure 4.2.2b)

As these are higher resolution satellite images than the others it’s worth zooming in a little more closely. Figure 4.2.2c shows the systems identified by the blue and green arrows in the Apollo and infra-red images.

Despite the satellite images showing the weather systems in the infra-red, the comparison between it and Apollo is superb, and there can be no doubt that they are showing the same systems.

Despite the satellite images showing the weather systems in the infra-red, the comparison between it and Apollo is superb, and there can be no doubt that they are showing the same systems.

It’s now worth comparing the full disk image with those partial disk ones shown in figure 4.2.0. Figure 4.2.2d shows the context of where those partial images fit with the full disk one and also how key elements of those images compare with the each other.
As can be seen in the images, it’s obvious that the full disk image was taken from a vantage point much further out than the ones taken just after TLI, and it’s also obvious that there have been subtle changes in the weather systems on view in the few hours between TLI and the full disk one. These are not cut and paste identical images, they are taken from different vantage points at different times of an evolving meteorology.

The Stellarium estimate of 22:00 is easy to verify thanks to images taken at the same time in what a landmark moment: the first live colour TV broadcast of Earth from space. The mission timeline puts the broadcast between 21:55 and 22:08 on the 18th, and the transcript of the broadcast can be found here. You can find the actual TV broadcast in this video.

As with Apollo 8, Apollo 10 was well reported in the press and CBS gave the mission large amounts of air time, including the broadcasts from the CSM itself. Most newspapers merely reported the event, or did mock ups of various stages of the mission, but some did present images from the live TV broadcasts on their front pages. There are reproductions of these front pages available on the internet, but for the most part quality is poor.

One relatively decent image can be seen from a local Wisconsin based newspaper, the Post-Crescent, available as a link from this web page at Newspaper Archive and reproduced in figure 4.2.3. The quality is not perfect, and it is simply described as the western hemisphere in the text, so it is initially difficult to identify where the weather systems are in terms of the satellite images featured so far. The wire photo shown with it however, is much clearer, and is also clearly dated - showing a time on the reverse of 20:09 18/05/69 (01:09 on 19/05/69 GMT). Also included is a still from a 1969 film, which shows the front page of the UK Times newspaper on the same date. The Times would have had to go to press much earlier than US based morning newspapers.

The front page from Australia seems like it’s a long time after the broadcast, but 20:00 GMT on the 18th is around 08:00 local time on the 19th in Melbourne - too late for the front page that day. The 20th is the next available front page for them.

One link that does prove helpful is this one from the NASA Archive that is described as a screenshot from the Apollo live TV broadcast. This screenshot, the satellite images, and the Earth screenshot from the TV broadcast is examined in figure 4.2.4. Figure 4.2.5 shows the same TV screenshot compared with a photograph taken in Mission Control during the broadcast. Figure 4.2.6 shows the same view taken by the 16mm DAC camera (footage available here).
Figure 4.2.3: The Post Crescent headline from May 18th 1969 compared with my personal copy of an Associated Press Wire image from the Baltimore Sun. Reverse side shows the time and date received as 20:09 18/05/69 local time. The newspaper version is upside down.
Figure 4.2.3 (continued) Front page of The Times, as shown at 12:09 minutes in this film. Reverse side shows the time and date received as 20:09 18/05/69 local time. Scranton Tribune dated May 20th (above). Above is a page from the Daily Sketch dated the 19th.
Figure 4.2.3 (continued): Greensboro Daily News (top), Melbourne based paper “The Age” dated the 20th (above right) and the Daily Times News (above left).
Figure 4.2.4: Comparison of TV broadcast screenshot, Post Crescent front page and ESSA & NIMBUS satellite images from May 18th 1969.
Figure 4.2.5: Full (top right) and brightness adjusted crop (middle right) of Mission Control image compared with TV screenshot from Apollo 10 in its original orientation. Below these is a 16mm still taken at the same time. Mission Control image source: NASA
Figure 4.2.5 continued: Live TV (top left) and 16mm (top right) and 3D reconstructions using digitally restored ESSA (bottom left) and NIMBUS (bottom right) satellite data
As with Apollo 8, it is worth remembering that this newspaper front page is from May the 19th, the day after launch, and therefore any photograph of Earth can only have been taken before that day. It is also interesting to note how well the Apollo mission is succeeding in distracting the media from the Vietnam war. The moon missions are often accused of being a deliberate distraction from Vietnam, but while Apollo 10 may have temporarily stolen the headlines, it is clear where the remainder of this paper’s focus lies.

Looking at the NASA archive image, it also becomes obvious why it is difficult to place things on the newspaper front page: the Earth is upside down. In all Apollo photographs the terminator is always on the Eastern side when the globe is correctly oriented (in some broadcasts, the cameras were turned upside down to ‘correct’ the view for those at home).

ESSA’s orbit covering the central part of the daylight image is orbit 1018 (track 4) at 20:02. NIMBUS’ orbit is 462, started at 18:10 on the 18th. Those two satellite images show clear correspondence to weather patterns on the TV image that were unique to that day.

One issue that did frustrate the TV networks was the lack of live footage of the Earth. The very first colour TV was not of the home planet, but of a long slow motion docking manoeuvre, which must have been extremely useful for mission control, but less than fascinating to the average TV viewer. The battle between pro and anti-TV camps in the Apollo 10 crew and support teams is well documented, but Walter Cronkite’s frustration with the broadcasts is evident at times. Cronkite, and his occasional co-host Arthur C Clarke, were aware of the technical difficulties and did discuss the orientation of the craft relative to the Earth, but they and the watching public wanted to see the home planet, not just hear the astronauts describe the view.

This particular broadcast was made between 21:55 and 22:08, during which the crew discuss what they can see with the ground. For example they describe the Eastern seaboard, the view of Baja California and Newfoundland, and the colours of New Mexico and the Rocky Mountains. Charlie Duke, acting as Capcom with Dick Gordon, tells them they are 26000 miles out, beyond the highest geostationary satellites.

An interesting variation on this photograph can be found on astronaut John Young’s website. It shows a photograph used on the front page of the Houston Post on May 20th 1969 of Gene Cernan’s wife holding a photograph taken of one of the TV broadcasts. It’s shown below in figure 4.2.6a.

![Figure 4.2.6a: Houston Post dated 20/05/69 showing Mrs Cernan holding a photograph of the previous day’s TV broadcast. Source.](image-url)
The high resolution version from John young’s website doesn’t seem show much detail on that image of Earth- or does it?

Figure 4.2.6b below shows the photograph of Earth held by Mrs Cernan enlarged (left), and on the right after noise reduction and level enhancement, then rotated to orient the North Pole correctly. Also shown is my personal copy of the same photo, which shows the scene in greater detail. The arrows used are the same colours as used in figure 4.2.4.

Figure 4.2.6b: Original (top left) and enhanced (top right) views of Earth is shown in a photograph in the Houston Post, 20/05/69, and my personal copy of an image dated the 19th.
Once you spot the ‘hammerhead’ shape (which is just visible on the unenhanced image) everything else falls into place, especially in the higher quality wire image.

Well, so what? This image is from the 20th, and the TV broadcast was on the 18th - plenty of time to fiddle things surely?

Not really. The likely sequence of events is that the Houston Post photograph the TV broadcast on the 18th. They then show the photograph they’ve taken to Mrs Cernan the following day. This event gets photographed and makes it into the newspaper the day after that - the 20th.

It shows once again that evidence can be found in the unlikeliest of circumstances, and that technology available to us today allows us to reveal new details of a photograph taken of a live TV broadcast. It helps to demonstrate that the photographs of Earth were contemporaneous with the Apollo missions, and not edited in later. They help prove we went to the moon.

Returning to the content of the broadcast, we have a long series of exchanges between the crew and Charlie Duke as Capcom describing the view.

005:07:07 Duke: Roger.
005:07:08 Stafford: See the Rocky Mountains sticking out? Baja California? Can't tell whether you have any smog in LA or not, but Alaska is pretty much socked in.
005:07:20 Duke: Roger.
005:07:25 Duke: It’s really a beautiful picture.

And

005:08:10 Stafford: Okay. And it looks like the Rocky Mountains are orange colored to me. The rest of U.S., Baja California, that really stands out as all brownish, and the oceans are blue; but there are so many clouds out to the northeast of the United States, you can’t believe it. Covers the Far East over to Europe as far as you can see.
005:08:26 Duke: Roger. We see all that. We’ve got a brownish spot that’s pretty hard to pick out just exactly what we’re looking at, but we do see the brown and the clouds out over the ocean about the center of the globe.
005:08:37 Stafford: Yes. Okay. The brown spot is the Rocky Mountains. It runs down around into New Mexico, up into Colorado.

We even have a close up zoom, which Duke says “has to be the greatest sight ever”. Figure 4.2.7 shows a compilation of screenshots from the maximum extent of this zoom along with a still from mission control taken during that sequence (from the film “Apollo 10 - to sort out the unknowns”).
It should be pretty obvious that the view you are seeing there is exactly the same one shown in the still image. Shortly after AS10-34-5013 was taken, we have AS10-34-5019 (figure 4.2.8).

![GAP scan of AS10-34-5019](image)

AS10-34-5019 already shows that Earth is much smaller than AS10-34-5013 despite being taken very shortly after it. The satellite images used are the same, but it is important to demonstrate that the images taken by Apollo are not of a static object, but of a rotating sphere that hides one part of the globe and reveals another as it rotates. ATS-3 is included, although much of the area covered has now passed beyond the terminator.

Stellarium shows that it was been taken just after midnight on the 19th of May. The ESSA image suggests that the orbits (tracks 5 to 7) covering the portion of the Earth visible here would have been carried out between 22:08 on the 18th and 02:08 on the 19th, so it is still appropriate to examine the image for the 18th when comparing weather patterns (figure 4.2.9).
Figure 4.2.9: ESSA9 Top left upper & lower), ATS-3 (bottom left) & NIMBUS 3 (bottom right) image from 18/05/69 compared with AS10-34-5019 and Stellarium estimate of time at terminator.
The overall weather patterns visible in AS10-34-5019 are clearly the same as in AS10-34-5013, but there are subtle differences between them consistent with a dynamic weather system pictured a few hours apart. To illustrate this point more, figure 4.2.9 shows a small section visible in both images.

Figure 4.2.9 continued: AS10-34-5019 and 3D reconstructions using digitally restored ESSA (left) and NIMBUS (right) satellite data.
The left hand side is from AS10-34-5013, the right hand side AS10-34-5019. The weather patterns are undeniably the same, but it does not take much time to identify the differences between them. Looking at the California coastline, the bank of cloud hugging the coastline south of San Francisco and extending south west into the Pacific is much less developed in 5013.

This bank of cloud then joins offshore with a much larger one between Los Angeles and Geronimo Island lighthouse, and it is very likely that these are large fog banks, as there is a small hole in the cloud in roughly the same position as Guadeloupe. The shape and size of the clear area north of Los Angeles is also different in the two photographs. Further to the west, a thin stream of cloud running north-south (top left) is much closer to the US coast in the later photograph, suggesting that this is higher altitude cloud moving more rapidly than the sea level fog bank.

Over the whole of figure 4.2.9, there is not a single cloud that has not in some way altered in a manner consistent with weather system development over time.

Like the ATS image, less of the NIMBUS image is available for use because of the orientation of the Earth and the availability of NIMBUS tracks, but those that are shown do feature weather patterns that match those of AS10-34-5019. ESSA’s orbit nearest the terminator is 1017 (track 3), which commenced at 18:07. NIMBUS’ equivalent was number 460, which commenced at 14:35.

It’s also interesting to compare AS10-34-5019 with AS10-34-5015, which (judging by the terminator) was taken at roughly the same time, but the amount of shadowed Earth visible suggests a slightly different angle — one consistent with a trajectory heading towards the moon away from Earth.

As with the previous still image we again have a corresponding view taken from a live TV broadcast. The timeline records it has having started just after midnight on the 19th, ending 25 minutes later on the 19th. Here’s a still from the broadcast, obtained from this youtube video, as well as a brief shot from a 16mm film (figure 4.2.10).
As in the previous case, the live broadcast is an exact match for the still image, and again there are numerous descriptions of the view by the crew and the Capcom, this time Bruce McCandless.
007:12:33 Stafford: Roger. That's correct. Looks like a beautiful sight. And either you have clouds over the Sierra Nevada's or they're snowcaps at this time. I can't tell which from here. You can still see the San Joaquin Valley.

007:14:51 Stafford: Yes. They start up in the Northwest Territories of Canada and actually ring out to Alaska, and from there they go down just about to the Canadian - United States border and go on east. But the whole northwest Pacific, across northern Canada and over to Greenland is all obscured with just a solid white mass of clouds as you can see in your - near the North Pole.

007:15:48 McCandless: Roger, 10. Up in the vicinity of Alaska, we see a swirl. Does that look like a storm system or low pressure area to you?

07:15:55 Stafford: Yes. You've got a swirl out there right on the - off the coast of Alaska.

007:16:16 Stafford: How are the colors coming through down there, Bruce?

007:16:18 McCandless: Oh, the colors are coming through beautifully. The oceans are a beautiful blue-green. We can see the land masses in a brown to reddish-brown. The vicinity of the North Pole, the clouds and ice caps seems to be saturating a little; but on the whole, it's all coming through nicely.

007:16:38 Stafford: Okay. Good. And you can - The area right east of the Sierra Nevada's, now - I guess around the Rockies - as nighttime starts to spread over the United States, is becoming more of a purplish-red. You can see Texas, Oklahoma, and that area; it's becoming more of a purplish-red, and the rest of it is still a bright red - a bright red to brown.

007:16:59 McCandless: That's right. We can see the terminator quite clearly moving up from lower right-hand corner of our screen.

As usual, the descriptions they give are spot on.

Moving back to the Hasselblad photographs, the next image to be examined is AS10-34-5026. It has been chosen for no particular reason as it is not near any other images in the magazine, but it does show a considerable portion of Africa. As it was taken after AS10-34-5019, but before the images of the lunar surface, it must be before the 21st. The photograph is shown in figure 4.2.11.

![Figure 4.2.11: GAP scan of AS10-34-5026.](source)

Based on the terminator position, the estimated time of the Apollo image is 15:30. It is worth pointing out that the view of the Stellarium image is from the lunar surface (Apollo 11, to be precise). Apollo 10 was not yet near the lunar surface, hence the slight difference in the amount of Atlantic Ocean visible from the spacecraft. This difference in perspective will be examined in more detail later. Figure 4.2.12a shows the ESSA 9, ATS-3 and NIMBUS 3 satellite images from May 19th, ATS-3 has only partial coverage here, but has been included for the sake of completeness.
Figure 4.2.12a: ESSA-9 (top left upper and lower), ATS-3 (bottom left) & NIMBUS-3 IDCS (bottom right) images from 19/05/69 compared with AS10-34-5026 and Stellarium estimate of time at terminator.
Figure 4.2.12a continued: AS10-34-5026 and 3D reconstructions using digitally restored ESSA (left) and NIMBUS (right) satellite data.
Examination of the satellite photographs taken during the mission show the Apollo image can only have been taken on the 19th. The clouds visible over southern Spain and north Africa (magenta arrows) are much less developed on the 18th, and by the 20th had moved eastwards towards southern France. The very striking north Atlantic system is also poorly developed on the 18th and a completely different shape on the 20th.

The ESSA track data show that the satellite passed over Africa between 10:00 and 15:05 (tracks 11-13 and 1), again tying in nicely with the Apollo image. The ATS images were taken at 17:04 & 17:07 on the 19th. The NIMBUS path for the same area is orbit 470 and commenced at 08:10 – several hours before the Apollo image and the path ESSA & the later ATS took over that part of the globe. The more spectacular north Atlantic storm was imaged by NIMBUS at 12:19.

We again have the luxury of infra-red imagery for this view, and that is shown in figure 4.2.12b.

As before we can see that there is an extremely good correspondence between the infra-red imagery and the Apollo view. To be even more certain we have a good match, let’s zoom in on the area around the UK (figure 4.2.13).
Yet again, superb correspondence despite the images being taken in completely different spectra.

The next photographs in this magazine repeat exposures of Africa, and there isn’t much point in repeating the analysis for very similar images. However it is worth demonstrating that they aren’t the same images, and that the terminator changes position over the course of them.

Two images that show this progression are AS10-34-5028 and 5031, and these are shown in sequence together with AS10-34-5026 in figure 4.2.14, zoomed only on the Earth part and compared with what Stellarium suggests for the time the image was taken.

Figure 4.2.14: Crops of Earth from AS10-34-5026 (top left), AS10-34-5028 (top centre) and AS10-34-5031 (top right) compared with Stellarium estimates of time taken.
This set of photographs, then, is taken over a period of a couple of hours and shows an Earth very obviously rotating in a consistent manner so that we lose Africa and start gaining the Americas. We also have some discussion in the mission transcript that confirms what they are looking at. At 21:33 MET, or about 14:22 GMT we have a weather report from the Command Module Pilot:

021:33:10 Young: Roger. It's a European/African weather report. Portugal - Portugal is clear. Spain - Western Spain is clear, eastern Spain along the Med is under clouds. Italy - Italy is clear south of about Rome. Sicily - Sardinia and Corsica are under partly cloudy to cloudy skies. Greece is clear. Crete's clear. Turkey is under very scattered clouds. Bulgaria is clear with partially scattered clouds, but the rest of Europe is mostly under the clouds. There's a large part of the Soviet Union north of the Black Sea that's in the clear, but the rest of it appears to be under clouds, too. Arabia appears to be clear. Israel, clear. Jordan, clear. Libya and Egypt are clear except for a cloud strip along the center of the country in Saudi Arabia that runs from Saudi Arabia across the Sinai Peninsula and through Egypt. Africa is clear in the desert to the north and cloudy farther south. It's clear pretty much to the south except for the Cape where South Africa appears to be under the clouds. That's your morning weather report from about 100,000 miles.

And a moment later the Commander says that

021:34:17 Stafford: Okay; stand by. We want to get, a couple of pictures of Europe; we're in good position right now.

It obviously took them a while to get the photographs as they precede them by at least an hour, but what they describe (in particular the thin cloud across the Sinai peninsula shown by the yellow arrow) is undoubtedly accurate.

The next set of images taken by the crew shows north and south America again coming into view. The common denominator between this photograph and the previous one is the large swirl of cloud highlighted by the blue arrow in figure 4.2.12 in the top left of the Earth's disk, just touching the terminator. The picture in question is AS10-34-5034, which is shown below in figure 4.2.15.

As before the Earth is visibly smaller, and the scene is dominated by a large polar cloud mass, and the remains of the large 'hammer' shaped formation picked out in figure 4.2.2 by the green arrow. The large swirl is now on the terminator, which Stellarium estimates at around 19:30 on the 19th. The comparison with ATS, ESSA and NIMBUS data is shown in figure 4.2.16a.
Figure 4.2.16a – ESSA-9 (top left upper and lower), ATS-3 (bottom left) & NIMBUS 3 (bottom right) images from 19/05/69 compared with AS10-34-5034 and Stellarium estimate of time at terminator.
Figure 4.2.16a continued: AS10-34-5034 and 3D reconstructions using digitally restored ESSA (left) and NIMBUS (right) satellite data
As before the Earth is visibly smaller, and the scene is dominated by a large polar cloud mass, and the remains of the large 'hammer' shaped formation picked out in figure 4.2.2 by the green arrow. The large swirl is now on the terminator, which Stellarium estimates at around 19:30 on the 19th. The blue arrow in figure 4.2.16a points to the same cloud system as the previous analysis, and it should be readily apparent that all three satellite images show the same weather systems as can be observed in the Apollo Earth. These systems are also described in detail by the crew during a TV broadcast made shortly after these photographs were taken. The blue arrow, for example, points to

027:03:02 Stafford: You've got a real weird cloud formation

and

027:03:46 Young: It's a real peculiar-looking cloud swirl. It comes off of what looks like Labrador and goes all the way across the ocean into Europe.

We also have a general description of the weather on view:

027:05:44 Stafford: ...It looks like broken clouds over the southeastern part of the United States. Northeast has a little bit more. Looks like Canada is all socked over today, and over that big cap that goes up over the North Pole and over to Russia it's just solid overcast.

Which is pretty much exactly what is visible in the photograph.

Stellarium’s estimate of the time compares favourably with the ATS image time of just after 17:00. The NIMBUS pass that corresponds best with the terminator (number 472) would have started at 13:51 on the 19th. The ESSA pass nearest the terminator would have been track number 2, or orbit 1029, which commenced at 17:01 on the 19th.

We again have the higher resolution NIMBUS orbits to examine, as shown in figure 4.2.16b.
As before the correspondence with the Apollo image is excellent, and it is worth pointing out that the start time of the final pass covering the area shown in the western limb of the Apollo photograph is 18:54 - a good half an hour before the image was taken, but that pass would not be complete before the photo was taken, and the data would certainly not be in NASA’s hands by 19:30. We again have a situation where an Apollo image has been taken before the satellite record that confirms its accuracy existed!

For a closer look at the high quality infra-red images, I’ve picked central America to examine - see figure 4.2.16c.

![Figure 4.2.16c: NIMBUS-3 infra-red image from orbit 475 compared with AS10-34-5034](image)

As before, the correspondence is excellent, and the only differences are easily accounted for by the time lapse between images (about 6 hours) and the different spectra of the photographs.

For our next subject we return to a TV broadcast, this time one made at 20:19 on May 19th. We know this partly from the mission timeline, and partly because it was stamped all over the CBS News broadcast on the day (see figure 4.2.17).

![Figure 4.2.17: Screenshot from a CBS news broadcast (Source)](image)
For the purposes of our analysis, however, a still from this source for the broadcast is much clearer, and the satellite comparison is carried out in figure 4.2.18.

Figure 4.2.18: Still from TV broadcast made at 20:17 on May 19 1969 compared with ESSA (bottom left) and NIMBUS (bottom right) data, and a Stellarium depiction of the terminator at that time.

As far as satellite timings are concerned, the ESSA’s terminator track (1030) started at 19:06 on the 19th, whilst the NIMBUS one (473) started at 13:51.

While broadcasting the image to Earth the crew again described what they were seeing in great detail:

027:01:25 Stafford: It looks like the North Pole and most of Russia is covered with clouds. The United States is pretty much wide open. In fact, the solar subpoint is right over the Gulf of Mexico now
027:02:08 Stafford: Roger. What you see there - What you see there is a little bigger than we actually see it, since I have the full zoom on it. If you look to the south, you can see all of South America there, and west of the Andes is clear.

027:02:23 McCandless: Roger.

027:02:28 Stafford: And in the tropical rain forest over Venezuela and Brazil and Columbia you can see the clouds that hang over there all the time. I noticed how clear it is west of the Andes.

027:03:02 Stafford: You've got a real weird cloud formation coming around down - just a minute. Let me get it focused.

027:03:46 Young: It's a real peculiar-looking cloud swirl. It comes off of what looks like Labrador and goes all the way across the ocean into Europe.

027:05:25 Stafford: Okay. Again, you can see Baja California coming in there just real clear, and the Rocky Mountains, particularly starting into Mexico going up through Colorado and Wyoming, are coming in.

027:05:36 McCandless: Roger. I'm having a little difficulty picking out the landmasses down here today.

027:05:44 Stafford: That's because of cloud cover. It looks like broken clouds over the southeastern part of the United States. Northeast has a little bit more. Looks like Canada is all socked over today, and over that big cap that goes up over the North Pole and over to Russia it's just solid overcast.

027:06:04 McCandless: Roger. We can pick up part of South America. Must be the Andes, just above or just to the west of the terminator down in the southern portion of the globe.

027:06:14 Cernan: Bruce, you should see all of North and South America from where you are. We're going to zoom it in again here. Show you a little bit closer.

As usual their descriptions exactly match what we can see.

The next still image showing any significant degree of rotation is AS10-34-5037. This is shown below in figure 4.2.19 together with AS10-34-5036, which was both numerically and physically very obviously taken at some point in between the this photograph and 5034.

Figure 4.2.19: GAP scan of AS10-34-5036 (left, AFJ source) and AS10-34-5037 (AFJ source)

South America has now largely disappeared, but north America is still visible. Some weather systems evident in figure 4.2.16 have now passed beyond the terminator, and there are new ones over the Pacific. The polar cloud mass is still evident, as is the system that runs from the north Atlantic down to central America.

Figure 4.2.20 shows a comparison of the satellite images of these weather patterns and the Apollo image, and the red, cyan, magenta and yellow arrows point to the same weather systems as in figure 4.2.16.
Figure 4.2.20: ESSA 9 (top left upper and lower), ATS-3 (bottom left) & NIMBUS 3 (bottom right) images from 19/05/69 compared with AS10-34-5037 and Stellarium estimate of time at terminator.
Figure 4.2.20 continued: AS10-34-5037 and 3D reconstructions using digitally restored ESSA (left) and NIMBUS (right) satellite data
The weather systems are still obviously the same, although there are new systems appearing on the western limb as the Earth rotates, and the large spiral system has now disappeared over the terminator. As the same systems are in view, and they do not look the same on the 20th, they must still be from the 19th, and Stellarium puts the time at around 22:45 on that date. This compares with an estimate of 20:00 for 5036. We already know the time of the ATS-3 image, and all that remains is to confirm that the NIMBUS orbit most matching the terminator is pass 474, which commenced at 15:39, while ESSA’s most representative track is number 3, or pass 1030, which commenced at 19:06. We’ll leave the infra-red versions from NIMBUS-3 for this photo, as there isn’t much difference between this and the previous one.

It’s worth noting that the crew draw attention to the Gulf coast being clear at around the time these photographs were taken (at 19:52 GMT to be precise), which it very evidently is.

The next images of Earth in the sequence taken on the outward bound leg of the mission are actually on two different magazines – one on magazine 34 and one on magazine 35. The best example of each image will be used whenever this occurs.

The two images, AS10-35-5174 and AS10-34-5041 (the latter part of a series of almost identical shots) are shown in figure 4.2.21. Stellarium estimates that only about 45 minutes have elapsed since the previous image. The analysis from AS10-34-5041 is shown in figure 4.2.22a.
Figure 4.2.22a: ESSA 9 (top left upper and lower), ATS-3 (bottom left) & NIMBUS 3 (bottom right) images from 19/05/69 compared with AS10-34-5041 and Stellarium estimate of time at terminator. Blue, red, green, yellow, cyan arrows are as figure 4.2.20
Figure 4.2.22a continued: AS10-34-5041 and 3D reconstructions using digitally restored ESSA (left) and NIMBUS (right) satellite data
Stellarium suggests the picture was taken at about 23:30, as judged by the location of the terminator near the swathe of cloud cutting across central America. As only 45 minutes have elapsed between this one and the previous photograph examined most of the weather systems identified earlier can still be seen. The satellite timings are also little different, but it is worth while noting that the system picked out by the purple arrow was not imaged by the NIMBUS IDCS camera until 00:48 on the 20th.

We can get some confirmation of the time from the transcript. At 30:27, or around 23:17, Charlie Duke on Capcom tells them that they will be changing to Goldstone in California as their receiving station, and that is pretty much centre stage in the photo. Meanwhile Tom Stafford tells him that

030:34:07 Stafford: From our angle now, it looks like the whole northern quarter of the whole globe is completely socked in there; and, again, the United States is what really stands out and part of Mexico. We can see the Gulf Coast from here real well, right through the hatch window.

Once again we have good coverage of the image by NIMBUS-3’s infra-red camera, and this is shown in figure 4.2.22b.

![Images showing NIMBUS-3 infra-red passes 475-478 with arrows indicating features](image)

Figure 4.2.22b: NIMBUS-3 infra-red passes 475-478. Colours used match those in figure 4.2.14a.

The correspondence between Apollo and the NIMBUS images is, as usual, extremely good, and to see how good it’s worth looking at the one taken last, orbit 479, which commenced just an hour before the Apollo image was taken (figure 4.2.22c).
The match between the two is extremely close, particularly with the lighter clouds north of the equatorial band. That band appeared in an earlier image (figure 4.2.2c) and it’s worth going back and seeing the change in that feature over 24 hours.

Also available from the same time is a 16mm still taken using the DAC camera, and this is shown in figure 4.2.23.
A little while later, we have an image from magazine 35 that shows a more significant degree of rotation, and therefore brings new weather systems into view. Figure 4.2.24 shows AS10-35-5177. Figure 4.2.25a shows the satellite comparison.

Figure 4.2.24 GAP scan of AS10-35-5177. Low quality version here: AIA

Stellarium sets the time at roughly 01:30 for this image, and shows the west coast of north America and Australia just in view. Close examination of the Earth shows that, beneath the thin cloud, the Americas are still there. Australia is more difficult to detect, but the bifurcated thin stream of cloud shown by the cyan arrow is off Australia’s east coast at the point where it splits, and what appears to be a small fog bank off Sydney on the satellite photograph is just discernible on the very western edge of the globe.

The Earth, therefore, seems to be where it is supposed to be – a few hours ago the crew were describing north America and now it is only partially visible. Can the satellite timings match up with this suggestion? ATS is not available for this image as it doesn’t cover anywhere visible. ESSA’s image is still dated the 19th, but is now covering areas that were actually imaged on the 20th, and in this case the orbit that best approximates the line of the terminator is number 1032 (track 5, although in reality the terminator is probably between tracks 4 and 5), which commenced at 23:06.

The NIMBUS image used here is actually a hybrid of two day’s passes. The 2 strips of images on the left of the NIMBUS part of figure 4.2.25 are actually from the image dated the 20th, and the remainder are from the image dated the 19th. The track best representing the terminator is number 475, which was commenced at 17:26 on the 19th. The extra amount of rotation brings an additional pass of the NIMBUS infra-red camera into play, and we can see a part of that pass (orbit 479) compared with the cloud band identified by the blue arrow in figure 4.2.25b.
Figure 4.2.22a: ESSA 9 (left upper and lower) and NIMBUS 3 (right) images compared with AS10-35-5177 and Stellarium estimate of time at terminator.
Figure 4.2.25a continued: AS10-35-5177 and 3D reconstructions using digitally restored ESSA (left) and NIMBUS (right) satellite data
Figure 4.2.25b: Section of NIMBUS infra-red orbit 470 compared with the same area of AS10-35-5177

Again, the correspondence between the two is excellent - almost as if Apollo 10 was photographing the weather from space! It’s interesting to note that while the bottom of the NIMBUS image identifies it as orbit 479, the top reports it as orbit 481. Orbit 478 is correctly identified top and bottom, but orbit 482 has a top label of orbit 786! Somewhere along the way the labelling has become confused! Orbit 482’s image (going by the bottom label) shows SE Asia, which is consistent with the numbering, and also shows the same weather patterns as can be found on the ESSA image from that day, so the top one seems to be in error.

After this image of the Pacific is taken there is a gap in photographs of any kind coinciding with a rest period for the crew. At 1d19h50m the crew are having breakfast and being given a summary of news from home, and they describe the view below:

043:49:32 Cernan: Jack, here comes the world. Looking right over Suez Canal, Saudi Arabia, the Mediterranean, Africa, back into the parts of Europe...right now I’m looking at all of Africa, which is almost totally clear with the exception of a few clouds on the western side. I can see across the Straits of Gibraltar, some cloud cover just on the eastern side of the Straits. I can see Spain which is totally clear, Portugal, almost all of the Mediterranean except the north - northwest corner of the Med, Greece, Crete, Turkey, Italy. They all look clear from here. Saudi Arabia, back up into the Soviet Union, is partially clear in great areas and actually almost back into parts of China where the terminator is, it’s just sort of partly cloudy. There appears to be a big, long, wide cloud swirl out into the Atlantic west of Spain. Generally, it looks like I can see Zanzibar. Generally, it looks like that whole portion of Africa and eastward – northeastward - is pretty clear today.

The time of this conversation translates to 12:50 GMT on the 20th, and there are two photographs taken on separate magazines that correspond with this time both in terms of where the terminator is, and in terms of what is visible below them.

AS10-34-5042 and AS10-35-5181 both show roughly the same scene of a largely clear Earth dominated by a view of Africa. The image chosen for comparison with the satellite image is AS10-34-5042, and this is shown in figure 4.2.26a. Figure 4.2.26b shows a close up of the Earth part of the image compared with the same close up of AS10-35-5181, and figure 4.27c shows a further close up of the two images focusing on India.
The extreme close up of India suggests that AS10-35-5181 was probably taken slightly earlier than AS10-34-5042, as the latter shows the two prominent north-south bands of clouds slightly further away from the terminator. It’s also worth noting the shadows cast by those two clouds, which is exactly what you would expect to see from clouds at sunset. In other words they are entirely consistent with where the Sun is in the sky back on Earth. The analysis of the chosen photograph is shown in figure 4.2.27a.
Figure 4.2.27a: ESSA 9 (top left upper and lower), ATS-3 (bottom left) and NIMBUS 3 (bottom right) images compared with AS10-34-5042 and Stellarium estimate of time at terminator.
Figure 4.2.27a continued: AS10-34-5042 and 3D reconstructions using digitally restored ESSA (left) and NIMBUS (right) satellite data.
The most obvious point to make about the image is that it shows exactly what the astronaut was describing. The ATS image only just shows the very western edge of what they can see, and certainly doesn't show any of Europe or Arabia. At the time the photograph was taken it would be several hours before those features would be visible on satellite mosaics. We can determine this by looking at the timings of the satellites concerned.

The ATS image shown here is taken just after 17:00 on the 20th. The ESSA image is complicated by the fact that the terminator line falls roughly along the line delineated by the last orbital pass on the image dated the 19th. The ESSA mosaic states that the last pass on that image is number 1037 (track 10), which commenced at 09:03. Track 11 (orbit 1038) passes along the west coast of India and is the first scan on the image dated the 20th, commencing at 11:08. While this is a good 90 minutes before the Apollo image was taken, the final part of the ESSA image covering what is visible in the Apollo photograph would not be imaged for another 5 hours.

The NIMBUS image is more straightforward, and the line of the terminator was covered by pass number 482 at 05:39 on the 20th, but again the final part of the area visible from Apollo wouldn't be completely imaged until around noon when the daylight pass of orbit number 485 finished. Speaking of NIMBUS, figure 4.2.27b shows the infra-red passes covering the image.

As usual there is an exact match between the NIMBUS and Apollo image, but the real devil is in the details (figure 4.2.27c).
The top section of this image is included mostly for comparison with an earlier image (4.2.13), which is obviously different. The Apollo image is again an almost exact match. The lower is included to show the presence of a tropical cyclone. A number of reports (eg this one) tell of an unnamed cyclone in the Andhra Pradesh region on the 19th, killing over 600 people. Andhra Pradesh is pretty much exactly where this cyclone is pictured and can also be identified in the Apollo image.

About an hour after the image discussed above, Apollo 10 took another set of images of Africa up to AS10-34-5048, low quality source available here: [AIA]. Little additional information is revealed by these images other than the obvious rotation of the Earth to hide India in darkness as illustrated in figure 4.2.28.
The next image to be scrutinised is another case where the same photograph exists on two different magazines. AS10-35-5187 and AS10-34-5049 both show exactly the same scene, and having examined them very closely the only conclusion that can be drawn is that they were both taken at exactly the same time. As for when that time is we have a little help from the mission transcript as well as Stellarium.

Stellarium puts the time at the terminator at around 17:30 GMT, and an hour before that in the transcript the crew describe being able to see the Suez Canal. This is clearly not in shot in the Apollo pictures, so they must have been taken after that time. They are able to describe.

047:26:30 Cernan: Charlie, the Suez Canal appears now to be going into darkness. We’re looking at most all of Africa, the Mediterranean Sea, Spain, Portugal are in view. So the folks down in that part of the area ought to be getting a good picture of themselves right now.

047:27:12 Cernan: Well, it’s a beautiful sight. All of Africa is brown again, of course, and the waters are very, very blue.

047:31:18 Young: …you can see, for example, the Pyrenees. And you can see there, - maybe cloud cover down along the coast there, down on the Mediterranean coast. You can see, almost see, I think, Gibraltar.

and when asked about the islands around Greece and Italy they say that

047:32:08 Young: They’re pretty close to the terminator right now, and it’s a little smoggier today than it was yesterday, but yesterday Crete was very clear, I could see Cyprus; the Nile Delta is very clear right now. You can see the Nile; the Nile Valley really stands out, and, of course, the Sahara Desert is very clear, you can see geological features in the desert. It looks like Lake Chad down there in the middle of the – middle of Africa.

Again, the middle of Africa and the Nile are not visible in the image, although Greece and Italy are not quite at the terminator at the time they are speaking.

An hour after the Stellarium estimate they discuss the weather situation over north America, thunderstorms over Brazil. We therefore have some distinctive weather features to look out for in both the Apollo image, and in the satellite photographs taken on the same day.

Those same distinctive features crop up in the next view of Earth in the time sequence, as shown in a TV broadcast sent down to Madrid. The signal was then sent on to Houston to be rebroadcast later. It’s worth noting that while the mission timeline indicates the recording as being between 16:49 and 17:04, the actual broadcast in the transcript starts just over half an hour earlier.

Figure 4.2.29 shows a screenshot from that broadcast compared with the satellite record.
Figure 4.2.29: Screenshot of Apollo TV footage compared with ATS (top right), ESSA (middle and bottom right) and NIMBUS (bottom left) satellite images dated 20/05/69, with Stellarium estimate of time at terminator.
Figure 4.2.29 continued: 16mm still and 3D reconstructions using digitally restored ESSA (left) and NIMBUS (right) satellite data.
As usual the crew provide ample and accurate descriptions of what they are seeing below them.

047:33:12 Young: That certainly is an interesting weather - weather patterns going across there. Now, I can see – I can see right now in Brazil, it stands out very clearly on the horizon. And Brazil is covered with those little thunderstorms that build in a tropical area. It just seems like each tree has its own separate thunderstorm down that way...Boy, it's really a fantastic, just fantastic view. We can see right across the top off the world right now, and it sort of looks like, I don't know exactly how we are oriented, but it sort of looks like the North Pole is open today, but it isn't very much open. The whole northern part of the world is right under the worst cloud bank I've ever seen.

047:34:03 Duke: Roger. That thing has been there constantly almost since, it seems like, since you guys started showing us the pictures back. Do - Can you still see that strange-looking storm system up over the Bering - I guess it was just south of the Bering Straits out over Alaska there. Is that thing still there? It was a funny-looking swirl.

047:34:26 Young: We're right - The terminator runs down through Africa right now, Charlie, so we're starting to look at only about three-quarters of the world.

The next image chosen for analysis is AS10-34-5049, mainly because it is slightly clearer than its equivalent on magazine 35. It is shown in figure 4.2.30.

![Figure 4.2.30: GAP scan of AS10-34-5049. AFJ Source](image)

In figure 4.2.31, ESSA's orbital data puts the time of the satellite passing over the west coast of Africa at 14:09 on the 20th (Track 1, or pass 1040), compared with NIMBUS orbit 485 over the same zone at 11:20. ATS-3 images were taken at 17:06 & 17:21. As with previous images, while the weather systems visible on the different images are obviously and definitely the same (to the point where the use of arrows to point them out seems both superfluous and ridiculous at times), there are subtle differences between them that indicate atmospheric flux over time.
Figure 4.2.31: ESSA 9 (top left upper and lower), ATS-3 (bottom left) and NIMBUS 3 (bottom right) images compared with AS10-34-5049 and Stellarium estimate of time at terminator.
Figure 4.2.31 continued: AS10-34-5049 and 3D reconstructions using digitally restored ESSA (left) and NIMBUS (right) satellite data
One example is the system arrowed in yellow. In the NIMBUS image, the earliest of the three, this small group of clouds touches the west African coast and trends north-east inland. There is a clear gap in terms of longitude between those clouds and the mass of cloud over southern Spain. A few hours later in the ESSA image, it has moved slightly further inland and there is no longitudinal gap, and by the time of the Apollo image it has moved further inland still and there is an overlap with the clouds over southern Spain.

To illustrate this point further, a small section of each image from figure 4.2.31 has been selected so that they can be compared more clearly – see figure 4.2.32.

Allowances need to be made for differences in image projection and quality, but as with other comparisons it is clear that these are the same cloud systems photographed at slightly different times – the Apollo image is not a coloured version of a satellite one.

Next in the time sequence is a 16mm image, this time unaccompanied by any still or TV images. It’s shown in figure 4.2.33. As it falls between two another detailed analyses, I’ve skipped over doing one here.

The distinctive cloud pattern visible in the still image has moved eastwards in the video still, and Africa has now disappeared from view. There is a distinctive curl at the top end of the south American continent where it joins central America, and by the time the video is taken this has also moved eastwards by some distance.

The basis for the timing for the terminator is from the position of the distinctive cloud patterns just above Africa, a small part of which is visible. As will become clear in the next photograph, the clouds around South America put it in the correct place for the timing in this image.
049:30:47 Cernan: Charlie, I'm looking at the Earth now through the monocular, and I can see the west coast of Africa. I can see Spain and Gibraltar very, very well. I can see just about 90 percent of South America, up through Central America. I can see the whole Gulf Coast all the way to California, and on this side now, Cuba is very visibly clear. All of Florida is clear. The whole Gulf Coast is clear. I can look up the East Coast maybe to about the Carolinas, and then it appears to get a little bit cloudy. And it appears that the Great Lakes, I think I can make out Lake Michigan and probably Lake Superior. And then there are some clouds up in the northwestern central United States...Coming out of the North Pole down into the Central Atlantic are some very weird, picturesque cloud formations. Swirls, not definite low areas, but big large swirls.

049:31:44 Cernan:...Coming out of the North Pole down into the Central Atlantic are some very weird, picturesque cloud formations. Swirls, not definite low areas, but big large swirls.

049:32:09 Cernan: It appears to be about the best view that I've been able to have of the whole Atlantic and South and North America from where I am, and it ought to be getting a little bit better as we go along...There are some scattered cloud coverage down in the Caribbean which may make it difficult to pick some of those islands out.

049:54:59 Stafford: Okay. I'll kind of narrate this, Charlie. I'm kind of at an odd angle to hold it out the window. Again, you can see the west coast of Africa, the Sahara Desert, they're all in orange. You can see the Atlantic Ocean with swirls of clouds over to the eastern part of Brazil. You can see the very weird cloud patterns that Gene described out over the northeastern part of the United States. Again, it looks like the North Pole and that whole area around Canada is completely socked in...Again, the one thing that is really so amazing, as you look at the Earth, is the amount of cloud cover that we have down there. Over the tropical rain forest of South America, there's just numerous small cumulus clouds.

049:56:22 Duke: Roger. Can you pick out the Amazon River?

049:56:23 Stafford: Negative. No. I can't pick out the Amazon. I am looking at it with my naked eye where Gene had the 28-power monocular. I do have the zoom on here, so you are seeing it a little bit bigger than we are on the standard vision, so the Earth as you see it there is bigger. And you can see the terminator, or nighttime, has moved over most of Africa at this time, and is starting to move over to Europe. It'll soon be nighttime in Spain, and also, it is getting daylight over in Hawaii, there. The cloud patterns are utterly fantastic as you look out at it.

The next image of Earth taken is the sequence containing AS10-34-5052, but as in other cases for Apollo 10 it was only taken around 45 minutes after 5049, and reveals nothing new other than (to labour a point) the obvious rotation of the Earth. A low quality version of that image is available here AIA.

The next image where any significant degree of rotation has occurred is in AS10-34-5054. This is shown below in figure 4.2.34, and analysed in figure 4.2.35a.
Figure 4.2.34: AS10-34-5054  AFI Source
Figure 4.2.35a: ESSA-9 (top left upper & lower), ATS-3 (bottom left) and NIMBUS-3 IDCS (bottom right) compared with AS10-34-5054.
Figure 5.2.35a continued: AS10-34-5054 and 3D reconstructions using digitally restored ESSA (left) and NIMBUS (right) satellite data
No comment is made in the mission transcript (other than the crew saying that they have a fine view of Earth at roughly the right time!), so we are reliant on Stellarium for an exact fix, based on the position of the south American coast on the Apollo image, which gives an estimate of around 20:00 on the 20th, still 24 hours from LOI.

The time of the ATS image has already been stated as just after 17:00 on the 20th, and the rotation of the globe is such that it is now a close match with what can be seen in the Apollo image, with the exception of the system pointed out by the blue arrow, which is just out of shot. The ESSA & NIMBUS mosaics are still a good match and show all the weather systems visible on the Earth.

As far as their timings go, ESSA's most representative orbit at the terminator is track 2, which in this case is orbit 1041, commences at 16:04 on the 20th. NIMBUS' best orbit is pass number 487, which would have commenced at 14:55 on the 20th.

The infra-red images here also confirm the Apollo photograph's accuracy (figure 4.2.35b).

At the risk of being repetitive, once again the Apollo image provides an excellent match with the infra-red observations, and again it's possible to zoom in closer in these high quality negatives (figure 4.2.35c).
Figure 4.2.35c: Section of NIMBUS-3 infra-red orbital pass 489 compared with AS10-34-5054.

The NIMBUS pass started at 18:11, just 110 minutes before I estimate the Apollo image was taken, which certainly explains the closeness of that match.

A couple of hours after this photograph was taken we have another brief TV broadcast and another series of detailed descriptions of the view looking back home. Figure 4.2.36 shows the details.

Figure 4.2.36: Still from TV broadcast compared with Stellarium depiction of Earth at the same time and 3D recons.
The TV broadcast took place between 22:24 and 22:49 on the 20th, and I’ve set Stellarium at 22:30. Here’s what the crew had to say for themselves. At 53 hours and 6 minutes (53:06), or 21:55, they describe the

053:06:59 Stafford:...storm center over Alaska. It’s finally started to rotate around and has developed into quite a system.

At 53:23 (22:12 GMT), there is a more detailed description:

053:23:06 Cernan: ...the eastern seaboard from about the Carolina’s on up, just on the seaboard, is going to be covered with clouds and then into the Atlantic...I mentioned this morning there was a long cloud bank from the northeastern part of the United States into Missouri. It looks like now that that cloud bank goes from central Indiana up across Lake Erie, north-northeastward into Canada...Michigan, Lake Superior, and the Midwest are very clear except for that cloud and there’s some clouds which appear to be over - oh, maybe Kansas, Nebraska, I hate to say it, but Oklahoma. I may get some disagreement up here but I think it’s Oklahoma, Colorado, Montana, up in that area; and then the West Coast is clear and the Southwest is all clear.

Capcom confirms that this description matches their weather map.

The descriptions continue:

053:23:37 Cernan: Okay, Charlie. And I mentioned this morning there was a long cloud bank from the northeastern part of the United States into Missouri. It looks like now that that cloud bank goes from central Indiana up across Lake Erie, north-northeastward into Canada...Michigan, Lake Superior, and the Midwest are very clear except for that cloud and there’s some clouds which appear to be over - oh, maybe Kansas, Nebraska, I hate to say it, but Oklahoma. I may get some disagreement up here but I think it’s Oklahoma, Colorado, Montana, up in that area; and then the West Coast is clear and the Southwest is all clear.

053:24:24 Duke: Roger, 10. We’re looking at a weather map that was just brought in, and we cast our vote with you, Gene-o. The clouds are over Oklahoma and your description is excellent. It follows a - There’s a low pressure up in the very far north turning from the Great Lakes northeastward into - and from - I guess it’s up around the - almost to Greenland, it looks like here; and from there, the low pressure weather system with a front comes down into the United States and touches the panhandle of Texas and then goes back on up into Canada again pointing towards Alaska. And there’s a band of clouds associated with that on this map, so your description is very accurate.

053:25:13 Cernan: Yes. Yes, I understand. I think you’ll see that big swirl of clouds Tom was talking about up Alaska way...Charlie, you asked Tom about the dense vegetation in South America. But if you look at the United States, the Mexican and greater American deserts are that orangish-brown as he described them; but when you look into the Midwest and into the East you go the greenish-brown. It’s not the bright orange-brown, it’s a darker, more subdued brown - maybe with subtle hints of dark green in it.

053:25:56 Duke: Roger. We copy that. It looks like this cloud system out in the Pacific is associated with another low-pressure system, that’s sitting probably north of Hawaii at about 40 degrees latitude. It’s located about 150 degrees west, so that’s probably what’s giving us the cloud pattern up off of Alaska.

053:26:21 Cernan: That’s affirmative. That’s going to be very easy to see.

While it isn’t easy to see the landmasses to which they refer, the cloud systems are certainly very distinct, and when compared with the next image taken a short while later it does become more obvious that they are accurately describing a real time view of Earth.

They still have some problems trying to locate landmasses on the TV footage, and the lunar module pilot helps them out with more detail on the view over north America:

053:45:40 Cernan: ...If you follow up...the Gulf of Mexico there - and then go straight north you see a little bit of V in the clouds and there’s one going off to the right and a little thin sliver going to the right is the one I’ve
been mentioning all day that goes from Indiana on through the northeast part of the country; and then that bigger blob that forms the left-hand side of the V is over the north, central United States and then right smack in center of the V is Lake Superior and Lake Michigan.

From this description that the cloud mass he is describing is the large mass over the northern US identified by the purple arrow in the next image. That image is AS10-34-5055, but examination of that image (low resolution source available here: AIA) shows it to be only marginally different from AS10-35-5068, so it is this one that will be examined next, and this is shown below in figure 4.2.37. In between 5055 and 5068 are several photographs of the LM, but it isn't clear what the purpose of these images was. The comparison with the satellite images is done in figure 4.2.38.

Figure 4.2.37: High quality GAP scan of AS10-34-5068. AFJ Source

The disappearance of most of south America beyond the terminator puts the time at 23:00, with the satellite images showing weather systems from the 20th. As far as the satellite timings are concerned, ATS is obviously from the same time as before, and nearly all of the land masses visible are now beyond its view. We can also see that the large swirl described in the TV commentary is identified by the blue arrow here. Not for the first time we have a very clear Hasselblad image showing exactly what was filmed and described in the TV footage.

As for satellite timings, ESSA's terminator position would have been on track 3 of its circuit, or orbit 1042, commencing at 18:09 on the 20th, but the area over the Pacific wouldn't be imaged for another hour after the photograph (track 6, orbit 1045). NIMBUS' track 489 was commenced at 14:55 on the 20th, and not all of the area in the photograph was imaged on the 20th.
Figure 4.2.38: ESSA 9 (top left upper & lower), ATS-3 (bottom left) and NIMBUS-3 IDCS (bottom right) compared with AS10-34-5068.
Figure 4.2.38 continued: AS10-34-5068 and 3D reconstructions using digitally restored ESSA (left) and NIMBUS (right) satellite data
The next photograph in the series showing rotation of the Earth is AS10-34-5070, and is shown below in figure 4.2.39. The comparative analysis with the satellite images is shown in figure 4.2.40a.

![Figure 4.2.39: GAP scan of AS10-34-5070. Low quality source here: AIA](image)

The quality of the image is such even without zooming in it is possible to see that the system identified by the blue and green arrows in the previous analysis are still visible in this one, but the systems shown by the purple and magenta arrows have moved beyond the terminator, and are no longer visible. There is no need to use the ATS image in the analysis, as in there is only the fog banks off the west coast of northern America that is still visible on it.

In terms of when the image was taken, Stellarium suggests a time of around 01:30 on the 21st, at which point the crew were roughly at the point where the Moon & Earth appeared the same size to them, and not far off the point where they passed from the Earth's gravitational sphere of influence and into that of the Moon's.

ESSA's most representative orbit for the terminator is track 5, or pass number 1011, which commenced at 22:00 on the 20th. NIMBUS' pass for the same area is number 490, commenced at 20:17 on the 20th.

Now that the Earth has rotated a little more it's worth looking at the higher resolution infra-red images from NIMBUS. For this image there have been issues with the NIMBUS data, and there are sections missing, but it is still possible to focus in on the western limb and the weather systems surrounding Japan (see figure 4.2.40b).
Figure 4.2.40a: ESSA 9 (left) and NIMBUS 3 (right) images compared with AS10-34-5070 and Stellarium estimate of time at terminator. Green, blue, red and cyan arrows identify the same cloud systems as 4.2.23.
Figure 4.2.40 a continued: AS10-34-5070 and 3D reconstructions using digitally restored ESSA (left) and NIMBUS (right) satellite data
As usual with these things the Apollo record and that of NIMBUS are an excellent match. Particularly worthy of note is the circular depression in the top right of both images. While no name storm is given in this area for these dates, it is certainly very obvious. This particular pass was started at 01:20, almost exactly matching the estimate for the Apollo photograph.

Not long after the AS10-34-5070 was taken, the crew entered a rest period, and it is some time before any new photographs are taken. The next image of Earth in magazine 34 shows a view of Africa, which obviously means some time has elapsed on the ground. This image is AS10-34-5071, and is almost identical to image AS10-35-5190. For the sake of continuity, 5071 will be used and is shown in figure 4.2.41. AS10-35-5190 can be viewed as a low quality image here: [AIA]. AS10-35-5190 is the last image in that magazine before the lunar surface in close-up begins to appear.

Figure 4.2.42a shows the analysis, and the most obvious weather systems visible are those in the northern hemisphere, particularly the striking spiral off the coast of Africa (red arrow), and the complex frontal system indicated by the blue and green arrows. Neither of these features were evident on the previous day’s satellite images, although they are obviously a development of the systems visible in figure 4.2.27 from the previous day.
Figure 4.2.42a: ESSA 9 (top left upper & lower), ATS-3 (bottom left) & NIMBUS-3 IDCS (bottom right) compared with AS10-34-5071 and Stellarium estimate of time at terminator.
Figure 4.2.42a continued: AS10-34-5071 and 3D reconstructions using digitally restored ESSA (left) and NIMBUS (right) satellite data
Stellarium suggests a time at terminator of around 16:15 on the 21st. South America is visible in the Stellarium image, but it is difficult to spot in the Apollo image until it is spied under a thin layer of cloud. The yellow arrow points to a triangle of cloud that will be more visible in later images.

ESSA would have imaged the terminator area in track 12 of its orbit. As the image dated the 21st starts with the area covered by track 11 onwards, this means that orbit 1051 is relevant pass, commencing at 12:07 on the 21st. NIMBUS' equivalent is orbit 497, commenced at 08:49 on the 21st.

We have good coverage of this image from the higher resolution NIMBUS-3 infra-red imagery, as seen in figure 4.2.41b.

As usual the infra-red imagery is an excellent match for that of Apollo. Particularly noticeable is the swirl of cloud off the Iberian peninsula. The missing portion in the final pass is covered well by the MRIR instrument. And the large band of cloud off the northern US is easy to make out. As we have northern Europe back in the frame, we can also look again at the area around the UK, as shown in figure 4.2.30c.
Once again, even when zooming into the smallest details the match is exact. The UK can be made out in the centre of the Apollo image, and the Atlantic fronts marching in are easy to make out. The distinctive swirl off Spain is very obvious.

Before the final Hasselblad is examined, we have one more TV sequence to look at. This sequence was broadcast between 17:26 and 17:43 on the 21st. A still from a CBS news broadcast is included in the analysis below (figure 4.2.42). It isn't all that clear, so a still from this source is also included.

As usual with the TV broadcasts there is a detailed description of the scene:

072:38:15 Stafford: Right. You can see the South Atlantic Ocean there and the orange spot to the right is the North African continent. You can see basically the Sahara Desert and, above that, the Mediterranean Sea. The rest of the world is pretty much encased in clouds. The solid cloud cover that’s covered the North Pole, and most of Europe, is still with us today. At this time, as we look at the Earth, we are 210,000 miles [389,000 km] away. We’ve only got about 9,000 miles [16,700 km] to go to the Moon and we’re traveling approximately 2,500 miles an hour [4,600 kph] relative to the Earth. Also, in about 15 minutes we will enter the shadow of the Moon and make our major burn to enter lunar orbit in approximately 3 hours. Now, at this distance, the Earth looks slightly smaller than a tennis ball to us and a little bit larger than a golf ball. And I hope it shows up the same way on your screen.

072:39:19 Stafford: …And again, South Africa - Go ahead, Charlie.

072:39:27 Duke: Roger. I was just going to add that we can see the northern part of Africa. We had a bluish tint to it at first but now it’s coming in to a sort of orangish brown and we can see the South Atlantic and the cloud covers very well. The colors are very good. Over.

072:39:47 Stafford: Roger. Again, the Sahara Desert, the Atlas Mountains, Morocco, Libya we can see from here. It is an orange brownish orange. The night time - the terminator has cut across the Suez Canal and most of Egypt and is now covering most of South Africa. I can see Spain. It is a greenish brown and is completely contrasted with respect
Figure 4.2.42: Cropped screenshot of Apollo 10 live CBS TV broadcast with ESSA & NIMBUS images from 21/05/69, and Stellarium insert showing terminator position at time of broadcast. Right is a clearer version of the same scene.
Figure 4.2.42 continued: Live TV still and 3D reconstructions using digitally restored ESSA (centre) and NIMBUS (left) satellite data.
to North Africa. However, you may have difficulty seeing it on your set due to resolution at this distance. Again, you can see Brazil, but it is covered mostly with clouds at this time... At this time Apollo 10 is going through the preparation for the Lunar Orbit Insertion burn, and the next - After we lose contact with the Earth, the next time that we come around, we will – To have contact with the Earth, we'll be at approximately a 60- by 170-mile [111- by 315-km] orbit around the Moon. Right now, we cannot see the Moon, even though it is rapidly accelerating us towards itself by its mass. Over.

072:53:32 Stafford: Looks like we’re right on trajectory, then. Okay. Here’s another look at the Earth through the 210-foot dish at Goldstone, and I hope the colors are coming through a little better. Again, the west coast of North Africa is still a bright orange, and the central part of North Africa is starting to turn purple as night-time approaches over the western part of Libya and the eastern part of Tunisia. Again, it’s awful hard to see Spain because Spain is a greenish brown this morning. You have the Mediterranean and the Atlantic covered with some clouds, so it’s awful hard to see any part of Spain. But again, the Earth to us this morning looks a little bit smaller than a tennis ball as we’re 210,000 miles [389,000 km] from the Earth and now less than 9,000 miles [16,700 km] to go to the Moon.

We also have available another 16mm view of Earth, obviously taken at the same time (figure 4.2.43).

![Figure 4.2.43: 16mm Apollo 10 still.](image)

One final photograph can be examined before coming to those featuring the Earth with the lunar surface, and this is AS10-34-5072, the last in this magazine before pictures of the lunar surface are featured. This photograph is shown below in figure 4.2.44, and analysed in figure 4.2.45.
Stellarium suggests an image time for Apollo of around 18:15. The ESSA orbit for the mid-Atlantic region is number 1053 (track number 1), which was at 15:08. The NIMBUS 3 track for the same area is orbit 500, which was started at 14:11. Again the NIMBUS orbit precedes the other two images. Conversely, the weather systems identified by the blue and green arrows were taken at the roughly same time as the Apollo image. Orbits 501 & 502 by NIMBUS occurred at 15:59 and 17:46, while orbits 1055 & 1056 (tracks 3 & 4) were at 19:08 and 21:03. ATS-3 images were taken at 17:17.

It should be clear from the Hasselblad still that it is showing the same weather details that can be seen in the TV and 16mm footage.

Next stop, the Moon!
Figure 4.2.45: ESSA 9 (top left upper & lower), ATS-3 (bottom left) and NIMBUS-3 IDCS (bottom right) images compared with AS10-34-5072 and Stellarium estimate of time at terminator.
Figure 4.2.45 continued: AS10-34-5072 and 3D reconstructions using digitally restored ESSA (left) and NIMBUS (right) satellite data

A couple of hours after AS10-34-5072 was taken, the crew performed the LOI manoeuvre, followed 4 hours later by a circularisation manoeuvre that change the orbital path from a much wider ellipse to one where the distance from the orbiting craft to the surface is more constant. Apollo 10 spent just over 60 hours in lunar orbit as it rehearsed the procedures Apollo 11 would need for the actual landing.

Over the first 24 hours the crew completed a variety of system checks in the LM, before finally undocking the LM from the CSM and the two craft began orbiting separately. The LM ascent and descent stages were separated just as they would be in a landing mission. A serious problem occurred during this latter separation after a switch was placed in an incorrect position. This caused a considerable amount of what NASA describe as 'anomalous motion' that put the mission at great risk of failure.

During this initial period, no photographs of Earth were taken – mostly because the crew were somewhat pre-occupied with other duties and with photographing the lunar surface. There were TV broadcasts and images taken by the DAC which will be examined in the next section.

However while Stafford and Cernan were in the LM they did observe Earthrise and had many attempts at getting photographs of it. While they wanted colour, the first images were actually taken using black and white film, and we’ll look at the logical deductions that allow us to conclude that now.

Figure 4.2.46a shows AS10-29-4231, pretty much in the middle of the magazine after a number of images of the lunar near and far side. Figure 4.2.46b shows the analysis of that image.
Figure 4.2.46b: Main image - AS10-29-4231 compared with ESSA (left) & ATS-3 (right) images from 22/05/69. Below that are NIMBUS-3 IDCS (left) and HRIR (right). Stellarium estimate of time at terminator is shown to the right.
Figure 4.2.46b continued: AS10-29-4231 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (centre) data
So, how can we tell that this is Apollo 10’s first Earthrise?

There is some information in the photographic index of the mission, but this does not give any information other than the features taken in these magazines. These features are usually known lunar craters that were planned to be photographed, or they were “T.O.” -targets of opportunity. In other words, anything interesting that caught the astronaut's eyes, or 'nice to have' features that were considered desirable but not essential.

There are some clues in the mission transcript, but there is nothing absolutely specific. So, having drawn some arrows on some fairly vague pictures, what other evidence is there to support them being in the right place?

First of all, let’s examine figure 4.2.46a. The photographic index (available here: AFJ) records that magazine 29 (originally designated 'P'):

“...contains photographs taken from the LM during the descent approach to landing site 2 (just missing the site)“.

So, any photographs on the magazine were taken from the LM. The crew were only in the LM between 15:51 on the 22nd and 03:31 on the 23rd. Several hours after entering and before leaving the LM, however, the crew would have been busy navigating away from and back to the CSM, so this gives a much narrower window on the 22nd for photography purposes. We know that they were frustrated by the lack of colour film on an earlier orbit thanks to this exchange:

099:09:50 Cernan (in Snoopy): Oh, Tom, get a picture of that - the world.
099:09:52 Stafford (in Snoopy): I don't have any color!
099:09:54 Cernan (in Snoopy): There's the world.
099:09:57 Stafford (in Snoopy): We don't have any color.
099:10:00 Cernan (in Snoopy): John, we just saw the world and it is fantastic!

Given the timing of that statement it’s likely that they have caught a mid-orbit glimpse rather than an Earthrise.

The closest approach to the lunar surface is recorded as being at 21:29 (100:27:46 MET) on the 22nd, on orbit 13, and around that time in the mission transcript we have this remark from the LM crew:

100:25:52 Cernan (in Snoopy): John, we just had Earthrise. Fantastic. Golly, John! Tom, get that if you can.

However shortly afterwards we have Stafford complaining bitterly that he is unable to get the colour magazines to work properly:

100:25:58 Stafford (in Snoopy): I don't have any color film on this son of a bitch.

Cernan then exclaims again:

100:27:46 Cernan (in Snoopy): Oh. Charlie. We just saw Earthrise and it’s got to be magnificent.

We then have

100:28:09 Cernan (in Snoopy): The only trouble is - We're stripping lots of film for him.

'him' being Jack Schmitt, the geologist who finally made it to the Moon on Apollo 17. The statement reveals that they were actively engaged in photography then using black and white film.

The Stellarium image coincides well with the terminator line on the Apollo image and the associated weather patterns around it, particularly the shape of the terminator. As far as the satellite images are concerned, the NIMBUS image at the terminator line (orbit 514) was commenced at 14:56 on the 22nd. The ESSA track covering the terminator was track 2 on orbit 1066, which commenced at 16:06. The ATS-3 image is timed at 17:03.

While Cernan and Stafford were having their traumas with still photography, a 16mm camera did manage to capture an Earthrise. There is no record of precisely when magazine H was set up, but shortly after the start of Revolution 13 we have:
100:04:57 Stafford (in Snoopy): What are you taking, 6?

referring to 6 frames per second on the DAC. A quick look at the maps showing 16mm coverage shows that the start of Magazine H’s coverage was shortly after the far side meridian (the standard delimiter for the start of orbits). It’s this magazine’s footage that shows the Earth. Figure 4.2.47 shows a still from that sequence.

The image can’t have been taken any earlier, as while the shape of the cloud near the terminator is similar to that in the Atlantic the preceding day, the Earth was more at the three quarter stage than the half it is here. To be absolutely certain we’re looking at the same scene, here it is compared with the black and white image used earlier (figure 4.2.48).

They are obviously showing the same scene, and Stafford was cursing his luck and their Hasselblads over catching Earthrise with the Hasselblads, Gene Cernan quietly, and probably without realising, managed to capture the historic footage. As they are the same scene, the reader is respectfully referred to the previous set of satellite images for the comparison.

The 16mm Earthrise capture was repeated a couple more times before they could get a colour still image. Magazine F was used on Revolution 14 to intermittently capture features of interest in the absence of a working Hasselblad. Figure 4.2.50 shows the still and its analysis.
Figure 4.2.50: Apollo 10 16mm still (top left) zoomed and cropped (top right) and compared with ESSA (middle & bottom left) and NIMBUS (bottom right) images from 22/05/69, and Stellarium depiction of time at terminator. Red, blue and green arrows as shown in figure 4.2.77
Figure 4.2.50 continued: Magazine F still and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (centre) data
As with the preceding example, it is possible to be very precise here. At roughly 23:00 on May 22nd, Apollo 10 was 90 minutes past its closest approach to the lunar surface and would, in another 30 minutes, experience the near catastrophic anomalous motion that caused such alarm. The Apollo 10 mission report states that Apollo 10’s craft (now separated & orbiting separately), would experience loss of signal (LOS) as it disappeared behind the Moon at 101 hours and 36 minutes into the mission, or 22:24 GMT.

Acquisition of signal (AOS) would be at 102 hours 22 minutes, or 23:14 GMT (NB: times given are for the CSM, the LM times are a few minutes later). As AOS can only occur when the Earth becomes visible to the orbiting craft, the Earthrise image was therefore taken sometime around 23:14, 22/05/69, exactly matching the crew’s exclamations:


Stellarium’s depiction of this time shows that the terminator should be crossing the east coast of northern USA at this time, and this is precisely what the screenshot shows. The next Earthrise still can be seen in figure 4.2.51, and as will be seen this is from the next orbit.

Figure 4.2.51: Apollo 10 still (top left) zoomed and cropped (top right) compared with ESSA (middle & bottom left) and NIMBUS (bottom right) satellite images from 22/05/69, and Stellarium depiction of time at terminator.
Figure 4.2.51 continued: Magazine K still and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (centre) data
Close examination of the zoomed video screenshot show that many of the features in 4.2.50 are still visible here, and the principle ones have been identified using the same arrows. The transcript record shows that at 104:22 we have the following exclamation at Earthrise:


Followed later by this explanation to Houston:

104:24:00 Stafford (in Snoopy): Roger. We had a nominal burn. Everything went good, and we had a beautiful Earthrise as you came up from behind the horizon.

This time equated to 01:11 on the 23rd, which Stellarium suggests should show a terminator that cuts across the mid-western US, and put the northern California coast at centre stage, which it evidently does. Another orbit, another perfectly consistent view of Earth.

We have quite a gap as we wait for the next Earthrise, and the crew’s frustration with the colour film shows, as we can see in these exchanges:

120:07:37 Stafford (onboard): Hey, look at - look at the Earth. See that Earth.
120:07:39 Young (onboard): Oh, God.
120:07:40 Stafford (onboard): Isn’t that beautiful?
120:07:42 Young (onboard): That’s just fantastic.
120:07:43 Stafford (onboard): Would you believe Africa?

Observant readers will notice that the first colour image we look at below only shows the very western edge of Africa, so clearly they didn’t get any colour photographs on this pass either, something confirmed by this statement of frustration:

120:08:11 Stafford (onboard): That’s why I want to get this color - Gene-o, that’s why we want to get this color stuff

Finally, on the next orbit they have another crack at it:

122:05:52 Cernan (onboard): There it is.
122:05:57 Stafford (onboard): The Earth. Hit it. Again, baby...
122:05:56 Young (onboard): What?
122:05:57 Stafford (onboard): The Earth. Hit it. Again, baby...

Did it work? Let’s see in figures 4.2.52a, which shows AS10-27-3889, and 4.2.52b which shows the various satellite comparisons available.

Figure 4.2.52a: GAP scan of AS10-27-3889. Link to low quality source: AIA
Figure 4.2.52b: Main image - ESSA 9 (top left upper and lower), ATS-3 (bottom left) & NIMBUS-3 IDCS (bottom right) compared with AS10-27-3889. To the right this are strips from an ATS-3 image (see introduction for source) showing the area identified by the cyan and magenta arrows (left) and below that NIMBUS-3 HRIR. Top centre page is a Stellarium estimate of time at terminator.
Figure 4.2.52b continued: AS10-27-3889 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (centre) data
The most visible weather system in the photograph is the long \( \lambda \) or fishtail shaped pattern stretching from the Caribbean to the mid-north Atlantic, a feature that is only visible in that formation on the 23rd. To the west of this system is a band of cloud running up the east coast of the USA, and extending westwards from this is a band of cloud running across the USA. These systems are identified because they can also be seen in the next image, AS10-35-5223 (figure 4.2.38).

Examination of the mission transcript shows that orbit number 24 of the mission’s residency around the Moon began at 18:16, and the first voice contact with the crew after AOS was at 18:56, so 18:45 seems a reasonable time to give for the Earthrise photo sequence. By happy coincidence, Stafford’s “Hit it” command is on Rev 24, his instruction would make the exact time as 18:54.

ESSA 9’s track covering the terminator in figure 4.2.34a is track 1, or orbit 1078. This would have been started at 16:08. The orbit covering the centre of the daylight part of the Earth (track 3) would have been started at 1900. NIMBUS 3’s equivalent orbits are 526 for the terminator, and 529 for the central daylight portions, which equates to 12:44 & 18:06 respectively. ATS-3’s image would, as usual have been at just after 17:00 on the 23rd.

As with other Earth images, the quality of both the Apollo photograph and the NIMBUS-3 HRIR image is so good that we can zoom in on fine details, such as that shown in figure 4.2.52c below.

![Figure 4.2.52c: Section of NIMBUS-3 HRIR orbit 526 compared with the same area of AS10-27-3889](image)

Even from nearly a quarter of a million miles away, the Earth is still shown in enough detail to confirm that the weather patterns on it are an exact match with the satellite record. This is even true when you look in much greater detail, for example the area shown in figure 4.2.35 above. NIMBUS orbit 526 commenced at 12:25 GMT, so any minor differences are easily accounted for by that time gap.

Now that the crew are re-united there are enough hands to operate more cameras, and as a result we also have a 16mm still showing exactly the same view (figure 4.2.53).
Figure 4.2.53: Magazine D still showing Earthrise.

It’s worth pointing out that while the AFJ video linked to in the caption says it is not shot in a mirror, the original footage from which the still was taken is reversed. The current AFJ video is correctly oriented. The zoomed and cropped still is reversed back into its proper orientation. There’s no indication in the transcript when the DAC was turned on, but it clearly was, and all three crew members were very keen to capture the moment.

Next we have an image from a different colour magazine, and as we shall see from the analysis it was taken on the next orbit. Figure 4.2.54a shows AS10-35-5223, and figure 4.2.54b shows the analysis.

Figure 4.2.54a: GAP scan of AS10-35-5223. Link to low quality source: AIA
Figure 4.2.54b: Main image - ESSA 9 (top left upper and lower), ATS-3 (bottom left) & NIMBUS-3 IDCS (bottom right) compared with AS10-35-5223. Right is NIMBUS-3 HRIR orbits and inset is Stellarium indicator of time at terminator.
Figure 4.2.54b continued: AS10-35-5223 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (centre) data
By figure 4.2.54b, the system described in the previous paragraph has moved eastwards. This movement represents the rotation of the Earth as the Apollo craft orbits the moon, which should take around 2 hours per orbit in a high altitude configuration, as opposed to some difference in the position of the craft above the moon (the craters visible in the whole image are the same). A quick trawl through the transcript reveals that each orbit is recorded as starting 2 hours apart.

The transcripts also record the time of the Earthrise and the issues the crew are still having with photography:

124:04:11 Cernan (onboard): What time’s that Earth coming up?
124:04:17 Stafford (onboard): Boy, oh, boy. Sun’s so bright, I can’t - It’s 24:04. Get it - here he comes, he...
124:04:31 Stafford (onboard): You better. We can get him next time. a se - next time, try to get a sequence on him too. Just a couple of short sequences.
124:04:51 Young (onboard): You missed him? You missed him? Know how I could tell he was coming? Because I heard the acquisition.
124:05:01 Cernan (onboard): Yes.
124:05:03 Stafford (onboard): Just take a couple in color, OK. F-1.

Stellarium shows that this image puts the terminator at roughly 20:45 – 2 hours after the first one. This would put the Earthrise as being from the next orbit around the Moon, which is recorded as commencing at 20:14, and with first voice contact after AOS being at 20:55. The time in the transcript works out at about 20:54, so again our Stellarium estimate is a reasonable one. It’s worth pointing out that Magazine 35 was on board the CSM with John Young, so he took this photograph.

In terms of what is in show, as the globe has moved meaning that more of the weather system that is visible running westwards across the USA has become more visible, as has a large mass of cloud over the Arctic. This system is visible in the next image in the sequence, AS10-35-5230 (figure 4.2.55a). This photograph, which also shows the window frame of the CSM is of poorer quality as Young has not used the zoom lens to the fullest extent. The larger weather systems are, however, still visible.

ESSA 9’s track across USA on the 23rd was orbit 1080, which would put the time for that image at 19:00. NIMBUS 3’s equivalent would be orbit 528 (which is actually missing from the dataset), at 16:18. As not much else has changed we’ll wait until the next images for more infra-red shots.

The next view of Earth is shown in figure 4.2.55a, and analysed in figure 4.2.55b.
Figure 4.2.55b: Main image - ESSA 9 (top left upper and lower), ATS-3 (bottom left) & NIMBUS-3 IDCS (bottom right) compared with AS10-35-5230. To the right are NIMBUS-3 HRIR orbital strips and Stellarium indicator of time at terminator.
Figure 4.2.54b continued: AS10-35-5230 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (centre) data
Stellarium suggests a time of 22:45 on the 23rd - is there any support for this in the transcript? Well, there is this:

126:02:43 Young (onboard): 39. Did you hear the S-band?
126:02:44 Cernan (onboard): Sure did. Here it is.
126:02:58 Young (onboard): Shooting at real time there, Gene-o?
126:02:59 Cernan (onboard): Yes

Cernan is obviously following Stafford’s instruction to ‘get a sequence next time’ and is shooting 16mm at the same time as Young is taking the Hasselblad images. They had already worked out that hearing the first signs of AOS from the S-Band meant that Earth would soon be in sight. A still from the 16mm footage is shown in figure 4.2.54c, along with a still from a 1971 documentary shown in schools, once again demonstrating that the Apollo image record was publicly available.

The ‘fishtailed’ system pointed out in the first of the Earthrise images is still visible (just) on the eastern side just behind the terminator, while the clouds running east-west are now in the centre of the image. Two other systems are also brought into view here. The first is the system arrowed in green south of Mexico, and the other is the whirl pattern off the west coast of the USA, arrowed in red.

Stellarium’s estimate puts the image at an orbit later than the previous image, and again the Earth has rotated an appropriate amount for that time gap. Orbit 26 in the transcript is recorded as starting at 22:12, with first voice contact after AOS at 22:55. ESSA’s orbit would now be track 4 for the part covering middle America, which is orbit 1081 commencing at 21:05.

While much of the NIMBUS data is missing from this orbit, it is worth zooming on one of the features that is available, the cloud picked out by the green arrow (figure 4.2.55d).

The Apollo image is a little blurry so I added some helpful arrows to remove any doubt. It’s the same cloud system.
What we also have here is a black and white image seemingly taken at exactly the same time.

Figure 4.2.55a shows AS10-30-4477, and figure 4.2.55b the analysis.
Figure 4.2.55b: AS10-30-4477 compared with ESSA (top left), ATS (top right), NIMBUS-3 IDCS (bottom left) and HRIR (bottom right) images from 23/05/69.
The image is not as clear as the colour one, but there are indications that it was taken at the same time.

The key is the cloud identified by the cyan arrow, which is obviously the same shape as the one in the colour image, and is also in the same position. The image also shows dark patches either side of the equator, with the southernmost one being particularly large. It is the contention here that this large area is the south Pacific off the coast of Chile, and the other dark area is the Caribbean. The white patch between these two would be the clouds over the coastal areas of northern south America.

This would give a suggested time of roughly 22 – 23:00 on the 23rd, at which point the crew were carrying out landmark tracking and photography operations. Again referring to the mission transcript, at 123:08 (or about 20:00 on the 23rd), Capcom have some jobs for them to do, but given them the option of continuing with photography work if they feel they haven’t yet completed it. The crew reply saying that

123:08:58 Stafford: ...We've shot so much photography we're about out of color film. We're saving a little bit for the way back. And we still have some black and white to go, and we'll do some of that

So they are using both colour and black and white film by this point. The reader is also referred to this section, where there is a 16mm still showing the same scene. The crew were not taking any chances by this stage!

The next orbit (orbit 25), and therefore the next Earthrise, came at just before 21:00. There is no reference at the time of AOS for photography, but the crew do discuss the weather systems they can see on Earth over the USA (see the final section for Apollo 10 on Meteorology). The Earthrise for orbit 26 was at around 22:45, which matches well with what figure 4.2.55b & 4.2.55b suggest.

The final colour Earthrise image in this sequence shows AS10-35-5239 (figure 4.2.56a) and was again taken by Young aboard the CSM. It is analysed below in figure 4.2.56b.

Figure 4.2.56a: GAP scan of AS10-35-5239. Link to low quality source: AIA
Figure 4.2.56b: Main image - ESSA 9 (top left upper and lower), ATS-3 (bottom left) & NIMBUS-3 IDCS (bottom right) compared with AS10-35-5239. Right is a NIMBUS-3 HRIR mosaic and inset is a Stellarium indicator of time at terminator.
Figure 4.2.56b continued: AS10-35-5239 and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS (right) data.
On the final colour image of this sequence, AS10-35-5239, the elongated cloud mass arrowed in green on the previous image is now at the terminator line, and the whirl arrowed in red is the most prominent system visible. Stellarium fixes this image at around 00:45, again an orbit later than the previous image. Orbit 27 started at 00:11 on the 24th, and voice contact after AOS was at 00:52. The crew give no indications that they are photographing Earth at this point but they are engaged in photography duties at the time, and AOS is marked at the time given in the Stellarium image.

The appropriate image is still that of the 23rd, because the orbits of Apollo 10 are effectively keeping pace with the ESSA & NIMBUS tracks and the satellite images commenced on the 23rd have yet to complete a full day’s coverage of the Earth. Because fewer of the NIMBUS tracks are available for this part of the Earth’s surface, there are fewer matches, but it is presented for the sake of consistency. It is still worth looking more closely at one of the higher resolution infra-red images just to confirm that the Apollo photographs are showing high levels of detail that are matched in the satellite record - see figure 4.2.56c.

As usual it’s an almost exact match, with less than three hours between the taking of the two photographs.

We have one last still image of Earthrise to look at, this time from a black and white image, AS10-32-4808. There is an earlier image on the same magazine (AS10-32-4802), but it has the same features on it as 4808, so must have been taken during the same Earthrise event.

Figure 4.2.57 shows the image, and figure 4.2.58 the analysis
Figure 4.2.5b: Main image - ESSA (left), NIMBUS-3 IDCS (right) images compared with AS10-32-4808. Below this is NIMBUS-3 HRIR image and Stellarium estimate of time at terminator.
Figure 4.2.58 continued: AS10-32-4808 and 3D reconstruction using digitally restored ESSA data.
For this image, while it is not as high quality as the colour image we can still make out important features that help us time the photograph, namely Australia. One of the two strands of cloud across Australia extends a little beyond its coastline, so we can put the terminator somewhere off the east coast of the continent. The Stellarium time for this image is set at 06:46 on the 24th, which is the first voice contact between Houston and Apollo 10 after the start of revolution 30. Figure 4.2.59 shows Australia in close up.

![Figure 4.2.59: Stellarium, Apollo and ESSA views of Australia at 06:46 24/05/69](image)

The timing is confirmed by this from the transcript:

133:13:57 CDR  Here comes the Earth. Beautiful.

And the positioning of Australia is spot on, as usual.

The NIMBUS orbit covering Australia was commenced at 02:44 on the 24th, while ESSA’s best track for the terminator is track 8 on orbit 1085, which started at 05:24 on the 24th.

Another feature of these images is that they show a clear rotation of the Earth over that time. The weather systems visible on the images come in and out of view in a manner consistent with that rotation. The amount of movement of the globe over the timespan of these photographs matches exactly what would be expected from the Earth in that time.

We can demonstrate this with a quick look at where we would expect the terminator to move to over that time over just the 6 hours separating the 4 colour images (which as we have seen also includes one of the black and white photographs).

Figure 4.2.60 shows a map of the Earth with 30 degree lines of longitude marked. Marked in red are the lines we would expect the terminator to follow at 2 hours intervals. As there are two hours for each orbit, which equates to 30 degrees of Earth rotation, this makes the task slightly easier.

It should be pretty obvious from the above that not only do the weather systems on the photographs match exactly the satellite images, but the movement of the Earth in between the Apollo photographs is entirely consistent with what would be expected.

Time to head for home.

![Figure 4.2.60: Terminator lines at 30 degree intervals. The red line on the right marks the terminator line as shown on AS10-27-3889](image)
4.2.1c - Apollo 10 – on the way home

Approximately 9.5 hours after the last Earthrise image in the images examined here, the crew began their TEI burn to launch them on the voyage home. During that voyage the crew took more photographs of the departing Moon and, thankfully for the purposes of this research, the approaching Earth.

One of the first images of the Earth on the way home (and the first of Earth after those of a full disk and obviously shrinking moon, is AS10-35-5258 (figure 4.2.61).

An experiment with Stellarium would show that at TEI the terminator would have been somewhere over Japan. As the terminator is somewhere over India, it is clearly taken after that. Figure 4.2.62a shows the satellite image comparison with this image. An ATS-3 image is not available here. The terminator line in the image also roughly crosses the boundary where the end of one day’s ESSA images starts and the next begin. For that reason the ESSA 9 image used is dated the 24th. Anywhere to the East of the terminator would have been imaged at the end of the image dated the 23rd.

Stellarium’s terminator estimates the time for the image at 13:00 on the 24th, which coincides with the end of a TV broadcast and was probably the last thing the photographer did before going to sleep – the next few hours are recorded as a rest period.

While there are likely to be timing issues in terms of the weather systems picked out in purple and magenta (and possibly green) as a result of their position either side of the ESSA mosaic’s dividing line, they are still easily identifiable on the ESSA and Apollo images. The purple arrowed system is one that will be visible in a number of up-coming images, as it represents clouds over the Himalayas.
Figure 4.2.62a: ESSA 9 (left upper & lower and NIMBUS 3 (right) compared with AS10-35-5258 and Stellarium indicator of time at terminator.
Figure 4.2.62a continued: AS10-35-5258 and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS (right) data
ESSA's image for the 24th started with orbit number 1088 (track 11), which commenced at 11:03 on the 24th. NIMBUS' equivalent pass is number 535, which started at 04:50. The two NIMBUS-3 orbits are covered by the high resolution infra-red scan, and these can be seen below in figure 4.2.62b (below left).

Figure 4.2.62b: NIMBUS-3 infra-red orbits 536 and 538. Colours used are those in figure 4.2.62a
Orbit 536 was commenced at 06:19, less than 7 hours before the Apollo photograph was taken. The close-up shot shown in figure 4.2.62c above shows again that despite this time gap it is still possible to identify broad climatic patterns. In this case we can pick out the cloud that runs to the north of both the Caspian and Aral Seas before heading north to join a larger cloud mass. The western end of the Himalayas is also identifiable in both.

The next image, as will be evident from the position of the terminator, was taken 24 hours after the first of the Earthrise sequences examined above. There are two variants of the same image here, as AS10-27-3952 (also the first image of Earth to be seen after photographs of a retreating Moon in that magazine) is very similar to AS10-35-5262 (amongst others in a short sequence of identical images). By way of variety, the one from magazine 27 will be examined here, and it is shown below in figure 4.2.63. The one from magazine 35 can be found here: AIA. Comparison with satellite images is undertaken in figure 4.2.64a
Figure 4.2.64a: ESSA 9 (left upper & lower and NIMBUS-3 IDCS (right) compared with AS10-27-3952 and Stellarium indicator of time at terminator.
Figure 4.2.64a continued: AS10-27-3952 and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS (right) data
At first glance the large weather system identified by the green arrow is the same as in the one shown for the 23rd (it is obviously the same cloud mass, but it now has a different shape). Features of the other systems on the satellite photographs mark the Apollo image as having been taken on the 24th, not the 23rd.

The distinctive fishtail has been lost, and it now extends a further 10 degrees of longitude over towards north Africa than on the day before. The curved cloud mass picked out by the magenta arrow runs more or less along latitude 30 degrees North on the 23rd, and the cloud bank to the east of the one identified by the blue arrow and north of the one marked by the green was not there at all. The red arrow points to a continuation of a system visible in the southern Hemisphere on the previous day in figure 4.2.62 (identified by a yellow arrow).

As with the previous day’s image, there is much less available from NIMBUS, but there are still identifiable weather patterns. This becomes more obvious in the resolution infra-red images, as shown in figures 4.2.64b-c below.

Figure 4.2.64b: NIMBUS-3 infra-red orbits 540 & 542. Colours used match those in figure 4.2.64a
How many times can we say it? The Apollo and satellite record correspond just as they should - even when zooming into small areas, like the one off North-Africa shown in figure 4.2.64b

As far as timings go, Stellarium suggests a time of 18:45 on the 24th, which would have been shortly before the start of another of their TV transmissions. ESSA’s orbit for the Atlantic on this date is number 1091 (track 2), which started at 16:08. NIMBUS’ equivalent (of the ones available) orbit is 540, which started at 13:47.

Having stated that this image is almost identical to one on magazine 35, it is possible to examine the two images together and show that they were not taken at exactly the same time, but perhaps 10 minutes apart. This can be determined by slight differences at the western edge of the Earth in visible cloud masses, and also in the amount of Africa visible by the terminator. Figure 4.2.65 illustrates this, showing an insert of the earlier image on top of the later image, with a line marking the westernmost part of Africa.

There is a very obvious difference between the two images in terms of where the west coast of Africa is. The terminator line has been lined up very carefully, but there is a difference in the position of the coast of about 2.5 degrees. As you would expect a movement of 15 degrees in an hour, this would mean that the two photographs were taken roughly 10 minutes apart.

A couple of hours after these photographs were taken the crew made yet another of their regular TV broadcasts, and again Earth was featured as part of it. The broadcast took place between 20:12 and 20:23 on the 24th, and a still from it is examined in figure 4.2.66.
The long arc of cloud in the Atlantic (blue arrow) is very easy to make out on the TV image, and once you have that located it's a pretty straightforward job to pinpoint the west coast of South America and the stream of cloud just off it (green arrow).

As ever the crew give us a description:

147:23:08 Young: Houston, this is Apollo 10, 184,000 miles [34,750 km] out. This is the Earth, half-Earth. It's about - the Moon right now. We have practically a full Moon. The Earth, as you can see it right now, is - The terminator is going right across the middle or the Atlantic. You see that big circular weather belt that goes up across the United - up across the east coast of the United States, covers up Florida, and it appears that some sort or point is in the Gulf of Mexico between Florida and Texas. It's difficult to make out any land masses and I doubt that you could see any, but with the monocular, I can see Cuba, Haiti, and the Indies, and most of South America which is cloud cover. The central United States appears to be open, as well as the western United States, as far as I can see.
Figure 4.2.66 continued: TV broadcast still and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS (right) data
And as ever the description is uncannily accurate.

We have an even clearer view taken a short while later on magazine W (figure 4.2.67).

Figure 4.2.67: Apollo 10 video still compared with ESSA satellite images from 24/05/12 and Stellarium estimate of time at terminator.
Figure 4.2.67 continued: Magazine W still and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS (right) data
While they two scenes look very similar, close examination shows that the Atlantic cloud front is much nearer the terminator and an additional weather system is now visible on the western limb.

There are no ATS images available for this date, and the Nimbus record is so patchy it was not worth including for this comparison. ESSA’s best track for the terminator line is track 3 (orbit 1082) was commenced at 18:02 on the 24th. Stellarium’s estimate of the time at 21:30 is mainly based on the visibility of most of Chile on the west coast of South America. There’s no record of any filming at this time in the transcript, but it’s likely that John Young was filming as Cernan and Stafford were giving a lengthy debrief to Houston at this time.

Next up is a return to still photography. After some photographs of the astronauts inside the CM (in an obviously zero gravity environment), and more shots of a receding moon, is image A10-27-3970 (figure 4.2.78). Apart from its appearance after the astronaut pictures, the image has also been chosen because it features another very obvious weather system visible on the satellite images, again illustrating that the Apollo photographs are of a consistently revolving planet.

The image shows north America, as well as the Pacific ocean. The low cloud off Mexico and southern California visible in AS10-35-5239 (figure 4.2.57) is still in evidence, and the spiral cloud system is a development of the one identified by the red arrow on that image. The satellite images are compared with A10-27-3970 in figure 4.2.69a and b.

Figure 4.2.68: GAP scan of AS10-27-3970. Low quality version here: AIA
Figure 4.2.69a: ESSA 9 (left upper & lower and NIMBUS-3 IDCS (right) compared with AS10-27-3970 and Stellarium indicator of time at terminator.
Figure 4.2.69a continued: AS10-27-3970 and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS (right) data
Figure 4.2.69b: NIMBUS-3 infra-red orbits 542, 544-5. Colours used match figure 4.2.48b.

Figure 4.2.69c: Section of NIMBUS infra-red orbit 545 compared with the same area of AS10-27-3970
The most obvious cloud mass is the complex 'S' shaped system stretching from the central Pacific to the Alaska. Another feature of note is the thin band of cloud off the California coast that stretches out into the Pacific. In the south Pacific there is a long band of cloud stretching from the Antarctic towards the tropics. Both ESSA & NIMBUS images show the 'S' system and the south Pacific arc of cloud, but loss of orbital information along the California coast means only ESSA shows detail there.

The NIMBUS-3 infra-red data (figures 4.2.69b-c) again show excellent correspondence with the Apollo image, and as we get closer to Earth the details become even more impressive.

As with previous images, the Stellarium date given is that of the 25th, but the satellite images are those of the 24th. As the Apollo photograph was taken after the previous one examined here, it must therefore be after the 24th. The rotation of the Earth means that the only date possible for this image is the 25th, as by the 26th at this time the shape of the terminator moves to a more curved position.

Can this be confirmed by satellite orbital data?

The ESSA orbit for the Pacific part of the image dated the 24th is number 1095 (track 6), started just after midnight on the 25th. As usual NIMBUS' orbit is behind that of ESSA, and orbit 544 from the image dated the 24th was started at 20:57 – 4.5 hours before the Apollo photograph. The final orbit visible in the Apollo image is 545, which commenced at 22:25, just less than three hours in advance of Apollo.

We have two other versions of this view, namely a 16mm shot from Magazine W, and also the view from a TV broadcast. These views are shown in figure 4.2.70.
It is hopefully obvious that the scenes on show in figure 4.2.70 are an exact match for that of the still image. We also have verbal confirmation of the scene in the crew’s comments to the ground.

152:36:04 Stafford: ...As you can see the Earth there, actually it’s upside-down with the white cap as the North Pole. And, since most of you watching your TV sets can’t turn upside-down very easily, what I am going to do is turn this camera over upside-down, since it’s no trouble for us. See if that will work... OK. There we go. It's pretty easy for us to go upside-down and right-side-up as far as attitude. It makes very little difference except for a maneuver. And so, instead of requiring all you people to stand on your heads to recognize the great state of California out there, I'll just turn this upside-down in my head. As we look out there, we can see the terminator, and it has definitely crossed over to the Arizona area, and at Baja California is barely discernible. You may not be able to see it through the cloud cover. Also, it looks like we have some clouds all the way up to Los Angeles. It may even be smoggy out there today. Toward Seattle, Washington, it looks like some cloud cover, and the North Pole still has that same complete coverage as Northern Canada, over into Russia; the same cloud coverage that we have observed all the way on our trip out from Cape Kennedy starting last Sunday. It's a very beautiful, beautiful view as we start our return visit - journey - there to the Earth, and we do have a great attitude for seeing it all the time. As we slowly rotate going back home to the Earth, we’ll have the Earth out one window and then the Moon out the other, and later on the Sun. At this time, again you can see that the majority of the features are strictly clouds. The blue you see down near the bottom of your screen there is the lower South Pacific Ocean, down toward the Galapagos Islands.

Once again the description of what is on show is spot on, and could only have been done if they were exactly where they were supposed to be: in cislunar space en route to home.

Returning to the Hasselblads, a few images later in magazine 27 comes AS10-27-3976 (figure 4.2.71). By now, the Earth has rotated to bring India towards the terminator and Africa is visible to the west, The Himalayas are picked out by thin cloud, and the larger cloud masses on near the terminator show clear shadows. The Earth is also much larger, providing more evidence that Apollo 10 is much nearer home. Figure 4.2.50a shows the satellite comparison.

For reasons which will become clear, 2 different day's ESSA images are used – one (top left) from the 24th, the other (bottom left) from the 25th.

Figure 4.2.71: GAP scan of AS10-27-3976. Low quality version here: AIA
Figure 4.2.72a: ESSA 9 image dated 24/05/69 (top left upper & lower and 25/05/69 (bottom left upper and lower) & and NIMBUS-3 IDCS (bottom right) compared with AS10-27-3976 and Stellarium indicator of time at terminator.
Figure 4.2.69a continued: AS10-27-3976 and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS (right) data.
Timing the Apollo photograph AS10-27-3976 is relatively straightforward. It must have been taken after AS10-27-3970, and the rotation of the Earth also means that the former must have been taken after the latter. Stellarium suggests that the actual time of the image was somewhere around 13:30 on the 25th of May. It is trickier to reconcile this timing with the satellite images available, and again this relates to the way that a day's satellite image as given in the NASA catalogues are worked out.

Examination of the satellite photographs used shows that while the cloud formations over India are an excellent match on the ESSA image from 24/05/69, the Africa cloud formations are much better identified on the ESSA image from 25/05/69. The reason for this can be found in the dividing line between the two images used to differentiate the two dates.

While ESSA (NIMBUS) operate continuously, our need to rationalise the data requires that we separate the information into discrete dates, and in this case the dividing line on the ESSA image from 24/05/69 is easily visible in the Indian Ocean bisecting a cloud formation. The time of ESSA's India orbit on the 24th (track 10, orbit 1099) east of that dividing line is put at 08:01. The track on the African side of the divide on this image is actually orbit 1088 which was commenced at 11:03 on the 24th. This means that the next ESSA image dated 25/05/69 has its first pass (track 12, orbit 1101) at 12:01, which is why the cloud formations over the horn of Africa (picked out with cyan and magenta arrows) are a better match on that image than on the previous day's.

The NIMBUS image for the 25th is much easier to work out, as the part of Earth shown in by Apollo is within the confines of a single set of orbits. The India pass, orbit 549, was commenced at 05:54. We can take a closer look at the NIMBUS image using the infra-red passes in figures 4.2.72b-c.

Figure 4.2.72b: NIMBUS-3 infra-red orbits 549, 551-2. Colours match that in figure 4.2.50a.

Figure 4.2.72c: Section of NIMBUS-3 infra-red orbit 549 compared with the same area on AS10-27-3976
As always these higher resolution images show an excellent correspondence with Apollo photography. The change in orientation of orbit 552 is interesting, but it’s as likely to be a problem with the image itself rather than a dramatic change in the satellite’s orbital parameters.

Returning to the earlier analysis, in a nutshell: any image of Earth taken at the boundary line in an ESSA satellite mosaic is going to be a little confusing, but the appliance of logic will reveal the answer! The answer in this case being that the Apollo photograph was taken on 25/05/69 at around 13:30, just after the crew awoke from their rest period. Not long after taking AS10-27-3976, the crew took AS10-35-5264, a low resolution version which can be found here: AIA. These two images are, as with other images taken on two different magazines at the same time, ostensibly identical, but close examination reveals they were taken a few moments apart. Figure 4.2.73 compares western Africa as seen on both images.

There is a definite change in the cloud masses visible on the western limb, and in order to show the same amount of Arabia in the crop from magazine 35, that part of the image has had to be wider than that from magazine 27, indicating a change in perspective as the astronauts get nearer home.

A little while after this pair of still images we have another 16mm clip of Earth, as shown in figure 4.2.74.
Figure 4.2.75: GAP scan of AS10-35-5266. Low quality source here: AIA

Figure 4.2.76: ESSA 9 (left upper and lower) and NIMBUS 3 (right) images compared with AS10-35-5266 and Stellarium estimate of time at terminator.
Figure 4.2.76 continued: AS10-35-5266 and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS (right) data
The tricky area of the dividing line between days has now (with the exception of some high latitude eastern parts of the northern hemisphere) passed beyond the terminator, leaving us with an image that is fairly and squarely taken on the 25th.

The weather systems north and west of Europe are particularly distinctive and do not appear in that configuration on other days' satellite records. Furthermore the Stellarium terminator estimate is 16:00, and by that time on the 26th Apollo 10 was on re-entering the atmosphere of the home planet after a successful mission.

The ESSA 9 track covering the terminator area is number 12, which corresponds to orbit number 1101, which commenced at 12:01. The equivalent NIMBUS pass is number 549, which commenced at 05:54 on the 25th. There isn’t much extra to be gained from an examination of the infra-red images, so we’ll save the space for later.

There’s little in the transcripts to identify what the crew are looking at, but Capcom does tell them at 169 hours (17:49 GMT) that they are receiving the signals from them via Madrid.

Shortly after the preceding image was taken, we get to see Madrid in shot in AS10-35-5269 (see figure 4.2.77). The photograph is analysed in figure 4.2.78a, and the red, green, blue and cyan arrows match figure 4.2.76.

![Figure 4.2.77: AS10-35-5269 (Low quality source)](image-url)

As can be seen from the Stellarium view, the time for this image is around 18:00 GMT and it is interesting to note that while the broad pattern of weather systems remains the same (and also interesting to see how the change in perspective alters how they look), the passage of a few hours since the preceding photograph has caused subtle changes – particularly over north west Africa as incoming ocean borne weather systems start to interact with the hot air masses of the northern deserts.

We also have the emergence on the western limb of the Atlantic weather system last seen in figure 4.2.45. a decayed remnant of the one visible in the Earthrise photographs in the previous section and another indication that we are observation snapshots in a continuum of weather, not some made up patterns.
Figure 4.2.78: ESSA 9 (left upper and lower) and NIMBUS 3 (right) images compared with AS10-35-5269 and Stellarium estimate of time at terminator.
Figure 4.2.78a continued: AS10-35-5269 and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS (right) data
As far as the satellite timings are concerned, ESSA’s pass over the terminator would be the first one of its orbits that session (pass 1103), which would have commenced at 16:02. The NIMBUS orbit over the same area would be number 553 which commenced at 13:04 on the 25th. While this is obviously several hours before Apollo photograph, it’s worth pointing out that the cloud identified by the magenta arrow was not photographed by NIMBUS until 14:56, which would give even less time for the team of alleged photomanipulators and graphic artists and spray painters to work on their perfect rendering of the scene. We can see how perfect that rendering would need to be by looking at the infra-red passes from NIMBUS in figures 4.2.78b-c.

Figure 4.2.78b: NIMBUS-3 orbital passes 552-554. The outer two swaths are from the HRIR instrument, the central portion the MRIR

Figure 4.2.78c: Section of NIMBUS-3 infra-red orbit 552 compared with the same area of AS10-35-5269
As before, the infra-red images show excellent correspondence with Apollo, despite the time gap between them.

The long band of cloud (magenta arrow) now makes a regular appearance in a series of 16mm and Hasselblad images. First up is this still from Magazine W (figure 4.2.79).

![Figure 4.2.79: 16mm still from Magazine W, with Stellarium estimate of time at terminator.](image)

We’re definitely getting closer to home now, and the detail in the 16mm view is becoming much clearer. The rotation of the Earth beneath the returning craft puts roughly half an hour on the clock since the previous image. We’ll save the more detailed analysis for the next in the sequence, AS10-27-3979 (figure 4.2.80). Figure 4.2.81a shows the satellite analysis.

![Figure 4.2.80: GAP scan of AS10-27-3979. Low quality version here: AIA.](image)
Figure 4.2.81a: Main image - ESSA 9 (left upper & lower) and NIMBUS-3 IDCS (right) compared with AS10-27-3979. Below this are NIMBUS-3 HRIR passes and Stellarium estimate of time at terminator.
Figure 4.2.81a continued: AS10-27-3979 and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS (right) data
The ESSA orbital pass for the Atlantic (orbit 1104, Track 2) commenced at 17:07 on the 25th. NIMBUS' orbit for the same area is number 554, which commenced at 14:51 on the 25th. It’s always worth looking in detail at a small section of the HRIR orbit section (figure 4.2.81b).

As you can see the Apollo image and NIMBUS match extremely well, despite there being several hours between the images.

Stellarium suggests a time of around 21:30 on the 25th for the Apollo photograph, shortly before commencing their penultimate TV broadcast. The mission transcript records discussions with ground control before the broadcast feature the Apollo crew describing the coast of Florida, Mexico and south America, exactly as featured in this image. Interestingly they also describe the weather system noted previously over Alaska & the Aleutian islands during that TV broadcast.

This area is not quite visible in the photograph, which suggests that it was taken slightly before that discussion took place. Crew comments refer to California appearing on the horizon during the TV broadcast, and they also have to wait for the Goldstone receiving station in California to come into view, which again suggests that this image was taken while waiting for this to happen.

Stellarium’s image from 21:30 does not, however, look quite the same as the Apollo image as far as the land masses visible at the western horizon are concerned, and figure 4.2.82 shows that the moon would not have been visible from Anchorage Alaska until 23:50 on the 25th, and the immediate question from a sceptic would be ‘why the difference?’. The answer lies in the position of the observer: while the terminator line will be in the same place regardless of the observer’s position, the land masses visible at the horizon is very much dependent on the observer’s viewpoint.

Figure 4.2.82: Moonrise from Anchorage Alaska, 25/05/69 as depicted by Stellarium
While orbiting the moon, the use of a point on it isn’t a problem when identifying visible land masses away from the terminator. As the spacecraft gets nearer to the Earth, however, there will be a difference that will get more pronounced. The Apollo 10 mission report (found here) gives trajectory information that helps explain this. The voice transcript gives distance information that puts Apollo 10 about 110000 miles from Earth, and it also gives the time of the TV broadcast at roughly 173.5 hours (7 days 5 and a half hours).

The trajectory images given in figure 4.2.83 taken from that mission report show that it would have been much more difficult to see Alaska from the vantage point of the moon at 173 hours into the mission (the blue line) than from the position of Apollo 10 at the same point (the end of the red line). These may seem like minor points, but in the hotly debated area of Apollo conspiracy theories, where scientifically illiterate, wilfully cynical and mendacious charlatan alike seek to exploit the slightest unexplained facet of an argument to score points it is essential that they are addressed.

In short, Stellarium is using a viewpoint that is growing ever further away and at an increasingly different angle from the vantage point of the photographer.

To complete the sequence we have this final still from Magazine D. It could be argued to show exactly the same view as shown in figure 4.2.81, but there does appear to be less visible of the systems in the northern hemisphere.

A short while after the 16mm footage was taken the crew made another TV broadcast. This took place between 22:16 and 22:26 on the 25th and again featured long shots of Earth with the crew describing the view. A still from the broadcast is shown in figure 4.2.85.
The most obvious feature is the storm marked with purple arrow, and this is west of a feature that (red arrow) that has now rotated beyond the terminator - something entirely consistent with the time of the broadcast. Again, the crew describe what is on show, telling Houston that they are looking at:

173:34:26 Cernan: Charlie, we'll be looking at - at the east coast of - of the United States. Primarily down from - off the tip of Florida. Actually to us here we can see the Grand Bahama Banks. You can see the color changes in the water. You can see most of Florida. It looks like almost all the Gulf of Mexico is extremely clear. The Gulf Coast of the United States, Florida, Alabama, Mississippi, Louisiana, on down through Texas all looks clear. We can look on across from Houston all the way into the San Joaquin Valley, all the way into the Los Angeles area coming over the horizon into Baja California.

173:35:15 Cernan: We're vertically right now above the Earth, somewhere between Caracas and Panama.

In addition to describing the weather, the crew inform Capcom that they are taking photographs of Earth every few hours to provide a record of its appearance. Figure 4.2.86 shows AS10-27-3981, which is analysed in figure 4.2.87. This image has a matched pair with AS10-35-5272.
Figure 4.2.87: Main image - ESSA 9 (left) and NIMBUS-3 ICS (right) images compared with AS10-27-3981. Below is NIMBUS-3 HRIR & Stellarium estimate of time at terminator.
Figure 4.2.87 continued:  AS10-27-3981 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (right) data
The large spiral (blue arrow) system off the west coast of the USA has again changed its appearance, re-consolidating into a more definite single spiral of cloud reminiscent of the shape this system had when observed in lunar orbit. Re-examination of figures 4.2.42 & 43 shows that they are definitely different in appearance, and not a 're-use' of a day's weather in a new photograph. What is also evident from Stellarium is the increasing curvature that would be visible in the terminator's appearance from the Moon's vantage point, something that is not as evident from Apollo as it nears the Earth.

Stellarium puts the time at 00:30 on the 26th. ESSA's 'best fit' orbit would be number 1106 (track 4), which commenced at 21:07. NIMBUS' equivalent would be orbit 555, which commenced at 16:38 on the 25th. We'll wait for more Earth rotation before looking at detailed NIMBUS scans.

We also have a matching 16mm image for this shot, again from Magazine D, shown in figure 4.2.88.

The next image in this sequence was taken not long after, but long enough for almost the entire American continent to have vanished beyond the terminator. AS10-27-3984 shows a small amount of rotation and adds little new information to that given in the previous image, but it does allow us to identify weather systems that link in with those found on the final Earth photograph from magazine 27. As before this has a matched pair with AS10-35-5275. See figures 4.2.89 for the original and 4.2.90a for the analysis.
Figure 4.2.90a: Main image - ESSA 9 (left) and NIMBUS 3 (right) compared with AS10-27-3984. Below this are NIMBUS-3 HRIR and Stellarium estimate of time at terminator.
Figure 4.2.90a continued: AS10-27-3984 and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS (right) data
The large spiral has moved much closer to the terminator, which now has most of the USA in darkness. Just emerging on the western horizon is another spiral of cloud (marked in green), and this is the system that is visible in the final image on magazine 27.

The blue, red, cyan and purple arrows used in figure 4.2.90a are the same as those in figure 4.2.87. The terminator gives an estimate of around 02:30 on the 26th.

The satellite timings are pretty much one orbit along from the previous image. ESSA’s nearest orbital pass covering the terminator is number 2303 (track 5), commencing at 23:07 on the 25th, while NIMBUS’ best orbit is 556, commencing at 18:26 on the 25th. The area covered has changed slightly thanks to the Earth’s rotation in the time elapsed between photographs, which brings an additional HRIR image into play. Here’s a close up from that image (figure 4.2.90b).

I just don’t get tired of repeating it: the satellite record vindicates the fact that Apollo went to the moon, and the image shown above is just one of a long line of examples where meteorological satellites match the Apollo photographs exactly. In this example there is around 3 hours between the NIMBUS image (started at 23:28) and Apollo, but again a hefty part of that three hours includes the rest of the satellite pass over the daylight side, then transmitting the data back to Earth at a receiving station in the US and transferring that data to the Goddard Space Flight Center for processing.

The final image in the sequence of regularly spaced Earth photos examined from magazine 27 is one of an identical pair, AS10-27-3986. It is shown below in figure 4.2.91 and analysed in figure 4.2.92a.
Figure 4.2.92a: ESSA 9 (left) and NIMBUS 3 (right) images compared with AS10-27-3986 and Stellarium estimate at time of terminator.
Figure 4.2.92a continued: AS10-27-3986 and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS (right) data.
There is still a small amount of the large spiral system off western north America (blue arrow) but the main weather system in the northern hemisphere is the green arrowed system to the west of that.

South-west of that system is a twin pronged succession of cloud bands off eastern Asia. Stellarrium's time is set at around 04:00, which is derived mainly by the absence of Australia (a small part of the east coast is just visible) and by only Alaska remaining of north America. In 12 hours’ time, Apollo 10 will re-enter Earth's atmosphere pretty much in the middle of what can be seen in the photograph.

In terms of the satellite images, their coverage of the area over the terminator starts with ESSA at orbit 1108 (track number 6), commencing at 01:08. In fairness, the terminator covered by ESSA is probably somewhere between tracks 5 and 6, just as with the previous figure the terminator was somewhere between tracks 4 and 5. NIMBUS doesn’t cover much of the area shown in the resampled modern version of the IDCS, so the main image shows the older scan of the HRIR image. The terminator is probably best covered by track 558, commencing at 22:01 on the 25th. Seeing as we can, let’s zoom in again on one small part of the Apollo image and compare it with a NIMBUS pass, again from orbit 559, this time looking at an area that was at a more oblique angle before (figure 4.2.92b).

![Figure 4.2.92b: Section of NIMBUS-3 infra-red orbit 559 compared with AS10-27-3986](image)

Once again the match is almost perfect, barring subtle changes caused by the time lapse between the two and the different spectra photographed.

We also have another 16mm still taken at the same time, as shown in figure 4.2.93.

![Figure 4.2.93: 16mm still taken at the same time as AS10-27-3986](image)
The final colour image to be analysed is AS10-35-5280 – part of the last series of Earth photos taken and featuring the Indian sub-continent. It is shown in figure 4.2.94, and analysed in figure 4.2.95a.

![Figure 4.2.94: GAP scan of AS10-35-5280 Low quality version here: AIA](image)

As with other images featuring this viewpoint, the dividing line between ESSA images makes life slightly difficult when pointing out weather systems. Those over Europe and Africa were taken at the start of the orbital cycle on the 25th, while India and Asia were imaged towards the end of the cycle on the 26th.

Stellarium suggests an image time of around 11:45 on the 26th, just a few hours short of re-entry, and the crew are able to describe the scene in a final TV broadcast made at the time. They discuss seeing India directly below them, China, and are able to zoom in on Arabia. The cloud caps over the north are the only thing interfering with the TV image.

ESSA's timings for track 10, the best fit orbit for the terminator, show that orbit 1112 (track 10) was started at 09:00 on the 26th. The eastern Africa passes are covered by orbits 1113 onwards, started at 11:05 on the 26th. NIMBUS' orbit 562 covers the Indian portion of the photograph, and was started at 04:51. The infra-red image definitely starts to suffer from the extended time gap between it and the Apollo image, but we’ll include a quick look at the area around the Himalayas just for the sake of completeness (figure 4.2.95b).
Figure 4.2.95a: Main image ESSA 9 (left) and NIMBUS-3 IDCS (right) images compared with AS10-35-5280. Below this is NIMBUS-3 HRIR and Stellarium estimate of time at terminator.
Figure 4.2.95a continued: AS10-35-5280 and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS (right) data
As with all the photographs, and even with this time gap, there is still a good correspondence with the NIMBUS image, and an extremely good match with the other satellite images.

We also have a TV broadcast to accompany this Hasselblad photograph. This is recorded as starting at 11:40 and finishing at 11:52, and this is shown in figure 4.2.96.
As always the crew describe the view

186:52:16 Stafford: ...This morning as we look out there we can see part of China, India is the most predominant feature. But also we can see Saudi Arabia, the Gulf of Oman, and the Indian Ocean at this time. And I'll try to give you a little zoom here in on Saudi Arabia and India.

186:55:05 Stafford: OK. Some final just color thoughts as we look in there. India appears to us to be a purplish tan over - I see that the - the Sun - the solar subpoint is right in the Gulf of Oman, now. It is nearly a yellowish bronze. Beyond that we have Saudi Arabia. And Saudi Arabia to us looks a sandy orange. Up to the right, up to the very top of your screen is covered mostly with clouds and this has been the cloud cover that has existed over the northern part of the world ever since we left Cape Kennedy nearly 8 days ago. Down below to the left, the long straight cloud is part of the ITC you can see it, or even down farther than that into the Indian Ocean. But throughout these telecasts, as you can see that the majority of the world is usually covered with clouds. Over.

And as always they are spot on with their observations.

The final set of images are all culled from 16mm observations of the same scene shown above, and they are shown below in figure 4.2.97. The left and right images are 16 stills, whereas the centre view is a composite from a pan across the Earth’s surface.

![Figure 4.2.97: Successive 16mm observations of India](image)

The still on the left is the first one shown in the sequence, while the composite video still is shown in the centre. There is not much between them, and it could be argued that the composite view is the same scene viewed through a better resolution zoom. There is, however, a suggestion of slight rotation between the two, particularly when looking at the northern hemisphere and the tip of the Arabia.

There is a much more obvious difference between these two and the final still, where the clouds over the eastern Himalayas have hit the terminator. This still is a much closer match to the Hasselblad image and TV broadcast, with about 15 minutes elapsing between the central pan and the final still.

As with a previous example, we have an obvious rotation of the Earth recorded on the journey home. Indeed we can state pretty categorically that the combined video and still photographs record a consistent and obvious rotation of the Earth, and the development of its weather patterns, over the course of the entire mission.

It should be an inescapable conclusion from the TV and video footage alone, showing as it does long sequences of the lunar surface not visible from Earth yet described by the crew in great detail, and long sequences of Earth filmed from great distances, demonstrates more than adequately that people filmed those views. Apollo 10’s series of Earth
photographs show that the astronaut's cameras took photographs of a revolving Earth with evolving weather systems over the course of the mission. The behaviour of the weather systems and Earth in those photographs are entirely consistent with the photographs having been taken in space on the way to, orbiting around, and returning from the Moon and this claim is completely vindicated by the satellite record.

Having dealt with the photographic and video evidence, it is now time to examine other supporting evidence in the form of synoptic charts.
4.2.4 Meteorological Evidence

Having discussed at some length the relationship between Apollo images and satellite evidence, it is again necessary, as with Apollo 8, to quickly confirm that the weather patterns indicated by satellite imagery do actually reflect terrestrial meteorological observations. Some quotes from the mission transcript may already have been referred to.

The same sources are available for Apollo 10 as for Apollo 8, but as few of the photographs available feature southern Africa clearly, the South Africa dataset is of less use. Several day’s weather charts will be examined – on the way out, during lunar orbit, and on the return journey. Meteorological data are from the same sources as referenced for Apollo 8.

Figure 4.2.98 shows zoomed & cropped versions of AS10-34-5026 and AS10-34-5013 featured earlier in this document, with main weather systems identified. Figure 4.2.99 shows these same weather systems identified on the north Atlantic, South African and north American synoptic charts.

As with Apollo 8, no meteorological expertise is claimed here, but the frontal systems, and also the areas of high pressure that tend to produce little or no cloud, marked on the charts have a clear correspondences with those on the Apollo photographs. In common with Apollo 8, the Apollo 10 crew spent some time describing the Earth to mission control, either as part of their regular TV broadcasts or as part of normal communications with the ground. Indeed it is evident in some of the conversations that Capcom are looking at weather charts and comparing them with what the astronauts are describing and the TV cameras transmitting.

At around the time AS10-34-5013 was taken, for example, the crew describe over several pages of transcript (around 5 hours in to the mission) the cloud cover over Alaska & Canada and a low pressure system near New England (in all probability the systems identified by the yellow & blue arrows respectively in the previous figure) and the associated cloud bank extending towards Florida, as well as the massive cloud cap over most of the Arctic. They even pick out the smog over Los Angeles identified in this analysis, compared with the clear skies over Baja California and Mexico. Hawaii is has “too much cloud coverage” to be picked out. The very distinctive weather system off Alaska is picked out by both Capcom and crew as a 'big swirl'.

Figure 4.2.98: Earth from AS10-34-5026 and AS10-34-50131 on 19/05/69
Figure 4.2.99: US, North Atlantic & South African synoptic charts for 19/05/68
Following some news reports (including sports scores that can only have been done at the time) at 21:50 MET, the crew then begin describing features visible at roughly the time AS10-34-5026 was taken, the describe the patterns over Europe, Africa and parts of Asia, picking out the clear areas over Portugal, western Spain, Italy & Greece compared with the cloudy areas of eastern Spain, Greece & Turkey. They also draw attention to the Arabian peninsula:

“Arabia appears to be clear. Israel, clear. Jordan, clear. Libya and Egypt are clear except for a cloud strip along the center of the country in Saudi Arabia that runs from Saudi Arabia across the Sinai Peninsula and through Egypt. Africa is clear in the desert to the north and cloudy farther south.”

The emboldened text is important because that faint line of cloud would not have been identifiable on a synoptic chart. As discussed in a previous section, they also talk about

“a real weird cloud formation ...it's a real peculiar looking cloud swirl. It comes off of what looks like Labrador and goes all the way across the ocean into Europe”

This one is obviously the system identified by the cyan arrows in figures 4.2.93 & 94 above.

This feature is mentioned again at 1 day 19 hours and 50 minutes as a

“a big long wide cloud swirl out into the Atlantic west of Spain”

after describing the clear conditions over southern Europe and Africa.

Atlantic weather conditions get more exciting for them as they move into 2 days into the mission, and by the time AS10-34-5034 was taken (see figure 4.2.16), and they describe the clouds as follows:

“picturesque cloud formations. Swirls, not definite low areas, but big large swirls.”

Meanwhile, in a description that illustrates image AS10-34-5054 (shown in figure 4.2.100) with key weather systems identified for comparison with synoptic charts) they very precisely identify the weather system over central and north-eastern USA:

“..go straight north [from the Gulf of Mexico] you see a little bit of V in the clouds and there’s one going off to the right and a little thin sliver going to the right is the one I've been mentioning all day that goes from Indiana on through the north-east part of the country; and then that bigger blob that forms the left-hand side of the V is over the north central United States and then right smack in center of the V is Lake Superior and Lake Michigan”

The magenta & yellow arrows pick out the 'V' they describe. Off Los Angeles the tell Capcom:

“you've got some clouds Just off the west coast of California that seem like they come Just short of the coastline.”

Capcom also describe what they can see, identifying the clouds running off the west coast of central & north America (cyan arrow):

“We have one section of clouds that looks like it is almost a circular area – a clear area and then clouds appear to come out of South and Central America - swing out into the Pacific and in the center of that it looks like the clear area which I am saying is the southern part of the United States, from Mexico along the Gulf Coast.”

Capcom are also looking at weather charts at this point and comparing them with what they can see on the TV images from Apollo:
“We’re looking at a weather map that was just brought in... The clouds are over Oklahoma and your description is excellent... There’s a low pressure up in the very far north turning from the Great Lakes north eastward into - and from - I guess it’s up around the - almost to Greenland, it looks like here; and from there, the low pressure weather system with a front comes down into the United States and touches the panhandle of Texas and then goes back on up into Canada again pointing towards Alaska. And there’s a band of clouds associated with that on this map.”

and also:

“It looks like this cloud system out in the Pacific is associated with another low-pressure system, that’s sitting probably north of Hawaii at about 40 degrees latitude. It’s located about 150 degrees west, so that’s probably what’s giving us the cloud pattern up off of Alaska.”

The synoptic chart for that day for north America, and the German charts for the northern Hemisphere are given below, and it is clear from these the cloud patterns over north America, south of Alaska, and the complex and picturesque patterns on the Atlantic are all reflected in the synoptic charts of the day (figure 4.2.101).

The orange arrow is the low pressure they pick out south of Alaska, & the red arrows pick out the ‘picturesque swirls’ in the Atlantic off Spain described earlier. Comparison of the charts from the 19th and 20th of May shows, just as the photographs do, that the weather systems do not exist in isolation but are part of an evolving pattern.
The astronauts do not describe much of the weather systems during their orbit around the moon, pointing out that

"we were kind of busy"

but we can fall back on the photographs taken during orbit and compare those with the available weather maps. Figure 4.2.102 contains all 4 Earthrises shown earlier in this analysis from May 23rd, and the US & north Atlantic synoptic charts and with the main weather systems identified. The main weather systems off the east coast of the USA, the chaotic system off Europe is still evident, as are the large swirls off Alaska.
Figure 4.2.102: Annotated amalgamation of (from left to right), AS10-35-5239, AS10-35-5230, AS10-35-5223 and AS10-27-3889, from 23/05/69 compared with US & north Atlantic synoptic charts from the same day.
By the 24th of May, the crew were on the way home and able to resume their regular weather reports, for example:

“You see that big circular weather belt that goes up across the United – up across the east coast of the United States, covers up Florida, and, it appears that some sort of point is in the Gulf of Mexico Between Florida and Texas. It's difficult to make out any landmasses and I doubt that you can see any, but with the monocular, I can see Cuba, Haiti, and the Indies, end most of South America which is cloud cover. The central United States appears to be open, as well as the western United States...There's a great big - a great big swirl right over the - right over the point south of Florida, goes up through the eastern states. ...and, also, another swirl; it looked like it was up north somewhere, possibly as far north as the Canadian border there, coming down to sort of join them together. Couple of very interesting weather patterns.”

They do describe the former system as covering over Florida, which it does not do in the satellite image, but given that they are still 184000 miles from Earth it is possible that they have misinterpreted what they were seeing. It's also possible that the ESSA image has failed to pick up lighter cloud cover, or that they are actually describing the much larger belt of cloud that arcs over the north Atlantic, a part of which does go close to southern Florida.

These weather patterns are still visible on the 25th, when better coverage of the USA is available in image AS10-27-3979, and again they mention a large system over the north, describing:

“That big low-pressure cloud so very distinctive over the Alaskan area, Aleutian area is very distinctive to us with the naked eye.”

This circular system is clearly visible on AS10-27-3970 (taken in the early hours of the morning of the 25th).

The Earth as seen on those two images are shown in figure 4.2.103, annotated along with the synoptic charts for the north Atlantic and north America. There is no useful angle on South Africa, so this chart will not be used.

Close inspection of north America, the main area that is visible on both images, shows that the weather systems do match up, confirming that they are from the same date.

As with the other synoptic charts, there is no difficulty identifying the same frontal systems on the Apollo images.

In summary: Apollo 10 images taken by the astronauts can be precisely pinpointed in time with the use of satellite images, and the weather systems on those Apollo photographs match with the satellite data. Images produced by TV broadcasts and recorded on 16mm video also match, giving further support to the already considerable body of evidence that Apollo 10 went to the moon, orbited around it, rehearsed the landing that would take place by Apollo 11 and returned home.
Figure 4.2.103: Annotated amalgamation of (from left to right), AS10-27-3970, AS10-27-3976 from 25/05/69 compared with US & north Atlantic synoptic charts from the same day.
4.3 Apollo 11

After the full dress rehearsal of Apollo 10 came the main event. Given the dramatic images sent by Apollo 10, it could be argued that this mission was less visually impressive. The crew spent most of the time on the lunar surface inside the LM, and did not venture far from it when they did finally emerge. Most of the photographs taken are of the lunar surface either from the ground or from orbit. It is, nonetheless, the most historic of the Apollo missions, for obvious reasons.

The mission itself commenced with the launch on July 16th 1969. The crew entered lunar orbit on the 19th, after which the Aldrin & Armstrong entered the LM and departed for the lunar surface on the 20th, landing at 20:17 GMT. The crew set foot on the moon at 02:55 on the 21st, and left it for the safety of the LM at 05:11. The lift off back to the CSM was at 17:54, and the two craft were reunited at 21:35. TEI was at 02:55 on the 22nd, and the crew finally splashed down on the 24th.

During the mission they used 9 magazines to take 1408 images and made 7 TV broadcasts (not including the transmission from the moon itself). Several weather satellites are available from the time of the mission: NIMBUS, ESSA 8 & 9, ATS-1 and ATS-3.

The NIMBUS data can be found here. This volume shows visible images from the Image Dissector sensor, and day & night infra-red images. The best quality NIMBUS image from any given day will be used (though none of the NIMBUS images are particularly clear). The Australian Bureau of Meteorology kindly supplied a photomontage of 3 NIMBUS frames covering Australia. High resolution and medium resolution infra-red (HRIR and MRIR) images are also available from scanned negatives found here. These will be used, wherever possible, instead of the poor quality images originally used in this report.

In a recent find this website revealed the release of NIMBUS 3 Image Dissector Camera data on the National Snow and Ice Data Center website. The site allowed ftp access to both large size TIF images of better quality that those linked to above, as well as the individual ‘tiles’ that make up the image. Where possible, these will be given in the text in addition to the existing images. They have continued this work by looking at ESSA imagery, and kindly supplied some images relating to Apollo 11, which will be added for comparison. I have saved the documents here.

ESSA 9 data can be found here, hosted by the HATHI trust. I’ve compiled the relevant images into a single document here.

The ATS images have been found in from a variety of sources. A search for ATS-3 images found this one for July 17th on Photobucket and a partial image for July 18th can be found in a research document here. The University of Wisconsin generously sent 2 images from July 20th and 21st, and an ATS-3 image for July 22nd can be found in the Monthly Weather Review Vol 100 No 10. An ATS-1 (and ESSA 8) image for July 22nd can be found here. A more complete ATS-3 source is available here, but is generally of poorer quality. The other, better quality, ATS images will be used where possible.

An unnamed satellite contributes a further picture for July 21st in a document examining the first 5 years of the environmental satellite programmes in this TIROS report. An ESSA 8 image of tropical storm Claudia was uncovered in the Eastern Pacific 1969 Hurricane season report, as well as good quality images of Hurricane Bernice from July 16th. The Mariner's Weather Log Vol 13 provides a better quality ESSA 9 image of North America from July 22nd. This MSc thesis BOMEX study provides more examination of ESSA 9 images specifically in the Caribbean from almost all the Apollo mission, and larger scale images from the same study can be found here.
This 1973 report contains strips of ATS-3 images, one set of which covers July 18th, and is therefore included in the next section. We have a few more ATS images here that can add more details in subsequent sections. These documents are mentioned not just as potential sources for discussion but also for the indication they provide that the data from the satellites were not hidden away – they were available for use by anyone who cared to look at them. Another example is this publication, which contains a number of NIMBUS images taken during the mission. I'll also be making use of the digitally recovered ESSA and NIMBUS data discussed in Chapter 2 and making 3D reconstructions where possible.

The Apollo images used will be the high quality versions found at the Apollo Image Atlas and the Apollo Lunar Surface Journal ALSJ. A newer resource is the Project Apollo Flickr Archive and these may also get used where appropriate. Some images are not displayed on the ALSJ, but their links can be deduced from those that are. Despite the obvious and understandable focus on the lunar surface, the crew did manage to capture a number of significant images of Earth both on the way to, on the surface of, and back from, the Moon.

Before proceeding to the analysis, there is an interesting aside concerning the satellite data covering the mission. That satellite data was available for the crews has already been discussed, and one example of that comes from images of the crew’s final breakfast before departure, during which flight director Deke Slayton gives them a final briefing. Video and still images exist of that breakfast, and the image in figure 4.3.1 shows that part of the briefing covered the weather at Houston.

![Figure 4.3.1: Deke Slayton shares breakfast with the Apollo 11 crew. Source](Image.png)

The document on the table is clearly a black & white satellite image (confirmed by colour videos), and available images shows that it covers North America and the North Atlantic from the 15th of July. Figure
4.3.2 shows the satellite image print-out on the table compared with the ESSA 9 image from that day. The previous day’s image does not show the same cloud patterns, and the data from the 16th would not have been available. It is a useful indicator firstly that the data they had was not as up to date as conspiracy theorists would like to pretend, and it is also not of the same quality as the Apollo images, not a whole Earth image, and not in colour.

![Figure 4.3.2: ESSA 9 image from 15/07/69 compared with satellite image used in astronaut briefing on 16/07/69](image)

After breakfast, the Moon!
4.3.1a Mission images – The outward journey

The weather system visible in the North Atlantic on the Apollo 11 breakfast table also makes an appearance in video footage recorded on board the CSM of the LM extraction manoeuvre. This video is widely available, for example here: Apollo 11: for all mankind. The opening shot of the video is shown in figure 4.3.3.

![Figure 4.3.3: Screenshot taken from opening of Apollo 11 LM docking footage, 16/07/69.](image)

If the weather system seen dominating this view of Earth looks familiar, it should. It is the same one shown in figure 4.3.2 over the north Atlantic. What becomes clear on closer inspection is that it is not the same as the satellite photograph – there are subtle differences. The satellite images from July 15th and 16th are compared with this screenshot in figure 4.3.4.

The most obvious difference is the area of cloud developed over north America (green arrow) that isn’t shown in the one being examined over breakfast. That part of the satellite image is obscured on the breakfast table, but the rest of the image confirms that the date is correct. A more subtle change is the small pair of narrow clouds forming a kind of ‘=’ sign (blue arrow) that isn’t visible in the breakfast image but can be seen in the Apollo screenshot and the ESSA image from the 16th. The cloud bank to the north of the main weather feature (red arrow) is much closer and larger on the launch day image, and the lower section of north-south trending cloud (magenta arrow) is wider on launch day. The ESSA image on the 16th would not have been collected until several hours after launch. The docking sequence itself was commenced at 16:37 GMT on the 16th and they are roughly 7500 miles from Earth. At 04:52 MET, Armstrong finds time to pass on what they could see during the docking sequence:

“the entire northern part of the lighted hemisphere visible including North America, the North Atlantic and Europe and Northern Africa... the weather was good all - just about everywhere. There was one cyclonic depression in Northern Canada, in the Athabaska probably east of Athabaska area. Greenland was clear, and it appeared to be we were seeing just the icecap in Greenland. All North Atlantic was pretty good; and Europe and Northern Africa seemed to be clear. Most of the United States was clear. There was a low - looked like a front stretching from the centre of the country up across north of the Great Lakes and into Newfoundland”

Although much of his description covers areas not shown by the video, the satellite record matches his description – the land masses are by and large cloud free.
Figure 4.3.4: ESSA images from the 15th (top left) and 16th (top right) of July 1969 compared with screenshot from the docking sequence video. Below (left and centre) this are two newly restored NIMBUS-3 IDCS frames from the 16th. The first 3 numbers in the frame represent the calendar year day of operation (197 is July 16th), and the remainder is the time in hh:mm:ss. On the right is a NIMBUS-3 HRIR negative from orbit 1250.
5 hours after lift off, the CSM had undocked from the SIV-B, removed the LM from it and discarded the empty Saturn. Having already taken a few low Earth orbit images before the undocking (including ones that confirm Armstrong's weather description) the crew now took photographs of the fast receding Earth. They are on their way to the Moon.

The first full disk image of the Earth in these photographs is AS11-36-5330 (AIA), shown below as figure 4.3.5.

![Figure 4.3.5: AS11-36-5330](image)

Stellarium suggests a time of 23:00 for this image, just an hour before their first TV recording (broadcast to Goldstone in California and then relayed to Houston at 01:30 on the 17th), and well on the way to the moon from Earth.

The annotated ESSA & NIMBUS satellite data from the 16th are displayed, along with a zoomed & cropped image of Earth from AS11-36-5330, in figure 4.3.6a. The NIMBUS infra-red image has been used as the American landmass is more easily identifiable, and will continue to be the preferred source unless the better quality new image is also available. In this case we also have the newly restored NIMBUS data as well. The Antarctic is, for obvious reasons, not visible. There are no suitable images matching the ATS-3's position for the 16th.

The ESSA data suggest that the orbit covering the west coast of the USA (track 4, orbit 1755) was commenced at 20:07 on the 16th, with the areas west of this covered in the early hours of the 17th. The terminator was covered at 16:07 (track 2, orbit 1753) NIMBUS' orbital data for the west coast suggest that the same west coast orbit image (number 1254) was taken between 19:34 & 20:23 on the 16th. The IDCS view is timestamped at 18:12 over Central America. The final MRIR orbit covering the Apollo view was commenced at 23:30.

One hour after the Apollo image was taken, the crew began transmitting TV signals to Goldstone in California. These TV images were sent to Houston one hour later - it isn’t clear when they were broadcast on TV. Press wire photographs (see figure 4.3.11b) suggest a 2 hour delay in sending the signal to Houston. The PAO commentary suggest 90 minutes to 2 hours.
Figure 4.3.6: AS11-36-5330 compared with ESSA 9 & NIMBUS 3 IDCS (bottom left) and HRIR (bottom right) images. Right is a Stellarium estimate of time at terminator.
Figure 4.3.6 continued: AS11-36-5330 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (right) data
Certainly Aldrin described accurately the view of Baja California at 23:41 on the 16th:

"Well, it's got some clouds up and down it, and there's a pretty good circulation system a couple of hundred miles off the west coast of California."

and Armstrong’s description of the view was transmitted live to Houston at 00:13 GMT on the 17th.

"We’re seeing the center of the Earth as viewed from the spacecraft in the eastern Pacific Ocean. We have not been able to visually pick up the Hawaiian Island chain, but we can clearly see the western coast of North America, the United States, the San Joaquin Valley, the High Sierras, Baja California, and Mexico down as far as Acapulco, and the Yucatan Peninsula; and you can see on through Central America to the northern coast of South America, Venezuela, and Colombia. I’m not sure you’ll be able to see all that on your screens down there”

Close examination of the video stills and also the Apollo photograph shows that this is exactly what they should have been seeing.

The broadcast footage is easily found on Youtube, particularly if you search for Armstrong's view of earth from Apollo 11. Although the best quality source for download is archive.org. Figure 4.3.7 is a screenshot of a camera test from the first broadcast, together with a Stellarium image showing the terminator line. The screenshot has had its resolution increased, the levels altered to provide more contrast and sharpened to improve the level of detail visible.

The comparison of the TV screenshot and the Apollo still image is important for two reasons. Firstly, the rotation of the Earth is clear in the hour between taking the image and the broadcast, showing that they were not taken at the same time. In fact, it’s even possible to detect rotation of the Earth from the start and end of the sequence, even if you only use the 15 or so minutes that they are at maximum (figure 4.3.7b).

The best place to look is on the terminator, where it is clear that cloud masses have moved beyond during the broadcast.
The second, and by far the most important reason, relates to what is in these two images: Hurricane Bernice.

On July 8th 1969 a tropical depression began forming in the Pacific Ocean. This depression strengthened to become a tropical storm, named Bernice, whose strength reached hurricane force on a number of occasions in its lifetime. By July 16th, Bernice was fading fast, and was reclassified again as a tropical depression off the coast of Guatemala.

Bernice’s lifespan was widely reported in meteorological journals, and is referred to in the Eastern Pacific Hurricane season report, and in the Mariner’s log cited earlier. References to Bernice are widely available elsewhere on the internet. This US navy document: *Summary of Tropical Cyclones 1969* shows that 35 warnings were issued to shipping, and gives detailed information of the hurricane’s track. Figure 4.3.8 shows the storm’s development as recorded in the hurricane season report. Figure 4.3.9 clearly identifies Bernice’s location on the Apollo image & TV broadcast, indicated by the blue arrow in figures 4.3.6-7.
Figure 4.3.9: Close up of Hurricane Bernice from AS11-36-5330, with inset from ESSA 9 (left) and TV broadcast (right). TV screenshot has increased contrast to improve detail. Below this are views from newly restored NIMBUS-3 data. Note the time gap between images. At the very bottom left is the HRIR view, bottom right is the Temperature-Humidity infrared view 12 hours later where only the central core of the storm persists.
Hurricane Bernice is clearly identifiable on both the Apollo derived images, and suggests that the only place the image & TV footage could have been obtained is from space. The filenames from the original sources reveal that the 6 restored NIMBUS images took a total of three and a half hours to photograph. The image centring on Bernice was done at 19:59 GMT.

This isn’t the first time they’d encountered the storm. During the initial Earth Parking Orbit phase of the mission, where equipment was checked out prior to firing up the engines to head to the moon, the crew passed over the Baja Peninsula, and on their way snapped a few images of the weather below. At 84 minutes in to the mission we have:

001:24:51 Collins (onboard): Trees and a forest down there. It looks like trees and a forest or something. Looks like snow and trees. Fantastic. I have no conception of where we're pointed or which way we are or a crapping thing, but it's a beautiful low pressure cell out here.

001:25:15 Collins (onboard): Beautiful low pressure.

Followed by

001:25:16 Aldrin (onboard): Must be past Hawaii by now. 01:28 is AOS.

Which puts them pretty much in exactly the right place to view Hurricane Bernice at an oblique angle on the horizon. Figure 4.4.9b shows the Earth orbit track of Apollo 11.

Collins took several images, and while the viewing angle makes it difficult to interpret what we’re looking at, there is enough information to verify that we are looking at Bernice from a very different angle, see figure 4.3.9c.

The spiral whorl of cloud at the heart of Bernice’s low pressure system is easy to make out, as are the peripheral bands of clouds. We therefore have a spacecraft in the right place and a photograph taken at the right time of a tropical weather system in its path. The 3D reconstruction helps to confirm the interpretation.

The storm was also captured just after extracting the LM from its S-IVB housing in a series of Earth images. Figure 4.3.9d shows one of them, and Bernice can be seen on the Western limb.

While we don’t have satellite confirmation of the phenomenon, it seems a shame to pass up on viewing some beautiful island wakes (also known as von Karman vortex streets) photographed on the next orbit in AS11-36-5308 (figure 4.3.9e).
The NIMBUS image isn’t clear enough to show whether the island wakes persisted long enough for it to photograph them, but they are a well known feature now that we have better quality observation platforms and there is certainly a gap in the clouds south of the island that looks much more like AS11-36-5326 taken at about 18:00 a couple of hours later. For good examples around Guadalupe see here, here and here.

Figure 4.3.9c: AS11-36-5298 (top left), restored NIMBUS-3 image (bottom left) and 3D reconstruction using NIMBUS-3 data (above).

Figure 4.3.9d: AS11-36-5326 showing Hurricane Bernice off the coast of Baja California
It’s worth pointing out a couple of things here. Firstly, the viewing angle is obviously different to the one analysed earlier, thanks to it having been taken about 6 hours earlier. Secondly, careful examination of the way the storm edge makes landfall shows that there is quite a difference in the shape of the cloud. Finally, the cloud patterns over on the eastern side are those recorded in the 16mm footage just after separation of the CSM from the S-IVB.

Back to Apollo 11 and Bernice, the irony here is that one of the most often quoted pieces of 'evidence' aimed at Apollo 11 (Bart Sibrel’s 'A funny thing happened on the way to the moon' - Wikipedia entry) claims two things. Firstly, the in space footage was filmed in low Earth orbit. Secondly, the image of Earth used in the broadcast was a fake. An image of Earth obtained from somewhere, but not actually filmed by the Apollo 11 crew.

The first claim is obviously ridiculous, as low Earth orbit images can not show the entire disk. Satellites aiming for full disk coverage go for high Earth orbit at 22000 miles out.

The second claim shoots itself squarely and firmly in the foot by using video clips from the broadcast with Hurricane Bernice visible in them. Not just any footage of Hurricane Bernice, but specifically footage featuring Hurricane Bernice in a configuration that can only have been obtained on July 16th from space. It could not have been obtained anywhere else. Sibrel’s own video contains the evidence that proves him completely wrong.

As with Apollos 8 and 10, we have supporting evidence from the media of the day to prove that the image of Earth shown on the screen is contemporaneous. Figure 4.3.10a-d below shows the front page of the august journal the Coshocton Tribune (Coshocton is a small city in Ohio, Armstrong’s home state), as well as the front page of ‘The Scranton Times’ (a newspaper for a city in Pennsylvania) on sale on eBay and online here. Also included are lower resolution copies of the front page from July 17th from other US newspapers, all of which include a still from the TV broadcast.
Figure 4.3.10a: Front page of Coshocton Tribune 17/07/69 (bottom left), The Scranton Times 17/07/69 (top), Palm Beach Post (centre right), partial front page of the Democrat Chronicle, printed in New York and labelled Thursday morning (bottom right)
Figure 4.3.10b: Assorted newspaper front pages from July 17th featuring hurricane Bernice
Figure 4.3.10c: Daily, Monroe Morning World and Denver Post July 17th
Figure 4.3.10d: The ‘Lancaster New Era. The Mexican “El Universal” article is dated the 18th and is linked to a story about the Soviet Luna 15 probe
On the Coshocton Tribune page, available here, we are shown what is obviously a kinescope image of the Earth from the TV broadcast, and the newspaper is clearly dated the 17th of July. It also says this as the caption:

"In an unscheduled telecast from space, Apollo 11 broadcast this view of the Earth back to earth-bound viewers Wednesday night."

As Coshocton’s local time is 5 hours behind GMT, the transmission to Earth of this view was at 19:00 local time, with actual transmission on the evening news schedules sometime after this - still in plenty of time for it to get in the next day’s newspaper. CBS news did have a broadcast at around 20:30, which would match with the availability of the footage (source). The book “The invasion of the moon 1969”, published in 1969 to capitalise on interest in the mission, states that this footage was released two hours after transmission, and also records the transcript quoted above. Claims by some hoaxers that this footage was a secret are clearly false. My own copy is dated by the original owners just one month after the mission, and contains many photographs and 16mm stills from it.
Even the Coshocton Tribune describes the broadcast and what was said:

"Before retiring, Armstrong, Aldrin and Collins beamed an unscheduled 10 1/2 minutes of television back to Earth. The pictures, taken nearly 60000 miles deep in space, showed a blue, green and white swirled Earth receding in the blackness of space behind the spacecraft. Armstrong said he could see the West Coast of North America, all of the United States and the northern top of South America from his 13 by 13 window"

Likewise the Evening News from New Jersey says this:

"With the Apollo ticking along smoothly, the crew presented an unscheduled 15-minute television travelogue featuring the Earth"

Before going on to quote the broadcast audio verbatim. The Palm Beach post confirms that the broadcast was recorded at Goldstone then relayed to Houston. The Daily News also has timings, saying that:

"While the astronauts rested, mission control treated the world to an unscheduled color TV show of the Earth as seen from some 60,000 miles in space. It had been taped by the Goldstone tracking station in California and was replayed at 9:45 pm New York time."

which is later than CBS’s news broadcast but still plenty of time to get into Thursday’s papers. All of the newspapers reproduced here are dated the 17th, and all reference what was said in the broadcast, words that can be verified in the mission transcripts.

Figure 4.3.11a shows the TV screenshot analysed earlier in comparison with the image reproduced on the front page of the Tribune the following day. While our image is much clearer, there are still obviously identifiable features on the newspaper’s rendering of the scene. On the right is a photograph actually taken of the TV during the broadcast, part of a set of slides sold on eBay. Figure 4.3.11b shows my own copy of a wire photograph, dated July 16th, together with other examples available on eBay.

Figure 4.3.11a: Comparison of TV broadcast screenshot (left), image from Coshocton Tribune front page (centre) and photograph of TV screen (right - Part of a set sold on ebay here (link may die!).

Figure 4.3.11b: Press wire photographs taken from Apollo 11 TV broadcasts. Images found on eBay and are copyrighted by Argenta images (far left) and Historical Images (far right). My own personal copy is centre left, and my own copy from a souvenir edition of the Evening Standard dated 25/7/69 is centre right.
The ITCZ clouds running east – west, the north-south trending cloud off Asia in the west, and the distinctive curl of Hurricane Bernice are all easily visible and confirm we are looking at the same scene in all of the images.

This website Apollo TV Analysis contains a much more thorough analysis of Sibrel’s nonsense claims than will be covered here, and is the source of the screenshot images, as they are generally of better quality than those available elsewhere. What would be useful is to know exactly when the photographs examined above were first broadcast on TV, as this would allow us to definitely state that they could not have had a satellite image of the view with which to work. My suggestion is that it would have been highly unlikely, if not impossible. We can also confirm with certainty that contrary to Sibrel’s claims, the images were all public thanks to the book 10:56:20 Pm EDT 7/20/69: The Historic Conquest of the Moon As Reported to the American People by CBS News over the CBS Television Network, a copy of which I own and which was published in 1970.

The book confirms that:

"On Apollo 11, the first "scheduled" transmission was in fact the third sent to Earth by Armstrong and his crew"

As part of a pictorial essay comprising photographs of the TV screen taken during the mission, it shows these images from the evening broadcast on Thursday the 17th, figure 4.3.11c (from my own copy) that were edited in from the Wednesday night transmissions. To emphasize further the non-secret nature of the photographs, the Apollo image of Bernice was also used as the basis of the 1981 book ‘Trap for Perseus’ (see here).

In a massive display of irony, self-styled Apollo hoax guru Jarrah White managed to provide even more supporting evidence in his ‘Moonfaker: Exhibit B part 1’ by providing a photo showing Bernice in an Australian newspaper dated the 18th (see figure 4.3.11d).

Jarrah gets all confused by the Julian date used in the image, which clearly identifies it as being taken on day 198, or July 17th. It even gives a time stamp of 01:15 - 01:30 am. He confirms that the newspaper would have gone to print at around 9pm on the 17th, which is 8 hours ahead of GMT, meaning that it had 12 hours to get hold of the images.
In a subsequent video he tries to explain away the confusion by not knowing if January first was day 0 or not. Since when was there a January the 0th? If he’d only looked at the news broadcasts instead of relying on compilation reels sent out after the missions he might not have shot himself in the foot so badly. On the other hand, he also wouldn’t have confirmed that the TV image was taken on the day it was always claimed to have been taken and appeared in an Australian newspaper, not kept a secret.

Let’s move on. The first whole disk image examined previously is one of a long series of photographs taken of the Pacific, most of which show an identical view to AS11-36-5330. A second batch of seven very similar images captures Bernice as it moves towards the terminator, and a final batch of three photographs show Bernice on the terminator.

A sample from the batch of 7 is shown in figure 4.3.12 to illustrate the Earth's rotation as Apollo 11 moves away from it, while the final image in the sequence, AS11-36-5351, is shown in full in figure 4.3.13, before it is analysed in figure 4.3.14. It is worth looking closely at the terminator east of Bernice in AS11-36-5343, as the sunset shadows cast by the clouds are quite stunning.

Figure 4.3.12: AS11-36-5343 (left) with Earth zoomed and cropped from it (right). High quality source: AIA

Figure 4.3.13: AS11-36-5351. High quality link source: AIA
Figure 4.3.14: Main image shows ESSA-9 (left) and NIMBUS-3 (right) images compared with AS11-36-5351 and Stellarium estimate of time at terminator. Image below is newly restored NIMBUS-3 IDCS image.
Figure 4.3.14 continued: AS11-36-5351 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (right) data
As with AS11-36-5343, it is worth zooming in on the clouds around the terminator to see the relief cast by the shadows on the clouds. The central portion of Hurricane Bernice is much more prominent, and the clouds to the south show lengthening shadows entirely consistent with early evening conditions. Although new weather systems have been brought into view by the Earth's rotation (magenta and purple arrows), and Australia is now clearly visible, all the other cloud patterns are identified using the same coloured arrows as the previous analysis.

The nearest ESSA track for the terminator region is still on the image dated the 16th, and was commenced at 20:07 (track 4, orbit 1755), compared with Stellarium's estimate of the time at terminator of around 02:30 on the 17th. NIMBUS' image is actually a composite of the final passes on the infra-red daytime image dated the 16th and the first infra-red daytime ones dated the 17th, with the orbit nearest the terminator being pass 1253, which commenced at 17:46 on the 16th. The newly restored mosaic is just from the 16th. The final part of the Pacific covered by NIMBUS would not have been covered until 04:30 on the 17th, 2 hours after the Apollo image was taken. Bernice was imaged at 19:59 by the IDCS NIMBUS camera.

The image after 36-5351 was evidently taken some time later, as we now have Africa clearly in view. AS11-36-5352 is shown below in figure 4.3.15, and analysed in figure 4.3.16a & b.

Figure 4.3.15: AS11-36-5352 High quality source here AIA

Figure 4.3.16a is, as always where Africa is in view, complicated by the dividing line between two days' ESSA images. West of a line stretching from around Madagascar up through the Red Sea and Eastern Europe, the ESSA mosaic dated the 17th is the most appropriate and the northern and southern hemisphere mosaics are the upper two in the top left of the figure. East of that line, the most appropriate mosaic is the one dated the 16th, as the tracks from that will have completed on the 17th, and portions of these are shown centre-left on the figure.

Comparison of the weather patterns identified by the magenta and blue arrows shows the difference between the two very nicely. On the Apollo image (which we know must have been taken on the 17th, and which Stellarium puts at 13:15), the clouds extending eastwards from just north of Madagascar are a wide band of diffuse thin cloud. On the ESSA image dated the 17th, this same band is a more cohesive thin band, compared with the one on the mosaic dated the 16th, which matches that of Apollo. The magenta arrow points to a cloud mass on Apollo's image that extends much further towards Arabia than can be seen in the ESSA image dated the 17th.

On the other side of the line the opposite is true. ESSA's relevant track for the terminator is number 10, or orbit 1761, which on the image dated the 16th was commenced at 08:00 on the 17th. ATS' image is labelled as being taken on at 14:55 on the 17th, while the NIMBUS orbit nearest the terminator (pass 1259) was commenced at 05:24 on the 17th.
Figure 4.3.16a: Main image shows ESSA-9 images dated 16/07/69 (top left upper & lower) and 17/07/69 (middle left), ATS-3 (bottom left) and NIMBUS 3 HRIR images (bottom right) compared with AS11-36-5352 and Stellarium estimate of time at terminator. Image below shows newly restored NIMBUS-3 IDCS mosaic.
A comparison of the terminator in AS11-36-5343 shows that it is slightly later than the TV screenshot, suggesting a time of around 01:00 on the 17th.

Figure 4.3.16a continued: AS11-36-5352 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (right) data
On the other side of the globe we have a good view of Northern Europe (figure 4.3.16b). The correspondence is remarkable, and at the time of the photograph no-one in the US would have had a copy of the satellite record - NIMBUS imaged the UK shortly after 10:00. The flat-lined cloud band bordering Northern Spain is reproduced perfectly, and is something that no-one could have predicted in advance.

This [youtube video](https://www.youtube.com/watch?v=example_video_id) tries to claim that the image is faked because it was taken on the 16th 40 minutes after launch, but his problem is that he started with the conclusion that it was faked and tried to force the data to fit that conclusion. The data speaks for itself - it was on the 17th. He also gets the location of the Arctic and Antarctic completely wrong and doesn’t check the images before this one (very convenient that) to show that it is definitely not taken in Earth orbit, as well as claiming that there are never any images of “the western hemisphere” which is self-evidently false as anyone who has bothered to look can see.

Interestingly, at about that time, the mission transcript records Capcom telling the crew about the Soviet craft Luna 15, bound for a lunar landing and [recorded by Jodrell Bank](https://www.jodrellbank.ac.uk), but from which signals had been lost. A short while after the previous image was taken we have an image that allows a greater contribution from the ATS-3 image. AS11-36-5357, which is shown below in figure 4.3.17, and analysed in figure 4.3.18.
Figure 4.3.18: Main image shows ESSA-9 (left), ATS-3 (top right) and NIMBUS-3 (bottom right) images compared with AS11-36-5357 and Stellarium estimate of time at terminator.
Figure 4.3.18 continued: AS11-36-5357 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (right) data
Figure 4.3.18 (continued): NIMBUS-3 HRIR view
The red and green arrows point to the same cloud patterns as shown in figure 4.3.14. The ATS time has already been given as 14:55. The NIMBUS orbit nearest the terminator is number 1261, which commenced at 08:06 on the 17th. The Mediterranean area is actually timestamped for the IDCS image at 10:22 ESSA’s equivalent orbit is number 1763 (track 12), which commenced at 12:00 on the 17th.

Stellarium’s estimate puts the time at 17:30, which is approximately 28 hours into the mission. At 27h18m in the mission transcript, Buzz Aldrin describes:

“an anticyclone going in the southern hemisphere south-east of Brazil, and some - Well, the diameter of it must be over 2000 miles across.”

and then tells them:

“You all are just beginning to cone over the limb now. I can see parts of Central America, and it looks to be fairly clear there. The islands in the Caribbean are beginning to come in and rather a few streaming lines of clouds. Looks like there is a system up to the - well, off of Greenland that has some large cloud streamers extending back down to the south-west. The east coast of the U.S. is just coming into view now, and it doesn't look too bad that I can see right now.”

The magenta arrow is pointing to the storm system of Brazil, and the 'streamers' are on the system identified by the blue arrow. We therefore have an Apollo image showing perfectly the weather systems visible on satellite images, but the astronauts are able to describe the weather conditions to the ground.

The next change of scenery in the picture sequence comes just before some photographs of the LM docking target. AS11-36-5362 is shown below in figure 4.3.19, and analysed in figure 4.3.20.
Figure 4.3.20: Main image shows ESSA-9 (top right upper and lower), ATS-3 (bottom right), NIMBUS-3 (bottom left) images compared with AS11-36-5262 and Stellarium estimate of time at terminator.
Figure 4.3.20 continued: AS11-36-5262 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (right) data
Figure 4.3.20 (continued): NIMBUS-3 HRIR
In the preceding figure, the blue, cyan and magenta arrows have been used to identify the same weather systems as shown in figure 4.3.18. The red arrow identifies the remains of Hurricane Bernice, just visible on the western limb.

Now that more of the USA is visible, Buzz again communicates some weather descriptions to the ground, telling Capcom:

“we’re just looking at you out our window here. Looks like there’s a circulation of clouds that just moved east of Houston over the Gulf and Florida area.”

and this system has been identified with a green arrow, so once again we have an astronaut accurately describing the view that he could only have had from space.

The ATS image time is still the same, but ESSA’s terminator orbit as moved on to number 1766 (track 2), and commenced at 17:06. The NIMBUS equivalent was commenced at 13:28 (pass 1264, with the blue arrowed storm imaged at 13:57), and both these timings can be compared with the Stellarium estimate of 18:30.

We now enter an interesting phase of the mission, because there are a couple of TV broadcasts made, with (as will we shall see shortly) contemporaneous photographs. The first TV broadcast took place as a camera test at 30:28 MET, or 20:00 GMT on the 17th. A screenshot from that broadcast is shown below in figure 4.3.21, and analysed in figure 4.3.22.

Figure 4.3.21: Screenshot from a camera test broadcast. Original source here: Apollo 11 TV Broadcasts
Figure 4.3.22: Main image shows ESSA-9 (left) images compared with screenshot of Apollo 11 camera test, and Stellarium estimate of time at terminator. Image below left shows newly restored IDSC NIMBUS-3 mosaic, below right the HRIR images.
Figure 4.3.22 continued: Apollo 11 TV still and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS (right) data
The yellow, green, red and cyan arrows point to the same patterns as shown in figure 4.3.20. The resolution of the image has been increased and the result sharpened to improve clarity.

The camera test seems to have been unscheduled. The Goldstone receiving station in California reported to Houston that they were receiving a signal, who ask the crew about it, and to which they reply:

“Roger, we're just testing the equipment up here”

The first images from the transmission are of the CSM interior, and the crew ask Goldstone to see if they can see any of the readings on the equipment. Half an hour later, they tell them that:

“Goldstone should be getting about the best picture of the Earth we can give them right now”

which puts the time of an Earth image at about 20:30. The analysis presented on the Apollo 11 TV broadcast site mentioned earlier gives the time as the start of the broadcast, but if that were the case all of South America would be visible.

What should be obvious is that Stellarium's terminator from that time shows that the Earth is in the configuration it should be for that time, and the weather systems visible in this broadcast match exactly what can be seen on the satellite images. The long band of cloud identified by the yellow arrow is particularly prominent.

The features in the image can be seen in a photograph that was evidently taken at the same time. AS11-36-5366 occurs immediately after images of the LM docking target and is shown below in figure 4.3.23, it is analysed in figure 4.3.24.

Figure 4.3.23: AS11-36-5366. High quality source here: AIA
Figure 4.3.24: Main image shows ESSA-9 (left) images compared with AS11-36-5366. Image below shows newly restored NIMBUS-3 IDSC mosaic (left) and HRIR orbits (right) and Stellarium estimate of time at terminator.
It should (again!) be obvious that the features in the Apollo photograph are not just a match for the satellite weather patterns but also the TV image. The position of the terminator shows that the two were taken at almost exactly the same time (hence no 3D model). Although the ATS-3 image has not been included this time, it is still possible to see some weather features that are visible on it.

ESSA’s terminator orbit this time is nearer to track 3 than track 2 this time, which puts the start of that orbit (number 1767) at 19:01. Likewise the NIMBUS pass is one further along, and the start of pass number 1265, which commenced at 15:15. I haven’t bothered repeating the use of the 3D models for this image, all you need to do is scroll up and you can see the match is exact.

The next TV broadcast was a live transmission (see here for that broadcast, which some people even recorded on 8mm), and this was started at 33:59 MET (23:31 GMT). There is another image showing a slightly different view before that broadcast, AS11-36-5366, but while much of south America has gone into darkness there is little extra to be gained by analysing it in depth. It is shown below in figure 4.3.25 for completeness. The next point for analysis is the live TV broadcast, a screenshot from which is shown in figure 4.3.26a, and analysed in figure 4.3.27. Figure 4.3.26b shows the same view as seen in mission control.

Figure 4.3.25: AS11-36-5366 original (left) and zoomed & cropped Earth. Source: AIA

Figure 4.3.26a: Screenshot from live TV broadcast. Original Source: Apollo 11 TV Broadcast
Figure 4.3.26b: The broadcast in Mission Control. Source
Figure 4.3.27: Main image shows ESSA-9 (top left) and NIMBUS-3 IDSC (bottom left) and HRIR (bottom right) images compared with live TV broadcast screenshot and Stellarium depiction of terminator at time of broadcast. Image below shows newly restored NIMBUS-3 mosaic.
Figure 4.3.27 continued: Apollo 11 TV broadcast still and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (right) data
We are again faced with an image from Apollo that shows exactly what is visible in satellite images, and this time it is an image that was shown to millions in a live broadcast. This broadcast took place at 23:31, which is where Stellarium’s terminator has been set, and this also shows that the view is showing what it should show. ESSA’s nearest terminator pass is that of orbit 1767 (track 3), which commenced at 19:01, while NIMBUS-3’s orbit for the terminator region is pass 1265, which commenced at 15:15. The final pass covering what we see was commence at 22:26.

The clouds shown by the blue arrow was imaged at 17:28. We have more confirmations of the time from what the crew describe to the TV audience at the very start of the broadcast:

“You’re seeing Earth, as we see it, out our left-hand window, just a little more than a half Earth. We’re looking at the eastern Pacific Ocean, and the north half of the top half of the screen, we can see North America, Alaska, United States, Canada, Mexico, and Central America. South America becomes invisible just off beyond the terminator or inside the shadow. We can see the oceans with a definite blue cast, see white bands of major cloud formations across the Earth, and can see coastlines, pick out the western U.S. San Joaquin Valley, the Sierra mountain range, the peninsula of Baja California, and we can see some cloud formations over south-eastern U.S. There’s one definite mild storm south-west of Alaska, looks like about 500 to 1000 miles, and another very minor storm showing the south end of the screen near the - or a long ways off of the equator, probably 45 degrees or more south latitude”

You might want to check figure 4.3.11c for a photograph taken of a TV screen during this broadcast, published in a book in 1970, this 1969 post-landing special, and the 1989 film ‘For All mankind’, which shows clips of it, again proving it was not hidden away and secret.

As usual, what they describe is what they should be able to see. The storm to the south west of Alaska is identified by the green arrow. The cloud across the south-east USA is identified by the blue arrow, but it is difficult to make out from the screenshot the storm system in the southern hemisphere. This is best viewed by looking at a photograph taken slightly earlier, which shows the storm more clearly. AS11-36-5373 is shown below in figure 4.3.28, and given the same analytical treatment in figure 4.3.29.

![Figure 4.3.28: AS11-36-5373. High quality source: AIA](image-url)
Figure 4.3.29: Main image shows ESSA-9 (left) and NIMBUS-3 ISDC (bottom left) and HRIR (bottom right) images compared with AS11-36-5373 and Stellarium estimate of time at terminator.
Figure 4.3.29 continued: AS11-36-5373 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (right) data
The position of the terminator is allowing a clearer view of north America than the TV screenshot, which suggests that the time is actually some 30 minutes before the broadcast, but it does allow a clearer view of the storm the astronauts describe to the ground.

Now that we have a clearer view of what the astronauts were looking at, it's possible to tell that the storm in the southern hemisphere to which Buzz refers is identified by the purple arrow. If the reader refers back to the TV screenshot it is possible to just make out where that whorl of cloud is pretty much on the terminator. Because of the short difference in time between the TV image and the photograph, the ESSA & NIMBUS orbits are effectively the same for this image as figure 4.3.27.

There is another photograph taken during this TV broadcast that adds another dimension to the story, this time taken on Earth.

Figure 4.3.30 below shows a scene in Mission Control during a broadcast with Earth in view. It is publicly available in this article describing the experience of reporters during the Apollo missions, Technology Review, and is credited to NASA, but the version shown below is an original better quality dated version offered for sale on eBay. As the eBay link is unlikely to persist, there is little point giving it. The same photograph is shown as published in the Daily News newspaper, dated July 18th, along with the view of Earth itself, again showing that these images were publicly available at the time.
This original image is clearly labelled as being from the 17th of July, but as the detail of the Earth is so poor, how can we be sure that it is from this date? The answer lies in viewing Armstrong’s footage. At 34:07, Armstrong says:

“Okay, world, hold on to your hat. I’m going to turn you upside-down.”

At which point he turns the camera. During that movement there is a point when the Earth appears in exactly the same position as is featured in the photograph, and this is shown in figure 4.3.31. Even after adjusting the levels on the newspaper image, details are still difficult to make out. However the gap in cloud off south America is easy to see, as is the west coast of north America.

Figure 4.3.31: Screenshot from TV broadcast, 17/07/69 compared with image taken in Mission Control on the same date.

The next still image in the magazine at the time of the broadcast shows the same view but with Florida on the terminator, suggesting at time for the photograph of around midnight on the 18th at the end of the TV broadcast. The whorl in the storm off Chile is still just visible in that photograph, demonstrating that Buzz would definitely have been able to see it in the TV broadcast, and therefore the purple arrow is definitely pointing towards it in figure 4.3.27. The next photograph with any significant degree of Earth rotation is the next image in the sequence, AS11-36-5374.

This image is shown below in figure 4.3.32, and analysed in figure 4.3.33.

Figure 4.3.32: AS11-36-5375. High quality source here: AIA
Figure 4.3.33: Main image - ESSA-9 (left) and NIMBUS-3 (right) images compared with AS11-36-5375. Below this is newly restored NIMBUS-3 IDCS mosaic (left), HRIR (right) and Stellarium estimate of time at terminator
Figure 4.3.33 continued: AS11-36-5375 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (right) data
Australia has now come into view, and only a thin part of the US west coast is visible, so there has been a longer time lapse between images than has been the case for the previous few photographs. Australia will be seen several more times during the orbital and landing phase of the mission, so it's worth making a mental note of the cloud formations around the coast for future reference.

It is still just possible to make out weather systems identified in those pictures, but they have mostly not been marked here. The storm off Chile, for example, is just passing beyond the terminator, but the Alaskan one is more visible and is picked out by the same green colour as in the previous analysis.

As for when this image was taken, Stellarium shows an estimate of around 02:00 on the 18th. ESSA's best fit orbit for the terminator region is number 1769 (track 5) which commenced at 23:02 on the 17th. The NIMBUS image is actually a composite from two days' worth. The westernmost pass included here is actually from the image dated the 18th, and the remainder the 17th. The orbital path covering the terminator is number 1267, which started at 18:50 on the 17th.

The next image in the sequence shows Africa returning into view. This represents a considerable time gap compared with the others, but the mission transcript shows that shortly after image AS11-36-5375 was taken the crew entered a rest period.

AS11-36-5376 is shown below in figure 4.3.34, and analysed in figure 4.3.35.

Figure 4.3.34: AS11-35-5376. High quality source here: AIA
Figure 4.3.35: Main image - ESSA-9 (top left upper & lower), NIMBUS-3 IDCS (bottom left) and ATS-3 (bottom right) compared with AS11-36-5376 and Stellarium estimate of time at terminator.
Figure 4.3.35 continued: AS11-36-5376 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (right) data
Figure 4.3.35 (cont’d): NIMBUS-3 HRIR passes
Stellarium estimates the terminator time as 14:00 on the 18th, which is approximately 48:30 MET. At 48:32 in the transcript, we have the following (edited) quote from Aldrin:

"We've got the continent of Africa ... facing toward us right now,... The Mediterranean is completely clear. The Sun looks like it’s about to set around Madagascar. The equatorial belt of Africa stands out quite clearly. We’re seeing the dark green or a muddy coloured green, compared to the sandier colours in the southern tip of Africa and, of course, the Sahara northern coast of Africa. There’s a rather remarkable cloud that appears in the vicinity of the border between Afghanistan and Pakistan. It's just about to go into the sunset now. It is casting quite a large shadow. It's isolated.”

The Afghan border cloud is not identified specifically in the preceding figure, as it would not be featured on an ESSA image dated the 18th. If we isolate that area of the globe and compare it with the ESSA image dated the 17th (which would show that storm on its final orbits on the 18th, we get figure 4.3.36.
It should be evident that there is a cloud in exactly the same place on the ESSA image in isolation. The boundary line of the ESSA image on the 17th is given as track 10 (orbit 1774), although the dividing line appears to be one later (orbit 1775) at the start of the image dated the 18th. The commencement times for these orbits are 09:09 and 11:04 respectively. ATS' time is recorded as 14:55 on the 18th, while NIMBUS' orbit 1273 started at 05:46 on the 18th. The HRIR image doesn’t show the cloud clearly, but you can see the wispy cloud over the Arabian Gulf.

The next image for analysis is AS11-36-5381, shown below in figure 4.3.37 and analysed in figure 4.3.38.

Figure 4.3.37: AS11-36-5381. High quality source here: AIA. Also shown is a version of the image from this document, published in 1970 and available for sale at Bonhams auction.
Figure 4.3.38: ESSA-9 mosaic (top right upper & lower), ATS-3 (bottom right), NIMBUS-3 (top left), journal ATS-3 image (bottom left) and BOMEX ESSA-9 image (bottom centre) compared with AS11-36-5381.
Figure 4.3.38 continued: AS11-36-5381 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (right) data
Figure 4.3.38 (cont’d): ATS-3 strips combined to make a single image (left) and NIMBUS- HRIR passes (right). Bottom left is Stellarium estimate of time at terminator.
The observant reader will have noticed several more images in figure 4.3.38 than is usual, with the additional images coming from detailed sections of an ATS image from a journal, ATS strips from a University of Wisconsin report, and an ESSA image from the BOMEX study referenced in the introduction to this section.

The cyan arrow in figure 4.3.35 picked out the area between a pair of parallel clouds, which in this figure have been picked out by the magenta and purple arrows, as using both clouds allows more detail to be picked out in the zoomed in ESSA & ATS image.

Stellarium estimates the terminator to be at around 21:00, shortly before Aldrin and Armstrong enter the LM to inspect it, and this Apollo image is the last in magazine 36 before that inspection. The ATS-3 image's time is given in the journal as having been taken at 14:31, at which time Buzz is describing weather systems over Afghanistan discussed earlier. The Caribbean portion of the ESSA-9 image is reported as being taken at 13:25, but the 'L' after the times in the original document refer to local time, not GMT. The actual satellite pass for the Caribbean (Track 3, number 1779), commenced at 18:04.

The NIMBUS pass over the Caribbean (orbit 1278) commenced at 14:31, which would explain why the weather system picked out by the blue arrows is more similar to the ATS-3 image, compared with the ESSA's later version matching more closely to the Apollo image. The magenta and purple arrows point to clouds imaged by NIMBUS at 13:06.

Although the NIMBUS image is again of poor quality, all 3 satellites clearly show the same weather systems as the Apollo image, and these systems are also very obviously part of developing global weather systems.

The Apollo image also marks the end of a long sequence of images showing continuous coverage of the Earth, ie one weather system is always visible in at least two consecutive shots. Stringing these images together allows us to see the Earth's rotation as Apollo 11 travels away from it. This can be seen in these videos (assembled by the author). Video 1 shows the Earth as it retreats as the astronauts would have seen it, while in Video 2 each photographic frame has been stretched to keep the size of the Earth the same.

While inspecting the LM, another live TV broadcast to Earth was carried out, most of which consisted of film inside the LM showing the various control panels & equipment. That broadcast also featured an image of Earth, and a screenshot of this – taken from a BBC documentary – is shown below in figure 4.3.39. This youtube link shows the Earth footage as broadcast on the news on the 18th. A comparison with ESSA & NIMBUS sources is shown in figure 4.3.40. A better quality version of the footage can be found here and a screenshot of that is used in the analysis in 4.3.39.

![Figure 4.3.39: Screenshot of Apollo 11 live TV broadcast 18/07/69. Source: BBC](image-url)
Figure 4.3.40: Brightness adjusted close up of video screenshot from 18/07/69 compared with ESSA (top and bottom left) and NIMBUS 3 (right) images from the same date, and Stellarium depiction of terminator at time of broadcast. The lower images are from recently restored IDCS (left) and HRIR (right) NIMBUS-3 photographs.
Figure 4.3.39 continued: TV broadcast still and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (right) data
We can pinpoint the timing of the TV picture fairly accurately by looking again at the mission transcript. At 56:38, we have the following exchange between Capcom and Armstrong:

**CC: 11, Houston. If that's not the Earth, we're in trouble.**

**CDR: That's the Earth, and we have a very good view of it today. There are a few more cloud bands on than yesterday when we beamed down to you, but it's a beautiful sight**

And a few moments later we get a brief description of the view:

**CC: 11, Houston. We see the - still see the banding along the intra-tropical convergence. I guess the most predominate one now is around the - up in the - around the equator or slightly north of the equator.....We have you - your sub-spacecraft point is just off the western coast of South America directly south of about Mexico City. Over.**

**CDR: That - That looks like what we observe from here.**

This puts the view of Earth just before the end of the TV transmission at around 22:10 on the 18th.

Stellarium's view in figure 4.3.40 shows that the description is accurate. It’s worth noting that the final NIMBUS-3 orbit covering the image was only started 15 minutes before that comment by Armstrong. Although the detail in the screenshot is not perfect, it is still possible to make out the long band of cloud just north of the Equator (red arrow), and the banks of cloud off the California coast (green arrow). The much lower latitude band of cloud off South America is also evident (blue arrow). The magenta arrow suggests the location of the cloud around the Florida coastline, but it is not absolutely certain. There are also differences in colour between the areas that should be occupied by ocean and land. In short, the screen capture is consistent with a planet Earth that has rotated over the short time interval since figure 4.3.38, and shows the weather patterns it should show. The higher quality screenshot, found much later in the writing of this piece, confirms these observations.

The next two photographs after the LM inspection pictures how that there has been quite a time gap between them and the pre-inspection ones, again coinciding with a rest period and preparations for LOI. AS11-36-5402 is shown below in figure 4.3.41, and analysed in figure 4.3.42. There aren't any high resolution NIMBUS images available for the image, but there is a low resolution one from the recovered data that covers Africa, so we'll use that.

![Figure 4.3.41: AS11-36-5402.](image-url)
Figure 4.3.42: ESSA-9 image dated 19/0/69 (above left) and 18/07/69 (above right), low resolution NIMBUS HRIR image (left) compared with AS11-36-5402 and Stellarium estimate of time at terminator.
Figure 4.3.42 continued: AS11-36-5402 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (right) data.
Stellarium puts the terminator here at around 14:00, which would be around 72:30 MET, a few hours after the crew resumed communications after their rest break. The crew are engaged in photographing the solar corona, getting news reports from home (including the progress of the Soviet Luna 15 probe), and preparing for LOI.

As usual with African views there is the split between ESSA’s orbital day, running up the East coast of Africa. In this case, there is relatively little difference between the weather patterns either side of that divide, as indicated by the purple and cyan arrows. What the low resolution NIMBUS data lack in quality is made up by the supporting evidence it provides, particularly covering the cloud systems off West Africa. The only ATS image available shows poor definition of the western hemisphere only, with the African part of the globe in darkness.

The most obvious weather systems are those showing around southern Africa, which don’t occur in that formation on any other day. The best fit orbit for the terminator is track 10 (number 1786), the penultimate on the image dated the 18th, which was commenced on the 19th at 08:02.

The next photograph examined is the first to feature the Earth with Apollo equipment in shot, and turns out to be the last one taken before images of the lunar surface appear. After this point we start to get images shown of the Earth from two perspectives: one from the crew bound for the lunar surface, and the other from Collins as he orbits in the CSM. AS11-36-5404 (shown in figure 4.3.43 and analysed in figure 4.3.44) occurs after the initial LM inspection, but the LM & CSM are obviously still attached, so it must have been taken (at the very least) before 17:44 on the 20th.

Figure 4.3.43: AS11-36-5404. High quality source here: AIA
Figure 4.3.44: ESSA-9 image (above left) and low resolution NIMBUS-3 HRIR image (below left) compared with AS11-36-5404 and Stellarium estimate of time at terminator.
Figure 4.3.44 continued: AS11-36-5404 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (right) data
Stellarium suggests that the terminator is at roughly 16:30. If this was 16:30 on the 20th, the crew would have separated into the two craft and be performing system checks, unlikely to be taking photographs, so it seems a reasonable starting point to assume this image was taken on the 19th. The NIMBUS data, despite the reduction in quality, again shows a useful corroboration.

The cloud patterns in the north and south Atlantic are distinctive, and easy to pick out on the ESSA images, despite them being fainter. As for timing, the terminator portion of the ESSA image was taken on orbit 1788 (Track 12), which was commenced on July 19th at 12:05, progressing over the Atlantic later that afternoon, coinciding very nicely with the time Stellarium says the Apollo image was taken.

The next series of images examined cover the period of CSM & LM separation, lunar orbit, landing, and then rendezvous of the two craft, and they will be covered on the next section.
4.3.1b Mission images – The first steps

Several images exist that allow comparison if different parts of the Earth's surface during the preparations for the landing. The first images to be examined are AS11-37-5435 & AS11-40-5845. As will be demonstrated, these were taken at the same time using different cameras. Figure 4.3.45 shows the original photos for 37-5435, figure 4.3.46 shows the original for 40-5845 combined with a zoomed and cropped Earth from it for comparison, and 4.3.47 the analysis of 37-5435, the clearer of the two photographs.

Figure 4.3.45: AS11-37-5435

Figure 4.3.46: AS11-40-5845 and zoomed & cropped Earth from it. High quality source here: AIA

Figure 4.3.47: AS11-37-5435, the clearer of the two photographs.
Figure 4.3.47: ESSA-9 image compared with AS11-37-5435 and Stellarium estimate of time at terminator.
Figure 4.3.47 continued: AS11-37-5435 and 3D reconstruction using digitally restored ESSA data
Both magazines are from cameras that made it to the lunar surface, as they both feature the surface in them later on. Magazine 36, from which most of the preceding images were taken, was taken with a camera that remained on the CSM, as can be seen by photographs taken later in the magazine 36 that show parts of the LM after Aldrin & Armstrong had transferred to it.

AS11-37-5435 occurs near the beginning of the magazine, after an image of a curved lunar horizon, suggesting that it is not yet in final orbit. It follows AS11-37-5434 showing the same weather patterns and more LM in view, although there is a suggestion that it may have been taken slightly earlier. It is also well before an impressive sequence of images of the CSM taking during separation, which puts this image sometime after 17:27 on the 19th, but before 18:11 on the 20th (the time of the separation manoeuvre). The ALSJ records that the image taken 2 pictures later in the magazine was taken at 94 hours and 50 minutes into the mission, or 12:22 on the 20th, which narrows down the window still more. The image shows the west coast of the USA near the terminator, and was evidently taken from behind glass, as there is a clear 'ghost' Earth on reflected on the window.

AS11-40-5845 also occurs at the start of its magazine and is immediately preceded by a very circular lunar horizon. There are no other indicators of the likely time period in which the image could have been taken, other than photographs showing the lunar surface. This narrows down the window to between 17:27 on the 19th and 20:05 on the 20th, the beginning of powered descent towards the surface. This image also features the west Coast of the USA close to the terminator, indicating that it was taken at the same time of day as AS11-37-5435. The sharp black line crossing the Earth’s is part of a Reseau mark used to calibrate the images for distance and perspective.

The first thing to note about the Earths visible in the figures is that they are pretty much identical, and the immediate question must be: why would two photographs be taken at exactly the same time? Stellarium’s terminator puts this time at roughly midnight on the 20th (confirmation of the date will follow) which would be around 82 hours and 30 minutes into the mission - before the final transfer to the LM. The ALSJ records a number of conversations between Armstrong, Aldrin & Collins concerning camera equipment that needed to be transferred to the LM. They complain about fogged windows, and then suggest that if they clean the windows they ought to be able to get some nice pictures. At 82:12 Aldrin says:

"Alright, then, I think - the way we're sitting, why, we're going to be able to get a picture - of the Earth coming right up there. What do you think about that?"

Followed at 82:15 by

"Okay. I'll get another good picture of what comes along. Well, hell, I guess we might as well load the other camera and make sure it works, too, huh?"

At 82:16 minutes Collins says

"Well, look, if we load this one - if I put the film on this one, and take a picture or two, well, I'll have to take it back off again; that's the only trouble. I won't have to, but it doesn't stow as neatly. If you don't mind doing - powered descent with the camera in there, I think that's probably alright. Well, wait a minute, I bet I could put this one loaded where the other one goes... “

At 82:32 Aldrin says:

"I see the Earth, but it's a lousy picture."

Then 5 minutes later

"I got the Earth down by the strut."
That strut and this picture could easily have been AS11-37-5434. An hour later, after Aldrin & Armstrong have transferred to the LM, we get this from Aldrin at 83 hours and 19 minutes:

“I'm checking out camera number 4 now.”

Then finally:

“Roger, Houston. Eagle has checked out both 70-millimetre cameras and both 16-millimetre cameras, and all work fine.”

So, it becomes pretty clear from this discussion that the reason for the two identical photographs is that just around 82 - 83 hours into the mission, prior to final transfer to the LM, the crew take a few shots to check that the cameras actually work, and 83 and a quarter hours is around 01:00 on the 20th. It is also clear that the Earth has definitely moved on since figure 4.3.36, and the weather systems visible on the ESSA image from the 19th are clearly present on the Apollo images taken in the early hours of the morning on the 20th. 01:00 would be the latest time for the image: other transcript data suggest around 00:20, supported by lunar terminator position research on this site, as Aldrin records taking a photograph over Tranquility Base at 082:56:25, or 00:28.

For ESSA, the relevant pass on the image dated the 19th occurred at around 21:03 (track 4, number 1798) – only 4 hours away from the actual time the images were taken. No NIMBUS data exist for the 19th, so none are given for this image.

As for the weather systems, the most obvious features are those of the low cloud off the coasts of north & south America. These cloud banks persist into the following day's satellite images, but their shape has clearly changed over the half a day+ interval between the Apollo images and those taken on the 20th by ESSA. Stellarium and the ALSJ transcripts provide, in this case, a better fix on the timing of the image.

Over the next 12 hours the crew busy themselves preparing the LM, and the next image to be examined is one taken from the CM a few hours into that preparation around the time of a rest period. AS11-44-6550 is one of the clearest sequences of Earthrise images over the mission, and is shown in figure 4.3.48.
Figure 4.3.49: ESSA-9 (left) and NIMBUS-3 (below) images compared with AS11-44-6550 and Stellarium estimate of time at terminator
Figure 4.3.49 continued: AS11-44-6550 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (right) data
The ALSJ initially reported that this image was probably taken sometime during lunar orbit 12 or 13, which would suggest a time of 98 hours or 100 hours in to the mission, or roughly between 15:00 – 17:00. Immediately following this Earthrise sequence, there are a number of photographs detailing the separation of the CSM from the LM, which we know is timed at 18:11 on the 20th. As time has moved on slightly from the previous analysis, two satellites are once again available and the satellite analysis is given in figure 4.3.49, together with the usual Stellarium terminator screenshot. The NIMBUS data used are visible spectrum, as they provided the best image. ATS-3 does not cover any of the area shown.

In this case, Stellarium suggests that the time of the image would have been somewhere around 04:00 in the morning, seems to be at odds with the ALSJ's interpretation of when the image was taken, and would put it as being taken somewhere after start of orbit 6, after which the crew got some sleep before the next phase of the mission. Had it been taken on orbit 12, it would have shown the Atlantic rather than the Pacific. Orbit 6 commenced at 86:06 MET, with Earthrise on this orbit at about 86:30 MET, or shortly after 04:00 GMT. At this time in the CM transcript, we have this exchange between Collins (CMP) and Armstrong (CDR):

03 14 24 48 CMP Where the hell is the horizon with the world coming over it? I guess it's behind us, huh?

03 14 24 58 CDR Up there? We should be getting Earthshine – Earthrise features - should be coming up pretty soon.

after which they discuss which films are available, so they are apparently looking for Earthrise with cameras at hand.

Both north and south Pacific have distinctive weather features that should be readily identifiable, notably the large swirl off eastern Australia, the '>' shaped feature over SE Australia itself, & the cedilla shaped cloud off China. All these features are clearly visible on the satellite photographs.

As far as placing a time on the satellite images, ESSA’s track covering the terminator line on the 20th is actually orbit 1796 on the image dated the 19th. This pass commenced at 03:05 on the 20th, so the satellite passed over Australia not much before the time the Apollo crew took their picture. Unsurprisingly, the weather patterns observed by ESSA match exactly those in the Apollo image.

The NIMBUS image is difficult to decipher because there is relatively little of it and what is there is of relatively low quality. There is, however, a clearer image made available by the Australian Bureau of Meteorology. This image was sent after an initial inquiry as to whether they had any data. This inquiry led to them finding an unscanned collection of old NIMBUS images, requiring them to buy new scanning equipment to archive it. The author would like to apologise to the Australian taxpayer for costing them money.

From the information they sent, the image was from orbit 1297 (which is how the composite image in the previous figure was selected – the continents were difficult to pick out otherwise), and the time for this pass was commenced at 01:22 on the 20th – 4 hours before the Apollo image. This NIMBUS image is shown with a zoomed & cropped part of AS11-44-6550 is shown in figure 4.3.50, along with the newly restored NIMBUS images from the same day.

Even allowing for the NIMBUS' flat images and the Earth's curvature, there is a huge amount of correspondence between the two pictures. It is a useful example that the level of detail present in many of the Apollo photographs belies the argument that they are clumsy, hastily produced fakes. The storm over Australia appears in both photographs because both cameras were where they claimed to be: Over Australia, one passing in from a few hundred miles, one from 240000 miles in orbit around the Moon.

Amusingly, one of the chief proponents of the ‘Apollo was hoaxed’ myth, the ‘Aulis’ website (I’m not linking to them, Google it) where you can buy lots of material (there’s a clue there people) also seem to have cottoned on to clouds as an indicator of precision.
The author of one article on here, who claims to have a PhD but is ‘too scared’ to put his real name to it, also noted that ‘orbit 12’ error (who knows, he may even have spotted it here), and has cleverly spotted the similarity in clouds patterns between the two images, and even notes that Australia is on view. He says this:

“Another aspect that could confirm the genuineness of any given shot of Earth at any given moment is the pattern of the clouds. Taken at a certain time, on a certain day over the Pacific Ocean, the cloud patterns on AS11-40-5923 and AS11-40-5924 are available for verification. However, the ‘cloud pattern’ aspect alone cannot lead to the conclusion that the photographs were taken either from lunar orbit or the lunar surface by the Apollo astronauts.”

It’s very strange that while he says the clouds could confirm the genuineness of the image he doesn’t actually bother trying - despite the fact that it’s not difficult to find everything you need. His other statement - that the clouds don’t prove it was on or near the moon’ is also nonsense given that the photo he discusses (and a later surface one taken by Armstrong with the lunar module) feature the Earth in exactly the right configuration for
the time of the photograph, and that they actually feature the moon, and all the other accompanying evidence that support the fact that they were there. They feature a time and date specific Earth, where exactly does he think they were taken?

As always, these people prefer to latch onto a simple mistake and try and attach way too much importance to it.

Here’s more evidence they can ignore: In another study of one of these same Earthrise photographs, a youtube user has also tried to verify the time of the images, this time by looking at the Earth’s physical appearance in terms of the angle of the terminator relative to the lunar horizon. His conclusion is the same as mine: it as taken at around 04:00 just as NASA said it was, in orbit around the moon, just as NASA said it was. I should point out that he gets the orbit wrong and says it is on orbit 5! The youtube analysis is [here](https://www.youtube.com/watch?v=dQw4w9WgXcQ). As the video shows – it’s not just the clouds that prove Aulis wrong, everything does.

Meanwhile, back in the real world. 12 hours later the crew were in the process of undocking the LM, recorded as being at 110 hours 12 minutes, and image AS11-37-5442 (figure 4.3.51) is part of an Earthrise sequence taken (according to the ALSJ) just after this and featuring parts of the LM in shot. Certainly the photographs immediately after this one shows the CSM taken from the LM.

![Figure 4.3.51: AS11-37-5442. High quality source here: AIA](https://www.nasa.gov/sites/default/files/thumbnails/image/figure-4.3.51-as11-37-5442.png)

The photograph is obviously taken from inside the lunar module, and time has clearly moved on as far as the Earth is concerned as the main landmass visible is Africa. The ALSJ records a photograph taken a few frames before this one (AS11-37-5437) as being taken at 94hrs and 50 minutes into the mission, or 12:22 GMT on the 20th. All three satellites can be used to compare weather features, and the analysis is given in figure 4.3.52a.
Figure 4.3.52: Main image - ESSA-9 (left), ATS-3 (top right) and NMBUS-3 (bottom right) images compared with AS11-37-5442 and Stellarium estimate of time at terminator
Figure 4.3.52 continued: AS11-37-5442 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (right) data
We’re at the moon, it would be rude not to take a closer look, so here’s that swirl off South America (figure 4.3.52b).

Figure 4.3.52b: Section of NIMBUS-3 HRIR orbit compared with the same area of AS11-37-5442

Anyone who denies that there is an exact match in this image is an idiot.

In terms of satellite timings, the ATS-3 image is labelled as having been taken at 15:53. The ESSA path over the east African terminator would be track 12, which would be orbit 1801 on the image dated the 20th, commencing at 13:01. The relevant orbit for NIMBUS would be orbit 1302, which commenced at 09:30. The final NIMBUS orbit start time can be seen above as 14:53, just over an hour before the Apollo image. Again, the satellite image would not have been completed by the time the photo was taken. The nearest orbit to the time suggested by Stellarium of 16:00 is orbit 12, which had an AOS time of 98:18, or around 15:50 on the 20th.

The satellite comparison again shows that there is excellent correspondence between all 3 satellites' images and the Apollo photograph. The most obvious weather system is that shaped like a bass clef picked out by the blue arrow. The large cloud pattern off Africa shown 24 hours earlier is still visible (magenta arrow) but has changed shape and position.

It’s interesting to note that the blue-arrowed system seems to appear in all 3 satellite images in roughly the same place, and the reason for this is based around the fact that the ESSA & NIMBUS images are composites of several orbits. The NIMBUS orbit passing over the system in question would have started at around 14:30. Likewise ESSA’s orbit over it would have been commenced at 15:06 (track 1, orbit 1802). These compare well with the ATS-3’s time of 15:53, and are all relatively close to the time Stellarium suggests of 16:00, which means that this image is one of the last taken before the LM & CSM separated.
While Armstrong & Aldrin were in the LM, Collins was left to orbit the moon alone in the CSM, and part of his responsibility during those orbits was to take photographs of the lunar surface (and with any luck identify Tranquillity Base. While orbiting he captured a series of black & white Earthrise images & one of those, AS11-41-6023 (figure 4.3.53) will be examined next. The suggestion of this analysis is that magazine 41 was used after separation of the two craft, and that this image was taken a couple of hours after the LM landed on the surface as part of a long sequence of Earthrise images. Figure 4.3.54 compares all 3 satellite images with a close up of Earth from this photograph.

Figure 4.3.53: AS11-41-6023. High quality source: AIA
Figure 4.3.54: Main image - ESSA-9 (left), ATS-3 (top right) and NIMBUS-3 (bottom right) images compared with AS11-41-6023 and Stellarium depiction of time at terminator.
Figure 4.3.54 continued: AS11-41-6023 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (right) data
The ATS-3 image was, as reported earlier, was taken at 15:52, and the by the time of the Apollo photograph
Earth has, for the most part, rotated beyond what ATS-3 can see from its geostationary position.
As the cloud masses picked out in red & green on the ATS are still visible in the Apollo image, it is reasonable
to assume it that it was also taken on the 20th. ESSA's image on the 20th covering the western coasts of south
America was commenced at 20:02 (track 4, orbit 1805), while NIMBUS orbit 1306, covering the same coast,
was commenced at 16:39.

The Apollo 11 transcripts show that at 103:24 MET signal was lost from the CSM as it disappeared from view,
and 41 minutes later at 104:15 (or 21:47) on orbit 15, Mike Collins says:

“Houston, Columbia. How’s it going?”

as he emerged from behind the moon and has acquired a signal from Capcom again. Given that an Earthrise
photo is taken at AOS, it seems reasonable to suggest that the black & white photograph was taken just
before Collins makes his ‘How’s it going?’ radio call. Stellarium’s terminator set at 21:45 shows that the Earth
in the Apollo image is an exact match for what should be there.

This Earthrise photo is part of a sequence that has been compiled into a video, and this can be seen here.

At around the same time as this image was being taken, the decision was made to start the EVA procedure,
and a few hours later at 02:56 on the 21st of July, 109 hours and 24 minutes after launch, Neil Armstrong sets
foot on the Moon.

While Aldrin & Armstrong worked on the lunar surface, Collins continued his orbits around the Moon and
captured another Earthrise image on magazine 44 in AS11-44-6604 (figure 4.3.55). This picture occurs
immediately after photos of the LM after separation, and later on in the magazine there are images of the LM
ascent stage returning, so this image must have been taken before 17:54 on the 21st. The photograph is
compared with ESSA & NIMBUS satellite images in figure 4.3.56a, and a small subsection is examined in
4.3.56b.
Figure 4.3.56a: ESSA-9 (left) images compared with AS11-44-6604. Below this are NIMBUS-3 IDCS (left) and HRIR (right) image, and Stellarium estimate of time at terminator.
Figure 4.3.56a continued: AS11-44-6604 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (right) data.
According to the mission transcript, at 4 days 14 hours and 7 minutes (or 110 hours 7 minutes or 03:39 GMT) & 20 minutes after the start of orbit 18 Capcom contacts the CSM to confirm AOS, which Collins acknowledges some 30 seconds later (it maybe that his message to Houston is not a confirmation of AOS, but querying Houston as to whether he had it).

Stellarium has been set at 03:45 on the 21st, and there is a clear match with the photograph in terms of Australia’s position. As with previous photographs where Australasia is featured, the ESSA image featured is not from the 21st but from the 20th, and the NIMBUS image is a composite of strips from the 20th and 21st, The timings will be examined shortly. As far as the weather patterns that are visible are concerned, the system picked out by the green arrow in figure 4.3.49 has moved from a position south of Victoria state to one covering New South Wales coastline. The detail in figure 4.3.56b of the cloud circulation around North Island New Zealand is superb. The clouds over Japan and off the coast of east & south east Asia have persisted, but have changed configuration from figure 4.3.49.

For the satellite timings, ESSA 9’s track 8 is the nearest one to pass the east coast of Australia. The ESSA composite dated July 20th shows this track (orbit 1809) as commencing at 04:03 on the 21st. As mentioned previously, the two passes available from NIMBUS covering the area shown in the Apollo image are picked from orbits 1309 and 1310. The former is shown on the composite image dated the 20th, the latter on the composite dated the 21st, these were commenced at 22:02 on the 20th and at 23:50 on the 20th respectively, several hours before the start of the EVA and the Apollo image.

Meanwhile on the surface, Armstrong and Aldrin are collecting samples and installing a variety of scientific equipment. They take many photographs, three of which show the Earth (two of these are the same scene taken twice). The first of these images to be analysed here is AS11-40-5924 (figure 4.3.57), which is done in figure 4.3.58. This is the other photo examined by Aulis mentioned earlier.
The weather patterns in shown in the image taken from the surface are a clear match with the ones taken from the orbiting CSM, although there is more detail observable in the clouds, particularly over Australia, and satellite timings will be the same.

Australia has evidently moved between the two images (the white arrows are the same length), and this movement is consistent with the suggested half an hour time gap between the time of AOS in Collins' orbital image and the Stellarium estimate of time in the ground based picture. At this point in the mission the timeline and mission transcript shows Aldrin engaged in photographing the LM landing gear, and AS11-40-5924 occurs between a series of images of the LM structure. It seems entirely reasonable that while moving around the base of the LM to capture the effects of the landing on the structure Buzz should look up and see the perfect photographic opportunity.

The next photograph of Earth is AS11-37-5506, which is shown below in figure 4.3.60, and analysed in figure 4.3.61.
Figure 4.3.58: ESSA-9 (top left) and NIMBUS-3 IDCS (bottom left) and HRIR (bottom right) images compared with AS11-40-5924 and Stellarium estimate of time at terminator.
Figure 4.3.58 continued: AS11-40-5924 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (right) data
Figure 4.3.59: Comparison of Australia's position in AS11-44-6604 and AS11-40-5924

Figure 4.3.60: AS11-37-5506. High quality source here: AIA
Figure 4.3.61: Main image - AS11-37-5506 compared with ESSA (top & bottom left) and NIMBUS (right) with Stellarium estimate of time at terminator. Overleaf is a NIMBUS HRIR-3 image.
Figure 4.3.61 continued: AS11-37-5506 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (right) data.
This photograph is the only successful attempt of several made to take a picture of the Earth from inside the LM. As the flag and astronaut footprints are visible in the images preceding and following this one, it is reasonable to assume that the crew are back inside the LM after their EVA, so this photograph must have been taken sometime after 05:11, when the LM hatch was closed but before returning to orbit.

Despite the lower quality, brought on both by Armstrong photographing the Earth through the LM window and misfocussing the camera, it is still possible to identify features common to the ESSA image, and that were also visible in figure 4.3.58, and only the blue and cyan arrows differ. The weather system that started off south over Victoria State before moving east of New South Wales appears to have progressed further eastwards, although it is difficult to tell how far. What is evident is that Australia has moved further eastwards with the Earth’s rotation, consistent with being taken 90 minutes later than the previous image, and also fitting in with the timeline of the mission. By 05:45, the time suggested by Stellarium’s terminator, the crew had been back inside the LM for around 30 minutes, but 90 minutes later the Hasselblads were jettisoned on the lunar surface to save weight. No more images could have been taken from the LM after that time.

The ESSA orbit at the terminator corresponds to track 8, or orbit 1809, and was commenced at 04:03, so the satellite’s orbital progress is matching Earth’s rotation as seen from the Moon. The clouds picked out by the red arrow were imaged at 00:18 by NIMBUS.

The next view of Earth requires a little speculation and interpretation. It comes in the form of an Earthrise sequence shown in magazine D of the 16mm footage - see figure 4.3.62.
The magazine starts with lift off from the lunar surface and after the Earthrise shows the CSM approaching, so the Earthrise must be some time between launch and docking. As will be seen below there is footage already from the CSM, as well as clear still images, that even while the view in the figure above is blurry obviously shows very different scenes. The reunion of Eagle with Columbia didn’t occur until three and a half hours after lunar lift off, which gives time for at least one orbit before docking. Earthrise for that would have been at around 19:00, and as can be seen in figure 4.3.63 this puts south America firmly in shot.

Stellarium shows us that the main landmass that ought to be present is South America, with the bulk of the top half of Earth being the north Atlantic. On the western limb is the eastern seaboard of the USA. Africa and western Europe would just be visible on the north-eastern limb. If we have it worked out correctly then we should have an area of cloud showing off Africa and in the south Atlantic off south America, with large amounts of cloud off the west coast of South America and the USA’s east coast. Figure 4.3.63 shows that this is not an unreasonable interpretation of what we have, although I am the first to admit it is less than conclusive.

The next usable image of Earth comes from a fantastic sequence of Earthrise images taken as the LM ascended towards the CSM. The Apollo Image Atlas only has poor quality images of most of this event, but the ALSJ has better ones. There is also a large TIFF image of AS11-44-6642, available from this site: archive.org. The ALSJ high quality version is shown in figure 4.3.64a, with a close up of a similar view from the 16mm footage in 4.3.64b, scanned from ‘Life’ magazine’s Apollo 11 special. The still image is analysed in figure 4.3.65a & b.
4.3.63 continued: 16mm still and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (centre) data
Figure 4.3.64: a) AS11-44-6642 (left). High quality source here: ALSJ b) 16mm video still as shown in Life Magazine (right)

Figure 4.3.65a: ESSA-9 (left), ATS-3 (top right) & NIMBUS-3 (bottom right) images compared with AS11-44-6642 and Stellarium depiction of Earth at time of photograph, Below the main image is are NIMBUS-3 HRIR images and a zoomed crop of a 16mm still from this video.
Figure 4.3.63a: ESSA-9 (left), ATS-3 (top right) & NIMBUS-3 (bottom right) images compared with AS11-44-6642 and Stellarium depiction of Earth at time of photograph, below the main image is the newly restored NIMBUS-3 mosaic and a zoomed crop of a 16mm still taken and reproduced in Life Magazine.
Figure 4.3.63a continued: AS11-44-6642 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (right) data
Figure 4.3.65a (cont’d): NIMBUS-3 HRIR

Figure 4.3.65b: Section of AS11-44-6642 compared with close up of ATS-3 image over the Caribbean area from the BOMEX study and a section of orbit 1318 from NIMBUS-3.
Another photosequence showing the LM arriving back at the CSM can be seen in the video.

Dating this photograph within the official chronology is pretty straightforward. The transcript at the ALSJ has this:

127:51:36 Collins (onboard): [Garble] I got the Earth coming up already. It’s fantastic!

and records the photograph as taken immediately afterwards. LM AOS is reported shortly afterwards. The MET equates to 21:24, and this is the time set on the Stellarium view.

As far as satellite timings are concerned, the ATS-3 image is unambiguous, stating clearly that it was taken at 14:11, some 5 hours before the Apollo image. The closest ESSA orbit to the terminator in south America is track 3, orbit 1816, commencing at 18:00 on the image dated the 21st. The NIMBUS orbit for the same area is orbit 1319, which commenced at 15:54.

It is, as usual, obvious that the Apollo image matches the satellite images for the date in question, displaying distinct features not visible in the same configuration on preceding or subsequent days. Particularly obvious are the large ‘X’ shaped formation over the north Atlantic (marked by the blue arrow in the preceding figure), and the elongated ‘C’ shape to the south-west of Chile marked by the magenta and purple arrows. Even in the relatively poor quality scan of Life magazine’s video still, the curl off Chile, th ITCZ clouds, and the ‘X’ of cloud across north America are still easy to make out.

Fog banks are also visible off the coast of California and Chile that differ in shape and extent from other days in the mission. Figure 4.3.64b shows that the formations in the Caribbean off the northern coast of south America are also identifiable.

On the subject of Chile, another satellite image is available covering that area for the 21st, as mentioned in the introduction to this section (shown in figure 4.3.66, along with part of AS11-44-6642. The image in question is from a summary report of the 5 years of uninterrupted meteorological observation by satellite. It is unclear which satellite is the source of the image (it could be one of several), but it is certainly much clearer than the ESSA or NIMBUS views used so far. The high degree of correspondence between the lines of latitude, longitude and various points of the storm system on this image and the ESSA image used in the previous analysis suggests this is a higher quality version of the ESSA 9 data. The image is clearly labelled the 21st, and is evidently a photograph of print-outs, as the cut allowing two piece of paper to be overlapped is obvious cutting across the storm and individual lines from the printer ribbon can also be made out.

Although this adds little to the overall analysis, it is again an illustration that very fine detail can be picked out on the Apollo images with an educated eye, and also that the sources of satellite information were never a secret. This particular image was used to pass on information about a storm in an area that was poorly covered by conventional forecasting, and part of the reason for the report in which the image was printed was to point out the usefulness of satellite data in meteorology, something that was still being evaluated.

While storms were gathering off Chile, the LM ascent module was heading towards the CSM to re-unite the three crew. After their rendez-vous, the re-joined craft continued to orbit the moon until the TEI burn at 04:55 on the 22nd, and during these last orbits a final series of Earthrise images was obtained. One of the best of these photographs is AS11-44-6651, and a high resolution version is available here: ALSJ. Even without zooming into the image, Australia is visible, and this should already tell readers that it was taken in the early hours of the morning (GMT). As this image occurs after the station-keeping photograph shown in the previous Apollo image analysed, a date of the 22nd is already a good starting point for the satellite images. It is shown below in figure 4.3.67 and analysed in figure 4.3.68.
Figure 4.3.66: Unnamed satellite image of Chile and part of AS11-44-6642. Newly restored NIMBUS-3 ISDC (left) and HRIR negative (below right) added for comparison

Figure 4.3.67: AS11-44-6651. High quality source: ALSJ
Figure 4.3.68: Main image - ESSA-9 compared with AS11-44-6651. Below this is newly restored NIMBUS-3 ISDC mosaic (left) and HRIR image (right). Finally a Stellarium illustration of Earth at AOS after TEI.
Figure 4.3.68 continued: AS11-44-6651 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (right) data
As far as timing is concerned, the ESSA pass over the terminator for the image dated the 21st is number 1820 (Track 7), which was started at 01:01 on the 22nd. The NIMBUS orbits used are the first started on the 22nd (1324). The last of which started at 00:54 on the 22nd. The restored NIMBUS version shows patterns much more clearly and other features can be identified.

According to the timeline information and the ALSJ, the TEI burn was performed at 04:55, or 135:23m MET, shortly after what would have been the start of orbit 19. Although before the burn the crew were concerned about the cameras getting in the way (as g forces would be generated by the engines, any free floating equipment is a potential hazard), after it had completed they were very keen to take more photographs, and there are many exchanged discussing what films are available and what should be photographed. We then have this conversation in the CM transcript:

05 15 34 11 CMP Yes, more than two. AOS.
05 15 34 34 LMP Yes, we sure as hell have.
05 15 34 38 CDR Get the burn status.
05 15 34 41 LMP Hey, I hope somebody's getting the picture of the earth coming up.
05 15 34 44 CMP ... Not quite pitched far enough. Well, maybe I can get it out --
05 15 34 53 CDR I can get around to here.05 15 34 54 CMP - - your window.
05 15 34 57 CDR Upside down; turn the camera upside down; then it'll look right.

At the time Aldrin was asking whether Earthrise was being photographed, the CM had increased its altitude to over 500 miles, which explains the increased curvature of the lunar surface, and it would seem that the photograph just analysed was the final Earthrise seen after the TEI burn. For this reason Stellarium has been set at the time of AOS, and the match between what should be there and what is there is obvious.

The scene was also captured on 16mm footage, and a high resolution version of the shot can be found here. Figure 4.3.69 shows a screenshot from the footage and a close up of Earth.

![Figure 4.3.69: Sill from 16mm footage in lunar orbit.](image_url)

Again we have video footage that matches the still images.

The next stop for Apollo 11 is home.
4.3.1c Mission images – The voyage home

The first image examined on the return journey is AS11-38-5684, and is the first one taken on magazine 38 to feature the Earth after a series of images of a departing Moon. It is shown below in figure 4.3.70 and analysed in figure 4.3.71a&b.

![Figure 4.3.70: AS11-38-5684. High quality source: AIA](image)

On the now magnified Earth, the storm identified in figure 4.3.63 off southern Chile (magenta arrow) has moved onshore and there are still persistent fog banks off northern Chile (yellow arrow). When the ATS-3 image for the 22nd is compared with that of the 21st, the large 'X' shape of clouds over the western north Atlantic is still discernible (blue arrow), but has changed configuration slightly while progressing eastwards towards Europe. A large circular cloud just inland from the east African coast has moved further inland and changed shape (but is not visible on the Apollo image). The ATS-3 image was used as part of an analysis (referenced at the start of this section) analysing the development of Hurricane Anna later in July. The band of cloud stretching from South America to Africa is part of the inter-tropical convergence zone, and instability in this zone led to the hurricane. The detail of the ATS image still shows identifiable cloud patterns off Venezuela and Guyana despite being taken 4 hours earlier.

The Stellarium time estimate puts the terminator at roughly 19:00 GMT. As far as satellite timings are concerned, the main ATS-3 image is recorded as being taken at 15:18, a few hours before the Stellarium timing. ESSA's orbit over the terminator commenced at 15:08. The NIMBUS orbit over the same area is number 1330, which commenced at 11:38.
Figure 4.3.71a: Main image - ESSA-9 (left), ATS-3 (top right) and NIMBUS-3 (bottom right) images compared with AS11-38-5684 and a Stellarium estimate of time at terminator.
Figure 4.3.71a continued: AS11-38-5684 and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS (right) data
Figure 4.3.71b: NIMBUS-3 HRIR (left) ATS-3 (centre) and Section of AS11-38-5864. The Apollo image has been stretched to compensate for the viewing angle.
There is a very similar colour photograph on magazine 44, AS11-44-6669, shown below in full and with a close-up of Earth from it (figure 4.3.72). A small section of the photograph around the terminator is shown in figure 4.3.73.

![Figure 4.3.72: AS11-44-6669 (left, source: ALSJ) and in close up (right)](image)

Although seemingly the same view of Earth as the black and white image from magazine 38, the colour image shows much less of Saharan Africa along the terminator. The view on the opposite limb, however, shows that the same weather patterns are present, and that the difference along the terminator is more a product of the different films and exposure used. It’s highly likely they were taken at the same time for comparison.

The next image from the 22nd is again one that is duplicated in magazines 38 and 44, although on this occasion there is very little difference between the two, and therefore they must have been taken very close together. On this occasion, the colour image (AS11-44-6670) will be used as the one for satellite comparison, and this is shown below in figure 4.3.74. It is analysed in figure 4.3.76.
The 'X' shape (blue arrow) is much more visible now, and is evidently not in the same configuration as the 'X' shown on the 21st. The storm systems off south America are coming into view, and these are also in a different configuration to those shown on previous days.
Figure 4.3.76: ESSA-9 (left), ATS-3 (top right) and NIMBUS-3 ISDC (bottom right) images compared with AS11-44-6670 and Stellarium estimate of time at terminator. Left are the NIMBUS-3 HRIR images.
Figure 4.3.76 continued: AS11-44-6670 and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS (right) data
Stellarium estimates a time of around 22:00 for the photographs, and this compares with an estimated start
time for ESSA’s terminator orbit (track 3, pass number 1829) of 18:09. The NIMBUS track for the terminator is
orbit 1332, which commenced at 15:12.

Having suggested that the two photographs were taken at the same time, it's worth double checking that they
aren't actually just the same photograph. Figure 4.3.77 shows a comparison of the two images at the
terminator region over Chile.

![Figure 4.3.77: AS11-44-6670 (left) compared with AS11-38-5687 (right).](image)

The suggestion here is that the colour image was taken marginally before the black and white image, as the
large band of cloud running left to right across the centre of the images appears closer to the terminator in
the black and white version, and there are similar differences elsewhere on the photographs. They could,
however, just be reflections of different image quality, but what does emerge is that there are enough subtle
differences to show that they are not identical images rendered black and white through some sort of image
processing. It is likely that the colour image was taken first, and the difference in the two around the
terminator represents the time difference involved in setting down one camera, picking up the other,
checking the settings and taking the photograph.

July 22nd also presents history with an interesting diversion involving the role of satellite images in the Apollo
11 landing.

In 2004, the Naval Postgraduate School, amongst others, published this article: Saving Apollo 11. It contains an
interesting and now declassified story about how naval Captain Willard 'Sam' Houston Jr & Air Force Major
Hank Brandli between them managed to divert the Apollo 11 landing site to avoid potential storms that could
rip the CM parachutes to shreds, killing the astronauts on impact. It is full of dramatic language, with tales of
secret meetings and information from a covert satellite. This satellite contained (according to Hank Brandli)
higher quality images than anywhere else (it is probably one of the DAPP/DMSP satellites described in Chapter
2).

Brandli’s own website contains a version of the story here: [http://libertyyes.homestead.com/hankbrandli-23.html](http://libertyyes.homestead.com/hankbrandli-23.html), in which it says:
In what Brandli claims was a career threatening move, he went to Captain Houston, who then went straight to the top with classified top secret data and convinced Rear Admiral (Donald C.) Davis (the man in charge of the Apollo rescue operation) that Apollo 11 was doomed, who then persuaded NASA to alter the landing area “without proof” to avoid impending disaster. According to the articles, “violent thunderstorms” were found by reconnaissance craft on the 24th (the day of the landing), vindicating the decision and Brandli’s meteorological skills. According to 'Saving Apollo 11', Houston was awarded a Navy Commendation Gold Medal for his work.

Brandli’s website also contains two other versions of the same events: [http://libertyyes.homestead.com/hankbrandli-15.html](http://libertyyes.homestead.com/hankbrandli-15.html) and [http://libertyyes.homestead.com/Hank-Brandli-25.html](http://libertyyes.homestead.com/Hank-Brandli-25.html), which are copies of those published elsewhere. It is a dramatic and interesting story, but is it borne out by the evidence?

In October 1969, well before the 1995 declassification of the CORONA mission with which Brandli was involved, ESSA published one of its quarterly publications “ESSA World” (source: NOAA Rescue Archives). In it is an article covering ESSA's support of the Apollo 11 mission, starting with the weather forecasting for the launch period, then describing their monitoring of solar flares, before finally covering weather forecasting for the landing period. An earlier edition of the journal outlines the same role for Apollo 7, and evidently satellite meteorology was a major part of the mission.

The article describes the work of the Spaceflight Meteorology Group's staff at Suitland and Honolulu (which you will recall from Chapter 2 worked for both NASA and DoD), whose job was to monitor incoming satellite images covering the target landing area, while other staff in Houston kept NASA informed of developments in the weather. On July 22nd, these meteorologists spotted a change in the weather on the satellite photos, and examination of successive images suggested relatively strong winds, 6 foot waves and the possibility of thunderstorms. The conditions were not too difficult for landing, but turbulence was a concern. To quote one of the meteorologists,

"On the basis of the Spaceflight Meteorology Group's forecasts, the end-of-mission point was shifted"

One of the key military contacts was a “Captain William Houston”, commander of the Fleet Weather Central at Pearl Harbour, and it seems likely that this is the same Captain Willard 'Sam' Houston described in the other articles, who held the same position and is also recorded as being the senior meteorologist for Rear Admiral Donald C Davis, commander of the Pacific Manned Space-flight Recovery Forces.

So, we appear to have something of a contradiction in the story. While Houston & Brandli weren't allowed to speak about their weather forecasting role in the Apollo mission, ESSA were freely discussing their own role, and seem more than convinced that they were responsible for re-routing the mission. One of the people involved in that decision was Captain Houston, and far from being “without proof”, Houston had access to rather a lot of it. Clearly, Brandli was not the “only person” with access to the information needed to save Apollo from some heavy showers. The article also features a picture of Armstrong & Aldrin with one of the chief meteorologists examining weather data from an earlier mission, so the crew would also be fully aware that this was going on.

ESSA World helpfully includes two satellite images from ATS-1 and ESSA-8 (remember that there were at least 2 other satellites also on patrol over the landing zone at that time), and these are of sufficiently good quality to be compared with an Apollo image. The articles covering Brandli & Houston's efforts also contain an image, with 'Screaming Eagles' (a piece of over dramatic hyperbole used to describe large thunderheads, but also the nickname for the 101st Airborne and coincidentally the US Navy's VF-51 squadron, for whom Armstrong flew in the Korean war), and this is below as figure 4.3.78. This image is reproduced from the article cited earlier, but lower quality versions of it occur in many places on the internet.
Figure 4.3.78: Photograph cited in this article ‘Saving Apollo 11’. No definite date is given, and the photograph may or may not be the one cited by Brandli as being responsible for his actions.

The Apollo image used is a black & white one, AS11-38-5693 and shows much of the area visible in the ATS-1 image. The image before this in the magazine (AS11-38-5692) shows the same detail but is evidently taken about an hour earlier, judging by the rotational difference between them. The former is preferred to the latter because it shows more identifiable features. AS11-38-5692 & 5693 are shown in figures 4.3.79 & 80 respectively, and are compared in figure 4.3.81. AS11-38-5693 is analysed in figure 4.3.82.

Figure 4.3.79: AS11-38-5692. High quality source: AIA  Figure 4.3.80: AS11-38-5693. High quality source: AIA
Figure 4.3.81: Comparison of Earth seen in AS11-38-5692 (left) and AS11-38-5693 (right).
Figure 4.3.82: Top image - ESSA-9 (left), ATS-1 (bottom centre inset), NIMBUS-3 IDCS (bottom left) ESSA-8 (bottom centre) images compared with AS11-38-5693 and Stellarium estimate of time at terminator and the landing area in detail (bottom right).
Figure 4.3.82 continued: AS11-38-5693 and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS (right) data
Figure 4.3.82 (cont’d): Front page of the Oneonta Star dated 24/07/69 and my own personal copy of the NIMBUS satellite image (dated 23/07/69) that features on the front.
According to Stellarium, the Apollo image used is actually from the early hours of the 23rd. The ATS-1 image is labelled as being taken on the 22nd at 22:09 GMT. However, the Apollo image from the 23rd is closer in terms of time to this ATS image than one actually taken on the 23rd some 17 hours later. The ESSA-9 part relevant to the image is track 4, orbit 1830, which commenced at 20:04 on the 22nd. It is not clear when the ESSA-8 image was taken, other than on the 22nd. The landing zone is identified by the blue arrow. The NIMBUS-3 terminator track was commenced at 19:18 (orbit 1334), and the landing itself was photographed at 20:56. As can be seen above, the NIMBUS image was released to the press on the 23rd and used by the media later.

This view of Earth is also captured on video. On the way back from the moon the crew made a couple of TV broadcasts capturing their thoughts after successfully landing. One such live broadcast shown on ABC news is recorded here: [youtube source](https://www.youtube.com/watch?v=source). The date of the broadcast is not given specifically in the clip, but the words in the mission transcript make it clear that is the one made at 155:36, or just after 01:00 GMT on July 23rd. There is discussion before the broadcast of trying to get the moon and Earth in opposite windows ready for the broadcast, and Mission Control initially mistake a now very distant moon for the Earth.

At 155:51, or around 01:20, after some demonstrations of life in weightless conditions, Collins says:

"Roger. Stand by one, and we'll get you that Earth one."

and begins a long zoom into what is initially a white blob, but ultimately ends in the screenshot shown in figure 4.3.83. Figure 4.3.84 shows that image in comparison with the ESSA & ATS images, as well as AS11-38-5693. The view was available not just to the US (below left) but any country that took the TV, as can be seen in the Dutch TV image shown below right.

After the broadcast, at 156:12 MET into the mission, or about 01:35 on the 23rd, shortly after a TV broadcast, Collins reports that:

"Roger. We were watching a few clouds in your area through the monocular along the Texas Gulf Coast this afternoon, and we also noticed there were clouds over Baja California, which is a little bit unusual."

so they were clearly positioned correctly in space to see what Stellarium says should be visible.

Returning to the Apollo rescue story, what is evident is that there were several satellites, and even eye witness reports from space, containing the information that NASA required to judge whether a landing site was safe or not.
Figure 4.3.84: TV image from 23/07/69 compared with ESSA-9 (left top & bottom), ATS-1 (top right) & AS11-38-5693 (bottom right). Colours are as in figure 4.3.79.
Can we find anything to support Brandli’s version? Certainly at this point in the mission NASA weren’t worried and advised through Capcom:

“We got the - along the tropical convergence line there, there’s a few clouds shown on the weather map I’m looking at here, but nothing of significance...are a couple of tropical storms in the - well, not in the area of landing but in the Pacific. A storm called Claudia which is north - correction - about east of Hawaii. It’s going north-west and dissipating. And there’s one called Viola, which is out over Guam, and so they aren’t any factor at all. It looks like it's going to be real nice for recovery.”

Even at about 172 hours in (around 17:35 on the 23rd), Capcom are still unperturbed:

“Present forecast shows acceptable conditions in your recovery area: 2000 foot scattered, high scattered, wind from 070 degrees, 13 knots, visibility 10 miles, and sea state about 4 feet. The forecast yesterday showed a tropical storm, Claudia, some 500 to 1000 miles east of Hawaii. The - the pictures from Earth satellites taken yesterday afternoon - afternoon showed Claudia dissipating, so this appears to be even less a factor than it was before. Your recovery area is now believed to be just a little ways north of the inter-tropical convergence zone, which you can probably see when you look out your windows there. Yesterday there was also a report of a tropical storm, Viola, further to the west. Its present location is some thousand miles east of the Philippines and moving northwest. Tropical storm Viola has been intensifying, and should be transferred to the typhoon category within the next 12 hours or so; however, that will be far to your west. As a matter of fact, sunrise terminator has not yet reached Viola. When it does several hours from now, you can probably distinguish it from your viewpoint quite readily. As a matter of fact it should be of interest to perhaps take some pictures. Comment on it when you get a chance to see Viola in a few hours. So that’s about the present weather state and situation for your recovery area.”

While NASA were relaxed, other areas of the operation were evidently concerned. The navy photographer for the recovery operation reports (in Navy History) that:

“Deteriorating weather with rain, high winds and rough seas approached the Primary Recovery Area and caused much concern on July 22. The Navy and NASA decided it was best to move the splashdown site to another location 250 miles from the storm. USS Hornet steamed at full speed to the new location 950 miles southwest of Hawaii. A few of the crew wondered if we’d be late for splashdown.”

And in this article Popular Mechanics, Chuck Deiterich, retrofire officer (RETO) for the black team at Mission Control and therefore responsible for the re-entry phase says:

“About 16 hours before re-entry the recovery guys came up and said, "Hey, we've got bad weather where you're going." It was too late to change the time of flight, to let the Earth rotate underneath you, so what we did was fly an entry range. You could actually fly a different trajectory through the atmosphere and land [further] downrange”

The above has been ‘translated’ from the many abbreviations used. “130” refers to Task Force 130, the naval flotilla responsible for recovery, of which USS Hornet was the lead vessel. The start of the log specifically notes that it will record weather reports and observations, so obviously they were keeping an eye on the situation regardless of any secret operations. It is interesting that the last comment says that it is 130’s forecast, rather than NASA or ESSA (in the book Space Launch Complex 10, which also recounts the story, it is mentioned that the US Navy were providing the forecasts).
The entry for 01:30 on the 24th says:

"Retro says if we move [recovery] he would want to move it no more than 80 nautical miles uprange or no less than 150 nautical miles downrange. 130 recommends approx 250 downrange for new [target point]."

And the move is confirmed in the log at 03:05, so that by 181:42 MET (c. 03:15 on the 24th) Capcom can relay the following to Apollo 11:

"the weather is clobbering in at our targeted landing point due to scattered thunderstorms. We don't want to tangle with one of those, so we are going to move the - your aim point uprange. Correction, it will be downrange, to target for 1500 nautical mile entry so we can guarantee uplift control. The new coordinates are 13 degrees, 19 minutes north, 169 10 minutes west. The weather in that area is super. We got 2000 scattered, 8000 scattered with 10 miles visibility and 6 foot seas and the Hornet is sitting in great position to get to that targeted position."

We also have evidence from USS Hornet herself. This document Military History records the official time of the course change as 04:04 on the 24th, giving the reason for that change as

"a forecast of marginal weather"

And later notes that

"The evening prior to splashdown... weather in the end-of-mission area became marginal. Dense cloud cover, thunder storms and frequent rain squalls were forecast"

USS Hornet’s own handwritten logs (available at Research Archives) also record the course change at that time.

It is entirely possible that Brandli’s version of events is true, and he did find evidence of likely problems in the landing zone independently of ESSA in the military’s DAPP satellite data, and went hell for leather to Captain Houston to report his findings. It certainly seems that the course change was sudden and relatively late in the day and his actions in relating that to someone who was in a good position to influence matters may well have been crucial. This has to be reconciled with ESSA’s own reports that they were seeing this by the 22nd that certainly weren’t top secret, and that Task Force 130 were producing their own forecasts (this magazine has an article stating that US Navy ships had their own receivers for satellite images).

We know from the numerous examples presented in this research that the satellite images used by NASA were of very high quality, certainly better than the one shown in figure 4.3.78. We know that ESSA’s satellites & personnel were closely involved in this and other missions so they must have had access to accurate forecasts. It’s also fair to say that DoD satellites had a more sophisticated array of specialist sensors, even if the overall image quality was comparable it could measure things more precisely and used more parameters to aid forecasting.

There are areas in the image shown in 4.3.78 that have broad similarities with ESSA & Apollo photographs, but others where there are clear differences. It is possible that the chosen DAPP image is one that was available, rather than the actual one presented by Brandli. There are also many areas where the two stories contradict each other. The 'Screaming Eagles' image is difficult to reconcile with those taken by ESSA & ATS-1 on any of the days of the mission.

For example where are the cloud and fog banks off Baja California and California that have been a persistent feature over the mission? It is possible that cloud bands picked out by the yellow arrow in the southern Hemisphere and the blue arrow in the north are those either side of the image label “Cu Streets” in figure 4.3.75, but the type of cloud is completely different, and the 'screaming eagles' don't seem to be there at all.
Maybe Brandli’s story is correct and ESSA’s is just a cover, but it is a cover that has the benefit of using many well publicised ‘free to air’ satellites and a team of meteorologists actually based with NASA and that was published months, rather than decades, after the landings. Houston’s Navy Commendation citation is certainly genuine, and specifically cites his role in diverting the rescue fleet.

We also know that the military had well documented involvement in weather forecasting. Patrick Air Force Base had their own newsletter, “The Missileer”, and just before Apollo 11 this edition detailed the convening of the support group, including a Lieutenant Colonel RH Dowd as being the liaison for weather. There is also the well known antipathy between military and civilian outfits to consider.

Interestingly, this edition discusses the role of the NIMBUS satellites in mission support in SE Asia, while this one details Apollo 9’s support role by the Department Of Defense - including weather support and showing RH Dowd as involved. However, the involvement of the military does not necessarily mean all of the military, and some programs may well have been too secret to share! Then again, this history of DMSP satellites suggests their existence was already well known in 1969, with all three military services using their forecasts. It’s worth noting that this book reports that the US Navy did not use DMSP imagery when at sea.

We also have slightly contradictory testimony from Scott Carmichael’s book “Moon men return: USS Hornet and the Recovery of the Apollo 11 Astronauts”:

"Hornet occasionally sent aircraft aloft to check weather conditions within her immediate operating area, but she had no means to collect weather data beyond the limited range of such flights. Conditions which developed far over the horizon were hidden from view. And commercial weather satellite systems simply did not exist in 1969. So it was impossible for Hornet to predict weather conditions days in advance of the splashdown."

This is obviously not quite correct - although commercial satellites were not around, there were certainly plenty of civilian satellites in operation covering the landing areas in detail and these were definitely available to NASA and you could do forecasts - that was the SMG’s job!

A likely scenario would be that Brandli, working at the same air force base (Hickam Field) that provided recovery and weather reconnaissance aircraft for Task force 130, sees the images and data and produces a forecast that threatens the mission. He then contacts an officer with direct links to the SMG - Captain Houston. Houston passes on his information, the SMG then deliberate the evidence from all sides, revise their forecasts and suggest a new landing area. It’s also possible that the Navy and SMG arrived at their conclusions independently! This would seem to be borne out in the book “Hornet Plus Three”, which states:

“Hornet relayed the on-scene weather information...while a Navy WC-121N based in Guam surveyed the larger frontal area. NASA had already received a warning from a national military weather operations group, whose data was based on the then-classified Defence Meteorological Satellite Program (DMSP satellite system. For safety reasons, Mission Control decided to move the splashdown point”

Which shows pretty much everyone was saying “hang on guys...”

The story they release is technically accurate in that ESSA changed the landing area thanks to a new forecast, but the detail revealing the role of a classified military satellite in the process was omitted. Brandli has also written elsewhere on the Data Acquisition and Processing Program and its results, which used military polar orbital satellites, eg Air Power and MWR and is clearly knowledgeable on the subject, with these articles appearing after the initial declassification in 1973. The claim made in some articles that DMSP satellites could provide a 5 day forecast is more likely to be due to his abilities as a forecaster than the satellite’s own properties. It’s also notable, and perhaps unfair, that he was not given the same recognition as Captain Houston.
It's unlikely that the image used in many articles showing the 'Screaming Eagles' is the one used by Brandli (he may even have coined the term!). Even the mosaic ESSA images are of comparable quality, and the zoomed in images from ESSA & NIMBUS used here are extremely clear and detailed.

It could even be likely that the eagles in question are the cloud formations, resembling waves, surrounded by the red box in this NIMBUS image (figure 4.3.85).

Figure 4.3.85: Cloud formation around the original landing area for Apollo 11 (marked with an X) from a NIMBUS image dated 22/07/69

If that is the case it further complicates the story, as this photograph is one publicly released to the media! Whatever the truth of the matter, Apollo’s eventual landing zone was altered, Captain Houston was credited with saving their lives, and the shifting weather patterns are recorded in Apollo’s images.

We digress – there is still some time to go before recovery, and there are more photographs to analyse, An example of this detail occurs next in the narrative.

Another weather system around on the 22nd, one that is mentioned on several occasions in the mission transcripts, is Tropical Storm Claudia. Claudia was a short lived storm that formed off Hawaii on July 21st and was dying away by July 23rd. It was reported in several journals, including the monthly weather review: MWR. It is also mentioned in the Mariner’s weather log in September 1969 (MWL). Claudia was hidden by darkness in the photographs from the 21st and 22nd, but should be visible as a remnant on the 23rd in AS11-38-5693.

Figure 4.3.86 shows Claudia as seen from ESSA 8 on the 21st (from the MWR), ESSA-9 (MWL), and in the early hours of the 23rd from Apollo 11 (AS11-38-5693). Capcom kept Apollo 11 up to date about Claudia as a possible problem with the recovery mission, but it was downgraded late on the 23rd to a depression and ceased to be an issue. The Weather Log identifies Claudia with an arrow, but this is indistinct on the reproduction and therefore a clearer arrow has been superimposed. Bearing in mind the preceding story concerning NASA's allegedly poor quality images, it is interesting to note the quality of the image published in the MWL.
Figure 4.3.86: Tropical storm Claudia on the 21st (bottom left), 22nd (right) and the early hours of the 23rd (top left). Sources identified in the text.

For the next image we have a return to a view of Australia, this time from Magazine 38.

AS11-38-5697 occurs after a few images of a now very distant Moon, and is shown below in figure 4.3.87. It is analysed in figure 4.3.88.

Figure 4.3.87: AS11-38-5697. High quality source: AIA
Figure 4.3.88: ESSA-9 (top left) and NIMBUS-3 (bottom left) images compared with AS11-38-5697 and Stellarium estimate of time at terminator. Bottom right is close up of Apollo image compared with NIMBUS tile.
Figure 4.3.88 continued: AS11-38-5697 and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS (right) data
There are some features on this image that can also be found in the previous one, but they are mostly unidentified to allow for new features to be picked out. The blue arrow in figure 4.3.73 shows the same arrow as the cyan arrow in this one. The purple and yellow arrows in figure 4.3.76 show systems that are still (just) visible in figure 4.3.87. It’s interesting to note that the weather systems that were so prominent around Australia on the days around the landing have largely disintegrated and are much less coherent than before. The storm picked out by the yellow arrow is shown in (level adjusted) detail with the corresponding NIMBUS tile just because it is undeniably there! The storm’s location is consistent with the track of Tropical Storm Viola, as shown here.

Stellarium estimates a time for this image as around 05:30 on the 23rd, derived largely from the position of Australia. ESSA’s terminator orbit (track 6, pass 1832) commenced at 00:05 on the 23rd. The NIMBUS terminator pass (or at least the first one with any data) is orbit 1338, which commenced at 01:57 on the 23rd. The next set of images of Earth consist of another pair taken with different cameras, one from magazine 38 and one from the colour magazine 44.

By way of variety, the colour image, AS11-44-6672 will be compared with the satellite images. It is shown below in figure 4.3.89 and analysed in figure 4.3.91. AS11-38-5703 is shown in original form and with the Earth zoomed and cropped as figure 4.3.90.

![Figure 4.3.89: AS11-44-6672. High quality source: ALSJ](image-url)

![Figure 4.3.90: AS11-38-5703 (left, source: AIA) and zoomed & cropped (right)](image-url)
Figure 4.3.91: Main image shows ESSA-9 (left), ATS-3 (bottom right) compared with AS11-44-6672. Stellarium estimate of time at terminator (bottom left). Overleaf - NIMBUS-3 IDCS is (left) and HRIR (right)
Figure 4.3.91 continued: AS11-44-6672 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (right) data
Figure 4.3.91 (cont’d): NIMBUS-3 IDCS (left) and HRIR (right).
Stellarium estimates a time of this image as around 17:00 on the 23rd, and it is beginning to be more noticeable that the Earth is moving towards a crescent shape as time passes. The colour image hardly differs from the black and white version, although the different angle of the Earth (caused by the PTC roll) suggests that there is a small time gap, it is difficult to pick out anything along the terminator that would indicate how much.

Figure 4.3.92 shows one area that hints at the colour image being taken first, as there seems to be more visible of the cloud trending from the centre to the 4 o’clock position at the terminator, but as before it could easily be a product of image quality.

Figure 4.3.92: Comparison of sections of AS11-44-6672 (left) and AS11-38-5703 (right)

Figure 4.3.93: AS11-38-5706. High quality source: AIA
Figure 4.3.94a: Main image shows ESSA-9 (left) compared with AS11-38-5706, ATS-3 (bottom left) and Stellarium estimate of time at terminator. Overleaf NIMBUS-3 IDCS (left) and NIMBUS-3 (right).
Figure 4.3.94a continued: AS11-38-5706 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (right) data
Stellarium puts the Apollo image as being taken at 19:30, and it is interesting to note that the crescent on Stellarium is more pronounced than that of the Apollo view, with Stellarium's lunar viewpoint becoming more divergent from the Apollo one as it nears home. Despite this being 5 hours after the ATS-3 detail was taken, the weather formations are still identifiable and obvious.
During their wake-up call from Capcom, the crew are informed that:

“The forecast yesterday showed a tropical storm, Claudia, some 500 to 1000 miles east of Hawaii. The pictures from Earth satellites taken yesterday afternoon – afternoon showed Claudia dissipating, so this appears to be even less a factor than it was before. Your recovery area is now believed to be just a little ways north of the inter-tropical convergence zone, which you can probably see when you look out your windows there. Yesterday there was also a report of a tropical storm, Viola, further to the west.”

This is, again, confirmation that NASA were using their own satellite images to monitor closely weather conditions likely to affect the landing area, and also that the landing zone had moved.

As far as the satellite timings are concerned, ATS-3’s recorded time is still 15:17, roughly 5 hours before Stellarium suggests Apollo took its image. ESSA’s orbital track over the terminator (track 1) on the 23rd is number 1839, which commenced at 14:02. NIMBUS’ equivalent orbit, number 1344, was commenced at 12:41.

A couple of images later, we have AS11-38-5708 for consideration. This is shown below in figure 4.3.95, and analysed in figure 4.3.96.

![Image](source.png)

Figure 4.3.95: AS11-38-5708. High quality source: AIA
Figure 4.3.96: Main image - ESSA-9 images compared with AS11-38-5708 and ATS-3 (bottom left) with Stellarium estimate of time at terminator. Overleaf – NIMBUS-3 IDCS (left) and HRIR (right).
Figure 4.3.96 continued: AS11-38-5708 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (right) data.
Figure 4.3.96 (cont’d): NIMBUS-3 IDCS (left) and HRIR (right)
In this photograph, there has been sufficient rotation of the Earth to allow the spectacular weather system off western south America to come more clearly into view, but not sufficient to completely remove some of the cloud patterns visible in the previous analysis. The cyan, yellow, magenta and blue arrows all point to features visible in figure 4.3.91.

Stellarium puts the time of the photograph as around 22:00. The time of the ATS image is, as usual unchanged. ESSA’s orbital pass over the terminator is number 1840 (track 2), which commenced at 16:07 on the 23rd. The NIMBUS pass for the same region is 1345, which commenced at 14:28 on the 23rd.

We also have another live TV broadcast on the 23rd with views of Earth to look at, where the crew gave their thoughts and impressions of their achievement to the folks back home. Towards the end of that broadcast they turned the camera towards that home to give us an upside down view of Earth. That view is shown in figure 4.3.97 together with a dated press screenshot and a newspaper front page dated the following day, and analysed in figure 4.3.98.

Figure 4.3.97: Screenshot from this [youtube](https://www.youtube.com/watch?v=example) footage of Apollo 11 TV Broadcast 23/07/69, a dated press photo taken from the broadcast, and a newspaper front page for sale on eBay dated 24/07/69.
Figure 4.3.98: Main image - Zoomed and cropped image from TV broadcast 23/07/69 compared with NIMBUS-3 (left) and ESSA (right) images from the same date. Stellarium depiction of terminator at time of broadcast is on the right. Overleaf are NIMBUS-3 IDCS and a compilation of two NIMBUS-3 HRIR orbits and an MRIR orbit.
Figure 4.3.98 continued: Apollo 11 TV still and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (right) data
Figure 4.3.98 (cont’d): NIMBUS-3 IDCS (left) and HRIR (right)
As far as timing goes we can be pretty exact about the Apollo image. The TV broadcast is recorded as being made between 23:04 and 23:16 on July 23rd. At 23:15 we have a comment from Houston as the camera focuses on Earth:

177:43:52: 11, this is Houston. We’re getting a zoom view out the window now.

Stellarium shows that North America would not be completely in view, but you would have the west coast of the USA and Mexico in daylight. The part of South America just visible in the preceding analysis is almost entirely gone in the 75 minutes or so that have elapsed since it was taken.

The satellite view confirms that this is indeed what we are seeing, even if the land masses themselves are not entirely clear.

The main feature in the northern hemisphere are the fog banks off California (blue arrow) that extend all the way to the western limb. Moving into the southern hemisphere we have a striking swirl off south America (purple arrow), and then the striking system identified by the red arrow that was not quite fully in view in the preceding analysis.

The scene is entirely consistent with the amount of rotation that would be expected over this time period, in terms of the position of the terminator and the change in weather patterns visible. It’s worth pointing out that even the medium resolution infra-red pass (used here in the absence of an HRIR pass) shows a more than adequate match with the Apollo image.

ESSA’s terminator pass would be roughly track 4 (orbit 1842), which commenced at 19:07 on the 23rd, whereas the NIMBUS pass (around number 1346) commenced at 14:28.

The next image of Earth is a return to the colour magazine, number 44, and shows the scene a few hours later, with the journey home into its final day.

Figure 4.3.99 shows AS11-44-6674, and this image is analysed in 4.3.100a.

Figure 4.3.99: AS11-44-6674. High quality source: ALSJ
Figure 4.3.100a: ESSA-9 (left) and NIMBUS-3 (right) images compared with AS11-44-6674. Lft is a NIMBUS-3 MRIR HRIR hybrid image and Stellarium estimate of time at terminator is above.
Figure 4.3.100a continued: AS11-44-6674 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (right) data
This photograph is clearly taken not much later than the preceding one from the TV broadcast. Now all of south America has gone, but much of north America is still visible, and the persistent fog banks off California (blue arrow) dominate the view of the northern hemisphere. The large system in the south identified by the red arrow is also visible in figure 4.3.79, but in a slightly different formation, and slightly further east. Stellarium puts the terminator, just off the east coast of the USA, at around 01:30 on the 24th, 15 hours before re-entry. ESSA’s terminator orbit is track number 3, or orbit 1841, which commenced at 18:02 on the 23rd. Much of the NIMBUS data is either poor or missing for this image, and few features are easily made out. However, the orbital pass over the terminator is still best represented by orbit number 1346, which commenced at 14:28 on the 23rd.

As with the Apollo 8 mission, July 24th is a day that sees the use of a Corona satellite, and three sections of that day’s orbits cover the USA seen in this Apollo image (figure 4.3.100b).
It’s worth pointing out here that the Apollo image (as well as having brightness and contrast adjusted) has been rotated to match the Google Earth orientation.

What the Corona images show is an area of cloud south of Baja California, broken cloud over the Sonoran desert, and thicker cloud over Utah. While it would be unwise in this case to state definitively that this is exactly what we can see in the Apollo image, there are certainly areas of agreement - particularly the area over Utah. Judging by the cloud shadows the images appear to have been taken around noon, compared with the Apollo image’s late afternoon local time.

The next image of Earth on magazine 38 shows a very similar scene, and was taken only an hour later (if Stellarium is to be believed) than AS11-44-6674. AS11-38-5712 shown below in figure 4.3.101, and serves merely as a bridge to the next image to be analysed fully, AS11-38-5719 is also shown below in figure 4.3.102, and analysed in figure 4.3.103a.

Figure 4.3.101: AS11-38-5712 (left, source: AIA) and zoomed & cropped (right)

Figure 4.3.102: AS11-38-5719. High quality source here: AIA
Figure 4.3.103a: ESSA-9 image (left) and NIMBUS-3 HRIR orbit 1351 (right) compared with AS11-38-5719 and Stellarium estimate of time at terminator.
Figure 4.3.103a continued: AS11-38-5719 and 3D reconstruction using digitally restored ESSA (left) and NIMBUS (right) data
It should be evident that there are still features visible on this photograph that are also visible on the previous two pictures used from this magazine. The red, yellow and cyan arrows all point to the same cloud features shown in those colours in figure 4.3.99 while the magenta arrow in that figure picks out the eastern end of the band of cloud marked by the green arrow in figure 4.3.102. The banks of fog off the US coast are still visible at the northern end of the terminator line.

ESSA’s nearest orbit to the terminator is number 1843 (track 5), which commenced at 21:03 on the 23rd. Stellarium’s estimate is that the photograph was taken at 02:30 on the 24th, 14 hours before re-entry. We only have one NIMBUS-3 pass of any use, orbit 1351, which commenced at 01:13 on the 24th. At first glance it does not look too similar to the Apollo image, but it needs to be remembered that it is infra-red, not visible spectrum. If we look more closely (figure 4.3.103b), the similarities become much clearer.

The closer examination makes it much clearer - the time gap between the two images is negligible (remember that the start of the orbit is timed from the poles) and as a result the two images are almost identical. The last images on magazine 38 are all repeat exposures of the image just examined, and we now return to magazine 44 for our final two images of a full Earth. The penultimate image examined is AS11-44-6676, which is shown below in figure 4.3.104, and analysed overleaf in figure 4.3.105.
Figure 4.3.105: Main image - ESSA-9 dated the 24th (far left) and the 23rd (left), and NIMBUS-3 (right) images compared with AS11-44-6676 and Stellarium estimate of time at terminator. Below is the newly restored NIMBUS-3 mosaic and orbit 1355 of the HRIR.
Figure 4.3.105 continued: AS11-44-6676 and 3D reconstruction using digitally restored ESSA data.
As the Earth becomes increasingly crescented, identifying cloud masses becomes a little trickier. The first task here is to identify the landmasses visible on the western limb, and close inspection reveals that we are looking at the east coast of Africa. The blue and green arrows point to clouds over Somalia and Arabia respectively. Life is complicated even further by the fact that as the image features Africa, the area visible on the western limb features weather patterns shown on the ESSA image dated the 24th, while those over the Indian ocean are the last featured on the image dated the 23rd. For this reason, sections of both ESSA mosaics are included. The NIMBUS data are poor quality and much of the area visible is either not available or difficult to make out, and for this reason only the blue and purple arrows are used with any confidence.

The cloud masses identified by the blue and green arrows are not visible on the image dated the 23rd, but are shown on the one dated the 24th, which helps date things more precisely. Stellarium estimates that the Apollo image was taken at around 17:30 on the 24th. ESSA's nearest orbit to the terminator is number 1848 (track 10), which commenced at 07:00 on the 24th. NIMBUS' nearest pass is number 1353, which commenced at 04:15.

The final image examined, and the final full disc image of Earth taken, is AS11-44-6689, shown below in figure 4.3.106 and analysed in figure 4.3.107. Alongside the still image is a still from magazine M of the 16mm footage, which is evidently the same view.

![AS11-44-6689](image1)

![Still from magazine M](image2)

Figure 4.3.106: AS11-44-6689 (left - high quality source: ALSJ) and still from magazine M of the 16mm DAC footage (right).
Figure 4.3.107: Main image - ESSA-9 (right) compared with AS11-44-6689 (centre) with Stellarium estimate of time at terminator inset, and NIMBUS-3 IDCS (below left) and NIMBUS-3 HRIR (below right) orbits.
Figure 4.3.107 continued: AS11-44-6689 and 3D reconstruction using digitally restored ESSA data
It should be evident to even the least observant that the preceding figure used only one satellite photograph. We do have the restored image from NIMBUS, but the path that is available covering Africa shows very little useful information relevant to the visible part of Africa on the Apollo image. No useful part of ATS-3’s view is available. Even with only relatively little satellite data, it is still relatively easy to pick out weather patterns on the image that are different to the ones visible on the 23rd's satellite image.

As for dating the image, the most representative track relating to the Apollo image terminator is number 11, which is 1849, and commenced at 09:05, which compares well with the 14:30 time suggested by Stellarium. We get few clues from the transcript, but at 193:03 (14:35) we have this from Collins:

“The Earth is really getting bigger up here and, of course, we see a crescent...We’ve been taking pictures and we’ve still got four exposures to go, and we’ll take those and then pack the camera.”

The remaining images in the magazine are zoomed in much more closely on Earth, and the terminator line on these is closer to the African coast, indicating that they were taken after this statement was made. The terminator line on the 16mm still in figure 4.3.107 suggests that it was filmed about 30 minutes prior to the still image.

One thing that is worth examining relates to data supplied by NOAA from their work rescanning and processing ESSA imagery mentioned in the introduction. They supplied an image not in the usual polar projection, but one where all the individual tiles have been overlaid as a flat image - see figure 4.3.108.

Figure 4.3.108: ESSA 9 image compilation supplied by NOAA
The backing paper has seen better days, but you can easily identify the landmasses on show. As only Africa is visible in these last Apollo images, so it’s worth zooming in on a the African part of this image to see how it compared with the most zoomed in image taken, **AS11-44-6692** (see figure 4.3.109).

Figure 4.3.109: AS11-44-6692 Compared with ESSA-9 image flat projection

As you can see there is an excellent match with the clouds in both images, particularly the arc identified by the blue arrow.

Roughly two hours after the Apollo image was taken the CM separated from the SM and the crew began the re-entry procedure. 140 minutes after the image was taken they were in the Pacific, safely away from stormy weather thanks to the satellite images used in this analysis to help prove that they went to the Moon.
So there we have it, the first lunar landing covered from start to finish, with every series of photographs of Earth analysed and compared with satellite photographs to demonstrate that the pictures taken by Apollo 11's cameras could only have been taken where they were claimed to have been taken, including, for the first time, the surface of the Moon.

Having compared a variety of satellite images with photographs covering all parts of the Earth's surface during all parts of the mission, there really should be no more need for any meteorological analysis, but there is always a need for thoroughness.
4.3.2 Meteorological sources

Thanks to the fame of the mission, many of the Apollo missions' critics and doubters focus on it in their endless search for the trivial that they believe will help to defend their position. The corollary to this is that much research has been done for Apollo 11 to support it.

Apollo 11's synoptic charts have already been examined in some detail on sites like Apollohoax.net, and at the end of this article on the Apollo TV broadcasts. These have tended mostly to focus on the data held as NOAA's weather charts for the USA. This report has deliberately not referred to this other work when writing the following discussion in order not to be influenced by them. The reader is free to make their own interpretations of the data available and use their own methods.

As well as the NOAA data, the same German and South African sources available for Apollo 10 are available here, and these are all from the same source as the Apollo 8 analysis. The Apollo 11 source for German data is here: http://docs.lib.noaa.gov/rescue/cd282_pdf/LSN1163.PDF and the South African data here: http://docs.lib.noaa.gov/rescue/cd126_pdf/LSN0734.PDF. There are also synoptic charts from Pakistan. Other sources are available that contain meteorological data, but these tend to be numerical records rather than charts and aren't useful.

A few days from the mission will be chosen that allow the maximum use of the available charts, starting with an image that was dealt with earlier and two images taken before and after it. AS11-36-5381 was, if we can assume the analysis presented here is correct, taken on July 18th. From the same magazine image 5377 and 5401 (also used earlier) show different parts of the Earth on the same day, which allows us more complete coverage. Figure 4.3.110 shows these Apollo images in comparison with German and NOAA charts.

As with previous sections for Apollo 8 & 10, no claim to in-depth meteorological expertise is made here, but there are obvious comparisons on the charts that match with the systems shown in the Apollo photographs. Also evident are the differences in interpretation that meteorologists from different organisations place on the information with which they are presented.

NOAA, for example, place a cold front off western Canada/USA (blue arrow) that isn't identified on the German synoptic chart. NOAA also place a pattern of broken fronts across the mid-west and north-eastern US states leading into the Atlantic, whereas the German data suggest a continuous unbroken front starting more around the northern Rockies area. Some of these differences may be related to differences in scale. The German map covers the entire northern hemisphere, and necessarily has less detail in it thanks to space considerations. NOAA has more details because it covers a smaller spatial extent.

What should be evident is that German & South African meteorologists drew weather charts that match the systems on an Apollo photograph. Sceptics can argue about the independence or otherwise of NOAA staff (it would be interesting to see them say it to their faces), but any arguments suggesting that weather scientists with absolutely no connection to NASA or the Apollo mission were also in collusion begin to stretch the already tortuous conspiracy argument even further into the realm of the ludicrous.

After the 18th there are relatively few Apollo images that provide useful vantage points from which we can compare synoptic charts, as the timing of the mission and the angle of the Earth as viewed from the Moon means that the usual northern hemisphere land masses are generally unavailable, at least for the period in lunar orbit, and other than South Africa, southern hemisphere data are not available.
Figure 4.3.110: AS11-36-5377 (top right), 5381 (top middle) & 5401 (top left) compared with German (middle), NOAA (bottom left) and South African (bottom right) synoptic charts.
For the period covering lunar orbit, we are therefore reliant on just two images, AS11-37-5442 and AS11-41-6023. These images were covered in figures 4.3.52 and 4.3.54 respectively and have been identified as taken on the 20th, the former from the CSM, the latter from the LM.

Not enough of southern Africa is available for a worthwhile comparison with the synoptic chart, as the only front (and therefore the only part of the only part likely to show any significant cloud formations) marked on the chart is in an area in darkness on the Apollo image, and for this reason only the NOAA and German synoptic data will be used.

Figure 4.3.111 shows these two Apollo images compared with the synoptic charts. As indicated, there are relatively few identifiable fronts on the weather charts, but the persistent front across the northern USA stretching into the Atlantic is still identifiable, as are the fronts associated with the depression off northern Europe. The high pressure zone marked over northern Canada is also producing a relative lack of cloud over that region.

Figure 4.3.111: German (top) and NOAA (bottom right) synoptic charts compared with AS11-37-5442 (bottom left) and AS11-41-6023 (bottom middle).
While most Apollo 11 images from the vicinity of the moon are of Australia, AS11-44-6642 (examined in figure 4.3.64) does show the Americas and a considerable portion of the North Atlantic. NOAA & German synoptic charts are shown with the Earth from this image in figure 4.3.112.

There is really only one definitely identifiable front on this image, the long one starting out over America (blue arrow) before heading out over the Atlantic (green arrow). The yellow arrow is used to suggest that the cloud mass visible on the Apollo image on the eastern horizon is the same as the front on the German chart, but this can not be absolutely certain thanks to the angle involved.

The final synoptic charts analysed are shown in figure 4.3.113-4 and are from July 22nd and 23rd.
Figure 4.3.113: German (top) and NOAA (bottom right) synoptic charts compared with AS11-38-5687 (bottom left) and AS11-38-5684 (bottom middle).
Figure 4.3.114: German (top) and NOAA (bottom right) synoptic charts compared with AS11-38-5707 (bottom left) and AS11-38-5703 (bottom middle).
Figure 4.3.113 shows AS11-38-5684 & AS11-38-5687. The former was examined in figure 4.3.71 and shown to be dated as the 22nd of July, and the latter was taken a few frames later the same day.

The blue and green arrows identify a single weather front (as identified by our German friends) but showing broken cloud along it. This broken cloud is reflection of the nature of the air masses along that front, as hidden under the red line used to mark it more clearly here is a mixture of warm & cold fronts (in other words a change in the nature of the 'leading edge' of the air masses. The German meteorologists have perhaps oversimplified the situation in using one long line.

Figure 4.3.114 features AS11-38-5703 & AS11-38-5707. The former was examined in figure 4.3.91 and identified as being taken on the 23rd, the latter in figure 4.94. The long trans-Atlantic system has continued to develop and is now no longer shown as an unbroken front, and appears to have split in two as one half heads towards Africa, with attendant clouds in tow.

One final image is worth including. Newspapers have long included weather forecasts in their pages, and after contacting http://www.honeysucklecreek.net/ on their website about ARIA support for the Apollo missions, a scan of the synoptic chart from “Sydney Herald” newspaper was very kindly supplied. The image shows fronts marked off south east Australia, fronts which brought snow to the Australian Alps, and heavy rain and wind elsewhere. The map is dated 20/07/69, and is shown in figure 4.3.115 in comparison with views of Australia from that the 20th and 21st of July.

![Sydney Herald Map](image)

Figure 4.3.115: Sydney Herald chart dated 15:00 20/07/69 (local time) compared with AS11-44-6551 crop of Australia.

The frontal systems marked on the map show clear correspondence with those on the Apollo image. The time given on the newspaper is local, and thus the GMT would be roughly 03:00 on the 20th. As discussed previously, a professional meteorologist is better qualified to comment on these synoptic charts, but to any observant eye there is no inconsistency between the weather charts produced on the ground and the weather patterns visible in the sky, from space, on the way back from the Moon.

Apollo 11 then, finally brought to a close. The most historic flight ever made, documented and analysed from start to finish by the clouds shown TV broadcasts and still photographs, with every image consistent with the Earth’s rotation and satellite photographs.
4.4 Apollo 12

Despite launching only 5 months after arguably the most historic event in history, Apollo 12 is remarkable for being almost forgotten in the grand scheme of human achievement, and in popular memory it has neither the excitement and hope of Apollo 11 nor the drama of Apollo 13. Politically, Apollo was already being shaved back (missions had actually been cancelled before Apollo 11 had even taken off), and many people began to hold the view that there were more important and pressing problems on the home planet that could use the money being spent on the Apollo programme. After all, we had “been there, done that”. We’d made our point, why go again?

It did, however, have the claim to fame of being the first mission to have a pinpoint landing. While Apollo 11 had a landing area within which the crew wanted to set down, the trajectories for Apollo 12 were calculated to put the LM in a very specific spot, something they achieved with sufficient skill and precision to allow them to rendezvous with a much earlier NASA experiment, the Surveyor III craft, which had landed in 1967 in a partially successful mission to sample & photograph lunar soil.

The Saturn V launched at 16:22 on 14/11/69, landing on the moon on 19/11/69. The crew stayed on the surface for 31.5 hours, re-uniting with the CSM on the 20th, and finally splashing down on the 24th. The mission's main claims to fame are being hit by lightning at launch, and the failure of the colour TV camera, which was burnt out almost as soon as it was set up on the Moon by being pointed directly at the sun. This forced the US TV networks to hire actors on a set to perform the astronaut's roles to the recorded voices of the crew. It's ironic that while many accuse Apollo 11's lunar surface broadcasts of being performed by actors on a set, Apollo 12’s actually were (figure 4.4.1).

They did, however, manage to take still images. During the mission they used 14 magazines of film to take 2119 images, the bulk of which are of the lunar surface (either from orbit or from the ground). Relatively few photographs exist of Earth once out of Earth orbit, and because of the mission’s timing, significant numbers of these are of a crescent globe – much less of the surface is visible than in previous Apollo missions.

These photographs are available at the ALSJ & AIA, but for several the images used show an overexposed Earth. Where necessary, images have been obtained from the Gateway to Astronaut Earth Photography (GAP). Some high quality TIFF images are available at http://archive.org. TV screen captures will be used where available (see figure 4.4.1 for sample source).

As with Apollo 11, 3 satellites are available for comparison with these still images: ATS-3, Nimbus-3, and ESSA-9. ATS-3 images for the period covering Apollo 12 are in this document. NIMBUS-3 images can be found here: Source, and ESSA 9 here: Source. The same NIMBUS data recovery project that provided new images for...
Apollo 11 also furnished new photographs for Apollo 12, and they will be added where appropriate. High resolution strips from the NIMBUS-3 HRIR are also available, again from sources cited for Apollo 10 and 11.

There are also isolated examples of close-ups from these satellites, which allows better quality. This document contains a close up NIMBUS image of the Sahara desert from November 18th Best of NIMBUS, and this one shows a close up of New Zealand, also from November 18th and also from NIMBUS, New Zealand Journal of Marine and Freshwater Research. The Mariners Weather Log from January 1970 (Volume 14, Number 1) contains a more detailed image from ESSA of North America on the 21st of November Source showing Hurricane Martha over Panama. An ATS-3 image is also included here. As with other missions, all these images have been freely available in one form or another since they were taken, and if possible they will be included in the analysis here.

Now that some sort of context has been established, we can progress to looking at the photographs.

4.4.1 Satellite Imagery

Given the issues with the TV camera it’s ironic that some of the first images of Earth were made in a TV broadcast. According to the timeline the broadcast started at 19:45 and continued until 20:50, and there is a copy of this broadcast available on youtube (from the same source as figure 4.4.1). A screenshot from this broadcast is given in figure 4.4.1a, together with satellite comparisons.

While the quality is relatively poor, it's clear that this live broadcast is showing the same features as the satellite images, and also that it could not be a re-transmission of ATS-3’s image as there is insufficient coverage of the northern hemisphere by it. The time on the screenshot appears to be mission elapsed time, as was common on ABC broadcasts.

Figure 4.4.2a: Main image - Rotated screenshot from live TV broadcast compared with ESSA (top left & middle), NIMBUS-3 IDCS (bottom left) and ATS (bottom right). Source given in text. Overleaf are the NIMBUS-3 HRIR strips
Figure 4.4.2a (cont’d): NIMBUS-3 HRIR orbits
Figure 4.4.2b: Screenshot from Apollo 12 broadcast on 14/11/69 (source given in text) with ESSA view (top right) and NIMBUS-3 views (below left and centre) and ATS-3 (below right) from the same date.
Particularly noticeable in this better quality shot is the band of cloud extending across Mexico, as well as the thin ‘V’ shaped stream of cloud to the south of this, and a similar thin band of cloud along the Mexican Pacific coast. NIMBUS IDCS tile was taken on day 318 (November 14th) at 17:56 – 2 hours before the broadcast. We’ll look at the timings in more detail in the next image, for reasons which will become obvious.

As in previous missions, the Astronauts communicated their own observations to Capcom of the weather conditions on the ground (these are recorded in the technical air to ground transcripts, available here: [ALSJ]). At 3:34 MET Dick Gordon says:

“Okay. You should be looking at the Yucatan Peninsula, Mexico; Baja California is in plain sight. It’s a pretty nice day down there. In the Gulf, Gulf - The western Gulf of Mexico has a cloud coverage along the coast; looks like it’s almost up to Houston. It’s south and west of it.”

followed a couple of minutes later by

“Hey, Jer, it’s a fantastic sight. The Mississippi Valley has a little bit of cloud coverage coming down from Canada, and there’s some in the north - north-east part of the country, up in the New England States. Looks like they may be getting some snow over here in the next day or two. Florida is cut in half by that front that went through this morning. The West Coast looks absolutely gorgeous; Baja California is clear, looks like the San Diego/Los Angeles area to the south and west of them is a little cloud coverage covered. I won’t say anything about smog.”

The smog he doesn’t want to talk about is the mass of cloud identified by the blue arrow, and Baja California is indeed clear compared with Los Angeles & San Diego. The green arrow points out the system cutting Florida in half, and the cloud systems descending from Canada into the Mississippi are immediately north of that arrow in the preceding figure, and the snow systems over New England are to the east of that. These features aren’t so obvious in the TV, but then you look at the still photographs taken around the same time they most definitely are.

The magazine with the first images taken of Earth is number 50, and the first image approaching a full disk is AS12-50-7331 shown in figure 4.4.3 - the best quality version of which is at the AIA (Source). A comparison with the relevant satellite images is given in figure 4.4.4a.
Figure 4.4.4a: Main image - AS12-50-7331 compared with ESSA-9 (top & middle left), NIMBUS-3 (bottom left) and ATS-3 (bottom right) and Stellarium estimate of time at terminator. NIMBUS-3 HRIR image is overleaf.
Figure 4.4.4a continued: AS12-50-7331 and 3D reconstruction using digitally restored ESSA data
Immediately prior to this, there are several frames showing the SIV-B with the exposed LM visible. The timeline for the mission (Source) shows that separation of the CSM from the SIV-B occurred at 19:40, docking with the LM at 19:48 on the 14th. This gives a pretty precise window for when this photograph (and numerous others at various zoom extents before docking) must have been taken. Immediately after it are photographs showing an empty SIV-B, recorded in the timeline as photography of the now defunct stae venting gas. That photography is timed at 20:41, compared with CSM separation at 19:40, so it seems reasonable to assume that this photograph was taken at some time between the two. A close examination of the TV image suggests that the band of cloud identified by the red arrow is somewhat longer than in the Apollo image, so I have erred on the side of caution and put the time nearer to the venting photography.

The crew took Earth images over quite some time - sufficient for Earth to rotate underneath them, as can be seen by comparing two images showing the terminator - AS10-50-7331 and the last in this sequence of photographs, AS10-50-7358 (figure 4.4.4b).
Returning to the satellite imagery analysis, the Apollo image has a number of unique features that are easily visible on the satellite photographs, particularly the large 'tick' shaped feature sweeping from the Mexican coast across the Gulf and up the east coast of the USA. The weather patterns either side of the tip of south America are also very distinctive and easy to spot on the satellite images.

The ATS-3 image provides a useful counter-argument to the suggestion that the colour Apollo photographs were somehow derived from the whole disk images provided by the HEO geostationary satellites. While the Apollo image used shows the Earth taking up a substantial portion of the image, other photographs taken at the same time show a much smaller globe, demonstrating that the Apollo craft was much further out than the ATS satellites. The portion of the Earth shown by Apollo is not matched by the ATS-3 image – it is over a different part of the Earth & at a different angle. ATS-1 was stationed over the Pacific, only a small part of which is seen in the Apollo image.

As far as timings are concerned, the ATS image was taken at 14:25. The NIMBUS orbit closest to the terminator would be number 2873, which was started at 14:14. ESSA's image is more difficult to interpret, as unlike previous missions the orbits that comprise the image dated the 14th are not given. However, the track covering the terminator area would be track 2. For an image dated the 14th this would correspond to orbit 3264, which was commenced at 16:06. As the Stellarium terminator suggests that the time for the image derived from the Apollo timeline is entirely reasonable, these figures suggest, at most, an elapsed time of about 5 hours between the ATS image and the Apollo one. This five hours is sufficient for the cloud system highlighted by the yellow arrow to move from the centre of the tip of south America in the ATS image to nearer the east coast in Apollo. This and many other features show that the overall similarity of the images belies a wealth of subtle differences, demonstrating that while all the images show the same thing, they are not identical replicas.

As mentioned, the sequence of photographs around docking continues until AS12-50-7353, before which are images of a now empty SIV-B shell, confirming the timing of the earlier image. AS12-50-7354 shows a slightly different view of Earth, and the satellite images should show that this is the same Earth photographed in the previous image, just rotated further around. Figure 4.4.5 shows the Apollo photograph, and 4.4.6 the satellite comparisons.

The Stellarium estimate of time based on the terminator line is difficult for this image, as no land masses are visible, but using the assumption that the weather system identified by the blue arrow borders the west coast of the USA, an estimate of 01:00 on the 15th has been derived. The satellite images used are still those of the 14th, as these are the nearest in time to that. The Apollo image is definitely from the early hours of the 15th rather than the early hours of the 16th, as the weather system picked out in blue has changed considerably by then.
Figure 4.4.6: Main image shows AS12-50-7354 compared with ESSA (top left), NIMBUS-3 IDCS (bottom left) and ATS (bottom right), with Stellarium estimate of time. Blue & purple arrows match those in figure 4.4.2. NIMBUS-3 HRIR images shown overleaf.
Figure 4.4.6 continued: AS12-50-7354 and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS (right) data
The ATS image has been included, but as should be obvious from the preceding page, only one fragment of a weather system shown in the Apollo image is visible in it (identified by the purple coloured arrow). This completely eliminates ATS-3 from any suggestion that it was involved in producing at least this image! The system picked out by the yellow arrow is just visible in figure 4.4.3 slightly to the left of the blue arrow on the Apollo image. This latter system, and the cloud whorl in the southern hemisphere, are obviously visible in the satellite images.

NIMBUS’ orbits covering the Pacific area in the image are 2876/2877, and these are shown as starting at 19:53 & 21:34 on the 14th respectively. The NIMBUS tile showing the clouds picked out by the magenta arrow was taken at 21:06. ESSA’s corresponding orbit would be 3267 (track 5), which commenced at 21:01. Again there is a good five hour gap between the satellite and Apollo images. As with the previous example, this time difference means that some of the weather systems have evolved by the time that the Apollo image is taken. The cloud pattern identified by the green arrow, for example, has moved some distance eastwards to a position more directly below that picked out by the blue arrow, and the red arrowed cloud has also moved much closer to the blue arrowed systems. The same weather systems but evolved into a slightly different configuration by the time the Apollo image is taken, and further indication that the Apollo image is not a straight copy of a satellite photograph.

Again, the crew discuss what they can see on the image, this time Alan Bean says at 08:23 MET (or around 00:45 on the 15th, during inspection of the LM):

“I can’t see any landmass at all. All I can see is water with lots of clouds, and I can see sort of a glare point on the Earth. I think that must be the zero phase point to us. Other than that, it’s very, very bright. And another interesting thing is, on the dark side, you cannot see where the Earth stops and space begins. It’s unlike the Moon at night on in the daytime where you can see it in earthshine. You just can’t see anything.”

The glare point is very evident, at about 9 o'clock on the Earth, and the absolute blackness of the night side is also obvious from the Apollo image. The 'zero phase point' is a point that won’t change on the surface regardless of perspective because it is the light from the sun, and the sun is not going to change position. A few frames later in magazine 50, after a couple of partial disk zoomed photographs, there are a few more full disk images, and again time has moved on slightly from the previous image. The first of this sequence is AS12-50-7362 (AIA), shown in figure 4.4.7. The main source of interest from this image is that Australia (and many other parts of Australasia) is visible beneath the clouds, and the shadows cast by the clouds. There are several large clouds that show very obvious shadows on the ocean below them, giving a third dimension to the images that the satellite photographs lack. Figure 4.4.8 shows the satellite comparisons.

Figure 4.4.7: AS12-50-7362. High quality source: AIA
Figure 4.4.8: Main image - AS12-50-7362 compared with ESSA-9 (left) & NIMBUS-3 HRIR (bottom) images. Right is a Stellarium estimate of time at terminator.
Figure 4.4.8 continued: AS12-50-7362 and 3D reconstruction using digitally restored ESSA data
Stellarium suggests a time of 03:00 for the picture, and the yellow arrow on the figures point to a system that is only visible on the 15th – on other days that part of Australia is clear. The NIMBUS part of the satellite images consists of orbit 2878-80 of the daylight IR passes, which are given over images labelled the 14th and 15th. Orbit 2878 started at 22:38 on the 14th and 2880 at 02:13 on the 15th. ESSA's most representative orbit for the area covered is number 3268 (track 6) which commenced at 23:07 on the 14th. On the subject of Australia, the astronauts again discuss what they can see with Capcom. At 12:53 MET (or 05:15 on the 15th) the crew give the following message:

“Okay, Houston. We've got Australia... in sight now at the - oh, it's about the 8 o'clock position, with respect to the terminator... There's a lot of clouds out there, Houston. I can see a lot of fairly small clouds, but there is so darn much cloud cover out in the Pacific, except right off the north-east coast of Australia that I really haven't found any islands yet.”

The astronauts are obviously describing what can be seen in the Apollo image, but the timings of these transmissions again call into question the Stellarium evidence. A closer look at the Stellarium terminator shows it is convex in relation to the daylight limb – it bulges away from it. The Apollo image shows a concave terminator – it bulges towards the daylight limb. Why the difference?

The answer again lies in the relative position of Apollo 12 in relation to the Earth and the Moon. Apollo 12 is on a course that is pointing at where the moon will be in 4 days’ time – the 18th, when it will enter lunar orbit. If the perspective of the Apollo 12 landing site is changed to that of the 18th, then it is obvious that the Earth assumes a more crescent profile (figure 4.4.9). Australia's appearance on the western horizon also changes from around 03:00 to more like 05:15, and the timing of the photograph more akin to 06:00 on the 15th.

Figure 4.4.9: Views of Earth from the Apollo 12 landing site at 06:00 on 15/11/69 and 18/11/69. Google Earth comparisons indicate the distance to terminator (170 degrees East) from Australia.
What figure 4.4.9 shows is that, while the position of Australia is different in the two views of Earth, the distance to the terminator is the same. The terminator is actually at roughly 170 degrees East, but for ease of interpretation the reader can use the anti-meridian of 180 degrees (the bright yellow line running north to south). If the photograph was actually taken 3 hours earlier, the distance to the terminator would be much greater.

The explanation, therefore, for the difference in the time for Stellarium is not some discrepancy in when the photograph was taken, but in Stellarium's assumption of where it was taken from. Apollo 12 was pointed in a more or less straight line to where the Moon would be at LOI on the 18th, and therefore using the Moon's location on the 15th to check the timings causes this discrepancy. Stellarium's data are correct, it is the perspective of the view that isn't quite right.

Conspiracy theorists can make of that what they will, but it is an honest interpretation of the facts that don't initially make sense until they are examined properly. This feature is something that is consistent across every mission: Stellarium views at the start and end of missions that differ from the Apollo version, but lunar based images that match exactly - it’s even more proof that the Apollo photographs are genuine. As the CSM gets nearer the Moon this discrepancy will become less obvious, and the next image is a little closer.

AS12-50-7367 is shown in figure 4.4.10 and is the last image taken before several photographs of a fouled hatch window, and Earth appears much smaller in the viewfinder now. The satellite comparison is shown in figure 4.4.11.

![Figure 4.4.10: AS12-50-7367. High quality source: AIA](image-url)
Figure 4.4.11: Main image shows ESSA-9 (left) and NIMBUS-3 (right) images in comparison with AS12-50-7367. In the centre are NIMBUS HRIR passes (left) and 3D reconstructions using digitally restored ESSA (centre) and NIMBUS (right) satellite data. On the bottom row are an individual NIMBUS 3 tile and a close up of the same area on the Apollo image, identified by the magenta arrow. Left is a Stellarium estimate of time at terminator.
Figure 4.4.11 continued: AS12-50-7367 and 3D reconstruction using digitally restored ESSA (right) and NIMBUS (centre) data
The photographs of the fouled hatch were taken sometime after 02:15 GMT, as this is the time that (according to the mission transcript) instructions on how best to photograph the windows were supplied by Capcom. They were first described to Capcom on the previous day, but are gone over in more detail half an hour prior to the photography instructions, so we have a latest time for the photographs of around 01:45. We also have descriptions from the crew of the terminator crossing Florida (although they do describe difficulties in determining land features) at around midnight GMT on the 16th, so we have a time for the photograph already of somewhere between those two. Stellarium has been set at 01:00 on the basis that no land masses are easily visible in the Apollo image.

Assuming a terminator line just off the west coast of north America, this would mean that the best ESSA orbit corresponding to that would be orbit 3280 (track 5), which commenced at 22:00 on the 15th. The equivalent NIMBUS pass is number 2889, which commenced at 18:18 on the 15th. The magenta arrow points to a cloud system imaged at 20:22 on the 15th, which is also shown in the image and matches exactly the NIMBUS tile.

The next image to be examined is AS12-50-7377 and is shown in figure 4.4.12. It appears after the photographs of a fouled hatch window, which again gives us the starting point for working out when it was taken, and Earth appears much smaller in the viewfinder now. The satellite comparison is shown in figure 4.4.13.

The NIMBUS data in the preceding image is night time infra-red, which has the only complete coverage of that part of the globe on that date. The orbit that best represents the terminator here is number 2897, which commenced at 10:28 GMT on the 16th. Shown above for comparison are the two passes of daylight HRIR available, and the pass that ends at north Australia started at 01:56.

Figure 4.4.12: AS12-50-7377. High quality source: AIA. Horizontal line is a fault on the original scan
Figure 4.4.13: Main image - AS12-50-7377 compared with ESSA (right top & bottom). Below this far left is night time NIMBUS HRIR (right). Next to that is day time IR. Stellarium estimate of time at terminator above.
Figure 4.4.13 continued:
AS12-50-7377 and 3D reconstruction using digitally restored ESSA data
As for ESSA, the Apollo image terminator is mostly covered by track 6, or orbit number 3281. This pass was commenced on the 16th at 00:05 and appears on the image dated the 15th.

These compare favourably with Stellarium's time estimate of 03:30 using the position of Australia as a guide, but as indicated earlier, this figure may be out by a couple of hours because of the difference in perspective between Stellarium and Apollo 12. If a terminator line along the central Pacific is used as a guide (something that seems to be confirmed by the position of the cyan and red arrowed clouds), 05:30 may be a more representative time.

The date of the 16th can be confirmed convincingly by the weather pattern over south-eastern Australia, which does not appear in that configuration on any other date, and is a clear development of the system identified by the purple and magenta arrows in figure 4.4.8. The next set of Earth photographs is a series of 4 showing the same view, and the first of these, AS12-50-7381, has been selected from this batch for comparison with the satellite images.

It is shown below in figure 4.4.14, and analysed in figure 4.4.15.
Figure 4.4.15: Main image - ESSA-9 images compared with AS12-50-5381. Below this are night (left) and day time (centre) NIMBUS-3 HRIR images, with Stellarium estimate of time at terminator (right).
Figure 4.4.15 continued: AS12-50-5381 and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS (right) data
The distinctive plume of cloud below Australia (marked by the yellow and magenta arrows) has moved much closer to the terminator than in the previous analysis, which allows a more precise estimate of the time of the image. Stellarium puts this photograph as being taken at around 07:00 GMT. As with the previous image, the night time infra-red image has been used for NIMBUS coverage, as this has the best data for the region on that date. It does mean that, as before, the cloud patterns visible on the NIMBUS mosaic are a reflection of the thermal conditions of the atmosphere, rather than what can actually be seen.

The NIMBUS orbit nearest the terminator is number 2897, which was started at 09:50 on the 16th. ESSA’s terminator orbit is number 3283 (track 8), which commenced at 04:06 on the 16th.

A few images later in magazine 50 there is a short sequence of images that can be identified by the cloud patterns as somewhere east of Australia. This automatically puts it almost a day after the previous image. Figure 4.4.16 shows AS12-50-7385, and figure 4.4.17 the satellite comparison.

Figure 4.4.16: AS12-50-7385. High quality source: AIA
Figure 4.4.17: Main image shows AS12-50-7385 compared ESSA-9. Below are NIMBUS-3 IDCS (right) and HRIR (right) images, with Stellarium estimate of time at terminator.
Figure 4.4.17 continued: AS12-50-7385 and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS (right) data
With no land masses present, the only time reference available to us is the terminator cutting across the large cloud bank in the southern Pacific, and the time works out at somewhere around 02:00 on the 17th. This estimate would put the mission time at around 57:00. A couple of hours earlier they were discussing weather conditions on the west coast of the USA, including mention of

“a nice crescent-shaped large weather system that appears to be several hundred miles out to sea”

but it’s difficult to tell which system he’s referring to here.

Also noticeable when comparing the Apollo image and Stellarium terminator lines is that now that Apollo 12 & the Moon are considerably closer together, and the position of the lunar viewpoint nears the point that Apollo 12 is aiming for, the shape of the terminator and the amount of the Earth's disk lit by the sun are becoming more similar.

NIMBUS' daylight visible spectrum view over the east coast of south America would be from orbit 2916, which commenced at 20:06 on the 17th. Depending on how accurate our estimate of the time is the NIMBUS coverage on the 16th could be closer to it time by a couple of hours, but the coverage provided by that day’s picture is not as good.

ESSA's best fit pass for the same area is orbit 3289 (track 6) 23:09 on the 16th. Once again, an Apollo image shows weather patterns that are only visible at a specific time on a specific day.

The next series of Earth photographs occur immediately before two images of a distant lunar far side of the moon as Apollo 12 approaches LOI. That photograph is shown in figure 4.4.18, and analysed overleaf in figure 4.4.19.

Figure 4.4.18: AS12-50-7388. High quality source: AIA
Figure 4.4.19: Main image shows ESSA-9 (left) compared with AS12-50-5788. Below that is NIMBUS-3 IDCS (left) and HRIR (right) and Stellarium estimate of time at terminator.
AS12-50-5788 and 3D reconstruction using digitally restored ESSA data
Around 24 hours since the last view of Australia and there is again a change in the configuration of the large frontal cloud mass south of Australia that extends up from the Antarctic (magenta arrow). The two distinct branches of the plume have gone, and smaller lobes extend off into the Australian interior than was the case the previous day. Australia is just visible on the western limb, and this puts the time of the image at around 04:30 on the 17th. The red and crimson arrows match figure 4.4.17.

ESSA’s orbit nearest the terminator is 3293 (track 6), which commenced at 23:09 on the 16th. Australia itself would not have been imaged completely until 05:05 on the 17th (track 9, orbit 3296). NIMBUS is even further behind, at least for the visible spectrum images, which covered the terminator at 19:25 (pass 2903) on the 16th, putting the NIMBUS satellite some 10 hours behind the Apollo 1. This would help to explain the discrepancies in some areas between the cloud patterns that are easily identifiable on the Apollo and ESSA images, but not the NIMBUS ones (eg the blue and green arrows). Night time infra-red images did cover the area nearer the time (around 03:00 on the 17th), but the quality of the image is much poorer, so little would have been gained in examining it.

The next few frames show a gradual change in the view beneath the CSM (AS12-50-7388 for example shows Australia just appearing on the western horizon) as it rotates from the 16th towards the 17th of November and ever closer to LOI.

In AS12-50-7391 Australia is very obvious, which makes it an obvious candidate for comparison with satellite images. Figure 4.4.20 shows the Apollo image, and 4.4.21 shows the satellite comparison.

Figure 4.4.20: AS12-50-7391. High quality source: AIA
Figure 4.4.21: Main image shows AS12-50-7391 compared with ESSA-9 (top & bottom left). Below this is NIMBUS-3 IDCS (left) and HRIR (right). Stellarium estimate of time at terminator.
Figure 4.4.21 continued: AS12-50-7391 and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS (right) data.
The position of the terminator on the very edge of eastern Australia puts the time of the Apollo image at around 08:15.

What decides the date of this image is the large pointed weather system off western Australia (picked out by magenta and yellow arrows on the satellite images. ATS-3 does not cover this part of the globe, so we are restricted to NIMBUS & ESSA for our image supply. The system off western Australia does appear on the visible spectrum NIMBUS image, but this does not show the areas north of Australia, and for this reason the daylight infra-red image has been used, which does show it. The NIMBUS pass over Australia is 2907, which commenced at 03:24 on the 17th, giving it a few hours head start on the Apollo image. The system in question was imaged by NIMBUS at around 04:43.ESSA’s best fit orbit is number 3296 (track 9), which is found on the image dated the 16th, but was actually started on November 17th at 05:05.

We get additional confirmation of the time from a TV broadcast made on the 17th between 07:14 and 08:10. While the broadcast was being sent through Goldstone in California, Australia got the show live through their own receiving stations, and the crew confirm that Australia is centre stage:

063:32:34 Conrad: Was the picture of the Earth any good?
063:34:29 Conrad: That landmass you're looking at there is Australia.
063:34:51 Carr: 12, Houston. The word is Australia is getting your TV show live.

We can have a quick look at a still from that TV broadcast in figure 4.4.22, with the same features from 4.4.21 identified:

While the quality is obviously not as clear as the still image, there is sufficient resolution to allow for identification of the same features, with the exception of the band of cloud identified by the yellow arrow in figure 4.4.21. There is insufficient separation of the white area in the TV shot to allow for clear identification of it, so I have left it out.

It is also worth noting that between this and the next sequence of Earth images there are two photographs of the Moon. They are noteworthy because they show the Moon in a completely different phase to that visible from Earth. Figure 4.4.23 shows the Moon from AS12-50-7389 (Source: AIA). The CSM is approaching the Moon on an intercept course that will place it in an east-west orbit (as viewed from Earth), and hence is looking towards the moon from the west, not face on as in the Stellarium view. It’s further evidence that the Apollo craft was not looking at the Moon from a terrestrial perspective.
Figure 4.4.23: The Moon as seen from Apollo 12 shown in AS12-50-7389 compared with Stellarium’s view from Earth at approximately the same time. The red arrow identifies the same crater, and the Moon has been rotated to the correct position.

The Apollo Image Atlas identifies this image (and the one following it) as showing the ‘far side’ and before the CSM’s first lunar orbit (‘Pre-REV 1’). The latter is definitely true, but at least half of the lunar disk would be visible from Earth. The fact that the other half could not is still significant.

Two final images will be examined from magazine 50 as these are the last before LOI, and occur after the images of the moon discussed above. As will be demonstrated, they were taken relatively closely together, and the second one shows the window frame and glass from the Apollo craft. The images themselves are shown in figure 4.4.24-5, and the satellite comparisons are shown on the following pages as figure 4.4.26 & 4.4.27.
Figure 4.4.26: Main image shows AS12-50-7394 compared with ATS-3 (top right), ESSA-9 (bottom middle & left) and NIMBUS-3 IDCS (bottom right)
Figure 4.4.26 continued: AS12-50-7394 and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS (right) data.
Figure 4.4.26 (cont’d): NIMBUS-3 HRIR. Top left is Stellarium estimate of time at terminator for AS12-50-7394.
Figure 4.4.27: Main image - AS12-50-7396 compared with ATS-3 (top right), ESSA-9 (bottom middle & left) and NIMBUS-3 IDCS (bottom right). All arrows except cyan as 4.4.26.
Figure 4.4.27 continued: AS12-50-7396 and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS (right) data.
Figure 4.4.27 (cont’d): NIMBUS-3 HRIR orbits, Stellarium estimate of time at terminator for AS12-50-7396
These two images were taken relatively close together, as can be determined by nearly all of the identifier arrows being used in both analyses (the cyan one has been used as a link to the next photographs). The first photograph has the west coast of South America just visible, and most of north America, which allows Stellarium to put the time at around 23:00. It is slightly more difficult to see the coast in the second image, but the cloud patterns picked out by the yellow and magenta arrows show that the terminator is just off the California coast, which would give an estimated time for the image of 00:30 on the 18th of November.

The most obvious features are the large circular cloud off Chile picked out by the cyan arrow (and the attendant flecks of cirrus clouds west of that that are visible once the circular feature disappears in to the night portion of the globe), the long finger of cloud stretching from the Antarctic north-westwards towards the equator (blue arrow), and the bifurcated equatorial cloud mass in the northern hemisphere picked out by yellow & magenta arrows.

As stated previously, the ATS-3 image is timed at 14:43 on the 17th, and as a result only those weather systems off the west coast of South America can be identified with any degree of confidence, but they are nonetheless identifiable. Both the NIMBUS and ESSA images are dated the 17th. The most representative daylight IR passes for NIMBUS are 2915 for figure 4.4.14 and 2916 for figure 4.4.15, which were commenced at 16:54 and 18:41 respectively. NIMBUS imaged the clouds identified by the blue arrow at 19:02. ESSA’s most representative passes are tracks 4 and 5, passes 3304 & 5, commenced at 20:07 and 22:02 for the two images respectively. The suggested timings for the Apollo images are vindicated by the timings of the satellite photographs.

The remaining images on magazine 50 are close ups of the lunar surface, starting with very rounded lunar horizons and ending with much flatter ones, indicative of a space craft approaching the Moon. LOI for Apollo 12 is recorded as being carried at 03:47 on the 18th, so it seems that AS12-50-7396 is the last photograph of Earth taken before entering lunar orbit, and the first lunar orbit proper started at 03:53 on the 18th, shortly before LOS.

For the next 24 hours the crew are somewhat busy checking out the LM and preparing for separation of the two craft and initiating the descent to the surface. This separation of the crew and their attendant cameras provides two vantage points for the Earth – one from the CSM & the other from the LM. Magazine 47 has a couple of Earthrise sequences before showing images taken on the lunar surface – one taken before separation from the CSM and one after, while magazine 51 shows one image of a distant Earth before separation, and several photographs of Earth taken on different orbits, including an Earthrise.

Pinning down exact timings of the images in these two magazines involves a certain amount of detective work. After LOI, the LM pilot entered the LM to perform system checks at around 08:50 on the 18th, finally entering with the mission commander at 00:42 on the 19th, where both crewmen remained. The LM & CSM separated at 04:16 on the 19th. Just after the start of magazine 47 are 4 images of an Earthrise. These occur immediately before 2 images of the CSM taken in to the sun, but after two images of the lunar horizon and a distant Tsiolkovsky – a far side crater proving that the image was taken after LOI.

It does not take a great deal of logical leaps to conclude that the 4 Earthrise shots were therefore taken before this time. Also featured in the images is one of the LM’s quad thrusters, which suggests that the photographs were taken while in the LM, and it seems reasonable to assume that this was after all the camera equipment and other gear needed for the landing was transferred. A likely time seems around 105 hours and 41 minutes, which would be around AOS on the final orbit before separation.

The 2 photographs immediately following this short Earthrise sequence feature Copernicus, a prominent near side crater almost completely opposite Tsiolkovsky. Copernicus gets an enthusiastic mention by the crew at 106 hours 30 minutes, but prior to this they report that they were unable to find it, which would seem to confirm the suggestion that it the Earthrise was taken on the final orbit before separation, after their sighting of Tsiolkovsky.
This would give a working estimate of around 02:00 on the 19th for this sequence, and AS12-47-6874 from that set will be examined next. This image can be found at the AIA (source: AIA), but the high resolution scan has been overexposed and the actual image used has been acquired from the Gateway to Astronaut Photography (GAP). Even the better quality scan from the Gateway is of poor quality, and the Earth is out of focus. Making out anything other than the largest scale features. This complicates matters as these large scale weather systems are broadly similar over the period of lunar orbit, but the additional supporting evidence discussed previously helps to narrow down the relevant portion of the relevant satellite images.

Figure 4.4.28: GAP scan of image AS12-47-6874
Figure 4.4.29: Main image - AS12-47-6874 compared with ESSA-9 (top & bottom left) & NIMBUS-3 HRIR (right) with Stellarium estimate of time at terminator. Magenta, cyan & blue arrows are as in figure 4.4.26.
Figure 4.4.29 continued: AS12-47-6874 and 3D reconstruction using digitally restored ESSA data
Timing this image is difficult as there is little in the way of landmass visible to pinpoint the terminator’s exact location. The absence of land mass does allow a certain amount orientation in Stellarium. Australia does not appear until 5am, and California disappears at 1am, so the image must fall between these two times. The yellow arrow points to a cloud system that falls on the 170 degree longitude line, and if it is assumed that this is the same one picked out on the Apollo image, then the western horizon is at 170 degrees. If this is the case then the terminator falls roughly along the line picked at 140 degrees longitude in the northern hemisphere, a line which also falls on Alaska. As Stellarium’s cloud patterns are fixed and there is a spiral one over Alaska, its estimate of 01:30 seems reasonable, and coincides well with the estimate worked out in the preamble to this image’s analysis.

Both of the satellite images chosen are from the 18th, as their orbital passes are closer to this time than they would be in images taken on the 19th. ESSA’s best orbit is 3318 (track 6) which commenced at 23:01, & NIMBUS’ orbit 2930 on the daylight IR image is the most appropriate one for the Apollo picture, and this commenced at 19:48.

Another film magazine contains an image of Earth before separation but is definitely from lunar orbit: number 51. This roll starts with a large number of ‘face on’ images of the lunar surface, placing it firmly in lunar orbit. AS12-51-7489 features a very distant shot of Earth, immediately after which comes a sequence of images showing the LM after separation. Image 7489 must therefore have been taken before separation at 04:16 on the 19th, and after LOI at 03:47 on the 18th. As with the previous image, the image is out of focus and blurred, with only large scale systems can be identifiable, but there should be sufficient detail to demonstrate the point. Figure 4.4.30 shows the original image and figure 4.4.31 the satellite comparison.

Figure 4.4.30: AS12-51-7489 (Source: AIA)
Figure 4.4.31: AS12-51-7489 compared with ESSA (top & bottom left) & NIMBUS-3 HRIR images. Stellarium estimate of time at terminator.
Figure 4.4.31 continued: AS12-51-7489 and 3D reconstruction using digitally restored ESSA data
The key weather systems here are the two identified by the green and cyan arrows off the western coast of Australia. The system picked out in blue is just off the Sumatran coast, which also helps to narrow down the location of the terminator. It is unfortunate that this weather system crosses the boundary between two day's ESSA data, and more unfortunate still that there is not as much overlap between the two day's data shifts in terms of longitude (so that we can't use the data from the next day to corroborate), but you can't have everything. The NIMBUS view does show that we have the correct weather system in our sights. The best estimate for the terminator position here gives a time of approximately 11:30 on the 18th.

ESSA's best orbit from this image is orbit 3310 (track 10) which was actually commenced at 08:09 on the 18th, while NIMBUS' best available orbit is 2922 which commenced at 05:25 on the 18th. The orbits covering Australia exactly do not feature clear images, or are absent.

A time of 11:30 would put the still joined spacecraft in lunar orbit after the second circularisation burn. This is supported by the first few images in the magazine, which shows an initially lit lunar surface over Mare Nectaris (on the eastern near side), followed by darker frames, then a brightly lit one of Mare Nubium in the south-east before the darker frames and then the photograph of Earth. The position of the lunar terminator (as documented here) supports a time of around 11:30. In fact the terminator position caused a re-assessment of the time of this photograph, as it was initially thought to feature Australia more prominently, putting it far too early in the process. Were this the case, areas shown to be just lit on the lunar surface would have been in complete darkness. 11:30 would equate to 90:30 MET, so we would be on the near side and about 30 minutes after AOS - pretty much in the right place for the terminator photography.

Immediately after separation of the LM from the CSM in magazine 40 is sequence of Earthrise images. As magazine 47 went to the lunar surface, and didn't complete more than one complete revolution as it did so, timing the image is much simpler than the preceding two, It is also helped by the astronauts' chatter in the LM as they discuss the upcoming Earthrise and making sure that they captured it (see the LM Voice transcript) at 4d13h43m, or 109:43 hours MET, or around 06:00 on the 19th – 55 minutes before landing.

Figure 4.4.32 shows one of these images, and figure 4.4.33 the satellite comparison.
Figure 4.4.33: AS12-47-6894 compared with ESSA (left) & NIMBUS-3 HRIR images (right). Stellarium estimate of time at terminator to the right.
As with the previous analysis, the key to this one is the weather system off south-eastern Australia, picked out in cyan, green and red arrows. Once these have been identified, the others are relatively straightforward to place, even with the blurred image available. As these clouds are on the western edge of the visible Earth, it becomes relatively easy to position Australia correctly and derive a time from Stellarium that the image was taken. Stellarium confirms very precisely the time suggested by the LM dialogue at 06:00. The satellite images are able to confirm the date as the 19th.

ESSA’s best track over this area is again number 8, and orbit 3321 on the image dated the 18th was commenced at 05:07 on the 19th. For once, the NIMBUS night time orbit gives the best visible data (and the day time images are absent!), and pass number 2938 on the 19th was commenced at 11:15 – 5 hours later than the Apollo image but providing a good match.

No more images of Earth from other orbits are available on this magazine, and none were taken by the crew on the lunar surface. By this time it was becoming an increasingly thin crescent and would not have presented much of an object in the sky.

While Bean & Conrad set off for the surface, Gordon continued his orbits, and took a further 3 sequences of Earth images in magazine 51. The first of those occur immediately after the separation images. As separation occurred over crater Ptolemaeus in the centre of the near side and the photographs contain no sign of the Moon, it is likely that the Earth image was taken by looking straight back towards home just after separation.

Of the two available, the image chosen is AS12-51-7513 as it is the sharpest. This image is available here: AIA and is shown in figure 4.4.34, figure 4.4.35 shows the satellite comparison.

![Figure 4.4.34: Gap scan of AS12-51-7513](image-url)
Figure 4.4.35: AS12-51-7513 compared with ESSA (top & bottom left) & Nimbus night time IR (right), with Stellarium insert. Colours are as used in figure 4.4.32.
The most obvious point to make about figure 4.4.35 is its similarity to figure 4.4.33. Indeed the satellite image sections are the same, so the ESSA and NIMBUS timings cited earlier will also be the same for this analysis, and there isn’t much need for an additional 3D reconstruction.

The only significant difference between the two Earths is that in this one the globe has revolved slightly further, exposing more of Australia (see figure 4.4.36), something that proves it is not merely a copy of the Earth seen in the Moon bound photograph. This rotation adds roughly 15 minutes to the time of this image compared with the previous one. The absence of any Moon at all in this photograph also confirms that it was taken some time after the Earthrise greeted so exuberantly by Bean and Conrad.

The relative sharpness of this picture also allows a degree more certainty in identifying the weather patterns on the satellite photographs compared with the Apollo Earth, and has helped to confirm the analysis given for figure 4.4.33.

After separation, the CSM continued to orbit and captured another 2 sequences of images. The first one consists of two photographs of a crescent Earth with no lunar surface visible. This is not an Earthrise sequence, but the CSM has obviously passed around the moon at least once since the preceding image, as there are photographs of the lunar surface in various stages of light and shade, and Mare Nubium on the east followed by far side craters such as Mendelev.

The best quality image is AS12-51-7523 (source: AIA), shown in figure 4.4.36, and analysed in figure 4.4.37.

Figure 4.4.36: GAP scan of AS12-51-7523
Figure 4.4.37: Main image - AS12-51-7523 compared with ESSA-9 (top & bottom left) and NIMBUS-3 IDCS (below left) and NIMBUS-3 HRIR mosaic (below centre). Stellarium estimate of time at terminator.
Figure 4.4.37 continued: AS12-51-7523 and 3D reconstruction using digitally restored ESSA data
The ESSA image used is again from the 18th, and the most obvious cloud that specifically pins it down to that day's image is the one highlighted by the yellow arrow, and as with previous images once the most obvious cloud is identified the rest fall into place. Track 10 covers most of the image's daylight portion, and this corresponds to pass number 3302, commenced at 07:03 on the 19th. The NIMBUS image is the daylight IR data from the 19th, and pass 2935 covers the coast off western Australia up towards India. This was started at 04:42.

Looking at the top of the Earth's crescent in this image reveals a landmass, and it is this that allows the time at terminator to be picked out. The clouds identified by the red arrow are over that landmass, and which puts the terminator position as at roughly 10:30 – about 3 orbits later than the preceding photograph. As it is not an Earthrise image it could have been taken at any point in the nearside part of the lunar orbit, but there is at least one orbit between the previous image analysed and this one. 10:30 would put the mission elapsed time at just over 114 hours 10 minutes, or 4d18h in. We know that the CSM was over the daylight side at that time, because at 4d18h23m Dick Gordon announces that he has sighted the LM through the sextant.

The final Earth sequence (but not the final Earth image) to be examined was taken immediately after the preceding one. AS12-51-7528 is towards the end of that sequence and is picked for no other reason than it is a high quality image available as a TIFF from Archive.org.

The image is shown in figure 4.4.38, and examined in 4.4.39.
Figure 4.4.39: Top image - AS12-51-7528 compared with ESSA-9 (top & bottom left) and NIMBUS-3 IDCS (right). Stellarium estimate of time at terminator is above. Yellow arrow same as figure 4.4.36. Left - NIMBUS-3 HRIR mosaic.
Figure 4.4.39 continued: AS12-51-7528 and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS (right) data
There are no intervening pictures of lunar surface to act as a guide for how many orbits have elapsed between AS12-51-7523 and 8, but the clouds identified by the yellow arrow are a clue. It is definitely the same cloud in both images as can be confirmed by the thin strip of cloud running parallel and below it in both photographs. The blob of bright cloud on the very western edge of this band of cloud is highly likely to be a tropical storm over the Comoros islands on the 19th, visible to the north of Madagascar on the NIMBUS image. This allows confirmation that the clouds picked out by the magenta arrow (just visible in AS12-51-7523 on the western edge of the Earth) start at the eastern end overlie Madagascar, which allows a pretty confident identification of where the terminator lies. This gives a Stellarium based estimate of the time of the image as around 12:00 on the 19th. This would put the CSM just one orbit further on than in the previous image.

Consequently, there is not much difference in the satellite image timings for the visible part of the Earth’s surface. NIMBUS orbit 2936 is the major part of the daylight IR image used, which commenced at 06:29 on the 19th. The magenta arrow identifies clouds imaged at 06:57 by NIMBUS. ESSA’s companion pass is 3323 (track 11), which commenced at 09:08. As usual, two satellites show images from a specific day with specific cloud formations unique to that day, and that match the Apollo image.

We have one more image from the moon to examine, this time from lunar orbit taken by the 16mm camera using magazine P. Magazine P starts off with poor quality footage from the lunar surface before switching to footage obviously taken from orbit. The movement of the camera strongly suggests it was taken during the lift off sequence. We know, therefore, that the footage has to have been taken after 14:33 on November 20th. As Earthrise can only have been almost ¾ of an orbit later, so let’s put it conservatively at 15:30. Figure 4.4.40 shows the still, compared with the Stellarium view of Earth at the same time.
What can also be seen in the window is the Landing Point Designator markings on the LM window, which strongly suggests that this is taken from the LM window before re-uniting with the CSM, which was at 17:58 on the 20th. We do get a few clues from the LM transcript, which has this exchange:

05 23 18 58 CDR Here comes earthrise.
05 23 19 00 LMP ...
05 23 19 01 CDR Too bad we don't have a camera.
05 23 19 02 LMP We do. Where is the earthrise?
05 23 19 05 CDR Right out your window.
05 23 19 06 LMP You take it. I got - My window's got - socked in. Just punch the button. Put it on 20 - here, lean over here just a minute. Okay, now take it. Just punch the button on the front.
05 23 19 18 CDR It would be better if you took it out your window.
05 23 19 20 LMP It's all frosted, Pete.

Earlier on they had been cursing the 16mm camera’s failure at lift off and it consequently not capturing the landing site as they viewed it from above. That timing works out at 15:41, so my initial guess was pretty good. While the image quality through the badly frosted window isn’t enough to see any detail on the Earth, we can at least see that its phase is completely consistent with what should be visible.

The final image examined from Apollo 12 is presented partly as a piece of detective work, and partly to point out a possible error in the Apollo Image Atlas.

AS12-51-7581 (figure 4.4.41) is described by the AIA as “Almost total eclipse of Earth”.

![Figure 4.4.41: AS12-51-7581 (Source AIA)](image)

Apollo 12 did experience a unique solar eclipse as it passed a point where the Earth completely blocked out the sun. There are, however, a couple of pointers to the fact that this is not a total eclipse. One fact is that by the time of the actual 'eclipse', the 24th, the crew had run out of colour film, and could only shoot the event in black & white. The other major clue is obviously present in the photograph: lens flares. The sun is off to the bottom of the picture (this is even more obvious in subsequent photographs in the magazine but they don't show the Earth crescent as well), so it can't therefore be behind the Earth!

So when was it taken? The image is actually showing the Earth as a crescent continuing to change phase naturally as it has throughout the mission. Figure 4.4.42 shows Stellarium views from the Apollo 12 landing site at noon from the 20th to the 24th of November, illustrating the changing phase from a lunar perspective.
Looking at these crescent views, the perspective most like that in the Apollo image is that of the 21st, probably later than the 12:00. The whereabouts of Apollo 12 by the 21st depends on when it was taken, as early on in the day it was involved in landmark photography while still in orbit, but at 20:51 it performed a TEI burn.

The size of the Earth in the photograph suggests it is much closer to the CSM than the views given in orbital images featuring Earth. The tricky part now is to identify any weather patterns. We have a very small amount of visible cloud, but at least a 24 hour window within which to search. The ESSA image dated the 21st will cover the globe from around noon on that day to noon the next day, so the clouds we are looking for should be visible on that image somewhere.

The visible cloud system consists of a large but well defined tropical cloud mass, (at that time of year, the centre line through the widest part of the crescent should roughly equate to the latitude 10 degrees south) to the north of which are high altitude cirrus type clouds and to the south an elongated band stretching south-westwards towards the south pole, and west of that a much larger cloud mass. Further north on the western horizon there is a more solid looking body of cloud showing a clear shadow beneath it.

For once, there will be no guarantee that the exact cloud has been found, but figure 4.4.43 shows the most likely candidate. The clouds arrowed in green are on the line of 10 degrees south, there are wispy clouds to the north of them, bands of clouds to the south. These patterns are particularly evident on the NIMBUS daylight IR image, and the cloud's shape is much more similar to the Apollo image. The pictures from the 22nd bear much less similarity to Apollo, and of course after this the Earth's crescent starts to become much too thin.

The exact time at terminator would depend on how much of Australia is assumed to be visible In this case at least some has been assumed, giving a time of around 07:30.

The NIMBUS image pass that covers the terminator line around the main cloud system is number 2959 from the 21st, which was commenced at 23:40 on the 21st, quite a bit later than the Stellarium time would suggest. ESSA's image, although less like the Apollo photograph, would have been started at around 03:04 (pass 3345 from track 8) on the 21st, with the image used having a date of the 20th. The 3D reconstruction of ESSA data would seem to confirm that we are looking at the right place.

We have one final sequence of images of Earth to look at, those filmed by the 16mm camera during re-entry. The footage comes from magazine G, and an example of it can be found [here](#).

According to the reference work ‘*Apollo by the numbers*’ the Earth entry interface took place at 13.8 degrees South, 173.52 degrees East eventually splashing down at 20:58 on November 24th at 15.78 degrees South,
Figure 4.4.43: AS12-51-7581 compared with ESSA (top & bottom left) & NIMBUS (right).
Figure 4.4.43 continued: AS12-51-7581 and 3D reconstruction using digitally restored ESSA data
Figure 4.4.44: Location of Apollo 12’s re-entry and splashdown on Google Earth.

The footage varies in what it shows, but we do get a clear shot from time to time of the ocean below them. Figure 4.4.45 shows some stills from the footage.

Figure 4.4.45: Screenshots of the Apollo 12 re-entry 16mm footage

The first thing to suggest is that looking at the trail behind the CM and the horizon in the distance we are still at quite a high altitude here. Can we match up what we’re seeing with any satellite footage?

The archives available for this mission don’t have any images for the 24th, but the US ESSA data recovery project does have an image of the southern hemisphere covering that date, and we can combine two of their images to produce a satellite image covering the re-entry corridor (figure 4.4.46). That image also shows a pair of overlapping NIMBUS image taken on the 24th.

The NIMBUS tile is clearly marked as having been taken at 22:54 on the 24th, while the ESSA data would suggest a time of between 01:00 and 03:00 to image the landing area.
I don’t think there is a clear enough image to determine exactly where we are looking, but the area to the north of the re-entry corridor is not inconsistent with the scenes filmed by the camera.

As always, the sources of information are there for anyone to repeat this analysis and draw their own conclusions, but aside from last one where this is a possibility of doubt, all of the preceding images have allowed a considerably degree of precision in identifying when a photograph was taken, and more importantly from where: On a Moon bound spacecraft carrying three astronauts.
4.4.2 Meteorological comparisons

For much of this particular mission, the phase of the Earth, the timing of the photographs themselves and the winter season (the Earth's tilt angling the northern hemisphere away from the lunar viewpoint) mean that the German, NOAA & South African data are of less use, at least for the latter part of the mission.

For the early part, however, we have a few days over which to confirm that the satellites were accurately reflecting the situation recorded by terrestrial meteorologists (and are therefore not fabrications), as well as the ground based recordings providing an accurate representation of the reality recorded by Apollo. The sources for the NOAA meteorological data are the same as those given in the preceding sections, and the German data can be found here: http://docs.lib.noaa.gov/rescue/cd277_pdf/LSN1157.PDF.

The Apollo image for the 14th of November (the first one used in this analysis) does feature enough of North America to allow the use of at least the German & NOAA weather charts. Figure 4.4.47 shows the relevant parts of these two charts compared with AS12-50-7354.

![Figure 4.4.47: German (left) & NOAA (middle) weather charts from 14/11/69 compared with AS12-50-7354](image)

The main frontal system picked out here is the one trending roughly west to east over the Pacific before veering to the north-east near the US coast. This front ends in the centre of a low over Canada/Alaska. Other fronts visible on the charts are not visible on the Apollo image. The Apollo image shows that front as a cloud mass in front of it, the cold air of the cold front pushing the warmer, moister air upwards causing the moisture to condense out.

Of the images examined in the previous section, the next one featuring any kind of frontal system that are shown on the weather charts is from November 16th, AS12-50-7385 (figure 4.4.48).

The system picked out in green is the one extending across the Atlantic from the Mexican Gulf towards Europe. The large weather system extending south-eastwards from Brazil does not reach far enough over to Africa to feature on the South African weather charts.

An image from the 17th examined earlier can also be looked in terms of the weather charts available (figure 4.4.49). AS12-50-7394 shows North America, with a band of cloud running west-east across from the Pacific into the southern USA. A large mass of lighter cloud can be observed extending across the north-east of the continent.
As with previous examinations of these meteorological charts from other missions, no absolute guarantee can be given of the accuracy of the author's interpretations, but it doesn't seem unreasonable that the long sweeping frontal system (blue arrow) is the same one in the synoptic charts and the Apollo image. The larger cloud mass over the north-east is bounded, it would seem, by the front indicated by the green arrow.

Apollo 12 then, as with the other missions examined so far, shows a wealth of detail in photographs of Earth that could not have been created in an artist's studio, and accurately portray the weather systems shown on the satellite images for the simple reason that they are photographs of those weather systems, taken from space.
4.5 Apollo 13

While the global populace had tired of the Apollo missions, questioning the value of missions in the face of social problems at home and abroad (Gil Scott Heron’s “Whitey’s on the Moon” captured the mood of many), NASA still had several missions to run, even if the numbers of them were being decreased by budget cuts.

Apollo 13 was launched on April 11th 1970 at 13:13 GMT, intending to land at Fra Mauro on the 13th. As anyone with even a remote grasp of modern history knows this didn't happen. A routine stirring of storage tanks led to a spark that caused an explosion in an oxygen tank, crippling the CSM and causing a substantial proportion of the crew's oxygen supply to evaporate into space. Already well on their way to the Moon, the crew had no option but to carry on towards it and use a gravitational slingshot technique (theoretically understood but never before tried) to propel the craft home after a far side lunar pass.

During the mission, they did manage some Earth photography, especially in the early stage of the mission when a weather photography programme meant an image of Earth was taken every 20 minutes. Later on in the mission, there is a poignancy to the many photographs of home that the crew took and that will be used in this analysis. Altogether 5 magazines of film were used, exposing 604 images. Many of these are focused on the stricken craft, and of the Moon during their slingshot pass. The crew did make several TV broadcasts, but such was the decline in interest that the 3rd one, immediately after which came the accident, was recorded instead of transmitted live, and it was shortly after this broadcast that the fateful instruction to stir the tanks was issued. The mission timeline cataloguing the events can be found here: NASA source.

Publicly available satellite imagery is in limited supply compared with previous missions. The NIMBUS-3 satellite had reached the end of its useful life as far as visual imagery was concerned and is not available here. The replacement NIMBUS-4 had not yet started full visual recording of its orbital passes (these commenced in full from April 18th). A test image of Scandinavia for the 13th of April can be found in the NIMBUS data catalogue volume 1, but examination of the photographs available from the Apollo mission revealed that no Earth images were taken that day. Given that the crew were somewhat pre-occupied with an exploding spacecraft at the time, this is hardly surprising. This article in ESSA News briefly describes the role of satellite meteorology in the rescue effort, but supplies no images. An image dated April 10th from NIMBUS 4 (see here) was made available for sale on eBay. The image was not released to the press until the 29th (if the text on the reverse is to be believed). This image is included in figure 4.5.1 for comparison. Other modern remappings as geotiffs of the NIMBUS IR data are available here and are included where appropriate.

Given that the crew were somewhat pre-occupied with an exploding spacecraft at the time, this is hardly surprising. This article ESSA News, and this ESSA World article briefly describe the role of satellite meteorology in the rescue effort, but supply no images.

There is also an image available from what appears to be ATS-1 for April 16th showing the Apollo 13 landing site (used to predict weather conditions on Apollo 13’s return) found in the ESSA publication The first five years of environmental satellites, but while several Apollo photographs were taken on the 16th none of them fell over the area covered by ATS-1.

We are therefore left with the ever reliable ESSA-9 and ATS-3. ATS-3 is not available for all the days of the mission, but is used where possible. ESSA’s catalogue can be found here. ATS data are contained in the same volume as those used in the preceding section for Apollo 12. An interesting alternative to the ESSA images comes in this video, which has the images in a ‘flat’ projection and in colour! The Apollo images used are from the Apollo Image Atlas, with the exception of a screenshot from the first TV broadcast. There are a few high quality TIFF images available at http://archive.org/ (namely AS13-60-8588, AS13-60-8591 and AS13-60-8600). All of the http://archive.org images are incorrectly described as being on the journey home. As will be seen shortly, they were all taken on the way to the Moon.

3D reconstructions will be used for date when the digitally restored versions of satellite data are available.
4.5.1 Satellite comparisons

Before looking at the post-TLI images it’s worth looking at an Earth orbit image, and a brief image of Earth from a broadcast made in Earth orbit as systems were being checked out. The orbit photograph shows us a view of Baja California, and as the transcript has this:

001:31:13 Swigert: And we're just coming up on Baja, and I've got the TV on. Do you want it?

It seems likely that this is when the photograph was taken. The time translates to 19:25 on the 11th. The image in question is shown below in figure 4.5.0a, together with satellite views.

The thin cloud is obviously equally wispy on the satellite images, and the gaps in the cloud match up well. If you’re a flat Earther, first of all well done for being able to read, and secondly note the nice curve to the globe on the horizon.

The TV image, taken here from a Dutch broadcast, shows a broad swathe of cloud. To get an idea of where we are in the world, the crew discuss their location with the ground and they work out that they are crossing the Gulf of Mexico off the southern US coast:

001:42:10 Swigert: Okay, Joe. It appears like that we've crossed out into the Gulf of Mexico here, and I've got a peninsula or an island that's down there.
The time stamp on the transcript tell us that this broadcast was made at 20:50 on the 11th. While it’s not possible from that image to tell exactly where we are, we can see of what we can see is consistent with other images. Figure 4.5.0 below shows a still from the broadcast together with an ESSA view of the area, and a close up from AS13-60-8588 which (as will be demonstrated below) was taken about three hours later.

Figure 4.5.0: TV still from Apollo 13 Earth orbit broadcast compared with a crop from AS13-60-8588 and an ESSA satellite view. Below this is a compilation of screenshots from the broadcast.

The ESSA image does identify clearly the broad swathe of cloud crossing the Gulf, and while the elapse of three hours means there is a difference in the exact configuration of clouds between the photo and the TV still, there are some similarities between them, notably thin strands of cloud trending north-south alongside the northern edge of the much broader west-east cloud band. The red arrow shows areas where the features are very similar.

After launch & TLI, the crew did the usual retrieval of the LM from the SIV-B, and this procedure was recorded as part of a TV transmission 16mm cameras. It’s not clear whether this live transmission was purely for NASA’s benefit as it covered a fairly dull procedure as far as the viewing public was concerned. This footage is available here Apollo 13 footage, and at 3:48 in we hear the words “Is that the world there” in response to a comment from Capcom about the view of Earth being shown. This timing is derived from the mission transcript (ALSJ).
Figure 4.5.1: Screenshot of Apollo 13 16mm footage compared with ESSA-9 (left) and ATS-3 (right). Below this is an image recently sold on eBay taken by NIMBUS 4 on the 10th - the cloud over Florida is much further north on this. The screenshot has been rotated to give the correct perspective.
Although it is not a full Earth view, the presence of images preceding it of the docking manoeuvre means that the craft was no longer in Earth orbit. Figure 4.5.1 shows a screenshot of that footage together with ESSA 9 and ATS-3 views of the Earth on April 11th.

It is not immediately apparent from the screenshot shown in the figure above, the darkness in the top right corner of the Earth image is actually the terminator line, something that can be seen more clearly when looking at the footage in its entirety. The time of the quote given in the transcript is 23:01 GMT, and if this is translated into Stellarium from a lunar viewpoint, the terminator line is as shown in figure 4.5.2.

Stellarium suggests a terminator line just off the east coast of northern America. The terminator line in the Apollo screenshot is just to the east of the cloud system identified by the green arrow, and the outline of north America on the ESSA satellite image corresponds exactly with this. The Gulf of Mexico is visible in the bottom right corner of the image, below the green arrowed clouds, and the yellow arrowed cloud is over the Texas/Mexico border.

The ATS image is recorded as taken at 16:23, just over six and a half hours before the Apollo image. ESSA's orbit for that part of north America is track 3, or orbit 5114, which commenced at 18:08. The terminator orbit (5113) was commenced at 16:02.

The satellite images confirm that the 16mm footage shot by Apollo 13 as it left Earth for the Moon does indeed show the clouds it should have seen.

Once safely on the way we begin to see images of the Earth as an entire disk. The first photograph showing the Earth as such is AS13-60-8588 (see figure 4.5.3).
Figure 4.5.4: AS13-60-8588 compared with ESSA (left top & bottom) and ATS (right). Stellarium estimate of time at terminator.
Figure 4.5.4 continued: AS13-60-8588 and 3D reconstruction using digitally restored ESSA data
The additional rotation of the Earth between the 16mm screenshot and the Apollo image suggests a terminator line consistent with a time of around 23:45 on the 11th. Zooming in close to the Canadian border on the east coast shows that the great lakes are just visible, and Florida would probably be visible if it wasn’t covered in cloud.

Of the two satellites ESSA has the best coverage here & the timings are the same as the previous image. The streams of cloud off Baja California are just visible in the ATS image, as is the large system peeling off the Antarctic (cyan arrow), but the north Pacific weather patterns over Hawaii (red arrow) are too far around. A few hours later in the mission comes a period occupied by weather photography. The idea was to photograph the globe at roughly 20 minute intervals. The exact reasons for it are not clear, but the assumption must be that as the exact time of the photograph is known, this can be tied in more precisely to ground based meteorological recordings.

The first image was taken at exactly 02:30:45. The next image of Earth is AS13-60-8590, and this is followed by 10 further ones. In the mission transcript at 11:24 hours in to the mission (06:37 on the 12th), the crew report that they believe they have taken 10 images and will take one more. As AS13-8590 is succeeded by 10 more images, then logically it must be the first in the series, and we can therefore attach a precise time to it.

Figure 4.5.5 shows this image, and figure 4.5.6 the satellite image comparison.
Figure 4.5.6: AS13-60-8590 compared with ESSA (top left) and ATS (bottom left) satellite images. Stellarium estimate of time at terminator. Cyan, magenta and red arrows are the same as on figure 4.5.4.
Figure 4.5.6 continued: AS13-60-8590 and 3D reconstruction using digitally restored ESSA data
The weather system identified by the red arrow is clearly the same as that in figure 4.5.4, and the clouds picked out by the blue arrow, although not identified specifically in the preceding analysis, is very obviously the same one.

Land masses are not readily obvious in either Stellarium or the Apollo image (which in itself is an indicator that the time for both is correct), but for those that wish to zoom in close enough, land is visible through the cloud cover towards the top of the globe, at what would correspond with north-east Asia around Kamchatka and Siberia. The blue arrowed system starts out over Alaska.

We already know the time of the ATS image, and the Earth as far as Apollo is concerned has evidently moved on since it was taken. ESSA's orbit covering the north Pacific best here is track number 6, or pass 5117, commenced at 00:03 on the 12th, so the Apollo image was taken within a few hours of the satellite version.

Given that the next photograph in the sequence (AS13-60-8591) was taken at 02:52, 22 minutes after the preceding one, we have another excellent opportunity to demonstrate that the Earth used in the Apollo images was the real one, rotating at the correct speed, and not a stationary image superimposed on a background. Figure 4.5.7 shows the terminator line near the weather system picked out by the red arrow above in AS13-60-8590 & 8591.

![Figure 4.5.7: Detail from AS13-60-8590 (left) and AS13-60-8591 (right). Red line on the left image represents where the terminator is on the right.](image)

It is quite obvious from these two images that the Earth has moved, and moved roughly the sort of distance you would expect it to have moved in around 20 minutes – roughly 5 degrees of longitude, or around 400 km at the latitude of these clouds.

The final image in the sequence of Earth images used here is AS13-60-8600 (figure 4.5.8). This is the 11th in the series of weather observation photographs, and is pinpointed in the mission transcript as being taken at 06:50:17 on the 12th. As by this time the viewpoint of ATS-3 has long since been passed, only ESSA’s images can be used to compare the clouds, and this is carried out in figure 4.5.9.

Stellarium suggests that by the time of the Apollo image Australia should be fully in view, and indeed it is.

The cloud mass identified by the green arrow is the one to the west of the system picked out in blue in figure 4.5.6, and the red arrowed band of cloud is a continuation of the one picked out in green in figure 4.5.6. As for whether ESSA’s timings can confirm the time given by the Apollo mission and Stellarium, the most relevant track is number 8, which corresponds to pass 5119, commenced at 04:04 on the 12th. Again, ESSA’s pass over Australia falls within a couple of hours of the Apollo image.

If the sequence of photographs taken by Apollo 13 as the Earth recedes behind it are strung together as a video, the result can be seen in this video. The rotational movement over the sequence is undeniable.
Figure 4.5.8: AS13-60-8600. Source AIA

Figure 4.5.9: AS13-60-8600 compared with ESSA satellite image and Stellarium estimate of terminator.
Figure 4.5.9 continued: AS13-60-8600 and 3D reconstruction using digitally restored ESSA data.
There is a considerable time lapse between these images and the next photographs of Earth. The next image in Magazine 60 (AS13-60-8601) is from the 14th, all other images showing it appear after it has passed around the far side of the moon. This particular image will be discussed at the appropriate point in the sequence of images taken on the 14th. Magazine 61's images featuring Earth all appear after those showing a receding Moon (and are therefore obviously on the way home), Magazine 62 shows a few images at the start of the film with a relatively large crescent Moon, after which there are a few images of a very small crescent Earth, and more are shown towards the end of the magazine after a sequence of far side lunar images. Magazine 59 shows pictures of a relatively large crescent Earth immediately before images taken after the damaged service module was cast adrift. These images of Earth will now be presented in the order that it has been calculated that they were taken.

The first in the sequence is AS13-62-8886, which occurs after the aforementioned set of images of the Moon through the spacecraft window. Figure 4.5.10 shows this image, and 4.5.11 the satellite analysis.

Figure 4.5.10: AS13-62-8886 compared with ESSA (top & bottom left) and ATS (right) satellite images, with Stellarium estimate of time at terminator

The key to identifying this image as belonging to the 14th of April is the cloud system off western Europe (cyan, green and blue arrows) that extends into the Atlantic to off the west coast of Africa. These clouds patterns do not appear in this formation on other days, and as will become clear, the system pointed out by the blue arrow moves progressively towards Africa over the next couple of days. What will also become clear over the next few images is that the blue arrowed clouds are connected to a weather system that extends over America that is visible in subsequent images.

Returning to this analysis, Stellarium’s terminator line through Libya puts the time at around 16:30 on the 14th, just over 13 hours after the crew reported that they had “had a problem”. The ATS image is recorded at 14:01. ESSA's most relevant pass is pass 5148 (track 12), which was started at 12:08. As usual, the reason for
Figure 4.5.11: AS13-62-8886 compared with ESSA (top left) and ATS (bottom) satellite images, with Stellarium estimate of time at terminator.
Figure 4.5.11 continued: AS13-62-8886 and 3D reconstruction using digitally restored ESSA data.
the close correspondence between the satellite images and Apollo is that there is relatively little time between them.

The next image in the sequence for the 14th is AS13-60-8601 (figure 4.5.12). Readers may wish to compare it with AS13-62-8901, which shows an almost identical viewpoint but is of inferior quality. Figure 4.5.13a shows this image compared with the available ESSA, ATS and NIMBUS geotiff images, while 4.5.13b shows a close up of the area east of Greenland compared with a higher resolution image taken by NIMBUS’s IR cameras.

![Figure 4.5.12: AS13-60-8601. Source: AIA](image)

Once 'correctly' oriented, the Florida coastline becomes very obvious, and makes positioning a Stellarium terminator much simpler, placing the time at around 20:45 on the 14th. The close up of the IR image beautifully picks out the swirl of cloud off Greenland.

At this time in the mission the crew are involved with almost continual dialogue with Capcom about the state of the vessel, levels of consumables, and upcoming manoeuvres to orient the craft and position it on a homeward trajectory ahead of a far side lunar pass.

The weather systems picked out by the cyan and green arrows are continuations of weather systems identified in figure 4.5.11 by the blue arrow. The ESSA orbit for the mid-Atlantic would be pass 5150 (track 1) which was commenced at 15:08.
Figure 4.5.13a: AS13-60-8601 compared with ESSA (top left), ATS (bottom left) and NIMBUS (bottom right) satellite images. Stellarium estimate of time at terminator inset.
Figure 4.5.13a continued: AS13-60-8601 and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS IR (right) data
Figure 4.5.13b: Crop of AS13-60-8601 (bottom) compared with close-up of NIBMUS 4 IR image (top).
The next image in this sequence is AS13-60-8716 (figure 4.5.14, source AIA). The photograph occurs after a large number of far side images, and therefore must have been taken after 00:46 on the 15th when they emerged from behind the far side. AS13-61-8826 features a very similar image of Earth (when zoomed in), and this also has far side images preceding it. The ever decreasing lunar disc shown on both these magazines suggests that the image would have been taken well after the TEI burn that occurred at 02:45. As can be seen in the analysis in figure 4.5.15a, the dominant weather system visible is in the Pacific, so only ESSA data are available. A close up the NIMBUS image is shown in 4.5.15b.

The dominant weather system (blue arrow and shown in figure 4.5.15b) on the map is a development of the one identified by the blue arrow in figure 4.5.6, and its centre is still located roughly over Alaska & Kamchatka. Close inspection of the south-west horizon shows that Australia is just visible, and this helps to pinpoint the time as being roughly 05:00 on the 15th. As far as ESSA's timings concerned, the image used is dated the 14th, but the most relevant orbital pass for this part of the globe is orbit 5155 (track 6), which was commenced at 01:04 on the 15th, again just a few hours before the Apollo image was taken.

The next image in the sequence is AS13-61-8864 (source: AIA). This photograph occurs at the end of a sequence of images showing an ever decreasing Moon. Towards the end of the magazine, there are a couple of photographs of the adapted lithium hydroxide canisters used to scrub the cabin air clean of surplus carbon dioxide. The procedure to adapt these canisters began at around 90 hours in, or around 13:30 on the 15th, so the images of the Earth must have been taken before then.
Figure 4.5.15a: AS13-60-8716 compared with ESSA and NIMBUS satellite images and Stellarium estimate of time at terminator.
Figure 4.5.15a continued: AS13-60-8716 and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS IR (right) data
Figure 4.5.15b: NIMBUS IR image compared with a crop of AS13-60-8716
Figure 4.5.16 shows the original Apollo image, and figure 4.5.17 the same image compared with satellite photographs.

What the image shows is that weather patterns that were towards the west of the globe have moved much closer towards the terminator, and systems identified in figure 4.5.15 can also be identified in figure 4.5.17. Australia’s position on the terminator allows a relatively precise estimate of the time the image was taken: 08:15. As the satellite photograph is dated the 14th this gives the appropriate orbital pass as number 5158 (track 9), commenced at 07:01 on the 15th. A few hours after the Australias enter darkness, ESSA starts a new collection of orbits that will have the next day’s date on them.
Figure 4.5.17: AS13-61-8864 compared with ESSA & NIMBUS satellite images and Stellarium estimate of time at terminator. Cyan, green and red arrows as figure 4.5.15a.
Figure 4.5.17 continued: AS13-61-8864 and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS (right) data
Two images later in this magazine we have a similar view in AS13-61-8867, again with the Earth framed by the LM quad thrusters. As with other Apollo images that are ostensibly identical, close examination reveals that there are differences along the terminator that show that it was taken a short while after AS13-61-8864, rather than at the same time.

AS13-61-8867 is shown in figure 4.5.18 below together with a zoomed and cropped Earth.

![Image](image1.png)

Figure 4.5.18: AS13-61-8867 (source: AIA) and the zoomed and cropped Earth, level adjusted to remove noise.
There isn’t any point in repeating the satellite analysis, which is obviously going to be the same, so we can look instead at the differences along the terminator that will allow confirmation of the time it was taken. Figure 4.5.19 shows a comparison of the terminator area by the cloud pattern picked out by the red arrow in figure 4.5.17.

It’s pretty obvious that there has been some rotation between the two images, the question is ‘how much’? The key to working this out is the area of cloud over south-western Australia, which is almost on the terminator in the second image. This suggests a time of around 08:45 GMT on the 15th, as indicated in figure 4.5.20.

The storm over south western Australia as moved to almost in darkness, and the setting the time any later would move it too far, and it does act a further confirmation that the two images are not the same photograph.
There are no firm hints in the transcript specifically about these last two photographs, but capcom is informed regularly at around this time of the angle at which Earth appears on the LPD (Landing Point Designator - marks on the LM window designed to aid distance gauging), and at 85:04 (around 08:20) Haise tells Earth that they are:

“just looking through the command module at you now”

so Earth is on their minds!

The next Apollo image to be looked at is AS13-60-8720 (Source: AIA). There are no real clues in the remainder of this magazine as to when it might have been taken, other than it is after images previously examined from this film, so we are reliant in what we can see in it (figure 4.5.18). Figure 4.5.19 shows the satellite images as a comparison.

![Figure 4.5.21: AS13-60-8720. Source given in text.](image)

It doesn't take much zooming in on this image to see that the terminator line crosses north Africa somewhere along the coast of Tunisia/Algeria, which gives a time of the photograph as around 18:00. The main weather system visible over the Atlantic is the same one observed in figure 4.5.11, but it has changed in the couple of days since it was first photographed, separating itself from the other clouds in the mid-Atlantic and rotating so that the south-western tip is closer to Africa than it was previously. The close-up NIMBUS image nicely shows the swirl of cloud in the Atlantic.

The movement of the Earth has also brought the ATS satellite back into play when confirming the timing of the Apollo image. ATS' image is time stamped at 15:59 on the 15th. ESSA’s most representative orbit is pass 5161 (track 12), which commenced at 13:06 – not long before the ATS image, and within a few hours of the Apollo photograph.
Figure 4.5.22a: AS13-60-8720 compared with ESSA (top left, ATS (bottom left) and NIMBUS (bottom right) satellite images, with Stellarium estimate of time at terminator inset.
Figure 4.5.22a continued: AS13-60-8720 and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS IR (right) data
Figure 4.5.22b: AS13-60-8720 zoomed and cropped and compared with NIMBUS IR image.
The next picture to be analysed is the final image in magazine 60: AS13-60-8726. Between the preceding image and this one there are only a few pictures of a now very small Moon. Magazine 62 again has a very similar image in AS13-62-8954, but there are few clues there as to when precisely this image could have been taken (other than it being after the lithium hydroxide conversion), so we are reliant again on the position of the terminator and satellite analyses. Figure 4.5.23 shows the image from magazine 60 (Source: AIA), and figures 4.5.24a & b show the satellite analysis.
Figure 4.5.24: AS13-60-8526 compared with ESSA (top left), ATS (bottom left) and NIMBUS (right) satellite images, with Stellarium estimate of time at terminator. Green arrow as in figure 4.5.22a
Figure 4.5.24 continued: AS13-60-8526 and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS IR (right) data
Figure 4.5.24b: AS13-60-8276 zoomed and cropped to compare with NIMBUS IR image over Canada.
At the risk of pointing out the obvious (again), there is a degree of overlap between this image and the previous one. The 'speech bubble' cloud identified by the green arrow in figure 4.5.22 has now been split by the terminator line, and the north American mainland can be made out to the west of it. The more detailed NIMBUS IR image shows excellent correspondence with the Apollo photo over Canada.

Using this terminator line Stellarium times this image as roughly 22:30. The ATS image is till the 15th, and the ESSA image is also dated that day. The ESSA pass covering the Atlantic seaboard is track 2, which translates to orbit number 5163, commenced at 16:07. By this time in the journey the CSM and its attendant LM had just passed into the Earth’s gravitational sphere of influence and were beginning to accelerate. The crew were also preparing for a mid-course correction burn.

While there are no more images to be used from magazine 60, there were still other magazines being used. Magazine 62 features image AS13-62-8977, which can be seen in figure 4.5.25 (Source: AIA).

It is always a source of amazement that a figure such as the photograph presented above can contain all the information needed to repel a conspiracist's argument. Ostensibly containing nothing, this photograph, and countless like it, contain sufficient detail of the Earth’s weather systems to prove that they were photographed at the same time, or at least within a few hours of, a satellite in orbit much much closer to the subject. Figure 4.5.26 shows the ESSA satellite in comparison with this Apollo photograph.
Figure 4.5.26: AS13-62-8977 in comparison with ESSA satellite image and Stellarium estimate of time at terminator.
Figure 4.5.26 continued: AS13-62-8977 and 3D reconstruction using digitally restored ESSA (centre) and NIMBUS IR (right) data
The terminator is falling across the west coast if the USA, and this allows the time of the photograph to be estimated at 02:30, which must therefore be on the 16th.

The main feature on this photograph is obviously the large sweep of cloud that has been a persistent feature over the entire mission, and this has extended from the relatively tight curl centred over Alaska to a much broader sweep. Despite the blurred image, the large swathe of wispy cirrus clouds off Baja California are still very much evident. What is also apparent is that the weather patterns identified by the blue and cyan arrows are noticeably further apart in the ESSA image. Although this may be a product of the angle at which the Earth is being viewed and the distorted perspective of the satellite composite's projection, but it could also be that the weather has moved on between the satellite image's exposure and that of the Apollo photograph.

ESSA’s most representative terminator orbit is track 4, which runs along the west coast. This would be pass number 5165, which commenced at 20:07. Examination of the records show pass 5166 is not listed in the data catalogue, and this is either because of some technical problem and data from the surrounding orbits has been used to fill in the gaps (there is a degree of overlap), or it has been missed when generating the list. If the latter is the case, it should have commenced at around 22:00, over 4 hours before the Apollo image was taken. Pass 5167 started just after midnight on the 16th.

The final image that attributable to the ESSA composite from the 15th and its attendant satellite analysis are shown in figures 4.5.27 & 28 respectively, and involves AS13-62-8993.
Figure 4.5.28: AS13-62-8993 compared with ESSA satellite image and Stellarium estimate of time at terminator
Figure 4.5.28 continued: AS13-62-8993 and 3D reconstruction using digitally restored ESSA data.
The land in the centre of the image is the Indian sub-continent, with Arabia on the western horizon. The bulk of the visible cloud mass is sweeps over the Himalayas before meeting with another weather system crossing northern India from the Indian Ocean. The terminator line falls roughly across Bangladesh on the coast, and this gives an estimated time for the image of 12:30 on the 16th.

ESSA’s pass over this part of the world is best represented by orbit 5171 (track 10, which intersects the Bangladesh coastline), commencing at 08:09 on the 16th. At this point in the journey, the crew were busy dealing with repeated problems with one of their batteries, and preparing for the final course correction that would put them in the correct alignment for re-entry.

Once ESSA’s satellite passes over eastern Africa, it starts a new page, and any images taken by Apollo will therefore be referenced by an ESSA composite labelled the 16th. The first in the final day’s images is AS13-62-9012, (figure 4.5.29). The image shows another development in the life of the weather system that has lain off the Europe and north Africa over the course of the mission, and the position of the terminator gives an estimated time of the Apollo photograph of around 18:00. The satellite image used is dated the 16th, and the analysis in figure 4.5.30 demonstrates that this is the appropriate date for it.

Figure 4.5.29: AS13-62-9012 (source: AIA)
Figure 4.5.30: AS13-62-9012 compared with ESSA satellite images and Stellarium estimate of time at terminator.
The weather front identified by the green arrow is very obviously the same one picked out in numerous previous images, but is also obviously a development of that system and not a reproduction of it. There are, as is often the case, subtle differences between the satellite images and the Apollo photograph that are indicative of a time gap between them. Several more images after this, up to AS13-62-9034 show a similar but slightly rotated view.

ESSA’s best path covering the photograph is track 13. In this case this would be orbit 5174, commenced at 14:05 on the 16th. The crew are now 24 hours away from a safe landing and are going through the housekeeping and entry procedures that will see them through those final hours.

The final image of Earth in magazine 62 is AS13-62-9038 (source: AIA). On the next page, figure 4.5.31 shows this image as shown in the Apollo Image Atlas, and 4.5.29 shows the analysis of the weather patterns in it. The terminator line is now runs down through the centre of the north Atlantic, clipping the eastern coast of Brazil. This places the time of the photograph at roughly 20:45, and as the cyan, green and blue arrows point to the same weather systems shown in the previous image, the Apollo image must, therefore, be from the 16th of April.

The terminator line is now runs down through the centre of the north Atlantic, clipping the eastern coast of Brazil. This places the time of the photograph at roughly 20:45, and as the cyan, green and blue arrows point to the same weather systems shown in the previous image, the Apollo image must, therefore, be from the 16th of April.

Figure 4.5.31: AS13-62-9038. Source given in text
Figure 4.5.32: AS13-62-9038 compared with ESSA satellite images and Stellarium estimate of time at terminator. Blue, green and cyan arrows as in figure 4.5.30.
The ESSA track that covers the central Atlantic around the terminator line is number 2, which means that the most representative orbit is number 5176, which was commenced at 17:05 on the 16th. As usual, the most obvious explanation for the high degree of correspondence between the Apollo & satellite images is that they were taken at roughly the same time, one from space, one from low Earth orbit.

The next photograph is one that only emerged recently after an enquiry on collectspace.com, where contributor LM-12 asked for the location of several ‘missing’ Hasselblad magazines recorded in inventories but not found on any of the usual Apollo related websites.

LM-12 mentioned magazine 63 from Apollo 13, and a quick search revealed that half a dozen images could be found at the Gateway to Astronaut Photography. Close examination of the photographs revealed that they were all of the same view taken with different exposure settings. One of these photographs is shown below in figure 4.5.33. Alongside the image is a mock up of a lunar module interior, in which can be seen the panel and equipment details shown reflected in the window through which Earth has been photographed. The simulator view has been rotated to match the view seen in the Apollo image.

Figure 4.5.33: Left - AS13-63-9045 (Source), Right - Apollo 14 astronauts in a Lunar Module simulator as seen through one of the windows, rotated to match the Apollo 13 view (Source).

Before dealing with the view of Earth, it’s worth pointing out that there are clear shots of the interior of the lunar module in the Apollo 13 photograph. I’m sure someone idiot will point out that the other photograph I’ve used is a simulator blah blah that’s how they did it drone drone, but what they have to then get around is the fact that there is a large planet Earth in the picture. Speaking of which, let’s have a look at what we can see on it, and when it might have been taken.

The shape of the crescent suggests very strongly that it belongs in the closing stages of the mission, so the search began on ESSA images from that part. The weather systems we are looking for turned up on the satellite view taken on the 16th, and this is shown below with a rotated and cleaned up version of the Apollo 13 photograph in figure 4.5.34.
Figure 4.5.34: Zoomed and cropped version of AS13-93-9045 compared with ESSA satellite image dated 16/04/70 and Stellarium view of Earth set at 06:30 on 17/04/70.
The first point of identification was the ‘y’ shaped system identified in the red arrow, only faintly visible on the Apollo view, but once that was spotted the rest fell in to place. The key to the time is the system shown by the magenta arrow on the east coast of Australia, placing the time at around 06:30 on the 17th.

There isn’t much confirmation of this in the mission transcript - the crew were supposedly on a rest period after some fairly intense technical exchanges aimed at getting them home in one piece. They complained that it was too cold to sleep, and one of them must have used a quiet moment to snap a photograph of home.

We do get a small clue that confirms that Australia should be in shot at the time I suggest it was taken. About an hour after Stellarium’s time capcom tell them that they will shortly be handing over to Honeysuckle Creek on Australia’s east coast - confirming that the Pacific would dominate their view of Earth at the time the photograph was taken. As for the satellite image, the visible area is best described by track number 7, or orbit 5181, which began at 03:02 on the 17th.

It’s also worth pointing out that the crescent on the Stellarium view is much narrower than that of the Apollo image, which is again consistent with it being cislunar space.

It’s are remarkable testament to the consistency of the Apollo record that a photograph that very few people even know exist, and equally few people have seen, can reveal details that match what should be visible. Yet another one in the eye for Apollo deniers.

The final image in this sequence is from a so far unused magazine, AS13-59-8492.

It occurs as part of a short sequence of images immediately before photographs of the jettisoning of the damaged service module part of the CSM, which occurred at 13:14 on the 17th. Prior to this are a number of photographs taken from within the CSM. The Apollo image is shown in figure 4.5.35, and the satellite analysis in figure 4.5.36.

Figure 4.5.35: AS13-59-8492 (source: AIA)
Figure 4.5.36: AS13-59-8492 compared with ESSA satellite images and Stellarium estimate of time at terminator.
As with the previous analysis, the main land mass visible is that of the Indian sub-continent, and there are a number of similarities between the two photographs. There are, however, subtle differences. The terminator line here crosses the coast of Vietnam, meaning it was taken before the previous one in terms of a single rotation (Stellarium estimates a time of 11:00). The concavity of the terminator line has increased which means that there has been a change in the apparent phase of the Earth, at least in terms of the view from the Apollo 13 craft, the crescent appearing narrower than the preceding day's photograph.

There are also clues in the shape of the cloud systems. While there is the same band of cloud covering the Himalayas, the green and blue arrows point to bands of cloud that do not show on the previous day's photographs of the area. The land either side of the broad swathe of Himalayan cloud is considerably clearer than in the photograph taken on the 16th.

ESSA's image, labelled the 16th, still covers this rotation of the Earth, and the most relevant orbital path is number 5184 (track 10), which was commenced at 09:08 on the 17th.

The crew were now only 48000 miles and 7 hours from a safe landing. At 136 hours into the mission (11:15), they ask about settings for black and white film for the upcoming separation from their CM, so the camera was around at this time too. 10 hours earlier, there was a considerable discussion about what cameras were available for photographing the separation manoeuvres, and some concern at the degree of misting on the windows that might interfere with it. This misting is visible on some of the photographs in other magazines.

Speaking of separation manoeuvres, we have one more set of images to look at.

At 16:43 on April 17th the LM Aquarius was cast adrift from the CM on the last lap of their journey home. A series of images was captured of that separation, which occurred just over 11000 miles about the Earth. Sharp-eyed contributor to collectSpace LM-12 spotted that reflected in the LM window was Earth. Figure 4.5.37 shows the best of the images (AS13-59-8555), with a close up of the window in question.

Figure 4.5.37: AS13-59-8555 and a close up of the LM window.
So, can we work out where we are looking? Well, we have a precise time and we have a precise altitude. We also know, thanks to the mission report, the precise position above Earth of the LM at separation (1.23 S 77.55 E), which means we can narrow it down quite a lot. Here are two views of Earth from Fourmilab showing how it looks from the moon, and from the LM separation position.

Figure 4.5.38: Fourmilab Earthview of Earth at 16:43 on 17/04/16 from the Moon (left) and from the separation point at an altitude of 11250 miles.

The terminator is running down the centre of Africa, and realistically not much should be visible in daylight other than eastern Africa and perhaps a little of Europe.

This illustration from Universetoday (figure 4.5.39) indicates that the view is more likely to be of equatorial Africa rather than Europe given the approach Apollo 13 took to its eventual landing site. However it’s also possible that the trajectory could have pointed the camera towards the north or south!

Figure 4.5.39: Ground track of Apollo 13 from re-entry to splashdown, as shown in Universe Today.
The track is looking all in the Southern hemisphere, and it the trajectory would again imply that the view reflected in the LM window is likely to be around the equator.

So, we should have a view of equatorial African reflected in the LM window. Let’s see how that turns out. First of all, we need to invert the view of Earth to stop it being a mirror image, and we can also help ourselves in identifying any weather patterns by stretching the view a little.

![Figure 4.5.40: Earth seen in the LM window. The view has been level adjusted and sharpened, and the view on the right perspective corrected.](image)

Can we realistically identify weather patterns here? Well, to be honest not with any great degree of certainty, particularly as we don’t really know how wide an area we are looking at. The width of the sunlit area here pretty much rules out anything other than central and sub-equatorial Africa, and the amount of curvature on show suggests a relatively small field of view, so let’s have a look at that the data from ESSA’s shots on the 17th.

As I said, nothing I would bet my house on, and I base my judgement on logical deduction rather than precise identification, but for now I am pinning my hopes on the area I’ve zoomed into above. It’s in the right place and contains the right sort of broken cloud. It’s just a shame that the satellite images aren’t as clear cut as in other examples.

Even if I am wrong in my estimate, what is interesting is that even in images reflected in a lunar module window there are clear details of the Earth and its weather systems, and the clouds even have shadows underneath them - such is the level of detail.

Apollo 13. Around the moon and home again, with the photographs to prove it.
Figure 4.5.41: ESSA image from April 17 of Africa, and a zoom and crop of south-west Africa.
4.5.2 Meteorological evidence

The same sources used for previous sections are again available here (the reader is referred to those sections if they wish to check them themselves), but as with Apollo 12 the ever diminishing crescent of the Earth and the fact that the majority of photographs show areas not covered by the synoptic charts limits the number of possible comparisons.

April 11th did, at least feature good coverage of North America, which allows us to revisit AS13-60-8588, Figure 4.5.42 shows the NOAA & German synoptic charts for April 11th compared with that NASA image.

![Figure 4.5.42: AS13-60-8588 compared with German (left) & NOAA (right) synoptic charts.](image)

Again, as with preceding sections no claim is made to any great degree of meteorological expertise, and those more expert are welcome to provide their own views as to which fronts correspond to which cloud masses. The front over the gulf seems simple enough to identify, and the German chart even shows the curl of the cloud band off the east coast.

Although less obvious as a band of cloud, the stretch of clear ocean above the front marked in yellow seems to match up. The blue arrow (not shown on the NOAA chart) would appear to correspond with the system off Alaska.

There is, again, no inconsistency in the meteorological charts available and the weather patterns displayed in the Apollo image.

The next brief examination of meteorological charts is for April 14th. The two images to be used have already been examined in the previous section and show the Atlantic, with a small portion of the Eastern US seaboard (AS13-60-8601), and the Pacific ocean (AS13-60-8716). They can be compared with the NOAA and German synoptic charts, and this is done in figure 4.5.43.

![Figure 4.5.43: AS13-60-8601 compared with German (left) & NOAA (right) synoptic charts.](image)

It should be noted that there is a difference of opinion as to whether there is a front associated with the depression over the Rockies between the NOAA and German charts, but this area isn't covered by either of the images so it is difficult to suggest which is correct. It is possible that the time difference between them accounts for the difference in interpretation, their being some 12 hours apart.

The other fronts are clearly visible in the photographs, although it should be acknowledged that the cloud pattern off Florida is more difficult to ascribe accurately. It is the contention here that the cyan arrowed front matches that on AS14-60-8601, and the clouds that connect with it across the Atlantic are those from the magenta arrowed front. The author is always open to other explanations.
Figure 4.5.43: AS13-60-8716 (top left) and AS13-60-8601 (top middle) compared with German (bottom) and NOAA (top right) synoptic charts. German data is at 00:00 on the 14th, NOAA at 12:00 on the 14th.

One final day's synopses will be examined before moving on to study Apollo 14, and that will be the final day for which Apollo images are available: April 16th. AS13-62-9038 and AS13-62-9012 cover the western and eastern Atlantic respectively, and German & NOAA charts should cover both (figure 4.5.44).

As with previous synoptic examinations, there is no discrepancy between the synoptic data collected on the ground and the Apollo images taken in space. The most reasonable explanation for this has been made many times: the Apollo images were taken from space, on the days they have always claimed to have been taken.
Figure 4.5.44: AS13-62-9038 (top left) and AS13-62-9012 (top middle) compared with NOAA (top right) and German (bottom) synoptic charts for April 16th 1970.
4.6 Apollo 14

Following Apollo 13’s near disaster, it took 9 months for NASA to re-start its remaining lunar missions, and it was not until the end of January 1971 that Apollo rose from the launch pad heading for Fra Mauro (named after a 15th century map of the world), the original destination of Apollo 13 and a replacement of its original destination of the Littrow region of *Mare Serenitas*. The mission launched on January 31st 1971 at 21:03. It left Earth orbit at 23:37, and was notable for taking several attempts to achieve a successful dock with the LM. It arrived in lunar orbit on February 4th at 07:05, and landing occurred at 09:18 on the 5th.

The mission timeline can be found here [http://history.nasa.gov/SP-4029/Apollo_14i_Timeline.htm](http://history.nasa.gov/SP-4029/Apollo_14i_Timeline.htm). Two 4 hour EVAs were undertaken, one on the 5th and one on the 6th, before the LM ascended to rejoin the orbiting CSM on the evening of the 6th. The crew splashed down at 21:05 on the 9th.

During the mission, 1342 images were taken on 15 magazines, but the vast bulk of these were taken on the two EVAs, and also of the Descartes region, which was an area deemed of sufficient interest to help move the landing site from Littrow, the orbital parameters for which would not have allowed Descartes to be observed.

Like Apollo 12 before it, the location of the landing site towards the western limb of the lunar face (as viewed from Earth) means that for there to be a reasonable amount of daylight to be available, the moon would need to be ¾ full, which also means that the Earth needs to be ¼ full by the time the astronauts land, and this limits the number of useful photographs available for this analysis.

In fact, very few images of Earth were taken at all during this mission, and some of those are of very poor quality, possibly a product of a problem with one of the Hasselblads that prevented its use. A number of NASA affiliates were approached to find better quality copies of those currently publicly available, but unfortunately only the same standard of image was made available.

It is a great pity that this image (figure 4.6.1) and the others in its sequence showing the LM Antares on the lunar surface proved unsuitable for analysis here. Even the 44Mb TIFF image held at [http://archive.org](http://archive.org) did not reveal any more detail than lesser copies elsewhere.

![Figure 4.6.1: AS14-64-9189. Source: AIA](AS14-64-9189.jpg)
It is a shame because apart from the obviously useful juxtaposition of Apollo hardware and the Earth, this series of images from magazine 64 has been shown to show Venus. The reader is referred to this website for full explanation of this: [http://www.hq.nasa.gov/alsj/a14/a14Venus.html](http://www.hq.nasa.gov/alsj/a14/a14Venus.html).

It is possible, however, to zoom in on one of the images in that sequence (AS14-64-9191: AIA) and by altering the levels of in the image's histogram and the degree of contrast reveal some degree of detail. The time of this sequence is given as 12:03 on 06/02/71, so we can use Stellarium to identify what should be visible. Figure 4.6.2 shows a zoomed & cropped version of the image after processing, compared with Stellarium's view of what should be visible.

![Figure 4.6.2: AS14-64-9191 (source given in text) zoomed to the Earth compared with Stellarium for 12:06 06/02/71](image)

The series of images of which this Apollo one is a part took only a few minutes to complete, so the actual time of this specific image would be around 12:06, as shown in the image. Very little cloud is recorded for this region on that particular day, but while an area of darkness corresponding to roughly where the Indian coast would be can be seen, it would not be wise to claim any degree of certainty as to whether the image is revealing actual detail or just features from image processing. It would certainly not be possible to compare any weather systems on it.

As for what satellite data are available ITOS 1 images are available from here: [ITOS 1](http://www.hq.nasa.gov/alsj/a14/a14Venus.html). ITOS 1 was launched on 23/01/70, and occupies the same orbital tracks as ESSA satellites. The introduction to the ITOS data collection describes its operation. NIMBUS 4 had become fully operational by this time, data for which can be found here [NIMBUS 4](http://www.hq.nasa.gov/alsj/a14/a14Venus.html).

ATS satellites had, by now, finished their regular visual imaging programme and are unavailable.

Occasional images from satellites can be found in journals and other publications covering this period. This [journal article](http://www.hq.nasa.gov/alsj/a14/a14Venus.html) contains a much clearer ITOS image from the day of Apollo 14’s splashdown, as well as a
synoptic chart. A February 4th ITOS image is also available in Satellite Activities of NOAA 1971. The Mariner's Weather log also contains an image from the 8th: Weather Log. As with previous sections, these are given more as an indication that the information presented here has always been available, should diligent researchers have cared to look for them, rather than an indication that they will be used.

Another interesting document is Weather Support to the Apollo 14 Mission from September 1971, which describes the role of weather forecasters during the mission (the launch was delayed thanks to bad weather). It also features synoptic charts and ITOS & NIMBUS images from during the mission. This document describing how satellite images can be used in weather forecasting also has images covering the mission, but again they are of little use. 3D reconstructions will be used where appropriate and where the data are available.

Given the lack of images with clear views of Earth, no synoptic charts will be examined.
4.6.1 Satellite comparisons

Unlike previous missions, no images were taken of Earth until the craft was in (or very close to) lunar orbit. This combines with the fact that those images that are available are of such a narrow Earth crescent and and/or of poor quality that it is very difficult to carry out any meaningful analysis on them. There was a TV broadcast made on February 3rd showing Earth but this is overexposed and no detail can be made out. Figure 4.6.3 shows a screenshot of that broadcast, together with a press photo from that date that wrongly identifies Earth as the moon.

Those few images that are suitable will be examined, but the results should in most cases be regarded with a degree of caution. More enhancement of the images is required than has been the case so far, but the process will be explained in each case and the reader is free to replicate it. The procedure is rendered even more difficult by the absence of images from the 6th (neither hemisphere) and 7th of February (southern hemisphere only) in the ITOS 1 record, which means that for much of the period when photographs were taken, only the less clear NIMBUS images are available.

In the end, it was determined that only 4 days were covered by identifiable images of Earth, the 5th to the 9th of February. The logic of these deductions is outlined below. AS14-66-9288 (figure 4.6.4) appears in a magazine that was taken to the lunar surface but is obviously of an Earthrise from orbit, and immediately after photographs taken from the LM showing the CSM. It must therefore have been taken after the 04:50 on the 5th when the two craft separated but before touchdown at 09:18 on the 5th. Shortly after separation at 05:23 the crew flew over the landing site (see the voice transcripts held here: ALSJ), which means the earliest it is likely to be is the start of orbit 13 and AOS at around 06:40. The start of orbit 14 is at roughly 08:00, and this is in all likelihood the last opportunity to image as the next orbit around sees the crew in descent mode and somewhat occupied! During this narrower window Australia comes in to view, and it is off its east coast that weather patterns will be searched.

The image is part of a series of photographs, but is one where image enhancement gave the best results in terms of recognisable features. In order to achieve those recognisable features the image needed some enhancement. Figure 4.6.5 shows the original zoomed and cropped Earth compared with the Earth after levels had been altered, and brightness and contrast values changed and the image sharpened.
Figure 4.6.5: Original Earth from AS14-66-9228 (left), Earth after level adjustment (centre) and then brightness/contrast adjustment (right). Level adjustment moved dark values from 0 to 68 and grey values from 1 to 0.44. White values were left untouched. Contrast was then increased to 40% and brightness decreased by 60%.
Figure 4.6.6: AS14-66-9228 compared with ITOS (top & bottom left) and NIMBUS (right) night time IR satellite images. Clouds and clear patches are both identified. Stellarium terminators for the suggested likely times are also shown.
Figure 4.6.6 continued: AS14-66-9228 and 3D reconstruction using digitally restored ESSA data
While not the best quality, the levelled and contrasted Earth suggests that there is a body of cloud in the very south of the planet, above which is a thinner band separated from this mass by a narrow band of sea. North of this relatively thin band is an area of blue, presumably sea, that is narrower at the west than it is at the east. Above this patch of ocean is more cloud, this time narrower at the east than the west. Above the pointed tip of this cloud at the terminator is a lobe of blue ocean, above which is more cloud that extends westwards in an arc to join the cloud below it. We now need to see if these features can be found in an area east of Australia on the 5th of February and this is shown in figure 4.6.6 on the preceding page.

As far as confirming timings, the ITOS images follow the same pattern as ESSA and an image dated the 4th will pass over Australia on the 5th. The most appropriate track for the area covered is number 8, which corresponds to orbit 4725, commenced at 04:09. The best coverage of the region by NIMBUS 4 turned out to be the night time IR images, as these were the only ones that covered the area completely (daytime IR and visible spectrum ones give incomplete coverage). On the image dated the 5th, the most relevant pass is number 4071, which was commenced at 11:48. The mission’s preliminary scientific report (Source: PSR) confirms that this image was taken 1 orbit before landing, and the Photographic index (ALSJ) states that it was taken on orbit 12, which started at about 08:11 on the 5th. As an aside, Venus is also recorded in the Earthrise sequence (see here ALSJ) and an analysis of its position here shows that it is consistent with this timing. The 3D reconstruction of ESSA data also seems to confirm the conclusions drawn from the original analysis.

Despite the caveats mentioned earlier, the images do show broad scale features visible on the satellite images. They may not be as clear as those analysed in previous sections, but the logic used to determine which part of the Earth to look at and the features themselves seem to provide a good match. It is important to re-iterate that nothing has been added to the image of Earth during enhancement. Close examination of the original Earth in the photograph shows the same features, they are just masked by an overexposed image. The reader is, as always, invited to repeat the process undertaken to check that this is the case.

The next image examined is AS14-72-10038 (figure 4.6.7). The image is part of a sequence of photographs of an Earth crescent occurring after a number of images taken looking down at the lunar surface. The photograph must therefore be after entering lunar orbit, and the width of the Earth crescent indicates it is some time after the image examined previously. It is also part of double series of photo sessions, as will become clear shortly.
Zooming in on the image reveals much more detail than in the previous image, and therefore only a small altering of levels to bring enhance it is required. The image shows the Americas on the Western limb, and the main weather features are a long band of cloud stretching in from the terminator towards Mexico, which almost a serrated edge. The south western end of this band appears to have another mass of cloud immediately to the north of it. Over north America is a large mass of cloud, and south America shows scattered clouds over Brazil, with a long chain of cloud runs across South America. Cuba is dissected by a thin band of cloud running roughly north-south.

Analysis of this image is made difficult by the absence of high quality images, but the exact date can be narrowed down somewhat by examining the satellite images for other days. As mentioned, the crescent is much thinner than the Earth seen on the 5th, and the 'serrated edge' cloud does not feature an additional mass of cloud to the north of it, so it is clearly not from them. The image from the 8th shows this same cloud has reached the coast of Central America (it actually developed into a substantial in the gulf storm, causing considerable damage to southern US states), ruling that date out.

This leaves either the 6th or the 7th of February as the likely date. The Stellarium terminator just off Florida suggests a time of around 22:30, at which time on the 6th the crew have just about to jettison the LM ascent stage, and the same time on the 7th the crew are long past TEI, have made a mid-course correction and are in the middle of on-board experiments. No mention is made of photographs, and the image could belong to either day. The size of the Earth in the image lends itself to the idea that it was taken post-TEI, but both the AIA and ALSJ describe the photo as being taken in lunar orbit.

Figure 4.6.8 shows a comparison of Stellarium terminator lines with the Earth crescent in the photograph in an attempt to pin down the date more precisely. This seems to pin down the date definitively to the 6th. The photographic index cited earlier seems to contradict this by stating it was taken on orbit 14, which was on the 5th and the preceding analysis shows began with Australia in view. The suggestion here is that the evidence of the photograph, rather than the index, is correct, as a 90 minute orbit beginning over Australia would be completed passing somewhere near India.
Having discounted the photographic index evidence and established with a reasonable degree of certainty that the date for this image is the 6th of February, we are left with the problem of a lack of satellite images with which to compare the Apollo photograph. NIMBUS 4 does have an image from the 6th, but only shows a small portion of the gulf in the night time IR image. The visible and daylight IR spectrum images fail to show any portion of the crescent.

We do, however, have images of the southern Hemisphere from the 5th and 7th, and also northern hemisphere images from the 5th and 8th. While not as ideal as in previous missions, it should be possible to demonstrate that the clouds visible on the Apollo image are a good interpolation of what should be there given the weather conditions on days before and after the 6th. Figure 4.6.9 shows the Earth crescent from AS14-72-10038 compared with southern hemisphere ESSA images from the 5th & 7th, and ESSA northern hemisphere images from the 5th and 8th. The NIMBUS image is from the 6th.
The NIMBUS image does show a band of cloud (blue arrow) extending across the Gulf towards central America. A band of cloud is also visible across where Cuba should be (green arrow). What is noticeable is that the extra cloud mass at the end of this band in the Apollo photograph is not visible in this image, but as it is an IR based image, it may be that this cloud simply hasn’t registered with the camera. The northern hemisphere image from the 5th is obviously more similar to the photograph than the one from the 8th, where the storm mentioned earlier has begun to develop in earnest. The ESSA northern hemisphere image from the 5th shows Cuba in its entirety, with band of cloud across it.
Looking over Central America, NIMBUS shows a couple of thin bands of cloud running across it (red arrow), and these seem to correspond to similar just visible strands in the Apollo image. The cloud cover on the 8th in the ESSA image is much more extensive over this region, while that from the 5th does bear some similarity.

The southern hemisphere in ESSA shows a much less dense cloud pattern in the image form the 7th compared with the 5th, particularly over Brazil. The most visible feature from the Apollo photograph’s perspective is the long band of cloud running first along the Andes before cutting across Chile & Argentina heading towards the south Atlantic (purple arrow). A number of shorter bands can be seen in the Apollo image running parallel with this larger band (yellow and cyan arrows), and one of these breaks away from running strictly parallel (yellow arrow).

None of these features are seen exactly in the ESSA image. There are definite resemblances between the two and these have been highlighted where a definite comparison can be seen. The 7th is the most similar, but it would be fair to state that the image taken by Apollo 14 shows a continental weather system that falls somewhere between the two states given in the ESSA satellite mosaics.

Despite not having the precise image available for a given day, the presence of images from preceding and following days allows us still to state the Apollo photograph was taken on 06/02/71 at around 23:00, because had it been taken at that time on the other days the craft was in lunar orbit it would have shown different features. For the record, the NIMBUS pass over the Mexican gulf is on the 6th is number 4081, which was commenced at 06:05 – still some time before the Apollo image. ESSA images over that region are track number 3, which are taken commenced between 19:00-20:00.

Initially, the sequence of Earth colour images taken in lunar orbit were thought to be taken at the same time, but careful examination revealed that the first few in the sequence were actually taken earlier. Out of sheer laziness, it was easier to slot them in after the previous image.

The image that gave the game away is AS14-72-10033, shown in figure 4.6.1. Although it isn’t a full crescent it is the clearest of the images taken. The crescent that is available is analysed in figure 4.6.11.

![Figure 4.6.10: AS14-72-10033.](Source: AIA)
Figure 4.6.11: Restored Nimbus image from February 6th 1971 compared with AS!4-62-10033 and a Fourmilab view of Earth set at 22:00 on that date. Apollo image has been level adjusted and sharpened to bring out detail.

We haven’t bothered adding the ESSA images from adjacent dates, partly because it’s confusing but mostly because the NIMBUS one has all we need. The sharpened detail identifies the northern coast of South America as well as the larger Caribbean islands, which means we must be looking at a time earlier than the previous image, probably by about an hour.

That time of roughly 22:00 would be about 144:57 MET, which would put Apollo 14 at just around AOS on orbit 33, making this a post-Earthrise Earth. Looking at Stellarium from that time Venus is frustratingly just out
of shot, and it may be that the crew were intentionally trying to get the image of the two things together first when Earth rose fully over the moon, and secondly just before it began to set again at the end of that orbit.

In addition to this colour image of Earth from lunar orbit, there is a black & white series of an Earthrise that must also have been taken before leaving orbit on the 7th. AS14-71-9845 (figure 4.6.12) is the second in a short series of exposures near the start of the magazine. Immediately after them are photos of craters strongly suggestive of increasing orbital altitude, as craters over 200km apart are recorded in the photos after the Earthrise and the lunar horizon becomes increasingly curved.

The width of the crescent in the photograph is roughly the same as that in the previous image, which suggests that it was also taken on the 6th. There are, however, no visible landmass features to allow us to work out where the image is, so we are reliant on weather features as a guide as to where the terminator is falling. The photographic index lists it as being taken in Trans-Earth Coast.

The most obvious feature is the large apostrophe shaped weather system in the northern hemisphere, which should at least be easy to find. The bulk of the tropical region seems to be cloud free, before scattered sub-tropical clouds appear in the southern hemisphere. Some other systems are just visible in the southern temperate region that may be visible in satellite images.

In analysing this image, we need to use the same technique as the previous image and use those days where there data do exist to cover for days where it is absent. It should be obvious from the previous analysis that the photograph must be later than the 5th, and appears to show a crescent consistent with the 6th of February rather than the 7th.

Examination of NIMBUS images from the 6th show that there is are systems resembling those in Apollo photograph in the northern Pacific, as well as the open equatorial oceans and scattered sub-tropical clouds in the southern hemisphere suggested in the Apollo image. The northern Pacific parts of ESSA images from the 5th and 8th are included to ensure complete coverage, and southern hemisphere ESSA images from the 5th and 7th. The NIMBUS image shows the visible spectrum image from the 6th. Figure 4.6.13 shows the analysis on this basis, with a terminator image from here as a reference.
Before discussing the image it is worth pointing out that several sections of the ESSA image from the 5th were over-brightened over significant areas. These areas have been selected and their levels altered to reveal the detail hidden by this excessive brightness.

Those readers who have actually been bothering to look at the analyses presented previously will probably have looked at the preceding figure and not quite understood the arrows drawn on the ESSA side of things. Arrows have been drawn, but the weather systems they are pointing at bear only slight resemblances to the Apollo image. The NIMBUS side of the figure is much more obvious—the apostrophe shaped system is very evident in the NIMBUS visible spectrum image, as are the thin band of cloud to the east of it and the scattered clouds to the south of it. This suggests very strongly that we have the date correct for the Apollo image. The track covering this cloud system is number 4090, which was commenced at 20:59 on the 6th.

However, we can see from the Fourmilab terminator that the time of the image will have been taken at approximately 02:00, and it seems reasonable to suggest that this would be in the early hours of the 7th. Part of this reasoning is based on the fact if the Apollo image was taken at 02:00, then it should match almost exactly with the ESSA image taken on the 5th, as Alaska would have been imaged at roughly the same time. The remainder of the logic behind dating this image relates to the position of the clouds on the image dated the 5th from ESSA and how they compare with those on the NIMBUS image. To explain this better, figure 4.6.14 shows a close up of the area off the Alaskan coast.
Figure 4.6.13 continued: AS14-71-9847 and 3D reconstruction using digitally restored ESSA data
Figure 4.6.14: ESSA image dated 05/02/71 (left) and 08/02/71 (centre) and NIMBUS image dated 06/02/71.

The weather system under discussion is highlighted by the green arrow in the NIMBUS image. The initial temptation was to assume that the cloud pattern on the 140 degrees west longitude line was the same one. However, by going through other images covered by the mission, it was soon established that the edge of the orbital track covering that weather system in the NIMBUS image is also on the 140 longitude line. This effectively means that for the clouds in the ESSA image on that line to be the same ones, the weather systems would effectively be going in reverse – travelling in the opposite direction to the prevailing winds – extremely unlikely.

The clinching observation, however, is the cloud pattern to arrowed in green on the ESSA image from the 5th and the NIMBUS image – they are clearly the same, and this makes much more sense in terms of how weather patterns behave. The NIMBUS image was taken some 18 hours after the ESSA image on the 5th, which allows plenty of time for the system picked out in blue in figure 4.6.14 to move eastwards to its new position in the NIMBUS mosaic, and for the weather patterns picked out in figure 4.6.13 to move to their new position in the early hours of the 7th.

If we refer to the Apollo mission transcripts and timelines, we can see that (assuming our deductions are correct) at that time the crew had completed their TEI burn (which would have been taken on the far side of the moon as the craft performed one last orbit), and were actually engaged in lunar photography. At 148 hours and 48 minutes (just a couple of minutes after AOS) the mission commander tells capcom that they are

“making like tourists with the cameras right now”

Again, despite missing key elements of the data, logical deduction allows us to make reasonable assertions using the data that are available. We have a photograph taken at Earthrise followed by other images indicating the Moon falling away from the Apollo craft, a crew stating that they are taking photographs, and a weather system photographed at around the same time that doesn't match the same area the day before or two days later.

One final image is available to us for Apollo 14. Shown in figure 4.6.15, AS14-73-10352 (Source: AIA) occurs after a series of images which, if they are zoomed in on, reveal the words “Fluid electrophoresis demonstration” on the CM control panel.
This was an in-flight demonstration of a process designed to separate different molecules in a zero gravity environment. At 02:00 on the 8th, the crew discuss with Capcom when this should be done. At this point the terminator line would be over Alaska, which like previous images means that we do not have direct ESSA coverage of the northern hemisphere. They then tell Capcom that they would like to do that experiment 'after the next P23', which is a navigation procedure involving fixing on stars. The next P23 procedure after this occurs at 03:00.

At 16:00 on the 8th, the crew are asked how they are proceeding with the in-flight demonstrations, and they state that they have finished almost all of them other than some in progress work on metal composites, but more importantly this conversation occurs shortly after waking from a rest period, and the last recorded communication prior to this was at 05:00 (although they report that they were 'not yet ready to go to sleep'. It seems reasonable to assume, therefore, that the photographs of Earth must have been taken after 03:00 and before 16:00 on the 8th.

In the photograph itself, once levels are adjusted to remove the over-brightened part, the most obvious feature is a large mass of cloud in the widest part of the crescent. To the north of this is a thin light grey lobe extending towards the terminator, but little detail is discernible in the thinner part of the crescent. South of this feature, it is possible to make out a south-east trending line of thin cloud, as well as another line parallel with this further south still. Towards the thinnest part of the southern crescent is a more substantial looking patch of white. There are also a couple of patches of brown in the thickest part of the crescent, suggestive of land masses.
There is mention of Earth dark side photography taking place at 02:47 on the 9th, 18 hours before re-entry. It is not clear how these images were taken, but at that time the terminator would again have been crossing the Alaskan border, and then the Pacific. Given the orientation of the Earth on the 9th, the thickest part of the crescent would be roughly in line with the Mexican border, and there is no large cloud mass in that area that would correspond to the one in the photograph. The crew also report that they aren't able to see any of the Earth's crescent at that point, so we can discount this.

Looking at the land masses that are covered by the timespan available to us, the most likely looking area is around the Asian coast between China and Thailand, which would be on the terminator between 09:30 and 12:00. A terminator here would descend through Indonesia, giving an alternation of land and sea areas suggested in the photograph, and it would also be at the right latitude. Australia would be at the thinnest part of the crescent. As before, however, we have to rely on an ESSA image taken some 14 hours later than the suggested time for the Apollo picture.

Using this as a basis, figure 4.6.16 shows the analysis. There does seem to be a degree of correspondence, but again there can not be absolute certainty in the exact location covered by the Apollo image. For the record the NIMBUS orbit (4112) was commenced at 13:05. ESSA's southern hemisphere image track for the 7th (number 9, pass 4764) would have been commenced at 07:01 on the 8th. The northern hemisphere ESSA image was taken 24 hours later, and will obviously not be a completely accurate picture of conditions for the day before, but will be a development of it.

Before signing off for Apollo 14, it’s worth pointing out another sequence of Earth images taken after the second EVA using Magazine 66. AS14-66-9327 to 9232 show a largely overexposed Earth, and while there was some consistency in the images when brightness levels were adjusted, there was little detail available to be absolutely certain as to what we were seeing. My own analysis (see here) suggested the position of Venus in a position consistent with them being taken at around 14:30 (there is a gap in the transcript here and before and after this time they were busy).

The image in figure 4.6.17 shows the level adjusted Earth from each of these photographs compared with what Stellarium shows for the same time and date.

To make life even more difficult, the satellite data for this time and date show that very little in the way of cloud would have been visible, and all we can really infer from the images is that the crescent is consistent with the suggested time from the Venus analysis. If we ever get a better scanned photograph, we might be able to do more with it!

There is one more opportunity to examine the weather on the way home from the moon, namely in the very last leg of the journey from re-entry to splashdown. During the re-entry phase the 16mm camera was set running while mounted in the LMP window, which would have been on the left side of the craft facing backwards during the re-entry process. The camera was set running at around 215:44 (around 20:47 GMT on 09/02/71). The main chutes opened around 16 minutes later.

This youtube video shows the footage taken, with the drogue chutes opening at 04:10 and the full chutes opening at 05:00.
Figure 4.6.16: AS14-76-10352 (centre left) compared with ESSA images from 08/02/71 (top left) and 07/02/71 (bottom left), and NIMBUS night IR image from 08/02/71 (centre right). Earthview image is 08/02/71 09:30. Cyan arrow shows suggested similar land feature.

Figure 4.6.17: Level adjusted cropped views of Earth in AS14-66-9327-32 (left to right) and Stellarium’s view of Earth at 14:30 on 06/02/71 (far right)

The point of re-entry and splashdown is well documented, as is the time, and from this we know that the ESSA image from February the 9th is the correct one to use, as the time of the satellite pass would roughly match that of re-entry. Figure 4.6.18 below shows two key stills from the 16mm footage compared with the ESSA view, with the approximate re-entry and splashdown points marked on. The arrow shows the direction of travel. ITOS and NIMBUS images from an article mentioned in the introduction show them more precisely. The arrow shows the direction of travel. ITOS and NIMBUS images from an article mentioned in the introduction show them more precisely.
Figure 4.6.16 continued: AS14-76-10352 and 3D reconstruction using digitally restored ESSA data
The still shown on the left is the earliest of the two, and the direction of the frames before and after both of the stills shown suggest that we are looking towards the west. Such is the nature of the clouds beneath Apollo 14 that it is difficult to be certain exactly what system we are looking at, nor is it easy to work out how far into the distance we are looking.

That said it isn’t unreasonable to suggest that what we are looking at is consistent with the weather systems along the corridor, particularly those about half way between the ‘official’ point of re-entry and splashdown. Given that the splashdown was also recorded on TV, you’d have to be a particularly dumb individual to claim it didn’t happen!

The preceding analyses represent all that can be examined for Apollo 14. It is conceded that there is an element of doubt over them, such is the poor quality of the images available. If the only source of data available were the satellite and Apollo images, it would have been extremely difficult to derive timings for any of the images based on observed weather systems, but the availability of other sources (notably the mission audio and transcripts) allow some certainty to be gained. We also have the invaluable evidence provided by Venus.

The reader is, as always, invited to perform their own analyses from the available data. As the crescented Earth is so thin for most of the mission photographs and the weather systems less than clear, it was decided that a comparison of synoptic charts would serve little purpose, and so the discussion of Apollo 14 ends here.
4.7 Apollo 15

Having re-established the Apollo missions with 14, Apollo 15 took them to new levels of scientific exploration of the Moon, rather than just a technical demonstration that it was possible. It was launched at 13:34 on 26/07/71. It arrived in lunar orbit on the 29th, and landed on the 30th. After 3 EVAs, the surface crew headed back to re-unite with the CSM on the 2nd of August. TEI occurred on the 4th of August, splashing down on the 7th.

Previous missions had been focussed on the need to get back once the surface had been successfully reached, and had resisted suggestions to extend the orbital stay for further study. Apollo 15 changed that by spending additional time in orbit before and after the landing. It featured a number of instruments in the SM's Scientific Instrumentation Module (SIM) to measure the x-ray and gamma ray characteristics of the lunar surface, and deployed a small sub-satellite with its own experimental equipment to measure and map the magnetic and gravitational features of the lunar environment, and to monitor charged particles. Data from the SIM were retrieved by a spacewalk in TEC.

This mission employed an ultra-violet camera, used at set points during the mission, in order to capture images of the Moon and Earth for comparison with similar images of our neighbouring planets. It was not judged a success, and future missions carried additional UV filters.

The crew also had the availability of the LRV (lunar roving vehicle), which greatly extended the exploratory capabilities of the astronauts. The presence of the LRV dominates the photographic record of the mission. 19 magazines were exposed consisting of 2640 photographs, the majority of which seem to consist of images taken from the LRV, with many photographs showing the small TV camera mounted on the front. The other dominant theme of the photographs is the lunar surface, and most of the orbital magazines are downward photographs of the moon.

While the mission took off with the Earth at ¾ full, the length of their stay in space meant that by the time they left for the return journey the Earth was again a thin crescent, and as a result the best photographs of Earth are from the early phases of the flight. Some good Earthrise images were taken, but unfortunately many are either overexposed or there is so little of the Earth's surface visible that little useful information can be gleaned from them. These images will be referred to, but not examined.

Many of the images available on line at the ALSJ and AIA are of also poor quality low resolution ones, and the bulk of the images used here were requested through the GAP (see previous chapters for links).

The satellite record is also diminished for this mission. ESSA 9 has good coverage: Source. One day of the mission is missing (July 31st), and many days clearly have technical issues, with missing or misplaced images in the overall mosaic. NIMBUS 4 was not routinely sending visual data from its orbits at that time (none, at least, are recorded in the final data catalogue), and the ATS-3 satellite, while still functioning, does not have a data catalogue of images from this period. Contemporary journals feature images from it, but none has yet been found from during the mission. Likewise ESSA 8 is operational but has no available data catalogue, only images from contemporary journals - some of which do coincide with the mission.

Of the journal sources available, the Mariner's Weather Log volume 15 (1971) and the Monthly Weather Report for July 1971 (Source) have again proved useful. The MWR shows images of Hurricane Hilary from ESSA 8 on two separate days within the timespan for the mission (July 26th and 31st), as well as Hurricane Illsa on the 2nd of August. This article on weather modification has an image from the NOAA-1 (also known as ITOS-A) satellite, launched in December 1970 showing part of the USA on July 27th.

The MWL shows Hilary on the 1st and an unnamed Atlantic storm on the 5th (Source). Having identified the available sources for the mission, it is now time to analyse those images of Earth provided by the Apollo 15 astronauts.

Like Apollo 11, there is a breakfast photograph of the crew showing them looking at a weather satellite print-out. It is shown below in figure 4.7.0a.
Let's see if we can straighten out that image and see where and when it refers to. Figure 4.7.0b shows the section of the satellite image nearest the camera rotated, straightened and compared with images from launch day and the day prior to launch.

Figure 4.7.0b: ESSA satellite images from 25/07/71 (left), 26/07/70 (right), and map from the Apollo 15 breakfast (centre). All images have been stretched and rotated to fit a square image view.

It should be fairly obvious, but the closest match for the image being held by Commander Dave Scott is from the image on the left, the one taken the day before launch, rather than one taken on the day. The same view taken on launch day wouldn’t have been available for a minimum of 3 hours after they launched.
4.7.1 Mission photographs.

The first image of Earth (part of a short sequence of Earth photographs) taken during Apollo 15 was taken using magazine 91. It occurs after a sequence of photographs showing the docking sequence of the CSM and LM and a discarded SIV-B, which immediately places those images after 17:52 on the 26th (see here for the mission timeline: NASA Source).

AS15-91-12342 (see figure 4.7.1) is focused on the Atlantic, with south America the dominant land mass visible. There is a curl of cloud stretching from the Gulf to the mid-north Atlantic, and above the thin line of cloud marking the inter-tropical convergence zone is an unusual system that should be obvious on the satellite image. South America is marked by long banks of cloud along its western coast, and a number of bands of cloud run across it. These weather patterns will now be identified in figure 4.7.2.

![AS15-91-12342 from the GAP](image)

Figure 4.7.1: AS15-91-12342 from the GAP. Low resolution version available at AIA

This image was also used as the basis for a 1973 cigarette advertisement, see here.
Figure 4.7.2: AS15-91-12342 compared with ESSA 8 images from July 26th. Stellarium insert shows time at terminator.
Figure 4.7.2 continued: AS15-91-12342 and 3D reconstruction using digitally restored ESSA data
As is usual with the first Earth images in a mission, there is no difficulty picking out the weather systems shown on the photograph. They are clearly contemporaneous, and as is the way with weather features the patterns visible on the satellite image are different on the following day. The ESSA track covering the centre of the Apollo image would be track number 2, which corresponds to orbit number 996, commenced at 16:01 on the 26th. Again, as has been the case all the way through this exercise, the timing of the satellite image matches that of the Apollo image.

After a duplicate image of AS15-91-12342, another Earth image shows a different surface configuration of clouds. Figure 4.7.3 shows AS15-91-12344.

Once correctly oriented it is easy to see that the only landmass visible is north America, with a prominent bank of low level cloud off the west coast. South of this cloud mass and just north of the equator is a long meandering line of cloud heading towards the western limb. South of the equator is a much more well defined line of cloud extending for the in-darkness south America towards the western limb. This image is compared with ESSA’s satellite image in figure 4.7.4.

The blue arrowed system in figure 4.7.4 is the same one as identified in figure 4.7.2, and this system will be discussed in more detail momentarily. The system picked out by the cyan arrow is also visible in 4.7.2, west of the system identified by the green arrow in that figure. As for the other systems, it should again be obvious even without the arrows that those visible in the Apollo image are also present on the ESSA mosaic.
Figure 4.7.4: AS15-91-12344 compared with ESSA 9 image and Stellarium inset. Blue arrow is as in figure 4.7.2.
Figure 4.7.4 continued: AS15-91-12344 and 3D reconstruction using digitally restored ESSA data
The terminator in Stellarium suggests a time for the image of 23:30. ESSA's most representative track covering this part of the Pacific is number 5, which corresponds to orbit 999. This orbit started at 22:07, giving a good correspondence with the Apollo timing.

The significance of the blue arrowed system can be identified in the weather records of the time, and in the documents mentioned in the preamble to this section. The reason it has been singled out here is because it is identifiable as Hurricane Hilary. The ESSA 8 image recorded in the MWR can be matched with the ESSA 9 images in figure 4.7.2 and 4.7.4, as shown in figure 4.7.5

![Figure 4.7.5: ESSA 9 (bottom left), ESSA 8 (bottom right), AS15-91-12342 (top left) and AS15-91-12344 (top right) images of Hurricane Hilary, 26/07/71.](image)

Hilary formed on the 26th (or at least the system was officially designated as a tropical storm on the 26th) and lasted just over a week before declining in strength. It succeeded Hurricane Georgette, and overlapped with Hurricane Ilsa, the remnants of the former still being just visible in the above figure, marked by the yellow arrow, and more clearly in figure 4.7.4 (purple arrow). ESSA 8’s image of Georgette from July 24th in the MWL on page 332 ([Source](#)) is shown in figure 4.7.6.

As with other examples in this research, it is worth noting that while all 4 images show the same features, they are not identical. The cloud immediately to the north of the eye (blue arrow) is thicker in the later Apollo image, and in the ESSA 9 version. The two adjacent small patches of cloud (green arrow) change their overall shape and position in relation to Mexico. Every component of the Hurricane is slightly different in each of the 4 images, showing that each image was taken at a different time and not, as some conspiracists would argue, merely reproductions of the same image.
The next in this short series of receding Earth pictures is AS15-91-12345 (see figure 4.7.7 – low resolution version at AIA).

Zooming in on this image shows that Australia has just become visible on the western edge, and a number of the weather patterns already identified in figure 4.7.4 are still visible in this one – notably the fog banks off California and the long lines of cloud stretching from east to west either side of the equator. Hurricane Hilary is just the other side of the terminator. The cloud systems that are still visible are compared with the satellite image in figure 4.7.8.
Figure 4.7.8: AS15-91-12345 compared with ESSA 9 satellite image and Stellarium terminator estimate. Green, cyan, magenta and yellow arrows are as figure 4.7.5.
Figure 4.7.8 continued: AS15-91-12345 and 3D reconstruction using digitally restored ESSA data
Stellarium's terminator line suggests time for the Apollo image of around 02:30 on the 27th, and the 3 hour time gap between this image and the previous one is amply demonstrated by the appearance of Australia and by differences that are evident in the cloud patterns that are visible in the earlier image. The system identified by the yellow arrow, for example, has clouds that are different to the north and south of it when they are examined closely – see figure 4.7.9.

Figure 4.7.9: Zoomed section of AS15-91-12344 and AS15-91-12345 showing the same weather system several hours apart. No two clouds are the same, but the overall features are.

The next image in this sequence of photographs is AS12-91-12347 (see figure 4.7.10, low resolution version available here AIA).

Figure 4.7.10: GAP copy of AS15-91-12347.
Figure 4.7.11: AS15-91-12347 compared with ESSA 9 image and Stellarium terminator estimate
Figure 4.7.11 continued: AS15-91-12347 and 3D reconstruction using digitally restored ESSA data
For this latest photograph, north America is back in focus, which means it was taken some time later than the previous photograph. Despite this time gap, some weather features persist from the previous one. Hurricane Hilary is still making progress across the Pacific (blue arrow), and while they have become less coherent systems, the sub-equatorial bands of clouds (magenta and yellow) are still there. Fog also persists along the west coast of north America. It’s worth comparing a close-up view of the Apollo image with one from the NOAA-1 satellite (see introduction for source), specifically the cloud system identified by the green arrow (figure 4.7.12).

Figure 4.7.12: Cropped area of AS15-91-12347 compared with NOAA-1 satellite view and section of 3D reconstruction.
The area covered by the NOAA satellite is given in the source document as North & South Dakota, which corresponds with the line of longitude shown. There is definitely a good match between the Apollo image, viewing the area obliquely, and the view from above taken by the satellite.

Stellarium estimates that this image was taken at 22:30, and the size of the disk is consistent with the suggested date of the 27th – as are the clouds featured on the ESSA mosaics, which are different in the following day's image. ESSA's best fit orbit for this image is number 1011 (track 4), which commenced at 21:01. As usual, the ESSA image and the Apollo image are taken with a short time of each other, which explains their similarity.

A further confirmation of timing is given by the two photographs immediately after AS15-91-12347 (eg AS15-91-12349). They are labelled simply as 'Spacecraft interior' on the AIA and in the photographic index (source: ALSJ), but comparison of them with other photographs available on the internet (eg LM interior) clearly identify them as belonging to the lunar module. The LM was inspected at 23:30 on the 27th, and the mission transcript (ALSJ) mentions the camera equipment (the crew were preparing for a TV broadcast). It does seem likely that these two photographs were taken as part of the LM inspection, and this acts both as a later limit for the image 12347 and an earlier limit for the next image, AS15-91-12350.

AS15-91-12350 (see figure 4.7.13) Low resolution version available here: AIA, is the last Earth image taken before arriving at the Moon, and indeed the next images in the magazine are looking down at the lunar surface. LOI occurred at 20:05 on the 29th, so we have a timeframe of 48 hours within which this photograph must have been taken. Comparison with satellite images is carried out in figure 4.7.14.
Figure 4.7.14: AS15-91-12350 compared with ESSA 9 image and Stellarium terminator estimate
Figure 4.7.14 continued: AS15-91-12350 and 3D reconstruction using digitally restored ESSA data
The weather systems shown in the Apollo image match, as usual, those visible on the satellite image but this is not the only story. Hurricane Hilary is still visible on the Apollo image, and the sub-equatorial cloud in the southern hemisphere is also still present, albeit in an evolved form.

These two features can not, however, be seen on the satellite image as there are large sections where data are absent. This will be discussed momentarily, but first there are some formalities to be attended to: Stellarium puts the terminator line at around 22:00, and the satellite image that most resembles the weather patterns in the Apollo image is from the 28th, so at around the time the Apollo astronauts were taking photographs inside the LM, there is a photograph of Earth. In all probability it is taken from the LM. ESSA’s most complete orbit for the Apollo image is number 1023 (track 4) commenced at 20:04. The similarity between ESSA and Apollo’s images of Earth is again a product of their being taken at roughly the same time – one from the vantage point of over halfway to the Moon, the other from LEO.

What needs to be addressed now is the issue of the missing data in the image. In doing this, it is worth refreshing our memories as to how these images were collated. The introduction to the data catalogue describes how:

“The digitized cloud maps that appear in this catalog are prepared by a high speed digital computer. In this process the signals comprising the picture taken by the satellite are assigned numerical values to indicate the relative brightness of each element. These data are normalized brightnesses, earth-located and repositioned in a standard map projection. Magnetic tapes are produced for input into a cathode-ray-tube film-display device.”

Each individual image is loaded from magnetic tape, recorded from the signal transmitted by the satellite, transposed into its correct position on a globe, and then placed on a kinescope for photographing.

As part of that process:

“In some instances, blank areas and mislocated clouds appear on the digitized cloud maps; these are caused by irregularities in the computer operation and should be disregarded.”

And:

“Day to day variations and irregularities which result in improper location or display of the data are apparent in this catalog. At present, inadequate computer facilities prevent any effort to reformat the mosaic on an after-the-fact basis. Some inconsistencies are related to photography and printing problems.”

This has obviously happened in the case of the ESSA image used in the preceding analysis. Large chunks of the image over the Pacific are blank, and there are no clouds marked where there should be some. There are also some very sharp boundary lines within south America that suggest missing data, but often such areas represent differences in contrast between parts of the mosaic.

Figure 4.7.15 indicates an area where there are misplaced clouds. There are 3 areas in the region of south America that show the same curl of cloud with a bifurcated ending – two in the south Pacific and one off the Argentinian coast. Evidently something has gone wrong in the process of positioning the images, or the tapes themselves may be corrupt, or the satellite transmission may have been interrupted. Whatever the cause, there should be only one of them. Examining the satellite mosaic does not reveal any real insight as to which is the correct, and there is insufficient coverage by Apollo images to suggest where they might be from.

Evidence of fakery? Manipulation? Hiding of data? This will no doubt be alleged by conspiracy fans, but the preface to the data catalogue points out that there are some days with problems. Some of these days fall outside Apollo mission days. The easiest thing to have done would be for ESSA to have not released this day's image, rather than use computer technology that didn’t exist to try and fake an image. What can be deduced is that the experienced eye can identify issues with data and recognise where problems exist.

The easy path for this document would have been to pretend there was no problem, when clearly there is, but problems with some parts of the data do not invalidate those areas where it is completely transparent that the Apollo image and ESSA match. If anything, it re-enforces the idea that the technology to manipulate these image did not exist at the time they were taken, and that no manipulation has been carried out on them since.
Figure 4.7.15: ESSA 9 image mosaic of South America from 28/07/71. The three darker contrasted areas are apparently the same, and are reproduced below the main image.

It also shows the importance of looking at evidence carefully, and using judgement and deduction to arrive at a conclusion.

The next image to be examined for this mission is from magazine 87. AS15-87-11722 (along with a duplicate image after it) shows a distant Earth between a series of images that show the landing sequence as shot from the LM. Figure 4.7.16 shows this image, and a low resolution version can be found here: AIA.

The first five images in this magazine show a distant CSM, and the timeline shows that undocking of the LM and CSM occurred at 18:13 on the 30th. Following this are several orbital images, including one set showing Hadley Rille, the ultimate landing area. Immediately following the photographs of Hadley Rille are the two Earth images described. These are then followed by other orbital images (including Mare Smythii) before the surface is photographed. The landing itself occurred at 22:16 on the 30th, so we have a relatively narrow window within which to look for satellite matches.

If only it could be so simple! July 30th is missing from the ESSA data catalogue.
Normally when a day's records are unavailable as a result of some technical issue, a blank page will be inserted stating that there is no record. In this case there is no such page, and there are no orbits missing in the record of passes in the Appendix. The obvious conclusion is that it has been missed out in error. Other pages were checked to see if there was a duplicate July 30th, but none was forthcoming.

What are available, however, are the ESSA mosaics from the 29th and the 31st, which should allow us to interpolate which weather patterns can be seen on the Apollo image. This is shown in figure 4.7.17 overleaf. We do now have the benefit of a digitally restored image from the 30th, and its 3D reconstruction is also included.
Figure 4.7.17: AS15-87-11722 compared with ESSA images from the 29th (top & bottom left) and the 31st (top & bottom right). Stellarium shows time at terminator.
Figure 4.7.17 continued: AS15-87-11722 and 3D reconstruction using digitally restored ESSA data (centre), and digitally restored ESSA map for July 30th 1971.
Two factors are making life difficult with this image comparison. Firstly, the fuzziness of the Apollo image, and its overexposure, means that it is difficult to pick out the weather systems that make out the bulk of the image over central America and off the coast of south America. Secondly, the satellite image itself appears to be under-exposed, so that those weather systems that are visible are not there in their entirety. This is less of an issue when the satellite image is from the same day as the Apollo image, but when we are having to interpret data between two days it can be difficult.

Despite this, there is a good correspondence between the three images, and it does not seem unreasonable to suggest that the Apollo image represents the mid-point between the two ESSA mosaics. As further corroboration, the photographic index records this image as being taken on orbit 13, the mission transcript identifies as starting at 19:20 on the 30th. The image immediately following these two Earth images shows *Mare Ingenii*, a far side feature recorded as in orbit 14, as are the images of *Mare Smythii* immediately before the images taken on the ground. LOS on orbit 14 is almost exactly at 21:00 on the 30th, so the estimate of 20:30 seems like a good one. The fact that we now have a digitally restored version of the image from the 30th confirms our estimates even more.

Thankfully the next image under the microscope involves a little more reliance on hard evidence rather than deductive logic, and sees a return to magazine 91. It is clear form looking at this magazine's images that it stayed in orbit with the CSM. AS15-91-12404 is the penultimate image in this magazine and one of two identical Earth photographs. A low resolution version is available here: AIA. A high resolution version is shown in figure 4.7.18 and analysed in figure 4.7.19.

![Figure 4.7.18: High resolution GAP version of AS15-91-12404](image-url)
Figure 4.7.19: AS15-91-12404 compared with ESSA satellite image and Stellarium terminator estimate
Figure 4.7.19 continued: AS15-91-12404 and 3D reconstruction using digitally restored ESSA data.
The dominant land mass shown is Africa, with the Saharan region showing towards the top of the globe. Brazil is visible in the south-western limb as a much darker landmass.

The main areas specifically picking out this Apollo image as being from the 31st are the bands of cloud pointed out by the blue and green arrows. The angle of the Earth photograph makes them less obvious that on the ESSA image, but they are there. The underexposure of the ESSA image also makes the thin band of cloud passing south through Spain into north Africa less obvious, but it is there. The ESSA mosaic again has data reliability issues, this time off the east coast of Argentina. The mosaic manages to capture the break in cloud on the yellow arrowed system, but where that cloud continues into the south Atlantic and South Africa in the Apollo photograph, it is truncated and mis-shapen in the ESSA version. The images over South Africa also show suggestions of duplication and misplaced mosaic components.

That aside, there is sufficient correspondence with the remainder of the ESSA mosaic to confirm that the Apollo image was taken on the 31st of July at around 17:00. ESSA’s own data suggest that the satellite was taking photographs of this area at 17:04 (track 2, orbit 1059).

It’s worth pointing out at this juncture that there are a couple of live TV sequences of Earth taken from the lunar surface, one at the end of EVA-2, one at Station 10 during EVA-3. Neither of these sequences show any great level of detail, but it’s worth having a quick look to see what we can figure out.

The first images (noted at the ALSJ as being the first live TV broadcast of Earth from the moon) were taken during the close-out of EVA-2. The camera pans up as equipment is being transferred to the LM, and is then forcibly panned back down again as the camera gets stuck pointing at the high upward angle. The timing of the footage works out at 18:40 GMT on August 1st 1971, so we can get a good idea of where the Earth would be in the sky at that point.

As there is a substantial gap between when we see the Earth in the pan upwards and the last recognisable landmark of the LM, it’s difficult to work out exactly how far above the LM the Earth is in the footage. It’s easier to use the forced return to horizontal of the camera as this is much quicker and therefore occupies fewer frames of footage. If we assume a constant speed we can use the lens flares in the frame as markers and try and get an idea of where the Earth is in the lunar sky.

Figure 4.7.20 shows a Stellarium view of Earth at the time of the broadcast compared with a compilation of screenshots from the footage. The lunar background is from Apollo 11, and is there purely to provide a horizon.

Figure 4.7.20: Stellarium view from the Apollo 15 landing site of Earth during the end of the EVA-2 TV broadcast compared with a screenshot compilation from the LM to Earth. Source.
It’s clear from the Stellarium shot that Earth is well above the horizon (the crew consistently complained of the difficulty of angling the LRV antenna towards Earth because of both the angle and the sun being in view). Earth is at angle of 204 degrees from lunar north. Examination of the Earth in the screenshot compilation shows it to be above St George’s crater. Figure 4.7.21 shows the angle of the crater from the LM.

Pretty much bang on. It’s also worth pointing out that the angle of the lens flares is completely consistent with where the sun is relative to the camera and Earth.

We can also see (figure 4.7.22) that the Earth’s phase is completely consistent with what should be visible.
While it would not be reasonable to suggest we can make out any detail in the image of Earth (of which I have adjusted the contrast) we can certainly see that the phase is consistent with what we should be,

The second TV view of Earth took place at Station 10 during EVA-3. The Earth view was pretty much achieved by accident and is seen at the start of the TV footage, which commenced at roughly 11:50 on August 2nd.

The camera is focused on Earth at the start of the footage but is repositioned so quickly once it is realised that it is stuck that we get nothing we can use to provide a sense of distance above the horizon. All we can do is compare what we should be seeing with what is shown, as indicated in figure 4.7.23.

![Figure 4.7.23: TV still of Earth compare with Stellarium view at the same time. Source.](image)

Once again the Earth’s phase is entirely consistent with what should be on view, even if we can’t make out any actual details on it.

For the next analysis we visit a new photographic magazine. AS15-88-11976 occurs two thirds of the way through magazine 88. The magazine starts on the lunar surface, but this image occurs immediately after a photograph of the CSM during rendez-vous. We therefore have an earliest possible time for the image of 17:11 on the 2nd of August. The LM & CSM were docked two hours later at 19:10, and it is just visible in the image, looming out of focus on the right with the Earth in the background. We therefore have a 2 hour window within which this image was taken, and we can now see if the satellite and Stellarium evidence supports this. Figure 4.4.24 shows the high resolution version of the image (low resolution available here: [AIA](#)) and figure 4.4.25 the satellite comparison.

![Figure 4.7.24: High resolution GAP version of AS15-88-11976](image)
Figure 4.7.25: AS15-88-11976 compared with ESSA 9 image and Stellarium terminator estimate.
Figure 4.7.25 continued: AS15-88-11976 and 3D reconstruction using digitally restored ESSA data.
The figures given by the timeline for the mission show that the Earth should have been showing the Atlantic, and at least some of Africa. The configuration of the Earth as seen from the Moon also means that the southern Hemisphere is more prominent than the north, placing north Africa at the top of the illuminated crescent. If the levels are adjusted in the image, Africa does become much more visible. This can be seen in figure 4.7.26, where the over-contrasted Apollo image is compared with Google Earth’s grid overlay as confirmation that the cloud patterns identified in figure 4.7.24 are in the right place.

The arrows in both sets of figures are identifying clouds bands either side of the equator in the ITCZ, and what appear to be low lying fog banks on Africa’s west coast. It should be remembered when looking at the Earth in figure 4.7.26 that the enhancement process effectively moves the terminator, making the crescent narrower.

![Figure 4.7.26: AS15-88-11976 enhanced by level reduction to remove excess brightness. Google Earth is oriented in the same way to show where latitude lines fall. Arrows used are as in figure 4.7.20.](image)

It is conceded that the view of Earth used here is blurry, but other evidence does corroborate that the features identified in this analysis are correct. Observant readers will have noted that the time on the Stellarium inset shows 18:57. This is the time recorded in the mission transcript for when the LM crew took what they had hoped was an image of the CSM SIM bay. Capcom was keen to have that image before completing the docking manoeuvre.

The ESSA 9 orbit covering this part of the Earth would have been commenced at 15:01 (track 1, orbit 1083), so ESSA’s satellite image was taken at around the right time. Stellarium shows where the terminator would be at the time the image is recorded as being taken, and there are cloud shapes in the right place and consistent with the weather patterns visible from ESSA. It would be preferable to have crystal sharp images, but even without them the available data corroborate the version of events that says the Apollo 15 crew met up with each other in lunar orbit on August 2nd just before 19:00 GMT.
With an increasingly crescent Earth matching satellite derived weather patterns with features from mission photographs becomes increasingly difficult. It is further hampered by over-exposure of the Earth when photographed. This is the case with AS15-88-989, the second of two consecutive Earthrise images. It is surrounded by pictures of the lunar surface, and there is another Earthrise sequence later, so it is obviously not yet at TEI, which occurred on the 4th at 21:22.

This image is shown overleaf in figure 4.7.27 (low resolution source here: AIA), and an attempt at satellite comparison presented beneath it in figure 4.7.28.

The analysis shown in figure 4.7.28 needs some explaining. Only 4 areas have been identified, and these are less indicators of specific weather systems as variations in light and shade on the Earth. The terminator estimate has been given by the Fourmilab Earthview site (used in previous sections) because it shows land masses more clearly than Stellarium – particularly when the Earth is a thin crescent and less is visible.

The time of the terminator has, in this case, been set at 23:30, because this is the time of AOS on revolution 64. The photo index labels this image as taken in orbits 64-72, but it is only the third in a sequence images with that label, the preceding two being craters on the far side. It seems reasonable to assume that this is the Earthrise from orbit 64 immediately after taking those first two images.
Figure 4.7.28: AS15-88-11989 compared with ESSA 9 satellite image from 03/08/71, with Earthview estimate of terminator line at 23:30 03/08/71.
This is not the preferred deductive route for these analyses, as it is effectively deciding in advance what the outcome is and then looking to see if the evidence matches, rather than looking at the evidence, deducing an outcome, and then seeing if the other evidence bears it out. That said, the Apollo image shows an area of bright white north of the equator (blue arrow) in an area that corresponds roughly to the southern USA Gulf states. Below that is a darker area (green arrow) that can be interpreted as ocean over the area corresponding with the Gulf. Below that is a further area of white (red arrow) over central America, and then a darker area (magenta arrow).

These areas seem to correspond well with the pattern of cloud over the southern Gulf states, the Gulf itself, central America, and the Pacific coast of south America. ESSA's satellite pass over this area would have been commenced at 20:02 (track 4, orbit 1098) on the 3rd. Confirmation of this being the 3rd rather than the 2nd or 4th can be deduced from the width of the Earth crescent.

The final Earthrise sequence on magazine 88 suffers from the same problems: overexposed subject and a small area available for image analysis. AS15-88-11999 (low resolution version here: AIA) is not even labelled in the photo index as an Earthrise, such is the glare on the CSM window. This image is shown below in figure 4.7.29, but there is so little detail visible, even after processing, it will not be analysed further other than to suggest that the crescent thickness suggests a time around 12 hours before TEI.

Figure 4.7.29: GAP version of AS15-88-11999
Two other colour images of Earth are available in 2 other magazines.

AS15-97-13267 is the first in a single sequence of Earthrise images on a magazine that otherwise consists solely of photographs of the lunar surface. The thin crescent suggests a date of August the 4th, and a considerable amount of time was spent attempting to find the exact cloud matches on that date. The image itself was processed by adding extra contrast to a level reduction, and this has been more useful than the same technique employed on magazine 88 images because the image is less exposed, and is zoomed more closely on the Earth.

The image is shown below in figure 4.7.30, and a low resolution version is available here: AIA.

![Figure 4.7.30: High resolution GAP image of AS15-97-13267](image)

As already mentioned, TEI occurred on at 21:22 on the 4th, which at least provides an upper limit to what should be visible – the tip of Brazil would just be visible at that point. The remainder of the magazine shows at least one orbit after this image, which would bring the time back to roughly 20:00 at the latest. The photographic index shows that it was taken on orbit 70, and figure 4.7.31 shows a satellite comparison on that basis.
Figure 4.7.31: AS15-97-13267 compared with ESSA 9, and an Earthview terminator set at 12:00 on 04/08/71
Figure 4.7 continued: AS15-97-13267 and 3D reconstruction using digitally restored ESSA data
AOS on orbit 70 occurred at 214 hours and 26 minutes into the mission, or roughly 12 noon on the 4th. This would mean that SE Asia would be just in view. In the widest part of the crescent, the terminator in the above figure (according to Earthview) is roughly following a line along Thailand, and there are definite consistencies in the clouds visible on the satellite mosaic along the terminator and those just discernible on the Apollo image.

ESSA’s image for that region would have been commenced at 08:02 (track 10, orbit 1104), with mosaic date being the 3rd.

One final image remains, and again there is only a small amount of Earth visible on it. AS15-93-12639 occurs in the middle of another magazine otherwise devoted entirely to lunar surface photography. The thinness of the crescent and the lunar surface photographs again mark it down as being on the 4th of August, and the photo index suggests that it was taken on orbit 71. AOS on Orbit 71 was at 14:00 on the 14th, and the presence of Humboldt crater is next image suggests that this Earth image probably was taken just after Earthrise. This would put a terminator line along the thickest part of the crescent as eastward of Madagascar.

Figure 4.7.32 shows the GAP version of this image, and a low resolution version is available here: AIA.

Figure 4.7.32: High resolution GAP version of AS15-93-12639.

As with other over-exposed crescent Earth images, simple level adjustment is inadequate in revealing much detail, and the analysis carried out on the image (figure 4.7.33) was done after contrast and brightness adjustments were also added.
Figure 4.7.33: AS15-93-12639 compared with ESSA 9 image and Earthview terminator estimate for 14:30 on 04/08/714
What becomes clear on the adjusted image is that there is a very obvious dark oval area in the central part of the crescent exactly in the place where Madagascar would be according to the terminator estimation. There is a white mark in this dark area which corresponds well to a cloud shown on the ESSA image, so it would appear that we have a good basis to assume that the photograph shows exactly what it should show.

Despite the difficulties with the image, there are visible features (not least Madagascar!) that confirm that this photograph was taken at the time it was claimed to have been taken. There are issues with the ESSA mosaic in that this area is often used as the boundary for delimiting between dates, and there is a clear change in contrast down the centre of the southern hemisphere portion of the image. The image chosen above is dated 03/08/11 and the track covering it is assumed to be number 12, which corresponds to orbit 1106, commenced at 11:03 on the 4th.

We have a couple more Earth images to examine, but it becomes more difficult to derive any meaningful analysis from them thanks to the increasingly thin size of the Earth crescent. The first one is AS15-96-13104, which occurs after Al Worden’s EVA to retrieve mapping camera magazines, but before images of a lunar eclipse that was broadcast as part of a televised press conference. This puts the time of the photograph somewhere between 16:10 on 05/08/71 and 18:34 on the 06/08/71 (although it’s likely that the first photography session was with the Nikon film and also UV). It’s officially labelled as being ‘blank’, but as can be seen in figure 4.7.34 - it isn’t!

![Figure 4.7.34: AS15-96-13104 - source: GAP](image)

There aren’t any specific references he transcripts that would help here, so we have to see if we can do some guesswork. While we the sun is still visible, we do know that the spacecraft was not directly between the Earth and Moon thanks to the trajectory it was taking, so some would also have been visible.
We also have a small clue in the UV images available, which were being taken at about 18:00 (according to the AFJ transcript here). These UV images are available in magazine 99 and are discussed in more detail in the next section, but an example is shown below in figure 4.7.35 together with a zoom of AS15-96-1304, and a Fourmilab projection of the view of Earth from the moon at 18:00. The similarity between the UV and visible spectrum views strongly suggests that the two sets of images were taken at the same time or comparative purposes, as suggested in the AFJ.

![Image](image1)

Figure 4.7.35: Zoomed and cropped section of AS15-96-13104 compared with Fourmilab views of Earth set at 18:00 on 06/08/71, and AS15-99-13482

As we’ve already explained, the view of the Earth doesn’t match what you would see from the moon because Apollo 15 isn’t on the moon, but the landmasses visible would be roughly the same.

A little more of Africa would be visible, and it seems likely therefore that the clouds evident in the widest part of the Earth’s crescent are those seen off the west coast of Africa, as indicated in figure 4.7.36.

![Image](image2)

Figure 4.7.36: ESSA-9 image from 05/08/71 showing Africa. The superimposed lines are scrambled, but the west African coastline in the southern hemisphere is clear to see.
We can say with some certainty is that it also shows a view of Earth entirely consistent with the timeframe available, sandwiched between an EVA and an eclipse that were both broadcast on TV to Earth. We can even show that the lunar images after this shot of Earth are part of the eclipse by comparing 4 taken together (figure 4.7.37).

![Figure 4.7.37: Crops from AS15-96-13106-13109, showing lunar eclipse in progress](image)

For the hard of seeing, the Earth’s shadow is moving across the lunar surface.

We now have a couple of final images to look at the end of the magazine, after the final lunar eclipse photographs, and which must, therefore, have been taken after 21:00 on the 6th, when the moon had re-emerged from the Earth’s shadow. One of them (AS15-96-13135) is part of a sequence of images, while AS15-96-13136 is the last in the magazine. The two are shown below in figure 4.7.38.

![Figure 4.7.38: GAP scans of AS15-96-13135 (left) and AS15-96-13136 (right).](image)

The AFJ again is helpful here in stating that AS15-96-13135 was actually taken using the UV lens but with normal film but the timing isn’t known precisely. We can, however, be more specific about AS15-96-13136 because again it was taken as a reference image for UV images taken at the same time (see AS15-99-13495 for example) - that time being 290 hours, or around 15:30 on the 07/08/71.
As can be seen in figure 4.7.39 this would put Australia in the middle of the image, and the sliver of sunlight is actually on the East of the image somewhere on the same longitude as Hawaii, so the area lit is largely of the ocean. The satellite data suggest very little would be visible.

![Images of Earth and sunlight](image)

Figure 4.7.39: Zoom and crop of AS15-96-13135 (left) and AS15-96-13136 (centre), compared with Fourmilab view of Earth at 15:30 07/08/71 (above).

This is in contrast to the image taken earlier, where there are a couple of identifiable cloud masses. While we can’t definitively say when this image was taken, it is clearly a different Earth compared with the previous one where there are no cloud masses on show and both photographs are consistent with the timeline.

These images also represents the last available visible spectrum image taken of Earth on this mission. It is not, however, the last set of analyses that will be carried out, as there were several UV spectrum images taken at specific points through the journey.

These UV images will be examined next.
4.7.2 Ultra-Violet images taken during Apollo 15

UV photography in Apollo 15's mission was carried out at set times, as shown in figure 4.7.40 – a reproduction of table 5.1 from the Apollo 15 Mission Report (source ALSJ). Their aim, as detailed [here], was to allow comparison with Earth images that would then allow interpretation of UV images of Mars and Venus.

The last UV images are discussed briefly in the previous section, and the reader will recall there is little of note in them! It is believed that the colour photographs taken are those discussed in the previous section, as they usually took a colour image to help with interpretation. The exception here is the first set of images taken in orbit, where the AFJ suggests that time pressures prevented it.

Only those images showing Earth will be considered, and only those where there is some level of discernible detail. This site recently turned out to have higher quality versions of the UV images, and these will be used in a reworking of the original analysis.
While there was no formal photograph matching for the Earth orbit image, the crew did take an image that covers the area it shows.

The photography itself took place 001:30 into the mission during the first full orbit. There is nothing to identify specifically where they were photographing, but we know the orbital path they were following (figure 4.7.41) and we know that they had just been acquired by Goldstone tracking station in California.

Figure 4.7.41: Orbital track of Apollo 15 (modified from the AFJ)

So we know that the craft is approaching the California coast, and we know that we have an image of that coast taken on the same day. We also have the ESSA image for that day, so this is my suggestion as to where we are looking (figure 4.7.42).

Figure 4.7.42: AS15-99-13408 compared with a section of AS15-91-12344 and a section of the ESSA view of the same area.

My suggestion is that we are looking at the California coast in the distance, and the little islet of clear water in the midst of the coastal cloud is that same one in both Apollo images. The ESSA view shows the thin offshore cloud and those inland in the distance.

The first full Earth images looked at were taken 60000 miles from Earth during TLC, and are first discussed in the mission transcript at 9 hours and 30 minutes in to the mission, or 23:00 on the 26th. Figure 4.7.43 shows both the original UV image and the satellite comparison with it.
Comparison of the photograph presented above with the image analysed in figure 4.7.4 (AS15-91-12344) suggests that they were taken at the same time – around 11:30 on the 26th, and is the companion colour photograph for this UV series. The meteorological match is undeniable.

The next sequence of UV images featuring Earth took place at 120000 miles and is the 4th in the sequence of UV images taken. The next time UV photography is discussed in the mission transcript is at 31 hours, or 23:00 on the 27th. The best image from that sequence is given in figure 4.7.44, along with a comparison with ESSA mosaics from the 27th.
With the doubling of distance from Earth has come some deterioration in the quality of the UV image. Despite this, however, it is easily possible to make out the long band of cloud in the southern hemisphere, and once this has been identified it is possible to infer the location of the other major systems identified on the ESSA mosaic. The companion colour image for this UV sequence was analysed in figure 4.7.11, where the time was identified as 22:30 on the 27th. The Apollo image taken at that time was AS15-91-12347.

The next image sequence was taken at 180000 miles out and the transcript records the crew as saying that they had completed them at 21:30 on the 28th. The best image from that sequence (AS15-99-13439) is shown, together with the relevant ESSA image from that date, in figure 4.7.45.
Obervant readers will recall that the 28th was the day when issues regarding ESSA 9 data quality were discussed, in relation to AS15-91-12350 (figure 4.7.14), and so much of what is visible in the UV image is not visible in the ESSA mosaic. It is still just possible to discern the overall shapes of the weather patterns that are present in the mosaic, and to note that the time recorded for the UV photography in this session coincides well with the time derived for AS15-91-12350 of 22:00.

The final image examined in the UV sequence is from in lunar orbit, and as will be evident from it, there is little point in examining the later images of Earth as there is very little detail visible on them.

UV imagery is next mentioned in the mission at being scheduled to start at 123 hours and 50 minutes, or around 17:30 on the 31st of July. Two sets were taken in this sequence. The photo index records this as taking place during orbit 24, which is recorded as starting at 123 hours 54 minutes. As this set of UV photos is of an Earthrise, this seems like a good set of timings.

Figure 4.7.46 shows the best image from these two sets (AS15-99-13447) combined with the ESSA image from the time of orbit 24 on 31/07/71.
Again, those readers paying attention will recall that the colour image this analysis refers back to is one where the ESSA data have some quality issues in the south Atlantic region. Notwithstanding this, it is possible to make out the long band of cloud across the south Atlantic in both Earth images. Once this is recognised then, as with the previous images, the other major cloud systems fall into place.

The ultra-violet images, while obviously not of the same quality as the standard Hasselblad images, provide yet more verification that Apollo took meteorologically accurate images of Earth, in whichever spectrum you choose to view it.

Now for a look at the meteorology itself.
4.7.3 Meteorological data

The preceding sections have already identified several tropical storms and hurricanes that existed during this mission, and these storms were reported in contemporary journals. As with other missions, synoptic charts are available from a few sources, but they are only of any real use for the first half of the mission when there was a sufficient amount of the Earth’s surface in view to allow meaningful comparison. The northern hemisphere is also not viewable in many of the Apollo photographs.

The usual synoptic chart sources (German, South African and NOAA) have been selected again here, as they are consistently available. See preceding sections for sources.

The first day of the mission is a good starting point here, as north America is visible, and we have two images taken within a few hours of each other to get good coverage of a considerable amount of the globe.

Figure 4.7.47 shows the NOAA and German synoptic charts for the 26th in comparison with the two Apollo images from that day: AS15-91-12342 and AS15-91-12344.
The weather system crossing the Atlantic (yellow arrow) is clear on the German synoptic chart, as is the one over north America. The purple arrowed system marks the line of disturbed cloud along the ITCZ. As with other missions, there is good correspondence between the synoptic and photographic data.

The next synoptic charts to be examined are from the 28th of July, which was analysed in figure 4.7.13 using AS15-91-12350. The synoptic charts for this date are shown, together with a reproduction of the Apollo image, in figure 4.7.48.

Figure 4.7.48: NOAA (top left) and German (bottom) synoptic charts compared with AS15-91-12350
The ITCZ is just visible on the Apollo image, but the other main weather systems, themselves a development of the ones seen in the previous image, are still visible and easily identifiable.

The final synoptic image is from the South African data covering July 31st. This allows us to compensate for the tilt of the Earth relative to the lunar based observers. Africa was covered in figure 4.7.19 using Apollo image AS15-91-12404. Figure 4.7.49 shows the resulting analysis.

As is obvious from the figure above, there is only one feature visible, and that is the front off the south African coast manifesting itself in the curl of cloud in the Apollo image.

4.7.4 Conclusion

It will come as no surprise to anyone that the photographs of Earth taken by Apollo presented here can be demonstrated to match with satellite derived weather patterns. Most images are easy to place, and it is a relatively simple task to derive a time for the photograph purely from the satellite data and then verify this by using secondary data. In other cases the secondary data assist in identifying the time of the photograph. The photographic evidence is backed up by meteorological evidence, not least the presence of a hurricane.

It all points to the conclusion that Apollo 15 went to the Moon and returned safely, just like the missions before it, and just like the next mission, Apollo 16.
4.8 Apollo 16

Apollo 16 saw another lunar rover head for the moon, this time in an exploration of the lunar highlands. It again involved several EVAs and the use of a CSM SIM bay to record experimental data in orbit while the LM carried its duties on the surface. UV photography was again employed to take images of Earth on the way to the Moon, and also from the lunar surface.

Even before this mission had begun, news reports were full of the next phase of NASA's space programme: the shuttle, and discussions on what to do with redundant launch towers were already under way. The economic cost of Apollo was freely discussed in these news programmes, and the perceived benefits of LEO satellite programmes became much more prominent in the discussions compared with the less immediately useful scientific data.

The flight was intended to launch in March, but technical problems with an explosive separation bolt between the LM and CSM forced a delay. The crew finally lifted off on April 16th 1972 and entered lunar orbit on the 19th. Landing did not occur until the 21st after more technical problems with the CSM engines caused a day's delay. After eventually landing and carrying out 3 EVAs, the surface crew were re-united with the orbiting CSM on the 24th. TEI occurred the next day, and the astronauts finally splashed down on the 27th. On the way back a televised EVA was carried out to retrieve data from the SIM bay, and an unmanned TV broadcast was also made from the lunar surface.

The mission timeline can be found here: NASA source

As far as mission photographs go, the AIA records that the Hasselblads took 22 magazines if film, with a total of 2808 photographs exposed. An additional magazine comprises the far right UV spectrum long exposure images taken from the surface.

As with Apollo 15 & 14, no high resolution images are stored at the AIA. The GAP has been used instead to request the images used here.

In terms of availability of satellite images, only ESSA 9 photographs have a full catalogue online, available here: NOAA. ATS-3 images were still being transmitted, and one can be found here: ATS-3 image in the MWL for April 18th. An ESSA 8 image for launch day can be found here: MWR, in an interesting article about the ARIA (Apollo Range Instrumented Aircraft) that collected meteorological data in support of Apollo missions. ARIA is mentioned several times in the early part of the mission in Earth orbit (see the Mission Transcript here: ALSJ), acting as a relay between receiving stations on the ground.

The ESSA image in the article was taken on launch day, but unfortunately the area of the south Pacific shown is not covered by any of the photographs from that day. Understandably, the crew will have been a little busy at TEI and would not have had the time to photograph it.
4.8.1 Satellite data

In a break with the usual format of these sections, the first images don’t show a full Earth. The first one is from Earth orbit and is included purely because of something small but significant above the horizon. AS16-118-18858 is the second image taken in the magazine. At 01:10 into the mission, Mattingley says this:

001 10 20 Mattingly (onboard): I thought I saw - maybe that was Hawaii. Huh? I thought I saw some land down there.

And at 01:29, answering questions about what he’s been photographing we have this

001 29 29 Young (onboard): No, I took two, one of which was the - No, that was the - it was the thunderstorm that really attracted me down there...

Shortly before this he references the coast of Baja California being visible, so we know that somewhere between Hawaii and California they photograph the storm in 18858. Between these two times we have:

001 16 15 Young (onboard): ...there's the Moon.

001 16 20 Duke (onboard): Where?

001 16 21 Young (onboard): Out the front window.

And then

001 22 28 Young (onboard): That's 10,000 pictures of horizons and sunrises. I got a picture of the Moon out there [garble] coming up.

Careful examination of AS16-118-18858 shows that this is the photograph of moonrise that he took. Figure 4.8.0a shows the details.

![Figure 4.8.0a: AS16-118-18858 (top left). Detail from that image top centre, and Stellarium view of the moon from that time top right. Above is a Celestia depiction of the moon from orbit above Hawaii with Baja California on the horizon. Right is a Celestia view from a lower altitude approaching Baja California](image)
The timings of the astronaut’s comments suggests the photographs were taken nearer to Baja California than Hawaii, but it is shown in the Celestia view purely to indicate that where it would have been in the sky for the crew. The other Celestia depiction is more realistic, but the proximity of it means the moon is much higher in the sky. The storms are therefore somewhere between Hawaii and Baja, and the moon is in exactly the right place and configuration in the sky for that.

Moving on the meteorological study, the first one we examine here appears to have been taken just after TLI (given the amount of curvature visible). Figure 4.8.0b shows AS16-118-18870 compared with the ESSA view from above and with a 3D reconstruction.

![Figure 4.8.0b: AS16-118-18870 compared with ESSA image and 3D reconstruction](image)

The 3D comparison is absolutely spot on, and we it is very obviously the same planet on view on both. We can confirm that it is taken after TLI by comparing it with an image take on the first orbit of Earth, AS16-118-18859 (figure 4.8.0c).

![Figure 4.8.0c: AS116-18859 (left) compared with the same area of AS16-118-18870 (centre), and an indication of where that area is in the latter (right)](image)

The area show is much bigger and the horizon much more curved, so it must have been taken after the TLI burn.

The next image to be examined is from a TV broadcast, and will also include an Apollo image that does not show the full Earth disc.
At 3 hours and 10 minutes into the mission (21:04 GMT) the crew started a TV transmission to cover the docking of the CSM with the LM. 15 minutes after starting the transmission, the crew have this to say:

“Houston before we turn the TV off...we want to give a picture of the Earth”

Capcom confirm they are receiving the image,

"very nice picture Charlie, we can see south-Western United States, Lower California. Very nice."

and also confirm that it is in colour. A few moments later the Apollo crew describe the view from 7000 miles out:

“...you just can't believe how beautiful it is. See the reds in the desert down there and the southern United States and northern parts of Mexico. And from here, you see the Great Lakes and the State of Florida out there. And it's just absolutely something.”

At 21:22 GMT, the TV pictures finished.

These TV images were used a short while later in a NBC news broadcast, available here: Apollo 16 News Broadcast.

Amusingly, the TV broadcaster’s voice, commenting on the pictures says that

“if my calculations are correct, the North Pole is to the right.. the Earth is tipped on its side”

He's correct about the Earth being viewed sideways on, but has got the location of the North Pole entirely wrong!

Two screenshots from this footage are given in figure 4.8.1a. One has been chosen purely because it has the words "Live from Space’ on it. The other one is from a couple of seconds later but covers more of the Earth’s surface. This is combined with the ESSA 9 mosaic from the 16th, and also AS16-118-18873 (source: AIA). This is not a full disk but is obviously taken at the same time. There are numerous small particles visible in the photograph from the explosive separation of the SIV-B petals to expose the LM, particles referred to by the crew just after starting their TV broadcast:

“We must have a zillion particles along with us”

This image precedes the docking, as photos later in the magazine show the LM still within the SIV-B. Figure 4.8.1b shows the same scene as viewed on a screen in Mission Control, although much more of Earth is visible.

The time is clearly shown on the news broadcast as 5:48 on April 16th. The timestamp itself is actually added as part of the Vanderbilt Television News Archive, which recorded all news transmissions at the time, and did not feature in the actual broadcast. The broadcast time relates to the Central Daylight Time zone of the NBC nightly news broadcast, which started at 17:30 CDT. The Vanderbilt archive has this link about the transmission. Interestingly, for all that Apollo deniers claim the missions were aimed at diverting interest from Vietnam, the war dominated the news program before the Apollo segment.

The shot was taken at the end of the Apollo TV transmission after docking, and the much reduced size of the Earth shows the speed at which they were travelling, and the news broadcast records that they are already 7000 miles out. The Apollo transmission ended at 21:22 GMT, or 16:22 EDT, with a second short 10 minute broadcast starting at 22:04 GMT (17:04 CDT), still in time for the TV news broadcast. While the label ‘Live from space’ is true in terms of it being broadcast from space, it is not strictly true for the news broadcast itself. The inset in 4.8.1b is a photograph of a TV taken during the broadcast.
Figure 4.8.1a: NBC news screenshots from 17:48 16/04/72 compared with ESSA 9 satellite mosaic and AS16-118-1887. Right is a 3D reconstruction using ESSA data.
Figure 4.8.1b: AS16-118-18873 compared with Mission Control screen image (top left) zoomed and brightness adjusted top right: Source. Bottom left is a photograph taken by a TV viewer during the broadcast (Source), and a different one from another TV viewer bottom right (source).
As for what is in the image, the most obvious feature is the large 'speech bubble' shape (green arrow) off the east coast of north America, and all of the other cloud features match perfectly between the TV, Apollo and satellite images. In terms of when the image was taken, we already have a definite match for the video screenshots, and therefore the Apollo image. Another interesting feature is that although the TV image was taken later, the 'speech bubble is further from the edge of the globe. As the Earth can't have gone backwards, the spacecraft must have changed its viewing perspective.

The ESSA track covering the east coast of the USA would have been orbit 4308 (track number 3), which started at 20:06. So, at the time of the Apollo images there was actually no satellite mosaic of the region photographed, and ESSA 9 could not, therefore, have been used as the basis for some sort of fake of the Apollo photograph. In order to demonstrate that ESSA 8, or ATS-3 images could have been used (remember both of these sent back black & white images), you would have to have the original source material, which at present are not available. Even ATS-3, which took half an hour to transmit its images, would have been had to have finished transmitting just as the news footage was obtained, then processed into a whole image, then converted to colour, all inside 25 minutes. Given the technology available this was just not possible.

The first full disk image to be examined from Apollo 16 is AS16-118-1885 (source: AIA), and was also used in the film 'Apollo 13' at 1 hour 48 minutes, as the crippled spacecraft is closing in on Earth.

This image occurs after a series of pictures showing the LM thrusters, now docked with the CSM, and the empty SIV-B carcass, which immediately puts the timeframe for the photograph at after 21:53 on the 16th. There is one more image of the SIV-B after this, then a sequence of Earth images showing an ever decreasing disk. The original GAP image is shown below in figure 4.8.2, and the analysis in figure 4.8.3.

![Figure 4.8.2: GAP scan of AS16-118-18885](image-url)
Figure 4.8.3: AS16-118-18885 compared with ESSA 9 satellite mosaic from 16/04/72. Stellarium insert shows time at terminator.
Figure 4.8.3 continued: AS16-118-18885 and 3D reconstruction using digitally restored ESSA data
It is unsurprising, given that the image was taken not long after the preceding Apollo photograph analysed, that the same broad weather patterns are visible. Even with the poor quality of the video screenshot, it is still possible to work out that the globe has rotated somewhat, as much more of the Pacific is visible, and the polar cloud mass has moved much further eastwards.

Also coming into view is a large hole in the Arctic cloud (yellow arrow). This feature is interesting because other conspiracy theorists suggest it shows the polar opening to a hollow earth, for example here and here. The tone of some of the articles makes it clear that they don't like using Apollo evidence, because they are forced to admit that the Apollo missions took place! It should be obvious that hole is at neither the magnetic nor geographic pole, and the sea can be seen, not a hole!

The ESSA timings have already been given in the previous image, and the timing of the East coast of the US part of the image would have been around 20:06. The terminator in the image is suggested to be at 22:00, just after the CSM had extracted the LM from the SIV-B.

The next few images of Earth are all from the same sequence of photographs in magazine 118. AS16-118-18887 (source: AIA). This image is shown in figure 4.8.4 below. Comparison with the ESSA mosaic is undertaken in figure 4.8.5a.
Figure 4.8.5: AS16-118-18887 compared with ESSA 9 mosaic. Stellarium insert shows terminator estimate. Yellow, Blue, Green, Magenta, Red and Cyan arrows are as in figure 4.8.3.
Figure 4.8.5 continued: AS16-118-18887 and 3D reconstruction using digitally restored ESSA data
The Apollo image shows that the Earth has rotated by some distance since the previous photograph, with more of the Pacific visible, and more than half of the northern USA now in darkness. Australia is about to come into view, and the long band of cloud extending from the Arctic towards it is now more prominent, thanks to a change in viewpoint. The entrance to Earth's hollow interior [sic] is also much more in focus, and it should be even more obvious that it is just a gap in the clouds, with other, lower altitude clouds inside it. We can even demonstrate that it's a dynamic system, changing over even just the few hours covering a small number of Apollo image. Figure 4.8.5b shows AS16-118-18876, which was taken shortly after separation form the SIV-B but before docking with the LM (judging by the images surrounding it, so it must have been taken between 21:00 and 21:15 on the 16th.

Figure 4.8.5b: AS16-118-18876 (top left) and in close up (top right) compared with the same area of AS16-118-18885 (bottom left) and AS16-118-18887 (below right)

There is a relatively short gap between 18876 and 18885 (about 45 minutes) so there is very little difference between them (though they can be detected on close examination). The 3 hours or so between 18885 and 18887 produces a much more obvious change.

Returning to the analysis, the terminator position gives an estimated time of about 01:15 on the 17th of April, as determined by its location through California and Mexico. ESSA’s orbits mean that track 4 would be closest to the terminator visible here, which equates to orbit number 4309, which was commenced at 23:01. Note the position of Australia in Stellarium, but absent in the Apollo image, which is again the effect of Stellarium’s lunar viewpoint instead of Apollo’s TLC position pointing at where the moon will eventually be. The Preliminary Science Report confirms the time of the photograph as being circa 8 hours in to the mission (page 17-3), as do the transcripts, which discusses taking matching ultra-violet photographs at this time.
In the next image in the sequence, AS16-118-18858 (source: AIA), figure 4.8.6, the Earth has shrunk considerably, and once the image is zoomed in there is again evidence of a rotating globe, not a static image in repeated use. Australia is now in full view, and south east Asia is visible beneath the clouds. The entrance to inner Earth has now almost disappeared from view completely. Figure 4.8.7 examines the weather patterns visible in ESSA’s mosaic in comparison with this image.

Figure 4.8.7: GAP scan of AS16-118-18888
Figure 4.8.7: AS16-118-18888 compared with ESSA 9 mosaic and Stellarium inset showing terminator time estimate. Green arrow is as used in figure 4.8.5.
Figure 4.8.7 continued: AS16-118-18888 and 3D reconstruction using digitally restored ESSA data
Having stated that Australia is clearly in view, the casual observer would have trouble identifying its location. Ironically the process used to enhance the clarity of the weather systems on the image has made the continents and some clouds around the terminator less visible, but they are there.

Although only the clouds arrowed in green are specifically pointed out, there are a number of clouds in this image that are visible in the preceding one, notably the band of cloud below the system identified in green, and the band of cloud above the system identified in yellow. Those clouds picked out by the blue, magenta and red arrows have been identified because they are likely to appear in the subsequent image.

The most relevant ESSA track for this image would be around track number 6. This corresponds to orbit number 4311, commenced at 01:02 on the 17th. As has already been established, this is consistent with an image dated the previous day. The position of Australia, and the location of India on the western limb without any suggestion of Arabia in the image points to a time at the terminator of around 05:30 on the 17th. Again, we have to allow for the position of Stellarium’s observer position and that of the Apollo craft and use the terminator as the reference wherever possible.

AS16-118-18889 (source: AIA) sees the Earth smaller still, and is becoming increasingly difficult in the low resolution images at the AIA to spot specific weather patterns without zooming in close. This image is shown below in figure 4.8.8 and analysed in figure 4.8.9.

Figure 4.8.8: GAP scan of AS16-118-18889
Figure 4.8.9: AS16-118-18889 compared with ESSA 9 mosaic, with Stellarium estimate of time at terminator
Figure 4.8.9 continued: AS16-118-18889 and 3D reconstruction using digitally restored ESSA data
On the face of it, AS16-118-18888 and 9 seem identical, but in reality they are just taken a short while apart. The change in terminator is only slight, but the time of this second image can be put at around 06:00 on the 17th. This can be demonstrated by a close examination of the system identified in red in figures 4.8.7 and 4.8.9 (see figure 4.8.10).

The differences are subtle but nonetheless there. There is a different shoreline configuration in the later as Arabia comes into view, and the system picked out in red is both further in from the western limb and is slightly less elongated. In fact, there is not a single cloud on the image that is exactly the same, although they are recognisably the same weather patterns. The magenta arrowed system is also noticeably further around in the second photograph. As with the preceding sections, this provides ample evidence (again) of a rotating, dynamic Earth photographed from space.

The next in the sequence of Apollo images is AS16-118-18890 (source: AIA), which is shown below in figure 4.8.11 and analysed overleaf in figure 4.8.12.
Figure 4.8.12: AS16-118-18890 compared with ESSA 9 mosaic and Stellarium estimate of time at terminator
Figure 4.8.12 continued: AS16-118-18890 and partial 3D reconstruction using digitally restored ESSA data
As north America is now visible on the image, it is obviously a photograph taken much later than the previous one, and the terminator estimate puts the time at around 23:00. The weather patterns are a clear and obvious match for those on the ESSA image dated the 17th. ESSA's most representative orbit for this area is orbit number 4320 (track 3), commenced at 19:09 on the 17th.

The entrance to inner earth (green arrow) has now completely broken up, showing once and for all that it was never anything other than a weather system, and the clouds that made up its eastern wall has moved onwards to become a clearly defined weather front (blue arrow).

A couple of hours before this photograph was taken at about 20:30 on the 17th, there is a conversation between Capcom and Apollo, where the command module pilot says:

"I think one of the most impressive sights...is the cloud formations you can see and polar icecap"

and then the lunar module pilot says that:

“There was that awful big storm up off the coast of Alaska in the Bering Sea, I guess it was yesterday. I can't see that now though.”

The storm to which he refers is the one forming the 'entrance to the hollow Earth' jokingly referred to here. Interestingly, Capcom report that their weather charts don't extend that far, as they only cover the landing area for splashdown.

The final image in this sequence on magazine 118 is AS16-118-18891 (source: AIA), seen in figure 4.8.13, and analysed overleaf in figure 4.8.14.
Figure 4.8.14: AS16-118-18891 compared with ESSA mosaic and ATS-3 image, with Stellarium insert showing time at terminator.
Figure 4.8.14 continued: AS16-118-18891 and 3D reconstruction using digitally restored ESSA data.
This image of Earth is only slightly more rotated than the previous one in the magazine, but the weather patterns are very obviously different and the Earth is much smaller in the image. There are two possible explanations: either NASA got sloppy and forgot to consult their continuity people before using this one, or it is just over 24 hours since the preceding image was taken.

The satellite images act to confirm that the image is actually taken 24 hours later. The ATS-3 image was featured in the MWL as part of their summary of the month’s weather, and is part of a discussion of the large storm close to northern Europe. The tail end of this storm is picked out in red on the photographs. The ATS-3 image was taken at 17:05 on the 18th. On the 17th, this storm can be seen in ESSA images in a different place, and is not as cohesive as in this photograph (see figure 4.8.15).

The ESSA track best matching the terminator area is number 3, which corresponds to orbit number 4333 commenced at 20:08. Stellarium’s terminator estimate is 22:30. According to the mission transcript, the crew were preparing for a UV photography session at this time, and Capcom confirm them as being over Florida at that time. Everything therefore points to the date being the 18th.

The next image to be examined is AS16-120-19187 (source: AIA), which is shown figure 4.8.16 below and analysed in figure 4.8.17.

![Figure 4.8.15: ESSA 9 mosaics of Atlantic storm on April 17th (top) and 18th (bottom).](image1)

![Figure 4.8.16: GAP scan of AS16-120-19187](image2)
Figure 4.8.17: AS16-120-19187 compared with ESSA mosaic, and Stellarium inset showing time at terminator.
Figure 4.8.17 continued: AS16-120-19187 and 3D reconstruction using digitally restored ESSA data
The Apollo photograph is a lone image of Earth on a magazine otherwise dominated by photographs of the lunar surface. Its appearance as a half illuminated disk immediately points to it being relatively early in the lunar portion of the mission.

Again this image shows north America, and again the weather patterns are considerably different to those featured on the previous day's images. A notable system is the circular 'bullseye' pattern south of Alaska that is very evident on the Apollo and ESSA pictures. The globe is rotated slightly more than in previous ones showing the same broad area, and less of south America is visible. The terminator time here shows 23:00 GMT on the 19th, and this is supported by the ESSA orbit covering north America (track 4) number 4346 commencing at 21:06.

More support for this timing comes from the mission transcript. At the beginning of their second orbit at 77 hours in to the mission (22:54 GMT on the 19th), the crew tell Capcom that they have

“just got the 10000th picture of a beautiful Earthrise.”

The number 10000 is obviously an exaggeration, but AS16-120-19187 was pretty obviously that image.

The next Apollo picture to be looked at, AS16-113-18289 (source: ALSJ) is one of a series of the most spectacular Apollo images, showing the CSM on the lunar horizon as the Earth rises behind it. It is, therefore, taken from the lunar module after separation from the CSM (the first half a dozen photographs in this magazine are of the CSM immediately after separation) but before the landing. This puts a timeframe for the image of between 18:07 on the 20th, and 02:23 on the 21st.

The image is shown below in figure 4.8.18, and analysed in figure 4.8.19.
Figure 4.8.19: AS16-113-18289 compared with ESSA mosaic and Stellarium terminator estimate
Figure 4.8.19 continued: AS16-113-18289 and 3D reconstruction using digitally restored ESSA data
Since the last photograph Earth has moved on again, and once again north America is the focus of the image with a different set of weather patterns, all of which match up with the satellite images taken on the same day, the 20th. Fixing the time by Stellarium shows a time of roughly 20:00, as the US west coast is not yet visible, but most of south America is. ESSA's orbit for that time would have commenced at 20:00 (track 3, orbit 4358), so there is a perfect reason for a good match.

There is also support for this time estimate from the mission transcript. While it is not specifically mentioned, revolution 13 began at 97 hours and 48 minutes, or 19:42, with radio contact re-established with Houston about 20 minutes later. The photo index for Apollo 16 (source: ALSJ) states that this Earthrise sequence took place on revolution 12, but this is likely to be a difference in interpretation as to when orbit 12 ended and 13 started. Certainly the first image after the Earthrise sequence (of the CSM) is marked as being on orbit 13. It can’t have been at the start of orbit 12, as this would have Africa in view, and very little of north America. The next available image of Earth actually has to wait until the end of the first EVA, and comes courtesy of the rover’s TV camera.

At 125:21, or about 23:15 on the 21st, Ed Fendell turns the camera towards Earth and zooms in on it. Houston communicates this to Young and Duke:

125:21:33 England: Hey, fellows, we're able to see the Earth with your big eye there.  
125:21:39 Duke: How about that. Pretty sight, isn't it?  

The video itself can be found [here](#).

Figure 4.8.20 shows a clip from this link, as well as one provided by Retro Space Images facebook page showing a photograph taken at the time indicating that it was a TV broadcast. Figure 4.8.21 analyses the view.

Figure 4.8.20: Screenshots of Earth from the end of EVA-1’s TV broadcast

Despite adjusting the brightness levels to improve clarity it isn’t easy to make things out. We can say with certainty that the view is entirely consistent with what should be visible in terms of the shape of the Earth and its terminator.

At the time of the broadcast that terminator line should be cutting a path just off the eastern US coast and off the western coast of South America. That being the case it seems reasonable to suggest that the red arrow points to the cloud mass covering most of the eastern USA.
Figure 4.8.21: Screenshot from Apollo 16 TV broadcast compared with ESSA images from 21/04/71
Figure 4.8.81 continued: Apollo 16 TV broadcast still and 3D reconstruction using digitally restored ESSA data.
The yellow arrow marks the cloud running across the southern Pacific, with a clear area above it definitely visible as a blue area. The green, magenta and blue arrows are my suggestion as to what other systems are visible, but the image is too over-exposed to be absolutely certain. The scene is, however, consistent with what should be there. ESSA’s view of the terminator is best covered by track 4 which would have been orbit 4360, commenced at 22:05 on the 21st.

EVA-2 has a similar sequence showing Earth broadcast live in TV, and thanks to the transcript we can place it very precisely in terms of time at 23:27 GMT on April 22nd. Figure 4.8.22 shows a screenshot from this broadcast.

As before the image quality isn’t crystal sharp, but we’ll have a look at what we can make out in terms of atmospheric detail in figure 4.8.23.
When the crew woke up before EVA-2 they were actually broadcasting to Australia’s Honeysuckle Creek, but by the time this TV view happened they had Houston in sight. It’s pretty obvious that the crescent Earth is the same size as it should be according to Stellarium, and the arrows in figure 4.8.24 show that the areas of cloud and clear are matched in the ESSA and Apollo TV view. As usual with this view, we are looking at ESSA track 3, which is orbit 4303, commenced at 20:02 on the 22nd. If you don’t think the view shows the same weather, then you are of course welcome to provide your own interpretation.

We do have a final image of Earth taken from the lunar surface, again showing it through the eyes of the Lunar Rover’s TV camera - this time shortly after the ascent module take off. The image is given at Honeysuckle Creek’s website and it takes place at the end of the TV broadcast of the ascent module lift off. We can time it fairly precisely as the crew tell Houston that a guidance tweak has been completed at 175:43, or 01:37 on the 24th.

While this part of the broadcast is not normally found on youtube, I have been able to acquire a copy from Honeysuckle Creek and can confirm that this is when the still was taken. I have stacked about 10 seconds worth of footage and combined them to produce a cleaned up version of the image (just as Honeysuckle Creek did with their version).

The original Honeysuckle Creek image is shown below in figure 4.8.24. Figure 4.8.25 shows my ‘stacked’ image taken from the video frames supplied by Honeysuckle on the left superimposed with an Earthview screenshot set at 01:30 on the 24th, made transparent so that the video can be seen beneath it. Next to that is the video still compared with the ESSA imagery dated 23rd, whose timings put it about 3 hours ahead of the Apollo broadcast.

Figure 4.8.24: Video still from the Apollo 16 LRV TV camera. [Source](#). The orientation is correct for Apollo 16’s landing area south of the lunar equator.
Figure 4.8.25: Video still compared with Earthview projection of what should be visible on 24/04/72 at 01:30 (left) and the ESSA satellite photograph dated the 23rd.
Once the orientation of the photograph is matched with the known orientation of the Earth at the time it was taken it is possible to start looking at whether the ESSA image matches up.

The details are admittedly not as clear as would be preferred, but I believe the inferences I have made to be not unreasonable. There is a broad band of cloud around the equator, with clear ocean to the south. Given that the satellite photograph precedes the Apollo shot by several hours, it is again not unreasonable that the green arrow points to the same storm system in both images. Likewise the band of white in the southern hemisphere temperate zone.

Even a blurry, low quality image from a TV broadcast sent from the moon has enough information in it to identify features supporting the fact that that is where it was: on the moon.

Only one more colour image of Earth is available. AS16-122-19564 (source: AIA) is part of a sequence of 4 over-exposed shots of a crescent Earth rising over the lunar horizon. The crescent phase already places it towards the end of the mission, and there are several photographs of the ascent component of the LM earlier on in the magazine. The remaining images in the magazine show an increasingly curved lunar horizon indicative of a post TEI photography session.

Figure 4.8.26 shows a high resolution version of this image, and figure 4.8.27 shows this crescent earth that has had the levels, brightness and contrast adjusted in comparison with the ESSA 9. Earthview has been used to provide a horizon as it shows a clearer view of the landmasses.
Figure 4.8.27: AS16-122-19564 compared with ESSA 9 mosaic, and an Earthview terminator set at 02:15 on 25/04/72.
As with previous missions where the Earth is a thin crescent, it does become more difficult to determine exactly when it was taken, and which weather systems on the ESSA mosaic match those on the Apollo image purely on the basis of the Earth photograph.

In this case there is some documentary evidence in the mission transcript and the photo index. The latter suggests that the image was taken during TEI in the early hours of the 25th (02:15 to be precise) – something the thickness of the crescent would support. The mission transcript records a conversation with Capcom at AOS after the TEI burn:

“We got some pictures of Earthrise as we were climbing out”

02:15 has therefore been used as the benchmark for the Earthview image. With this knowledge in hand, it is possible to identify the dark area of the visible crescent as the California coastline (blue arrow). This then allows what cloud systems that are visible to be placed on the ESSA mosaic. That mosaic's best fit track around the terminator would be number 4, or orbit 4409, commenced at 22:09 on the 24th. As always with thin crescent images, it is difficult to be absolutely certain that the cloud patterns identified on the photograph are the same as those on the ESSA mosaic, but the supporting evidence of the photo index and mission transcript do help.

One final, very fleeting image of earth can be found in the 16mm footage (available [here](https://example.com)). Immediately after shots of the returning ascent module docking with the CSM, there is a short sequence of shaky, hand held footage taken from lunar orbit (this in itself should be evidence of enough, as it shows features not visible from Earth yet is being filmed by a person, shown reflected in the CSM window). The curvature is pronounced, but there is no complete disk shown. As there is footage shortly after this of a complete lunar disk, it is likely to have been filmed around TEI.

Earth appears in shot for only a few frames, and there are no discernible surface features, but the size of the crescent is entirely consistent with the view that should be seen from the Moon at TEI. A still from the video is shown below in figure 4.8.28 and the reader is referred to figure 4.8.27’s representation of the Earth crescent that should be visible.

![Screenshot from Apollo 16 16mm footage showing Earth at around the time of TEI.](https://example.com)

There are no other images available of Earth in the visible spectrum, but there are some taken in the UV spectrum in TLC.
4.8.2 UV photography in TLC

UV images were taken during TLC and were originally analysed from magazine 131 at the AIA (Source: AIA). A new source for these images (archive.gov) revealed higher quality images than were previously available at the Apollo Image Atlas, and the images were re-analysed using those. The aim of the photography was to use comparisons with colour Earth images to allow better interpretation of images of Mars and Venus (see [here](#) for more).

The first of these is AS16-131-20100 (source: [archive.gov](#)), which is seen together with the weather analysis in figure 4.8.29 and 4.8.30 respectively.

![Figure 4.8.29: AS16-131-20100](#)

The satellite images show the same weather patterns in the UV image as the visible spectrum one, so the conclusion that they were taken at roughly the same time seems entirely reasonable. There are also mentions in the mission transcript. At 6 hours 40 minutes, the crew get a reminder about settings for the UV camera, and at 07:19 hours in they discuss a checklist they will attend to after the photographs. Five minutes later they appear to discuss that checklist. This would put the time at around 01:15 on the 17th, the same time as that estimated time for figure 4.8.5. This would match up with the stated intention to match UV images with at least one Apollo image for comparative purposes. The images taken are compared in the Preliminary Science Report ([page 17-3](#)).

The second of the UV sets looked at will use AS16-131-20115 (Source: [archive.gov](#)), see figures 4.8.31 and 4.8.32, and shows the Earth as a much smaller target in the photograph.
Figure 4.8.30: AS16-131-20100 compared with ESSA 9 image from April 16th. Arrows used match figure 4.8.5
Figure 4.8.31: AS16-131-20115

Figure 4.8.32: AS16-131-20115 compared with ESSA 9 mosaic dated April 16th – arrows match figure 4.8.9
The observant will already have noticed that this UV image bears a striking resemblance to figures 4.8.7 and 4.8.9, where again there is a colour photograph that can be used in comparison with the UV one. There are again references in the mission transcript at the time this image was taken.

At 11:01 Capcom tell the crew that they specifically want UV images taken at the time dictated by the flight programme: 12:20 hours in to the mission, or about 06:15 GMT, and comments made at 12:22 hours suggest that the photography is progress. The position of the terminator close to Australia in figure 4.8.9 suggested a time of around 06:00 on the 17th, so there is again a good correspondence there.

The final UV image worth looking at is the third is AS16-131-20116 (source: AIA). On the face of it there is very little detail there, but close examination does reveal that weather systems identified in figure 4.8.12.

Figure 4.8.33 shows the original image, and figure 4.8.34 the weather analysis.

Once the weather patterns have been pointed out, it becomes obvious that they are the same as picked out in the colour Apollo picture from April 17th. Figure 4.8.12 puts the time at the terminator as about 23:00, and the mission transcript gives just one clue that that is about the same time as this image. At 29 hours 11 minutes the crew state that they are going into the correct attitude for UV photography, and this would equate to 23:05 GMT.

Figure 4.8.33: AIA scan of AS16-131-20116
The newly available higher resolution images mean one more set is available for examination, and the best of those is AS16-131-20125. This is shown below in figure 4.8.35 and analysed in figure 4.8.36.
The UV image here is taken at the same time as AS16-118-18891 (see figure 4.8.14), and while the level of detail is nothing like the same as the colour photograph, the same cloud patterns can still be seen in it once you know what to look for.

We have one final session of UV photography, this time taken on the way home and in fact almost there. The session occurred at 16:44 on April 27th, and figure 4.8.37 (derived from the astronomy app ‘Sky Safari’) shows where Apollo 16 was at that time, together with a Fourmilab projection of the Earth’s sunlit area.
The models above indicate that the terminator is running down the centre of Africa, and only a thin sliver of daylight would have been visible. Shortly after the photography, Young confirms what they could see:

10:23:15:46 CDR Hank, we got the Earth out of window 5. It’s a very thin crescent and the subsolar point is spectacularly bright.

Figure 4.8.38 shows the view of Earth taken by Apollo during that session together with satellite views.

As the Apollo image shows what appears to be a bright cloudy area in the centre line of the image, it’s tempting to interpret this is the ITCZ line along the equator. The views from the astronomy app and Celestia seem to confirm that this is the case.

The UV images are therefore consistent with both the colour photographs that were evidently taken at the same time, and with the ESSA satellite images taken on Earth some time later.
As with Apollo 12, we have one final element to the story that we can examine: views of Earth taken during re-entry, as visible on the 16mm magazine GG, available here.

The reference book Apollo by the numbers gives the re-entry location as -162.13, -19.87, with the eventual splashdown occurring at -156.22, -0.7. Those locations are shown in figure 4.8.39.
The re-entry process is recorded as starting at 19:31 GMT on the 27th, which puts the nearest available satellite image as one commenced on the 27th, but with the relevant pass (number 6) starting at around 01:00 on the 28th. Figure 4.8.40 shows the ESSA image concerned.

As with other Earth re-entry footage, there isn’t much in the way of wider context views to be absolutely certain, but what we again have is a view that is not at all inconsistent with the satellite view, despite the 5 hour time gap.

The final section will deal with any available synoptic charts and compare those with the Apollo photographs.
Figure 4.8.41: Selected re-entry screenshots.
4.8.3 Meteorological analyses

As with previous missions, the main sources of information for synoptic charts is the German and South African data held at NOAA, and the daily charts also held by NOAA. However, none of the Apollo images feature Africa, so only the German and NOAA daily charts can be used. The lack of Earth images available means that only 5 days are suitable for analysis. Launch day is the first for which charts are available, and figure 4.8.42 shows the weather charts in conjunction with AS16-118-18885.

Figure 4.8.42: German (top left) and NOAA (bottom) synoptic charts for April 16 1972 compared with AS16-118-18885. Click image for larger version.

Time differences between the charts, and differences in interpretation of the meteorological data from which the charts are derived account for the differences between them, but the broad patterns are consistent: the complex low towards Alaska, and two broad frontal areas acting as boundaries for the USA, leaving the continent largely clear, other than the complex system towards the east coast.

The second day's charts cover April 17th (see figure 4.8.43). In this image, showing much less of the globe overall thanks to the change in relative position of the Apollo craft, compares the synoptic data with AS16-118-18890.
The frontal systems here are relatively straightforward, although whether the yellow arrowed system on the NOAA charts is just a continuation of the one identified in magenta is one for debate. Either way there is a system in blue across the south east, green starting out in the Pacific, and the magenta one across Canada. All of these also appear on the Apollo image.

The next day’s image is covered by AS16-118-18891, and is examined overleaf in figure 4.8.44.
Figure 4.8.44: German (top left) and NOAA (bottom) synoptic charts from April 18 1972 compared with AS16-118-18891.

Sadly the main feature of the weather on the 18th, the 'monster' storm featured in the MWL doesn’t show on the NOAA chart, but the yellow arrow indicates the tail end of it on the German and Apollo parts of the figure. The magenta arrowed front is the one crossing the USA in the Apollo image.

The charts from the 19th are compared overleaf in figure 4.8.45 with AS16-120-19187.
The main feature evident here is the front crossing the USA, with an offshoot to the south, that is covered by 3 different coloured arrows, and this is easy to identify on all 3 of the composite parts of the figure above.

The final day's synoptic chart analysis is for April 20th, and uses AS16-113-18269. This is shown in figure 4.8.46.
Figure 4.8.46: German (top left) and NOAA (bottom) synoptic charts from April 20 1972 compared with AS16-113-18269. Cyan arrow represents the ITCZ.

Again, there may be differences in interpretation between meteorologists, but there is a broad consensus that coincides with the features shown by the Apollo image.

Another mission where the Apollo images, satellite photographs, video screenshots and synoptic charts all tell a consistent story: the photographs were taken in space on the way to and back from the Moon.
Apollo 17 was launched at 05:33 on 07/12/72, the only night launch of the Apollo series. It performed LOI at 19:47 on the 10th. The last two astronauts to walk on the lunar surface, Gene Cernan (who also took part in Apollo 10’s rehearsal mission) and Jack Schmitt (the only scientist to walk on the moon) landed at 19:55 on the 11th. The lunar surface was departed for the final time at 22:55 on the 14th, and the crew finally landed back on Earth on the 19th. The timeline for the mission can be found here: NASA timeline.

During the journey, and the three EVAs of the lunar landing, 23 magazines of film exposed 3584 photographs, the majority of these being sequences on board the LRV used in exploring the surface. Eight magazines containing 404 images were also taken using a Nikon 35mm camera. The mapping camera contained one sequence showing an Earthrise. The majority of the images are available in high quality at the AIA and/or ALSJ sites, but some have had to be requested from GAP. Archive.org also contains some high resolution scans of the more famous images. Video footage will also be used, and referenced as appropriate, including stills from the 16mm footage.

There is a change in satellite for this mission, with NOAA 2 being the main source of information. The meteorological data catalogue for the mission can be found here: Hathitrust source. This satellite provides images in the visible and infra-red (IR) spectra. Visible spectrum images will be preferred, but IR images will be used where necessary and/or appropriate. The data catalogue for this satellite is also interesting in that it does not give timings of orbits. Instead, it gives the time in GMT on longitude lines. The visible spectrum satellite day is still run from around the east coast of Africa onwards, and therefore it is assumed that the weather patterns to the east of this line as far as the west coast of the Americas will be dated the day after the date of the image. The IR night time images seem to start in the Atlantic with the date on the image being appropriate for the whole image.

Surprisingly, there are very few other sources for satellite data for this mission, despite other countries launching their own missions. NIMBUS 5 data became available for the latter part of the mission but is of little use. One instrument on board (the Electrically Scanning Microwave Radiometer, which measured microwave radiation from the Earth’s surface) did have data covering images on the lunar surface but as will be seen later are difficult to interpret. Those data can be found here. Other satellites do not have a comprehensive data catalogue. As usual, however, there are other individual sources that may prove useful, and at least demonstrate (again) that the satellite images were readily available.

Satellite activities of NOAA 1972, for example, contains images from December 7th, 11th and 18th, all covering small areas of the north-east of north America, but none of which would prove of any use. This Journal of Applied Meteorology article has a NIMBUS 5 image of the US east coast down to Florida from December 13th, but again there was no opportunity to use it. NIMBUS 5 was launched on the 11th of December and early images were tests, but the data catalogue for it does not start until the 19th. The MWL provides, as ever, useful images of a tropical storm (Therese) on the 7th, which occupied the north Pacific for the first half of the mission, and also of Tropical Storm Violet on the 13th. DAPP satellite images also exist for the 13th of central America in this military publication, but this region does not seem to be covered by Apollo images on that day. We have a recorded DMSP image in this publication for the 16th and that does get used.

Therese can also be seen on December 6th in a couple of places, notably the MSL and the Annual Typhoon Report, and while these are from before the launch, they are interesting in that they come from the DAPP satellite. This journal article has some sections of ATS-III images of Puerto Rico, but again the area isn’t photographed by Apollo on the relevant dates.

One ESSA image has been found, thanks to an Army veterans’ site covering life on Midway Island. The ESSA 8 image is clearly identified as being from December 11th 1972, but no other details are available – the image was sent to the website for posting, and the site owner has no further details about it.
We also have for the first time images taken by NASA’s Landsat satellite. *Landsat 1* (originally named *Earth Resources Technology Satellite 1*) was launched in July 1972 not to observe the weather but to examine terrestrial resources and land-use. It was based on the NIMBUS-4 weather satellite and had the capability to produce colour images. Images are available throughout the mission (sourced from http://earthexplorer.gov.), and will be used where appropriate.

As with previous missions, digitally recovered satellite data is available and will be used where possible.
4.9.1a - Mission images: Outward bound

The general procedures for any Apollo launch are the same: launch, orbit, TLI, LM extraction. The LM’s extraction and docking with the CSM was usually filmed, and sometimes as part of that filming other shots were recorded. One such shot is given in this recording from Apollo 17: Youtube (this can also be found as a real media file on the Apollo Archive multimedia section). The footage features the camera rolling over the Earth’s surface before it goes on to focus on the SIV-B and its cargo. Separation has only just occurred, as indicated by the numerous small pieces of debris. The timeline suggests that this is part of a TV broadcast, but it may also be from 16mm footage.

By taking several screenshots from this footage, it is possible to see, if not a complete disk, at least a full north to south pan. This pan can be seen in figure 4.9.1, together with a satellite image taken on the same day as the launch.

Before looking at the weather patterns there, it’s worth looking at the quality of the images themselves. The lower frame of the Earth image created from the video screenshots is considerably darker than the other three, and this is probably a result of the camera adjusting to the light conditions. Despite the difference, the video as a whole is still a single piece of unedited footage. The globe is completely lit, which is what would be expected from 09:15 GMT – the separation time for the SIV-B.

The second observation is that the NOAA image has evidently suffered some of the image stability issues discussed in preceding sections, particularly off the west African coast. This problem unfortunately obscures an extremely prominent cloud just off South Africa.
The weather system to the east of the system identified by the cyan arrow also looks to have had problems with data interpretation from the satellite image. Lines can be made out running up through southern Africa, and the angle of some of the clouds is not consistent with the overall pattern. Some of the clouds off the eastern South Africa coast, for example, seem to belong to the outer edges of the large sub-Antarctic whorl of cloud. While the cloud identified by the blue arrow has a position consistent with that in the satellite image (i.e., it extends from the southern Cape to a position south of Madagascar, it is partially obscured by erroneous data from elsewhere.

Despite the quality issues in the satellite photo, there are still obvious features that occur in the Apollo video and in the satellite image. The large whorl of cloud south west of the Cape is very evident, as is the finger of cloud extending from the Antarctic near the coast of South America. The broken clouds across all of southern Africa show the same distribution on both images, as does the small area of localised cloud north of Madagascar.

The time of the Apollo video has already been established at around 09:15, and NOAA's image is recorded as being 06:48 GMT for the east coast of Africa, and 10:48 for the mid-Atlantic.

At the same time as filming the separation, still images were being taken (as evidenced by the cloud of debris in the photographs, and it is these images that allow a good comparison with the first set of Landsat passes. We have two available to start with, one over the Red Sea into Eritrea and northern Ethiopia, and the across a section of Southern Africa. We have two Apollo images available here, namely AS17-148-22685 and AS17-148-22686. I've used the ‘March to the Moon’ site as a source as these have very high resolution scans of the images that allow us to match the high quality of the Landsat images. These are shown in figure 4.9.1a, and each is marked with a red box indicating the Landsat path.

![Figure 4.9.1a: AS17-148-22685 (left) and 22686 (centre) marked with Landsat image paths, shown in Google Earth (right).](image)

The data from the Landsat images shows that they were taken between 07:00 and 08:00 on the 7th, giving only around 2 hours at the most between when they were taken and those taken by Apollo, so there should be good correspondence between the two. Let’s see how that works out in figure 4.9.1b.

Looking first at the southern Africa image, we can see a clear correspondence between the two, starting with the long thin band of cloud over the area west of Kruger National Park, to the larger mass of cloud off the South African coast. North of that larger cloud mass is the thinner offshore cloud that moves inland in the Durban area. In the image covering the Red Sea there is the band of cloud between Eritrea and Yemen/Saudi Arabia, as well as a patch of cloud on the edge of the Danakil desert where it meets the sea. Covering the desert area itself is a large area of broken patchy cloud that is exactly matched in the Apollo image.

Also part of this sequence are two other photographs that give us a perfect view of the two Landsat passes, namely AS17-148-22717 and AS17-148-22718. These are shown in figure 4.9.1c together with the Landsat locations on Google Earth.
Having identified where the image paths are, we can now compare them with the Landsat images themselves in figure 4.9.1d.

Figure 4.9.1b: Close up of AS17-148-22685 (left) and 22686 (above) compared with Landsat passes.

Figure 4.9.1c: AS17-148-22717 (bottom left) and 22718 (bottom right) with Landsat image paths marked on, as shown on Google Earth.
The correspondence between the two sets of photographs is absolutely spot on. The pass over the Indian ocean shows clear blue water between the coast and the wispy clouds to the south, matched exactly by the Apollo photograph. The Antarctica image is interesting because here we are not looking to match cloud formations but ice. The Antarctic ice regime is a constantly shifting pattern of bergs and open water as the coastal ice shelf breaks up in the Antarctic summer. Here we can very easily identify the clear water of the Mawson coast north of the Framnes mountains either side of a headland. It is very obviously the same area of coastline photographed by Apollo and by Landsat. And every single contour of ice and sea can be made out exactly, even down to the markings inland away from the coastal shelf. Oh, and in case anyone wants to claim these images are modern and weren’t public arena before the digital age, they’re wrong - as shown by this 1988 publication.

Next up for analysis is one of the most iconic Apollo images. Actually part of a sequence of Earth photographs, the so called ‘Blue Marble’ image has been reproduced many times. Students of a certain age (and I am one) undertaking geography studies will remember being asked to identify the various weather system components on the image as part of exam questions. Mine was in 1980, just 8 years after the mission.

Apart from the fact that it is of stunning quality, it also shows the Antarctic region in much more detail than is the norm for Apollo photographs, thanks to the trajectory the CSM was given. The Antarctic is also not a region shown in any great detail on any satellite images – at least not those used in this research, thanks to either the orientation of the geostationary satellites or the techniques used in assembling the geosynchronous mosaics.

Of the many versions of the photograph that could have been chosen, the one used here is AS17-148-22725 (figure 4.9.2). This is the first image on that magazine to feature a full disk Earth, and appears after several
images showing the LM extraction and docking procedure. The photograph immediately preceding it is of the discarded SIV-B drifting towards its eventual destination of the lunar surface. The 16mm footage also shows a brief glimpse of the same view after an extended shot of the departing S-IVB. Once correctly oriented, it is very easy to make out the same African continent visible in the video sequence used for figure 4.9.1, and also the same weather systems from that video given a wider context without the limitations imposed by the CSM window frame. Figure 4.9.3a shows the comparison between the Apollo image and the NOAA-2 satellite image.

Figure 4.9.2: AS17-148-22725 (left, source: AIA) and still from 16mm footage (right)
Figure 4.9.3: AS17-148-22725 compared with NOAA-2 satellite mosaics from 07/12/72. Blue, green, magenta and yellow arrows are as in figure 4.9.1.
Figure 4.9.3a continued: AS17-148-22725 and 3D reconstruction using digitally restored NOAA data
Of the cloud systems picked out, one is worth mentioning in particular as it is often referred to in articles about this image, and that is the compact swirl of cloud over southern India, identified by the cyan arrow. This swirl is in fact a cyclone that started on the 1st of December and lasted until the 8th, causing 80 deaths and considerable damage in the state Tamil Nadu. The storm, also known as the Cuddalore cyclone, is described in detail in this 1974 article in the *Indian Journal of Meteorology and Geophysics*. It developed from December 1st onwards, and a satellite view from the article taken on the 6th is shown in figure 4.9.3b compared with the cyclone shown in AS17-148-22725 and AS17-148-22718.

The satellite view is recorded as 10:15 Indian Standard Time, which is equivalent to 04:45 GMT. Despite being taken just over 24 hours prior to the Apollo image the storm structure and location is an extremely good match. It’s also possible to make out subtle differences between the two Apollo images, reflecting the fact that they were taken an hour or so apart. The research paper identifies the images as being from ESSA-8, which explains the slight difference in appearance compared with the NOAA-2 image.

One of the data sources for that paper is a report on how a newly installed (and only partially operational) radar station in Chennai (then known as Madras) monitored the storm as it made landfall. The report (a copy of which was kindly supplied by India’s Meteorology Service because it is not available online) has more radar images, and those from the 6th are shown in figure 4.9.4c.

It’s worth remembering that these are radar images from a system still being installed at the time of the storm, and that the images are from the day before the Apollo photograph was taken, but their significance is two-fold. Firstly, they show a storm exactly where Apollo photographed it. Secondly, they show a storm that was being monitored by Indian weather services independently of any outside agency, and it was a storm for which they had comparative data in the form of weather satellite images. At no point has anyone from those weather services come out and said “hang on, these aren’t right...”. Why? Because the Apollo photograph is genuine and as such shows a true reflection of the data collected about it.

![Figure 4.9.4b: Top row: Sections of AS17-148-22718 (left) and AS17-148-22725 (right). Bottom row shows the NOAA-2 images from December 6th (left) and the 7th (right).](image-url)
Other reports also give details of the storm, for example this one, which describes its meteorology in detail, including its track over the sub-continent and a synoptic chart (figure 4.9.3d).

The same report also has this to say about infra-red satellite imagery of the event contained in another volume:

"Various stages of the development and dissipation of severe cyclone between 2 and 11 December 1972 are clearly seen in the Infrared satellite images at 21:00 IST from [NOAA data]"

And

"the infra-red satellite pictured appear more realistic and show more vividly the life-history of the Cuddalore cyclone. Such infra-red pictures would therefore be of great forecasting value in similar cases in future."

The source of those images is this book, published in 1977 along with a detailed account of the storm, and a copy of which I own. Figure 4.9.3e shows the images.

The images are recorded as being taken at 21:00 IST, which is 5.5 hours ahead of GMT, putting them at 15:30 GMT. This would put the December 7th satellite image as taken some 5 hours after the Blue Marble (even less for the earlier partial Earth shot showing the storm). Despite the satellite being infra-red rather than visible spectrum there are excellent comparisons to be had with the Blue Marble photographs. There is, for example, the double prong of clouds at the northern end of the spiral, and the much thinner fan of clouds on the south-western end spreading into the Arabian Sea. We also have the clouds spreading over Sri Lanka and then heading westwards.
Again, we have freely available satellite records used in an academic volume bearing no relation to Apollo or NASA confirming details in the Apollo photograph.

Returning to the Blue Marble analysis, the time frame for the NOAA image is obviously still the same, and while there is no terminator visible we can estimate the time based on what is visible. Stellarium’s view of the Earth at 10:45 GMT seems reasonable and is consistent with the timeline, as by this time the LM docking procedure was complete and the SIV-B disposed of.

It’s also worth looking at the two images of Antarctica covering the area photographed by Landsat (figure 4.9.3b), as well as the same area shown in AS17-148-22685 (see figure 4.9.1a).
Five hours would normally be enough to change cloud patterns recognisably (and if you look carefully at the other areas of the photographs clearly has been), but less so with the ice flows. The only differences readily apparent here are accounted for mostly by viewing angle and focus. Just in case anyone thinks it’s all a bit convenient that these Landsat images are around digitally, well, they’ve been public a long time - one of the tiles of this Antarctic series appears in this 1988 publication, long before the internet.

Another comparison possible is of the Apollo still and 16mm images. The two are taken around 90 minutes apart, and if the viewpoint was from a stationary point above the Earth there would be no change in the landmass visible. If it was from a geosynchronous orbit, more of the south American continent would be visible as these go against the rotation of the planet. Instead (this is more obvious in the full size stills), we have more of Asia visible in the later still photograph, which indicates a movement both with and faster than the rotation of the Earth as it travels away from it – launches were in fact arranged that way to capitalise on the momentum this rotation gave the Saturn V.

In comparing this Apollo image with NOAA's mosaic the image chosen has been that dated the 7th of December. However, the bulk of the Apollo image shows land and ocean that would actually have been imaged on the mosaic dated the 6th. With this in mind, figure 4.9.4 below shows a section of southern Africa from the mosaics dated the 6th and 7th compared with the same sections of the post-launch stills. The 3D reconstruction used above has been done by merging the two day’s images. The overlap around the East coast of Africa does cause issues, but otherwise the match is extremely good.

![Figure 4.9.4: NOAA image dated 06/12/72 (top left) and 07/12/72 (top right) compared with video screenshots (bottom left) and a section of AS17-148-22725 (bottom right). White dashed line superimposed to show overlap between days.](image-url)
As far as the weather systems are concerned, they are clearly the same overall, but as with other examples in other sections, there are subtle differences accounted for by the time gap between them and not accounted for by the slight difference in perspective. The blue arrowed clouds are further east in the later picture, as is the green arrowed one, which has also merged with an onshore cloud mass. The red arrow points to clouds that have also joined another, more easterly, cloud mass later on. The yellow arrowed clouds have apparently moved little but the clouds either side of them have changed their relative positions. The magenta arrows pick out adjacent strips of cloud that have closed the gap between them.

In going over this small area in fine detail it is possible to find many differences that demonstrate that they are not simply the same photograph treated. It should also be obvious that they do not match the satellite images exactly. The key point here is the comparison with the clouds as they appear over (and to the west of) South Africa, which are imaged at the start of the satellite's day, and those to the east of South Africa, which were imaged nearly 24 hours later. Despite issues with data quality for the 7th, it should be obvious that the cloud mass over the Cape bears a much better resemblance to the NOAA image from the 7th rather than the 6th.

East of the Cape and it starts to become more difficult. A closer look at the full size image shows that the edge of the large white cloud mass ends more or less on a line of longitude just east of Madagascar, while on the image dated the 7th it ends much further to the east. The blue arrow is relatively easy to place, but the yellow and magenta ones are much trickier to locate precisely. It is suggested here that the dashed lines on the NOAA-2 images, drawn to coincide with changes in contrast, are lines that delineate the different day's images.

Does this mean the satellite images aren't genuine? No, they are as good as they can be given the technology of the time they were produced, and anyone who denies that the clouds you can see in them aren't reflected in the Apollo images needs their lenses checking, they clearly are the same. Does this prove that the Apollo images aren't genuine? No, but it does make it more difficult for people to claim that they are simply faked directly from satellite photographs!

Perhaps the best possible confirmations of the weather from space come from the astronauts themselves. The crew (usually Jack Schmitt) give possibly the longest sequence of descriptions of the Earth’s appearance of all the missions, with only the occasional interruption from Capcom with mission related technical information. The conversation starts at 10:48 GMT:

“You've got a pretty good size storm over the north - I guess it's the northwestern coast of India, where it starts to wrap up and around to the west. It's a - rounded out on the horizon, so I can't make out exactly where it is too well.”

This is evidently the tropical storm discussed earlier. A few minutes later at 10:51 GMT, there is this contribution:

“Antarctica is what I would call effectively just a solid white cap down on the - South Pole. There’s a definite contact between the continent and the water. But, as Ron said, most of the clouds seem to be very artistic, very picturesque - some in clockwise rotating fashion but appear to be very thin where you can, for the most part, kind of see through those clouds to the blue water below...The continent - the continent itself is - is the same colour as the clouds; but, of course, more dense - and striking difference than any of the other white background because you can definitely see that contact with the water and with the clouds over the water.”

And again a few moments later:

“We've got a - I guess probably the continent of Africa dominates the world view right now. It's covering the - oh the upper third - upper and western third of the - of the world. We can see the Sinai; we can see up into the Mediterranean; we can see across the Mediterranean, although we can't make out the countries up there, we can see across into India. I catch a glimpse of Australia out in the far horizon. Got Zanzibar on the southern tip of Africa, the Cape down there just almost directly below us. And, I don't know exactly how big Antarctica is,
but I guess we can certainly see more than 50% of it. And - the rest of it is all ocean. The Indian Ocean out into the Pacific Ocean and back into the Atlantic Ocean. And for the most part relatively clear of clouds except in the Antarctica region, and up towards Europe which is - which is on the horizon, across the Mediterranean, it looks like there might be some clouds back up in that way. I probably - probably - well, not probably - I can make out the entire coast of Africa from Mediterranean around to the west, coming back to the south back where it takes its big dip to the east, back around the cape, back around the Suez Canal, almost perfectly..and there’s one batch of clouds in northern Africa, just a small batch, it looks like it may be up near the - well, no, it’s not near the mouth of the Nile; it’s quite a bit west of that, as a matter of fact, I can see the mouth of the Nile; I can see it running straight down towards us as it parallels the Suez and then sort of fades out into the central darker brown of darker green portions of Africa.”

At 11:02 Schmitt takes over the commentary:

“It must be an awful clear day for the so-called convergence zone across Africa...most of Africa is clear. Only some - probably are broken and scattered clouds - cumulus in the east central portion that are running along the line of north/south lines. Looks like a major circulation system off the southern tip of Africa...plus one [east] of that, 20 or 30 degrees of longitude...and southwest of the tip of South Africa at the Cape Good Hope, there looks to be an incipient circulation system developing about half way between the coast of Antarctica and Africa.”

There are another couple of pages of this, including confirmation they had been taking photographs of the view, and it should be evident that they are describing what is in the photograph, and that there is no way they would have known this other than seeing if for themselves, as the satellite evidence would be unavailable for several hours yet.

The next image is again part of the long sequence of photographs of a receding Earth. AS17-148-22736 can be seen below in figure 4.9.5, and the satellite analysis on the next page in figure 4.9.6.
Figure 4.9.6: AS17-148-22736 compared with NOAA-2 satellite mosaic dated 07/12/72 with Stellarium inset of time at terminator.
Figure 4.9.6 continued: AS17-148-22736 and 3D reconstruction using digitally restored NOAA data
On the face of it the Apollo image is little different to the previous figure analysed, but there are some interesting points to be made. Firstly, the weather system discussed in much detail in preceding pages (identified by the purple arrow) has moved further eastward and is much more in line with the location given on the satellite image than the earlier Apollo photograph.

Secondly, the Earth is now less than a full disk – night is just beginning to fall across Arabia, and the estimate from Stellarium for the terminator is about 13:00.

The large reduction in the amount of Earth visible in such a relatively short time is explained by the third item of significance. During the conversation describing the Earth's weather systems described earlier, Capcom relay a piece of information about the crew's trajectory, saying at 10:59 GMT:

"...shortly you're going to start heading backwards on the Earth here and head back across the Atlantic. That ought to be some sort of a first. You cross the Atlantic twice, going from west to east, and the, now you're going to cross it going from east to west"

So, having started with a path that sped them with the Earth's rotation they now start moving (in relative terms given they are now 20000 miles out) against the rotation.

We already know that the ESSA time over Africa would be early morning on the 7th, and the timing of the Apollo photograph is confirmed by the Schmitt at 7:57 in to the mission (around 13:30) while confirming numbers on the camera magazines, stating that:

“...I just took another set of Earth pictures”

We therefore have another example of photographs that are consistent not only with the weather patterns described by the crew, consistent with satellite images taken at the same time, and also that show a consistency with the mission flight path.

The next photograph in the sequence is taken some time after this one, as it shows the Pacific and Australia. Figure 4.9.7 shows the Apollo photograph, and figure 4.9.8a the satellite analysis.

![Figure 4.9.7: AS17-148-22737 Source: AIA](image)
Figure 4.9.8a: AS17-148-22737 compared with NOAA 2 satellite mosaic dated 07/12/72 and Stellarium estimate of terminator time.
Figure 4.9.a continued: AS17-148-22737 and 3D reconstruction using digitally restored NOAA data
The visible portion of the globe has shrunk again since the previous image as time passes and the Earth’s orientation relative to Apollo 17 changes – certainly Stellarium’s visible disk showing Earth as seen from the moon is much larger. The time markings on the satellite suggest a time around the terminator of around 10:40 GMT on the 7th, with Australia being overpassed about 12 hours later. Stellarium’s suggested time (based on the absence of land masses other than Australia and the clouds by the terminator) is somewhere around 01:00 on the 8th – roughly 19.5 hours since launch.

The appearance of Australia in the frame is useful in terms of confirming that suggested time of. While no mention is made directly of photography, there is discussion of the Earth’s appearance some time before and after midnight (as an Earth scientist, Schmitt was particularly keen to describe what he could see, earning him the description “human weather satellite” from Capcom). At just short of 19 hours (00:30) Capcom tell the crew that:

“...we’ll be having a communications handover to Honeysuckle in about a minute and a half”

with Schmitt responding:

“That’s great. Next time I look at Earth I’ll see what’s happening in Australia.”

As communication is by line of sight and Goldstone in California was just about to disappear, Honeysuckle in Australia becomes the next link in the communications chain as it comes into view. Australia is visible in the image, whereas the coast of the USA is not, which suggests a time for the image after that statement. More helpfully for this analysis, he does at 20 hours (01:30 GMT)

“I took two 5-50-millimetre pictures.”

Schmitt then gives a lengthy description of what he can see:

“...It looks like there’s a very well developed front coming out of the north-western portion of Antarctic ice shelf....That front looks like it starts and develops as a small - it - it actually seems to start with an anticyclone development off the coast of Antarctica. Moves up across New Zealand. Looks like the South Island primarily, a little bit of the North Island is still visible and into the eastern coast of Australia...”

“...that front is going off across to the coast of Australia north of Sidney and largely a little south of Brisbane and - and swings across the whole of Australia and seems to come - near as I can tell, go by into the Indian ocean about - well, where the Great Sandy Desert intersects the north-western coast of Australia....That front does cross. Probably Brisbane is probably cloudy. it does cross that area, and - however, there is a bank of clouds that runs off of it down the coastline. So Sidney is either cloudy or has some pretty nice clouds off - off shore. And the remnants of the front as it dissipates in the hinterland of Australia dies out at about the Great Sandy Desert, and there is not a good indication that it crosses into the Ind - Indian Ocean. ...it looks more and more like the cyclone circulation developing right over the top of New Zealand, the South Island, I think...anticyclone circulation is centred on the ice shelf. “

“Now the north of Antarctica... there is a large cyclone circulation pattern that has its southern extremity right on the edge of the ice shelf. And that - that is east by 20 or 30 degrees of longitude of the front that I was just discussing....Between New Zealand and Australia, the front I was discussing previously has some fairly strong transverse cloud patterns......but the bulk of Australia is very clear, all the south and the north. It’s just one line of clouds that crosses the centre section."

As before, he describes the scene uncannily accurately, almost as if he was actually looking at it!

At 02:20 GMT, Schmitt says:

“I’ve been trying to spot tropical storm Teresa [sic], which is is - a couple of days ago was in the Philippines. But I can’t - I don’t think I quite have that visible to me right now.”

The Philippines are only just visible on this image, and Schmitt also refers earlier to the Hawaiian Islands weather, which is further support that he is looking at a scene where Australia has only just become visible.
Tropical storm Therese began life on 30/11/72 and lasted until December 12th, but causing damage to the Philippines and Vietnam on the 3rd and 9th respectively and the introduction to this section provides links to the images of it. This storm becomes more interesting in light of the next couple of images analysed. Before we do that, it’s worth taking a quick look at a set of Landsat images showing the area of the northern coast of Australia’s Northern territory - the western part of the Gulf of Carpentaria. Australia is only just visible in this image but it’s a more useful one to look at because the image’s timing differs from the Landsat path by only about 30 minutes. Figure 4.9.8b shows the relevant details.

Figure 4.9.8b: Google Earth showing Landsat passes over Australia (bottom left). The same locations are shown on AS17-148-22737 (top left) and compared to the right. Apollo image has been brightness adjusted and sharpened for clarity.
Comparison of the Landsat and Apollo image is somewhat compromised by the angle of the Apollo image’s view of Australia and the increasing distance of the Apollo spacecraft from its subject. That said, there are points of similarity between the two. Coastal cloud over Nhulunbuy separated from other clouds on the coast of Papua by blue ocean. We then have a gap in the cloud before we get to the broader swathe of it over the Tanami desert. Not conclusive as I am the first to admit, but the two images are not at all inconsistent.

Moving on now, a short while after Schmitt’s long range weather report, another couple of photographs are taken. AS17-148-22739 is shown below in figure 4.9.9, and analysed over the page in figure 4.9.10.

![Image of Earth seen from space](image_url)

Figure 4.9.9: AS17-148-22739. Source: AIA

Before assessing the photograph, it’s worth drawing your attention to the area over northern Territory shown in figure 4.9.8b. We’ve moved on a few hours since the Landsat image was taken the change in viewing angle allows the comparison to show the very clear match between the two sources (despite the accumulation of more coastal cloud).
Figure 4.9.10: AS17-148-22739 compared with NOAA-2 satellite mosaic from 07/12/72 and Stellarium estimate of terminator time. Cyan, green, yellow and red arrows are as in 4.9.8.
Figure 4.9.10 continued: AS17-148-22739 and 3D reconstruction using digitally restored NOAA data
As with the preceding image, the first question to settle for figure 4.9.10 is the time at terminator. The Stellarium estimate is given as 04:00, but the Earth as seen from the Moon is obviously still almost full, compared with the three quarters full as seen from Apollo’s vantage point. This, combined with a Pacific view, makes defining the line of the terminator much more difficult. How then was the estimate derived?

At the risk of again employing circular logic, the satellite photograph comes in useful here, and it can be seen from that the terminator line cuts along the westernmost edge of the band of cloud identified by the green arrow. The furthest edge of this cloud falls along the 170 degrees West line of longitude (making Hawaii all but invisible to the crew), and by using a combination of Google Earth and the Earthview website, it’s possible to determine that the terminator line would follow a line from 30 degrees East of New Zealand (visible at the point of the cyan arrow) up towards the Bering Straits. Australia is slightly over 20 degrees west of New Zealand, and this distance of around 50 degrees gives a time at the terminator of roughly 04:00. To complete the time analysis the time at the terminator on the NOAA image is given as 19:40 GMT.

Having established a rough time for the image, we can now take a look at what is in the image, and what Jack Schmitt has to say about it! Perhaps the most impressive feature is the procession of angular fronts proceeding across the sub-Antarctic oceans, features that are easily spotted on the satellite mosaics, and we will see Schmitt’s description of them shortly. His first observations about the state of the weather for this picture occur at 22:26 MET (roughly 04:00 GMT):

“...we’re starting to be able to see the coast of Asia. The Philippines are wide open today. And the - that tropical storm Theresa [sic] that I mentioned that I thought I could see - indeed, I’m sure that’s what that little concentrated mass of clouds was north of New Guinea. And, I suspect, that the folks in Guam may be in for some heavy weather...oh and Bob, I got another pair of pictures...about 10 minutes ago.”

This is a fairly good clue that the AS17-148-22739 (and its companion in the magazine) was taken at roughly 04:15 on the 8th. Examination of the Apollo photograph does indeed show that East and SE Asia are just beginning to be visible. Guam is located north of the area of cloud arrowed in red. New Guinea (now called Papua New Guinea) is just north of Australia and south of Guam. From this description it looks as though he suspects that the red arrowed cloud mass is Therese – but is he correct?

Fortunately for us, we have a few satellite photographs available, as described in the introduction to this section, namely the original NOAA-2 pass and also a DAPP satellite image. They are not from the exact date of the Apollo image used here. We can, however, use them to identify where Therese is. Figure 4.9.11 shows the north-west corner of AS17-148-22739 compared with the DAPP and NOAA images from the 6th and 7th respectively. As with any time-series images of weather phenomena, there is no exact match here, rather an indication of the storm’s progressive development as it moves westwards towards land and an overall indication of the weather system's make-up.

Figure 4.9.11: AS17-148-22739 compared with DAPP from 06/12/72 (left) and NOAA from 07/12/72 (right) images.
The spiral arms of the storm are nicely picked out by all three images, and the long band of cloud trending north-eastwards from it is also well defined. The gap between Therese and the other north/north-east trending system further to the west is visible in the NOAA image, and the southern tip of that secondary band is just included in the DAPP image.

It is a pity that there are no publicly available photographs from the 8th of December that would tie in more precisely with the Apollo image, but (like the Tamil Nadu cyclone) it is present in the image where it should be.

Cynics will argue that Schmitt (and presumably NASA and ESSA) knew about the storm, and would know that it should be in the photographs. They will probably also argue that Schmitt’s apparent inability to see Therese was a pretense, instead of the reality that he was observing the Earth through distant optics. The mission transcript does indicate exactly what information Capcom had to hand, and this will be dealt with shortly.

We can at least attempt to clarify the exact date of the NOAA-2 image. The original source gives it as December 7th, which is the date of the satellite mosaic originally used to look at the Apollo source picture. Does this mean that the NOAA-2 image is one taken actually on the 7th (and would therefore appear on the mosaic dated the 6th) or part of the dataset starting the 7th, and therefore actually imaged on the 8th? Figure 4.9.12 compares the NOAA mosaic versions dated the 6th and 7th with the NOAA image from the MWL dated the 6th.

Figure 4.9.12: NOAA-2 mosaic segment dated the 6th (left) and 7th (centre) compared with NOAA-2 image dated the 7th (right) in the MWL (source given in the introduction to this section).

Figure 4.9.12 illustrates 2 things. Firstly, that the NOAA-2 image published in the MWL is dated the 7th correctly, and can be identified in the mosaic dated the 6th. The cloud mass over the Vietnam coast and the ones adjoining Therese at sea are a better match in the left hand mosaic section compared with the right, and the long thin cloud over the Vietnam coast on the centre image matches Apollo’s more closely. Secondly, the degradation in image quality when compiling the mosaic is very evident. The original source image used in the MWL is much clearer and has far more detail.

We will return to Jack’s hunt for Therese shortly, but first he has other descriptions of what he can see for Capcom. At 22:35 MET he gives a lengthy description of Australasia’s weather:

"...I was talking about the circulation patterns around Antarctica. We were looking then at the Indian Ocean, actually, South Atlantic in the Indian Ocean region. And you see the same pattern at about the same latitude, say 60 degrees south, where all the linear cloud patterns which presumable are - reflect the various cold fronts have - are arcuate with their convex sides, or more actually, almost pointed sides are all lined up in a west-to-east direction around that latitude. It’s quite a spectacular appearing circulation pattern. And the little wave that I mentioned on New Zealand seems to be beginning to form another arrow or another convex point on that front that’s fitting right into the same circulation pattern..that would make four of those major convex fronts that I can see from this view crossing - south of Australia up into the South Pacific.”
The fronts he describes are those that appear south and then east of Australia in the photograph, with the green arrow identifying the largest of them.

Having briefly gone over Australia and the Antarctic Ocean, he then returns to the search for Therese. In order to help those less familiar with the region, figure 4.9.13 shows an annotated Google Maps page, with the main places mentioned identified.

Figure 4.9.13: Google Maps page showing the Asian Pacific region, with additional annotations identifying locations mentioned in the Apollo 17 mission transcript

He starts the discussion with:

“On that tropical storm that was Theresa...I'm not sure it may be a little south of Guam. Guam may be in trouble with that one.!”

So, while we know exactly where Therese is at this point, Schmitt is still unsure, and is picking out what to him would appear as the largest and most obvious tropical disturbance, rather than Therese's actual location at the end of a longer band of cloud. Capcom, meanwhile, have their own maps and are trying to locate Therese as well, and they respond with:

“It looks like it's just a bit to the west of Manila there - about 5 or 6 degrees, no more that about. it looks like it's about 5 degrees west of Manila and 5 degrees south.”

To which Jack replies

:“...I don't like to argue with you but I think our analysis chart is a little more up to date ...That area you mentioned...is very clear and the centre of the - what appears to be the storm I'm speaking of, would be about 142 longitude and maybe 8 degrees north latitude...which would put it south of Guam”

We then have the following exchange between Capcom and Schmitt, which reveals interesting information about the weather data held by ground crews supporting the mission:
Capcom: “Okay yes, you're over in the area between Guam and the Carolines, then.”

Schmitt: “Yes, you're probably looking at a - oh, I don't know - maybe a what - a 12 hours old prog, or something.”

Capcom: “Yes, that's the one I had for launch date...We'll get a satellite photo and bring it in here in a bit”

Schmitt: “Okay, well, it's - it's - moved quite a bit now and I guess it's the same storm; still seems to be very well organised but quite concentrated and small.”

Capcom: “Okay we'll get in a new prog and compare your estimate there”

Schmitt: “OK, I think that's pretty good - those 142 and 8 degrees would be pretty good centre of that storm. I've got some pretty good coor - I can see Mindanao, and I can see the - let's see - just a second, what is that on Australia?...Yes of course, that's Port Moresby. I can see that point there, and between those two - I can pin down that one probably with a couple of degrees”

Capcom: “OK. We'll get a satellite photo and bring it in here in just a bit.”

It appears from this exchange, then, that Capcom are predominantly using synoptic charts for their information, and are looking at relatively old data compared with Schmitt’s view. As the main concerns for the weather are mainly with launch day and re-entry – and even then only for the Florida and splashdown locations, this is unsurprising. It would be up to other agencies like ESSA to monitor any emergent trends on a wider regional level, who would update NASA as required. Schmitt’s fascination with the weather is something that was evidently not anticipated by Capcom (and to a certain extent seems to bemuse them somewhat, particularly as his lengthy dialogues do get in the way of essential technical transmissions governing spacecraft maintenance and mission details. Jack’s amateur meteorologist status (which he does briefly mention by way of explaining any errors he may be making) is revealed by his assumption that Therese has shifted several thousand miles over a relatively short period!

Briefly mentioning the front over New Zealand (cyan arrow in figure 4.9.10), he then returns to SE Asia:

“...Borneo is very clear today; and, as is the Philippines. And as I mentioned, there's a - looks like a very strong system that stretches from, oh, let's the south coast of - or southeast coast of Vietnam up - up between and across Tai - between the Philippines and Taiwan and across Taiwan. And right along, and I can't tell I think, just off - just south of Japan...The strongest storm centre that I can see on that is - is way north, and probably - Hokkaido is - has a fair amount of weather from the storm system. There seems to be a tropical depression just north of Borneo, a very strong circulation system north of Borneo and, I guess, just south of - of Vietnam.,.,that's not what's left of Sally is it?”

He has now managed focus in on the correct area for Therese, which is lurking at the end of that storm front over Japan. Tropical Storm Sally was a small event that had pretty much died out by the time Apollo 17 launched, and the tropical depression he describes is actually Therese! Capcom can't identify that depression on their current chart (probably because Jack has confused them by mis-identifying storm systems!) and are still awaiting their more up to date chart. Schmitt goes on to describe clear skies over Korea and cloud cover over Japan before returning to the area around Therese:

“...As I recall, they had a tropical storm called Sally that went into - ... a few days ago, and so I suspect this new one that seems - that I think I see between Borneo and Vietnam maybe something else; a new depression or I maybe - be fooled by it.... Mainland China, Bob, was the last pass here. I can't see the Ear - see the Earth now, but Mainland China looked like it was clear as far as I could see. There might be a front quite a ways inland...but Korea, Yellow Sea, and the regions of China south of there - Shanghai, Nanking and those places are - looks as if they are quite clear....It looks like some residual cloudiness would be affecting the Pusan region of Korea. And, also, that's residual after the frontal passage. And it looks like maybe Shanghai, after all, may have some storms associated with it, but it's really hard to pick out exactly 0 the exact coast line of Asia, but I - there are some clouds in the Yellow Sea behind the front. Looks like they might be possibly some high cirrus is all.”
It's worth pointing out that the above conversation took place over 45 minutes after the Apollo photograph under discussion took place, so that while initially the coast of China would have been difficult to make out clearly, it would have moved into view by the time Jack made the comments above. He is, however, managing to pick out areas and their weather conditions accurately, even if the storm that is Theresa is still confusing him! By now it is 23:17 MET and Capcom ask Schmitt about the storm around Guam, to which he responds:

“I see there is this cloud concentration between New Guinea and Guam. The more I look at it the less well developed it appears to me compared to some of the other circulation patterns. It could be just a residual depression from Teresa [sic] that has moved out into that area. It is an isolated, a relatively isolated cloud pattern, fairly small, but apparently fairly dense. But has - does not have a strong cyclonic pattern to it. Nothing at all like the pattern that now exists above Borneo and seems to be moving towards Luzon.”

He has therefore managed to identify that the circulation pattern we would expect for a cyclonic storm is absent in the clouds near Guam, but is still sticking to his guns that it is a leftover from the (still active) Therese, despite the very obvious cyclonic pattern he can actually see on the storm that is Therese!

Twenty minutes later, he gets asked about Wake Island, prompted by requests from the ARIA support team based there, to which he responds:

“...around Wake, or in the vicinity of the Kwajaleins and north of Wake, about all you have is a lot of cloudiness although - and in a generally - over wide part of that Pacific, I’m talking about 15 or 20 degrees of longitude and latitude, there’s a - roughly a clock - a clockwise circulation pattern. But the clouds do not look very dense or concentrated in any one area. And at leading off to the south-east from that general cloud mass, they’re cyclonic - anticyclonic cloud mass is a - is one of the old fronts - or at least one of the old linear cloud patterns that extends down into the south Pacific....I wouldn’t expect [winds] to be anything - anything what might be down - associated with the remnants of the tropical depression Theresa. Now that Theresa - what’s left of it, if I’m correct in - in picking out there, probably is - is moving in that direction, although it looks weak enough. But right now I don’t think it would be any big problem. And it may, in fact, go south of there.”

The general cloudiness is obvious on the Apollo photograph, although the circulation pattern of the cloud would appear to be more perceived than actual, as it is difficult to pick out with any certainty any rotational evidence other than a slightly arced band on the eastern side of the cloudy area he is describing. The old front moving south-east is picked out by the green arrow in figure 4.9.10.

Capcom then deliver a bombshell to Schmitt:

“..The prog I got in my hand for 3 hour old weather has Theresa located just about in the Manilla area. Did you concur with that, or do you think it passed the - the Philippines.”

The 'prog' they refer to indicates that they still don't have an up to date satellite image, and instead are relying on synoptic charts. Jack then responds with:

“Well, I don’t - Manila’s clear. The only thing approaching near Manila is - is this other storm center that is north of Borneo. And to the east of Manila, it’s clear all the way over to this little cloud mass that I was guess might be Theresa.”

Schmitt is displaying a classic symptom of confirmation bias, which is ironic because it is something of which conspiracy theorists are routinely guilty: he has made a judgement based on incomplete information, and despite all evidence to the contrary suggesting he is wrong, he is sticking with his original story! He believes Therese to be a spent force, so the obviously active storm he can see can't be Therese! His final comment on the subject for the day is that:

“...that circulation pattern or tropical depression possibly that I saw earlier north of Borneo is now even more strongly developed at the tail end of the front that stretches up towards Japan. And it - it really looks like a humdinger from here. Beautiful circulation patterns and very concentrated. And it is now east of Vietnam, and again between Vietnam and - and the island of Luzon.”
Following this statement, and with a few technical and housekeeping matters, the crew (who have all taken sleeping tablets) have a rest period and Jack's weather forecast service ends for the night, but not before he takes another pair of photographs. He confirms this before the final weather observation cited above, saying at 24:00 MET (05:30 GMT):

“I'll probably take two more pictures before we go to sleep”

After the rest period, Schmitt confirms that he did take two photographs before retiring, and one of those, AS17-148-22742, is shown below in figure 4.9.14.

Australia has moved around under the CSM while Jack has been delivering his synoptic sermons and is pretty much directly below them. New Zealand is now equidistant between Australia and the terminator, and this allows a quick determination of the time to be not long after Schmitt said he would take the photograph. The added rotation of the Earth allows a much better view of Theresa, and we can confirm that it is where Capcom think it is, and not where Jack thinks it is, and also that the image mosaic dated the 7th is correct for Therese, and not the one dated the 6th. This can be seen in figure 4.9.15. The full satellite analysis for this image is given in figure 4.9.16a.
Figure 4.9.16a: AS17-148-22742 compared with NOAA-2 satellite mosaic and Stellarium terminator estimate. Red cyan and blue arrows are as in figure 4.9.10. Blue arrow points to Tropical Storm Therese.
Figure 4.9.16a continued: AS17-148-22742 and 3D reconstruction using digitally restored NOAA data
There is little to add to this image, given that we have already had a lengthy description of it from Jack already. It is worth mentioning the obvious rotation of the Earth over time that is entirely consistent with the narrative recorded in the mission transcript. The remnants of the Cuddalore cyclone first identified in AS17-148-22725 can be seen on the western limb, picked out by the yellow arrow.

In the spirit of open reporting, we also have a couple of areas covered by Landsat in this image (Borneo, Burma and Korea), though they are less than revealing in terms of producing any conclusive proof that they show the same thing. Figure 4.9.16b identifies the locations concerned and shows the image comparison.
While the Apollo 17 image is timed at around 04:00, the Korea images were taken around 02:00 with Borneo imaged shortly afterwards. Burma was photographed at 03:44. With this in mind it is more likely that the Burma image would show the greatest degree of correspondence with the Apollo photograph, but the viewing angle and poor focus makes this difficult to state conclusively. There are certainly clouds near the coast that fit the bill. The Korean and Borneo images are similarly inconclusive, but are certainly not inconsistent with the Apollo image when you allow for the time gap involved.

Later in this mission day, Schmitt asks Capcom if they had managed to find any more information on the storm he had picked out by the Philippines. Capcom confirm that the storm is, in fact, Therese, after which Jack asks about the storm he had thought was Therese over in the Guam area. Capcom tell him that they have no detailed charts of the Guam area. It is likely that the more detailed charts over the Philippines and Vietnam are a consequence of the still ongoing military operations in that area.

As well as confirming that he had taken a pair of photographs before going to sleep, Schmitt also advises Capcom that he has taken another couple at 33:30 MET, or about 15:00 GMT. One of those photographs, AS17-148-22743, is shown in figure 4.9.17, and the satellite analysis is shown on the next page in figure 4.9.18a.

![Image](image)

**Figure 4.9.17: AS17-148-22743. Source:** AIA

The first observation that can be made here is that, with increasing distance from Earth (the crew are now over halfway to the Moon), the shape of the visible Earth is becoming much more similar to the view from the Moon as given by Stellarium's terminator estimate. It is also very obvious that Stellarium's predicted terminator line for Jack's stated time for this image of 15:00 is exactly right.

The satellite image suffers the usual problem when viewing Africa of featuring a portion of the image that was actually scanned the following day. The yellow arrowed cloud pattern is one that is further East on the satellite image compared with the Apollo version for that reason. The time at the terminator on the NOAA mosaic is difficult to determine because of that, but an estimate of around 08:00 GMT on the 8th would fit in with the time markings shown on the lines of longitude.
Figure 4.9.18: AS17-148-22743 compared with NOAA-2 satellite mosaic, and Stellarium estimate of terminator time
Figure 4.9.18 continued: AS17-148-22743 and 3D reconstruction using digitally restored NOAA data
In this mission, if there is a photograph of Earth, our resident meteorologist has observations to make about it, and this image is no exception. At 33:45 MET (or 15:15 on 08/12/72) he observes the following:

“...Africa looks in pretty good shape. There is a - except for an area probably around Zambia and Rhodesia [Zimbabwe] in the tropical convergence zone there, where it looks pretty cloudy and probably quite rainy. There’s a strong circulation pattern, and presumably a storm off - just off the coast of north-west Africa. Very spectacular spiral formation of clouds in a cyclone development. it looks like there are probably two fairly week Southern Hemisphere cyclones in the South Atlantic, One, south-west of Cape of Good Hope, and other about due west of the Falkland Islands, maybe a little bit north of that. South America looks to be in quite good shape weatherwise, except possibly Uruguay and maybe northern Argentina which appear to have a - at least some fairly thick clouds there, although no strong circulation currents associated with this.”

His most obviously accurate description is of the 'spectacular spiral' in the north Atlantic (green arrow), which is visible very faintly in the NOAA mosaic but is still clearly there. There is indeed cloud cover over what is now Zimbabwe and Zambia just to the north of it. The yellow and cyan arrows pick out the fronts off the Cape and Falklands respectively. The thick cloud over Argentina is identified by the magenta arrow.

Again we have a series of Landsat passes covering the area, figure 4.9.18b shows where they are.

![Figure 4.9.18b: Landsat paths shown on Google Earth and on AS17-148-22743](image)

We’ll only be looking at four of the path here, as the one over Arabia and Ethiopia is under darkness at the time of the photograph, and these are shown in figure 4.9.18c.

As far as timings are concerned, Antarctica was imaged at around 06:00. No time is given for the southern African images, but as the central African ones are timed at around 09:00 they are likely to be on the previous orbit at around 07:30. Likewise no time is given for West Africa, but it’s likely they were taken at around 10:30. All of the images therefore pre-date the Apollo one by several hours, but despite that there is still a great degree of correspondence between them.

Continuing with the mission analysis, Schmitt has much more to say about the next image he took. He begins his narrative at 38h19 MET (c. 19:45), but the key moment for this research is his statement at 38:33 (c. 20:00):

“about 15 minutes ago I took two more Hasselblad shots of the Earth...and also, Houston, frame number – let’s see, that’s 16 or 17 - were taken of the Earth about 15 minutes ago too. And that’s magazine Sierra Sierra.”
We therefore have photographs taken at about 19:45 on magazine 148, and also on Sierra Sierra, magazine number 162, a colour roll of 35mm film in a Nikon Camera. The image chosen to examine from magazine 148 is AS17-148-22745, and this is shown in in figure 4.9.19. AS17-162-24047 from the Nikon 35mm film is shown below it in figure 4.9.20.
The satellite analysis of the Hasselblad image is given in figure 4.9.21a, and this is briefly repeated without the NOAA mosaic in 4.9.21b. The Nikon image is not of good quality and the usual procedures of level and brightness/contrast adjustment did not much more than confirm they show the same features. The focus therefore has been on the better quality image. Figure 4.9.22 shows an annotated map of the visible landmasses that Jack then goes on to discuss at length.

As far as dating the image is concerned, the Stellarium estimate is again a perfect match for when Schmitt states he took the photographs, and both photographs show the same features, with the Hasselblad’s superior zoom lens giving the better detail than the Nikon.
Figure 4.9.21a: AS17-148-22745 compared with NOAA-2 satellite mosaic and Stellarium estimate of time at terminator.
Figure 4.9.21a continued: AS17-148-22745 and 3D reconstruction using digitally restored NOAA data
Figure 4.9.21b: AS17-162-24047 with weather patterns identified in figure 4.9.21 identified. This image has had brightness and contrast levels adjusted and the degree of blue enhanced.

Figure 4.9.23: Outline map of the Americas with annotations showing places referred to by the mission transcript.
In terms of what can be seen, we may as well let Jack do the talking again. His opening statement at 19:45 GMT is:

“...it looks like there is a fairly strong mass of polar air moving from the southwest up towards Tierra del Fuego. It’s mixed with some cloudiness that extends from that area all the way down to the Antarctic ice shelf. But it looks like some pretty good movement patterns from the south-west, north-north-east. No strong weather waves or cyclone development on that yet, although one may be picking up halfway between Tierra del Fuego and the coast of Antarctica, the - where the front, or at least the cloud masses, curve from the east-west direction to an almost due south direction. Most of South America looks like pretty good weather. There is cloudiness on the Andean Ridge and also in the Amazon Basin , stretching from the eastern coast of South America on up about, oh, 2/3 of the way towards Central America. It doesn't look like frontal weather there. It’s probably tropical convergence weather. Now there is this - still this small, moderately developed cyclone pattern that's hanging pretty much over Buenos Aires now, I think. Uruguay and Buenos Aires.”

The developing cyclonic system, and the frontal clouds associated with it are picked out by the magenta arrow. The cyan arrow identifies the clouds running from the east coast to central America. The clouds over Buenos Aires aren't given an arrow, but they are visible south of the system pointed out by the cyan arrow.

Schmitt then moves on to the northern hemisphere:

“...Except for scattered clouds, Central America and Mexico, for the most part, are clear - as is most of the Caribbean islands. Cuba and he others are - all look like they’ve pretty good weather. There's a little clouds off - cloud pattern off to the east of those islands, but it doesn't look like any major weather in that area. The eastern half of the Midwest of the United States is completely cloud covered right now. There - however, the - extending from Mexico to Sonora and up into Arizona and New Mexico, and possibly as far north as Colorado, is a clear band. But there is more cloudiness to the north of that. The Pacific regions west of - The West Coast of the United States is cloudy at least west of Southern California. I cannot see Baja, so that cloudiness extends down south of - into Baja California. I see no strong new frontal patterns, although I’m looking right across the limb at the Earth now. There may be one that would be lying maybe across northern California and - and into Colorado, with a little clear area ahead of it, possibly in Kansas. But then into this, a solid bank of clouds that stretches from Brownsville, at least, clear up to - well, along the Gulf Coast and on out past Nova Scotia, I’m sure. Florida is clear. Florida - the peninsular portion of Florida is - it looks very clear...”

Capcom are able to confirm his observations on their synoptic charts and also on a satellite image, although they are not up to date. The satellite image is probably an ATS-3 one, as Capcom state that it covers the same areas that Schmitt is describing. Schmitt is also informed that his broadcasts are being listened to with great interest by

“weathermen and a lot of other people around here”

At 38:49 MET, or around 20:15 GMT, Schmitt goes back to the southern hemisphere to describe the scene there:

“..there's an axis that runs from, say, the outer portion of the Ross Ice sheet along the - and just off the coast of Antarctica, then bends up so that it would pass just to the east of Tierra del Fuego and - and then continues on that heading so that it would intersect the far east coast of South America, if it continued. Now along that axis, the - what appear to be multiple frontal patterns or at least frontal cloud bands, bend very sharply and change from a heading that roughly parallels the axis around the one that is roughly north-south. And some of the front - frontal direction changes that I gave you earlier, down in that area, are - also bend around that axis...and there just, oh, there are probably a dozen, if you tried to pull them out, cloud bands between the Ross Sea and Tierra del Fuego that bend around the same axis”

“...the whole coastline of Chile is, or all of Chile practically, is clear, beautifully exposed to us here, particularly the Atacama desert...and the coast of Peru is also clear with clouds following the Andes ridge, probably the - certainly the coast side of the Andean ridge. Lima ought to be enjoying a very nice day today. The - Ecuador, however, looks like it might have a little more cloudy weather, although it doesn't look like any major storm activity.”
The Ross Sea can be found south of New Zealand, and the 'axis' he is describing is really the edge of a bank of cloud running along a rough line of latitude starting from there and ending at the northward trending cloud arrowed in purple. The cloud bands and fronts to which he refers appear to almost 'peel off' this long axial bank of cloud, then double back on themselves. His description is complex, but it does match what is there. This accuracy also extends to the absence of weather patterns over Chile and Peru (although admittedly a lack of clouds over Atacama is no great surprise).

As with previous images we also have several Landsat images to choose from, with varying degrees of usefulness. Figure 4.9.23a shows the areas identified on the Apollo image and Google Earth.

As you can see there aren’t many, but we’ll have a go anyway. The first area to examine is the path covering the Antarctic Ocean. We’ll do this in figure 4.9.23c, but first up 4.9.24b examines whether we can be sure we have the right area by looking at an extremely brightness adjusted close-up of the image.

I should point out first that not all of the coastline is visible in the Apollo image, and I have used my best guess in places, but as far as I can work out I have the blue square in roughly the right place. I’ve also used the
weather patterns visible in the satellite image to double check the location. You are welcome to do the same. Let’s have a look at how it compares with the actual Landsat images, together with the ones from the Mexican coast and the Caribbean in figure 4.9.23c.

![Weather patterns comparison](image)

Figure 4.9.23c: Areas of AS17-148-22745 compared with Landsat images covering the Antarctic (left), Mexico (top centre and right) and the Caribbean (bottom centre and right).

The areas covered by the single Mexican and Caribbean frames are very small on the Apollo image, and all that can really be said is that they aren’t inconsistent - assuming that I have selected the right area. We also have to bear in mind the timing of the images - 15:46 for the Caribbean and 15:48 for Mexico. The Antarctic was imaged from 16:13 onwards, and these all compare with an estimate of 19:45 for Apollo. Of all of them, assuming I have found the right piece of ocean, the Antarctic one shows the most resemblance to Apollo. We’re getting increasingly distant from Earth, and while the resolution of the Apollo photographs is good enough to match the meteorological satellites, it’s no match for the high resolution of the Landsat probe.

There follows quite a gap between the previous image and the next one, largely thanks to the Schmitt, the lunar module pilot, being heavily involved in checking out the LM systems. The next image of Earth we come across is still in magazine 148, and is AS17-148-22747. This image is shown in figure 4.9.24, and the satellite analysis in figure 4.9.25a.
Such has been Jack Schmitt's influence on this part of the narrative of Apollo 17 that mention of the actual satellite photographs that are the point of this research has been almost put to one side. To redress the balance slightly, the satellite image used here, dated the 8th but showing cloud formations on the 9th of December, is a clear match with what Jack sees and describes from Apollo 17. The northern hemisphere mosaic has issues with data quality, and some of the features are difficult to identify clearly – particularly in the eastern part of the picture. There is a clear line on the mosaic inland of China's east coast where the clouds are much better defined.

It is still, however, possible to pick out the patterns. Therese (about we will hear from Jack later) is just visible, highlighted in blue and heading for landfall in Vietnam. Southern hemisphere systems are much better defined, and the clouds off Australia and over New Zealand are very easy to identify. The time markings suggest a rough time at the terminator on the NOAA mosaic of around 22:00.

Systems easy to identify in an image taken from a few hundred miles up are still easy to identify from over 150000 miles away, with the benefit of good monocular viewing equipment (anyone with a telescope will have a similar level of detail available to them of the much smaller Moon from much further away!). After the hiatus of testing the LM systems, Jack is able to return to his meteorological observations.

We start his synopsis some time before the photograph was taken, at 44:17 MET (c. 01:45 GMT), discussing the weather patterns over New Zealand (red arrow):
Figure 4.9.25a: AS17-148—22747 compared with NOAA satellite mosaic and Stellarium estimate of time at terminator.
Figure 4.9.25a continued: AS17-148-22747 and 3D reconstruction using digitally restored NOAA data
"...looks like a little - cyclonic circulation we had over New Zealand is still there. It's - looks like the front it was associated with is broken up a little bit; however, that pattern is - seems to be hugging the New Zealand area, and - but not - has not intensified. If - if not - it may have even weakened a little bit since yesterday. It's hard to be sure exactly. The front does not look as strong, and it still seems to be hanging just stabilised and with all of Australia clear now and the western edge of that front being just offshore south of Brisbane. The - there is - east of New Guinea - in the vicinity of the Solomon Islands, it looks like a fairly moderate-sized cyclone developing at the western edge of the - of a front that was somewhat farther north and west than the one over New Zealand. North that - Wake/Kwajalein region that was of interest yesterday to the ARIA people - still seems to be in general overcast conditions, but the clouds do not look very heavy or impacted at all."

The emerging cyclone he describes is the one identified with the purple arrow, and the front south of Brisbane in yellow.

Not to be outdone, mission commander Gene Cernan joins in at 44:35 MET with his own interpretation of what he can see:

"...that big storm that Jack was referring to - that has moved off to the - well to the east of Australia. Very definite counter-clockwise rotation and then it stretches to the south or what even be the south-east. And then just rolls right - we...a big frontal pattern and then rolls right into another – another clockwise - clockwise rotating low down there near Antarctica. It gives me the impression of a parrot's comb when he's got his feathers ruffled. And it, in turn, has another low trailing it, arcing and then flowing into another - another low that is very near the continent down there in Antarctica. They form a chain, as I just described forming - coming from - well, possible south-east of Antarctica...South of Australia, you get a hint of a very large cloud mass, from there all the way down to Antarctica."

Cernan is trying to describe the front that rolls up from Antarctica towards New Zealand, heads westward towards Tasmania before merging with a thin front off Perth. Closer examination of the Apollo image does show other systems with similar patterns below that large front, and the cloud mass is indeed fairly solid below that towards the ice sheets.

Capcom respond by referring to their ATS satellite image:

"...You might be interested; we've got an ATS map in here from this morning. Just - you're just about on - We can see the flow patterns in the Antarctic just about at 120 degrees west, which is a little closer to South America than what you're calling, I guess. But we do - we do see that activity down there."

Evidently the ATS images are available to them, but equally evidently the images they have are not as up to date as the Apollo descriptions. Cernan has a final contribution here:

"...and there is a very large cloudy air mass between Australia and Antarctica. It has a tendency to want to start a rotation, and can see a hint of that; it's not too strong right now. We're seeing about 3/4 of the Earth, I guess. Judging from our clocks and what we can see, it looks like the Sun is setting out over the west coast."

A couple of hours later, Schmitt resumes the commentary and describes the New Zealand front in more detail at 46:36 MET:

“...It looks like it's merging with some more weather to the south-east. I suspect it's stormy there, but I still - It's not a terribly well developed storm, although it seems to be broadening in its extent. Australia is completely free of any significant weather and almost completely free - free of clouds. The - there appears to be a front - although right now it does not look too intense -approaching from the south-west. And it looks like it's about 5 degrees of longitude south of the south-western tip of Australia. The typhoon Cirrus - or Therese, I guess it is - appears to be just about the same position it was yesterday. And that is north of Borneo and between Vietnam and the Philippines.”

After Capcom acknowledges that this matches their synoptic charts, he continues:

“...I need to make a correction. It looks as if that storm area that was in New Zealand yesterday has moved up across the two islands and is now sitting north-west. It's getting a little hard to identify the smaller islands in

"
the Pacific, but - pretty sure I’ve got it in the right place now looking at the map. And it looks north-west of New Zealand. And it looks like New Zealand is probably having reasonably good weather today, although I suspect it rained last night.”

This time, Capcom tell him they don’t have up to date coverage of the area he’s describing, so it’s likely the previous agreement is for his identification of Therese (blue arrow).

Schmitt’s appraisal of Australia's conditions are spot on. He identifies the thin front to the south-west (magenta arrow), and correctly notes that New Zealand is also out from under the clouds. Jack continues:

"...the front that’s south of Australia now - I presume front - just looking at a fairly well-developed, although narrow, cloud line, is about 5 - about 10 degrees south of Perth right now, south-west of Perth and runs on a north-west - south-east line - over a point about 10 or 15 degrees south-west of Tasmania. And then it intersects a curved front that runs from there up to - to Tasmania, and then back around down south of New Zealand about 10 degrees......we’re starting to get...just off Luzon on the north-east trend...seen is a shadow line of fairly thick high clouds overlying some thick lower clouds behind the front."

His greater detail on the thin front shows we have correctly picked out what he was describing earlier, and the Tasmanian front we have identified using a yellow arrow is also very obvious. All of these antipodean systems are evident on the NOAA mosaic.

He then moves back to SE Asia, and the north-east trending cloud from the Philippines is identified here by a cyan arrow. Schmitt continues his description of Asian weather:

“...generally, South China looks clear. I haven’t had a real good look at it yet, it’s out on the limb. I’s clearly, however, overcast over Korea and Manchuria. It does not appear to be frontal weather, though. The dominant front in the north-western Pacific stretches on a north-west line from just off Luzon on up as far as I can see to the terminator. And it seems to be an extremely strong front with what I would guess is heavy air-mass weather all along with it. And up to the east-north-east of Japan, there's an excellent example of a shadow line from some fairly thick high clouds on solid overcast of lower clouds.”

The main front he is describing there is the one picked out by the cyan arrow, and rather than “north-west” being the compass bearing, he means “north to west”, as this line of cloud does go from the Philippines area to the terminator. The 'shadow line' he refers to is close to the terminator, pretty much on the point of the cyan arrow, where the smooth lower level cloud to the left of the arrow point contrasts with the higher altitude 'lumpier' cloud mass to the right of it.

Capcom again tell Schmitt that they don’t have all of the area he describes on their charts, but that what they do have matches what he's telling them. Schmitt then goes back to Australia and predicts heavy weather for South Australia in a few day's time. He then tells Capcom at 47:43 (c. 05:15 GMT) that:

“I'm going to take two more pictures before I go to sleep.”

Followed at 48:00 MET (05:30):

“I got those pictures...that typhoon off - north of Borneo - looks like it's right off the coast of - the east coast of Vietnam now ,And it’s about as tightly organised and solid as anything I can remember seeing in photographs. It looks as if, from yesterday, it's moved quite a bit to the west.”

So we have a pretty accurate time for the image under discussion of 05:30 GMT, and an examination of the Stellarium inset included in the previous figure shows that the distance between the terminator and Australia matches exactly what it should be, as does (allowing for the relative viewpoints of Stellarium and Apollo 17) the distribution of Asian land masses on the western limb.

The photographs to which he is referring are general pictures of hurricanes and tropical storms, not this specific one, although we do know that photographs of a nicely formed spiral Therese with a defined eye were around before launch. Therese has indeed moved west, and is due to make landfall in Vietnam in the very near future. Capcom’s weather charts also show a tightly formed storm, and predict that landfall will be in...
another 6 hours’ time. Jack is even able to describe Therese as being roughly the size of South Vietnam, which is a reasonable estimate of its diameter.

We have a couple of Landsat passes to examine on this date that cover areas of this image, namely central Australia and Antarctica. Earth is getting increasingly distance and the amount of resolvable detail in close up is reducing all the time, but we should at least have a go. Figure 4.9.25b gives the details

The most obvious feature of the two sets of satellite views is that central Australia is clear of cloud in both Apollo and Landsat, but to be fair it often is. Antarctica is covered in ice in both images. The Landsat view shows clear sea in a couple of coastal patches, and there is a similar area to be seen in the Apollo view, but this is not unusual and it also assumes that I have the right area under scrutiny - something much more difficult to prove in these much more distant images. Again, they are consistent with each other, but not in any way conclusive. Australia’s start time isn’t recorded for Landsat, but Antarctica’s is given at 11:40 and it is on the same orbit, so there is a good 6 hours separating Apollo and Landsat.

Next up in magazine 148 is AS17-148-22749. This must have been taken some time after the previous image, as it now shows west Africa and south America, so the Earth has rotated some distance during the ‘overnight’ rest period. The image itself is shown in figure 4.9.26, and the satellite analysis on the page after that in figure 4.9.27.
The terminator on the image runs almost through the prime meridian, at least in the northern Hemisphere, suggesting a time of around 17:00 GMT, and the time indicators along the edge of the NOAA mosaic suggest a time of noon on the 9th at that location.

The mosaic again suffers from very poor image quality, with lighter clouds difficult to make out, and a large data 'hole' in the north Atlantic off the coast of north America. Sub-tropical clouds southern hemisphere weather systems have fewer issues of this type.

As far as the weather systems themselves are concerned, we again have Jack's observations, found at 58h39m MET in the transcript:

“...That...fairly big storm - that was off the coast of north-west Africa yesterday, has moved inland and presumably is giving those people up there some weather. Might even be getting some snow up in the Atlas mountains. It's still fairly well organised and inland a few hundred miles - or the edge of it is inland a few hundred miles. The people at the Cape of Good Hope ought to be seeing some clouds that are forerunners of a large circulation system that's south - south-west of them - that, although large, it seems to have most of its heavy clouds to the south-east of the centre. And they may not be get any major weather out of this one. But they'll probably have cloudiness for a few days. the storm that was over Buenos Aires yesterday has apparently moved out to sea and is now west - or east-south-east of that area. Otherwise the - except for those three storm areas, the South Atlantic looks relatively calm.”

Schmitt's description of the large and spectacular frontal system that used to be in the north Atlantic is again accurate, and it is interesting to note that while his description (and the observable reality of the photograph) find the leading edge of that storm (indicated by the green arrow) inland on north Africa, it is still on the shore 5 hours or so earlier in the NOAA mosaic. The tight central spiral of cloud is also not visible on the NOAA image, but it is possible that NOAA's sensors and/or the mosaic compilation process have not used the required level of detail to see what are obviously thin clouds.
Figure 4.9.27: AS17-148-22749 compared with NOAA satellite mosaic and Stellarium estimate of time at terminator.
Figure 4.9.27 continued: AS17-148-22749 and 3D reconstruction using digitally restored NOAA data
The large system he identifies off the Cape of Good Hope is picked out by the magenta arrow. The other system picked out by Jack is the one that was over Buenos Aires, which is picked out here by the yellow arrow. In the Apollo image this storm has moved almost completely out to sea, as Jack describes, but in the NOAA mosaic it is still half over the Argentinian capital.

A few moments later, at 59:20 MET, or 16:50 GMT, Schmitt tells us that:

"I took three pictures of the Earth. I thought I might have moved one of them"

The image used in this particular analysis is indeed one of three, rather than the pairs of images Schmitt has been taking to date. The time he specifies there confirms the earlier rough estimate of about 17:00 for the time at terminator, and 16:50 was used to derive the Stellarium image, which shows a perfect match in terms of what land masses can be seen.

The next images in magazine 148 show the CSM as viewed from the LM, as Cernan and Schmitt carry out some telemetry checking from the LM. Following this sequence of pictures, the next one of Earth is AS17-148-22758. This is shown in in figure 4.9.28, and analysed in figure 4.9.29a.

In addition to the civilian satellites recording the view we also have Corona images taken on this date and there are two small areas covered of western USA. The images concerned are shown in figure 4.9.29b.
Figure 4.9.29a: AS17-148-22758 compared with NOAA satellite mosaic from 09/12/72 and Stellarium estimate of time at terminator.
Figure 4.9.29a continued: AS17-148-22758 and 3D reconstruction using digitally restored NOAA data
What we have visible in the Corona image is a band of cloud stretching from offshore onto land and we have the same pattern visible in the Apollo image. The Apollo image was taken at around 14:00 local time, and the Corona image was likely to have been taken an hour or so before that. The patch of cloud shown in the northernmost images taken by Corona is also matched by the Apollo photograph. As with other Corona image it has not totally conclusive, but it is consistent.

We have another satellite to choose from as well for this image, namely a long Landsat pass over central Canada and the USA. There is also a pass over a small section of British Columbia, but it is at such an angle on the Apollo image it would not provide any useful information. Figure 4.9.29c shows the relevant locations and details of these images.

As usual there is a broad correspondence with the Apollo image - we have clear skies with some cloud and land surface visible in the south and an increasingly white covering as you move north. At the top end the white starts to fade as the land surface becomes visible again. What is interesting to note, however, is that if you look very closely at the Landsat view then what appear to be white clouds in the Apollo view are obviously not that. Figure 4.9.29d shows one of the Landsat tiles and has with it an NSIDC map of weekly snow coverage and the NOAA-2 satellite view of North America.
Figure 4.9.29c: Landsat pass over North America shown in AS17-148-22758 (top left) and Google Earth (bottom left), and in close up (right)
The Landsat tile clearly shows that the ground is white, but there isn’t much in the way of cloud - we can easily see all of Lake Fort Peck. The white we are seeing then, exaggerated by the oblique viewing angle, is not necessarily cloud cover. The NSIDC map shows that there was snow around at the time, and close examination of the meteorological satellite does show that there’s a much less obvious white over the same area of the US compared with what we see in Apollo.

Along with the Hasselblad we also have a Nikon image taken at the same time (AS17-162-24071), and this is shown in figure 4.9.30, with the same arrows used to analyse it in figure 4.9.31.
Before seeing what Cernan and Schmitt have to say about their view of Earth when these were taken, NOAA should be given a quick examination. The image used is from the 9th of December, and for once the quality of the cloud representations is roughly equal between the hemispheres, although there is a substantial gap off the east coast of North America. For this photograph this gap is of no consequence as it is that part of the Earth is no longer visible. The two most obvious features are the large loop of cloud from the Antarctic up towards Australia, and the ' < ' shaped twin bands of clouds stemming from the western Pacific towards California and south America. The terminator line just on from the US east coast would have been scanned by NOAA at roughly 15:00 GMT.

As for what Apollo's image shows us, it is Cernan who takes up the narrative at 62:52 MET (roughly 20:30 GMT):

"It looks like Houston might be right on the fringes of either being clear or clearer. The entire Gulf is pretty nice. Florida looks pretty clear, and Mexico looks pretty clear. There's a but air mass of clouds that looks like it picks up somewhere around the coast at Houston, heads on up north, and then covers most of the mid-west and the east - from about the middle of Mississippi, Alabama and Georgia on north. It's clear enough now to even see the coral reefs down off of Florida. And it looks like west Texas is probably also pretty clear, at least in a run from east to west. We can see Baja, and on up the coast of California up north."

His description is, as expected, an accurate one. The cloud mass covering Houston and northwards is picked out by the green arrow, and his assessment of the clear areas matches what we can see. Schmitt then takes over the narrative, effectively repeating Gene's description, before commenting on the southern Hemisphere:

"One of the more unusual features is developed - as I see - developed in the south-east Pacific just north of the Ross Sea and that is a very striking mushroom pattern on a very large scale. It has north/south clouds streaming streamers from the Ross Sea. And when it gets up about the latitude of Tierra del Fuego, but quite a bit west of that land, it branches out to the east and west in a large mushroom pattern. And it looks like the top of that mushroom may be a curved cold front that's pushing its way up into the south-east Pacific. It currently - the eastern edge of that front is probably 10 degrees longitude from Tierra del Fuego, and it looks like that land in southern Chile is picking up high clouds, probably associated with that front's movement. I'll get some shots of that next time around. That's a spectacular pattern."

The mushroom pattern is the system identified by the magenta arrow, and again the description is very accurate, right down to the 'streamers' that head northwards from roughly where the magenta arrow head is, and the high clouds mentioned next to Tierra del Fuego are marked by the red arrow.

After a brief discussion on whether he can see any changes in the Ross Sea, Capcom given another mention of their use of satellite images, saying at 64:21 MET:

"I'm looking at a satellite picture here, which I guess is about 12 hours old though. But over to the east of Australia, maybe about a continent width east of Australia, there is really striking long frontal system - striking because it's so long and so straight, sort of west-north-west, trending west north-west and east south-east trending. Can you see that?"

Capcom's description matches what Jack & Gene have already described, but his ATS image must lack the detail of their monocular view of a colour Earth.

At this point Gene takes over again, and discusses the various sub-Antarctic systems he can see:

"Now Jack and I may be talking about two different frontal systems or patterns, but the one I think you might be referring to is the one I referred to yesterday as a ruffled parrot's beak. Actually two of them tied together, one starting up probably south-east of Australia and - and then heading down with a long arcing frontal system to another clockwise rotational parrot's - parrot's comb, I should say, down around - near the tip of South America, between it and Antarctica. There is one strong tributary front heading up to the north-north-west from the western side of this big, arcing, frontal mass. I'm not sure, I can't quite see Australia coming up over the - over the horizon yet."
Gene is right in thinking that this is the same weather system he described earlier, and all three of them are describing the same system, but Jack's “mushroom” analogy is the better description of it. Capcom tells Gene that his ATS image doesn't go as far south or west as far as he is describing, after which Gene continues to describe the same system:

“There is some tremendous - western side of that curve front is a tremendous clockwise rotational air mass. It must cover hundreds of square miles. The one down near - near the continent of Antarctica, down there, near the tip of South America, seemed to be squashed slightly as if there is possibly some - some squashing or effect coming off - off the South Pole near Antarctica. I think, if I turn around and look at it the way Jack was looking at it, it's a cap of a mushroom. Only instead of simply curving in underneath the cap, it has clockwise rotations on both sides as it curves under.”

In this passage Cernan first describes the system marked by the purple arrow – where there are several circles of cloud at one end of the 'mushroom'. The other system he mentions is at the eastern end, just below the clouds marked by the red arrow.

Confirmation of the timing of the Apollo photograph comes from Schmitt at 64:28 MET, when he says that:

"I just took two pictures of the Earth"

and after another brief exchange about what Capcom's ATS image covers goes on to give his description:

"...that mushroom pattern we've been talking about, on either edge - either end of the cap - and the mushroom points north - is a major cyclone circulation system. And also taking - moving, in one case - or trending, in one case, to the north-west and the other to the north-east, there are some linear cloud patterns. Gives it a very symmetrical and a striking appearance.”

A few moments later, Jack confirms that he has taken some more photos of Earth with the Nikon:

"just took a series of the Earth with the 35-mm using the polarising filter”

So we have both Gene Cernan and Jack Schmitt describing weather patterns, many of which are not available on Capcom’s ATS images, showing an Earth that matches exactly what should be visible according to Stellarium. The weather systems they see and describe are matched by NOAA's satellite mosaic.

The timings given for the remaining images in the mission are open to some confusion, as there was an update to the mission clocks during TLC. Updates to the clock were done where, for example, a launch delay introduced a lag between the planned time of events for the mission (eg ultra-violet photography, EVAs) and the actual time thanks to the delay. The aim of changing the clock was so that the time shown on the mission clocks (usually referred to as GET, or Ground Elapsed Time in the transcripts, but what this research has called MET) was synchronised with the events programmed into the flight plan. It is analogous to the change in the clocks for daylight saving time.

Technical problems during the countdown sequence for Apollo 17 introduced a substantial delay to the flight plan, and as a result at 65 hours GET 2 hours and 40 minutes were added to the mission clocks. This event is referred to in both the timeline and the mission transcripts referred to here, but there is no apparent alteration to the actual times recorded. It is assumed that times referred to by Capcom and the crew are the adjusted times, while the times recorded in the documents themselves are the unaltered original elapsed times. Certainly when photographs are recorded as being taken, the recorded times match those derived from Stellarium, rather than the time 160 minutes later. The analogy here is that, for example, the astronauts are using daylight saving time, but all the documents continue to record GMT.

Having accounted for any likely discrepancies in what the various mission personnel may say and when they are recorded as saying it, we can move on to discussing the next image in the sequence.

That image is again from magazine 148, and again there is much narrative description of the view they have as the image is taken by Cernan and Schmitt. The photograph in question is AS17-148-22760. This can be seen below in figure 4.9.32, and analysed overleaf in figure 4.9.33a.
The absence of South America but the persistence of the 'mushroom cloud' shows that this image was taken not long after the previous one, and therefore the NOAA mosaic is still the one dated the 9th of December. The similarities between the Apollo photograph and the NOAA mosaics are still obvious, and the reader should, as usual, have no problem identifying any particular cloud from Apollo in the NOAA image. The time markers on the mosaic suggest that the area around the terminator was scanned at around 17:00 GMT on the 9th.

As far as the crew's observations are concerned, they begin at 65:24 MET (or c. 22:55 GMT) while Jack is using the polarising and colour filters available with the Nikon camera, when he makes the following observation:

"..there's a very strong band of clouds, shaped sort of like a narrow fir tree, with a base about 20 degrees of longitude west of Baja California, that extends up to, I believe, into the vicinity of Hawaii. And the top terminates in a very strong northern cyclone pattern."

The 'fir tree' analogy describes the cloud formation identified here by the green arrow, and is perhaps easier to understand if the globe is viewed from the same angle as astronauts were seeing it. The strong cyclonic pattern he describes is where the green arrow head is.

Capcom are able to find (after first misunderstanding Jack's description of the location) on the satellite image they have available, and also on their synoptic charts. The term actually used is "from one of our satellites", which is an indication that other satellite images may be available in addition to the ATS ones.
Figure 4.9.33a: AS17-148-22760 compared with NOAA satellite mosaic and Stellarium estimate of time at terminator.
Figure 4.9.33a continued: AS17-148-22760 and 3D reconstruction using digitally restored NOAA data
Jack gives us more details on this cloud formation at 66:56 MET (c. 00:30 GMT on the 10th)

"... that line of clouds I called a fir-tree pattern that swings up towards Hawaii - Hawaii, if you will - has - also has a mushroom pattern on the top. it has the appearance is if two major air masses - one going from west to east and other from east to west - have converged along that line, and the joint movement of air at the interface being south to north. And up in the area of Hawaii, I think it tends to mushroom so that the pattern then goes back to flow from west to east on the east side and from east to west on the west side....in a little while, we’ll probably get a pretty good look at a - what looks like a very concentrated intense storm that, I think is just east - east ..."

The use of the word 'up' needs again to be taken in the context of the upside-down view the astronauts have at the time, but the description is again detailed and accurate. Unfortunately the description is interrupted by the need to go over details for the upcoming LOI manoeuvres, so we won’t know which storm he was about to describe, but it’s possible that it is the one marked by the cyan arrow, which is east of Australia.

Schmitt doesn’t mention at the time when he took the picture of the scene he is describing, but he does mention it sometime later. He was describing the view just after completing an experiment designed to explore what was believed to be the influence of cosmic rays on the crew – the widely reported phenomenon of ‘light flashes’ seen on the retinas while they had eyes closed or blindfolded ready for sleep. He says, at 68:44 MET (c. 02:15 GMT):

"I took another picture of the Earth and forgot to give you the GET on it. That was about 15 minutes before the end of the [light flash] experiment."

The light flash experiment ended at 00:12 GMT, which supports the Stellarium estimate of midnight for the time of the image.

Once again we have a Landsat pass available to us on this occasion crossing the Antarctic. See figure 4.9.33b.

![Figure 4.9.33b: Landsat passes shown on Google Earth (bottom left) and AS17-148-22760 (top left). The eastern pass is shown in the centre and the western one above.](image-url)
In the absence of visible landmasses we first need to verify whether we are looking at the right locations, and we can do this by double checking the weather features in the satellite image. The easternmost Antarctic image starts along the 105 degrees west line of longitude, with the clear patch of ocean visible at around 110 degrees. Close examination of the NOAA-2 image shows that the long arc of cloud that extends across the southern Pacific and into the Antarctic ocean also ends along that 110 west line. That clear patch of ocean on the edge of the ice-sheet is seen in the Apollo image as well in what is a clear and obvious match. Again, one of these Landsat tiles appears in a 1973 publication, and these 1973 conference proceedings - these images have never been hidden away.

The other area, just off the Antarctic coast, can be found by looking for the arc of cloud covering New Zealand that then extends to the Danfell peninsula. There is clear ocean visible around the Antimeridian, and the Landsat pass covers the area north-west of that. As can be seen in the image above, it doesn’t exactly reveal much!

For the record, the eastern pass was recorded at around 14:45 and the western one at 19:51.

The next image of Earth in magazine 148 is one of a pair showing Australia taking more centre stage. Image AS17-148-22762 is shown below in figure 4.9.34, and analysed in figure 4.9.35.

Figure 4.9.34: AS17-148-22762. Source: AIA
Figure 4.9.35: AS17-148-22762 compared with NOAA-2 mosaic and Stellarium estimate of time at terminator
Blue arrow as in figure 4.9.33
Figure 4.9.35 continued: AS17-148-22762 and 3D reconstruction using digitally restored NOAA data
The NOAA image from that the 9th does have quality issues for a large part of the Pacific and Australasia, but the underlying cloud pattern is still visible. A rough guideline for the time the terminator region was scanned would be 21:00 on the 9th. The cloud patterns visible can be found easily on both NOAA mosaic and Apollo image, and some features (notably the clouds identified in figure 4.9.33 by the blue arrow). The storm system shown by the cyan arrow in figure 4.9.33 is identified by a green arrow in figure 4.9.35, and the front shown by the red arrow in figure 4.9.35 appears to the east of the system identified by the purple arrow in figure 4.9.33. An estimate of 03:30 has been given as the time of the Apollo image. There is therefore, as usual, an obvious continuity between the images.

The crew’s description of the view begins some time before the suggested time of the photograph, with Schmitt beginning his narrative at 67h31m MET (c. 01:00 GMT):

"...The coast of Australia is starting to come into view. Still looks pretty clear. We’ll give you more of that later, probably. That cyclone I talked about yesterday in the vicinity, I believe of the Solomon Islands, looks even better organised than yesterday. It's really tightening up. Starting to look very bright and dense right in the core, not too dissimilar from Therese. Although it has a little broader extent in the south-east quadrant."

The Solomon Islands are in the region of the large cloud mass identified by the green arrow, and after Capcom state their difficulties finding it, he confirms that it is the system he began to describe before he was so rudely interrupted to be the tedious business of organising going into orbit around the Moon.

Although the photograph analysed shows Australia very obviously in view, Stellarium users can easily confirm that it would be appearing on the western limb at around 01:00 GMT.

Capcom are then able to find the storm:

"I've got a pretty disorganised area to the east of New Guinea. It's probably right over the Solomons. Looks pretty disorganised on our satellite photo - from, let's see, I guess that was this morning sometime."

As usual, the ground personnel have access to satellite images, but they are relatively out of date.

At 67:49 MET (c.01:20 GMT) MET, after Capcom asks if New Guinea is in for bad weather, Schmitt resumes his description:

"No, not really. New Guinea is at the western edge of a cloud zone that is part of that inter-tropical convergence zone that starts at New Guinea and swings east north-east in an arc for about half the visible Pacific, and then that arc crosses back down over the equator and heads generally towards Central America, I suspect, although that's beyond the terminator. The storm I'm talking about is clearly south and separate from that inter-tropical convergence cloud - pattern...it's getting very tightly wound in the -the clockwise sense, and - and is - is just where there was a less well-organised pattern yesterday. Although maybe it's moved northward a little bit....just one last thing on that line of clouds that stretches up towards Hawaii. They're very - they look very thick and dense based on the structure you can see as that - as the terminator approaches them. They cast a pretty strong shadow to the west."

He correctly picks out the location of Papua New Guinea and the ITCZ cloud under which it is hiding. The Solomon Islands weather is below that cloud, and the storm itself is probably Tropical cyclone Diana, described in this link: [Australia Severe Weather](#). The storm track shown in the link suggests it was around from the 6th and persisted throughout most of the mission. Unfortunately no other information seems to be available about this storm. The line of clouds he mentions running towards Hawaii is likely to be the one identified by the cyan arrow, and again Capcom confirms that they are visible on a satellite photograph.

At 68:48 MET (c. 02:20 GMT), after more discussion on the Ross ice sheet changes and the sub-solar point and the precise location of Hawaii, Jack returns to the antipodes:

"...that weak front that I talked about south of Australia yesterday has moved north, but it looks considerably weaker than it did yesterday even. Just a very thin line of clouds - very thin line of clouds that is touching the - the tip of Australia, south of Perth."
This particular one is the system identified by the magenta arrow in figure 4.9.25, and it has evidently got much thinner since that photograph was taken, although it is not quite touching land just yet. Capcom again point out the shortcomings of the data they have available to them in response to this:

"...I can’t tie up with you in that one, Jack, because my prog doesn't go down that far; it only stays up in the landing area. And my satellite photo doesn't go down that far south either."

Thus confirming earlier suggestions that the ground personnel would have information relevant to their part in the mission, rather than global data ready to cover any point the Apollo crew may wish to discuss. Capcom’s role was not to prompt the crew to describe what they could already see on the ground, it was to have information about the launch and re-entry. They were also not in a position to confirm every observation Apollo 17 made.

Jack’s response to this is:

"OK, well it looked stronger yesterday, and it might have developed. Now there is a larger disturbance at the south-eastern end of that front, still south of Tasmania..."

and he is therefore describing the much larger cloud formations shown by the magenta arrow in the current image.

He then returns, at 68:53 MET, to tropical cyclone Diana:

"...that disturbance over the So - Solomon Islands is an awfully tightly wound little storm system. And right now, I finally have seen New Zealand for the first time in a couple of days for sure. And the South Island’s got some, probably high cirrus over it. North Island looks pretty clear."

New Zealand is nestling in the arc of cloud shown by (and just to the east of) the red arrow,. It requires some zooming in to see that, and this is something Jack is able to do using the sextant, which he describes as a fine instrument, and better than the binoculars he has also been using.

Much of the discussion after this point refers to local weather conditions and sea state around Hawaii, but he does return to wider issues with:

"...that major front we talked about last night as being east and south of Japan has progressed even farther and is, oh, maybe 20 degrees longitude - about 20 degrees longitude from the Hawaiian islands."

It’s not immediately obvious which front he is referring to, but in the vantage point of the image Japan is on the north northern part of the horizon, while Hawaii is in darkness over to the east. This makes it likely that he is describing the cyan arrowed band of relatively thin cloud stretching horizontally (as portrayed in the preceding figure) across the northern quarter of the photograph. Capcom confirm that this is shown on the satellite photograph and charts, before Jack briefly describes the clear sky over Australia.

At 69:21 MET, Jack makes an interesting comment:

“...I hope you’re going to save all those charts you’re gathering together as we talk about it on this outbound leg. Be interesting to compare them, and the pictures we take sometime in January.”

Capcom confirm that the ‘weather people’ are very keen to do just that, and it would be really interesting to know if this meeting and its results are recorded anywhere.

As a brief aside, Schmitt does give some insight into his meteorological interest in an oral history interview that many astronauts gave many years after the missions, available on this website Oral history. He describes his fascination with the changing views of Earth as it receded, and then he is asked how he it arose that he took on the role of meteorologist for the mission. He describes his childhood interest in the subject before going on to say:

“as I approached the launch, I started talking with the Air Force meteorologist at the air base that supported the launches down in Florida (Patrick Air Force Base)...They got interested in this, and so just as I suited up, one
of my friends with that group brought in the latest satellite pictures that covered the Earth, that gave me the whole southern hemisphere of the Earth. So I had those in my pocket as we went out to the launch pad.

I had planned, and we had talked about it, that in my spare time on the three and a half days to the Moon I would try to build on those, what those satellites pictures showed, primitive as they were, and try to experiment with how well could I forecast the weather, because the Earth in what we called a lunar reference trajectory, we would see the Earth turn every twenty-four hours beneath us. So you could see what the weather pattern was, try to predict the trend for the next day, and then see how well you did the next day.

Of course, we were getting farther and farther away and the Earth was changing from full to about two-thirds. But we had a 10-power binocular on board, so you could look out the window and see it. So all of that several inches of transcript was me exercising that little experiment, because there really wasn't much else to do, except try to get a little exercise and eat and check out systems. But it certainly was not a full day's work any one day.

Interestingly enough, somebody just recently has contacted me and they want to put together a journal of that particular phase of the mission, which is not in the [ALSJ]... So I think we're going to see a Web-based version of that transcript. I can't believe it's going to be of any great interest to anybody, but we'll see.”

Well, Jack, it certainly has been of very great interest! It's useful to know that he did have some satellite photographs with him – he evidently had something to work with from the start, but it's also informative that he says quite clearly that those images were primitive. It's also useful to know that he only had images of the southern hemisphere, which of course is the only part he would be able to see at the outset of the mission.

He confirms this story in his diary of the mission, which he has started to publish here. He has this to say:

“As most pilots in the modern era, we received our last weather update before flight from the Air Force meteorology team from Patrick Air Force Base. They not only covered the launch area weather but also the several abort landing areas around the world. In addition, these gentlemen delivered copies of the latest geosynchronous weather satellite photographs that I had requested a few days earlier. I wanted to carry these near-full Earth photographs as a pre-launch control on my plan to systematically observe changing cloud patterns during the three and a half days it would take us to get to the Moon.”

He also mentions in this video that he specifically wanted to monitor the changes in the weather over time, and his photos were a way of recording his accuracy in predicting what would happen.

Returning now to the Apollo 17 mission; as with the previous image, Jack doesn't record immediately when he took the image we have just discussed, but after a rest period the following day at 79:44 MET (c. 13:20 GMT) he says that:

"I just completed two pictures of the earth about 5 minutes ago. And there's one I did not report late yesterday about 72:30."

We need to remember here that this time is actually 2 hours and 40 minutes later than the actual time of the photograph, so this would convert to an MET (as used here) of 69:50, or around 03:30 GMT, the time used by Stellarium.

This quote also provides a useful reference point for the next image to examine in magazine 148, AS17-148-22763 (see figure 4.9.36).

As this image features the whole of Africa, and therefore the dividing line for the start and end of new satellite mosaics, there will be the same issues of interpretation as previous images of Africa. The analysis of that image, containing the NOAA mosaic, can be seen in figure 4.9.37a.
Figure 4.9.37a: AS17-148-22763 compared with NOAA satellite mosaic and Stellarium estimate of time at terminator
Figure 4.9.37 continued: AS17-148-22763 and partial 3D reconstruction using digitally restored NOAA data
It's fairly easy to tell where the join is between the start and end of the mosaic started on the 10th, and the estimated time that NOAA would have scanned the terminator is around 07:00 on the 10th. The 3D model is built from two days' worth of images.

We may as well see what Jack has to say about the view, seeing as we know he will have done. He starts at 78:59 MET with this:

"...we got a pretty spectacular view of - of Africa today. We can see the Sinai, can see the Red Sea, the Sea of Aden, and for the first time I think we can not only see the Mediterranean, but we can see the - most of the Southern European countries, Turkey and Greece and up into Italy and some of those places, can't quite see Spain because you're just about on the horizon. And for the most part, it looks like the weather throughout the Mediterranean and Northern Africa looks pretty good."

So far so accurate, there is indeed more of Europe on display than in previous views of this type, certainly in comparison with the classic 'Blue Marble' image, although his inability to see Spain may be more influenced by the cloud over it than its position on the horizon.

It's after this initial comment that he records taking his two pictures of Earth, and these are the last two on this magazine before the landing, and only one more image of Earth is recorded on it during TEC.

As far as the rest of the weather conditions are concerned, he continues at 79:56 MET with:

"...That storm I talked about yesterday that was in North Africa, looks like it has left the area and has moved in - maybe, of it's there at all, it's just over the - Iberian Peninsula. And maybe Gibraltar and that area is getting a little activity today...the storm I guessed yesterday - I thought might be moving into the Cape of Good Hope looks like it's dissipating and also staying south of that area. The whole of Africa is essentially clear, except in the southern part of the inter-tropical convergence area where there's scattered patches of - of fairly dense clouds. They're probably getting scattered rain showers this morning. Some of those extend farther down south than I've - than we've seen them - down into South Africa. There's a - On one of the earlier revs, although now it's at the terminator, it looked like there was a depression developing about 30 degrees longitude east of Madagascar in the middle of the Indian Ocean. A little bit north-east of Madagascar, there's also a new area of clouds developed that looks like it's getting organised into a cyclone pattern."

The initial description is correct, and the storm over north Africa has gone, but it may have moved north as there are just visible circular bands of cloud on the horizon and on the satellite image, picked out by the cyan arrow over the Iberian peninsula (he has now realised he can see Spain). Storm south of the Cape (yellow arrow) that started to the south-west has now moved to south of it and is not as prominent as it was before, and this is also reflected in the NOAA mosaic. The red arrow, rather than picking out a specific cloud or storm, is pointing to the general area of the ITCZ clouds in the southern half of Africa.

The depression he describes north-east of Madagascar is shown by the magenta arrow, and a quick examination of the same system identified on the NOAA mosaic shows that it has consolidated by the time that area is imaged at the end of the 10th. The front to the east of Madagascar is just on the terminator and has not been identified here, but it is visible on the NOAA mosaic which does include areas beyond the terminator line.

An hour later, Jack has more to say, this time about the southern Africa and the South Atlantic:

"...it looks like the cloudiness and possibly the showers associated with the inter-tropical convergence over Africa are moving as far south as Johannesburg right now. It's quite a distinct change from even an - an hour or so ago - a couple of hours ago. They're down in an area where, presumably, they're not normally found if vegetation indications are any criteria. And also, in the Atlantic - South Atlantic near Goa Island, there seems to be a possible storm developing as part of what was probably now a fairly weak front."

and 15 minutes later still:

"That weak front I mentioned in the South Atlantic stretches from the apparent storm centre around Goa Island...up to the coast of South America from Brazil, where it reaches its maximum eastward extent."
The words 'Goa Island' have been taken directly from the transcript, but Jack clearly means 'Gough Island', which is in the South Atlantic (not Goa Island off Mozambique) – he does say that he is unsure of its pronunciation. It is, at least, in the correct place as the starting point for the large band of cloud marked by the purple arrow.

We again have Landsat paths over two sections of Africa - one from northern Zambia to the South African coast, and the other over the Western Sahara, as well as a short Antarctic one. Figure 4.9.37b gives the details.

For the southern African view I’ve decided not to bother with the two outlier frames in the north, it makes the images less detailed when presented here. That southern Africa pass was captured between 07:31 and 07:39, compared with 13:15 for the Apollo image. Despite the time gap we still have some broad matches - coastal cloud to the south, a broader band of cloud cutting across the South Africa-Zimbabwe border, and clearer areas to the north. The west African pass was started at 10:46, and again has the same broad patterns to it - clear skies over the Sahara and a patch of cloud around Agadir. The Antarctic pass has no start time recorded, but was likely to have been commenced in the early hours of the 10th, given that a pass over Pakistan ended at 05:40 and this was likely to have been on the preceding orbit. Again though we have the satellite recording clear water off the Kemp coast just as the Apollo image does.

Returning to the Apollo images, at 3 days 10 hours 7 minutes, we have a mention of an additional source, namely the movie footage, with film taken through an adaptor intended for stellar viewing:
In the 16mm footage, we have this brief glimpse of Earth shown in figure 4.10.37c, obviously shot through some sort of eyepiece. If we compare that view with what we should see of Earth using Stellarium, it’s pretty obvious that this is the footage to which he is referring. Little has changed in terms of the visible weather systems, hence no satellite comparison.

Figure 4.9.37c: Video still from 16mm footage showing earth at around 15:30 on 10/12/72

Even without the satellite photographs in attendance, it should be self-evident that the weather patterns are the same as in figure 4.9.37a, and the view is exactly as it should be at the time it is mentioned in the transcript.

90 minutes after this last observation, magazine NN, ore number 148, is stowed away for the time being, and we will move onto other magazines, at least until the journey home.
Figure 4.9.37c continued: 16mm still and partial 3D reconstruction using digitally restored NOAA data
The next image viewed is from magazine 149. This magazine evidently stayed on board the CSM during the mission as it contains pictures of a returning LM. The photograph in question is AS17-149-22779, the clearest of a series of 3 identical images of Earth at the start of the magazine. No high quality version of the image could be found online, and so the one used was obtained from the GAP. The image itself is shown in figure 4.9.38 and analysed in figure 4.9.39.

The first point to make about the satellite comparison is that southern hemisphere data for the mosaic in the visible spectrum are missing. In order to compensate for this, the mosaics for the IR spectrum are included. By and large, these show the same cloud patterns as the visible one, but it should be remembered that colder clouds will not show as well as warmer ones, and warm air masses will also be included in the image. IR scans are done during the dark parts of the NOAA orbit, and therefore have different time values to the daytime visible spectrum passes. The terminator position is estimated as being at around 19:00 using Stellarium, and the time at terminator on the NOAA mosaics is roughly 23:00 on the IR spectrum and 11:00 for the visible, however the bulk of the image was taken in the early hours of the 11th.

It will also be fairly obvious that the Apollo image is not of the best quality, and has been affected by camera shake.

![Figure 4.9.38: GAP scan of AS17-149-22779. Low quality source: AIA](image-url)
Figure 4.9.39: AS17-149-22779 compared with NOAA visible spectrum dated the 10th (left) and infrared (right) satellite mosaics, the 11th, and Stellarium estimate of time at terminator.
For once, the time of the Apollo image isn't recorded directly, but despite the mission entering one of its most intense periods of activity (LOI), Schmitt still finds time to give a casual observation:

“...and just to round out things as we pitch back into LOI attitude, lo and behold from over the top of the LM came the Earth...we can - we can see we’re right over South America and, of course, we can see up the Gulf Coast. And it looks like Houston is covered in clouds, but poetically enough, we can see the Cape, at least we can see Florida.”

He makes this observation at 85:40 MET, or just after 19:00 GMT.

Although the image quality is not the best, it is still evident that south America is central to the image, and the Gulf coast is clear below the prominent front picked out by the blue arrow. This cloud band for this front is visible north of the Gulf coast in both the IR and visible spectra.

The other weather systems on the Apollo image are also relatively easy to pick out, particularly the long band heading north west from the tip of south America that eventually loops back downwards, seemingly towards the Antarctic (yellow arrow). On the opposite side of south America there is another well-defined band heading from Brazil south-eastwards, and this is likely to be the same front identified by Jack in the previous image analysis.

The northern hemisphere's feature picked out by the blue arrow is a twin pronged thin band of cloud that is likely to appear in a subsequent image, hence its being identified in this one.

It’s also interesting to compare this image with one from magazine 154, AS17-154-23598 (see figure 4.9.40). No high resolution version of this image is publicly available, but there are a few clues to suggest it was taken at roughly the same time as the preceding photograph.
The first is the Earth seen over the lunar module, and the reader's attention is drawn to Harrison's previous statement about the Earth appearing over the top of the LM. He actually says that they:

"Got the whole thing in one big package."

Although this does not necessarily refer to taking a photograph of the scene.

The remaining clues are to be found earlier in the mission transcript from the time of the previous photograph used here, and the magazine as a whole. This photograph occurs after several images of a crescent moon as seen through windows suffering greatly from glare from the sun.

The nature of the mission trajectory meant that for most of the flight, the Moon was not actually visible as the sun was behind it. Only when it finally got to the lunar surface did the lit part of the surface come into view, initially described as

"a sliver of a sliver"

and gradually becoming larger.

At the same time, the crew made numerous references to the glare from the sun, and how difficult it is to see through it (even suggesting that they shut the blinds at one point). Capcom also help them orient themselves, pointing out that if the crescent is at the bottom of their field of view, then north is on the right, and this is how the moon appears in the photographs.

So we have an emerging crescent visible only with difficulty that seems to match the photographs shown at the beginning of this magazine.

The image immediately after this photograph (AS17-154-23599) is described as being taken on the first orbit. Looking at the scale of the features shown (this can be done by overlaying the image on Google Moon), it would seem that the spacecraft is still some distance out when the photograph was taken (see figure 4.9.41).

![Figure 4.9.41: AS17-154-52599 superimposed on Google Moon. Length of yellow line is 200 km](image)

Finally, there is the photograph itself. This can be compared with the colour image given in the preceding analysis, as shown in figure 4.9.42. The image used has had its dpi increased and brightness levels altered to make the features hidden by over-exposure clearer. It has then been rotated slightly to match the orientation of the Earth in figure 4.9.39.
On a general point, it should be clear that the size of the visible Earth, and the curvature of the terminator, is the same as that of the colour image, suggesting again that it was taken at the same point in the mission. While the black and white photograph lacks the fine detail of the colour one, the broad patterns of weather fronts are still discernible. The most obvious reference point is the long swirl of cloud (yellow arrow) extending into the South Pacific from Tierra del Fuego, below which is a mass of cloud associated with the Antarctic ice cap (red arrow). The curl of cloud extending from the southern Atlantic and eventually crossing into central South America (magenta arrow) is also noticeable, as is the relatively clear area between this front and the yellow arrowed cloud mentioned above.

The lighter cloud covering most of the Amazon basin (blue arrow) is also identifiable, and it can be seen that the shade of grey on the black and white image is much less intense than the sharp white of the more solid cloud cover over Antarctica. Two other bands of cloud extend from South America into the south Pacific, and these are identified by the cyan and green arrows.

It is more difficult to be certain about the clouds that are visible north of the equator because the process of enhancing the image has removed much of that part of the image. There does, however, seem to be a degree of correspondence between the cloud mass visible in the southern Caribbean/north Atlantic Ocean on both images. The band of cloud covering the southern USA shown in the colour image may also just be visible in the black and white one. These general features do appear to suggest, when viewed in the context of the mission transcript, that the black & white image was taken at roughly the same time as the colour one.

The next images occur after LOI, and so it is time for a new section.
The next image for examination is from magazine 151. AS17-151-23173 (figure 4.9.43) appears after several images of the lunar surface, the curvature of which suggests it is at, or not long after LOI. Analysis of this image can be seen in figure 4.9.44.

Before discussing anything else about this photograph, it is worth drawing attention to what it is. We have become accustomed to seeing Earthrise images from Apollo, but this one is the start of a sequence of Earthset pictures, ie it is looking back at the Earth as it disappears behind the Earth. The next few images in that sequence show an Earth sinking below the lunar horizon, increasingly obscured by mountains and crater rims.

As far as timing the image is concerned, zooming closely in on the photograph shows that the west coast of north America is still just visible, which would give a time, as shown by Stellarium, of around 23:30. The date is identified by the weather patterns visible on the NOAA mosaic, which is dated the 10th and shows patterns not visible on those formations on other days. As before, the IR mosaics have been included thanks to a lack of southern hemisphere data for the 10th. The pass covering the area of the terminator would have been around 18:00 on the 9th, on the visible image, and 06:00 on the 11th for the IR.

We also have Jack Schmitt, who helpfully asks Capcom to:

“...log us a picture of the Earth at 92:40 on mag Oscar Oscar”

Magazine Oscar Oscar is number 151, and 92:40, thanks to the time adjustment, is 90:00 MET, or 23:30 GMT.

Schmitt also says that:

"You've got a lot healthy weather out there in the Pacific today. Looks like most of those things we talked about yesterday, up in the Hawaii region and also in the south, have intensified"

This time of the image is also recorded as

“...about 3 minutes until LOS”

putting the craft in just the right place for a few follow-on photographs of the Earth setting.
Figure 4.9.44: AS17-151-23173 compared with NOAA visible spectrum (left) and IR (right) satellite mosaic and Stellarium estimate of time at terminator
Figure 4.9.44 continued: AS17-151-23173 and partial 3D reconstruction using digitally restored NOAA
The most obvious feature that can be made out on both the mosaics and the Apollo image is the large spiral of cloud towards the top of the Earth, shown by the red arrow. It is Gene Cernan who, on the next lunar orbit at 91:37 MET (c. 01:00 GMT on the 11th) gives us some more detail on it:

"...there is really one heck of a big low-pressure area developing somewhere off the coast of California, Washington, or Canada, out in the Pacific north-west part of the country...we were watching it earlier today, but I tell you, now, it's really dragged in some other clouds with it. It must cover an enormous distance and it's got some real spectacular circulation."

after an interruption from Capcom, during which he confirms he is using binoculars to see this, he continues, saying that he has lost sight of the continent now, and describing a:

"...tremendous trailing front. Roughly north north-west, south south-east, and it looks like it may just sweep up the western coast. It's hard to tell how far off the actual centre rotation or even a front is. I just remember from earlier this morning, when I could see landmasses, that it appeared to me to be off the Pacific north-west out in the ocean."

This large cloud mass is also visible on an ESSA 8 picture, obtained from a Midway Island veteran website described in the introduction to this section. The ESSA image (which has been converted from its original sepia to a slightly clearer monochrome) is shown, together with the relevant part of AS17-151-23173, in figure 4.9.45.

Figure 4.9.45: Part of AS17-151-23173, compared with ESSA 8 mosaic from 11/12/72
Both the cyclonic cloud mass and the trailing front are very obvious, dominating the north Pacific.

An interesting feature of the ESSA image is that it there appear to be the marks of a spiral bound notebook across at least one section of it (the left hand part of the triptych, halfway down the page). It looks very much like a printout (possibly from a fax machine) that has been manually compiled and then photographed. In the interests of continuity, there are other weather systems shown on the Apollo image that are a follow-on from the previous photograph under scrutiny, and that are also obvious on the NOAA mosaic. The yellow arrow shows the long looping system visible in the rather shaky image from magazine 149, and it should be evident that this loop encloses what remains of the 'mushroom' formation described in such detail earlier. The formations at the eastern end of that cloud band have not changed as much as the weather it encloses to the south of it.

Tropical storm Diana is just about coming into view, and is identified by the purple arrow on the western limb. The IR image gives a much sharper view of this emergent storm than is shown by Apollo.

The next photograph to be analysed is also from magazine 151, and is part of a short series taken from the CSM, showing the LM, the lunar horizon, and the Earth hanging just above it. The orientation of the home planet shows that it is an Earthrise image. The LM is still obviously attached here, and there is a later sequence of photographs showing it after separation, which tells us that it must have been taken before 17:20 GMT on the 11th, but obviously after 23:30 on the 10th, the previous Earth images in the magazine.

A time of 17:20 would put the terminator over Africa, and close inspection of this image shows that it still features that spiral storm described so vividly by Cernan. It must, therefore, be taken shortly after the previous image, probably at AOS on orbit 3 at 90h54, or around 00:30 on the 11th, half an hour before Cernan gives us his description of the large storm.

AS17-151-23188 is shown below in figure 4.9.46, and analysed on the next page in figure 4.9.47.

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![Image of Earthrise with LM](image)

Figure 4.9.46: AS17-151-23188. Source: AIA
Figure 4.9.47 AS17-151-23188 compared with NOAA visible spectrum (left) and IR (right) mosaics and Stellarium estimate of time at terminator
In terms of the weather systems we can see, there is little to add from the previous image.

What is obvious is that the Earth has rotated some distance since then in a manner consistent with roughly an hour’s worth of rotation. The crew had, during this orbit, gone from the higher LOI orbit to the lower descent orbit for LM separation, and thus the orbits were still relatively long.

As Cernan observed, the west coast of the US has now disappeared, and Australia is just coming into view on the western limb, which matches the time on Stellarium of 00:30 for the 11th.

NOAA’s mosaics are the same ones used before, and the area will have been passed at a correspondingly later time.

There now follows quite a hiatus in terms of Earth photography for this mission. The crew’s next objectives are to transfer to the LM, separate, descend and land. The next image of Earth, at least in a time-based series, that we can use for analysis turns out to be in magazine 134. This magazine went to the lunar surface, and starts with the first EVA after the extraction of the LRV and the erection of the flag. This latter event is recorded as being at 01:13 on December 12th 1972.

The first image showing Earth on this magazine is after flag deployment, which gives us a start marker for the event, and is part of a short series of pictures showing astronauts in close up with the flag. Two of those images feature the flag, and the 2nd one of these, AS17-134-20387 is used here. This image is shown below in figure 4.9.48, and analysed in figure 4.9.49.

Figure 4.9.48: AS17-134-20387. Source: ALSJ
Figure 4.9.49: AS17-134-20387 compared with NOAA IR (left) and visible spectrum (right) mosaics, and Stellarium estimate of time at terminator
Figure 4.9.49 continued: AS17-134-20387 and partial 3D reconstruction using digitally restored NOAA data.
Both NOAA mosaics covering this time have been included here (the IR one actually dated the 12th), as the IR one has a better definition of the visible features. The passes over the terminator line are given as roughly 08:00 and 20:00 GMT on the 12th for the infra-red and visible respectively. The visible spectrum image is dated the 11th as this is closer to the Apollo photograph’s time.

Recording the time of the image requires a little deductive work, as the image is not clear. The main cloud feature dominating the image is the one starting at the equator in the west (green arrow), heads roughly eastwards before looping back on itself in a kind of letter mirrored 'C' formation (blue arrow). The terminator falls some way east of this inverted C.

The location of the blue arrow on the NOAA mosaics suggests that the terminator is perhaps another 20 degrees of longitude to the east. The western end of this long band of cloud meets up with tropical storm Diana (red arrow), now east of Australia. Close examination of the image shows that blue sea is just visible beyond Diana, which suggests that Australia is only just coming into view. This would suggest a time for the photograph of around 01:00 – 01:30 GMT.

The ALSJ gives a specific time for this image as 118:26, which is almost 04:00 GMT. If this were the case, then Australia would be clearly visible. The timeline that has been used so far, however, says that at 04:00 Cernan and Schmitt would have just completed installing the lunar seismic experiment equipment at the ALSEP, not at the flag. The most obvious answer is that the ALSJ is using the GET, which is 2 hours 40 ahead of the timeline and transcripts. If this time difference is removed from the ALSJ time, we get a time of 01:20 GMT, putting the astronauts exactly where the photograph says they should be (at the flag) and the Earth’s features exactly as they should be.

This article in ‘Designs’ claims that my interpretation is incorrect, stating that:

“We believe that the above explanation has nothing to do with GMT, or local time for that matter, since the ALSJ GET time of 118:26 simply indicates 118:26 h from lift off (ie the start of the mission), irrespective of the time system used. We believe that a better explanation is the following: one can assume that the Earth image was staged before the start of the mission 118:26 GET [sic]. Hence the “planned” image of the Earth would be 2 h and 40 min behind the actual time and could not correspond to the correct view.”

What they conveniently ignore is that the satellite images could not have been staged in advance, despite their claims that ‘professionals’ could have, and that the astronauts broadcast the taking of these photos on live TV. That broadcast also shows them bending their knees to get the shot, something else the authors failed to notice. In ‘Apollo: the definitive sourcebook’, in the actual mission transcripts, and in the timeline given by NASA here, the launch delay has been accounted for and their timing agrees with mine.

They also state that NASA have never officially commented on the photo’s authenticity, and that by referring to this study they accept my arguments. Firstly, the ALSJ is hosted by NASA, not run by it. Secondly, they have no need to comment on its authenticity, as they know it’s genuine and taken on the moon. Hilariously, the journal that hosted this article have retracted it, saying that:

“Serious concerns were brought to the attention of the publisher. The article was re-examined, revealing that the complaints were valid and that the article does not meet the standards of editorial and scientific soundness for Designs.”

Well done to whoever complained, and bravo to the journal for retracting it.

The next image comes from a different magazine, number 137, which was taken n EVA 2. AS17-137-20910 is one of several photographs taken showing the Earth above a large boulder (named, with no sense of grandeur whatsoever, 'Boulder 2'). The photographs were taken at the equally unspectacularly named Station 2. Several other images from around station 2 also feature the Earth taken at the same time. The image itself is shown below in figure 4.9.50, and is analysed in figure 4.9.51.
Figure 4.9.50: AS17-137-20910. Source: ALSJ
Figure 4.9.51a: AS17-137-20910 compared with NOAA visible (left) and IR (right) mosaics, and Stellarium estimate of time at terminator.
Figure 4.9.51a continued: AS17-137-20910 and 3D reconstruction using digitally restored NOAA data
As with the previous image, there is some detective work to do in the absence of obviously visible land mass (something that automatically points towards a view of the South Pacific in the early hours GMT). The size of the visible disk is narrower than in the previous photograph, which means that it must be later in the mission.

The key areas on the photograph to pinpoint where the terminator is falling are the two lines in the northern tropical area (cyan and magenta), and the purple arrowed lobe of cloud near the western horizon. In the case of the former, following the line of longitude north would put see that line crossing half way through Alaska. The latter clouds are a good 15 degrees east of Australia, which would therefore not be visible. Using Stellarium, we can achieve a configuration of the Earth where Australia is not visible and Alaska just crossed by the terminator as roughly 01:30 GMT. The NOAA times for visible and infra-red passes over this area would be approximately 19:00 (on the 12th) and 07:00 (on the 13th) respectively.

At 01:35 on the 13th, we find from the timeline that Cernan and Schmitt are indeed at Station 2 on EVA 2, and they leave it 65 minutes later. A photograph of a damaged LRV fender’s repair was taken just before that departure (AS17-137-20979), as recorded by the ALSJ, several frames after the photograph used here. At the start of this video the ALSJ suggest that Gene can be seen arching backwards at boulder 2 to get the photographs of Earth, and they put the time for this at 02:01, so our initial estimate is not too far out. By 02:01 the eastern edge of Australia would only just be coming in to view.

This image contains enough detail to try and examine photographs taken by the ESMR instrument on NIMBUS-5. This is a typical one (figure 4.9.51a).

![Figure 4.9.51b: ESMR image from NIMBUS-5](image)

This particular image contains one orbital pass from December 13th, and we can combine that with the other passes from the 13th to produce an image covering the Pacific (see figure 4.9.51c).

The arrows used in this image are the same as those in 4.9.51a. It’s worth pointing out that the image is measuring microwave radiation and as a result is inferring the water content of clouds. The path covering eastern Australia and New Zealand was made on orbit 30. It’s difficult to tell when this orbit commenced as
data are not given in the accompanying catalog, but the image itself records times around 12:30 GMT, which would be consistent with night-time passes in late orbits of the same area.

While my use of arrows should be treated with caution, it’s clear that there are areas that tie in with that shown on the ESSA image and consequently the Apollo photograph.

![Image]

Returning to the visible spectrum, something else that should be visible in the image is Tropical Storm Violet. Violet developed over the Marshall Islands, a small group of islands just north of the equator and just west of the 180 degree longitude line.

The storm began as Therese died away, but was most active between the 12th and 15th of the month. On the 13th, the MWL (reference given in the introduction to this section) shows a more detailed NOAA image of Violet, with lines of longitude and latitude clearly marked, and this is shown below in figure 4.9.52.

Figure 4.9.51c: NIMBUS-5 ESMR compilation from December 13 1972.
The first thing to note on the MWL image are the latitude and longitude markings, which puts the storm as being at 10 degrees north and 170 degrees east on the 13th of December. If figure 4.9.51 is examined, particularly the NOAA mosaic, then there is indeed a storm there with a similar, but less detailed, configuration as is shown in figure 4.9.52. This storm (identified by the yellow arrow) also has the same overall shape (a sort of extra-wide '9'), although the lower level of detail masks this in the mosaic. That storm is to the east knot of white cloud that marks the join between the twin bands of cloud marked by the cyan and magenta arrows.

If the corresponding point is searched for on the Apollo image, the same storm pattern can be found, as can the bank of less well defined cloud to the north-east of it shown in figure 4.9.52. This gives us another tropical storm visible at a specific point in time and space on NOAA and Apollo images.

Additional evidence for the time comes from TV signals sent back to Earth from station 2. The ALSJ has video links to some of this TV coverage, and one of them, found here: ALSJ, contains a picture of Earth. A screenshot of from that video is shown below in figure 4.9.53, together with a zoomed in version of it and the NOAA visible spectrum mosaic from 4.9.51.
Figure 4.9.53: Video screenshot from EVA-2 TV broadcast (top right, source given in text), zoomed in (main image) and compared with NOAA mosaic (left) and Stellarium terminator estimate (top, middle). Arrows are the same colours as used in figure 4.9.51
Figure 4.9.53 continued: TV broadcast still and 3D reconstruction using digitally restored NOAA data
The screenshot shows the same scene as was shown in figure 4.9.51, and the text of the broadcast confirms its timing. At 140:37 MET (roughly 02:10) Capcom tell the astronauts:

"..17, if you want to take a minute, you might want to look up in the sky and notice that our camera is taking a beautiful picture of mother Earth...isn't that a beautiful picture of the Pacific there? Ed finally found it"

If the video is watched from the start, the camera operator does take a while to find the image, and the words spoken there coincide with the Earth appearing in shot. The similarity between the video screenshot and the astronaut photographs is undeniable, as is the resemblance to the satellite mosaics. There is a suggestion that the cloud bands marked by the cyan and magenta arrows in this screenshot are slightly shorter than in figure 4.9.51 which would be consistent with the still image being taken earlier in the EVA, but this could also be a product of the poorer quality.

As an interesting aside, the images in the EVA make an anachronistic appearance in a scene from a NASA film ‘On the shoulders of giants’ about the mission. At the end of the film they showed a few still images, and one of them is from EVA 3 at Station 6, AS17-140-21497. You can see a still from the movie below in figure 4.9.54.

![Figure 4.9.54: Still from ‘Apollo 17: On the shoulders of Giants’, with zoom of the Earth to the right.](image)

The quality of the image and the distribution of the clouds suggests it may be a still from the TV broadcast rather than the Apollo image. I’m sure some nutjob out there will seize on something like this, but all it is is artistic licence and as we’ve demonstrated above the meteorological data identify it as being an image taken by Apollo 17 on the moon and nowhere else.

A short while after this video was broadcast, there is another video segment from the EVA TV broadcast showing an image of Earth. This time, the crew are at Station 4, and are busy sampling the famous ‘Orange soil’ that was initially suspected to be some form of oxidation. The mission audio puts the time of the footage at 143:12, or 04:50 GMT, 13/12/72.

There is a version of the video available at the ALSJ, and various versions of variable quality on Youtube, eg here. A screenshot of the scene in question is in figure 4.9.55, together with a comparison with satellite images. The levels have been adjusted considerably in the screenshot to reveal detail, as it is not zoomed in as closely as the previous video of Earth. What is visible is blurred, but as with other images of this type broad patterns can be determined.

Stellarium tells us that, at the time of broadcast, Australia was not quite fully in view, and should be visible on the Earth's western limb. There is a suggestion of discolouration that might represent the Australian land mass, but this could also be a product of the treatment the image has had.
The main features of the adjusted Earth image are a band of cloud in the southern Pacific, a pair of cloud bands in the Equatorial region, another clear patch of ocean in the northern Pacific, and a final band of cloud towards the northernmost visible latitudes. It should also be clear that there is a good correspondence with the TV image in figure 4.9.53.
As far as the satellite comparison goes, the bands of cloud seem to correspond to the line of cloud east of Australia (red arrow) and along the equator to the north of Australia (magenta arrow). There is a suggestion of the north-east trending band of cloud identified by the cyan arrow in figure 4.9.53 but in this image the split from the ITCZ cloud is nearer the terminator.

The clear patches of ocean in the screenshot are evidently there in the satellite photograph (green arrows), as is the cloud cover in the extreme north and south (yellow and blue respectively). In short, despite the poor quality of the video still's representation of Earth, there is still a high degree of agreement with the atmospheric features visible on the satellite image that was taken 8 hours before on the 12th (the image from that date being nearer to the time of the Apollo still).

We get another LRV camera view when the crew visit Station 6 at around 162 MET. While Gene and Jack examined “Tracy’s Rock” (the unofficial name for a large mass of material that rolled down the North Massif slope). The camera pans around and eventually manages to find Earth again. Videos of station 6 are on youtube, including this one, as well as at the ALSJ. The time is recorded at 162:42 minutes (according to the transcript), which is 00:15 on the 14th of December. Unfortunately the quality of this image is even less clear than previous views from the rover, but we can still have a go at identifying what’s there. Figure 4.9.56 shows a still from the transmission, together with a zoomed, cropped and level adjusted view of Earth from it. This is compared with Fourmilab’s Earthview prediction of what should be visible and the satellite view.
The satellite view (timed at a couple of hours before the broadcast) is complicated by the image errors in the southern hemisphere, and the LRV camera does not show a very clear view of Earth. Despite this, I don’t believe the suggestions I make there as to which weather systems are identifiable are unreasonable. The bank of cloud off California is there, together a gap between it and the cloud in tropics. There is definitely a clear gap in the clouds in the Equatorial Pacific, before much denser systems off southern America.

Returning now to magazine 134, from image AS17-134-20461 to AS17-134-20473 there are several photographs featuring, variously, the LM, an astronaut, the flag and the LRV and the Earth. One of these, AS17-134-24071 is one of the better quality ones in terms of the view of Earth it provides, and this is the next image for examination here. It was chosen partly because of that image quality, and also because it is often cited by conspiracy lovers as an obvious fake, given the “unbelievable” juxtaposition of astronaut and Earth in the same photograph. It must, because of this appearance together, be the result of chicanery. It is shown below in figure 4.9.57, and analysed in figure 4.9.58.

Figure 4.9.57: AS17-134-20471. Source: ALSJ
Figure 4.9.58: AS17-134-20471 compared with NOAA IR (left) and visible spectrum (right) satellite mosaics, and Stellarium estimate of time at terminator.
Figure 4.9.58 continued: AS17-134-20471 and 3D reconstruction using digitally restored NOAA data.
The Apollo image is recorded as being from the end of EVA 3. The EVA itself ended at 168:07 MET, or 05:40 GMT on the 14th. The image is recorded by the ALSJ (after subtracting the extra 160 minutes) as 166:53 MET, or about 04:25 GMT on the 14th – just over an hour short of the mission being a week old. Setting Stellarium at this time shows that Australia should just be visible on the western limb of the Earth, and that is exactly what we can see. The slightly less than half full Earth also matches what should be visible, according to Stellarium.

Again, the analysis includes both the IR and visible spectrum images, and these, again show perfect correspondence with what is visible in the Apollo image, despite issues with the data near the southern hemisphere terminator region with the visible spectrum mosaic (the grid overlay is offset by some distance, and there appear to be errors in the data over to the terminator area (over the cloud mass picked out in blue).

Between them, the IR and visible spectrum mosaics provide an exact match. The times their orbits over the terminator area would have been made are roughly 07:00 on the 14th and 19:00 on the 13th respectively. The storm identified by the blue arrow is a particularly good match, as is the multi-pronged storm identified by the green arrow. The large cyclonic storm in the northern hemisphere is much less visible in the IR spectrum and is probably much colder winter air. Tropical storm Violet is still evident, marked by the yellow arrow.

An interesting diversion from this comes from a photograph taken a couple of frames later, AS17-134-20473. It is taken at an odd angle but shows Cernan against the lunar rover against a backdrop of the South Massif. Earth is pictured above the Massif, and although it is blurred it still contains features that can be identified in the preceding image of Earth. What is more interesting about this is the comparison that can be made with a photograph taken at the start of the EVA, AS17-140-21391, again with Cernan against the LRV but this time with his back facing the opposite direction. Clearly visible in the Cernan’s visor is Schmitt, and also clearly visible in the higher resolution version is a pale blue dot: Earth, in the same part of the sky as in the later photograph and, more importantly, exactly where Stellarium says it should be at the time.

Figure 4.9.59a shows the two photographs in comparison and a zoomed, cropped, enhanced and reversed shot of the visor. Figure 4.9.59b shows Stellarium’s projection of where Earth would be in the sky, with the important feature being the compass direction, with a Google Moon illustration of the direction from the LM to the centre point of the South Massif.
Close examination of the reversed visor image shows Earth to be above the South Massif slightly to the right of centre, or in other words nearer the west than the south. This is borne out by the slightly later image at the end of the EVA, and Stellarium confirms that this is exactly where Earth would be, right down to the angle of the terminator line. It’s worth noting that Jack Schmitt was also photographed in roughly the same position, and the same view of Earth can be seen in his visor, as shown in figure 4.9.58c.

While I managed to work this out the view of Earth for myself, it is worth noting that there is nothing new under the sun, and it is already discussed on the ALSJ in the image library there.

Even a reflection in a visor contains evidence that Apollo 17 astronauts were on the moon.
It’s worth noting here that Stellarium does have an Apollo 17 landscape, but it is incorrectly oriented and shows the centre of the South Massif to be south, rather than south-west of the LM, hence the pretty flowers.

Only one image remains from the surface, and it was not taken by anyone on the surface. While Cernan and Schmitt were in the LM awaiting the time to lift off and rejoin the CSM for the journey home, the LRV camera, positioned a safe distance away, remotely scanned the horizon and, eventually, the distant Earth. A screenshot of that video, which can be found at the ALSJ is analysed in figure 4.9.60.

This video clip is recorded by the as commencing at 170:40 in the ALSJ, but as they are recording GET time 160 minutes ahead, this can be reduced to 168h, or 05:34 on the 14th. At exactly this time in the transcript (and in the video!), Capcom tell the crew:

"And as you guys say farewell to the Moon, we're looking up to the Earth down here"

Shortly after this, Gene Cernan utters the final words as the last man to have his feet on the Moon, stepping back inside the LM for the last time.

As this is only an hour after the previous still image used, the features visible should, image quality permitting, still be broadly visible.

The arrows used in figure 4.9.60 match those used in 4.9.58, with the exception that where it isn’t clear where an arrow should go, it has been omitted. Can we be sure that it is an appropriate match? We are relying here on the words spoken on the video matching those of the transcript, which gives a time, and then using that time to see what clouds should be visible, and drawing arrows to what we assume are the same clouds. The argument here is that this is a reasonable use of the evidence to support the suggestion, but it is somewhat circular.

We do have, however, a large mass of cloud in the northern hemisphere (magenta arrow) next to a large band of clear ocean that ends with a band of equatorial cloud (yellow arrow). In the southern hemisphere at the roughly 4 o’clock position there is a distinct and thinner band of cloud corresponding to the blue arrow, and below that is (if it is examined closely) the multi-pronged cloud mass heading north from the Antarctic. This multi-pronged cloud mass can be examined in more detail my cropping and zooming into it, and then altering levels to bring out any detail. This is shown in figure 4.9.61.

Although the image on the right from the video is much brighter, swamping detail in the dark areas, it is still possible to make out the gap between the multi-pronged cloud and the thinner band above it in the top right the picture. It’s also possible to match other gaps in the cloud in each picture. Arrows have been deliberately left off to avoid confusing the image.
Figure 4.9.60: Screenshot of Apollo 17 LRV footage (top right) zoomed and cropped (main image) compared with NOAA 2 IR (left) and visible spectrum (right) mosaics and Stellarium estimate of terminator at time of broadcast.
Figure 4.9.60 continued: TV broadcast still and 3D reconstruction using digitally restored NOAA data
Are we, however, victims of our own prejudice?

In the initial stages of preparing this section, a video was found (since removed by the youtube user) showing this same segment of LRV footage combined with the later footage of the ascent module firing and returning to orbit. With no audio to confirm the timing, it was assumed that the footage showing Earth was done much later. This mistake was compounded by the 160 minute time addition in the ALSJ to effectively infer that the Earth should be showing features visible some 14 hours later. Equipment visible outside the LM was assumed to be that dumped by the astronauts (2 sets of equipment disposals were carried out during preparations for launch to reduce weight), when in fact they were part of experimental equipment.

This led erroneously to the assumption that what was visible in the image was a view of north and south America. On other words, a conclusion was made, and the available evidence was made to fit that conclusion. On closer examination, it was found that while there were broad generalisations that could be made that seemed to provide a good fit, the details, such as those compared in figure 4.9.58, did not stand up to close scrutiny.

Three important lessons can be learned here. Firstly, there is always a danger of making evidence fit the theory, and this is just as unwise for people who don't adhere to conspiracy theories as it is to those who will dismiss this work out of hand.

Secondly: check the data. Check it again. Don't rush to publish until it's right!

Finally: Don't be afraid to admit your errors. There is, to quote the song, always someone somewhere with a big nose who knows. Somebody will remember them and use it as evidence against all your other explanations. In the mind of a conspiracy theorist, one easy mistake will always outweigh 99 perfectly correct answers. I did, at least, double check the facts, which is more than your average conspiracy theorist ever does – if they did, they would have no conspiracy theory.

Having finally left the surface of the moon, the re-united crew orbit the Moon for a day before heading home. During that day they continue with orbital observation experiments, including use of the Metric Mapping Camera described in chapter 3.
4.9.1c - Mission images: Up up and away

During orbit number 62, the first 55 frames use an oblique angle to take images of the lunar surface, capturing the lunar horizon as they do so. As this orbit reaches Mare Smythii, the camera captures a sequence of images showing Earth rising. Unlike other Earthrise sequences, this capture is entirely coincidental: the photography is automated, and it just so happens that Earth is in the right place, as opposed to other sequences where the astronauts have set out to photograph this orbital feature.

The image chosen from this sequence is AS17-M-2193, and while a high resolution version is available here AIA and is shown in figure 4.9.62, a more useful version of the view of Earth can be found by zooming in to the image on this website: LROC Viewer.

The distortion introduced by the oblique angle can be corrected using image editing software, so that the position of landmasses can be better approximated in comparison with Stellarium. It must be stressed that the only alteration carried out here is to alter the brightness and contrast of the image, and to make the crescent shape of the Earth less distorted.

The first step to comparing with satellite images is to determine when this image was taken. Orbit 62 was commenced at 206 hours and 14 minutes on the 15th. The mission transcripts record a conversation before the commencement of this orbit marking the opening of the Mapping Camera before LOS at the end of orbit 61. There is also this conversation as the crew approach Mare Smythii (visible on the lunar horizon in figure 4.9.62) on orbit 62 at 206 hours 41 minutes:
CDR: There’s … Oh, fantastic. That’s the first one I’ve seen. Out 5. Beautiful, beautiful. Look at that … Look at that - Let’s get it the next time around …. in this attitude, Ron?

CMP: Yes.

CDR: Yes. Let’s - Yes, that’s - Oh, man. Look at that.

CMP: I don’t know, I’ve looked …

CDR: Yes …. a little late. We needed it just when it came up. Yes, let’s make sure we do that. That is beautiful. It’s just unbelievable

This would give a time of the Earthrise on orbit 62 of around 20:40 on December the 15, during which time they are recorded as undertaking lunar orbital science.

Stellarium suggests that what should be in view at that time is South America, with some parts of the southern USA also visible, cloud cover permitting. The crescent Earth’s size is a good match for that shown by Stellarium, and although the original has been changed, the dimensions of the widest point are still consistent (see figure 4.9.63).

Figure 4.9.63: View of Earth from AS17-M-2193 (left) compared with adjusted (right).

Figure 4.9.64 shows the Earth from the mapping camera image in comparison with a number of satellite images. Unfortunately only IR data are available for the 15th, and that satellite image is shown on the left. Visible spectrum data from the 14th and 16th are shown to the right. The times along the terminator are around 11:30 and 23:30 for visible and infra-red images respectively.
Figure 4.9.6: Close up of image AS17-M-2193 As depicted in the LROC viewer compared with NOAA IR spectrum image from 15/12/72 (left), visible spectrum from 14/12/72 (centre right) and 16/12/72 (right), and Stellarium estimate of time at terminator.
Figure 4.9.64a continued:
AS17-M-2193 and 3D reconstruction using digitally restored NOAA data
The quality of the image is still relatively poor as the main focus of the mapping camera was the lunar surface, and thus only broad patterns can be made out rather than precise detail. This problem is compounded by the lack of visible spectrum data from the satellite, but it is still possible to show that the area over Argentina is relatively clear (green arrow), and is bounded north and south by cloud (the red arrow identifies the northern cloud mass). The IR image and the visible spectrum images from the 14th both indicate an area of coastal cloud off South America's Caribbean coast (yellow arrow) that is absent by the 16th, and that forms a separate lobe of cloud to the Amazon cover.

The north Atlantic & Caribbean areas are difficult to discuss given the presence of a data anomaly over most of it in the visible spectrum images, but the IR photograph from the 15th does suggest light cloud cover over the former compared with thicker cloud over the latter. The blue arrow shows similar areas of circular cloud masses over the Caribbean. The IR camera does not pick up the much colder air masses over the Antarctic.

The partial view of the southern hemisphere in 3D corresponds well with what's visible in the MMC image.

Despite the relatively poor quality view of Earth we have here, there is still a Landsat path with which we can compare it. That path was commenced at 13:06, 7 hours before the Apollo image, while a pass over Newfoundland was taken at 14:34. The latter pass is in an area almost entirely covered by darkness at the time of the Apollo image so is not covered here. The details are given below in figure 4.9.64b.
The first part of the question we need to ask here is ‘do we have the locations correct? For the South American pass we can make out the weather patterns more clearly as well as the angle of the western coast along Peru and Chile, so it seems reasonable that we have. The clouds here are relatively easy to interpret - we have an area that is clear on the coast, a belt of cloud across northern and central Brazil, with clear areas to the south, and again this is reflected in the Landsat view.

The crew continue to orbit the Moon for some time after this image, and it is another 4 orbits before the Earthrise image they want to capture is taken, using magazine 152. This magazine starts with that Earthrise sequence which covers images AS17-152-23271 to 23277, and the last one in that sequence is used to compare with satellite images.

AS17-152-23277 is shown below in figure 4.9.65, and analysed in figure 4.9.66.

The crescent Earth is an early indicator that some time has passed since the last photographed examined here. The timeline tells us that the LM & CSM were re-united at 01:10 on the 15th, and that TEI was carried out at 23:35 on the 16th, so the last possible Earthrise would be shortly after that. We also have a couple of clues from the Photo Index, and the mission transcript.

![Figure 4.9.65: AS17-152-23275. High resolution source: Archive.org](image)

At the risk of carrying out exactly the sort of pre-judgement warned against only a few paragraphs ago, the Photo Index tells us that this image was taken on orbit number 66. At AOS on this orbit, which occurred at 04:10, Cernan says:

“*We've been taking [Earth's] picture just as we came up*”

Can we therefore find weather patterns on the crescent Earth that we would expect to find at that time and date?
Figure 4.9.66: AS17-152-23275 compared with NOAA IR mosaic from 16/12/72 and Stellarium estimate of terminator using mission transcript data.
Figure 4.9.6a continued: AS17-152-23275 and 3D reconstruction using digitally restored NOAA IR data
Before going on to answer this question, it is first necessary to point out that only the IR spectrum image was available covering this time. No data were available for the 15h in the visible spectrum, which is the mosaic that would have been required to cover the early hours of the 16th. The time of the orbital pass at the terminator would be around 06:00 on the 16th. The most obvious feature to be seen is the large arc of cloud just on the terminator, and this can easily be made out on the IR mosaic. Once this is correctly picked out, all other weather features are easy to match up, and we therefore have an Apollo photograph taken 2 hours before even the very first part of the infra-red mosaic was taken that matches exactly with it.

One of the best clues to look for here is the return of Storm Violet into the frame - conveniently identified by the magenta arrow. This document looks at DMSP images and their use in examining tropical storms, and features an image that it times at 01:25 GMT, and gives a precise location of 8.9 degrees North, 167.6 degrees West. If we zoom in on the Apollo image above we can compare it with the DMSP photo in figure 4.9.66b

Figure 4.9.66b: DMSP image of Tropical Storm Violet compared with a section of AS7-152-23275

If you care to check the location of the storm in the Apollo image and compare it with the coordinates given, you’ll find they match, just as the storm itself does perfectly.

The next image presents us with something of a dilemma, for reasons that will become apparent. It is a return to magazine 148, the final Earth image in the magazine, and is shown in figure 4.9.67a. It is analysed in figure 4.9.67b.

Figure 4.9.67a: AS17-148-22773.  
Source: AIA
Figure 4.9.67a: AS17-148-22773 compared with NOAA IR mosaic, and Earthview depiction of terminator at 08:00 GMT 16/12/1972.
Now we come to the tricky part - proving that this image was taken when we think it was taken.

Initial studies focused on South America as the land mass on the eastern limb. This is because the mission photo index records it as being taken between two lunar surface features - a crater called Sulpicius Gallus and crater on the edge of Mare Smythii, recorded as being taken on revolutions 73 and 74 respectively. There’s just one small problem - if this were true then the image would have been taken at somewhere between 17:30 and 19:15 on the 16th, but close examination of the image revealed Australia, which could not have been photographed between those two times. For Australia to be visible where it is, and with such a gap between it and the terminator, we have to be looking at a time nearer 08:00 GMT on the 16th.

What we need to do is trace through the records to see when these images were taken. We have this exchange at 08:22:49 in the transcript during rev 66:

"I took a picture of that one in Smythii - is frame 160 on mag November November"

That image is AS17-148-22766, and the time in the transcript equates to 216:30 GET, or around 06:05 am on the 16th.

A couple of hours later, recorded as 09:01:46 in the transcript, we have Schmitt stating that:

“Bob, that’s the most beautiful crescent Earth I’ve ever seen.”

and then:

“That bright spot. See it - how bright it is? Right in the center of the crescent? Yes, yes, but it’s never been that bright. Usually you just get the zero phase. It’s getting so it’s glancing off now and giving you a ... It used to be - I guess that’s what the term ...reflection."

If you look at the photograph you can see that there is indeed a bright solar reflection in the centre of the Earth crescent, and it seems likely that Schmitt was impressed enough at the time to photograph it. Shortly after this they then enter a rest period and there is no communication recorded with the ground. By way of confirmation that he photographed Earth, we have this remark from the Command Module transcript as he continues to discuss Earth’s crescent:

"Oh, darn. There’s the picture. Oh gosh. Never even thought about it. Oh well. Remember it, gang."

So where has the confusion come from? It would appear that it comes from the crew relating back details of photographs taken during the preceding hours when during their rest.

For example at 09:12:49 and 09:13:04 we have Evans saying:

"Frames 163 and 164 and 165 were taken of the mud craters and Smythii...that’s mag November November."

“Frames 166 and 167 were taken of a crater...to the west of Sulpicius Gallus.”

We also know that the Schmitt wanted specifically to take the Sulpicius Gallus area much earlier, as recorded at 08:20:55

“I’m going to try to also shoot, if you’ll let me, two pictures on KK of that depression - colorful depression we saw near Sulpicius Gallus, if I can see it. Is that okay?”

Again, if you read the transcripts at around this time you will find many references to using KK instead of NN (magazine 148), and there was obviously some confusion between the two.
The obvious conclusion is that the image of Earth was not taken during rev 73 but several orbits earlier, and the way the information has been given by the crew has led to them being mis-recorded in the photography index. Having decided when we are seeing the image, we can look at what’s in it. Again we are restricted to an infra-red view, with an estimated satellite image time at the terminator of 10:40 GMT. We have a distinctive curl of cloud extending from the Northern Territories to the east coast (yellow arrow). The band of cloud north of Papua New Guinea (green arrow) is also easy to make out. The Pacific has many thin east-west trending bands of light cloud that are also matched in the IR view. All of these (and the other ones identified) serve to confirm that we are definitely looking at Australia in this photograph, and consequently the Photography Index is wrong.

We also have a Landsat pass over Australia on this date, and we can see this in figure 4.9.67b.

![Figure 4.9.67a: AS17-148-22773 compared with NOAA IR mosaic, and Earthview depiction of terminator at 08:00 GMT 16/12/1972.](image)

It would hardly be reasonable to draw any solid conclusions from these images, but there we are - largely cloud free areas in the Apollo image largely cloud free in the Landsat ones! It also doesn’t help us when we learn that the Indonesian images were done at around 01:00 on the 16th, whereas Australia was imaged at nearly 23:35 - both passes many hours either side of the Apollo photograph.

Moving on from the confusion over image timings after the Earthrise sequence in magazine 152 shown earlier, there is an Earthset, comprising AS17-152-23278 to 23282. The first in this sequence will be used here.

In addition to photographs from magazine 152, we also have a contribution from 139, this time in black and white. Magazine 139 was taken to the lunar surface, and the first half of the photographs on it are those from an EVA. AS17-139-21300 and 2301 also show an Earthset, and these are also shown as being from orbit 71 in the
Photo Index. As the 2nd of these shows an Earth almost totally hidden behind the lunar horizon, 20300 will be used.

Again, we can use the Photo Index and mission transcript to act as a guide as to what part of the Earth's surface is appropriate to start looking, and we find that the photos are recorded as being taken on orbit 71. The mission transcript has this to say towards the end of orbit 71,

“...we're going to get your picture as you set this time.”

LOS on orbit 71 is recorded as 225:45 MET, or 15:25 on the 16th.

Both these images are shown overleaf in figure 4.9.68 a and b, and they are analysed together in figure 4.9.69a.
Figure 4.9.69: AS17-139-21300 (centre left) and AS17-152-23278 (centre right) compared with NOAA visible spectrum (left) and IR (right) mosaics, with Stellarium indication of terminator position at time image recorded.
If the colour version of the image is examined carefully, it is possibly to make out the coast of South Africa, and the fog shrouding that coast is marked by the red arrow. Land continues north of that fog almost all the way up the image, so we can be confident that our prediction for what should be visible is correct, and the images do show Africa.

As far as the NOAA images are concerned, the visible spectrum image (now available again) has the usual problem of half of Africa being commenced at the start of the day in question, and the other half 24 hours later. The IR spectrum however has no such problems. The times for these mosaics at the terminator are roughly 19:00 GMT for the IR image, and 07:00 for the visible spectrum. For the visible spectrum, most of Africa was started on the 16th, but the terminator area would actually have been imaged on the 17th. The Stellarium image confirms that Africa should be visible at the time of the photographs, but were they both taken at the same time?

Neither image shows the moon, so there is no reference point that we can use to say “this one was taken before that one”.

We can also conclude that the clouds shown in the central part of the image are the same ITCZ clouds, and the long strips of cloud in the top half of the image are over the Sahara in the mosaics.

If the 'V' shaped cloud picked out by the blue arrow is looked at more closely, it appears that the colour version shows it to be further from the terminator than the black and white one. This is matched by other surface and atmospheric features on both images, for example the long band of cloud shown by the magenta arrow ends shortly before the terminator in the colour image, but is coincident with it in the black and white. Likewise the distance between the coastal fog (red arrow) and the terminator is much less in the black and white compared with the colour. This would suggest that colour image was taken first. It also demonstrates that the Earth is moving as time passes, and not some static representation of Earth.

We also have a good pass over Southern Africa by Landsat, and the details are shown in figure 4.9.70.

![Figure 4.9.70: Landsat passes recorded over southern and central Africa as shown on Google Earth (bottom left) and AS17-152-23278, with close ups of southern Africa (centre) and central Africa (above).]
As before the angles are oblique, and several hours have elapsed between the Landsat images and Apollo (South Africa was photographed at 08:05), but again we have a broad consistency between the two. We have clear air over most of the areas covered with some coastal cloud.

That’s the last of the images from lunar orbit - we now move onto the final phase of the mission, the last voyage home from the moon by Apollo.
4.9.1d – The last leg

During TEC, Ron Evans, the command module pilot, carried out an EVA to retrieve equipment from the CSM SIM bay. During that EVA, several photographs were taken that show the Earth, including the one below in figure 4.9.71, analysed in figure 4.9.72, AS17-152-23395.

![Image](image.png)

Figure 4.9.71: GAP scan of AS17-152-23395. Low resolution source: AIA

The NOAA satellite would have imaged the area around the terminator at around 13:30 GMT.

The EVA commenced at about 20:30 on the 17th, ending just over an hour later. Evans makes several references to the crescent Earth and mentions wanting to take photographs of it, but doesn't mark specifically when photographs were taken. Although the photograph used (featuring one of the cameras that recorded the event) appears relatively early in the EVA sequence, a mid-point time of 21:00 has been used for the Earthview terminator estimate, which again has again been used to identify the distribution of landmasses in an increasingly thin crescent.

The most obvious weather pattern, and one that can definitely be identified, is the large 'tick' shaped mass in the northern hemisphere, partially obscured in the NOAA mosaic by data errors. This band, the cloud mass to the north of it, and the gap between them, are easy to pick out. The Amazonian cloud masses and south Atlantic weather bands are also simple to locate once the correct orientation of the land masses at the time of the EVA is determined.

A few photographs taken during the EVA show Evans with the Earth in the background. Unfortunately these are all, by and large, showing a very small and out of focus Earth and there is very little detail to seen in them. In the interests of completeness (bit little hope of conclusiveness), the image with the best view of Earth, AS17-152-23401 is shown over the page in figure 4.9.73, and compared with the same NOAA mosaics as in figure 4.9.74.
Figure 4.9.72: AS17-152-23395 compared with NOAA mosaic and Earthview estimate of terminator at 21:00 17/12/72.
Figure 4.9.72 continued: AS17-152-2339 and 3D reconstruction using digitally restored NOAA data
Figure 4.9.73: GAP scan of AS17-152-23401. Low resolution source: AIA

Figure 4.9.74: AS17-152-23401 compared with NOAA mosaic & Earthview estimate of terminator at 21:00 17/12/72
The view of Earth presented in figure 4.9.74 is so blurred there is little point in doing anything more than identify areas of light and shade. We know roughly when the image was taken, we know roughly what should be there but it would be unwise to state definitively what is there.

What has been picked out is the high latitude cloud mass (green arrow) to the north of the 'tick' shaped band (blue arrow), and there is a suggestion of darker blue between those two masses. The location of the Amazonian clouds is pointed out (magenta arrow), and again there is a suggestion of a gap between that and the blue arrowed cloud to the north that may well be the Caribbean Sea. Whether these are reasonable conclusions to draw is left to the reader to decide.

At the end of this magazine come the final pictures of Earth. There are half a dozen of them, seemingly in sets of 4 and 2, and they follow a number of photographs of the moon. Close inspection suggests that the first 4 were taken about an hour before the last 2, and this will hopefully be demonstrated by the following.

The first of two images, one from each set, is shown below and is AS17-152-23415 (figure 4.9.75a). It is analysed in figure 4.9.76. Also shown is a still from the 16mm footage, which (once reversed) shows the same scene.

Figure 4.9.75a: GAP scan of AS17-152-23415 (left, low resolution source: AIA) and 16mm still, cropped and reversed (right)

The key to identifying when this picture was taken lies not so much in the cloud patterns as in what can be seen on the surface. The glare from the sun and the subsolar point shows that there is a considerable amount of ocean on view, but we do also have evidence of land. We’ll deal with that shortly, but first let’s try and work out where it could be. By looking at various astronomical simulators, we can work out that at this position on the Earth’s crescent at this time of year there are only three locations that show land masses - Australia, Africa and South America. Figure 4.9.75b shows some examples of possible configurations using the Worldwide Telescope (WWT).
Australia seemed like a promising candidate because of the apparent line of a coast to the south and north but it is difficult to tell whether this is something that has been introduced more by manipulating the image rather than something that is actually there. Africa has far too much land around the subsolar point, and not enough clouds to the north when comparing it with the satellite image. Africa, like Australia, would also be several hours further on than South America, and while intuitively one would imagine that the Earth crescent would be getting larger, we have these observations from the Cernan as they get nearer Earth:

"...the crescent is getting smaller and smaller although the moon is getting - is getting larger"

There’s another observation much later by Schmitt, made at 286:18

"For the first time in seemingly several days we see the Earth"

Which does seem to suggest that they hadn’t observed the Earth much after the series of photographs we are examining here, and that those photographs were taken not long after the EVA.

To bolster the suggestion that the area we are examining is focused on the Americas, we have this area visible in the Apollo image (figure 4.9.75c).
Figure 4.9.76: AS17-152-23415 compared with NOAA visible (left) and IR (right) mosaics and Earthview depicting the terminator at 22:00 on 17/12/72
The Earthview depiction shows what should be visible at 22:00 on the 17th. If the photograph was taken on the 18th, the crescent would be much thinner. Zooming in close to just north of the thickest part of the crescent reveals, faint but still detectable, the thin lines of the central American coast, and from there the bulge of south America becomes clear. Having identified those landmarks, placing the clouds becomes relatively straightforward.

The westward end of the ‘tick’ shaped cloud discussed previously is positioned over the Gulf and central America, and the clouds of northern Amazonia are also visible. The glare on the western horizon shows the subsolar point is over ocean and not land. The video still appears to show a degree of additional rotation, and is therefore taken slightly later than the photograph.

As with the previous images taken around the EVA, NOAA would have imaged the terminator region on this image at around 13:00 on the 17th. The IR mosaic equivalent was imaged at around 01:00, and is therefore nearer to the time of the image than the visible spectrum one and improves the match between the two. The second image is AS17-152-23420, which is shown below in figure 4.9.77 and analysed in figure 4.9.78.

![Figure 4.9.77: AS17-152-23420.](source: Archive.org)

As before, the thickest part of the Earth's crescent shows the coast of central America, but in this instance it has rotated further round and much more of it is visible in the photograph. An estimated time lapse of around an hour has been used, and this does seem to correspond with the change in the amount of central America visible in the two Apollo images.

In broad terms the weather systems are still the same, but they do not necessarily appear in the obvious place, thanks to the orientation of the Earth and its rotation.

As before we have the large cloud mass over the USA (blue arrow), and the long 'tick' shape (green arrow) ends in the gulf near the central American coast. The red arrow picks out the cloud over northern Amazonia.

The magenta arrow picks out what appears to be coastal fog, which would explain why it does not appear on the IR image, either because it was ephemeral in nature or because the cool air mass that would produce this fog is less visible to IR cameras. The yellow arrow is really only there to pick out features within those coastal fog banks. The cyan arrow points to the curve of the top end of a cyclonic south Atlantic system. The times for the NOAA mosaics would be an hour further on than those for the previous image, assuming that the time gap between the Apollo images is correct.
Figure 4.9.78: AS17-152-23420 compared with NOAA visible (left) and IR (right) mosaics and Earthview depiction of terminator at 23:00 17/12/72.
A final image from Apollo 17 can be found in the 16mm footage. After the example given in figure 4.9.72, there are a couple of slow pans taken of a crescent Earth occurring in the midst of long distance shots of the Moon. Examination of the lunar images shows that, like the previous 16mm image used, the footage is reversed, and as is demonstrated by the brief analysis given elsewhere on this site (Sideways on) the view of the Moon is not quite what would be seen from Earth, thanks to the position of the astronauts in cislunar space.

By taking several screenshots of the pan, a full version can be assembled, and this is shown below in figure 4.9.79.

![Figure 4.9.79: Photomontage of stills from 16mm footage.](image)

Dating this image precisely is difficult. There are no specific references to filming in the transcript or mission reports. The width of the crescent suggests it is from roughly the same time as the preceding few images, and it must be from a later time than that suggested for figure 4.9.75, but there are no recognisable features showing that are visible in figure 4.9.78. As there is a degree of overlap between figure 4.9.76 & 4.9.78, it is reasonable to suggest that it was filmed slightly later than those two, but not so much later as to diminish the crescent’s size.

There are two features that suggest a possible time for the footage, and this is indicated in figure 4.9.80 below using a level adjusted version of 4.9.79.
The analysis presented in the figure above relies mostly on the assumption that the green and magenta arrows are correctly identifying cloud patterns off the western Americas. The blue and red arrows are useful guides to cloud free areas that are consistent with that suggestion, and other features also seem favourable to the idea that the film was taken very earlier on the 18th.

As with other images of a similar nature throughout this analysis, the reader is welcome to come up with their own suggestion.

No more images of Earth exist for Apollo 17, and the next stop for the crew is the final re-entry procedure for a returning CM, and the end of the Apollo programme.

The end of this part of this research will be after selected parts of the available synoptic data are examined.
4.9.2 Synoptic data

Disappointingly, given the many and beautiful pictures taken of the weather during their voyage, there are relatively few opportunities to compare with the synoptic charts of the day.

This is thanks to a combination of most of the images being from the southern hemisphere, and also a large gap in the German data that has proved so useful so far.

The daily weather charts are available for north America, but for the most part there are few opportunities to use them. Mexico charts are available for the mission periods, but they add little to the information given by the north American ones (as will be seen shortly). There are many pictures of Africa, and so the South African data are useful, but it is a shame that more of the continent is covered. There may be other data sources out there, but they have not been uncovered during the writing of this report. A final problem is the fact that most of the images are taken during the outward journey, and cover only a few days. The period on the moon and the return have many fewer images and those that do exist are, obviously, of a much narrower Earth crescent.

The first image compares the African part of the 'blue marble' image with the South African weather chart from 7/12/72. This can be seen in figure 4.9.81.

![Figure 4.9.81: AS17-148-22725 compared with South African synoptic chart from 7/12/72](image)

The two fronts marked on the synoptic chart are so obvious there is no need for arrows, and it is interesting to note the high pressure zones south of Madagascar and west of South Africa are largely cloudless, in short, the Apollo image shows exactly what it should.

On the 8th of December, two images were taken that cover Africa and the Americas, and therefore we can introduce the chart from North America as well as Africa. Figure 4.9.8 below shows a section of AS17-148-22743 compared with the South African synopsis from 8/12/72.

![Figure 4.9.82: AS17-148-22743 compared with South African synoptic chart from 8/12/72](image)
The progression of the weather fronts across South Africa over 24 hours is self-evident in both the Apollo image and the synoptic chart, and the two fronts marked on the synopsis are again obvious. The high pressure zone between the two fronts is not clear of cloud, but the cloud is broken. Highs to the north of both fronts are much clearer.

The situation in north America is shown in figure 4.9.83.

Figure 4.9.83: AS17-148-22745 compared with NOAA (top right) and Mexican (bottom) synoptic charts from 08/12/72

The red lines on the Mexican chart are used to emphasise thin lines that appear to be those of fronts. It is unclear what the dashed lines are meant to imply on the drawings.

The main point to make about the north American image is the good degree of correspondence between the hand drawn Mexican chart and the more modern looking chart from the NOAA, despite the many obvious amendments of the former. While they are not identical, there are broad similarities.

The meandering front across the continent (blue to green) is well marked, and zooming in closer to the image makes it possible to differentiate between the leading and trailing edges of the large bank of cloud that marks the border between that front and the one to the south (red arrow). The line marked in yellow seems to match the orientation of the cloud seen in the Apollo photograph, even if it does not quite match the orientation of the NOAA front drawn several hours earlier.
A similar exercise can be undertaken for the following day. AS17-148-22749 and 22758 show most of Africa and north America respectively. The South African comparison is shown in figure 4.9.84. North America's data are shown in figure 4.9.85.

Figure 4.9.84: AS17-148-22749 compared with South African synoptic chart from 9/12/72

Figure 4.9.85: AS17-148-22758 compared with NOAA (top right) and Mexico (bottom) synoptic charts for 09/12/72.
Again from South Africa we see a development of the frontal systems from the south-west, and there is also the fact the cloud mass in the Apollo image is oriented east-west as is the frontal system, in the front, showing again that the two correspond well. The NOAA and Mexican data also see good correspondence with the Apollo image. The long sinuous front shown on the NOAA image is matched by that on the Mexican one (although the markings on the latter were difficult to see and have been emphasised in red here. Florida is just out of view on the Apollo image, and thus it was not possible to place the front there reliably.

The 10th of December sees another good image of South Africa in AS17-148-22763, and this is shown below in figure 4.9.86.

![Figure 4.9.86: AS17-148-22763 compared with South African synopsis from 10/12/72.](image)

The three fronts on the chart can easily be found on the Apollo image, right down to the right-angled bend in the system to the west.

There is also a blurred view of north America available on the 10th in AS17-149-22779 (figure 4.9.87).

![Figure 4.9.87: AS17-149-22779 compared with NOAA synoptic chart from 10/12/72.](image)

The Mexican chart showed no front, but does show the same undulating front boundary area along the Mexican border. It has been omitted as much for space reasons as for the fact that it doesn't show as much detail as the NOAA chart. What is visible on the Apollo image is that long front across Mexico and the Gulf, showing a band of cloud along the cold front to the north of it.

Africa has one final bow to make in AS17-152-23278, which was taken on the 16th. Figure 4.9.88 shows South Africa with its attendant frontal system visible in both the Apollo image and the synoptic chart.
The curl of the band of cloud off South Africa is, as with the other images, self-evident on both the synoptic chart and the Apollo image.

Although, from the 16th, German data become available, the angle of the Earth and the size of the crescent visible means that little is added to the debate by including them, and as a result this section of this research will come to a close.

Nine missions sent around the Moon and back, all shown to have weather patterns in the photographs they took that conform with the synoptic data taken in several countries, and with satellite images from a number of different satellites in images that were available to anyone who cared to look at them.

That should, you would think, be the end of it. Or is it...
4.10 The Orbital Missions

No sooner is a project put to bed and you think that there is nothing more to say on a topic than someone asks a question you can’t help but answer. While the mainstay of most deniers of the Apollo landings is that any footage of weightless astronauts was filmed in LEO, and that images of Earth (despite all attempts to explain how much of the Earth is visible from LEO) were sourced in the same way, there is an even more extreme element of the conspiracy theorist camp that suggests that the orbital Apollo missions were faked.

Stupidity aside this may be down to pure stubbornness, but the orbital missions pose a problem for the hoax believers, namely that the equipment they will frequently claim was never tested was actually thoroughly tested in LEO by Apollo 7 and 9. It is therefore a logical extension to deny that they occurred, because if astronauts can perform EVAs in LEO wearing a PLSS to keep them cool, then that hardware will also work on the moon.

Having been set a challenge to identify the locations of a couple of entirely non-descript images of the LM from Apollo 9 above almost featureless ocean (more of which later), it became obvious that there is still a gap in the story that conspiracy theorists will try and wriggle through in their attempts to defend the indefensible.

This section, an unforeseen add-on to the following ones and written afterwards, will therefore examine Apollo 7 & 9 by looking at their Earth imagery. Before doing so it is worth taking a brief look at the unmanned orbital missions that tested out the Saturn V & CSM hardware systems and procedures.

4.10.1 Apollo 4

Apollo 4 was a brief mission designed to provide the first workout for the Saturn V. It was launched on 09/11/67 at 12:00 GMT. It landed 8 hours and 37 minutes later, having performed three orbits of the Earth. The first two were ‘parking orbits’, after which a much more elliptical orbit was attained that gave an apogee of over 9000 miles away from the home planet. There isn’t a full mission timeline generally available on the internet, but it can be found in the mission report, along with all the technical details of the mission, [here](#).

It was during this final elliptical orbit that a series of photographs were taken automatically, capturing the Earth below, and there is a detailed analysis of that photography [here](#). Before looking at what that photography shows, there is another image sequence supplied by Apollo 4 that anyone who has watched a documentary of the missions will have seen several times. In addition to the Hasselblad camera in the CSM, a pair of video cameras was attached to the Saturn V to capture the separation of the first and second stages. This sequence has become almost stock footage for any Apollo related programme (including ones produced by NASA), and has often been mistakenly attributed to the Apollo 11 mission.

There are many sources for the footage, and this one is typical: YouTube. Once the first stage falls away it reveals a wide expanse of ocean, with a few fingers of cloud stretching from below the Saturn towards the middle distance, but where is it? Logic tells us that the wide expanse of ocean so soon after launch is going to be the Atlantic. Examination of the satellite image from launch day (available [here](#)) can be seen in figure 4.10.1a together with a screen grab from the Youtube footage.

The first thing to note about the image is that the video of the separation is actually reversed, a common feature of much of the Apollo video footage. Once the image is reversed to the correct orientation, it is a quite obvious match for the satellite photograph. The coast line shown on the ESSA mosaic is that of west Africa, mostly in the southern hemisphere.

Simple enough right? Not quite.

The interstage separation footage took place at 3 minutes into the flight (see [this document](#)). The first part of the footage (at 02:30 minutes) is recorded as taking place just 45 nautical miles downrange. There is no way that weather systems off the coast of Africa would be visible from this location, and the separation itself was observed (and filmed) from the ground in Florida (see figure 4.10.1b).

There is also quite a lot of missing cloud in the image compared with the satellite photo. Combine this with a launch azimuth of 72 degrees (effectively the heading it takes from Florida) and it therefore can’t be the cloud masses initially identified. It is far more likely to be the ones shown in off the coast in figure 4.10.1c.
Figure 4.10.1a: Saturn stage separation image compared with ESSA 3 satellite photograph.

Figure 4.10.1b: Interstage separation as seen from both the ground and the Saturn itself. Source.

Figure 4.10.1c: ESSA image from launch day showing the Florida area.
The document analysing the photographs from the mission is interesting in that it stresses in its conclusions that high resolution colour photography would be a useful complement to the black and white satellite images in terms of meteorological analysis, and also recommends the involvement of meteorologists in mission planning. Naturally the meteorologists looking at the photographs were keen to emphasise their importance and wanted to include more weather based photography on future missions, but this seemed to have fallen by the wayside somewhat once the moon became a serious target until Harrison Schmitt’s efforts on Apollo 17 – naturally the mission planners’ focus was elsewhere!

The report also does a more than adequate analysis of the photographs by identifying the location of the major weather systems visible and confirming their location. The focus is on using Apollo images to confirm ground and atmospheric observations rather than this document’s use of satellite data to confirm the veracity of Apollo images.

As a result there is little point in re-inventing the wheel, but a couple of the photographs will be examined to try and fill in a few details that the report does not mention, as well as present better image quality than the web based document shows.

The report does provide a reproduction of an ESSA satellite image and this is shown below in figure 4.10.2.

![Figure 4.10.2: ESSA 3 satellite image reproduced from the Apollo 4 mission photography report. Source given in text.](image)

The reproduction omits northern hemisphere data (some of which can be seen on some of the mission photographs), and identifies South America on the left and Africa on the right.

The distinctive cloud formation visible in the Apollo separation video can be made out at the top of the image in the centre, so we are clearly using the same data. A reproduction of the same data from the ESSA catalogue, including northern hemisphere data, is shown in figure 4.10.3.
The Apollo images themselves can be found at the AIA here: [Apollo Image Atlas](#), although the first thing to point out is that they are all upside down, with the Antarctic (where visible) shown at the top of the images. Those available at the GAP site are better quality and are correctly oriented, and these will be used in preference.

The mission report documents that apogee occurred at 17:46 (more accurately it records it as 5:46 ground elapsed time, but as the launch was noon the time is self-evident), and it was shortly after this that photography commenced. This conforms well with the mission profile showing that there had already been 2 orbits, which would have taken around 3 hours, and that the final ellipsis which is given as a 4.5 hour orbit. The first images in the sequence show the edge of Earth appearing in shot as the CSM heads back towards perigee.

Perhaps the first task open to us is to confirm that we are looking at the correct area of Earth on the satellite image. Figure 4.10.4 shows AS04-1-250, which is one of the first images showing most of the south Atlantic, and only Antarctica is missing. Figure 4.10.5 below that shows the area of daylight on the Earth’s surface at apogee. Figure 4.10.6 compares the Apollo image with the ESSA data.
Figure 4.10.4: AS04-1-250 and digital 3D reconstruction from ESSA data. Low resolution source here: AIA

Figure 4.10.5: Projected area of daylight at 17:45 GMT on 09/11/67
The main thing to establish here is where the location of the terminator is, and whether this matches with the terminator shown on the daylight projection. The purple arrow identifies a cloud mass south of Nigeria, a country that would be just on the terminator at the time of apogee. The terminator should follow the west African coast, and that seems to be the case in the Apollo image. Unsurprisingly, the mission record is correct!

The remaining arrows on the image serve merely to point out the location of weather systems in both images.

Another point of interest is how the length of the photography session changed the view underneath Apollo 4. According to the records, roughly 10 seconds elapsed between images, and over the course of 750 photographs this amounts to a couple of hours of orbit time. During this time, not only will the relative position of Apollo 4 have changed over the Earth, but there should also be a change in the surface visible from space thanks to the Earth’s rotation.
To see how these changes manifest themselves we can look at a number of images from the course of the photography session and see how the visible features change.

The changing position of the spacecraft is best illustrated by the apparent curvature of the terminator line. In figure 4.10.7 below, the image on the left is AS04-1-350, almost half-way through the sequence. The figure on the left is AS04-1-650, nearer the end. The curvature is clearly more pronounced in the photograph from later in the mission, showing that it Apollo 4 has moved quite some distance in the space of those 250 photographs.

Figure 4.10.11: AS04-1-100 (left, low quality source AIA) & AS04-1-500 (right, low quality source AIA)

Figure 4.10.12: Comparison of western limb as viewed on AS04-1-100 (left) and AS04-1-500 (right)
What the arrows pointing to different weather systems in this image confirm is that despite over an hour’s worth of orbital movement taking place, relatively little has moved over the western limb!

On the face of things, this may present an own goal against Apollo – have we not just proved that an automated Saturn V can take off, orbit the Earth and merrily take photos of an entire globe with no human intervention? No-one has ever denied that such a thing could be possible, but it is worth pointing out that there are no astronauts in these photographs, no mission hardware, no lunar surface, no consistent view of a rotating Earth taken from ever increasing distances, no live video transmission making it into the following day’s papers..

The automated process could not even guarantee that it would take photographs of the Earth – several images before apogee show nothing in shot at all, and the final images in the sequence truncate the crescent Earth. An image in the photographic report shows what the mission planners believed would be beneath Apollo 4, and while it may be an accurate representation of where the CSM actually was it clearly isn’t the area that was photographed (figure 4.10.13).

![Photographic portion of Apollo AS-501 mission](image)

Figure 4.10.13: The photographic part of the mission as recorded by the NASA report into the images. Camera on, off and expected altitude in nautical miles are recorded

The sequence of photographs can be compiled to show the orbit as a video, and this is available [here](#).

In short, of course we can photograph the Earth remotely – that’s what the satellite photographs are, but in order to know exactly what is being photographed it’s kind of helpful to have a pair of human eyes to do it, and you still need to overcome the problem of being in orbit and the Earth moving beneath you and getting the photos home without anyone realising you were there all the time.

We do have a small footnote to be added here. There is a companion video to the separation sequence that is usually shown alongside the Apollo 4 footage. It shows the separation from the opposite view, with what looks like a CSM departing into the distance.

The full length video shows the view as the now free floating connecting ring tumbles Earthward, and it is often also shown as stock footage for the manned Apollo missions. Figure 4.10.14 shows two of the views from it.
The origin of the footage is a matter that has been hotly debated for many years, and the technical arguments revolve around the number of ullage jets on the supposed CSM – three, as shown in the screenshot.

Based on that information, the search has been narrowed down to one of the early test missions, with most of the evidence pointing at AS-201 or AS-202. This video does identify it as AS-201 (which is subtly different to that of the footage used here) but sadly there is no available satellite imagery for AS-201 - however we do have it for AS-202.

The mission is described here, and the post-mission report is here. AS-202 launched on August 25th 1966 at 17:15 GMT, and according to the mission summary linked to earlier,

“Two recoverable movie cameras mounted on the forward end of the first stage will record separation and ignition of the second stage”

This separation was set to occur at 2 minutes 23.7 seconds into the mission, so the craft would not have travelled far from the launch pad. While the camera we are looking at appear to show the S-IVB/CSM separation and is often reported as such, this was recorded as being at 597 seconds in and around 875 nautical miles downrange of the launch site as opposed to the 30 nautical miles if it was the initial separation phase. This would be too far to see the Florida coastline. We also don’t see any SLA panels being ejected, as would have happened at CSM separation.

The report shows that the S-IVB has a single engine bell and also 3 ullage motors, so we aren’t actually seeing the base of the CSM at all but the S-IVB/S-IB separation!

Figure 4.10.15 shows a part of the ground track diagram from the mission report. The S-IVB cut-off marked on the map occurred just after 10 minutes into the flight.
So far so good, but can we nail it down with any more certainty?

Well, fortunately we do have satellite data from that date available at the NIMBUS data rescue project. As well as the overall daily mosaics, we also have the individual tiles. These tiles are available in HDF format, which are more detailed than the .png images on the site but do require a specialised viewer to extract the image data. I used HDF-View, which as well as being free gave better results than other shareware viewers.

As it appears likely that the cameras did their filming not that far from Florida, two of these tiles showing the peninsula have been joined together. This composite can then be compared with the view of Earth from the tumbling and now spent rocket stage – see figure 4.10.16.

![NIMBUS image dated 25/08/66 at 16:35 compared with separation footage still and Google Earth estimate of view from AS-202. Red X shows approximate point of separation.](image)

The key to identifying the correct viewing angle is the circular mass of white cloud in the centre of Florida, at a guess somewhere between Cape Coral and Lake Okeechobee. Running behind this are parallel streams of cloud that can also be made out in the video still, as can streams heading eastward. The larger masses of cloud to the north also seem to be evident. So, unless proved otherwise I’ll declare the mystery (such as it was) solved - AS-202 it is!
4.10.2 Apollo 6

The next unmanned mission in the Apollo program was Apollo 5. Its aim was to test the LM in space conditions, and provided the first firing of an engine with a throttle in space. It did not have a full Saturn V set up, and did not include cameras in the mission profile. Its mission report can be found here.

The next full Saturn V workout was Apollo 6, launched on April 4th 1968, its progress largely unnoticed thanks to the assassination of Martin Luther King.

Apollo 6 was again a brief mission lasting only 10 hours, and was mostly an LEO mission. Its main aim was to test the ability of the Saturn to carry out a TLI burn, measure radiation levels in the Van Allen belts, and to test the CM’s re-entry heat shield. Again cameras were taken on board and triggered automatically over the course of three orbits, providing coverage from the Pacific to the east coast of Africa. There is also video footage taken once the craft was placed into a higher orbit to test the TLI procedure archive.org, and of re-entry archive.org. Like Apollo 4, separation footage exists and can be found here.

As with Apollo 4 we can have a look to see whether the footage matches what should be there. Figure 4.10.17 below shows a small section of the ESSA photograph from that day compared with a screenshot from the separation video.

The separation events are all recorded as being east of Florida, and you can see the US landmass in the background. The cloud masses aren’t as clear as in Apollo 4’s imagery, and it wouldn’t be prudent to identify specific clouds here.

One magazine of photographs was taken, successfully exposing 373 colour photographs Figure 4.10.18 shows the path covered by the photographs (Source: AIA). The Apollo Image Atlas shows all the images (AIA), but they are low quality reproductions. The documents showing the satellite photographs for that date in question can be found here and here.

A basic summary of the photography process is given in the photography index linked to above, but a more detailed description of procedures is given in the Science report on the 70-mm Earth photography of the Apollo 6 mission. This is not, however, freely available at the time of writing (it is lodged in a number of sites required paid membership). Some academic analysis of the photographs has been undertaken, for example Shenk et al. (1975) and Shenk (1971). This article compares the trans-Atlantic Apollo images with ATS-3 photographs. This document, as well as describing how to obtain and plot ESSA data, has a good ESSA image of the Great Lakes from April 4th, the tail end of which can be seen in figure 4.10.20.

The Shenk et al. papers attempt to use the images taken by Apollo to try and identify and classify clouds and to see how this compares with similar attempts made using ESSA and ATS imagery. Unsurprisingly, the general conclusion is that high resolution full colour images capable of being viewed stereoscopically (thanks to the close time interval between photographs) are more useful.

As with Apollo 4, there is little point in re-inventing the wheel. The publicly available work more than adequately covers the identification and discussion of the weather features seen in the satellite photographs. What is worth a cursory glance is to see where the photographs fit globally, compared with where the Apollo orbital track shown overleaf puts them.

To do this, each image recorded in the AIA link was joined with the next one by matching cloud patterns. The first part of the sequence consists of the Earth horizon, after which the camera pans down and begins taking photographs from a near vertical perspective. Joining one photograph to its neighbour is relatively straightforward, but it is worth mentioning that no rotation of the images was carried out to fine tune the resulting montage. Two extremely long photo compilations are the result, and these are shown in figure 4.10.19.

Figure 4.10.20 shows these mosaics placed in Google Earth, aligned by the location of the coasts (where visible). The positions are not 100% accurate, but they are close enough. Central Africa’s colour is related to the lighting conditions at the time of the photography.

How do the Apollo photomosaics compare with the satellite mosaics? Figure 4.10.21 shows the relevant parts of ESSA’s imagery.
Figure 4.10.17: Separation footage from Apollo 6 compared with ESSA satellite image
Figure 4.10.18: Orbital path of the photography sessions taken by Apollo 6. Sources given in text
Figure 4.10.19: Photomosaics from Apollo 6 orbits. The top 2 are from the pass over America, the bottom 4 the pass over the Atlantic and Africa. All travel west to east. Larger versions of the two entire passes are available here and here.
Figure 4.10.20: Photomosaics from Apollo 6 orbital photography placed on Google Earth.

Figure 4.10.21: ESSA images of Earth covered by Apollo 6 photography sessions.
ESSA shows that for the most part the US is cloud free for the bulk of the orbital photography with the exception of the Gulf states, where there is a thick band of frontal cloud, to the east of which is lighter cloud cover. The Atlantic has a few areas of dense cloud cover off the US east coast and some frontal bands, but otherwise has relatively little cover. The African coast has light cloud but the area of west Africa overflown by the mission is mostly cloud free, and the only significant cloud is the east coast and towards Madagascar. Apollo’s images show the same pattern.

By way of comparison, the ATS-3 image examined alongside Apollo 6 images mentioned earlier are shown below for the trans-Atlantic section (figure 4.10.22a-d).

Figure 4.10.22a: ATS-3 image from April 4th 1967 showing the path taken by Apollo 6 divided into sections based on cloud type.

Figure 4.10.22b: Section i from figure 4.10.22a comparing Apollo 6 images with ATS-3.
Figure 4.10.22c: Sections ii and iii from figure 4.10.22a comparing Apollo 6 images with ATS-3.

Figure 4.10.22d: Sections iv (part) to vi from figure 4.10.22a comparing Apollo 6 images with ATS-3.

It’s quite easy to identify the cloud formations in the two sets of images even without my added arrows, but some people refuse to see what’s in front of them!

The video footage is more difficult to identify, and is not helped by the amount of footage purporting to be Apollo 6, but is actually from other missions. There is, for example, footage showing S-IVB separation, which starts with a rocket stage pulling away from the camera and ends with the now discarded lower stage tumbling Earthwards and revealing the planet below. This is often claimed to be Apollo 6, but is believed to from AS-202, an early test of the Saturn engines.

The mission report describes the video operation:

“The 16mm movie camera operated through the left rendezvous window during the launch and entry phases...the camera photographed the departure of the boost protective cover and the launch phase until insertion, and then command module turnaround and plasma flow during the entry phase.”

This video, Apollo 6 film 5, does seem to be from Apollo 6 as it matches what the mission report describes. Nothing much is discernible for the first part of the video, but at around 30 seconds we can see the departure of the boost cover and the view shows the Earth’s horizon through the CSM window, with the sun clearly in view. After some rotational manoeuvres the window swings down to show the surface below. It’s obvious from the direction of movement that the video is upside down, as the surface below the CSM is moving from left to right, when the apparent movement should be right to left.

The next question is: what does the video show? As the camera began operating 70 seconds after launch, and the boost cover disappears after about 30 seconds, it is only a couple of minutes after launch, so the view should be of the mid-Atlantic, as shown in figure 4.10.23 below.
The orbital height at this stage means we are looking at a relatively small section of Earth in any one frame, but by stringing several screenshots together it is possible to extend that view to a more useful size. This is shown in figure 4.10.24.

This gives us a longer path to look at, but the path itself is still only a hundred miles or so wide. The clearest image of the Atlantic (and the nearest in time to the launch) comes from the photographic analysis referred to earlier and the ATS-3 image from it. This image is shown below in figure 4.10.25a, and a Google Earth screenshot with the launch track overlaid is shown below that in figure 4.10.25b.
Figure 4.10.25a: ATS-3 image 04/04/68. Source given in text.
From the preceding images, it looks as though the area covered by the video is shown in a more detailed close up of the ATS-3 image, shown in figure 4.10.26.

The area highlighted by the red rectangle is on the flight path, and has a solid mass of cloud followed by the more broken cloud trending in the appropriate directions. The match is not exact, but the image was taken nearly two hours after launch, so a small amount of change is to be expected.

The second half of the video shows the re-entry approach. At this point in the mission the CSM was in an elliptical orbit, and the video starts with a clearly distant Earth crescent that gets gradually broader, before there is a change in orientation and plasma from the ablating heat shield can be seen.

Re-entry itself occurred at 21:39 at roughly 33°N 166°E, a point 2000 east of the southern-most tip of Japan. The terminator at that time fell across eastern China and the Philippines.
The area of sunlit ocean covered by the returned spacecraft must therefore be between China and the re-entry point about the central north Pacific. Figure 4.10.27 shows the mission report re-entry track on an Earthview depiction of the terminator location.
The track covering the area on the ESSA image (figure 4.10.28) dated the 4th would have been just after midnight on the 5th.

Figure 4.10.28: ESSA view of re-entry corridor. The red arrow is discussed shortly

Figure 4.10.29: Compilation of screenshots from Apollo 6 re-entry vehicle.

The screenshot compilation starts with a darkened area, so obviously this is close to the Chinese mainland, and the cloud on the right is close to the landing zone (it is difficult to tell, but the re-entry video suggests a blue sky directly above the CM as it descends by parachute). The resolution of the ESSA image makes it difficult to be absolutely certain, but my suggestion is that the curve of cloud left of centre in figure 4.10.29 above (red arrow) is the cloud just south of Japan.

Having launched and tested the Apollo hardware and procedure without the presence of people, it was time to launch some actual astronauts up there: Apollo 7.
Apollo 7 is often argued to have ended the flying careers of the three astronauts who crewed it. Walter Schirra, Donn Eisele & Walter Cunningham manned an occasionally tetchy mission, disagreeing with the ground on a number of occasions over procedural matters, disagreements compounded by illness and tiredness. Despite this the mission was actually a technical success in that it achieved all the things it set out to achieve, and while the complaints and very public spats were well reported, most of the mission went well and there are numerous good-natured exchanges with the ground. Gene Cernan, commander of Apollo 17 and the last man on the moon, records in his autobiography that in any event Deke Slayton (the man who rostered the crews and ran the Apollo show) never had Schirra in mind for a lunar landing mission. Schirra himself said prior to the flight that he had no interest in a lunar mission. That said, he never got any other kind of mission.

Schirra went through many of the reasons for his more contentious decisions during the mission, including the cancellation of a TV broadcast. He gave TV a low priority during the mission, regarding it as a potentially dangerous distraction: while broadcasting and filming the crew were paying attention to the camera and not the spacecraft!

Apollo 7 was launched at 15:02 GMT 11/10/68, and returned to Earth on 22/10/68, and during its 11 days in orbit tested life support systems and docking procedures, as well as the ability of three people to live in a confined space for extended periods (many readers of the mission transcript will find amusement in descriptions of the practicalities of urination and bowel movements in orbit!). The mission timeline can be found here.

In terms of photography, the aims were the same as previous missions in terms of photographing Earth surface features and weather formations for comparison with ground and aircraft based observations. The general mission report can be found here and the report covering the photography in depth can be found here.

In total 533 photographs were taken on 9 magazines of film, low quality versions of which can be found here: AIA. The crew also made the first TV broadcasts from space, providing TV viewers with the first live images of planet Earth. These broadcasts do not seem to be readily available in their original form, but footage taken by the mission can be found in the NASA film ‘Flight of Apollo 7’, which can be downloaded here: archive.org.

The ESSA satellite images covering the mission period can be found here, and the ATS ones here. There are several additional images covering the mission dates in this publication: Applications of Satellite Meteorology, that are of better quality than the ESSA mosaics. We also have the benefit of another ESSA World publication (found here ESSA World) that deals specifically with the weather aspects of the mission. The article expands on the edition referred to in Chapter 2, and describes the work of the Spaceflight Meteorology Group with specific reference to Apollo 7 from the preparation of the launch vehicle to the choice of landing areas. This article has good quality ESSA and ATS views of two hurricanes photographed during the mission.

It also describes how astronauts would be briefed on global conditions so that they would be familiar with the types of weather formation over which they would be flying. It becomes clear from reading it that there were many agencies involved in preparing meteorological data for a variety of purposes, all of whom needed to coordinate and disseminate their information. All of these would need to be added to the global conspiracy of silence that must have prevailed if the conspiracy argument is true.

As with the missions described earlier, the photography report does a more than adequate job of describing the features visible from orbit, and there is little to be gained from reproducing it fully here.

As with the missions described earlier, the photography report does a more than adequate job of describing the features visible from orbit, and there is little to be gained from reproducing it fully here.

What we will attempt to do here is follow the timeline and mission transcripts (available here), picking out references as appropriate and seeing if photographs can be identified, then compared with the satellite record. One feature of this (and other LEO missions) that can be observed in the transcripts is a telling indicator that lunar bound crews could not possibly have been in LEO ‘pretending’ to be somewhere else.

These low orbit missions are moving at 17000 miles an hour, and consequently require a huge number of tracking stations to keep voice communications relayed successfully. Figure 4.10.29 shows the orbital path of Apollo 7 and also lists the various tracking stations involved. The mission transcripts are littered with notifications of impending communications hand overs and acquisitions, and there are breaks in communications where the on-board recordings are needed to fill in the gaps.
These gaps in communications also necessitate regular downloading of mission data for analysis on the ground. Contrast this with the much less frequent changes in tracking stations required by moon-bound mission, where changes are necessitated by the Earth’s rotation rather than the spacecraft moving over the Earth. Had the landing missions been in Earth orbit this discrepancy would have been obvious to anyone trying to track the missions (both amateur and national radio hams and tracking stations did). Neither could they have been in HEO, as they would have been geostationary, which the photographs and video footage show they very definitely weren’t.

It’s also probable that these rapid handovers between ground stations (sometimes as little as a few minutes were spent on any given receiver) caused some of the communication problems that added to the occasional frustrations of the crew – requests to repeat a message are much more frequent in Apollo 7 than in the lunar landing/orbit missions.

Now to explore the transcripts. We have two approaches to follow here – firstly, to identify a specific feature on specific photographs identifiable in the text, and secondly to use those photographs as markers to pick out images with more distinctive cloud formations on them. The former is complicated slightly by errors in the transcripts (eg magazine ‘S’ is occasionally written as ‘F’), and by the crews miscalculating the frame numbers of the magazines. This was probably caused in part by occasional jams in the camera mechanism, but is also from simple miscounting of the number of photographs they had taken. Magazine S, for example, is described as having many more photographs than were actually developed, and the frame number identified by the crew to Capcom often does not match the frame count of the developed photographs. Despite this, it is possible to work out from their descriptions which photographs are being discussed, and the photographic report does list the photographs and their timings.

One of the first magazines used (M) contains a photograph of a weather system that is also featured in the Applications of Satellite Meteorology document, and occurs early on in the mission. The image in question is shown overleaf in figure 4.10.30. The ASM document identifies this as a low pressure trough in the mid-Pacific and is a mosaic of several images taken either side of 00:00 GMT 10-11/10/68.
Figure 4.10.30: AMS image from 10-11/10/68 over the Pacific Ocean

The image that seems to match this quite well is AS07-3-1555, and a high quality version from GAP is also in figure 4.10.31. No time for this image is recorded in the photography report, but one taken 9 images prior to that is recorded as being taken at 03:18 GMT on the 11th. The photograph occurs after the rendezvous with the ‘angry alligator’ SIV-B, which was over Florida at 03:00 on the 11th, and after a couple of images of tropical storms mentioned in the transcript at 21:22 on 11/10/1968 (AS07-3-1553-1554). The transmission about those two photographs is through Hawaii, which means that a Pacific location for the 1555 image is a reasonable assumption.

Figure 4.10.31: GAP scan of AS07-03-1555. Low resolution version here AIA. Photograph is rotated 180 degrees to match the ESSA image
The central whirl of cloud in the preceding figures is so clear it needs no illustration with arrows, but it is worth noting that the satellite image from figure 4.10.29 was taken some 21 hours before the Apollo image. The satellite photograph in the ESSA data catalogue from the 11th was taken some 4 hours later and is show below in figure 4.10.32, along with the ATS1 image from 22:26 on the 11th. The detail is much less clear, but the overall storm structure is still evident, and the two central spots of cloud are well defined.

On the following day, the crew begin a sequence of images starting over Hawaii (although not actually featuring Hawaii), and ending in the region of the Bahamas. There are two parts of this sequence that can be picked out from the satellite record, the first at the coast where Apollo 7 picks out an area of cloud, and the second in the centre of the north American continent where there is a small area of distinctively shaped cloud in an otherwise cloud free zone.

The end of the sequence is announced at 18:15 GMT on the 12th, and is identified as being on Magazine P. The frame numbers are not given, but 3 hours before that a picture of the end of the Florida canal north of Tampa (labelled in the transcript as a breakwater at Tallahassee), and this is AS07-11-2016. As AS07-11-2019 is the first image after this showing the west coast of the USA, it's reasonable to assume that AS07-11-2041 is the end of the sequence announced by the crew.

It is possible to combine several images together to produce a more complete image of the west coast than can be shown by a single image, and this is shown over the page in figure 4.10.33. The corresponding portion of the ESSA mosaic is shown in figure 4.10.34.

The long band of cloud stretching onshore from the Pacific is very obvious in the satellite picture, although the other less substantial cloud masses are not as easily made out. The satellite pass for the ESSA image would have been 00:05 on the 13th, around 6 hours after the pass by Apollo 7. It should again be obvious from the photomontage in figure 4.10.33 that despite using 4 photographs, the portion of the Earth visible is still extremely small, covering a swathe around 500 miles wide. The difference between a fixed camera position used for the preceding unmanned missions and the obviously human hand should also be clear.

In the same pass over the USA, another image is captured that shows a distinctive cloud feature – can this be identified on the satellite image? The photograph (shown in figure 4.10.35) is recorded by the GAP as being over Llano Estacado in Texas, and the photograph below has been oriented to match (roughly) the correct orientation based on features visible on the ground. The local time of the photograph is recorded as around 11:30 am, and close examination of the ground under the clouds shows the well-defined shadows almost vertically beneath them.

The corresponding part of the ESSA mosaic is shown below in figure 4.10.36, the bulk of which shows the state of Texas. The pointed end of the cloud pattern in question is almost exactly in the centre of the image, exactly where the photograph says it should be.

Again it should be obvious that the photograph, despite the oblique viewing angle, shows a much smaller area than the photographs examined in preceding sections, and any image showing a whole Earth image is absolutely not going to be in LEO.
Figure 4.10.33: Montage of AS07-11-2019 – 2022. The large elongated island in the centre is Santa Cruz Island, just south of Santa Barbara. The cloud to the east of the island is off the coast of Los Angeles.

Figure 4.10.34: ESSA image from 12/10/68. The red dot marks the position of Los Angeles.
Figure 4.10.35: AS07-11-2031. Low quality version available here: AIA

Figure 4.10.36: ESSA mosaic dated 12/10/68 showing Texas in the centre.
Most of the photographs taken over the next couple of days are of landscapes free from cloud or of weather patterns too faint to be visible on the ESSA mosaics in use here. One day’s data (from the 14th) is missing from the ESSA photomosaic data completely but there is one image shown in the ASM document off the Canary Isles. The image is recorded as being taken in two passes between 15:00 and 16:50 GMT. These are not the times recorded for the appropriate passes in the data collection, so it is likely to be from a different ESSA satellite. It is given in figure 4.10.37.

The area covered by the satellite data is shown in AS07-06-1713 – 16, a montage of which is shown overleaf in figure 4.10.38. Close examination of the two images suggests a disparity between them – the Canary Isles are visible in the ESSA image but the band of cloud just off them is either absent (a very faint suggestion of one is there but is not definite) and there is no suggestion of the thin coastal banks of cloud off Morocco. These banks would be visible in the ESSA imagery, as shown by this one from 12/10/68 that can be seen in AS07-11-2012 (figure 4.10.39).

Figure 4.10.37: ESSA image from 14/10/68, rotated to match the orientation of figure 4.10.35. Possible light cloud indicated by red arrow.

Figure 4.10.38: Photomontage of AS07-06-1713 – 1715.
The answer to this apparent discrepancy is obviously the time gap between them and the nature of the clouds involved. The sequence of photographs taken on the 14th are specifically recorded in the transcript at 10:56 on the 14th, around 5 hours before the coastal part of the ESSA pictures, which would be plenty of time for the coastal cloud to disperse and the light cloud off Lanzarote to move on. The time gap between the ESSA 7 image on the 12th is similar, with the Apollo image recorded as being taken at 11:08 in the photography report, 6 hours before the ESSA photograph but in this case the coastal cloud has persisted. (Photographs AS07-11-2005 and AS07-11-2013 show the coastal clouds of Morocco in more detail).

Another nice coastal image is AS11-07-1807, which is described as being of Ecuador in the transcript and taken at 20:55 on the 15th. The ESSA track covering Ecuador would have been taken at 21:04, and in this case little time would have elapsed between the two photographs. Apollo and ESSA images are shown in figure 4.10.40 and 41 respectively. The approximate area covered by the image is bounded by the red square in the ESSA mosaic.
It is just possible to determine from the ESSA image the clear area to the south of the Apollo photograph, the coastal bank of cloud, and the thin fingers of cloud extending southwards from the top of the photograph.

A short while later, Apollo 7 flew over the Indian sub-continent, and took a few photographs that can be compiled into a montage. One of the photographs in the montage (AS07-07-1811) is incorrectly identified as south-west India in the photography report, and as the west coast in the GAP index. In fact it can be located as the south-eastern tip of India, just west of northern Sri Lanka. The montage is shown below in figure 4.10.42, and the relevant ESSA image in figure 4.10.43. The other two images are AS07-07-1812 and AS07-07-1813.

Figure 4.10.42: Photomontage of AS07-07-1811 – 1813.

Figure 4.10.43: ESSA image of southern India and Sri Lanka dated 15/10/68
As with all ESSA mosaic images of this region, the image dated 15/10/68 was actually taken on the 16th at 08:05, 32 minutes before the Apollo photograph (as recorded in the CM transcript). The cloud over southern India and the north-western tip of Sri Lanka are visible in the ESSA image.

Magazine S ends with the most famous photograph from the mission, AS07-07-1877, which shows the hurricane in all its glory and has been used in many documents. The orbit before that image was captured, a couple of photographs are taken that show the edges of the weather systems surrounding it. AS07-07-1863 (figure 4.10.44) is recorded as showing the area around Waco and Fort Worth, and examination of the photograph in detail shows that it is looking eastwards, with Lake Whitney visible in the foreground and Lake Fork reservoir in the distance just before the thick banks of cloud on the horizon.

AS07-07-1864 (figure 4.10.45) shows Galveston in the foreground, and it is possible to recreate the angle of view in Google Earth to show that the lines of cloud in the distance are the edges of Hurricane Gladys. Figure 4.10.46 shows the ESSA photomosaic & ATS image from the 17th showing the Gulf states. Fort Worth and Galveston have been identified with red and green dots respectively on the ESSA image. The clear skies over the bulk of Texas are very obvious, as is the bank of clouds. The view across from Galveston is also mostly cloud free, until the edge of the hurricane is encountered.

Figure 4.10.44: GAP scan of AS07-07-1863

Figure 4.10.45: GAP scan of AS07-07-1864

Figure 4.10.46: ATS (left) and ESSA (right) images of the Gulf and Hurricane Gladys. The red dot identifies Fort Worth, the green dot Galveston.
Figure 4.10.46 (continued): High quality ATS & ESSA views of Gladys (see introduction for sources)
The last images in the magazine are, as mentioned above, discussed in many reports scholarly and otherwise, with good reason. The mission is the first to view tropical storms in such detail with from space, and the eye of a hurricane was marked for the first time by an overflying spacecraft. The usefulness of the space observation was not lost on the general public – one newspaper report (read out to the crew) describes them as a “manned weather satellite” under the headline “Big storm tracked by Apollo 7.”

Comparisons of satellite, radar and Apollo images of the hurricane are made in this journal article: Journal of Applied Meteorology, which describes the event as the first time all these tools had been used to examine a hurricane, and discusses photogrammetric techniques used on the Apollo image to determine the locations of key elements of the hurricane structure and explore the 3-dimensional structure of the storm.

The Apollo mission report described the photographs taken of Gladys as

“The best colour photographs of a tropical storm circulation taken from space”

observing that the Apollo photographs are better than the black and white ESSA image as

“ colour photograph enables the meteorologist to ascertain more accurately the types of cloud involved”

After the shots of the hurricane, the crew do record many more images as being taken on magazine S, but they are either mistakenly attributed, or there was a malfunction. Either way there are no more from that magazine publicly available.

The next magazine utilised in photographic work is ‘R’, and there is an interesting remark made during its use. At 166:37 GET, or 12:39 on the 18th, Schirra says that

“We can see all the launch pads and it looks like she’s ready for business.”

after which Eisele says

“We can see Saturn V on the pad”.

This obviously begs an interesting question: Could they have seen a Saturn V on the pad?

The Saturn in question would have been the Apollo 8 launch vehicle. This left the assembly building on 09/10/68, and is pictured on route to pad 39A in figure 4.10.47.
The Saturn was definitely in place when the crew made their statement. This ESSA News article notes that ESSA’s weather forecasts were critical in making a decision as to whether the Apollo 8 vessel should be returned to the safety of the hangar as Gladys approached on October 16th.

Having established that Apollo 8 was present when the observation was made, the next step is to see whether it was visible from Apollo 7. So that we can work out what we are looking for, figure 4.10.48 shows the view of Pad 39 in Google Earth, both from a distance and in close up.

Figure 4.10.48: Google Earth views at varying distance of The Apollo launch pads.
The Apollo 7 crew did take a photograph at the same time as mentioning the Saturn on the pad. A few moments before their comment, they record photographing the eye of Hurricane Gladys (AS07-08-1892). The next recorded frames mentioned in the transcript are taken of coral islands Caribbean on the next orbit, and these would correspond with photographs AS07-08-1894 to AS07-08-1898. This leaves us with AS07-08-1893, which is shown below complete with a close up of the pads in figure 4.10.49.

Figure 4.10.49: AS07-08-1893 (top), with zoomed and cropped view of Apollo launch pads (bottom)
To be fair, it is difficult to tell whether there is indeed a Saturn on the pad, but it is equally difficult to tell if there isn’t! What is clear is that they could indeed see the launch complex on that day and at that time. There are other photographs with good views of the Cape, and perhaps the most spectacular are two of the SIV-B in angry alligator mode AS07-03-1545 and AS07-03-1545. The latter is included below in figure 4.10.50 partly as a comparison image, partly because it exists as a high resolution TIFF image and partly because it is such a great photograph!

Figure 4.10.50: AS07-03-1545 (top), with zoomed and cropped view of Apollo launch pads (bottom)
AS07-11-2038 also has a good view of the cape, but the pads are obscured by little fluffy clouds (figure 4.10.51).

One continent so far missing is that of Australia. The crew did take several sets of images of Australia, sometimes trying to capture the Carnarvon and Honeysuckle receiving stations as they passed over. Most of these photographs show no or very little cloud, but one image of central Australia shows an apparently considerable band that ought to be easier to pick out on the satellite image.

The picture in question is AS07-08-1903, and this is shown in figure 4.10.52, with the ESSA image shown in figure 4.10.53.
The photography report states that this image was taken at 183:45 MET, or around 06:45 on the 19th. We can also check the mission transcripts, which specifically mention the photographs of the Nile that are next in the magazine as being taken just over an hour later.

The photograph itself centres on a feature visible on the south-eastern edge of the Simpson Desert in Australia, and this feature has been marked on in figure 4.10.53. The bank of cloud on the edge of the picture is evident in the ESSA mosaic, whereas on the previous and subsequent day’s mosaic it is somewhere else entirely – confirming the timing of the Apollo image. Those of an inquisitive nature may wish to look at the photographs taken around Shark Bay (AS07-08-1907 to AS07-08-1910), where the small amount of cloud around the bay appears to be discernible on the ESSA mosaic.

Just for completeness, the ESSA mosaic pass, while dated the 18th, was actually carried out at 05:04 on the 19th.

Later on in the magazine, we have another good set of clouds that are recorded in the transcript as just the African coast, but in the GAP and the photography report as being Luanda, on the coast of Angola. The image in question has to be AS07-08-1911, which is shown below in figure 4.10.54, with figure 4.10.55 showing the ESSA image.
Once again we have, despite a low resolution and poor quality image, a satellite mosaic that still manages to be consistent with an Apollo photograph, with the coastal city visible on both pictures surround by patchy cloud. On the preceding day the ESSA image shows the area to be covered with cloud, and on the following day it is completely clear. Track 1 on the 19th was commenced at 15:09. Compared with the Apollo 7 photograph’s recorded time of 12:39.

Magazine R continues to be the magazine of choice for the next day or so, capturing as they travel what the mission report describes as

"one of the best views from space of the eye of a tropical storm"

in the form of AS07-08-1930. It is zoomed in too close to be compare with ESSA data.

One of the best shots of cloud formations off the west coast of the USA comes in the form of AS07-08-1937, (figure 4.10.56) which is described as showing the gulf of California and two of the larger islands within it, Isla Angel de la Guarda and Isla Tiburon. In reality, these two islands are quite distant landmarks, and the dominant feature in the photographs is the large bank of low lying thin cloud off the coast. We can tell that it is low lying because the island of Guadalupe (below centre) is acting as a barrier to it, as evidenced by the gap in the cloud to the east.

One of the best shots of cloud formations off the west coast of the USA comes in the form of AS07-08-1937, (figure 4.10.56) which is described as showing the gulf of California and two of the larger islands within it, Isla Angel de la Guarda and Isla Tiburon. In reality, these two islands are quite distant landmarks, and the dominant feature in the photographs is the large bank of low lying thin cloud off the coast. We can tell that it is low lying because the island of Guadalupe (below centre) is acting as a barrier to it, as evidenced by the gap in the cloud to the east.

Figure 4.10.56: GAP scan of AS07-08-1937

Figure 4.10.57: ESSA mosaic from 19/10/68.

Figure 4.10.57 above shows complete correspondence with the Apollo image. The spacecraft is above the large mass of cloud to the left of centre looking towards the relatively clear Gulf (there is a suggestion of hazy cloud), beyond which is the American Continent with more substantial cloud in the distance. Should anyone care to check the records either side of this image, they will find that clear skies prevail off the coast of North America, and once again this can be the only day on which the photograph could have been taken.

About 12 hours after these images were taken we have photographs of another tropical storm, Typhoon Gloria. Two images were taken showing the centre eye and some of the surrounding wall of cloud, but they aren’t zoomed out enough to confirm the details in the available ESSA image. Figure 4.10.58 shows the images.
For the final part of the mission other magazines are used with black and white film, but many of the photographs that are recorded as being taken are not available at the AIA, and the ones that do exist are blurred and indistinct – insufficient detail can be derived from them to determine their location. We are therefore left with colour images taken on magazine N, which returns into use in the final part of the mission.

Of those taken, the best one available for the purposes of this report is AS07-04-1592 (figure 4.10.59), which shows the Chilean coast at Antofagasta. This is specifically referred to in the transcript at 243h57m, or just short of 19:00 on 21/10/68.

The ESSA section of the photomosaic commenced on the 21st is given in figure 4.10.60, and this part of the mosaic was commenced at 18:04 on that date. The location of the distinctive coastal feature clear of cloud above centre in the Apollo photograph is shown by the green arrow. In both figures, the peninsula is clear and has an
arc of cloud offshore, which curves round to meet the shoreline further south. Another clear match between the two.

Slightly less than 16 hours after this photograph was taken, Apollo 7 began re-entry and its descent to Earth, paving the way for Apollo 8’s lunar orbital mission.

It is a shame that the video footage obtained during the mission is not well categorised in terms of when they were taken, as these do contain many beautiful sequences showing some nice weather patterns. However, without clear indications of when they were taken it is considered to be a pointless and overly time-consuming exercise to demonstrate their location. The photographs are just as useful and documented much more completely, and demonstrate more than adequately that human hands directed the cameras that took the photographs that match the satellite data.
Apollo 8’s hurried conversion to a lunar mission still left some technical issues to be resolved for the Apollo programme. The LM and other important equipment were still untested in a space environment, and docking procedures with it needed to be worked out.

This testing was left to the crew of Apollo 9: Rusty Schweickart, James McDivitt and David Scott (the only one of the three to make it to the moon). It launched at 16:00 GMT on 03/03/69, landing 10 days later on 13/03/69. The mission timeline can be found here.

The transcripts from the flight can be found here, but to be frank they are possibly the dullest transcripts of any mission. The vast majority of the conversations are technical in nature, and there is little in the way of banter recorded between the crew and Houston (certainly when compared with other missions). On top of that, neither the weather nor photography are discussed in any great detail other than requests from the ground to photograph specific targets, and little confirmation is given that these have actually been taken (although they clearly were).

The images that were taken during the mission can be found, as usual, at the Apollo Image Atlas, and high quality TIFF scans can also be found at archive.org by searching for Apollo 9. In total 1373 photographs were exposed on 11 magazines, although a substantial amount of these are from a bank of 4 cameras comprising the Lunar Multispectral Experiment (see here for more details). Detailed information about the content and location of photographs can be found in this report and accompanying spreadsheet, and for the Multispectral photos, here.

In addition to still images, video images were recorded and much of this can be found in various sources in the internet, but perhaps the best are here and here, which includes some of the most stunning sequences taken from an orbiting craft, particularly the shots taken of the CSM from the LM. Footage taken from the CSM of the LM was the inspiration for this section and will be discussed at length later.

The best satellite source is the ESSA data catalogue, which can be found here, although ATS data are also available here. NIMBUS data would be available, but the quality is generally so poor there is little point in using it. Additional sources include this image of tropical storm Rita from 08/03/69, a brief mention of Apollo 9 imagery in this journal article AMS, and an ESSA image from March 7th is given in this article studying Brazilian weather. Another ESSA image for March 10th can be found here.

As with a lunar mission, one of the first tasks to be undertaken on an Apollo mission is the extraction of the LM from the SIV-B. The only difference on this occasion is that the extraction occurred in orbit rather than on the way to the moon post-TLI. This makes for some spectacular video and photographic images, but unfortunately much of these are over relatively indistinct areas of ocean with little cloud. The exceptions to this rule are the images taken after the LM extraction, notably AS09-19-2948, AS09-19-2949 and AS09-19-2950. AS09-19-2948 is also available as a 92Mb TIFF image here.

AS09-19-2949 is shown below in figure 4.10.60, and shows the now empty SIV-B approaching the California coast, with the islands of Santa Rosa, San Miguel and Santa Cruz in view in the bottom left. As we know when this procedure took place, and where, figure 4.10.61 shows the ESSA image of California dated 03/03/69.

What the photograph shows is a relatively cloud free ocean off the coast, a large mass of thin cloud in the north of the USA, some coastal cloud on the north Mexican shoreline and a cloud free area over Mexico and the southern USA. This would seem to be what the satellite image shows us, within the limitations identified in earlier discussions of these orbital missions. On the ESSA image dated the 4th, the cloud is much less clear and is much further inland, and on the day before launch this area was

The next major stage in the mission was the EVA carried out by the crew, which involved Scott emerging from the CSM while LM pilot Schweickart observed from a loftier position out of the LM hatch as he tested out the PLSS equipment. They practised a variety of simple procedures, all of which were filmed and photographed from several angles, the most spectacular being from the 100 mile up viewpoint of the LMP.

While the photographs are stunning, the best way to determine where they were geographically is by looking at the video footage, which is effectively in three segments separated by brief pauses in filming: one over the
Pacific ocean, one crossing the Gulf of California and the final part crossing the southern US/Mexican border area and ending north of Galveston with the Mexican Gulf below.

Figure 4.10.60: GAP scan of AS09-19-2949

Figure 4.10.61: ESSA image dated 03/03/69 showing west coast of North America, with approximate location of Santa Cruz Island marked by red dot.

To illustrate this, screenshots of the video have been taken at regular intervals and overlapped to form a continuous image. The results are given in figure 4.10.62a-c.

Figure 4.10.63 shows the ESSA image covering the same area from 06/03/69.
Figure 4.10.62: Screengrabs from Apollo 9 video footage of the EVA compiled into continuous images.
It is difficult to pinpoint with certainty the location of the first section of video footage. It is evidently over a long expanse of ocean, and we know it must be the Pacific because it occurs before the Baja California segment.

The EVA started at 16:59 on 06/03/69 with the opening of the LM hatch, followed a few minutes later by the opening of the CM hatch. As the foot of the LMP emerged from the hatch, the signal was being routed through Huntsville, a ship stationed east of Papua New Guinea, and shortly after the commander emerged they switched to Redstone, stationed at roughly the start of the red line in figure 4.10.63. It seems reasonable to assume then, that figure 4.10.62a shows the EVA passing over the light cloud west of Baja California, finally passing over clear blue ocean just off the coast.

The cloud free zone continues all the way across Mexico and the southern USA, and it is possible to make out Lago Boquilla, Lake Amistad and Canyon Lake on the way to the last section at Galveston, where some beautiful cloud formations can be seen stretching into the Gulf before a much more solid band of cloud is seen in the distance over Florida.

At the end of the video sequence, there is a bit of rapid camera work while passing over the large bank of cloud covering the eastern Gulf coast, before a good shot is obtained that looks eastwards. This is shown in figure 4.10.64, and the patterns in the cloud suggest that the shot is taken looking south-eastwards over the Florida peninsula.
In addition to the video footage, there are still images of the Gulf portion of the EVA taken by Schweickart, and these can be joined together to form the photomontage in figure 4.10.65. The photography report for the mission actually mis-identifies the date for these photographs, stating that they are from the 9th, when they feature between shots of astronauts taking part in the EVA.

Figure 4.10.65: Photomontage of GAP scans of [AS09-19-2989], [AS09-19-2990], [AS09-19-2991] and [AS09-19-2992].

There are also still images of the Pacific sequence of the video taken by the LMP to be found on magazine 20, and these seem to be taken above the location of Redstone, looking westwards. Figure 4.10.66 shows one of these photographs, [AS09-20-3080]. The object near Schweickart’s head is a thermal experiment, and he can be seen trying to retrieve it in the video.

Figure 4.10.66: GAP scan of AS09-20-3080
There is another view of the EVA featuring the weather beneath Apollo, but it is not perhaps where you would expect to find it. One of the cameras used to film the EVA was attached to the CM hatch window – it can be seen in figure 4.10.67.

Figure 4.10.67: Close-up of GAP scan of AS09-20-3061 showing the mounted video camera

In the video footage shot by this camera there are several moments when Schweickart is directly in front of it. Reflected in his helmet is the view below him: Earth. Figure 4.40.68 shows a collection of screenshots taken of Schweickart in this sequence. The screenshots have been reversed, because the helmet is reflecting the image below and is therefore showing it back to front, but the time markers have been left as in the original screenshot.

Figure 4.10.68: Succession of reversed screenshots from video taken by the CM window camera during the Apollo 9 EVA.
It should be emphasised that the curvature visible is obviously a product of the helmet, and is not the actual curvature of the Earth below. It isn’t clear what weather systems the footage is showing, and as Schweickart is mostly out of shot during the video it is difficult to tie it down to his actions, but as the continental landmass is mostly clear it can only be over the Pacific or from the Mexican gulf. If a choice had to be made, it is possible that the large isolated ‘blob’ of cloud in the top left image is the same one visible on the eastern side of figure 4.10.65, just inland of the Gulf coast.

It is also interesting to compare a rotated view of the last image with a section of the ESSA mosaic showing the coastlines of Louisiana and Mississippi (figure 4.10.69).

Figure 4.10.69: Helmet reflection (top) compared with ESSA view (bottom)

What is obvious is that Schweickart is looking at a moving scene beneath him, and that the scene is the terrestrial weather. Similar views are to be had in Scott’s helmet eg AS09-19-2994.

The next step in the mission was to test the LM in solo flight, and therein lies the subject of the challenge that led to the writing of this section. The challenge was: identify the location of the two photographs in figure 4.10.70, and the assumption of the challenger was that it would not be possible. His was the claim that Apollo 9 was faked and did not occur, and he was confident that he would be able to continue to claim so when the location of the image proved impossible.

This author likes a challenge.

Figure 4.10.70: GAP scans of AS09-21-3181 (left) and AS09-21-3199 (right)
The solution to the problem of locating these images is, however, a simple one of logical deduction using all of the information available – something conspiracy theorists are not famed for doing.

The undocking of Gumdrop and Spider took place at 12:39 07/03/69, 92 hours and 39 minutes into the mission. At this point, the communications were being routed through Antigua. The orbital path of the two craft at that point follows one across the Atlantic and hitting the coast around Morocco, as shown in figure 4.10.71.

![Figure 4.10.71: Flight paths across the Atlantic for Apollo 9. Source: NASA](image)

In order to solve the mystery of where these two images are in that Atlantic path, we need to switch to the video footage of the ‘formation flying’ of the two vessels. As before, it is possible to take regular screenshots and merge them together to get a continuous transect of the Atlantic ocean.

As we know that the event occurred on 07/03/69, and we know where, we can say with certainty that the ESSA 7 mosaic from that date covering the north Atlantic is the correct one to use. In order to make life easier, it is possible to superimpose that mosaic on a Google Earth sphere, as this will allow us to compare the video montage. This is shown below in figure 4.10.72, and the montage itself in figure 4.10.73, in which the photographs taken during the formation flying have been placed according to their position in the video montage.

![Figure 4.10.72: ESSA photomosaic from 07/03/69 superimposed on Google Earth. The red line indicates the Apollo 9 flight path](image)
Photomosaic of Apollo 9 LM formation flying with photographs from magazine 21 in their geographically correct location.
As figure 4.1.73 shows, the photographs clearly match up with the weather patterns on the video footage, but can we be certain that we have the locations correct?

The best clue here comes near the end of the sequence in the form of AS09-21-3206. This photograph features the coast of Morocco, which is easily shown by superimposing it on Google Earth, as shown in figure 4.10.74.

![Figure 4.10.74: AS09-21-3206 superimposed on the Morocco coast in Google Earth.](image)

So, we have the start of the formation flying as somewhere in the Caribbean, and the end of it over Morocco. Does this now allow us to pinpoint the location of the two photographs? The answer is in figure 4.10.75, and, to put it bluntly, the answer is ‘yes’.

![Figure 4.10.75: Photomontage from video footage of ‘formation flying’ matched with photographs from magazine 21, and superimposed on ESSA photomosaic from 07/03/69.](image)

The overlay is not perfect, but considering that the ESSA mosaic superimposed on Google Earth has been perspective distorted, and there has been no attempt at correcting the orientation of the video stills, there is an excellent match between the clouds shown and the video photomontage. Even the length of the video sequence matches the distance that would be covered – just over 4000 miles in about 15 minutes where the ocean is visible on the video.
The still images are placed in their correct position underneath the video montage, and this allows us to state with a good degree of certainty that AS09-21-3181 is in the location marked by the white ‘X’, and AS09-21-3199 over the black ‘X’.

The end of the video sees the camera view move to a more oblique view, and that view can also be seen in the series of photographs beyond the Moroccan coast, where the vista extends as far as Libya. There is, on that view, a clear shot of cloud formations that ought to be visible on the satellite data. Figure 4.10.76a-c assesses if this is the case.

Figure 4.10.76: Annotated views of north Africa: a) From video footage (top) b) Photomontage of AS09-21-3210 - AS09-21-3217 (centre) & c) ESSA image dated 07/03/69 (bottom). Features in a) & b) are identified in c)
The bank of cloud found in the video still is also very obvious in the ESSA image, which was taken a couple of hours after Apollo 9’s images. Further inland there is the patchy area of cloud that I have identified with a green arrow on the still image montage. This is a more approximate location on the ESSA photograph than the others used, but it fits with the other features visible, most obviously the location of the Tunisian and Libyan coast in the distance.

We can also be certain that we have the correct date for these cloud features, as figure 4.10.77 shows that the cloud features were not the same on the days before or after the formation flying sequence.

![Figure 4.10.77: ESSA images from the 6th (left) 7th (centre) and 8th (right) of March 1969.](image)

Could there have been some magical jiggery-pokery with satellite photographs? Well, frankly, no. As hinted at above, the Apollo images were taken at least 2 hours before the ESSA image, and the Apollo craft was travelling in the opposite direction to the satellite in a west-east direction, rather than ESSA’s geosynchronous north-south movement.

It is a shame that the person who made the original challenge leading to the preceding analysis was banned from the forum in which it was made shortly before the response to it was posted. He may never have seen his argument comprehensively refuted, and he might still be ignorant of the facts presented. No sleep has been lost over this.

After a few more orbits, the LM descent stage was jettisoned, and there was more formation flying of the LM ascent stage and CSM. Separation of the LM into its component parts occurred at 96:16 MET, or 16:16 on 07/03/69. Formation flying is recorded as occurring at 18:40, and the LM & CSM were re-united at 19:02.

At the time of separation, communications were being routed through Tananarive on the island of Madagascar, although the flight plan records the initiation of the co-elliptical flight manoeuvre began over the mid-south Atlantic. This manoeuvre positioned the LM some 10 miles below the CSM and 82 miles behind it. The two craft were then brought together to within 100 feet to allow photography from both vessels. Communications by this point were routed through Goldstone in California, but at the start of the manoeuvre were through Hawaii.

Much of the early co-elliptic sequence is over indistinct ocean, but there is a sequence of images as the two craft are brought together that identifies where they are, despite the photographic report not giving any indication. The key image turns out to be AS09-21-3234, which is simply described in the records as ‘Lunar Module, Clouds’. Closer inspection of the image, and a little altering of the light levels, shows in figure 4.10.78 that the island of Hawaii is centre stage.

The preceding 10 or so images can be combined to produce a photomontage, but as the camera is quite oblique and the photographs are taken close together, they are little different and not quite as good as a sequence of screenshots from the video footage of the event. That video sequence is shown below, roughly to scale and superimposed on Google Earth in figure 4.10.79. Figure 4.10.80 shows the ESSA image of Hawaii (identified by the red dot).
Figure 4.10.78: AS09-21-3234 (centre) with zoomed inset from it of Hawaii (top) and Google Earth image of Hawaii from the same angle (bottom)
Figure 4.10.79: Photomontage of video screenshots from the ascent stage flight towards Hawaii on 07/03/69

Figure 4.10.80: ESSA image dated 07/03/69 with red dot identifying Hawaii
The cloud surrounding Big Island in the ESSA photo also seems to be evident in the video montage in figure 4.10.79, as does the light cloud seen on the approach to the island.

The location of the video sequence prior to that of the Hawaii approach is a little less clear. It consists of a long sequence of ocean shot at varying speed, with no land mass evident. The amount of time involved between the initial co-elliptical burn over the mid-Atlantic and the station keeping and formation flying means that only about 1.5 orbits could have occurred. As the final path ends over Hawaii, this means that realistically there are only two possible locations for this video sequence, either the southern Indian Ocean or the Pacific between Australia and Hawaii.

The satellite image available for the 7th suggests that the equatorial region between Australia and Hawaii should feature a thick band of cloud bounded by much clearer conditions, but this doesn’t appear to be what the footage shows. It seems more likely that it shows the ocean between Madagascar and western Australia. Figure 4.10.81 shows the video screenshot montage compared with the ESSA mosaics over the Indian Ocean and Pacific respectively.

![Image](image_url)

**Figure 4.10.81:** Ascent stage flight paths shown by a) video montage (top) b) Australia to Hawaii (bottom left) and c) Madagascar to Australia (bottom right).

While the LM was being photographed by the command module, the command module was also being photographed and filmed by the LM. There is a particularly impressive film sequence taken (according to the narrative in ‘Three to make ready’, a NASA documentary on the mission) while the descent and ascent stages were still joined together. The start of the sequence looks back eastwards across Egypt (the Nile is visible at one point), and towards the end the Red Sea is shown beautifully as the LM recedes from the CSM. Figure 4.10.82a shows the view back across Egypt towards Libya, and 4.10.82b the view of the Red Sea. Figure 4.10.82c shows the ESSA mosaic of the region on the 7th.

While much of the desert area is cloud free, it is possible to make out the stripes of cloud in the darker patches of the Libyan desert (blue arrow), that would, if you were to go far enough east, eventually lead to the larger cloud patterns featured in images taken from the CSM.

There are also images of the CSM taken after separation of the descent and ascent stages and these are to be found in magazine 24, Several frames that can be joined together to make a longer montage, namely AS09-24-3653 to AS09-24-3660. This is shown below in figure 4.10.83a, with its companion ESSA mosaic in 4.10.83b.
Figure 4.10.82: North Africa as seen from the LM a) Looking west towards Egypt and Libya (top) b) Over the Red Sea (middle) and c) The ESSA mosaic from 07/03/69 – red line indicates orbital path
Figure 4.10.83: a) Photomontage of the view of the CSM from the ascent stage (top). Note the reflection of the ground and clouds in the CM’s reflective covering. b) ESSA mosaic from 07/03/69 (bottom). Red line indicates approximate orbital path

The video footage of the CSM hovering above the Red Sea is matched only by the still images of the shiny spacecraft above its homeland, aerials pointed towards ground receivers, the clouds reflected in the thin skin separating the human cargo from an icy breathless void.

The thin clouds above New Mexico and Texas are there in the ESSA mosaic just as clearly as the clear skies over the Californian Gulf visible in the distance. While you would be hard pressed to identify specific cloud features in ESSA’s photography, you would be equally hard pressed to deny that the clouds in the photograph are not those pictured by the orbiting satellite.

Once the ascent module was discarded, there are few events that allow us to be completely certain when a photograph was taken other than the records kept by the crew, but there are still several days’ worth of photographic objectives to study!

While the relative low altitude of these missions continues to make comparison with satellite photomosaics difficult, there are several occasions here multiple images can be combined to produce a much broader image that can be used. Two such montages are available from the 8th of March.

The first occurs with views of the Californian coastline, recorded as being taken on the 8th, using AS09-22-3356 to AS09-22-3359. The result is shown in figure 4.10.84, along with the ESSA image from the 8th.
Figure 4.10.84: a) Photomontage of AS09-22-3356 – 3359 (top). b) ESSA mosaic from 08/03/69 (bottom). Red line indicates approximate orbital path.

There is a good degree of correspondence here between the ESSA mosaic and the still image montage, so much so that it is actually worth putting a few arrows on - from the larger cloud mass off California to the thin line of cloud just inland. Larger areas of cloud further away from the coast are also visible in the Apollo photographs. It’s worth noting that two other photographs showing Baja California on the 8th, and these show different viewpoints - AS09-21-3262 and AS09-21-3263. The simple explanation for this is that these latter images were taken at just after 17:00 GMT, compared with the images in figure 4.10.84’s 21:17. ESSA’s pass over the region was commenced at 22:06, so obviously will resemble Apollo 9’s images more.

Meanwhile, on the opposite coast, a few more photographs were taken looking up the eastern seaboard from South Carolina towards a cloudy New York. The photomosaic of images AS09-21-3270 to AS09-21-3276 is shown in figure 4.10.85.

There is a good degree of correspondence here between the ESSA mosaic and the still image montage, so much so that it is actually worth putting a few arrows on - from the larger cloud mass off California to the thin line of cloud just inland. Larger areas of cloud further away from the coast are also visible in the Apollo photographs. It’s worth noting that two other photographs showing Baja California on the 8th, and these show different viewpoints - AS09-21-3262 and AS09-21-3263. The simple explanation for this is that these latter images were taken at just after 17:00 GMT, compared with the images in figure 4.10.84’s 21:17. ESSA’s pass over the region was commenced at 22:06, so obviously will resemble Apollo 9’s images more.

This pass by ESSA would have been commenced at 18:06, compared with the recorded time for the Apollo images of 17:16. It is difficult to make out the main cloud features because they are quite small, but suggested locations of the two obvious ones are shown by the green and yellow arrows.

A much easier to place cloud system described as in the Atlantic can be found in images AS09-21-3277 and AS09-21-3278, which are combined in figure 4.10.86.
Figure 4.10.85: a) Photomontage of AS09-21-3270 – 3276 (top). b) ESSA mosaic from 08/03/69 (bottom). Red line indicates approximate orbital path.

Figure 4.10.86: AS09-21-3277-8 showing cloud systems in the Atlantic.
The east-west banding in the centre of the image shown by the maroon arrow is obviously the same as in the ESSA mosaic in figure 4.10.85b. The orbital path of Apollo 9 is entirely consistent with the view up the coast and the view of these clouds.

We return to the US on the 10th, with a series of pictures covering the Gulf and Florida area taken around 17:40 GMT. The first set (AS09-19-3040 to AS09-19-3045) show the area around New Orleans & the Mississippi delta. The second set show features a little further east in AS09-19-3047 to AS09-19-3049. The compiled photographs are shown over the page in figure 4.10.87, together with the ESSA mosaic from the 10th.

The ESSA pass for this area was commenced at 20:06, so roughly two and a half hours elapse before the Apollo photographs are taken. The spear-like strip of cloud cutting across Florida in 4.10.87c is very obvious in the ESSA mosaic, but is much further south, something obviously explained by the time gap involved. The cloud banks over New Orleans are less obvious, but the clear air to the south of it is.

Zooming in on 4.10.87c also shows Cape Kennedy’s launch pads.

Figure 4.10.87: a) Photomontage of AS09-19-3040 – 3045 (top). b) ESSA mosaic from 10/03/69 (middle). Red line indicates approximate orbital path, yellow dot New Orleans. c) Photomontage of AS09-19-3047 - 3050
A few hours later, the crew take a couple of photographs of central Honshu, Japan, in the form of AS09-23-3503 and AS09-23-3504. These are shown combined in figure 4.10.88 below, together with the ESSA image of the area.

![Photomontage of AS09-23-3503 – 3504](image)

![ESSA mosaic from 10/03/69](image)

**Figure 4.10.88**: a) Photomontage of AS09-23-3503 – 3504 (top). b) ESSA mosaic from 10/03/69 (bottom). Red line indicates approximate orbital path, yellow dot is Nagaya.

Again the ESSA mosaic lags behind the Apollo photograph by some time (04:06 on the 11th for the former, 23:35 on the 10th for the latter), but there is still a clear area over Nagaya and a bank of cloud behind it. There are also cloud formations nearby that would match the thin strip of cloud in the area.

On the following day we return to the eastern US seaboard with a montage of images AS09-23-3552 to AS09-23-3557, which are recorded as being taken at 14:42 on the 11th. The combined image is shown below in figure 4.10.89. The missing states are the Carolinas and Georgia.
What we can see in the photomontage is clear skies over the southern states, light cloud over the gulf and northern USA merging with thicker cloud off the coast. The ESSA view shows the same scene, with a few minor differences, easily explained by the time difference between the mid-afternoon Apollo image (14:42) and the early evening ESSA pass (19:06). The clear shoreline in the south is the same, the merging of light cloud with thicker off shore cloud in the north is the same, as is the light cloud on the gulf coast of Florida. The main difference there is that cloud from the Gulf has moved across northern and southern and Florida.

Meanwhile, in the Pacific, a spectacular cyclonic system is captured in AS09-23-3592 and AS09-23-3593 and which is shown below in figure 4.10.90. The storm was captured at 19:17 on the 11th, at around 160°W 30°N, or south of the Kamchatka peninsula and east of Japan.

Although there are two cyclonic patterns evident on the ESSA montage, there are a number of features identified with arrows that allow us to be certain that the position given in the photography report is accurate. The time difference between the two sets of images (19:17 on 11/03/68 for the Apollo photographs compared with around 01:01 on 12/03/69 for ESSA) is the main reason that accounts for the differences between the two – notably the much less well defined central whirl of cloud in the ESSA image.
And finally we reach 12/03/69 – the last full day of the mission, and for today’s example we turn to one of the multispectral photography passes that were carried out daily after the completion of the EVA and LM testing part of the mission. On one pass completed on the 12th, successive images were taken making a continuous transect starting from Baja California and ending in Texas. These images (AS09-26A-3796A to AS09-26A-3811A) have been combined and superimposed on Google Earth in figure 4.10.91.

The pass starts with a mass of cloud west of the coast, intersects another cloud mass in the central portion, before ending with another small area of cloud. The ESSA mosaic shows exactly the same pattern despite it having been assembled over several hours compared with several minutes for the Apollo photomontage. Apollo’s photographs were commenced at 16:27, compared with ESSA’s 20:06 commencement over that part of north America.

24 hours after commencing this pass over north America, the crew splashed down in the Atlantic, and NASA began preparing for Apollo 10’s full rehearsal for the lunar landings.
Figure 4.10.91: a) Photomontage of AS09-26A-3976A – 3811A (top). b) ESSA mosaic from 12/03/69 (bottom). Red lines mark approximate start and end of transect.
4.10.5 Conclusions – again

So, what have we learned in this section?

It should be obvious from the preceding discussions that LEO missions do not cover anything like enough of the Earth’s surface to show a complete globe. Only when the orbits become highly elliptical or when the camera view is very oblique do we get a significant portion of the Earth’s surface covered.

The well-defined orbits of these missions means that significant portions of the earth are not seen at all, compared with the lunar missions where the entirety of the globe can be seen. Perhaps HEO orbits would provide the necessary coverage? Well, they would, but these orbits are geostationary, and would not see the entire Earth. Elliptical orbits may show more, but they still travel west to east, compared with the lunar mission images that show Earth rotating below them in the opposite direction.

Even a spacecraft positioned a few thousand miles up would not see the entire globe – as shown in the montage in figure 4.10.89. This image is a combination of Apollo 11 made to demonstrate what was being shown by the photographs to sceptics – it seemed a shame to waste it. It is shown with the appropriate ESSA mosaic for reference as well as a mosaic of the latest NIMBUS scans. Also included in the image is an inset of AS11-36-5300. This photograph was taken 1 hour 25 minutes into the mission while still in - the Earth Parking Orbit occupied during systems check-out, compared with the photomontage taken after TLI.

Figure 4.10.92: ESSA mosaic from 16/07/69 (left) compared with photomontage of AS11-36-5302 to AS11-36-5309 (right). Centre image is AS11-36-5300, reduced to the correct scale and orientation. Below this is a montage of 7 NIMBUS tiles.
Two things should be immediately obvious. Firstly, the amount of the surface visible in the component images of the larger photomontage is vastly greater than the still-in-orbit photograph. In the space of a couple of photographs the amount of distance above the surface has increased massively, from a few hundred to a few thousand miles.

Secondly, there is the change in weather between the two images. Even over just a couple of hours there has been a distinct alteration in the pattern of clouds over Baja California. This again illustrates the general rule when looking at the micro-scale weather patterns of small regions compared with the macro-scale patterns visible on entire planet images – small areas will exhibit changes over time that can alter the appearance of a weather system dramatically. On the global scale, these changes are less likely to make a dramatic change to the overall appearance.

Perhaps less obvious is the change in angle of the photographs. The LEO image is looking across the surface towards the horizon, and the elongation of landscape features (and fantastic shadows under the larger clouds) is visible as a result of this. The post-TLI images are looking more or less vertically down. As a result shadows are much less pronounced and the only distortion evident is as a result of the Earth’s curvature.

Given the issues just outlined, can we be confident that we have identified weather systems appropriately in the preceding sections? There is always the danger of pareidolia – seeing what you want to see, and I have always strived to avoid that. Certainly in some of the photographs it is difficult to be absolutely certain, but in others it is much clearer.

What has been demonstrated is that with diligence, detective work and the application of logic, it is possible to determine where photographs have been taken, when, and what they should be showing. While in some cases it hasn’t been possible to be absolutely certain that we have identified a specific cloud, not once has there been an occasion where someone can say ‘this is completely wrong’.

Can we be sure that Apollo 7 & 9 did happen as described?

Yes, of course we can. Only an idiot would claim otherwise. The photographs and video footage are obviously genuine, and techniques that could produce ‘fake’ ones of such accuracy and realism would not exist for decades after the missions (and arguably still don’t).

The only possible motivation for claiming them to be fake is that accepting Apollo 7 and 9’s testing of Apollo’s techniques and hardware seriously compromises claims that astronauts could not have reached, or survived on, the lunar surface. A working LM and a functional PLSS completely ruins sceptical claims that the equipment was untested and incapable of the jobs required of them.

Apollo deniers need to face facts: we went to the moon in tried and tested equipment and took photographs and films to prove it. Those photographs and films feature Earth, and that Earth looks different every day. Every satellite photograph is a visual fingerprint uniquely identifying a moment in time, and those fingerprints match Apollo’s visual record consistently and accurately.
4.11 A Closer look at Apollo 10 and 11.

As an evolving project, this researcher has always been keen to look for new sources of data that support the idea that satellite meteorology provides conclusive proof that the pictures of Earth taken by Apollo are absolutely genuine. One such proof recently emerged with the discovery of a book compiling satellite images as part of the BOMEX study.

BOMEX (Barbados Oceanographic and Meteorological Experiment) was a research project looking at the interaction between the Ocean and Climate in the Caribbean, as detailed here. It ran between May 1st and July 28th 1969, and thus covered the Apollo 10 and 11 missions. Some data from this research was found when looking into Apollo 11 (see here), but recently a more detailed collection of satellite images from the ATS-III and ESSA-9 was uncovered using the top secret hush hush method of ‘Googling’. The document in question is this one, and is useful because with the ATS images it not only gives several taken in quick succession but actually zooms in much closer than the hemispheric view we usually get. It also presents ESSA images in the original format, rather than the circular projection used for much of this research and these were used by BOMEX when ATS had a transmitter problem. Additional studies of the ESSA and ATS images can also be found here, here and here and are included where possible. ATS images were also produced for this conference paper in 1972. We’ll also include NIMBUS-3 tiles where available.

The time sequence of photographs allows us to pick the image that matches most closely the times that we have estimated for selected Apollo images to see how they compare.

Rather than overcomplicate the existing structure, and to avoid having to do a lot of renumbering of figures, I’ve added this as a new section.

So, let’s start with Apollo 10.

4.11.1 - Apollo 10

The BOMEX study was focused on the Caribbean, which means that the first image available to us from Apollo that is any use is actually from May 23rd - AS10-27-3889. This is the first date where we have images available from Apollo 10 and ATS-III that cover the area we need to see, and is actually one of the first Earthrise images from the mission.

Observations given here suggest a time for the photograph of around 18:45, based on the terminator position and the weather data available in other satellite images. We also have this from the mission transcripts:

122:05:53 Stafford (onboard): Hit it, quick. Go, baby, go.

122:05:56 Young (onboard): What?

122:05:57 Stafford (onboard): The Earth. Hit it. Again, baby...

Followed by some suggestions about with camera settings would work. This converts to a time of 18:54 on the 23rd.

The BOMEX document has 3 close up images from that date, taken at 11:41, 16:04, and 17:54 GMT, so we have one taken within an hour of the Apollo image. As Earth’s climate is a dynamic and evolving thing, a photograph taken 7 hours before the Apollo one is likely to contain a broad similarity to it, but the finer details should be different.

Let’s see how that works out by looking at figure 4.11.1.
Figure 4.11.1: ATS-III images take at 11:40 (top left), 16:04 (top right), 17:54 (bottom left) compared with AS10-27-3889.

Left is a NIMBUS-3 image taken at 14:33.
The square on the ATS photographs represent the location of ocean going research vessels. At the bottom of each image is the coast of northern South America. The details in the Apollo image are slightly affected by the difference in viewing angle.

So - which one do we think contains the most similarity to the Apollo picture? The answer is, quite obviously the one taken an hour before the Apollo one. The most obvious feature showing this is the one in the top right of the satellite observations, which can be seen developing over time. I've not used arrows here - if you can’t see the resemblance there’s no point nailing it on a mast for you!

The next available shot of the Caribbean is covered by an ESSA-9 image, and while we only have one it is considerably more detailed than the one available when writing this section. The Apollo photograph in question is AS10-27-3952, and in figure 4.11.2.

Figure 4.11.2: AS10-27-3952 compared with an ESSA-9 image from the BOMEX report.
The estimated time here for the Apollo image is 18:45, which compares well with the 16:32 time for the ESSA-9 frame. As this image is relatively low quality, I’ve added some indicator arrows so you can work out what’s what, and I’m sure you’ll agree the correspondence is very good.

The next ESSA-9 shot 24 hours later has a better quality Apollo image, AS10-35-5269, and this is shown in figure 4.11.3 below. In this example I have compensated for Apollo’s viewing angle by stretching the Caribbean area to match the ESSA perspective more closely. You are welcome to try this yourself to ensure it doesn’t introduce image artefacts.

![Figure 4.11.3: AS10-35-5269 compared with an ESSA-9 image from the BOMEX report.](image)

The Apollo picture is estimated [here](image) to have been taken at 18:00, compared with an ESSA time of 17:29, and the correspondence is obvious enough not to need illustrating with arrows. Amazingly, the closer the satellite image time to that of the Apollo image, the greater the degree of correspondence between them.

That’s all we can do for Apollo 10, time to look at Apollo 11.
4.11.2 - Apollo 11

The first photographs we can look at for Apollo 11 were all taken within a short time span on the way out towards the moon. As discussed here, AS11-36-5357, 5362 and 5366 were taken at around 17:30, 18:30 and 20:30 respectively on July 17th 1969. The ATS photograph used in the earlier analysis was the larger view taken at 14:55 on that day.

The BOMEX document supplies additional 2 additional images from ATS taken at 11:15 and 20:17, so we have one image taken almost at the same time. Before we look at those, let’s see how Caribbean weather patterns develop in the three Apollo images in figure 4.11.4.

![Figure 4.11.4: The Caribbean area in AS11-36-5357 (top left), 5362 (top right) and 5366 (bottom).](image)

The first thing to point out is that the three images are not identical. The broad patterns of weather are the same, but there are notable subtle differences between them, particularly in the movement of the horizontal strips of cloud in the top right, and the development of the clouds over the South American landmass bottom left.

We know that the closest image to any of the ATS ones is the one on the right, taken at almost the same time, so how the Apollo image compare with the satellite ones?
Figure 4.11.4: ATS-III images compared with AS11-36-5366. Below this is a NIMUS-3 IDCS image.
It’s obvious really, and it shouldn’t have to be pointed out, but the ATS photographs very clearly show that the nearer you get in time to the Apollo photograph the closer the degree of correspondence. As you would expect, the last one in the ATS sequence (bottom left), while it has suffered from the fading light as the region nears the terminator, shows an exact correspondence with the Apollo photograph taken at the same time. The NIMBUS image does not quite cover the same area, and was taken at 15:38 and is a match for the earlier ATS images but less so for Apollo.

We have another sequence of ATS photographs taken on the 18th and an Apollo image (AS11-36-5381) taken at around 21:00. Figure 4.11.5 shows the sequence.

As before, the development of weather systems is very obvious from the sequence of ATS photographs, and as before the closer in time the ATS image is to the Apollo one, the greater the degree of correspondence between them.

As well as BOMEX collecting satellite data, it also collected photographs taken from the ground. One example of that can be found in this report, which shows advancing cumulus clouds viewed south from Barbados. Barbados’ location, and the photographs themselves, are shown in figure 4.11.6. The ground based images were taken around an hour before the ATS view (10:07 - 10:22 GMT), and therefore roughly seven hours before Apollo’s photograph. That combined with the relatively low resolution would make it very unwise to say “these are the same clouds in the Apollo image”, but the ground images match the satellite ones, and the satellite ones match Apollo. If anyone wants to prove they don’t, feel free to try.

Most of the Apollo images taken during the landing itself show the Pacific, so sadly we don’t get the opportunity to repeat this exercise for images taken at the moon itself. The only two that do show the relevant area of the Caribbean are either too out of focus (AS11-37-5442) or the ATS sequence isn’t available (AS11-44-6642) so we wouldn’t be able to reveal much more than has already been done here.

The next clear image of the region was taken on the way home, and while there are only two ATS images, the view of the Caribbean is very clear and worth examining. Figure 4.11.6 shows the two ATS images together with AS11-38-5684 which I estimated here to have been taken at around 19:00 on the 22nd.

Despite the fact that the Apollo image was taken nearly 3 hours after the last ATS one, it bears much more resemblance to that satellite photograph than the one taken 6 hours earlier. Most notable is the separation of the long cloud mass running along the bottom of the image into several distinct masses, a developmental process that is seen to be complete in the final (Apollo) photograph in the temporal sequence.

A similar theme can be seen in the final image available to us showing the BOMEX study area, AS11-38-5706, which I estimate to have been taken at 19:30 on the 23rd. Figure 4.11.8 shows the sequence.

As before, the Apollo image can be seen as part of a logical developmental sequence showing weather patterns evolving over time, and it bears much more similarity with the image taken a couple of hours before it compared with the one taken several hours before it.

So, until I get round to buying the actual book (copies are available but aren’t cheap) or getting hold of images, that’s all we can do here. What we have managed to is provide more evidence that the unique meteorological fingerprint represented by the Apollo images are indeed time and date specific and that the Apollo images are part of a temporal sequence showing the continuous evolution of weather systems - they aren’t just a one off scene existing in isolation or part of some set designer’s imagination.

It also shows that the data supporting Apollo are, and have always been, publicly available to anyone who cares to look, and if you want you can even buy the books (figure 4.11.9).
Figure 4.11.5: ATS-III photographs taken at 11:37 (top left), 15:31 (top right) and 20:17 (bottom left) compared with AS11-36-5381 (bottom right). Below this is a NIMBUS-3 IDCS image taken at 14:54.
Figure 4.11.6: Map showing the location of Barbados, cumulus images photographed viewed south of Barbados, and close up of the ATS satellite view of that area.
Figure 4.11.7: ATS images taken at 11:35 (top left) and 16:10 (top right) compared with AS11-38-5684 (bottom right). Left is a section of AS11-44-6669, taken at roughly the same time as the B&W image - note the sunglint off Lake Brokopondo in Suriname.

The Apollo image has been perspective corrected.
Figure 4.11.8: ATS images taken at 11:25 (top left) 14:26 (bottom left) and 16:11 (top right) compared with AS11-38-5706 (bottom right). Below this is the NIMBUS-3 IDCS tile, taken at 14:49.

The Apollo image has been perspective corrected.
Figure 4.11.9: BOMEX books published in 1971 and for sale on eBay.
Apollo 17 in orbit

Most Apollo missions only began their photographic record once they had left Earth orbit. Apollo 11 and 17 are the exceptions, but while Apollo 11 took a small number focused mainly on a hurricane off Central America, Apollo 17 used its time in Earth Parking Orbit (EPO) to take many photographs of the landscape below them before the TLI burn that took them to Taurus-Littrow.

While the location of some of the images are known, many of them are listed simply as ‘Earth, Ocean, Clouds’, and when you’re locked down with not much else to do, what else can you do but try and see if you can put some more detail into what is already known. The question, therefore, that this page will try and answer is “Can we work out where, and when, these images were taken?”. To do this we have a number of tools at our disposal, namely the known EPO track of the orbiting Saturn IVB stack, the weather satellite record, the mission transcripts, and the famous ‘Blue Marble’ image (as well as others taken after Trans-Lunar Injection, or TLI) that shows the broader context of the daylight illuminated planet below them.

Let’s begin at the beginning.

Apollo 17 launched at 05:33 on December 7th 1972, a couple of hours behind schedule after two unscheduled hour long delays thanks to technical issues. They inserted into Earth orbit at 05:44, commencing the TLI burn procedures 3 hours later after two successful EPO passes. Figure 4.12.1 shows the charts with the orbital trajectories on them, figure 4.12.2 shows which parts of the Earth were in daylight at those times, and figure 4.12.3 shows the relevant satellite image view of the Earth on the 7th.

![Figure 4.12.1: Earth Orbit charts (also known as APO charts). The one on the left is from this book, the other two from copies sold at auction (hence the autograph).

NB: The December 6th date refers to what would have been the date in the USA had the mission taken off on time.](image-url)
Figure 4.12.2: Daylight portions of the Earth at Earth Orbit Insertion (top) and Trans-Lunar Injection (bottom).
Figure 4.12.3: NOAA-2 satellite data from 07/12/72, both from the original document (left) and the digitally restored version (above).
Figure 4.12.4 shows the famous Blue Marble shot in its original uncropped form and cropped to show the area covered by the EPO trajectory. Other images taken after TLI show these areas in greater detail and were taken nearer in time to the orbital phase. For the most part, the links provided will be to the Project Apollo Flickr account, but more detailed images from this site will also be used.

The scene is set, the task now is to look at the orbital images and place them on the map.

The first shots are pretty easy as their locations are already known. AS17-148-22607, 22608 and 22609 are in North Australia - two from the coast of the Gulf of Carpentaria, the other on the eastern shore of the Cape York Peninsula in northern Queensland (figure 4.12.5).

Photos 22607 and 22608 are obviously of the same place, so let's deal with those first. The Gulf of Carpenteria is the area between the two ‘prongs’ on the north Australian coast, and if you refer back to the EPO charts you’ll see it is clearly covered by the flight path. The photos were taken around an hour into the flight, as at 59 minutes we have this comment:

000:58:03 Cernan: Okay, we’re looking at the deserts of Australia right now

At this point communications were being routed through Honeysuckle Creek, as noted by the PAO (Public Affairs Office). This page shows the times of Honeysuckle Creek’s involvement. In terms of where we are looking, the photographs are pretty much oriented in the direction of travel, and we can confirm their location by looking at Google Earth (see figure 4.12.6).
The final photograph in the trilogy is looking almost vertically downwards, and we have confirmation of the time in this exchange:

*001:00:33 Evans (onboard): Oh, look at the coral reef there, Geno.*

* Cernan (onboard): Yes.  
  
* Evans (onboard): Look at it; that's coral.  
  
* Evans (onboard): Fantastic, Coral atolls.  

The coral reef they are discussing is the Great Barrier Reef, and figure 4.12.7 shows a detail from the image compared with Google Earth.
The next sequence of photographs presents a more difficult challenge, in that there are no definite visual clues as to where they are. Figure 4.12.8 shows the triptych.

We're clearly looking at quite an impressive cloud feature, and at 1 hour 9 minutes we have the following:

001:08:56 Schmitt (onboard): There are some pretty lively looking clouds down there.
    Evans (onboard): Yes. Yes, yes.
    Schmitt (onboard): Better than [garble].
    Evans (onboard): Are we going right around the equator, must be.
    Cernan (onboard): Yes, we're - we're northwest of Samoa.
    Evans (onboard): [Garble] we went on a 91-degree [garble].
    Schmitt (onboard): There's a good-looking cloud for you; look at that one.
    Evans (onboard): Yes.
    Schmitt (onboard): Boy, you could snap a picture of that. [Chuckle.] I forget I got the darn camera.
    Cernan (onboard): I can get that, Jack; give me that.
    Schmitt (onboard): I got it.

So, it sounds very like they are talking about this set of photographs.

As it happens there is quite a lively set of clouds along their flight path, shown below in figure 4.12.9.

The position of the terminator shows that this lively looking cloud is pretty much on the terminator, and Schmitt (the crew's resident meteorologist as well as geologist) does point out that:
“In fact, it's a little low-pressure area, see it?”

shortly after the exchange given above.

That storm is approximately 1300 miles from the previous photograph, which must have been taken at about the point the crew were referring to seeing coral atolls. The speed recorded for them at this point is 17443 mph, or 290 miles a minute. The low pressure system identified on the satellite map is roughly 1550-1600 miles from the location of the previous photograph, so would have been taken at the most 6 minutes later.

Unfortunately there are no precise timings available for the Command Module audio transcriptions, and a lot depends on exactly how much time elapsed between seeing the coral reefs and them passing over them for the photograph.

That said, we know that around this time the crew experiences sunset, so it can’t be much further along their orbit, and the time gap between the two sets of photographs is about right. The tropical storm east of Papua therefore seems like a reasonable suggestion for the location of these three photographs.

The next image in the magazine (Figure 4.12.10) has very little to help us, and neither does the transcript).

It’s pretty obvious that we are looking at either a sunrise or a sunset, and not one of the many references we get to an airglow or other lights on the horizon, eg:

001:33:47 Schmitt: Okay, I think we got the Gulf Coast showing up now by the band of lights, Bob.

We know from our maps that sunrise actually occurs over the mid-Atlantic. While they would see that sun approaching from some distance thanks to their elevated viewpoint, it would still be a while after that remark before it appeared.

There are quite a few exchanges once they cross the California coast that indicate that the cameras have been put down, or away, or misplaced - for example, some time around 001:23:00:

Schmitt (onboard): Guess what I've lost?

Cernan (onboard): What?

Schmitt (onboard): Camera.

The crew were also quite busy as the cross the USA with the various check-out procedures they needed to complete before TLI, but despite that the only possible angle they can use to take the photograph is forwards, so it must be of the approaching sunrise.
We can be a little more definite about the next sequence of images, given that they start with an obvious only just daylight area of ocean and end, quite definitely, in the African coastline (more about this later).

The first three in the sequence are shown in figure 4.12.11.

![Image of three photographs showing sunrise over the ocean, with elongated shadows of clouds near the horizon.](image)

Figure 4.12.11: AS17-148-22614 (left), AS17-148-22615 (centre) and AS17-148-22616 (right)

We can tell that these are sunrise images mostly from the slightly darker left hand edge of the first two photographs, but mostly from the hugely elongated shadows of the clouds nearer the horizon (see figure 4.12.12).

![Image showing contrasted adjusted sections of two photographs, demonstrating elongated shadows at sunrise.](image)

Figure 4.12.12: Contrasted adjusted sections of AS17-148-22615 (above) and AS17-148-22616 (left) showing elongated shadows at sunrise.

We also have a couple of references in the transcript that allow us to position the photographs. Here we have Schmitt giving us a precise reference point:

*001:38:43 Schmitt: Looks like we're right over the Bahamas now, Bob.*

Which at this point would still be darkness. We then have the crew losing direct communications with Houston, transferring first to the airborne ARIA system and then Ascension island at 001:51.
17 minutes later we have:

001:55:26 Schmitt: Okay, Bob. We had - as usual - up here [laughter] a spectacular sunrise

Figure 4.12.13 shows the relative position of the terminator and the location, and receiving capability, of the Ascension Island tracking station.

[Image: Figure 4.12.13: Terminator position (above) and the location and receiving capability of Ascension Island tracking station (Source).]

The evidence of these two maps should put us fairly and squarely between South America and Africa.

We also have the following descriptions by Schmitt

001:56:20 Schmitt: Bob, we’re over - what might be - intermediate to low stratus that have a very strong crenulation pattern

and

001:56:38 Schmitt: Looks like about a north-south lineation with a very strong crinkling, roughly east-west.

which seem to match what he’s describing.

For the third image in this sequence we can bring in a view from one of the post-TLI images. It’s obviously looking towards the rising sun, and when the contrast and brightness are enhanced we can see north-south trending lines of clouds, with some decent looking thunderheads casting long shadows and a decent sized cloud mass in the north. If we compare that view with that from AS17-148-22680 (figure 4.12.14) we can find an area over near the horizon, just after where the terminator would be and south of Saharan Africa. In just the right spot, in other words.

[Image: Figure 4.12.14: AS148-22680 with a section highlighted (right) matching AS17-148-22616.]
The green arrow gives a rough approximation of the EPO flight path, and this is a great help in identifying the location of the next two images.

Finding the location of these two (AS17-148-22617 and AS17-148-22618) requires a little detective work, and being able to locate a later photograph more precisely. That later image is the next in the sequence, AS17-148-22619, which is shown below in figure 4.12.15.

Figure 4.12.15: AS17-148-22680 (left), AS17-148-22619 (centre) and the same area in AS17-148-22680 (right)

The picture shows an area of thicker cloud viewed looking down and slightly across. The EPO photograph has an area in the post-TLI that very closely matches it that just happens to be right below where Apollo 17 was passing. It’s not an exact match, but why would it be given that the two photographs were taken a couple of hours apart?!

We also have an excellent description of what we’re seeing in the transcript, with Schmitt saying:

001:58:26 Schmitt: Well, I certainly am, Bob, and - again there’s a big - a fairly continuous intermediate cloud deck, I think. And it has patterns comparable to what I’ve seen on pictures of ice floes.

001:58:40 Overmyer: Roger. Understand.

001:58:40 Schmitt: And - of pack ice; I should say pictures of pack ice in the Antarctic.

An extremely accurate description! Schmitt also waxes lyrical on his website about the view:

“New patterns suddenly jump into view. Over the South Atlantic, between Africa and South America, a solid layer of morning clouds lies crenulated from one horizon to the other like an old washboard. Jagged breaks in those wrinkled strata give the illusion of polar pack ice fracturing and moving apart.”

We now know where this image was taken, and we know what sort of area we need to be looking at, can this help us track down the images taken between sunrise and this one?

Well, we know the trajectory of the EPO, and we also know where Apollo 17 passes over Africa, which allows us to plot which parts of the Atlantic they crossed on the way to that point (figure 4.12.16). The size of the area covered in figure 4.12.15 also helps us determine the size of the search area. With that in mind, let’s see if we can narrow things down to specific areas.

Figure 4.2.16: Approximate EPO trajectory of Apollo 17
The arrow above is approximate, it should bend downwards slightly to allow for the Earth’s curve, but you get the idea. With that in mind, figure 4.2.17 shows what I believe AS17-148-22617 and AS17-148-22618 are looking at.

Figure 4.12.17: AS17-148-22617 (left), AS17-148-22618 (centre) and their locations on AS17-148-22680 (right)

In the figure above the green box shows the cloud bank in 22617, yellow 22618, and the red box is a reminder of the location of AS17-148-22619. The arrows show the approximate viewing angle. The EPO path is running roughly diagonally from just below top left to just above bottom right.

It is a guess, but it’s an informed one based on what we know about where the Apollo craft was as well as examining things like the shadows on and under clouds and the angle of view to determine the photograph’s orientation and the striations in the thin cloud banks that can also be seen in the post-TLI image.

Finding the location of the next image isn’t too difficult, as the information you need is also in the one we’ve just looked at. Figure 4.12.18 shows AS17-148-22621 and compares it with an area visible in AS17-148-22620.

Figure 4.12.18: AS17-148-22620 (left), its location on AS17-148-22619 and suggested location on AS17-148-22682.

Can we be sure we’ve got the correct place? Nothing is ever certain but if we look closely at the image we can see that its right hand edge there is much more open water, and the gaps between cloud masses are becoming wider. To the north we have a boundary of thinner cloud, and this seems to be what we have around the area I’ve outlined. I think we can be reasonably confident that we have located another photograph in this sequence.

The next one is again looking towards the east, and we can help in our identification process by stretching the area at the eastern limb to make it look more like the view from above (see figure 4.12.19).

Again, allowing for a couple of hours’ time to elapse and changes in perspective we have a very good match for the location of this final trans-oceanic image. Once this photograph is out of the way we start to get recognisable features as the mission hits the African coast. Figure 4.12.20 shows the collection of coastal images.
Figure 4.12.19: AS17-148-22621 above) compared with a section of AS17-148-22679 (above right), and with a section elongated to compensate for curvature (right).

Figure 4.12.20: (top row left to right) AS17-148-22622, AS17-148-22623, AS17-148-22624, AS17-148-22625. Bottom row: merged image of those on the top row (left) Google Earth with superimposed AS17-148-22626 (centre), AS17-148-22626 (centre right), Section of satellite image (bottom right).
There isn’t much we can add here as it’s pretty obvious that Apollo 17 took these images as they passed over the coast at the Angola-Namibia border, taking some great shots of Baia dos Tigres on the way.

After crossing into African airspace they continue to take photographs, some looking almost straight down, others at an oblique angle, mostly looking towards the north or in the direction of travel. Figure 4.12.21 shows the location of those photographs, with the approximate centre point of oblique images shown by the yellow markers.

Figure 4.12.21: Location of Apollo 17’s trans-African photography

There’s not much to say about these as it’s pretty obvious that the mission is following the well-defined EPO path across Africa just as the charts show, but what we can do is show what the oblique images are looking at (figure 4.12.22a-d).

Figure 4.12.22a: AS17-148-22627 and AS17-148-22628 looking at the Etosha Pan (left) and Bicuar & Mupa national parks (right)
Figure 4.12.22b: AS17-148-22629-30 to AS17-148-22633-35 over the Okavango Delta and surrounds

Figure 4.12.22c: AS17-148-22636 - AS17-148-22640 showing the Ntwetwe and Sua pans (left) and the Botswana, Zimbabwe and South African border area on the way to the Mozambique coastal port of Maputo (below)
And finally, having traversed Africa, here for comparison is the view of the continent after TLI, and of the area close to Maputo harbour as shown in AS17-148-22640 in figure 4.12.22c (figure 4.12.23).

Figure 4.12.22d: AS17-148-22641 - AS17-22645 showing the Limpopo river and Mozambique coast.

Figure 4.12.23: Section of post-TLI view of Africa in AS17-148-22701, the NOAA-2 satellite image for the area (immediate right) and a Landsat tile from the same day covering the area west of Maputo (far right, see also here).
There isn’t any kind of commentary recorded while crossing Africa, but we do have an exchange when they establish contact with Carnarvon later:

02:28:32 Schmitt: Okay. You’ve got Omni Charlie. And, Bob, we had almost a completely weather-free pass over Africa and Madagascar. And the scenery - both aesthetically and geologically - was something like I’ve never seen before, for sure.

002:28:56 Overmyer: Roger.

002:28:59 Schmitt: We got odds and ends on the tape and quite a bit on the film.

002:29:04 Overmyer: Roger; good show. Are you saying that you didn’t have any weather over that southern Africa there?

002:29:10 Schmitt: Not very much. Barely broken clouds in some places. Most of the countryside was clear.

The description is undoubtedly accurate and entirely borne out by the satellite record, both in general terms as shown by the NOAA-2 record and in detail by the Landsat tile. It’s worth pointing out here that the satellite image used there is actually dated the 6th, not the 7th, but thanks to the way the mosaics are constructed the time recorded for the pass for Africa is nearer to the mission photographs than the one dated the 7th.

The next stop for our planetary photographs is Madagascar (figure 4.12.24).

![Image of Madagascar from various sources](image-url)

**Figure 4.12.24:** Merged photo using AS17-148-22646-7 (left), AS17-148-22650 (top centre), AS17-148-22649 (bottom centre), NOAA-2 view of Madagascar (top right) and Google Earth view showing approximate location of AS17-148-22646-50 (bottom right).

So far so good, and again we have the added bonus of the clouds visible in the EPO photographs also being shown in the satellite imagery from the day of launch.

The next two images present more of a problem, as again we are faced with photographs that have no apparent land masses visible, and no transcript record available to help us. Figure 4.12.25 shows the pair.
The second view in particular is one taken at a near vertical angle, so we can deduce that it covers a relatively small area. That said, we can see a small amount of the horizon’s curve. What we can also notice below some of the higher altitude cirrus clouds is a shadow cast on the ocean below, and the angle of that shadow is comparable to the angle of the shadows cast by clouds in the preceding photographs (not to be confused with patterns on the landscape).

The conclusion I draw from this is that these two images were taken at around the same time and location. Are there any clouds we can identify in the post-TLI images? Let’s look at one in figure 4.12.26.

Can I be absolutely certain that I have the right area? No. Can I be specific about which group of clouds in that area is the one photographed in EPO? No? Is it consistent with where Apollo 17 was at a time when photographs were being taken? Absolutely yes. It’s south-east of Madagascar at the right position for their EPO pass and shows an area populated with twin bands of thicker cloud crossed by lighter high cloud and clear ocean around it.
Leaving that whacking great set of assumptions behind we can now move on to the next set of images. Some of these are easier to locate than others and we sometimes have to delve deep behind the clouds to find their locations. Figure 4.12.27 shows the first in this series.

Figure 4.12.27: AS17-148-22653 and AS17-148-22654

At first glance we have very little to go on, however if we look carefully halfway down the right hand side of the image we see this (figure 4.12.28).

Figure 4.12.28: Close up of AS17-48-22653

Where in the world could this be?

A bit of scouting around on the flight path finds that what we are looking at is the western end of the Indonesian island of Pulau Wetar. It’s shown in close up and in context in figure 4.12.29, together with an image taken from orbit by a Space Shuttle mission.
The orientation of the island shows that this view is towards the north from a position below Timor, which is underneath the long bank of cloud across the centre of the photograph. At this point in the orbit they will have just passed out of contact with Carnarvon on Australia’s west coast but are sill out of range of the next tracking station and are waiting to be picked up by Hawaii. As in the previous gap between tracking stations we have no record of what was said by the crew, and for the location of the next photograph we have to skip onwards to two photographs taken after it. These three photographs are shown in figure 4.12.30.

As with the previous apparently oceanic images we have little to go on, but once again if we zoom in closely we can find a useful detail (figure 4.12.31.)
We now have a confirmed location for the 2 pairs of photographs either side of AS17-148-22655, can we provide a definite location for it?

In a word, no.

We can, however, look at a few indications as to where it might be. One obvious indicator of the orientation of the photograph is in the bottom left corner, where the shadows of the taller more prominent clouds are long. It’s heading towards sunset in this part of the world, and the sun is behind them over the Indian ocean, so we can be certain that we are a still looking roughly in the direction of travel. The presence of the CSM window on the right hand side also suggests a slight change of the viewing angle to the right of the images that followed.

If that is the case then we ought to be able to see some sort of land mass somewhere. Figure 4.12.32 shows a close up of the horizon in AS17-148-22655.

![Figure 4.12.32: Close up of sections of the horizon in AS17-148-22655.](image)

While it isn’t possible to identify with any certainty at all exactly which land mass we are looking at, we can say that we are looking at a land mass, and the only land mass of any significant size in the direction in which they are travelling and from this position is Papua New Guinea. The photo might also help us to identify the location of what comes next, more of which shortly.

The final set of images in the sequence before the post-TLI photographs, AS17-148-22658 to AS17-148-22668. The final 3 images are of a bright horizon but otherwise in the dark, so we are either looking at airglow (which they do mention seeing) or backwards at the sunset. We’ve already established where the last two photographs were taken, we know where Apollo 17 was heading, and we also know that before long they will be passing into darkness. Figure 4.12.33 illustrates the point.

![Figure 4.12.33a: Celestia projection of the Earth at the time of the last orbit around the terminator. The red circles mark the last positively identifiable photograph locations and the red arrow the approximate path of the EPO. The arrowhead marks the terminator.](image)  ![Figure 4.12.33b: EPO map superimposed on Google Earth. Yellow markers identify known locations of photographs and the yellow line the suggested orbital path.](image)
We have, therefore, a relatively narrow window in which the final photographs were taken. However, we know where they were going and have a pretty good idea of exactly which path they were following, so we now need to see if we can identify where the following three photographs are showing (figure 4.12.34).

![Images of photographs](image1.jpg)

Figure 4.12.34: AS17-148-22658, AS17-148-22659 and AS17-148-22660

The angle of this cloud, the change in direction of the horizon and the direction of the shadows are all suggestive of the camera looking further to the right than the images showing Pulau Adi. The pattern of the clouds are also suggestive of covering a mountainous land mass and then breaking up along the coastline in the distance. The sequence of the images also shows that they are taken along the EPO flight path, given that the final image is taken looking straight down over the cloud mass in the centre of the photographs taken immediately before it. The last photograph also seems to show dark land where any gaps in the cloud can be seen.

Figure 4.12.35 illustrates the view along that flight path over the Sudimar Range and Moake Mountains, and the satellite view confirming the presence of the clouds we’re seeing.

![Image of flight path](image2.jpg)

Figure 4.12.35: EPO flight path over Papua New Guinea, as derived from the EPO map superimposed on Google Earth, and satellite view of the same area.

As hinted at earlier there are also possible clues in AS17-148-22655 (figure 4.12.36).
As usual, we have to add the caveat that other cloud masses are available, but it is in the right place, and has the right morphology, so it seems a reasonable conclusion to draw.

Now on to the final images, taken as they approach the terminator and prepare for the TLI burn (figure 4.12.37).

We have the same issue here as we have had with previous photographs in that we have no land mass on which we can pin with any certainty. However if we assume that the last photograph examined is directly over the high peaks of Papua New Guinea and we are continuing to take images in the direction of travel, then we can safely assume that we are looking at the last section of open ocean before the sunset. The angle has changed again, suggesting we are looking slightly north of East than the last images that were slightly south of it.

We can determine that the first image does contain the location of the other 3. Figure 4.12.38 shows that we can follow the progress of the crew towards the terminator. While it's relatively easy to find the areas in the first 4 photographs, the last one is slightly trickier, and I’ve used an area of cloud on the horizon to confirm it.

The next question then, again, is ‘can we identify where this is’?

Again, in a word, no, but we can see if there are any areas in other photographs that look similar. Figure 4.12.39 shows AS17-148-22660 with an area identified. That area has been stretched to try and make it cover the same sort of area as AS17-148-22661.

The main reasons for picking out this area are that firstly it lies in the path of Apollo 17, and secondly the presence of the shadow line under the band of cloud running across the photo, together an obvious gap in that cloud and an area of more broken cloud before that.

We’ve now, admittedly with some conjecture and guesswork, identified the locations of all the photographs taken while Apollo 17 was in EPO. The final three photographs before we start to see images that are definitely post-TLI are shown in figure 4.12.40.

Figure 4.12.40: AS17-148-22666, AS17-148-22667 and AS17-148-22668
They are obviously of the approaching sun, and Cernan mentions that TLI would take them through sunrise.

That’s it, all done. We now have a complete map of where images were taken, and for the tl:dr generation, here it is summarised on the map (figure 4.12.41).

Figure 4.12.41: Suggested locations of Apollo 17 EPO images.

As a final point - if anyone claims images of Earth taken by Apollo were done in Low Earth Orbit, show them how small an area a photograph taken from there actually covers!
5: Discussion & Conclusion

Section 4 has gone over, in painstaking and occasionally painful detail, the photographs and videos taken of Earth by the 9 moon bound Apollo missions and compared them with the satellite images of Earth taken by geostationary and Low Earth Orbit satellites. The process of writing it has been as immensely repetitive and tedious as no doubt it has been to read it. Points have been laboured, minutiae have been microscopically examined, arrows have been used to point out the blatantly obvious lest someone claim that they could not see the obvious.

What have we learned? That the satellite record contains a wealth of corroborating evidence to support the claim that 9 Apollo missions went to the moon, 6 of which landed. As stated at the start, they are not the be all and end all of proof but, taken in conjunction with the wealth of other evidence, they are a hefty nail in the conspiracy theory coffin.

If you believe in the Apollo landings and have enjoyed this work, thanks for sticking with it. Feel free to quote it wherever you like, as long as you reference it when you do.

If you did not believe in the landings, or were equivocal about them, and this evidence has helped persuade you that they did in fact happen, then I am pleased that it has been of some use.

If you have waded through the arguments and still disbelieve in the truth of the Apollo missions, then there is no hope for you. I am only glad I was able to keep you out of contact with normal people for as long as you were sat reading it, and that the town centre shop windows were unlicked for at least a short while. Enjoy wearing whichever tinfoil hat is in fashion this year.

This work will not be without its critics, and I am sure there will be attempts to disprove it, or to claim it is another establishment lie. There will be those whose response to this entire discussion will be “There are no stars in the photographs and Von Braun was a Nazi” as if that is all the evidence they need.

I will now take the opportunity to fend off the most likely claims, and throw in some interesting stuff in the process.

5.1: You are a NASA shill

Listen very carefully, I will say this only once: I have no affiliation with NASA, or any of its subsidiaries or affiliates. I have never had any affiliation with NASA or any of its subsidiaries or affiliates. I am not even American. I have never been approached by anyone, ever, to post or write on their behalf. I have not been paid, ever, by anyone to post or write on their behalf. I have never been supplied with information to post by a third party unless I have asked for it as part of this research. I have not been paid, ever, to post on the internet, unless you count the time I updated Facebook at work when I should have been doing something else.

I have contacted various branches of NASA during this research, some of which has been useful, but for the most part they have either ignored my requests for information or were unable to help.

Occasionally information has been supplied and I have used it, but I have never taken instruction on how to use it. Any accusation that I am simply a mouthpiece for NASA is a lie, and besides that, anyone who dismisses cast iron evidence purely on the basis that it is from NASA is an idiot. The research either works or it doesn't. The source of the information is irrelevant.
5.2: You admit to doctoring the photographs

Now this I will spend a little time explaining, after I have made this clear (again):

I have never added to, or taken away from, any of the photographs used in this research. Ever. I have not manipulated any image in order to misrepresent its contents. Ever.

I am happy to state (and have said so in the text) that I have used some basic techniques to enhance images in order to make what is there clearer. This is entirely different from doctoring or faking.

I will now demonstrate those techniques so that readers can try it for themselves using a free image editing software package: GIMP, available for download here: [http://www.gimp.org](http://www.gimp.org).

The main technique used is adjusting the 'levels' in an image. Any image can contain the balance of light and shade you want, but it can also contain light and shade that you don't want. Image editing software like GIMP contains a simple tool that allows you to remove unwanted brightness and dark areas. If you have ever had a photograph that looks very 'washed out', for example on a hazy summer day, you will find the following useful in removing that haze and revealing the image behind it.

As a worked example, I opened the high resolution GAP scan of AS16-118-18885 (used in section 4.8) and navigated to the 'Levels' menu ('Tools', 'Colour Tools', 'Levels').

In figure 5.2.1 below, the tool is on the left and has already been applied by moving the two triangle markers in from the outer edges, and the effect on the selected part of the image should be obvious.

![Figure 5.2.1 – Level editing tool in GIMP](image-url)
Next, I decided to add a little sharpening to the 'entrance to inner Earth'. The sharpening tool can be found in the 'Filters', 'Enhance' menu, and I have chosen 'Unsharp Mask' tool. The operation of the tool can be seen in figure 5.2.2, and figure 5.2.3 shows the end result on a selection of the image. It’s an easy one to overdo (as in this example) but can be useful in bringing out detail in blurred images. When it has been used in this research, I have identified it.

![Figure 5.2.2: The Unsharp mask tool. Adjusting the 3 sliders alters the level of sharpening.](image)

Now that it’s been level adjusted and sharpened, let’s have a quick look at contrast and brightness ('Colours', 'Contrast – Brightness' menu) in figure 5.2.4:
So no, the use of an image editing programme does not constitute altering the content in the sense that conspiracy theorists would like to have you believe.

It might be relatively easy to manipulate an image, but that doesn’t mean that everyone is skilled at it, and sometimes poor use of those skills allows conspiracy morons to try and gain some mileage from it.

In one example of it, a particularly unpleasant moonhoax moron, who I’m not even going to name so that he won’t get any links from this page (suffice to say he may be an ex-pat, but he is in no way brilliant), claims that NASA has photoshopped all the images (see the next page in this discussion for an explanation as to why that’s impossible), and often cites an image of Earth as an example.

The image in question is AS11-44-6668, which is one of a number of photos taken during Trans-Earth Coast discussed at the start of this section. Here it is, as shown on the AFJ and ALSJ sites (Figure 5.2.6).
Obviously someone has used the lasso tool very badly here, and has tried to compensate for the low exposure of the Earth in the original by enhancing the brightness of it.

Can we sure that this is the case? Well, let’s have a look at other versions of the photograph available (figure 5.2.7).

![Image of Earth photos](image)

The image catalog (published in 1970) is a significant one, as it shows that the photographs were all available long before anyone could manipulate photographs as they can now. Hard copies of these volumes do come up for sale, eg [here](#), and I own a copy of the one released for Apollo 12. It also publishes it correctly oriented (ie north at the top), which will disappoint our protagonist here as he claims NASA publish photos upside down on purpose to fool people.

It should be pretty obvious from these versions of the photo that the original Earth is under-exposed, so why wouldn’t you try and enhance it to make it more visible? The scan of the positive film from the March to the Moon site is a good one to look at, what happens if we apply some modern image enhancing techniques?

![Image of enhanced Earth photos](image)

Figure 5.2.7: AS11-44-6668 as seen at the [Apollo Image Atlas](#) (above left), [March to the Moon](#) (above centre), the [70mm photographic catalog](#) (above right), [Project Apollo Archive Flickr account](#) (far left), and the [Gateway to Astronaut Photography](#) (left)

Figure 5.2.8: Earth from the scan of the Kodak positive untreated (left) initial treatment (centre) and final level adjustment (right)
As can be seen in figure 5.2.8, a couple of applications of image enhancement and level adjustment reveals the Earth in all its splendour, including the lovely sunglint from Brokopondo reservoir. No sign of any differences between Earth and background here, because I didn’t use a lasso tool. Neither did whoever scanned the image at the Project Apollo Flickr archive. Apparently the not very brilliant troll claiming these are all fake images thinks I had something to do with that, and that I have altered the images. He claims this because he’s an idiot desperately clinging on to a delusional fantasy. Let me make it clear again: I have never added, or taken away, anything in any Apollo image, ever, and neither has anyone else.

You’ll also get people looking at other low resolution versions of other Apollo photographs of Earth and seeing things that to them are evidence of some sort of photoshopping, but in reality are image compression artefacts, or they’ll see the word ‘Photoshop’ in a scanned image’s metadata and cry foul, when the reality is that using Photoshop as an image processing tool doesn’t make an image fake, nor can it somehow magically alter the hard copy originals freely available during the Apollo era and that can be easily obtained now.

What these people are trying to do is divert attention away from what’s in the object: Earth. An Earth that contains details that can be proven to match what we should be seeing in terms of the landmasses visible, the position of the terminator, and the weather features visible on it. An Earth that matches what should be seen so exactly it can only have been taken during the Apollo mission. An individual photograph of Earth amongst many other, equally accurate images of Earth that exactly conform to the mission timelines. They have no explanation for the existence of these photographs and hope to distract the unwary by cherry picking individual examples, ignoring obvious explanations, and failing to understand things so spectacularly that they are either being deliberately dishonest or they need help tying shoelaces.

Here’s the deal: if you think the images were faked, you need to prove it. If you think I, or anyone else, somehow altered the images online or in 50 year old documents to add or remove things, then prove it. Stop whining about Photoshop, or people hacking your computer, or claiming that images have been replaced to hide something, provide some proof. You won’t be able to.
5.3: They did it all in Photoshop

Well, I just did, so surely NASA must have, right?

It is a common mistake amongst many conspiracy theory lovers to assume that what they see around them on a daily basis has always been available. Films show levels of special effects where the clearly impossible happens in front of the viewer's eyes, and image manipulation tools like Photoshop are used to change images or manufacture them completely almost routinely. It is difficult for them to conceive that these are recent developments, and that there was a world that had to cope with non-digital methods of recording and storing information, where camera films had to be developed in darkrooms, and photographers had no idea what images they were taking until some time after they had taken them.

Ironically, it is often claimed that the computers in Mission Control were incapable of managing simple navigational computations, but at the same time capable of altering Apollo images. Pictures of the computers used to process the satellite images have already been shown in Chapter 2, but it is perhaps worth going over the state of the art in terms of computer graphics at the time of Apollo to see whether the claim that digital manipulation is reasonable, or whether simple airbrushing could have been up to the job.

In 1968, the year of the first Apollo circumlunar mission, the first mass marketed PC was launched by Hewlett Packard, the HP 9100A. You can see what it looked like in figure 5.3.1.

The HP museum states that his little beauty helped Dr Van Allen, the man after whom the Van Allen belts are named (and whose evidence is often misused and misquoted by conspiracy lovers to 'prove' the landings never occurred), to calculate the use of Jupiter's gravity to slingshot a space probe towards Saturn.

![Figure 5.3.1: The HP 9100A. Source: HP Museum](image)

It is obviously capable of significant calculations in terms or orbital mechanics, but it has no graphics capability other than an LED alphanumerical display.
There were more powerful mainframe computers. These were large central computers, the equivalent of a modern server, that could be interrogated directly or by satellite terminals. The terminals themselves would have little functionality other than as a communications device to the mainframe.

Figure 5.3.2 shows an example of an IBM mainframe that would have been around in the late 1960s:

![Figure 5.3.2: The IBM System/360 Model 30. Source: IBM](image1)

Have a careful look at the picture. Where is the monitor? Where is the graphics capability? Here is IBM's top of the range personal computer 9 years after the end of the Apollo mission (figure 5.3.3):

![Figure 5.3.3: The IBM Personal Computer 1981. Source: IBM](image2)
My undergraduate dissertation was written on something not dissimilar to this just 8 years later.

The ESSA World journal cited in chapter 2 also has images of the kinds of computer technology available to those receiving the satellite data.

Figure 5.3.4 shows banks of computers and tapes that were used to process meteorological data (not just satellite data, while figure 5.3.5 shows the kind of graphics capability available to ESSA meteorologists. In this case it is being used to show isobars on a map, along with the various overlays that could be used in the process. ESSA also used computers to re-align the individual images into a global mosaic.

![Figure 5.3.4: Computer equipment at ESSA. Source: ESSA World](image)

So, the computers shown above had no graphics capability, but does that mean there were no computer graphics at all? Or digital images? Not quite, but as we will see the capabilities of computers at the time are far less than imagined by hoax believers.

The first digital image is widely reported as being the one shown in figure 5.3.6.

![Figure 5.3.5: Computer terminal used to produce weather charts. Source: ESSA World](image)
This image is a scan of a photograph and was achieved in 1957 by Russell Kirsch. This news must fill the heart of every sceptic with joy, but let's take a look at it.

Anyone imagining that we suddenly have the capability of high resolution digital images, and therefore the ability to manipulate them, is surely going to be disappointed. Granted there are another 11 years until the first Apollo photograph of the Moon is taken, but we still need in that time to achieve colour display and graphics software, and we didn’t do that.

The sharp-eyed amongst you will have noticed that the image is black and white, not colour. Colour television was indeed around at the time of Apollo, but there wasn't any computer hardware capable of rendering colour. Colour rendering did not actually appear until 1977 with the introduction of the Apple II. The first dedicated graphics cards did not appear until the 1980s, and the first edition of Photoshop appeared in 1990. In a nutshell, because the history of graphic computing is beyond the scope of this study, the techniques of computer manipulation of graphic images were in their infancy during Apollo. Neither the hardware nor software existed that would allow the photographs taken by Apollo astronauts to be manipulated by a computer in order to incorporate satellite images.

As an example of what was possible it’s worth mentioning the work of Charles Csuri. Csuri was a pioneer in the field of computer art, recognising that the kind if things being generated by engineers and mathematicians on a computer display could be put to use in generating art. His first major works were done in the late 1960s, including ‘Sine wave man’ and ‘Hummingbird’, all done on a massive mainframe computer with punch cards to program in each individual movement of a plotting pen. As detailed here, Csuri initially used an IBM 1130 and then a PDP 11/45, shown in figure 5.3.7.
Notice the lack of monitors to display any visual output. In reality, while his art was computer generated the actual images did not appear on a screen but on paper or microfilm. Csuri used the computer to generate coordinates and move a pen from one area of the plotting medium to another. By repeatedly photographing the sequence a time lapse movie of the art could be generated. In this article he describes the process:

"The subject was a line drawing of a hummingbird for which a sequence of movements appropriate to the bird were outlined...Over 30,000 images comprising some 25 motion sequences were generated by the computer. For these, selected sequences were used for the film. A microfilm plotter recorded the images directly to film. To facilitate control over the motion of some sequences, the programs were written to read all the controlling parameters from cards, one card for each frame."

And in this article he says:

"After processing a Fortran program you got back punch cards. The punch cards which contained the graphics information were used to drive a drum plotting device. The software for the device only understood pen down and pen up for the beginning and the end of line segments. No animation language, modelling tools, nothing."

This is self-evidently a world away from the sophisticated programming and video techniques you would need to generate images of Apollo's quality and well short of the that imagined by those who suggest CGI as a source for these early images of Earth. Figure 5.3.8 shows a couple of examples of the finished product.
on screen plotting to work, saved on cassette tape. Csuri was using punch cards and had to wait until it was plotted on paper before knowing he’d got it right. Is this good enough to generate Apollo 8’s Earthrise? Is it bollocks. Even if it was, the conspiracy nuts still need to prove that that is what actually happened. They have never done that, all they do is claim it was without any supporting evidence. They drop CGI into the conversation in the hope that you won’t know anything about it and assume they’re right. A small amount of effort is all that is required to show that they aren’t. Here’s another example done in 1969 (or thereabouts) from this video actually showing the moon landing (figure 5.3.9).

![Figure 5.3.9: Stills from an early CGI film showing the lunar landing](image)

Again, this was filmed by producing each frame of the film on a computer screen and photographing the result. It is certainly not real time rendering and it is certainly not anything like the real thing.

What the conspiracy fans expect us to believe is that photographs were taken on the ground. Those photographs then had added to them images taken by black and white satellites that were converted to colour, rendered in a 3D realistic form, given the correct orientation in space and then reproduced for public release, with no seams or joins or errors or inconsistencies. I am reluctant to use the word impossible, as it’s not a scientific term, but that is what the task would have been: impossible. Impossible to do in a photograph and certainly impossible to do in a live TV broadcast.

Yes, NASA had access to higher quality satellite images than were available here, and Jack Schmitt even managed to take one to space with him, but black and white images in 2D projection are not realistic 3D colour images with shadows and shading and perspective thanks to the curvature of the Earth. In theory, it could have been possible to transmit images to an Apollo craft, assuming they had the kind of equipment we have already seen that is needed to reproduce a satellite image, but why do this? If they are on the way to the Moon they can see the weather and there is no need to send them the images.

In short, no, it could not have been done using a computer.

Could other techniques have been used?

‘Faking’ photographs has been around almost as long as the photograph, and there are many reported examples from the Soviet Union in particular where individuals who have fallen out of favour with the regime have been removed from photographs, and political slogans added to flags and banners that weren’t there originally.

There were a variety of techniques ranging from directly touching up negatives and photographic plates, composing new photographs by cutting up originals or superimposing multiple negatives or plates together, and airbrushing.
Airbrushing is a skilled technique where fine mists of paint are applied with a jet of air to a surface. Its most common use is to remove imperfections and blemishes from a photograph, but it can, in the right hands, add things. Fine detail can be achieved by a skilled practitioner, but there are obstacles that they would have had to overcome. Assuming for just one second that the Apollo images were done in a studio or in LEO, the Earths rendered in the Apollo photographs could not have been done at the same time as the photographs were taken as they would not have had the satellite images available to them.

They would have to have been done after they had the satellite images to work with. For the higher resolution LEO satellites, it could take 12 hours just to acquire the images needed for a full disk Earth image. These would then have to be reproduced by an artist who not only knew how to airbrush well, but understood meteorology well enough to know how the weather patterns would progress. They would then have to faithfully reproduce these weather patterns in photograph after photograph (not to mention frame after frame of video and live TV) all the while adjusting the photograph for the correct amount of Earth rotation and producing incredibly fine detail without a single hint that it was added after the fact.

Airbrushing in details on the kind of negatives produced by Hasselblad cameras frankly could not have been possible. The only method available would have been to produce a large print, airbrush that, then re-photograph it. The silence of the original developers of the photographs would have to be guaranteed, because it would be pretty obvious that the Earth was missing from them.

The same obstacles exist for composing fake photographs using the addition of satellite images. The satellite photographs are not in colour. The mosaics used in this research are obviously mosaics. Somehow these need converting to colour and placed realistically on a globe without anyone noticing. Consistently, time after time. Without any hint that there was ever anything different about the photographs. If you search the internet for examples of these pre-digital composites, what emerges is firstly there is always an original with which to compare the fake, and secondly there are mistakes.

Figure 5.3.10 below shows an example of both. It’s my own scan (hence the poor quality!) of an image from a copy of Life magazine in April 1970 specifically about photograph manipulation.

Figure 5.3.10: Doctored image from Soviet occupied Czechoslovakia with Alexander Dubček removed.

Czech leader Alexander Dubček is standing 3rd from the right in the photograph on the left. In the photograph from the right he has gone. In order to achieve this everything on the left of him has been moved across so that other people and buildings are filling the space he used to occupy.

The main points here are that the original exists, someone kept hold of it despite the political implications the photograph has (although it may have been one printed outside the USSR). Secondly, anyone can go to that
area now and check the building positions and notice that in the doctored image they are wrong. Finally, Dubček’s shoe is still there. The photograph editor forgot to remove it. Oops!

For something like this to have been done with Apollo photographs every original photograph and negative would have had to be destroyed. Not one single person in the process would have kept an original or mentioned it to anyone.

If the scenes on the Moon are fake, then all the craters and rocks in the alleged studio set would be fake, and yet (as shown on this site) details shown by modern lunar probes show that the smallest craters and rocks are absolutely correctly positioned despite it not being possible for NASA to know that they were there.

The fakery would also have had to be done without a single mistake creeping in. While some people have made a handsome living on the internet pointing out where digital enhancements have been made to Apollo photographs, or pointing out digital artefacts as some sort of proof of aliens, UFOs and other such nonsense, the original photographs show no such errors (see the discussion on slides and newspaper articles below).

Impossible to fake them? Again, I am reluctant to use the word but to all intents and purposes it is. The task would have been too much even for a team of skilled airbrushers and photograph editors who would have to be relied on to keep quiet about their fakery and the use of computer imaging techniques that they simply didn't have.
5.4: This is the modern world

As well as seeming to think that Photoshop was invented before there were computers to run it on, you’ll also get people frothing at the mouth at the digital versions of the images online, making wild accusations that they have all been touched up, and that this must be how satellite imagery has been added. They’ll even point at spots and scratches on these versions as evidence of something important or other.

Leaving aside the fact that these people have clearly never scanned a photograph and the blemishes on the photographs are from the paper copy and from dust on the scanner glass, they also have to explain the large numbers of photographs in existence that are not digital, lots of which I actually now own in the form of contemporary slides, newspapers and magazines.

One example of this is the collections of slides available for purchase showing mission photographs. A quick trawl of auction and memorabilia sites reveals several collections of Apollo related slides available for purchase. For the benefit of younger readers, slides are ‘positives’ of the photographic film. When a light is shone through them they can be projected on to a screen for presentations. It’s what people used before Powerpoint was invented. You can still buy slide projectors for them.

Figure 5.4.1 shows several examples of the collections for sale. As they are all from auction sites there is no real point giving links to them. Google ‘Apollo slides’ - you’ll find them- I did and bought several lots of them, but we’ll look at those in a moment.

Figure 5.4.1 Slide collections from Apollo 8, Apollo 10 and Apollo 11. Various eBay sources.
Each one of those collections has at least one photograph of Earth featured, and some of these can be seen below in figure 5.4.2.

Each one of those collections has at least one photograph of Earth featured, and some of these can be seen below in figure 5.14.

Figure 5.14: Selected Apollo slides from figure 5.12 shown with their corresponding still images.
It’s pretty self-evident that all the slides shown there are matched by their digital counterparts, but so what?

Well, the point here is that the original slides can not have been altered, neither can the newspaper and magazine photographs. The digital copies are therefore faithful reproductions of originals and not digitally manipulated copies of material only held by NASA in some darkened vault with double key access.

Just in case anyone is now entertaining the idea that those eBay ads are fakes, I’ve also spent my own hard earned money on some of these slides, and newspapers and other original media items, so let’s have a look at actual real life examples of Apollo images from my own slides projected on to my wall (figure 5.4.3).

Figure 5.4.3: Slides from the Daily Express box set of Apollo 11 images (shown against my laptop on the right)
These slides were issued by the UK newspaper the Daily Express, who sold a lot of Apollo memorabilia (including 8mm films that I also own), but I have others, including a set issued by Zeiss, who supplied lenses to NASA (figure 5.4.4).

There will, of course, be conspiracy fans who just stop at the words ‘so what?’, and argue that obviously NASA just released doctored images into the wild that were blindly reproduced by everyone else (who may or may not have been in on the deal).

Did they have time to doctor the images? The invisible and never tracked down airbrushers or image compositors that are alleged to have been involved in all this mass doctoring of photographs would have had to work overtime to get these images out.

This document, for example, describes the time scale for developing and then releasing images from Apollo 11. The photographs would be developed in two batches as soon as they were released from the decontamination process in the Lunar Receiving Laboratory. Public release was intended for just 1 week after being collected from the photographers, and the majority of that time was to be spent in decontamination. The first record I’ve found of Apollo 11 images in print comes from here, where they appeared in the UK on July 30th.

The image below (figure 5.4.5) taken by David Royal and posted on collectspace.com, shows some of the photographs from Apollo 12 being printed. The photographs present (from Magazine V) suggest that the same image is being printed several times at different levels of development. It gives a good indication of the size of the images, something difficult to tell from the internet versions.

Other missions went through similar processes. The Apollo 8 photograph below (figure 5.4.6 left) is shown in a newspaper dated 31/12/68. This obviously means that it had to have been in the hands of the newspaper on the 30th, and freely available ever since. We also have another one from Apollo 8 from my own collection in a souvenir supplement of the Evening Post (published in Reading) dated January 6th 1969 (figure 5.4.6, right), which the sharp-eyed amongst you will notice is a black and white version of AS08-16-2593 used in figure 5.4.2. Also included is a press photo, again available on eBay, dated the 29th - just 2 days after the mission completed.
Figure 5.4.5: Photographs being printed in the Apollo Lunar Materials Receiving Laboratory. [Source.]

Figure 5.4.6: AS08-14-2383 featured in the Bennington Banner (above left, original image from eBay), and AS08-16-2593 (above right) shown in a local UK newspaper from my own collection. The same image is shown right in a press image dated December 29th.
One interesting thing about the image on the right is that it may have been associated with the first use of the term ‘Blue Marble’, as used in the 1969 album ‘Blue Marble’ by Sagittarius (figure 5.4.7).

The cover and text on the reverse, as well as the lyrics of the title track all obviously reference the image, and as it was published 3 years before Apollo 17 it clearly has first dibs on claiming credit for the term.

Folky prog seemed to like the image, as it was again used in the 1977 Eponymous album by the group ‘Of the Earth’ (figure 5.4.7b).
This *Life magazine* special, complete with many images of Earth, was published in January 10th 1969. This edition of *Life* covering Apollo 10 was published on June 6th 1969, 10 days after landing, and Apollo 11’s on August 8th. The cover image for Apollo 11’s *Life* magazine special was all over US newspapers on July 30th, meaning that photographs from the mission were in the hands of the media just 5 days after landing back on Earth - 2 days ahead of the original scheduled release. British newspapers had to wait until the following day, but figure 5.4.8a shows a few examples, again from my own collection.

The images were in the hands of the media even before this date, as shown by the date shown on a wire image version of *AS11-37-5458* for sale on eBay - July 29th (figure 5.4.8b), 5 days after splashdown in the Pacific.

The Daily Mirror was even quicker off the mark for Apollo 10 - this front page shows the Earthrise image *AS10-27-3887* just 4 days after landing (figure 5.4.8c)

The Sunday Times also had several magazine issues devoted to Apollo photographs when they were published, and I now have copies of these along with many newspapers: in short, the photos were out there long before some computer nerds worked out how to get them on a screen, and no-one has been round to confiscate my copies or distract me so they can edit them without me knowing.
In addition to newspapers, many enterprising people also photographed their TVs in memory of these achievements. A recent eBay purchase of mine included a substantial number of slides taken during the Apollo 16 mission.

Can we be sure they are genuine? Well, there’s the shape of the TV screen for a start, quite obviously of the cathode ray curved variety rather than the modern square screen. The slide cases are obviously home made in blank cases, and are clearly taken of a TV screen in someone’s house. The various clues are shown in figure 5.4.9.

Figure 5.4.8c: Daily Mirror dated 30/05/69

Figure 5.4.9: Selected images from slides bought from eBay of the Apollo 16 mission.
Let’s look at the evidence. On the left is a test photo of a nice pot plant. Bottom right is the handsome TV presenter with a hair style and choice of clothes typical of the era, and top right what is now called a station ident. Both the images on the right carry a clear reflection of the room’s light, and this is also reflected on the edge of the TV screen in the ident image. Figure 5.4.10 shows a selection of Apollo images of from this collection, and also one beautiful shot of Earth captured from TV and shared by Retro Space Images via Facebook.

Figure 5.4.10: Photographs taken of the TV during Apollo 16.
Speaking of TV, here’s a nice use of Apollo 17’s ‘Blue Marble’ shot for the live coverage of the Apollo-Soyuz link up in 1975 (figure 5.4.11).

Figure 5.4.11: BBC Radio Times publication showing the forthcoming Apollo-Soyuz link up to be covered by the broadcaster

Well OK so what? It’s on TV, so therefore it’s real?

Yes it was real, but that’s not what we’re arguing here. We’re pointing out that these are not some badly converted youtube videos of ‘found footage’ only just made available. People like me watched these missions live on TV at the time, not 40 years later on the internet. The TV footage was there for people to see and pass judgement on, not secreted away somewhere waiting for a Freedom of Information request. As we’ve already shown, that TV evidence contains material that could not have been made up.

But wait, there’s more. On top of all the press reports and magazines making very public use of Apollo media, and all the films and TV that used them, there also the official NASA reports. Contrary to what your average hoaxie would have you believe the photographs and reports were publicly available to anyone who was prepared to pay for them. Here, for example (figure 5.4.12) is a copy of the Apollo 17 Preliminary Science Report, published in 1973 complete with colour images of the Earth’s weather, amongst other things. There’s that Blue Marble again!
That isn’t just any old Apollo 17 PSR. That’s my personal copy that I bought off eBay for £17. It’s not on a NASA archive, it’s not electronic, it’s actual paper with actual unalterable colour photographs in it.

Figure 5.4.12: Apollo 17 Preliminary Science report
As well as these public releases of Apollo material, we also have its use by what could be described as the same kind of counter-culture that spawned the modern conspiracy movement. Following an LSD induced flight of fancy, Stewart Brand (the eventual founder of the Whole Earth Catalog) produced badges (figure 5.4.13) to try and encourage those involved in the space race to photograph Earth, the idea being that it would encourage wider involvement in the burgeoning environmentalist movement.

The next stage for Brand was to produce the Whole Earth Catalog, a list of products made from sustainable materials or that would allow people and communities to live ‘off-grid’. The covers of these magazines usually included an image of Earth. The first one used the ATS-3 image of Earth shown in section 2, but the Autumn 1969 edition (shown in figure 5.4.14 - top left) made good use of AS08-16-2593. Other covers given in figure 5.4.14 also feature images from Apollo. The Spring 1969 edition informed readers where to get film of the mission featuring the earthrise, as well as NASA publications featuring Gemini and Apollo images.

Eco-warrior survivalists were not the only ones to capitalise on these NASA images. Many advertisers also wanted a cut of reflected glory.

One such company was the producers of Tang, a popular orange drink. It was famously taken into orbit on Mercury and Gemini flights to experiment with food and drink taste and behaviour in zero gravity. In 1969, Tang produced this advert (figure 5.4.15) to cash in on Apollo 11’s success.
Figure 5.4.14: Whole Earth Catalog covers featuring AS08-16-2593 (top left), AS08-14-2383 (top centre), a view from Apollo 4 (top right - example), and an Apollo 12 Earthrise (far left - example). Centre left is a page listing NASA media available to order from the Spring 1969 edition.
The view of Earth they’ve used there is actually from Apollo 8 and, unfortunately for them, it’s also reversed and therefore the wrong way round, and was taken from cislunar space, not lunar orbit as the photograph implies!

The National Geographic Apollo 11 special has a couple of slightly more accurate examples, using images from Apollo 8 and 10 (figure 5.4.16), although the TRW advert again has the view reversed!

Naturally Hasselblad were proud of their role in the missions, and this 1973 advertisement uses the ‘Blue Marble’ to good effect, and they’d even send you a copy of it for $1. They also used the image of Hurricane Bernice from Apollo 11 (figure 5.4.17).
So while a vocal minority in today’s ‘we reject everything and everything it stands for whatever it is’ counter-culture might also reject the scientific achievements that allow them to post their nonsensical dribblings on the internet, their ancestors in the 1960s recognised the importance of Apollo images of Earth and used them, publicly. Their opponents in big business used them to promote a different aim, but the point is they were in use and in the public eye.

Apollo images were also popular in philately circles, with first day covers and commemorative issues regularly featuring Apollo images.

Here, for example, is one from 1979 that shows an obviously fictional scene, but where the image of Earth used might look familiar when it’s rotated the right way up.
That’s right, it’s the famous Apollo 8 Earthrise shot, which also features on the stamp for this first day cover from 1969 commemorating Apollo 11. This scene from a 1971 cover dedicated to Apollo 15 is also loosely based on it:

![Figure 5.4.19: 1971 commemorative envelope.](image)

The actual Earthrise image also features on the stamp for this first day cover from 1969 commemorating Apollo 11, while another Apollo 8 image (AS08-16-2593) forms the basis for the other Apollo 11 commemorative issue overleaf.

The three examples in figure 5.4.20 are from a series depicting the entire mission, and I’ve picked them because they feature mission images - next to each one is the photograph it uses and the area selected from it.

These covers are from my personal collection.

There are many other examples from all over the world freely available to buy on the web.

![Figure 5.4.20: First day covers and stamps commemorating Apollo 11 featuring Apollo 8 images](image)
Likewise the many viewmaster reels (figure 5.4.22) that were made to give a pseudo 3-D view of the Apollo missions to the thousands of people that owned them.
Sometimes Apollo imagery could get used in conceptual art used to promote the missions. In my own July 25th souvenir edition of the ‘Evening Standard’ we have the front page illustration shown in figure 5.4.23. Close examination of that image shows that the view of Earth is actually drawn from the same Apollo 8 photo illustrated earlier in this section.

![Figure 5.4.23: Evening standard dated 25/7/69 (left), zoom of the view of Earth (centre) and AS08-16-2593](image)

An interesting point here is that the Evening Standard souvenir edition was published about a week before any actual images from Apollo 11 were released, so their shots of the moon were all taken from Apollo 10, and other shots were those from live TV broadcasts or official pre-mission press releases.

Apollo images continue to be used in popular media, and a good example is shown in figure 5.4.24. This shows the cover of a book published in 1981, just 12 years after the photograph was taken by Apollo 11 and still a long time before Photoshop. The book is by well-know space artist and author [Luděk Pešek](#), although the cover was actually done by Jane R. Wattenberg.

![Figure 5.4.24: ‘Trap for Perseus’ cover, featuring part of an Apollo 11 photograph showing Hurricane Bernice.](image)

If the photograph looks familiar you may have spotted it [here](#), as it’s one of the ones showing Hurricane Bernice. Bernice is the storm photographed and broadcast on live TV, published on the front page of newspapers and generally proving that Apollo 11 was exactly where they said it was: on the way to the moon.
Another Apollo image, AS11-36-5352, also found its way into print as part of a 1976 artist impression of the Meteosat-1 satellite to be released the following year (figure 5.4.25).

![Figure 5.4.25: A11-36-5352 as featured in an artist’s impression of Meteosat-1](image)

Returning to adverts, another one that turned up in a Space Group was for Benson & Hedges 100s that came out in 1973 (figure 5.4.26).

![Figure 5.4.26: 1973 Benson & Hedges advertisement compared with Earth as seen in AS15-91-12342.](image)

As can be seen above, the Earth in the background is very obviously derived from the Apollo 15 image taken in 1971 (discussed on this page).

The photo has another appearance in popular culture. In 1973 little known crooner by the name of Elvis Presley was involved in an ambitious live event that broadcast a concert from Hawaii to 36 countries around the Pacific by satellite - the first time this was done. The event took place in January 1973, and in April an album was released. The cover is shown in figure 5.4.27a.

The same photo also made the poster of the 1974 sci-fi film “Invasion of inner earth”, though alternative versions of the poster feature A11-36-5352 (figure 5.4.27b).
Figure 5.4.27a: 1973 album release ‘Aloha from Hawaii’, featuring AS15-91-12342.

Figure 5.4.27b: Posters for the film “Invasion from Inner Earth”
Returning to music, Chick Corea opted for a nice Apollo 10 Earthrise to illustrate his 1984 album ‘Voyage’ (figure 5.4.27).

The same Apollo 10 Earthrise sequence, this time reversed, also appears on Mark Murphy’s easy listening opus “This must be Earth” (figure 5.4.29).

We can also find other examples of album covers featuring a variety of Apollo missions (figure 5.4.30).
|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
Returning to Apollo 10 for a moment, we have in figure 5.4.31 three examples of AS10-34-5013 used on the front of the May 1972 edition of “The American Rifleman”, on the front of a 1973 museum exhibition catalogue, and on a poster for the 1978 film “The late great planet Earth”. The latter is not the original photograph, but it is clearly drawn from it.

And finally, we have the original Earthrise image from Apollo 8, Apollo 11’s view of Africa and Blue Marble from Apollo 17 used on book covers (figure 5.4.32).

To sum it all up, all the Apollo media were available during and after Apollo, often long before any kind of software existed to create them, and certainly long before nutcases started claiming they were all faked (particularly the Dunning-Kruger victims who think they are “brilliant”), or somehow produced years after the missions.

The Apollo missions were played out in newspapers, magazines, books, TV, you name it the media were all over it, sometimes using well known images, sometimes more obscure ones.

Publishers Apogee were printing the entire mission reports for each mission from 1999 onwards, complete with CDs full of all the images, and occasionally EVA footage. You can go buy them if you want, no-one is going to stop you. NASA themselves published complete volumes of all the images that anyone could purchase, like these ones for Apollo 8, 10 and 12 from my personal collection (figure 5.4.33), and these ones for Apollo 11 and Apollo 13. Added to that are the countless scientific and technical publications littered with Apollo photos and easily available in both print and online.
Feel free to browse my ephemera page for examples of contemporary Apollo media in my collection.

There is just no way that someone could present a different version of those images and get away with it, or magically introduce new images without it being spotted. It’s even obvious when the originals have been modified for artistic reasons. The photos have always been public domain, and were always taken on the way to, in orbit around, on the surface, or on the way home from the Moon.

Figure 5.4.33: Personal copies of the Apollo 8 and 10 Analyses of Photography and Visual Observations, and Apollo 12 70mm photographic catalog
5.5: Hooray for Hollywood

As well as Apollo photographs being reproduced in slides and in popular journals, they were also used in popular TV programmes and films almost as soon as they were publicly available, meaning that many people will have seen Apollo photographs without even realising it. Let’s now look at some fine examples of Apollo images in popular culture so that we can prove that you could see Apollo pictures quite easily, and that they weren’t hidden away from the public gaze. I’ll try and present them in some sort of chronological order.

One of the earliest examples comes from the now legendary Star Trek programme. In the next section I’ll show some not so realistic Earth images, but here we have some use of original Apollo material.

The last episode of the second season was broadcast on March 29, 1968 and was called ‘Assignment Earth’. Although it pre-dated the manned missions of Apollo it does produce some convincing Saturn V pad and launch views, as well as some shots from orbit, largely by using NASA images. Figure 5.5.1 shows some of the relevant images.

![Figure 5.5.1: Screenshots from ‘Star Trek: Assignment Earth’](image)

If you bothered to read the section on orbital images you’ll recognise the sequence used from Apollo 4’s separation footage (top right), and the Saturn launch is also Apollo 4 (as can be seen on youtube). The other two images are exceptionally clear views of Earth, as they can’t be taken by Apollo they must be from Gemini missions. A brief trawl through the superb ‘March to the Moon’ website shows that this is exactly where they came from, although the Star Trek versions are horizontally flipped compared with the Gemini originals. The two photographs in question are from Gemini IV (bottom right) and Gemini IX-A (bottom left).

Meanwhile in the UK, the British TV series ‘UFO’ was being filmed while Apollo was in progress by the late and legendary Gerry Anderson, and used Apollo images as backdrops. The most obvious one is from Apollo 8 (AS08-16-2593), as shown on this website and this is shown together with a still from the closing credits shown in figure 5.5.2.
While some film-makers were grabbing Apollo photographs as props, some were still sticking with good old Gemini. 1971’s “Earth II” (a TV pilot about an orbiting space station) has a variety of space images, some of which are from Gemini and others painted scenes obviously based on Gemini. A couple of examples are shown below in figure 5.5.3, where small details of a larger photograph (S65-34747) are isolated, and in one case reversed to look as though a different backdrop has been used.

Meanwhile in the world of cinema, one of the best sci-fi films made in the period capitalised on the ecological message prompted by the early images of Earth from space. Silent Running was released in March 1972 and featured a ship containing precious examples of biological specimens from a ruined future Earth. Looking back at Earth from a spot around Saturn, our hero sees this view through his telescope (figure 5.5.4).

It’s not the best quality reproduction and as a result it isn’t entirely obvious what it is, but if you flip the image horizontally and rotate it, you’ll find it is our old friend AS08-16-2593.
It’s not the best quality reproduction and as a result it isn’t entirely obvious what it is, but if you flip the image horizontally and rotate it, you’ll find it is our old friend AS08-16-2593.

Returning to TV, Gerry Anderson also produced another immensely popular TV science fiction show in ‘Space 1999’, at that point a year ludicrously far away for most viewers.

This Space 1999 fansite (another Gerry Anderson series filmed in the mid-1970s) details other Apollo Earth images used in the programme, including some from Apollo 11 and the famous ‘Blue Marble’ from Apollo 17. Often they would add minor tweaks to the images to make them unique to the program, like this one from Apollo 16 (figure 5.5.5).
Figure 5.5.6 shows another adapted Apollo image used in the series. In the opening episode of series 1 shows a scene from inside the base, and as the camera pans across the interior a view of Earth can be seen in the window. This image turns out to be an upside down version of AS11-36-5355.

A slightly tweaked version of the same image makes an appearance in the introduction to series 2, as shown in figure 5.5.7.
While UFO and Space 1999 have a certain kitsch value about them now, others were pretty corny even at the time. Another gem from the 70s also shows us TV's use of Apollo imagery, although to be honest it seems like the budget only stretched to buying the rights to two of them. Moonbase-3 was a low budget BBC drama, and it can be found on youtube quite easily. Screened in 1973 it boasted James Burke (a well respected science presenter who contributed a great deal to the BBC’s Apollo coverage) as an advisor. As shown in figure 5.5.6 it features an old friend in the opening credits (left), again in a panoramic sweep (centre) and as I’m sure you’ll know, movie sets are expensive, so why pay for another photograph when you can resort to the simple expedient of turning one you’ve already used upside down (right).

The majestic sweep of Hurricane Bernice is clearly visible just as it is in the original, and nothing has been added or taken away since the photos were taken. The other Apollo image to feature regularly is AS11-36-5353. Usually it was just as a background, both upside down and right way up, but it can also be found in one shot reflected in the visor of an astronaut out on an EVA. Figure 5.5.9 shows it in its various appearances.

It’s worth pointing out that in the shot where the astronaut is leaving the base, Earth is lit by the sun from the left, but the shadows are falling as if lit from the right. That is how easy it is to make and spot mistakes.

One episode had the base deciding whether to warn Earth of a potential hurricane before it went into blackout thanks to a solar storm. They were therefore required to use an image of Earth with a hurricane on it. Let’s see how they did in figure 5.5.10.
Where do we start? Well, hurricanes in the northern hemisphere spin anti-clockwise, and this one is clearly spinning clockwise and would not head in that trajectory at that latitude, so strike one for accuracy there. The coastlines of the Americas are not exactly accurate (particularly the eastern US seaboard) and the colours are all wrong, so strikes two and three there. If anything, the view looks very like that of Earth from the ATS-3 satellite, particularly in terms of the colours of the land.

A much better use of Apollo in popular culture comes from the incredibly successful ‘Six Million Dollar Man’ series. In an episode entitled ‘Rescue of Athena One’ filmed in 1974, our hero Steve Austin is called upon to rescue Farrah Fawcett-Majors from an incident bearing a good deal of similarity to Apollo 13, but using the then current Skylab mission as a bolt-on to the plot.

While it seems a little unsure as to which Saturn rocket it should be showing at launch, and mixes docking footage from lunar module and Skylab sequences the views of the CSM in space are actually quite good, and the dialogue is considerably more accurate than other examples I use here. The first use of Apollo footage comes with a short sequence of Earth, and I’ve spliced together a few screenshots in figure 5.5.11 below.

![Figure 5.5.11: Composite image formed of screenshots taken from ‘Rescue of Athena 1’](image)

Readers with a good memory will immediately spot that this is the same view of Earth taken by Apollo 17 astronauts and already used in this section, but on this occasion it has not been reversed to compensate for it being shot in a mirror through the CSM window.

There’s some interesting mixing of footage from Apollo 9’s LEO EVA (astronaut has red helmet) and the SIM bay retrieval footage in cislunar space (no red helmet) to show a spacewalk outside Skylab, as well as actual Skylab spacewalk footage. We also have the LM undocking sequence from Apollo 9 mixed in with the animated CSM and Skylab undocking.
The only real failings come with any depiction of the behaviour of people and objects in zero gravity. The only visual device they can use is the exaggerated slow motion movement that they think represents movement in space, rather than the careful but free flowing movement that it actually is. It is my opinion that this dramatic device of using slow motion to simulate space movement has wasted a ridiculous amount of youtube space by people who can’t think independently and seem to think speeding up lunar surface video makes it look normal.

From a decent attempt at replicating space conditions using Apollo footage to a pretty dismal one. The film ‘Stowaway to the Moon’ was sent to me by a contributor (thanks Graham!) and is a 1975 cheese-fest that features quite hefty chunks of Apollo footage - often incorrectly.

There are lots of sequences showing the CSM filmed from the LM, of lunar orbit, and astronauts working on the surface from Apollo 17, but of real interest to us are the sequences where Earth is used.

As part of the post-launch pre-TLI shots, they use the two sequences below in figure 5.5.12. After the second sequence one of the actors asks “What am I looking it?”, “Africa” is the response. It isn’t - see for yourself:

![Figure 5.5.12: Screenshots from ‘Stowaway to the Moon’.

The sharp eyed reader will have noticed that it’s the same Apollo 16 image used by Space 1999, and they’ve just panned the camera across it.

Perhaps relying on the short attention spans of their young target audience, the same photograph was used towards the end of the film, and used the cunning device of zooming in on the image to illustrate getting closer to home on the way back.

In lunar orbit they use a classic 16mm Earthrise sequence from Apollo 10, this time played in reverse to show that they were going behind the Moon (see figure 5.5.13).
As with the Apollo 16 footage, we’ve already established that these pictures of Earth show exactly what they should show in terms of the Earth’s terminator and the visible weather patterns, and we now have them publicly available decades before YouTube would turn every basement internet crusader into an expert on something in which they have no experience or understanding.

Similar proof of Apollo’s veracity can be found in Stowaway’s use of landing footage. I’ve discussed the Apollo 16 landing footage on this page, and shown that there could have been no prior knowledge of the rocks and craters that it shows. Its use in this film (see figure 5.5.14a) confirms that it was freely available before the LRO took more detailed images of the Descartes Highlands. Likewise Apollo 11’s view of the lunar surface is discussed here, and the 16mm DAC footage was used in the film (figure 5.5.14b) to show the scene immediately after landing. Sadly for the film makers they didn’t seem to notice that the Apollo 11 EASEP equipment was very clearly in shot.

![Figure 5.5.14: Apollo 16mm DAC footage used in ‘Stowaway to the Moon’ a) Apollo 16 (left) and b) Apollo 11 (right)](image)

Other unintentional howlers include the sequence supposedly illustrating the docking of the returning LM with the CSM that instead shows the LM inside the SIV-B just after TLI, and the use of early Apollo stage separation footage to show separation of the LM and CSM (see this section for clarification), and launch footage of a Saturn taken from Earth to show re-entry.

Perhaps the film’s best use in this context, although it might be slightly unfair to say so given the obvious low budget, is to illustrate just how poor the state of special effects were even 3 years after Apollo ended. In figure 5.5.15 below we have a shot used to show the re-uniting of the LM and CSM in space (left) and it’s worth comparing that with the genuine footage (right) also used in the film. Ask yourself - which one looks real? Try watching the actual video and then ask yourself again.

![Figure 5.5.15: Special effect (left) and real (right) footage of the CSM in lunar orbit from the film ‘Stowaway to the Moon’](image)
Other visual cues about them being in space are just as badly done. The crew’s movement is illustrated entirely by them moving incredibly slowly, always with one foot on the ground. There is no-one hanging upside down, no spinning of objects, nothing free floating, no globules of water or juice in zero gravity, clothes and other material stubbornly flattened by Earth’s gravity on the film set.

To be fair there are occasional scenes where someone does some floating about and there are no wires visible anywhere, but it is noticeable how short these shots are in comparison to the long uncut sequences seen in Apollo footage and also how forced and unnatural the motion is.

Also from 1975 is another Gerry Anderson production ‘The Day After Tomorrow’, a frankly pretty dreadful tale of deep space exploration that even Brian Blessed can’t rescue. In one shot we have their spaceship of choice against a backdrop of Earth. I’ve turned it the right way up so we can see what it is and shown it in figure 5.5.16.

![Figure 5.5.16: Screenshot from ‘The Day After Tomorrow (1975)'](image)

The image used is one from the outward journey of Apollo showing Africa, AS11-36-5353, which was one of the most popular images from that mission when you look at what was published in the popular press.

That image crops up again in what is perhaps one of the most ironic uses of Apollo footage is in the 1977 BBC ‘mockumentary’ “Alternative 3”. It’s ironic because it has often been quoted as being genuine evidence of a hoax, particularly the badly acted and technically incorrect script voiceover for genuine Apollo footage (including the usual Apollo 4 separation and some moonwalk footage). The hoax in this case being that they did actually go to the moon, and also Mars, but the existence of Alien life was covered up on both. The end credits show the familiar Apollo image (figure 5.5.17). Also shown is my own copy of the book that was produced from the TV film. The back cover clearly identifies it as ‘fiction’.

A year after this, we have the first mainstream appearance of a sadly departed legend, Robin Williams.

As part of the introduction to the series ‘Mork and Mindy’, which started in 1978, we have the use of Apollo 17’s Blue Marble image (figure 5.5.18).
Also from 1978 we have another TV film exploring orbiting space station life and the contributions they could make to an over-populated resource starved Earth. *Libra* was inspired by the work of Gerard o’Neill, a pioneering scientist who thought through many of the things that would be needed for genuinely functional space stations to work. In figure 5.5.19, you can see the now obligatory Blue Marble shot (used first in the opening sequence and then later on in the view shown), as well as a different Apollo 17 view used as a backdrop for a spacecraft rising from Earth.
Figure 5.5.19: Screenshots from ‘Libra’. On the left is Apollo 17 image AS17-148-22669, used as the backdrop for the shot shown top right.

A year later still we have an all-star disaster movie in the shape of 1979’s ‘Meteor’. The basic premise of the film is that a meteor is heading our way, and the Cold War stand-off between the USA and USSR has to come to a halt so they can unite to defeat the approaching rocky horror show.

In the process, they actually make a decent fist of the use of Apollo style control rooms and make good use of Apollo pictures in the process, as shown in figure 5.5.20. By ‘good’, I mean ‘economical’, as they use different parts of the same image to make it look like different scenes quite cleverly.

Figure 5.5.20: Apollo images used in ‘Meteor: AS17-148-22726 (top left and right), AS09-23-3512 (centre left and right), AS11-36-5305 (bottom left) and AS16-118-18873 (bottom right).
The ‘blue marble’ Apollo 17 image has actually been inverted so that it is a mirror image of that proper one, and also has a cameo role in the another scene where a small corner of it is visible. The Apollo 9 view also makes more than one appearance filmed from different angles. The special effects may have been a little shaky, but the Earth looks great.

Also in 1979 is the utterly abysmal ‘Salvage 1’, a story of a homemade rocket ship heading for the moon to retrieve Apollo hardware for salvage. The special effects are woeful (the spaceship is very obviously being swung on a rope during the launch sequence), and the script is dreadful. It gets included in the next section of this site thanks to a depiction of a pretend Earth, but here it makes an appearance thanks to its use of (you guessed it) the Blue Marble.

Figure 5.5.21 shows the marble as seen through the broadcast antenna of the now landed spaceship (top left), which is pretty impressive forecasting given that it is also used in their backyard mission control (top right). It gets used again in a ‘coming home’ shot (bottom left). An Apollo 16 shot does get used for variety in one episode.

Figure 5.5.22: Screenshots from ‘Salvage 1’ showing the Blue Marble.

In the same year as Salvage we had the revamp of ‘Buck Rogers’ - transporting him to the 25th century. While he didn’t always stick around Earth he did use images of Earth - some of which were made up, others genuine.

In the screenshots below, for example (figure 5.5.22) we can see our old faithful AS11-36-5353, for some reason presented the wrong way round!

Figure 5.5.22: Screenshots from Buck Rogers in the 25th century.
Other images used of Earth were fictional, but the creator of them obviously used Apollo as an inspiration - as can be seen below in figure 5.5.23.

![Image of fictional Earth with Apollo inspiration](source)

By now we’re heading away from the Apollo era and towards the Shuttle era, when views of Earth from LEO become more commonplace and film technology begins to be able to generate more realistic Earths.

Despite this we still see Apollo and even Gemini images being used, even in relatively recent films. The 1984 film ‘The Noah’s Ark Principle’, a cold war story of the threat of destruction from orbit, uses Gemini images for several views of Earth (figure 5.5.24)

![Image of Gemini images S66-63529_G12-S (Gemini 12, left) and S65-63780_G07-H (Gemini 7, right)]

Speaking of the Cold War, the US government didn’t mind appropriating Apollo imagery for its own ends, well, after all, they had paid for it. This [youtube video](youtube) showing the proposed ‘Strategic Defence Initiative’ is undated, but the programme was proposed in 1983 by Ronald Reagan. In between the poor quality computer animations we have both the Blue Marble image with pretty missiles painted all over it, as well as an Apollo 11 image (AS11-56-5376). Figure 5.5.25 shows two screenshots from it, together with a cropped view of the Apollo 11 image.
Continuing the cold war theme (readers of a certain age will remember the nervy nuclear tensions well) 1985’s ‘Def Con 4’, a cheery tale of nuclear holocaust, makes economical use of an Apollo 9 image (see figure 5.5.26), using all or part of it in several scenes.

A year later, Superman comes to the rescue in 1987’s ‘Superman IV’, where a horizontally flipped and cropped view of Hurricane Gladys photographed by Apollo 7 appears (figure 5.5.27).

A couple of years later we have 1989’s “Dark Side of the Moon” (no relation to the Pink Floyd classic), a seemingly satanic space film with a very ‘Alien’ like plot. It does feature several views like the one in figure 5.5.28, which bears more than a passing resemblance to the view of Earth taken as part of an Earthrise sequence by Apollo 11.
It’s worth pointing out that while the rendering of the lunar surface is good, the lighting appears to be inconsistent, as it seems come from the right in the crater, while Earth is lit correctly from ‘above’.

Also in 1989 we have more low budget sci-fi in the form of Moontrap, notable mainly for the appearance of Walter Koenig - Mr Chekov in the original Star Trek and obviously trying to scrape a living in poor quality science movies in between reprises his more famous role in the Star Trek film franchise. This one is yet another that crowbars in the usual Blue Marble image (several times), but also manages to recreate a lunar landscape using elements of Apollo 17 surface photography. Figure 5.5.29 shows the Blue Marble in use, a compilation of a panorama across their lunar landscape, and Tracey’s rock, in AS17-140-21496.

Figure 5.5.28: Screenshot from ‘Dark Side of the Moon’ compared with AS11-44-6555 (bottom right).

Figure 5.5.29: ‘Blue Marble’ used on Moontrap, AS17-140-21496, and a Moontrap moonscape.
The broader landscape is a clever pastiche of what can be seen in other images of Taurus-Littrow from Apollo 17, which a hint of Mons Hadley from Apollo 15 for good measure. The rock in the foreground, however, is actual moon rock, and has been cleverly compiled by taking elements of Tracey’s rock and using it a couple of times, stretched and rotated a little.

Even into the 1990’s, where film and digital technology has improved by leaps and bounds, Apollo still has a role. Honourable mention here goes to Tom Hanks’ 1995 Apollo 13, which makes good use of images from Apollo 16 and 17. While the recreation of the behaviour of lunar dust and gravity is a little on the shaky side, the use of Apollo 16 image AS16-118-18885 to show Lovell dreaming of his now vanishing moonwalk is much better. The same image is re-used in the scene where Apollo 13 is making its final approach to Earth (see figure 5.5.30).

Figure 5.5.30: Screenshots from Apollo 13 showing AS16-118-18885: the lunar surface sequence (upper 2) and final approach (bottom). The landscape in the top image is taken from a famous image taken at Taurus-Littrow AS17-140-21496.
Another image that gets used more than once is the famous ‘Blue Marble’ - again! It appears through the LM window in its original form as the crew are discussing a course correction burn (an event Fred Haise insists was not as dramatic as portrayed in the film). The same image, slightly edited to remove the really obvious storm feature, appears in the sequence as the crew round the moon (ie before Lovell’s ‘dream sequence’ and during the correction burn itself - see figure 5.5.31). For all you blooper fans, as the scene intercuts between the exterior and interior shot, you keep getting a change between the edited and unedited blue marble.

Figure 5.5.31: Apollo 17’s Blue Marble appearing in edited form as Apollo rounds the moon (top) unedited through the LM window (centre top) and edited again during the course correction burn (centre bottom) and the actual compared with edited version (bottom).
Also from 1995 is cult computer themed movie ‘Hackers’, wherein teen heroes take on the bad guys by hacking into computer systems and sticking it to the man. One clip shows a rather over-adapted Skylab with Earth as a backdrop. That backdrop is provided by Apollo 17 image AS17-148-22679. The screen shot and Apollo image are shown below in figure 5.5.32.
Next we have 1998’s space disaster film “Scorpio One” which once again has our old favourite the Blue Marble on several occasions, and it is still starring nearly 40 years on in 2010’s excellent “Moon” (figure 5.5.33).

Figure 5.5.33: Apollo 17’s Blue Marble in ’Scorpio One’ (left) and “Moon” (right).

We also have an honourable mention for 2011’s “Apollo 18”, a ‘found footage’ style horror that uses the technique extremely well to incorporate original and slightly modified Apollo images, as well as echoing many of the more famous Apollo moments like saluting the flag and filming astronauts from the LM. The two shots shown in figure 5.5.34 show examples of Apollo images incorporated into the film.

Figure 5.5.34: AS10-30-4477 (left) and AS11-44-6653 (right) used in ‘Apollo 18’.
Whatever the merits of the plot and the film’s style, their attempts at reproducing a convincing lunar environment is done well - amazing that it has taken over 40 years to achieve it.

Even in 2013, film makers are still using Apollo to show Earth. In Elysium, the hero is given a necklace as a child, and that necklace contains an image of Earth from space. The image they’ve used is from Apollo 8 (see figure 5.5.35).

![Image](image.png)

Figure 5.5.35: Promotional image showing a still from Elysium with the Earth image in the necklace, and a close up of AS08-14-2383.

You could argue, and I’m sure some conspiracy theorists will, that this is how easy it is to fool the public. Splice a few stock scenes together, get a half decent script and a few special effects and people will swallow any bullshit they’re fed as long as their brains aren’t made to hurt too much. I for one remember being heartily convinced by ‘Alternative 3’, particularly as I’d just seen ‘Capricorn One’. I was 13, give me a break. I read books and now I know better.

The converse argument is that it really doesn’t take long to spot when mistakes are made, when footage is used repeatedly, and to find from whence footage originated. It’s taken me a very short amount of time between learning about ‘Stowaway...’ and ‘Rescue...’ to find out what footage was used and what continuity errors have been made. Granted it’s easier in the internet age, but there are plenty of experts out there who know how to use a reference book. Not everyone is as dumb as a moon hoax believer, and there are too many people who know what they’re looking at to be fooled for long. Moonbase-3, for example, had more than its fair share of critics precisely because of its shoddy special effects.

Even modern films with seemingly fine images are soon caught out. As well as the minor Apollo 13 slip-ups identified earlier, 2016’s “Independence Day: Resurgence” features this nice shot (figure 5.5.36) of the moon with a splendid Apollo 8 Earthrise accompanying it. While getting the phase details and angles correct, this view of the moon is not astronomically possible (the orientation of the moon is all wrong for the view of Earth) and it took no time at all for people passionate about space and space exploration to figure that out.

I can only imagine that they thought it just looked nicer.

Honourable mention also goes out to 2011’s ‘Another Earth’. The film is a story of redemption and forgiveness using dreams of escape to an alternative Earth that appears in the evening sky. Some of the Earths hovering in the sky are more modern, such as the 1989 Galileo probe view of Earth as it swung by on its way to Jupiter, and the view of Hurricane Dean from 2007 (figure 5.5.37).
Figure 5.5.36: Apollo 8 Earthrise image featured in ‘Independence Day: Resurgence’

Figure 5.5.37: Screenshots from ‘Another Earth’ showing a Galileo image of Earth (top right and left) and a GOES West satellite image from 2007 (bottom left and right).
The bulk of the imagery, however, consists of our old friend the blue marble, shown in various stages of fullness with scant regard for the direction of the sun or the gravitational impact on tides and what not. Still, if we can accept the sudden arrival of a duplicate Earth we can accept the various other breachings of the laws of physics. I’m being unfair, it’s a decent film, and it also manages to sneak in a couple of glimpses of Apollo 11 image AS11-36-5352 (figure 5.5.38).

Figure 5.5.38: Screenshots from ‘Another Earth’ showing images from Apollo 17 and Apollo 11

That Apollo 11 image still continues to be used, even when modern CGI could easily generate a convincing one. Here it is in December 2020’s Chanel number 5 advert (figure 5.5.39).

Figure 5.5.39: Apollo 11 image used in Chanel number 5 advert
I must give honourable mention to a film that, although it didn’t use an Apollo image did at least go to some lengths to achieve a level of authenticity that the film didn’t deserve. The film is ‘Horror Express’, a low budget affair where a frozen monster corpse turns out to be an alien being, like they do, whose eyes record memories. When the scientist heroes examine some eyeball fluid (around 48 minutes onwards), it reveals a view of Earth - supposedly from the creature’s original Martian home (figure 5.5.39).

A quick bit of internet searching finds that this image of Earth is, in fact, an upside-down version of an ATS-3 satellite view (see figure 5.5.40).

It’s shown three times, and oddly while they show it the wrong way up when the scientists and finally a Rasputin like priest view it, the female viewer who sees it second gets it the right way up (figure 5.5.41).
Even a low budget schlock horror movie uses an actual image of Earth when it wants to be accurate, even if they aren’t sure which way up the picture needs to be.

Likewise terrible scifi films and UFO pseudo-documentaries. The former is the 1975 film “Strange New World”, which manages to use really poor renditions of Earth while at the same time utilising an actual image (AS16-118-18885) as an Earthrise view. The terrible UFO documentary takes the form of “Mysteries from Beyond Earth”, also from 1975, and also using the same Apollo 16 image as well as Apollo 11’s AS11-36-5353. The documentary is an exercise in sucking money out of the stupid by going “I’m not saying it’s aliens, but...” a lot, and these two photos are used to support an “I’m not saying the Earth is hollow, but...” segment. Screenshots from both films are in figure 5.5.43.

Figure 5.5.43: Screenshots from “Strange New World” (top left and right) and “Mysteries from Beyond Earth” (bottom left and right).

Just as with the popular media of the time, popular fiction’s use of Apollo images (and other space program photographs) pre-dates the internet, pre-dates digital manipulation of images and (as is obvious if you watch the programmes) pre-dates the kind of special effects that would have been needed to fake the Apollo images. You can’t go back and undo the material that’s out there, and what’s out there matches the historical narrative in a way that the hoax argument miserably fails to.

I haven’t proved Apollo landed on the Moon here, but we have shown that the photographs weren’t stashed away in a hiding place - just like their newspaper and magazine counterparts they were out there all the time and as the next section shows, if you want realism in science fiction, you use the real thing.
5.5: Hooray for Hollywood

As well as Apollo photographs being reproduced in slides and in popular journals, they were also used in popular TV programmes and films almost as soon as they were publicly available, meaning that many people will have seen Apollo photographs without even realising it. Let’s now look at some fine examples of Apollo images in popular culture so that we can prove that you could see Apollo pictures quite easily, and that they weren’t hidden away from the public gaze. I’ll try and present them in some sort of chronological order.

One of the earliest examples comes from the now legendary Star Trek programme. In the next section I’ll show some not so realistic Earth images, but here we have some use of original Apollo material.

The last episode of the second season was broadcast on March 29, 1968 and was called ‘Assignment Earth’. Although it pre-dated the manned missions of Apollo it does produce some convincing Saturn V pad and launch views, as well as some shots from orbit, largely by using NASA images. Figure 5.5.1 shows some of the relevant images.

![Figure 5.5.1: Screenshots from ‘Star Trek: Assignment Earth’](image)

If you bothered to read the section on orbital images you’ll recognise the sequence used from Apollo 4’s separation footage (top right), and the Saturn launch is also Apollo 4 (as can be seen on youtube). The other two images are exceptionally clear views of Earth, as they can’t be taken by Apollo they must be from Gemini missions. A brief trawl through the superb ‘March to the Moon’ website shows that this is exactly where they came from, although the Star Trek versions are horizontally flipped compared with the Gemini originals. The two photographs in question are from Gemini IV (bottom right) and Gemini IX-A (bottom left).

Meanwhile in the UK, the British TV series ‘UFO’ was being filmed while Apollo was in progress by the late and legendary Gerry Anderson, and used Apollo images as backdrops. The most obvious one is from Apollo 8 (AS08-16-2593), as shown on this website and this is shown together with a still from the closing credits shown in figure 5.5.2.
Figure 5.5.2: Screenshot from an episode of UFO showing AS08-16-2593 and one from the closing credits of the first ever episode of ‘UFO’ (Youtube source). The image used is a version of AS08-16-2593

While some film-makers were grabbing Apollo photographs as props, some were still sticking with good old Gemini. 1971’s “Earth II” (a TV pilot about an orbiting space station) has a variety of space images, some of which are from Gemini and others painted scenes obviously based on Gemini. A couple of examples are shown below in figure 5.5.3, where small details of a larger photograph (S65-34747) are isolated, and in one case reversed to look as though a different backdrop has been used.

Figure 5.5.3: S65-34747 (Gemini 4) and the section of it used in ‘Earth II’. The part used in the screenshot bottom right has been flipped horizontally.

Meanwhile in the world of cinema, one of the best sci-fi films made in the period capitalised on the ecological message prompted by the early images of Earth from space. Silent Running was released in March 1972 and featured a ship containing precious examples of biological specimens from a ruined future Earth. Looking back at Earth from a spot around Saturn, our hero sees this view through his telescope (figure 5.5.4).

It’s not the best quality reproduction and as a result it isn’t entirely obvious what it is, but if you flip the image horizontally and rotate it, you’ll find it is our old friend AS08-16-2593.
It’s not the best quality reproduction and as a result it isn’t entirely obvious what it is, but if you flip the image horizontally and rotate it, you’ll find it is our old friend AS08-16-2593.

Returning to TV, Gerry Anderson also produced another immensely popular TV science fiction show in ‘Space 1999’, at that point a year ludicrously far away for most viewers.

This Space 1999 fansite (another Gerry Anderson series filmed in the mid-1970s) details other Apollo Earth images used in the programme, including some from Apollo 11 and the famous ‘Blue Marble’ from Apollo 17. Often they would add minor tweaks to the images to make them unique to the program, like this one from Apollo 16 (figure 5.5.5).

Figure 5.5.4: View of Earth in 1972’s “Silent Running”.

Figure 5.5.5: Fictional planet from Space 1999 (left) compared with AS16-118-18885
Figure 5.5.6 shows another adapted Apollo image used in the series. In the opening episode of series 1 shows a scene from inside the base, and as the camera pans across the interior a view of Earth can be seen in the window. This image turns out to be an upside down version of AS11-36-5355.

A slightly tweaked version of the same image makes an appearance in the introduction to series 2, as shown in figure 5.5.7.
While UFO and Space 1999 have a certain kitsch value about them now, others were pretty corny even at the time. Another gem from the 70s also shows us TV's use of Apollo imagery, although to be honest it seems like the budget only stretched to buying the rights to two of them. Moonbase-3 was a low budget BBC drama, and it can be found on youtube quite easily. Screened in 1973 it boasted James Burke (a well respected science presenter who contributed a great deal to the BBC's Apollo coverage) as an advisor. As shown in figure 5.5.6 it features an old friend in the opening credits (left), again in a panoramic sweep (centre) and as I'm sure you'll know, movie sets are expensive, so why pay for another photograph when you can resort to the simple expedient of turning one you've already used upside down (right).

![Image of Moonbase-3](image1)

Figure 5.5.8: AS11-36-5337 featured in Moonbase-3.

The majestic sweep of Hurricane Bernice is clearly visible just as it is in the original, and nothing has been added or taken away since the photos were taken. The other Apollo image to feature regularly is AS11-36-5353. Usually it was just as a background, both upside down and right way up, but it can also be found in one shot reflected in the visor of an astronaut out on an EVA. Figure 5.5.9 shows it in its various appearances.

![Image of Moonbase-3](image2)

Figure 5.5.9: AS11-36-5353 as used in Moonbase-3. In then centre it is a reflection, on the right it is upside down.

It's worth pointing out that in the shot where the astronaut is leaving the base, Earth is lit by the sun from the left, but the shadows are falling as if lit from the right. That is how easy it is to make and spot mistakes.

One episode had the base deciding whether to warn Earth of a potential hurricane before it went into blackout thanks to a solar storm. They were therefore required to use an image of Earth with a hurricane on it. Let’s see how they did in figure 5.5.10.

![Image of Moonbase-3](image3)

Figure 5.5.10: Artist renderings of Earth from Moonbase-3.
Where do we start? Well, hurricanes in the northern hemisphere spin anti-clockwise, and this one is clearly spinning clockwise and would not head in that trajectory at that latitude, so strike one for accuracy there. The coastlines of the Americas are not exactly accurate (particularly the eastern US seaboard) and the colours are all wrong, so strikes two and three there. If anything, the view looks very like that of Earth from the ATS-3 satellite, particularly in terms of the colours of the land.

A much better use of Apollo in popular culture comes from the incredibly successful ‘Six Million Dollar Man’ series. In an episode entitled ‘Rescue of Athena One’ filmed in 1974, our hero Steve Austin is called upon to rescue Farrah Fawcett-Majors from an incident bearing a good deal of similarity to Apollo 13, but using the then current Skylab mission as a bolt-on to the plot.

While it seems a little unsure as to which Saturn rocket it should be showing at launch, and mixes docking footage from lunar module and Skylab sequences the views of the CSM in space are actually quite good, and the dialogue is considerably more accurate than other examples I use here. The first use of Apollo footage comes with a short sequence of Earth, and I’ve spliced together a few screenshots in figure 5.5.11 below.

![Figure 5.5.11: Composite image formed of screenshots taken from ‘Rescue of Athena 1’](image)

Readers with a good memory will immediately spot that this is the same view of Earth taken by Apollo 17 astronauts and already used in this section, but on this occasion it has not been reversed to compensate for it being shot in a mirror through the CSM window.

There’s some interesting mixing of footage from Apollo 9’s LEO EVA (astronaut has red helmet) and the SIM bay retrieval footage in cislunar space (no red helmet) to show a spacewalk outside Skylab, as well as actual Skylab spacewalk footage. We also have the LM undocking sequence from Apollo 9 mixed in with the animated CSM and Skylab undocking.
The only real failings come with any depiction of the behaviour of people and objects in zero gravity. The only visual device they can use is the exaggerated slow motion movement that they think represents movement in space, rather than the careful but free flowing movement that it actually is. It is my opinion that this dramatic device of using slow motion to simulate space movement has wasted a ridiculous amount of youtube space by people who can’t think independently and seem to think speeding up lunar surface video makes it look normal.

From a decent attempt at replicating space conditions using Apollo footage to a pretty dismal one. The film ‘Stowaway to the Moon’ was sent to me by a contributor (thanks Graham!) and is a 1975 cheese-fest that features quite hefty chunks of Apollo footage - often incorrectly.

There are lots of sequences showing the CSM filmed from the LM, of lunar orbit, and astronauts working on the surface from Apollo 17, but of real interest to us are the sequences where Earth is used.

As part of the post-launch pre-TLI shots, they use the two sequences below in figure 5.5.12. After the second sequence one of the actors asks “What am I looking it?”, “Africa” is the response. It isn’t - see for yourself:

![Figure 5.5.12: Screenshots from ‘Stowaway to the Moon’](image)

The sharp eyed reader will have noticed that it’s the same Apollo 16 image used by Space 1999, and they’ve just panned the camera across it.

Perhaps relying on the short attention spans of their young target audience, the same photograph was used towards the end of the film, and used the cunning device of zooming in on the image to illustrate getting closer to home on the way back.

In lunar orbit they use a classic 16mm Earthrise sequence from Apollo 10, this time played in reverse to show that they were going behind the Moon (see figure 5.5.13).

![Figure 5.5.13: Apollo 10 Earthrise footage used in ‘Stowaway to the Moon’.](image)
As with the Apollo 16 footage, we’ve already established that these pictures of Earth show exactly what they should show in terms of the Earth’s terminator and the visible weather patterns, and we now have them publicly available decades before youtube would turn every basement internet crusader into an expert on something in which they have no experience or understanding.

Similar proof of Apollo’s veracity can be found in Stowaway’s use of landing footage. I’ve discussed the Apollo 16 landing footage on this page, and shown that there could have been no prior knowledge of the rocks and craters that it shows. Its use in this film (see figure 5.5.14a) confirms that it was freely available before the LRO took more detailed images of the Descartes Highlands. Likewise Apollo 11’s view of the lunar surface is discussed here, and the 16mm DAC footage was used in the film (figure 5.5.14b) to show the scene immediately after landing. Sadly for the film makers they didn’t seem to notice that the Apollo 11 EASEP equipment was very clearly in shot.

![Figure 5.5.14: Apollo 16mm DAC footage used in ‘Stowaway to the Moon’ a) Apollo 16 (left) and b) Apollo 11 (right)](image)

Other unintentional howlers include the sequence supposedly illustrating the docking of the returning LM with the CSM that instead shows the LM inside the SIV-B just after TLI, and the use of early Apollo stage separation footage to show separation of the LM and CSM (see this section for clarification), and launch footage of a Saturn taken from Earth to show re-entry.

Perhaps the film’s best use in this context, although it might be slightly unfair to say so given the obvious low budget, is to illustrate just how poor the state of special effects were even 3 years after Apollo ended. In figure 5.5.15 below we have a shot used to show the re-uniting of the LM and CSM in space (left) and it’s worth comparing that with the genuine footage (right) also used in the film. Ask yourself - which one looks real? Try watching the actual video and then ask yourself again.

![Figure 5.5.15: Special effect (left) and real (right) footage of the CSM in lunar orbit from the film ‘Stowaway to the Moon’](image)
Other visual cues about them being in space are just as badly done. The crew’s movement is illustrated entirely by them moving incredibly slowly, always with one foot on the ground. There is no-one hanging upside down, no spinning of objects, nothing free floating, no globules of water or juice in zero gravity, clothes and other material stubbornly flattened by Earth’s gravity on the film set.

To be fair there are occasional scenes were someone does some floating about and there are no wires visible anywhere, but it is noticeable how short these shots are in comparison to the long uncut sequences seen in Apollo footage and also how forced and unnatural the motion is.

Also from 1975 is another Gerry Anderson production ‘The Day After Tomorrow’, a frankly pretty dreadful tale of deep space exploration that even Brian Blessed can’t rescue. In one shot we have their spaceship of choice against a backdrop of Earth. I‘ve turned it the right way up so we can see what it is and shown it in figure 5.5.16.

![Figure 5.5.16: Screenshot from ‘The Day After Tomorrow (1975)'](image)

The image used is one from the outward journey of Apollo showing Africa, AS11-36-5353, which was one of the most popular images from that mission when you look at what was published in the popular press.

That image crops up again in what is perhaps one of the most ironic uses of Apollo footage is in the 1977 BBC ‘mockumentary’ “Alternative 3”. It’s ironic because it has often been quoted as being genuine evidence of a hoax, particularly the badly acted and technically incorrect script voiceover for genuine Apollo footage (including the usual Apollo 4 separation and some moonwalk footage). The hoax in this case being that they did actually go to the moon, and also Mars, but the existence of Alien life was covered up on both. The end credits show the familiar Apollo image (figure 5.5.17). Also shown is my own copy of the book that was produced from the TV film. The back cover clearly identifies it as ‘fiction’.

A year after this, we have the first mainstream appearance of a sadly departed legend, Robin Williams.

As part of the introduction to the series ‘Mork and Mindy’, which started in 1978, we have the use of Apollo 17’s Blue Marble image (figure 5.5.18).
Also from 1978 we have another TV film exploring orbiting space station life and the contributions they could make to an over-populated resource starved Earth. ‘Libra’ was inspired by the work of Gerard O’Neil, a pioneering scientist who thought through many of the things that would be needed for genuinely functional space stations to work. In figure 5.5.19, you can see the now obligatory Blue Marble shot (used first in the opening sequence and then later on in the view shown), as well as a different Apollo 17 view used as a backdrop for a spacecraft rising from Earth.
A year later still we have an all-star disaster movie in the shape of 1979’s ‘Meteor’. The basic premise of the film is that a meteor is heading our way, and the Cold War stand-off between the USA and USSR has to come to a halt so they can unite to defeat the approaching rocky horror show.

In the process, they actually make a decent fist of the use of Apollo style control rooms and make good use of Apollo pictures in the process, as shown in figure 5.5.20. By ‘good’, I mean ‘economical’, as they use different parts of the same image to make it look like different scenes quite cleverly.
The ‘blue marble’ Apollo 17 image has actually been inverted so that it is a mirror image of that proper one, and also has a cameo role in the another scene where a small corner of it is visible. The Apollo 9 view also makes more than one appearance filmed from different angles. The special effects may have been a little shaky, but the Earth looks great.

Also in 1979 is the utterly abysmal ‘Salvage 1’, a story of a homemade rocket ship heading for the moon to retrieve Apollo hardware for salvage. The special effects are woeful (the spaceship is very obviously being swung on a rope during the launch sequence), and the script is dreadful. It gets included in the next section of this site thanks to a depiction of a pretend Earth, but here it makes an appearance thanks to its use of (you guessed it) the Blue Marble.

Figure 5.5.21 shows the marble as seen through the broadcast antenna of the now landed spaceship (top left), which is pretty impressive forecasting given that it is also used in their backyard mission control (top right). It gets used again in a ‘coming home’ shot (bottom left). An Apollo 16 shot does get used for variety in one episode.

![Figure 5.5.21: Screenshots from ‘Salvage 1’ showing the Blue Marble.](image)

In the same year as Salvage we had the revamp of ‘Buck Rogers’ - transporting him to the 25th century. While he didn’t always stick around Earth he did use images of Earth - some of which were made up, others genuine.

In the screenshots below, for example (figure 5.5.22) we can see our old faithful AS11-36-5353, for some reason presented the wrong way round!

![Figure 5.5.22: Screenshots from Buck Rogers in the 25th century.](image)
Other images used of Earth were fictional, but the creator of them obviously used Apollo as an inspiration - as can be seen below in figure 5.5.23.

![Figure 5.5.23: The work of Janet Kusnick, showing AS11-36-5353 on the wall (Source)](image)

By now we’re heading away from the Apollo era and towards the Shuttle era, when views of Earth from LEO become more commonplace and film technology begins to be able to generate more realistic Earths.

Despite this we still see Apollo and even Gemini images being used, even in relatively recent films. The 1984 film ‘The Noah’s Ark Principle’, a cold war story of the threat of destruction from orbit, uses Gemini images for several views of Earth (figure 5.5.24)

![Figure 5.5.24: Gemini images S66-63529_G12-S (Gemini 12, left) and S65-63780_G07-H (Gemini 7, right). Both versions in the film use a small portion of the full image, and Gemini 12’s has been flipped horizontally.](image)

Speaking of the Cold War, the US government didn’t mind appropriating Apollo imagery for its own ends, well, after all, they had paid for it. This youtube video showing the proposed ‘Strategic Defence Initiative’ is undated, but the programme was proposed in 1983 by Ronald Reagan. In between the poor quality computer animations we have both the Blue Marble image with pretty missiles painted all over it, as well as an Apollo 11 image (AS11-56-5376). Figure 5.5.25 shows two screenshots from it, together with a cropped view of the Apollo 11 image.
Continuing the cold war theme (readers of a certain age will remember the nervy nuclear tensions well) 1985’s ‘Def Con 4’, a cheery tale of nuclear holocaust, makes economical use of an Apollo 9 image (see figure 5.5.26), using all or part of it in several scenes.

A year later, Superman comes to the rescue in 1987’s ‘Superman IV’, where a horizontally flipped and cropped view of Hurricane Gladys photographed by Apollo 7 appears (figure 5.5.27).

A couple of years later we have 1989’s “Dark Side of the Moon” (no relation to the Pink Floyd classic), a seemingly satanic space film with a very ‘Alien’ like plot. It does feature several views like the one in figure 5.5.28, which bears more than a passing resemblance to the view of Earth taken as part of an Earthrise sequence by Apollo 11.
It's worth pointing out that while the rendering of the lunar surface is good, the lighting appears to be inconsistent, as it seems come from the right in the crater, while Earth is lit correctly from 'above'.

Also in 1989 we have more low budget sci-fi in the form of Moontrap, notable mainly for the appearance of Walter Koenig - Mr Chekov in the original Star Trek and obviously trying to scrape a living in poor quality science movies in between reprising his more famous role in the Star Trek film franchise. This one is yet another that crowbars in the usual Blue Marble image (several times), but also manages to recreate a lunar landscape using elements of Apollo 17 surface photography. Figure 5.5.29 shows the Blue Marble in use, a compilation of a panorama across their lunar landscape, and Tracey's rock, in AS17-140-21496.
The broader landscape is a clever pastiche of what can be seen in other images of Taurus-Littrow from Apollo 17, which a hint of Mons Hadley from Apollo 15 for good measure. The rock in the foreground, however, is actual moon rock, and has been cleverly compiled by taking elements of Tracey’s rock and using it a couple of times, stretched and rotated a little.

Even into the 1990’s, where film and digital technology has improved by leaps and bounds, Apollo still has a role. Honourable mention here goes to Tom Hanks’ 1995 Apollo 13, which makes good use of images from Apollo 16 and 17. While the recreation of the behaviour of lunar dust and gravity is a little on the shaky side, the use of Apollo 16 image AS16-118-18885 to show Lovell dreaming of his now vanishing moonwalk is much better. The same image is re-used in the scene where Apollo 13 is making its final approach to Earth (see figure 5.5.30).

Figure 5.5.30: Screenshots from Apollo 13 showing AS16-118-18885: the lunar surface sequence (upper 2) and final approach (bottom). The landscape in the top image is taken from a famous image taken at Taurus-Littrow AS17-140-21496.
Another image that gets used more than once is the famous ‘Blue Marble’ - again! It appears through the LM window in its original form as the crew are discussing a course correction burn (an event Fred Haise insists was not as dramatic as portrayed in the film). The same image, slightly edited to remove the really obvious storm feature, appears in the sequence as the crew round the moon (ie before Lovell’s ‘dream sequence’ and during the correction burn itself - see figure 5.5.31). For all you blooper fans, as the scene intercuts between the exterior and interior shot, you keep getting a change between the edited and unedited blue marble.

Figure 5.5.31: Apollo 17’s Blue Marble appearing in edited form as Apollo rounds the moon (top) unedited through the LM window (centre top) and edited again during the course correction burn (centre bottom) and the actual compared with edited version (bottom).
Also from 1995 is cult computer themed movie ‘Hackers’, wherein teen heroes take on the bad guys by hacking into computer systems and sticking it to the man. One clip shows a rather over-adapted Skylab with Earth as a backdrop. That backdrop is provided by Apollo 17 image AS17-148-22679. The screen shot and Apollo image are shown below in figure 5.5.32.
Next we have 1998’s space disaster film “Scorpio One” which once again has our old favourite the Blue Marble on several occasions, and it is still starring nearly 40 years on in 2010’s excellent “Moon” (figure 5.5.33).

![Figure 5.5.33: Apollo 17’s Blue Marble in ‘Scorpio One’ (left) and “Moon” (right).](image)

We also have an honourable mention for 2011’s “Apollo 18”, a ‘found footage’ style horror that uses the technique extremely well to incorporate original and slightly modified Apollo images, as well as echoing many of the more famous Apollo moments like saluting the flag and filming astronauts from the LM. The two shots shown in figure 5.5.34 show examples of Apollo images incorporated into the film.

![Figure 5.5.34: AS10-30-4477 (left) and AS11-44-6653 (right) used in ‘Apollo 18’.](image)
Whatever the merits of the plot and the film’s style, their attempts at reproducing a convincing lunar environment is done well - amazing that it has taken over 40 years to achieve it.

Even in 2013, film makers are still using Apollo to show Earth. In Elysium, the hero is given a necklace as a child, and that necklace contains an image of Earth from space. The image they’ve used is from Apollo 8 (see figure 5.5.35).

![Figure 5.5.35: Promotional image showing a still from Elysium with the Earth image in the necklace, and a close up of AS08-14-2383.](image)

You could argue, and I’m sure some conspiracy theorists will, that this is how easy it is to fool the public. Splice a few stock scenes together, get a half decent script and a few special effects and people will swallow any bullshit they’re fed as long as their brains aren’t made to hurt too much. I for one remember being heartily convinced by ‘Alternative 3’, particularly as I’d just seen ‘Capricorn One’. I was 13, give me a break. I read books and now I know better.

The converse argument is that it really doesn’t take long to spot when mistakes are made, when footage is used repeatedly, and to find from whence footage originated. It’s taken me a very short amount of time between learning about ‘Stowaway...’ and ‘Rescue...’ to find out what footage was used and what continuity errors have been made. Granted it’s easier in the internet age, but there are plenty of experts out there who know how to use a reference book. Not everyone is as dumb as a moon hoax believer, and there are too many people who know what they’re looking at to be fooled for long. Moonbase-3, for example, had more than its fair share of critics precisely because of its shoddy special effects.

Even modern films with seemingly fine images are soon caught out. As well as the minor Apollo 13 slip-ups identified earlier, 2016’s “Independence Day: Resurgence” features this nice shot (figure 5.5.36) of the moon with a splendid Apollo 8 Earthrise accompanying it. While getting the phase details and angles correct, this view of the moon is not astronomically possible (the orientation of the moon is all wrong for the view of Earth) and it took no time at all for people passionate about space and space exploration to figure that out.

I can only imagine that they thought it just looked nicer.

Honourable mention also goes out to 2011’s ‘Another Earth’. The film is a story of redemption and forgiveness using dreams of escape to an alternative Earth that appears in the evening sky. Some of the Earths hovering in the sky are more modern, such as the 1989 Galileo probe view of Earth as it swung by on its way to Jupiter, and the view of Hurricane Dean from 2007 (figure 5.5.37).
Figure 5.5.36: Apollo 8 Earthrise image featured in ‘Independence Day: Resurgence’

Figure 5.5.37: Screenshots from ‘Another Earth’ showing a Galileo image of Earth (top right and left) and a GOES West satellite image from 2007 (bottom left and right).
The bulk of the imagery, however, consists of our old friend the blue marble, shown in various stages of fullness with scant regard for the direction of the sun or the gravitational impact on tides and what not. Still, if we can accept the sudden arrival of a duplicate Earth we can accept the various other breaches of the laws of physics. I’m being unfair, it’s a decent film, and it also manages to sneak in a couple of glimpses of Apollo 11 image AS11-36-5352 (figure 5.5.38).

![Figure 5.5.38: Screenshots from ‘Another Earth’ showing images from Apollo 17 and Apollo 11](image)

Finally, I must give honourable mention to a film that, although it didn’t use an Apollo image did at least go to some lengths to achieve a level of authenticity that the film didn’t deserve. The film is ‘Horror Express’, a low budget affair where a frozen monster corpse turns out to be an alien being, like they do, whose eyes record memories. When the scientist heroes examine some eyeball fluid (around 48 minutes onwards), it reveals a view of Earth - supposedly from the creature’s original Martian home (figure 5.5.39).

A quick bit of internet searching finds that this image of Earth is, in fact, an upside-down version of an ATS-3 satellite view (see figure 5.5.40).

It’s shown three times, and oddly while they show it the wrong way up when the scientists and finally a Rasputin like priest view it, the female viewer who sees it second gets it the right way up (figure 5.5.41).

Even a low budget schlock horror movie uses an actual image of Earth when it wants to be accurate, even if they aren’t sure which way up the picture needs to be.

Just as with the popular media of the time, popular fiction’s use of Apollo images (and other space program photographs) pre-dates the internet, pre-dates digital manipulation of images and (as is obvious if you watch the programmes) pre-dates the kind of special effects that would have been needed to fake the Apollo images. You can’t go back and undo the material that’s out there, and what’s out there matches the historical narrative in a way that the hoax argument miserably fails to.

I haven’t proved Apollo landed on the Moon here, but we have shown that the photographs weren’t stashed away in a hiding place - just like their newspaper and magazine counterparts they were out there all the time and as the next section shows, if you want realism in science fiction, you use the real thing.
Figure 5.5.39: Screenshot from ‘Horror Express’ showing a captured memory floating in bodily fluid under a microscope.

Figure 5.5.40: Close up of screenshot in 5.5.30 compared with this ATS-3 image.

Figure 5.5.41: ATS-3 image shown the right way up in ‘Horror Express’.
5.6: Quiet on set

What the preceding nicely leads us into is that often the most convincing thing about these films is the Apollo photography. What, however, about the films that when they didn’t use Apollo imagery made up their own?

There are those people in the conspiracy movement who argue that it was actually Hollywood that did the faking, that it was all special effects and clever secret stuff. Usually it involves Stanley Kubrick. So perhaps now is a good time to look at the standard of those special effects and whether they are up to the job.

To kick off this section let’s again look at Star Trek, specifically the 1966 episode ‘Miri’.

Miri was either a cloned Earth or a parallel Earth, or even actually Earth, depending on which website you read, but there is no doubt that our own Earth was the backdrop used in the special effects. Some screenshots from the episode are given below in figure 5.6.1.

![Figure 5.6.1: Screenshots from ‘Star Trek: Miri’.

I’m assuming I don’t have to point out the obvious here. Even though the episode aired in October 1966 amidst a flood of mercury and Gemini images showing the most beautiful cloud patterns around, there is not a single one to be seen here. They managed to get a nice convincing globe, even had it rotating as they approached, but forgot to put clouds in. A later re-mastering of the episode made sure they were put in (see figure 5.6.2), and this re-mastered version is the most commonly found version on the web.

Yeah yeah I know, it wasn’t actually Earth, but it’s a water planet - were people not paying attention in geography?
It’s not entirely fair to focus on low budget TV series, so let’s look at big budget Hollywood. The 5th film in the James Bond franchise was ‘You Only Live Twice’, and was released in 1967. While this predates Apollo, it was filmed during the Gemini missions, and used a Gemini launch sequence in place of a Russian launch, and what is clearly a Gemini capsule in the US space sequences.

What we need to see, however, is Earth - how does that look? Figure 5.6.3 shows a couple of screenshots from the space sequences compared with a real Gemini image.

The most obvious feature here is that the two shots contain the same land masses, but you’d be hard pressed to identify which land masses they are!

To be fair, the actual depiction of Earth isn’t too bad, but you would have to be short sighted to argue that it is completely realistic.

The surface is perhaps not bright enough, and the clouds are not quite right, but they have attempted to draw in an atmosphere and the clouds have a three dimensional aspect to them. Almost as if they were basing their view on precisely the kind of Gemini image I’ve used above.

It still, however, has that indefinable ‘something not quite right’ about it, particularly the two space capsules which look completely two dimensional, and given where the light is supposedly coming from the shadows on the capsules seem a little out. It’s even less convincing when viewed as a film rather than a still from a film.

It feels slightly unfair putting the next entry into our hall of fame of unrealistic Hollywood portrayals of space missions, given that much of it is actually very well done. Robert Altman’s 1968 release ‘Countdown’ (coincidentally the title of Apollo 8 commander Frank Borman’s autobiography). The plot centres around the race to the moon with the USSR and a hurried launch with a man to try and pre-empt their attempt to get their first. The depiction of mission control and hardware is actually pretty good, but is obviously based largely around the Gemini missions - there are many Gemini images on the wall and the lander is obviously based on a Gemini capsule.

The film uses a Gemini image to depict the view from Earth orbit, and uses lots of detailed lunar photographs to depict lunar orbit seemingly from the 1967 ‘Consolidated Lunar Atlas’ compiled from high power terrestrial telescopes (figure 5.6.4).
Figure 5.6.3: Screenshots from 'You only live twice' compared with Gemini 7
So far so good, but once they try and look back at Earth, something not attempted outside LEO when the film was being made, then things start to look a little more shaky, as shown in figure 5.6.5.

Apart from the technical error in the lunar image (the surface can’t be fully lit by Earth and have a full moon at the same time), and the ingenious method of simulating lunar gravity (by basically not bothering), the real issue here is the lack of anything remotely resembling Earth in the view of Earth. Without any clear idea of what it should like, they’ve opted for a bland, vague, “kind of sort of like this’ look for our brilliant blue planet.
Later that year we have perhaps the most famous space scenes at the time of Apollo belong to those shot for Stanley Kubrick’s epic ‘2001: A Space Odyssey’. Kubrick was famed for his attention to detail, so if anyone was going to get it right he would surely?

Kubrick’s shots of Earth were done by creating transparencies from artwork (see here for more info) and then back lighting those so that the Earth had the appropriate albedo - something he was keen on recreating accurately, and something I think is done well. Where he fails is in the depiction of what you can see. Figure 5.6.6 shows a couple of famous examples of his views of Earth from orbit.

![Figure 5.6.6: Screenshots from 2001: A Space Odyssey](image)

When you compare this with the rather dull looking Earth from YOLT, this is certainly an improvement, but is it good enough? Once again we have pretty unidentifiable looking land masses and you’d be hard pressed to say where we were supposed to be above the Earth.

Kubrick may have paid a lot of attention to the brightness of the Earth in the shot, but his choice of colour is not there at all - it is nothing like the Earth we have seen in countless photographs from space, no matter which space agency took them. There is also no apparent atmosphere visible on the horizon, and the clouds...
suffer from both a lack of texture and sense that they are 3 dimensional as well as from a lack of coherent meteorology. There is no apparent weather system on there, just a collection of pretty and very wispy clouds over unidentifiable landmasses.

To be fair, some parts of the planet do look like that, and the artist probably took his cues from photographs taken during the Gemini and Mercury missions supplied to Kubrick by NASA, to which (to be fair) the images do bear some resemblance. You might want to look at MA-5-4712-039, MA-5-4712-211, S63-06428, and S65-34655_G04-H for an idea as to where he got his inspiration. What is noticeable, however, is the sense of depth and the visible atmosphere in the NASA images.

The appearance of Earth against a lunar backdrop is similarly confused (figure 5.6.7).

Leaving aside the fact that Earth is impossibly low on the horizon considering where it is allegedly being viewed from, and the rapid change in phase, where is the detail? Where are the weather systems and continents that we know should be visible even from early unmanned probes? Kubrick has designed a set based on what is artistically correct rather than scientifically accurate, just as his lunar sets favoured dramatic licence over accuracy.

How can it be so inaccurate? One answer is that we really didn’t know what the Earth as a whole disc actually looked like from space - we had no visual cues to work from. Kubrick filmed these sequences long before Apollo 8 gave us a true colour idea of what we look like from space.

The other is that it is a mere backdrop to the main action - the attention is not on the Earth here, it is on the foreground and middle distance. Earth adds drama, but it is not the main feature we should be observing. It’s the same problem with his close up view of Earth early in the film - the visual spectacle, the obsession with
making it look right, took precedence over the accurate one. Had Kubrick waited a year, his vision of Earth from space could have been achieved much more realistically.

The next film I want to look at had no such excuse. The 1969 film ‘Marooned’ won an Oscar for visual effects and does a creditable job of recreating Mission Control procedures and language. They used an early Apollo command module, mock-ups of the real Mission Control and genuine astronaut headgear. Scenes filmed inside the spacecraft are well done and convincing. You would think, then, that they would be able to do a pretty reasonable job of replicating Earth from space, given that they had actual Apollo photographs and film to use as a basis. Let’s have a look at figure 5.6.8 to see.

Figure 5.6.8: Screenshots from ‘Marooned’
OK, so the models look good and they are lit correctly but the Earth is not in the least bit realistic. You have to ask whether the special effects guys had access to any kind of map while they were building their Earth, as the coastlines are pretty much vague approximations of the real thing. Nice fluffy clouds, but there is no variety in them and no real sense of any kind of weather system.

As before, the focus of the film makers here is not to create a faithful reproduction of Earth, but to depict how two space craft move together. Earth is a backdrop not the main event.

Later in 1969 (or early in 1970 depending on where you lived) we have the release of a truly awful piece of what can only be described as ‘cashing in on the whole Moon thing’ n the form of ‘Moon Zero Two’. Despite managing to use a genuine image of Earth from ATS-III in its promotional poster (figure 5.6.9a) it fails dismally to take advantage of any of the Apollo images it could have used of Earth. As shown in that figure it does manage to make good use of Apollo 8 image of the surface, but it is taken from orbit and therefore the representation of the astronauts in the poster couldn’t happen. Furthermore the moon image is looking westwards over Rima Cauchy, and as such the view of Earth it shows is impossible. South America could only be viewed in this way from behind the western limb looking back eastwards towards an Earthset, not an Earthrise.

As can be seen in figure 5.6.9b it couldn’t even get the Earth’s phase right in the space of a few shots, never mind get anything like a realistic representation of the Earth’s surface.

Figure 5.6.9a: Promotional poster for Moon Zero Two, AS08-13-2344 (bottom left) a close up of the Earth used in the image (top right) and the ATS-3 image for comparison (bottom right).
A couple of years on from You Only Live Twice, Bond revisited space - this time in 1971’s “Diamonds are Forever”. The plot involves a space-based laser capable of destroying superpower equipment and can thus be used as a way of handing world supremacy to the highest bidder. Naturally as it’s a satellite there are scenes supposedly in orbit, and a sample of these are shown in figure 5.6.10.

To be fair, the one in the top left does have a reasonably convincing look to it, but I’ve not been able to track down any Gemini or Apollo image that might be the source. The other three, on the other hand, show the same completely unrealistic portrayals of the Earth. Ironically, the most convincing view of the planet comes from the fake moon set used in the film, and figure 5.6.11 shows a screenshot from it.

I can hear conspiratards shouting about how they are shoving it in our faces from here! It’s not a bad Earth, but it obviously isn’t real, and while it isn’t supposed to be there are still issues with lighting (the moon should be dark given the Earth’s phase. Again it seems to bear more similarities with the ATS-3 view of earth than any genuine photograph, of which there had been several published very freely before the film was made. Even Hollywood’s fakers producing a fake moon set with a fake Earth in the sky fail at faking a moon landing.
Film and TV that do well at an aspect of space often don’t do well in another. While Star Trek didn’t do too well over two different episodes, the 6 million dollar man slips up in the same programme. It made good use of NASA footage in the episode examined in the previous section, but when it came down to the lunar surface it fares less well, as shown in figure 5.6.12.

Clouds are not sharp, the terminator line is at an odd angle and place, the night portion is still visible, which it would not be, and the lunar lighting is all wrong.

You could argue that we are only taking our visual cues of what Earth should look like from the very photos that the anti-science brigade claim are fake, but Apollo photographs are not the only source of Earth images, and as we will see in the next section the USA’s ideological enemies produced very similar shots from their unmanned probes in the same era.

The truth is that the special effects of the time, and the understanding of how Earth looked from space, were very much in their infancy. Film makers had neither the technical know-how nor the visual experience to reproduce our planet from space with any kind of accuracy. Even by 1979 when Bond revisited space in Moonraker the effects were (by today’s standards) abysmal.
Likewise the lunar surface and depiction of low gravity in 979’s ‘Salvage 1’ (examined in the previous section), were pretty dreadful and despite using the Blue Marble image in a few places they opted for a reproduction Earth (figure 5.6.13) which, to be fair, isn’t actually that bad and the version shown on the right bears a strong resemblance to AS15-91-12342.

![Figure 5.6.13: Screenshots from ‘Salvage 1’ showing a reproduction Earth.](image)

Another one from 1979 is the truly dreadful ‘Unidentified Flying Oddball’, which masqueraded under a couple of other names depending on when and in which country you were unfortunate to see it, and which is an appalling adaptation of the Mark Twain story ‘A Connecticut Yankee in King Arthur’s Court’. Ironically it’s a Disney film, ironic given the hooah some conspiracy nutjobs make over Disney’s alleged link with the Apollo missions. Here’s their view of Earth from the film (figure 5.6.14).

![Figure 5.6.14: Earth as seen in ‘Undentified Flying Oddball’.](image)

Just 7 years after the Blue Marble and this is the best a supposed co-conspirator can do.
Things were just as bad in 1980’s Superman II, where the moon sequence shows an Earth in the background that is extremely well lit to say that the sun is behind it (figure 5.6.14).

![Figure 5.6.14: Moon scene from ‘Superman II’ (left), with close up of Earth (right).](image)

The schoolboy error they make is, of course, that the image of the moon is ingrained in the modern consciousness thanks to Apollo. Many TV and film writers rely on that cultural meme and cut corners with grey landscapes, dust, slow motion, and an image of Earth in the sky. Because these things are backdrops to the main action, most people don’t pay enough attention to them to notice that they’re often hopelessly wrong.

The Apollo deniers who claim it was all done in a studio also fail, routinely, to produce any evidence of where the studio was (other than vague gesticulations at ‘Area 51’) who built it, who crewed it, where the materials were made and who transported them, who assembled the footage and so on and so on and so on. The bald statement ‘it was faked in a studio’ is, apparently, enough for them without any requirement to provide supporting evidence.

So there we have it, several big budget films and TV series (and some cheaper ones) containing views of Earth released around the time of Apollo, and not one of them produces a convincing and 100% accurate rendering of our blue marble.

Generally speaking then, the conclusion here is that rather than Hollywood special effects being used to re-create pictures of Earth from space, if Hollywood wanted any kind of pretence at realism they used Apollo images, or other NASA sources like the Gemini missions. If it looks like a convincing view from space, the chances are it’s because it actually is. The realism they added was because they are real.
5.7 Oh those Russians

If NASA’s airbrush monkeys were busy faking the satellite record to match Apollo (as some have claimed), they were equal opportunity fakers and did it for all comers.

Figure 5.7.0: Press photo of a satellite image taken by Molniya-1 on 30/05/66 compared with NIMBUS-3 image taken the same day

The landmass just below the centre on the right of the terminator is north Africa, and once you know that you can match the cloud patterns quite easily, especially when you use the 3D view.

The Soviets also returned images from of Earth from around the Moon from their many probes. The better quality images of returned by the Zond probes are shown on a number of websites, for example Mental Landscape. Zonds are now widely acknowledged as the USSR’s rehearsal craft for a manned lunar mission.

Figure 5.7.1 shows one of the images from Zond 5. Encyclopaedia Astronautica states that Zond 5 was launched on 14/09/68, entered a lunar orbit on 18/09/68 and splashed down in the Indian Ocean on 21/09/68. The ESSA data for this period can be found here: TIROS anniversary site and the Zond 5 image can be found here: Mental Landscape. ESSA and Zond images were compared in this article.

Figure 5.7.1: Zond 5 photograph of Earth compared with ESSA mosaic from 21/09/68 and 3D reconstruction using digitally restored ESSA data. Left is the image shown in the USSR publication ‘Soviet Photo’ from August 1969.
As an aside Zond 5 has its own place in the hoax mythology as it carried a biological payload around the moon (including some tortoises), proving that space radiation was not instantly lethal. It also returned a signal to Earth featuring cosmonaut voices. Initially this was thought to be taped, but is now thought to have been cosmonauts sending the signal from Earth to test communications in space. While conspiracy nuts like to claim that ‘if the Soviets could fake transmissions so could we’, they usually fail to mention that the source of the voices was determined even before the craft landed back on Earth. They also shoot one of their own arguments down in flames given that the transmissions were tracked independently by observatories in several countries (including the US, Germany and the UK - see here), conclusively proving that you can track space craft and their communications from Earth quite easily (as an aside this document shows a lunar surface image produced from a transmission intercepted from Luna 9).

Returning to the weather, for once you can make up your own mind, Does the ESSA mosaic show the same weather patterns as the Zond 5 image? The mosaic used is from the 21st of September, and the location of Arabia suggests a time of around 12:00 GMT for the image – 4 hours before re-entry and splashdown.

A similar study can be made of Zond 7, which shows spectacular colour images of Earth as seen rising above the lunar horizon. Zond 7, according to this page: NASA, was launched on 08/08/69, and managed several photography sessions of Earth. A close up of the Earthrise photo is shown in figure 5.7.2, compared with an ESSA mosaic from 10/08/69. The ESSA mosaic is found here Hathi Trust, and the Zond 7 image is from here: Mental Landscape.

Figure 5.7.2: Zond 7 image compared with ESSA mosaic dated 10/08/69.
As with the NASA images, the ESSA mosaic is dated the 10th, but this part of the world would have been imaged on the 11th. As before, you can answer the question for yourself: does the Soviet image match the data supplied by their superpower rival? It’s a shame that the craft did not wait a little longer to take its images, as lurking off to the west in the Caribbean is Hurricane Camille, which caused considerable damage in August 1969.

One final image from the Zond program can be found from Zond 8. This photograph (source: Mental Landscape) is usually referred to as an Earthrise, but a quick check of what it shows (and which can be confirmed by Stellarium) proves that it is actually an Earthset.

The probe was launched on October 20th 1970, and orbited the Moon on the 24th. A close look at the images from that probe show that Australia can be seen in the image, which means that any showing it as an Earthrise are actually upside down.

As it features Australia, this means that the ESSA mosaic needs to be dated the 23rd in order to show it. The ESSA data catalogue can be found here (source: TIROS Anniversary) and a comparison of the relevant part of the mosaic with a close up of the Zond 8 image can be seen in figure 5.7.3.

Again, you be the judge: do the weather patterns match or not?

It should be pretty obvious that in all the Zond images the satellite mosaics are a match.

It’s also worth pointing out that while these photographs are less freely available in the west, they were being issued publicly, as long as you were the right public. Figure 5.7.4 shows a souvenir postcard issued in what was then East Germany and a Soviet stamp from 1969.

Figure 5.7.3: Zond 8 image compared with ESSA mosaic dated 23/10/70 and 3D reconstruction using digitally restored ESSA data.
Figure 5.7.4a: Zond 7 image of Earth from an East German postcard. The image was taken on 21/08/69, but the postcard itself is stamped 1982, 7 years before the fall of the Berlin Wall.

They weren’t entirely unavailable to the west though, as shown by figure 5.7.4b which features an Italian newspaper front page (available on eBay) covering the Apollo 13 crisis and where the artist has used the Zond image to produce the graphic.

Figure 5.7.4b: Zond image used in a graphic on an Italian newspaper front page.
So not only does NASA data match that of their political enemy, the Soviets were also in a perfect position to blow the US out of the water with their own views of Earth.

They never did. Ask yourself why.

There is an amusing side note to Soviet Earth images. [This website](#) does some pretty deep analysis of the poster shown in figure 5.7.5, noting how it is intended to ram home images of Soviet superiority in the space race.

![](image)

Figure 5.7.5: Soviet propaganda poster featuring an Apollo image.

Unfortunately, the image of Earth superimposed on the image is actually one taken by Apollo 8, AS08-16-2593 to be precise, which the USSR would have easily been able to get hold of as it featured in many press articles. The page’s author believes it to be from the 1960s, but my guess is that it is actually an anniversary photograph.

Apollo images were not the only ones ‘borrowed’ by the Russians for their propaganda needs. Figure 5.7.6 shows a 1970 Soviet poster intended for classrooms that shows a somewhat doctored (and upside down) version of the ATS-1 colour view of Earth.

There is one final point: I genuinely do not believe it has ever occurred to anyone at NASA, or ESSA, or NOAA, or whoever has the data in their hands at the moment, that the weather data they had held the key to so much supporting evidence for the Apollo missions.

Aside from the fact that no-one there believes extra evidence is necessary, I don’t think it occurred to anyone that the photographic record from Apollo and the meteorological evidence from the satellites could be married in this way. If the conspiracy believers are right, they would have gone to all that trouble just on the off chance that someone would check, and it has taken 40 years for someone to start doing that.
Figure 5.7.6: Soviet educational poster compared with ATS-1 image. Source.
5.8: The military own NASA

Again, there are undeniable links as NASA launched them, but the military had their own satellite programme. The Apollo 11 'rescue' story is indicative of parallel development, not cooperation. If the histories presented in chapter 2 are anything to go by, the military were in fact frustrated at NASA's lack of speedy progress in the field and went their own way.

Of course the conspiracy theorists will argue that "they would say that, wouldn't they?", but even with a proven link between the military, NASA and the Apollo programmes, this does not invalidate the evidence presented here.

The military were obviously involved in the Apollo programme even if their role was only to pick up the newly returned astronauts and provide support through ARIA, but the question there is "so what?". Does military involvement mean that Hurricane Bernice didn't exist? Or Tropical Storm Therese? Or any other of the hurricanes and cyclones visible from space in the Apollo images showing storms where they should be on the dates they should be there and in the correct configuration?

The weather is not a military secret, neither were any of the weather satellites that provided the information about the weather, and neither was that support for Apollo by those weather satellites. The military also made use of civilian satellites, indeed this article from the 1960s suggests that the weather satellites are being used for military purposes.

Several videos exist from 1971 of seminars given by the USAF as an educational film to trainee military meteorologists. ATS, ESSA, ITOS and NOAA satellites are directly referenced, and photographs from the Gemini program are used to illustrate cloud patterns and types. In a seminar on cloud types (part1 here, part 2 here) Gemini images are compared with satellite images - exactly what we’ve done for Apollo! Apollo images also make an appearance, notably this one discussing cumulonimbus clouds, and this one discussing dendritic snow patterns in the Himalayas (it is actually inverted in the presentation). Both are from Apollo 9.

The second seminar on cyclonic systems (part 1, part 2) also uses a Gemini image, but is more focused on the satellite records. Figure 5.8.1 overleaf shows some examples from the presentations. We shouldn’t have to point out here that obviously this are Apollo images in the public domain - even if it was aimed at military personnel!

Interestingly, in terms of the discussion on how much was achievable technologically, they discuss matching up satellite images by hand, as well as how the data from the advanced vidicon system was translated into georectified projections. They also emphasise the need for a complete arsenal of meteorological data and geographical understanding in order to interpret satellite data correctly. Satellite records do not automatically give rise to perfect understanding of the weather, understanding the weather allows you to interpret satellite data.

This is the case with or without a uniform.

An additional argument concerning the military involvement is they had their own satellites up there, and perhaps they were of superior technology that would have been used to somehow generate the information needed to re-create the scenes shown in Apollo.

Well we do know that they had a separate programme of satellite development and launches that they used to support their military campaign in South East Asia and to keep an eye on the Russians. It has been suggested that these produced better quality images, but this is a bit of a red herring as while the photographs may have been better, they were still collected at the same time and collated in the same way. A weather photograph taken on the launch day of Apollo 11 is going to show the same thing no matter what took it.
Figure 5.8.1: Gemini and Apollo images used in USAF meteorology seminars
A second factor to consider here is the purpose of the military images. On the one hand general weather conditions were useful for planning air campaigns, but on the other they needed clear conditions to see the ground, and much of the imagery they collected was designed to do the latter.

The CORONA missions, for example, were not there to predict the weather, and because of the way they operated they would have been useless in the context of gathering data that would be of any use in faking Apollo images.

To illustrate this we can use this website to look for the declassified images from CORONA and see what they show. What we find is that there are very few from the Apollo mission dates, but we do have some luck with Apollo 8, where we have pictured taken on launch day taken over California. The metadata from the search results (source) show that it was taken by a CORONA probe, probably launched 12/12/68 (source).

What does it show? Figure 5.8.2 shows a view of 20 of the photographic strips superimposed on Google Earth (if you register on the site you can export search results as a kmz file).

So far so good, and what we need now is a close up view of California from Apollo 8 with which to compare it. The best candidate is AS08-16-2596, which was discussed here. Figure 5.8.3 shows the Corona images next to the bit of California covered by the Apollo photograph.
There is an argument to suggest that the white band visible in the Corona images matches a band in the Apollo photograph, but it could equally be something else. We also have no data on precisely when the Corona images were taken, and they could be some hours apart.

If you’re wondering why the Apollo view (which I have level adjusted and sharpened) isn’t particularly good, figure 5.8.4 shows the area in context.

![Figure 5.8.4: AS08-16-2596 with red square illustrating the area covered by the Corona passes.](image)

It should be obvious that it would take quite a few Corona missions to cover the area needed to reproduce an Apollo image!

It’s also worth reminding ourselves of the somewhat turbulent relationship between NASA and the military. The military were frustrated by NASA’s slow progress, were unhappy with the quality of the products they were offered and did not like the risk of some very secret and occasionally not quite officially funded projects potentially being made public by using NASA launch facilities and hardware.

NASA, for their part, did not like military intrusion into their civilian organisation and resented taking orders that intruded into their own mission goals. The excellent, but still heavily redacted ‘History of Satellite Reconnaissance’ is well worth a read if you want to explore the military’s satellite development programme.

The story of the supposedly secret photographs that showed the risk to Apollo 11’s splashdown is a perfect illustration of how NASA and the military’s satellite programmes had completely different priorities. They co-operated where they needed to, but the military side of satellite development preferred not to involve those pesky boffins if they didn’t have to.

So, military satellites are a bit of a red herring. Detailed or not, covert or not, they suffer the same issues as civilian ones. It doesn’t matter where the information comes from, it’s either reliable or it isn’t. The weather is the weather.
5.9: NASA owns the satellites, they have all the opportunity to fake satellite images

It is another feature of those who believe that the moon landings were faked that NASA is some omnipotent organisation that both controls and dictates all of the scientific information worldwide on any facet of the space programme by anyone, ever. This is despite the fact that they hold them to be incapable of the most basic science in the alleged fakery.

They are unable to grasp the idea that once the satellites were launched, they were no longer the responsibility of NASA but of the organisation that paid for them. It is like assuming Ford are still entirely responsible for everything that I do in my car.

Granted it is difficult to deny the interlinked nature of the various organisations involved. ESSA, NOAA, JPL, NASA are all involved in building and launching satellites and operating them afterwards, but while many hoax believers will raise a big “A-HAA!” at this, it is not in itself proof of anything and merely adds more players into the cast of alleged fakers.

The other factor to bear in mind here is that the satellite images were ‘free to air’ broadcasts. Anyone could download them providing they had the equipment. As this 1968 first day cover in figure 5.9.0 shows, 45 countries used the data that these satellites collected.

![First day cover from my collection celebrating the launch of ESSA-8 in 1968](image)

The other factor to bear in mind here is that the satellite images were ‘free to air’ broadcasts. Anyone could download them providing they had the equipment. The images were used in many journals and research programmes, and no-one has ever questioned them. They were used in conjunction with weather charts and no-one has ever questioned these. As mentioned in section 2, I’ve done it myself in the 1980s. Contributors to this [amateur radio website](#) describe receiving and processing ATS-3 signals in the early 1970s, and here’s one produced in 1972 by a Czechoslovakian amateur (figure 5.9.1)
The free to air aspect extended to official co-operation between the USA & USSR, who (as described in this document) agreed to share data about and from their meteorological satellites. Of course the USSR was not the only political rival to the US. China were also very much ideologically opposed, but that didn’t stop them making good use of US weather data, as detailed in this book on the Chinese space programme:

"At the end of the 1960s, China developed its first meteorological satellite cloud image receiver and began to obtain meteorological satellite images from ESSA satellite."

So the Chinese were more than happy with the veracity of US images to use in their own forecasting.

The images were also distributed to newspapers well in advance. Figure 5.9.2 shows one issued in advance of Apollo 12’s splashdown, and while Apollo 12 doesn’t have any images of Earth taken on this date it does show that the images were available and not some carefully controlled secret.

Figure 5.9.1: Amateur radio receiver image of a Polar Orbital satellite from 1972 (source)
There are a couple of things worth pointing out here. Firstly, we can check the ESSA data to make sure that it is actually from the date it is claimed to be, and indeed it is. The cloud patterns around the landing area on the 23rd are very different on the days 22nd (there is no global ESSA mosaic for the 24th). The second point is the source - it is given as ESSA in the photograph, but it seems highly unlikely given the way that ESSA images were compiled. My opinion, and I am happy to stand corrected, is that this is an ATS-1 view of the landing area. An image dated the 23rd would actually not have covered the landing area until as late as 02:00 GMT on the 24th, and even a west coast press photo at 8 hours behind GMT would struggle to get that image collated, processed, georectified to produce the correct 3D view of the Earth and then released on the 23rd. There are also subtle differences between the image shown and the ESSA view. A single ATS-1 image, however, would simply need to be processed and then released. While we don’t have access to any, we do know the satellite was still active, and it seems the newspaper is mistaken.

The point remains: the satellite image was freely available and published in a newspaper.

A further indication of how available these images were is indicated in this paper. It is based on the activities of a UN cruise off West Africa using a Bureau of Commercial Fisheries vessel (the ‘Undaunted’) registered in Miami. The vessel was fitted with receiver terminals for both ATS and ESSA satellites. The authors discuss how the images were obtained and their quality, give a couple of example, and also make this comment:

Figure 5.9.2: Press photo sold on eBay showing the satellite image of landing area of Apollo 12 compared with ESSA view of the landing area on the 22nd (top and bottom left) and the 23rd (bottom middle and right).
“To supplement the shipboard TV-pictures, 276 E SSA-6 pictures of African coastal waters during September 15 -December 1, 1968, were purchased from the Mulemba Astronomical Observatory, Luanda, Angola.”

At the time Angola was still effectively a Portuguese colony. Not only were they able to download them on board, they were able to get copies from an African observatory to verify that their images were accurate. Likewise this article, discussing what was then Rhodesia’s attempt to download satellite imagery for weather forecasting says:

“Meteorological Office technicians now regularly record the pulses emitted by weather satellites, particularly Nimbus II, as they pass over southern Africa – but instead of using the sophisticated equipment designed for the purpose which may be imported from Britain or America at a cost of between £10,000 and £18,000, they use equipment designed, constructed and adapted in their own workshops at a cost of less than £200.”

and

“Outside Rhodesia, Kenya is believed to be the only country in Africa at present tapping the information available from the American weather satellites as they cross and re-cross the skies of this continent. The weather pictures recorded in Salisbury are made freely available to forecasting stations in other parts of the sub-continent.”

Two African countries there helping themselves to satellite data freely available. Similarly this article describes how

“...in 1974 in an attempt to investigate the possibility of receiving satellite signals. Results with relatively unsophisticated apparatus showed that these radio signals could be tracked very well. Since very strong signals were received from the weather satellites ESSA 8 and NOAA 3, it was decided to develop the necessary apparatus for the demodulation of picture data from weather satellites.”

The page also mentions Russian Meteor satellites and their broadcasting frequencies. Countries all over the globe were clearly making use, officially or otherwise, of the satellite transmissions showing the weather.

Given the ready availability of satellite transmissions and the relative ease of decoding them, suggesting that the satellite images themselves were faked really is clutching at the flimsiest of imaginary straws.

A side argument here is a claim by some morons (specifically Jarrah White) that satellites had been used by NASA to predict the weather, then they were able to predict where the clouds would be and therefore make fake images to put in the broadcasts.

Here, for example, is Jarrah’s knee-jerk take on it, which he repeats on many of his youtube uploads:

“...these videos have been compared with photos of earth taken by weather satellites in orbit at the time. Naturally, the pro-NASA side has been quick to call this "evidence". This trait is typical among propagandists: they present a piece of data or video that they don’t know how to fake, and they assume that anything they don’t know how to fake must be evidence that Apollo was real. Considering that NASA had many weather satellites in orbit long before and during Apollo, and that meteorologists had been using such satellite photographs to predict cloud formations and thus make forecasts for the week’s weather, I’d say that’s how NASA was able to get the cloud positions right in these videos.”

I’d argue first of all that his response is typical of liars who make stuff up about Apollo - they get evidence that blows their crap out of the water and they respond by making things up. I call it more than evidence, I call it proof.

Jarrah also says that

“Apparently the cloud formations seen in these telecasts are similar to those seen by weather satellites”.

Here’s the thing Jarrah, they aren’t similar, they match perfectly, which is remarkable given that the images hadn’t been completed at the time of the broadcasts. The use of the word ‘apparently’ also suggests he hasn’t
actually seen any of the satellite images, so he’s trying to pass a judgement without knowing what he’s actually making a judgement about.

As was discussed in the introductory pages of this research, in the early days of satellite meteorology weather images were used to verify other data, not to predict the weather. They were still unclear as to how clouds behaved and what the satellite images were actually showing, and much of the early research publications are based around ‘ground truthing’ satellite data. How, for example, could they have taken the satellite image of Hurricane Bernice from the day before launch and converted that into what was visible the day of the broadcast, as shown in figure 5.9.3.

The quick answer is: they couldn’t and didn’t. They were relying on ground and atmospheric data to predict the track of the hurricane, there is no way they could predict that it would end of in that shape.

They also didn’t have weather satellites “long before” Apollo - in fact it was just a few years - the science was in its infancy. This 1973 publication (which contains the images of Hurricane Bernice’s development in July 1969) summarises the state of the art nicely:

"Knowledge of the physical behaviour of this kind of storm has progressed to the point where it is possible to issue alerts and provisional warnings to the public for areas which may be affected by them. But so far, it is impossible to predict the exact times and locations at which these severe storms may occur."

and

"The public benefit [of satellite information] is tremendous but the system is too new for its potential to be fully realised"

So even after Apollo had finished the science of satellite meteorology is still in relative infancy and could not do what Jarrah claims. This 1968 article also makes an interesting point when discussing the use of satellite data in predicting the development of hurricanes:

“Satellite data, which have become increasingly available during recent years, have helped in the detection and tracking of the hurricanes...They have not been used, however, in the development of forecasts of hurricane motion”

Showing that, during the Apollo era at least, while you can tell where a hurricane might be heading, you can’t tell what it will look like when it gets there.

Even by 1972 we have comments like this in the Mariner’s Weather Log.

“The meteorologist is often asked whether satellite observations have reduced the need for ship reports. Quite the contrary is true. Before the satellite meteorologist can understand what he sees in the pictures, he must compare them with other known data...”
Showing that satellite images were not (and still are not) the be all and end all of weather forecasting.

This paper from 1975 looks at the use of satellite imagery to predict hurricane development, and is interesting in that it uses images downloaded in Berlin from US satellites. However, in a response to it a contributor to the journal notes the need for experienced satellite image interpreters and wonders whether different people would arrive at different interpretations. Clearly the early years of satellite meteorology not only required the development of instrumentation that complemented visual ones but also the training of meteorologists in interpreting the data correctly. Even by the mid 1970s this was still under debate.

This page, written to commemorate 50 years since Apollo 11’s landing, used modern computers to input the known weather details for Apollo 11 and 17 to see what the computer could come up with. It is close, but even modern technology can’t get it absolutely right. You could not, absolutely not, have predicted the Earth as seen by Apollo using the weather data they had.

Figure 5.9.5: Computer modelling of Apollo era data in comparison with actual photos (sources given in text).

There is an interesting corollary to this argument. While the photographs are not exact replicas of Apollo images, the powerful modern computing techniques applied to the available data at the time were able to produce good facsimiles of them. Despite not having the computing power to predict what the visual
appearance of Earth’s weather system would look like, Apollo photographs are a very good match with those created by 21st century computer models. In other words the modern techniques verify the accuracy of Apollo’s imagery. This can only be because it’s genuine.

By way of comparison with modern technology, figure 5.9.6, taken from a video promoting the DoD’s DMSP programme, shows just how advanced the interpretation of weather images from space in the early days of the science.

![Figure 5.9.6: analysis of a hemisphere’s weather data. Source: Youtube](source)

That’s right, no computer terminals, no banks of whirring tapes, just a bunch of guys gathered round some print-outs.

Jarrah also needs to consider that the TV broadcasts were made before the satellite images were available, so in order for his scenario to be true it’s actually the weather forecasters who are having to fake the data to match Apollo images. Which is it Jarrah? Were all the world’s meteorologists in on it, given that anyone could get these satellite images? Is everyone wrong except you?

In a nutshell Jarrah, and everyone else who tries to dismiss the weather satellite data, is just desperately clutching at straws to try and handwave away the proof of what they are: ignorant bullshit artists.

Speaking of bullshit artists, this site came to my attention thanks to a moon hoax social media group. It was posted as a way of saying that the Russians never said “but it was faked”. They seem to have mistaken “some Russians are saying it was faked” for “actual Russians who know what they’re talking about said was faked at the time”, but whatever.

One article on there, namely this one, makes some claims that are relevant to this discussion, so let’s have a look.

We have to make allowances for Google translate, but in a nutshell their argument is that NASA used the ATS satellites in geostationary orbit to fake the Apollo images, and that they were able to do this by not releasing many images of Earth.

One of their first objections to the available satellite image record is that ATS-1 only posted black and white images. This is despite them finding this website stating that:

“Experiments successfully conducted with the ATS-1 included photographs of earth, color television transmission, and a demonstration of multiple access capability with several ground stations at the same time”
They conclude from this that there should be images of Earth in colour. The problem is that the colour television images are just that: colour television. ATS-1 was a multi-purpose satellite, and could be used to relay TV pictures. It had, however, no colour capability of its own.

The authors then turn their attention to ATS-3, which genuinely did have colour capability, at least for the first few months if its life before the cameras malfunctioned. In their version of events, the successful deployment of Soviet satellites with colour capability in a Molniya orbit (an eccentric one designed to maximise coverage of the USSR) forced NASA to show colour images. Then, for some reason, they decided to stop.

This is, of course, utter nonsense. The colour images (and there were far more than the three claimed in the article, and not all of them were fully illuminated disks) were published because they existed. They existed because they could be taken. The Soviets had no influence on them whatsoever - in fact, the main role of colour was to help determine cloud heights, not act as a background for Apollo. The partial disks, they claim, were hidden so as to reserve them for faking Apollo photographs. Again, nonsense, as can be seen from the many examples of partial disks available in the data catalogs that were freely available (figure 5.9.7).

![Figure 5.9.7: Partially illuminated ATS-3 images from the Apollo 11 period, reproduced from the data catalog.](image)

Not to mention this film, again freely available, that showed the passage of night and day across the Earth’s disk.

The authors then move on to construct ever more elaborate strawmen. They have managed to find two special publications (Life Magazine and Look magazine) both of which contain one image of Earth, namely AS11-36-5355, but seem to think this is the only image of Earth published by anybody anywhere. Anyone who has perused the entirety of my site will know that this is nonsense - many images of Earth from the mission were available in a variety of publications. They are puzzled as to why the image’s metadata aren’t published, but they really need to take that up with the publishers. NASA themselves were quite free with the information, as shown in the contemporary print below from my own collection (figure 5.9.8).

![Figure 5.9.8: Original print of AS11-36-5355, from my own collection, with image details on the reverse shown above.](image)
Likewise they need to contact the owners of other publications and websites to ask them why they produce different distance and date figures from NASA’s, and edit the image differently. The actual facts have been freely available for over 50 years, you just need to be prepared to look for them. They are not different images taken on different days, they are the same image that people have given the wrong information for. Do your research!

There’s a lot more strawmen production and “this is what they must have done” involving nothing more than fabrication and ignorance.

Different images of Earth are claimed to be reproductions using satellite images with no proof. They claim that because geostationary satellites can be placed in transfer orbits that allow them to change position, then they must have moved them around. They would have been very busy, because at the same time as Apollo 11 was photographing Africa ATS-3 was firmly positioned over the mid-Atlantic. They claim ATS-1 was imaging Australia, despite the fact that it didn’t cover Australia. Figure 5.9.9 shows images of Earth taken at different times (which can be confirmed by the clouds on ATS-3 images!) but all over the same spot. In other words, it didn’t move, it couldn’t have within the time available and wouldn’t have had the fuel!

![Figure 5.9.9: Images of Earth taken from the original 70mm catalog compared an the ATS-3 image from the same day. The Earth images were taken over a span of about 5 hours.](image)

It’s worth bearing in mind here that an image was taken every 20 minutes by ATS-3, any sudden movement from side to side would have been noticed very quickly. They note in their article that the ATS images don’t change latitude much, but while (for example) Greenland is obviously visible in Apollo 11 views, it is barely visible at all in ATS-3 shots. While they point at the Molniya orbits and the photos taken by Zond showing similar angles (see this section), they can’t produce any actual evidence for anything producing similar photos for Apollo 11 - except Apollo 11!

Likewise their accusation that ATS-1 images were used to fake three different views of Australia (figure 5.9.10).

![Figure 5.9.10:](image)

Unfortunately for them there is an ATS-1 image available for the last image on the 22nd, (figure 5.9.11). It should be obvious from it that Australia is considerably off camera. They also conveniently ignore AS11-37-5506’s view of Australia, where it is even more central. There is no way ATS-1 could move over that distance in order to photograph all of Australia.
They make the same kind of claims for Apollo 15 and AS15-91-12342 (figure 5.9.12), claiming that the show the continents in exactly the same position as the 1967 ATS-3 photo, and therefore must have been taken by ATS-3 at a different time.

Well, for one thing the continents are not in an identical position, and for another this article, this article and this article all have ATS-3 in a position much further west at the time of the mission (figure 5.9.13). Compared with the 47 degrees West claimed by the authors.
The authors handwave away any possible counter-arguments by claiming that there might have been other satellites covering the areas launched in secret, despite the fact that even military satellite launches were well publicised (figure 5.9.14). Rocket launches are noisy and very visible. They’re difficult to hide and can be seen from the ground.

Like many hoax idiots, they assume that NASA is behind this flickr account and claim all other images of Earth have magically appeared in 2004 when in reality they were publicly available at the time - even appearing on CD-ROMs available in the late 90s. Original prints showing Earth come up regularly at auctions and on sites like this. My own site has plenty.

They ignore all the 16mm and TV images of Earth and seem to think that the only images that exist are ones in popular magazines, not realising that documents like this published all of them. They don’t seem to know that there are images taken at regular intervals that can’t possibly have been taken by a satellite because it couldn’t have moved that far or that fast.
They don’t trust the electronic versions of the photographs but don’t seem willing or able to find the many original copies that exist out there.

They base a hefty chunk of their hoax claims on the editorial decisions of magazine editors rather than the facts that are available to anyone who cares to look: Apollo happened, weather satellites are the nail in the coffin of the hoax, not some magic wand they can wave at their illusions.

Doesn’t matter whether the cow the laid the turd is Australian or Russian - bullshit is bullshit. Starting with a conclusion, bending what few facts you’ve bothered to find to fit, forcing in a bunch of “maybes”, “could haves” and “secret stuff” isn’t going to make it smell any less.

We get a recent and particularly aromatic addition to this particular section in the form of a facebook post on a moon landing hoax group, a group that helpfully collects all the world’s stupid in one place where we can keep an eye on them.

The poster first became noteworthy by declaring that images from the surface were fake because they didn’t show the Americas, which was mainly because he couldn’t tell the difference between am and pm when setting the time in his astronomy software. That post disappeared, to be replaced by one that didn’t understand time zones, didn’t understand that the landing and the photography happened at different times, got the date of his chosen photos wrong and didn’t seem to realise that there was a camera in orbit at the same time as on the ground. A collection of screenshots are shown in figure 5.9.15 for your amusement, and to record for posterity that he offered £10k (twice) to prove him wrong.
When another user pointed out (for a different reason, see here) that a black and white photo existed he declared that it was a satellite photo, saying this (figure 5.9.15).

There’s a lot of word salad there, and as you might imagine very few of those words are actually his. It’s heavily lifted from this publication. In a nutshell, what he’s trying to intimate is that you can’t see city lights, therefore it’s a fake because satellites also don’t see them. The reality is that you can’t see city lights for pretty much the same reason you don’t see stars in Apollo photos: exposure time. It doesn’t help his case that the article in question discusses infra-red data, not visible spectrum, and is based on a study of satellite instruments carried on a plane - instruments way beyond the capabilities of Apollo era satellites.

On top of that, we also know that there are whole sequences of these black and white images that show the Earth rotating - something not possible with a geostationary satellite, and the rotation shows views not consistent with the actual satellite view (in terms of the visible landmasses). He also doesn’t know that there are matching colour photos taken at similar times as the black and white ones.

What he’s doing, as he has done all along, is demonstrate his lack of knowledge of the subject, his lack of awareness of just how many Earth images there are, and a willingness to cherry pick information that suits his narrative even when it doesn’t. Sadly, the thread got deleted. Why? Figure 5.9.16 has the explanation, given to someone wondering why entire threads were deleted.

That’s right, you really don’t need any help to look really dumb.
5.10: Your evidence is self-supporting and therefore suspect

There are two strands to this. The first being that the evidence is pretty much all from NASA and its affiliates, and the second being that where it isn't immediately obvious what weather systems are visible, a supporting argument has been constructed around other evidence, possibly introducing biased interpretation.

As far as the first point is concerned, it's an unfortunate fact that the vast majority of the evidence concerning the Apollo missions comes from NASA or related organisations, and many sources have been referenced from them (eg the mission transcripts, photo indices). The satellite evidence also has a link with NASA, as previously discussed. In an ideal world there would be other sources of information, but it is a fact of life that at the time of the missions the two major players were either NASA or their Soviet rivals. The former of these two has been very free with all its information, the latter less so.

I have no doubt that somewhere there are satellite photographs produced by other countries such as India, China and the USSR that would absolutely verify the weather patterns in the Apollo images. They might even be completely different, which would prove the argument against once and for all as well. Unfortunately I do not have the time, contacts or resources to find them. The door is open for anyone who cares to have a go to find that evidence and either blow my theory out of the water or prove it absolutely.

The second point was at least partially covered during the section on Apollo 17, but is worth further examination.

Wherever possible the approach I have taken throughout this research has been to take an Apollo photograph, find a matching weather pattern, and then try and see what other evidence supports the suggestion that they were taken at the same time. Stellarium, the mission transcripts, the photograph indices, and any other sources I could find are all used to back up the suggestion that the Apollo image was taken at a particular time.

What needs to be avoided is making a decision based on incomplete evidence, then trying to make all the other evidence fit (and ignoring the inconvenient evidence that says you are wrong). There have been a number of occasions where I have had to completely re-think when a photograph was taken because what looked right on the screen couldn't possibly be right because the evidence of other sources said otherwise.

As far as I can tell everything included in this research is correct, and is consistent with all the sources of evidence available. It is not correct because I have forced it to be so. If you believe there are errors or inconsistencies, you have all the information you need to repeat the exercise yourself. Knock yourself out.
5.11: Remote probes took the photographs

This seems to be the argument the hoax community have decided on. It gets them out of a hole nicely. With the work of fraudsters and charlatans like Bart Sibrel, Jarrah White and David Percy completely discredited by this research (it clearly isn’t a transparency overlaid on a window neither was it filmed in LEO), this is the only recourse for them.

Is it reasonable?

Well, evidently there is the capability to transmit TV images over long distances, and evidently those TV images can be in colour. There is also the capability to control unmanned vehicles remotely. What the conspiracy lovers can not do, however, is identify which unmanned probe took the live TV images, or state when this probe was launched, or who was controlling it, or why the voices of Armstrong, Collins and Aldrin are tracked as coming from the moon (with the correct delay for the distance) and not from either Earth (which would give an incorrect voice delay) or from LEO (which would be instantly detectable because of the orbital speed this would require).

We do, at least, have evidence from lunar orbit that photographs could have been taken by US probes, namely the Lunar Orbiter series ones that were used to provide mapping and other supporting data for the Apollo landings.

Figure 5.11.1a shows Lunar Orbiter 1’s first image of Earth from lunar orbit as printed in magazines at the time. The LOIRP have produced a much cleaned up version (see the articles on this page), but it should be pretty obvious that the view of Earth is not the quality we have seen in Apollo photographs, and neither is it in colour. Figure 5.11.1b shows that cleaned up version in comparison with a NIMBUS image from the date it was taken, August 23rd 1966.

Figure 5.11.1a: First ever Earthrise photograph, taken by Lunar Orbiter I on 23/08/66. Source.
Figure 5.11b: Lunar Orbiter Earth image compared with NIMBUS mosaic and 3D reconstruction using digitally restored NIMBUS data
Lunar Orbiter V returned a much better photograph on 08/08/67, available [here](#) and shown in figure 5.11.2. This image is very good quality, and we have to concede that there is an impressive amount of detail. It is, however, still in black & white, not colour, and the unfortunate thing for the conspiracy theorist is that all of the Lunar Orbiters were crashed into the moon long before the first Apollo went anywhere near there. The probes also did a lot of research into things like radiation, micro-meteoroids and radar tracking that the conspiracy lovers always like to claim wasn’t researched at all. They’d also have to concede that camera film works just fine in space without getting ruined by all that radiation, because the Orbiters used Kodak film.

What about photographs from the lunar surface? Were there any taken there? Well, yes there were, by the Surveyor probes, probes that also looked at surface temperature and radiation levels.

![Lunar Orbiter V image of Earth compared with ESSA data](#)

Figure 5.11.2: Lunar Orbiter V image of Earth compared with ESSA data. This image from [here](#), original image [here](#). Left is 3D reconstruction from digitally restored dta.
Surveyor 1 provided the first colour photographs of the lunar surface, but the first colour photograph of Earth (taken 30/04/67) came from Surveyor 3, which can be seen in figure 5.11.3. The photograph could only be taken because of a favourable libration (the moon’s “wobble” caused by its interaction with our gravity), and Earth was not usually visible.

Surveyor’s images were sent back as TV signals, and the lines in this image are obvious. It is also nothing like as clear as most of the lunar based Apollo views of Earth.

Fans of Apollo 12 will remember that the piece of equipment that broadcast this image was retrieved by the Apollo 12 astronauts from the surface of the moon.

A later probe, Surveyor 7, did produce some much better quality pictures of Earth.

The images can be found in this document, which summarises the results from all the Surveyor probes. Interestingly, Surveyor VII also took pictures of laser beams fired from Kitt’s Peak observatory, something that was also tried during Apollo 11 and that also acted as proof that the planned laser reflector experiments deployed during Apollo would work. Figure 5.11.4 shows the images of Earth taken by the probe.
Just for fun, here’s a close up in figure 5.11.5 of a re-digitised version of the Surveyor image taken at 12 noon on the 23rd in comparison with the satellite image from the same day. The landmass taking centre stage is South America.

They are undeniably of good quality. They are also undeniably in black and white and from a probe that stopped sending images long before Apollo 8 got anywhere near the moon, and the projection does make identification difficult in places -it isn’t easy mapping out a 3D globe on a 2D piece of paper.

The discarded S-IVB has also been suggested as a possible source of the footage, but as these either impacted the moon during the missions (thereby discounting them as a source for images after they crashed) or were sent into solar orbit (where they remain today), this can also be discounted. Given that the S-IVB was still in use after TLI until the LM was extracted from it, they are unable to answer which craft is filming the S-IVB during undocking if the astronauts remained in LEO. The S-IVB can’t possibly have filmed the images of Earth taken by the rovers on the lunar surface, nor could they have taken the high quality still images. It also fails to explain how uncut shots taken during TLC & TEC can go from showing people in the lunar module to long distance shots of Earth showing features that satellites had not yet imaged.

In short, it is a glib throwaway dismissal based on nothing more than pre-supposition and with no basis in fact whatsoever. It is pretty much “well they must have”, and no evidence is offered to support it. Ever. Denial is all that is required, apparently.

If you believe it was filmed by some remote vehicle, then you need to prove it. Find the vehicle concerned, tell the world how the images were transmitted back to Earth, who controlled the probe and from where. Put up or shut up.
5.12: But all these websites say we didn’t go?

Oh dear, you’ve been looking at Youtube videos and conspiracy websites haven’t you?

Why are there so many sites with all this information on them? Easy: follow the money. Ask yourself why they are so keen for you to visit their website and generate advertising revenue, or buy their book, or their DVD, or sign up for their mailing list. Is it from the goodness of their hearts or a desire to milk you of your money? I know which version I believe there.

Are these sites really interested in seeking out truth and protecting freedom of information and the right to freedom of expression, or are they just looking out for their own interests? Try going to places like David Icke’s forum (search for it, I have no interest in promoting it for him) and expressing an opinion in favour of the Apollo landings, see how long you last. Try posting evidence in support of the landings and see how long it takes before you start accumulating warning points from ‘moderators’ claiming to be acting in the interests of the forum but really just inflicting their own bias on the place.

See how long it is before you’re accused of being a ‘NASA shill’, of spamming, or deliberately derailing threads with off-topic material when no such official warnings are given to people posting against the Apollo program. See how long it is before supposedly neutral people turn out to be nothing of the sort, and in fact are just sanctimonious bigots.

See how long it is before you attract the attention of the wilfully stupid who really shouldn’t be allowed on a computer, or lazy knee-jerk trolls who buy into every piece of bullshit they’re fed by people selling them Apollo hoax snake oil, or the spambots who just want to bury your posts in walls of irrelevant ill-informed text. See how long it is before the moderators are collaborating behind the scenes to ban you on the flimsiest of pretexts. These sites love freedom of speech, as long as it’s their version of it and you don’t ask awkward questions.

As a classic example of their hypocrisy, a long standing thread at David Icke’s forum originally in their private ‘Rant Room’ for contentious and argumentative discourses was resurrected for public viewing. A post was made supporting the landings. Within minutes that post was deleted. Hey it’s their website, they can do what they like, but let’s not pretend they’re into open and honest discussion.

Here’s another example of what happens when you post what they don’t like:

I’ve now had two sets of those, one at David Icke’s forum, the other at LetsRoll forums. Go try it yourself if you don’t believe me. They don’t like people who don’t agree with them, and you won’t last long. It’s one of the reasons this site exists - to discuss it on my terms, not theirs.

Ask yourself if these are the actions of honest people you can trust to give you reliable and impartial information, or the actions of uptight, short-sighted, narrow-minded hypocrites.

If you want to be open minded about the Apollo landings that’s great, but bear in mind when you’re looking at websites who don’t like NASA that a lot of the people posting on them have their own agenda, are often intellectually deficient, and in some cases just downright dishonest.
Being open minded doesn't mean just 'read the evidence you like and ignore the inconvenient stuff that proves you wrong', it means looking at all the evidence and applying the same standard of critique to all of them. Questioning authority doesn't mean just questioning the official stance of government departments, it means questioning anyone claiming to act as an authority, and that includes people posting scientifically illiterate and historically inaccurate videos on Youtube.

5.13: There are no stars in the photographs

There's no hope for you is there? This document isn't about that issue, you need to go elsewhere for it. In the mean time, go outside and take some photographs of stars, see how you get on. Alternatively, look at another part of my site and see that actually, plenty of stars can be found in Apollo images.

See how short this section is? That’s all it’s worth.

5.14: Summary and Conclusion

We went to the Moon.

It's that simple.

Anyone who says any different either hasn’t looked at things in any detail, or is not interested in looking at things in any detail, or is a moron, or is a liar. I’ve met two of the moon walkers, and another who went to lunar orbit and I know they aren’t lying.

In addition to all the photographic and hours of video evidence, the soil samples that could not have been made on Earth, the scientific data transmitted from Moon to Earth by equipment that could only be installed by people, the radio tracking of the spacecraft, we now have weather satellites that show that the clouds in Apollo photographs match those taken by satellites to which anyone with the right equipment had access.

There really is only one question to answer: Do the satellite photographs and Apollo images match?

The inescapable answer is that they do, and the only conclusion that makes any sense is that the Apollo photographs were taken where it has always been claimed they were taken: on the way to, on the surface of, or on the way back from the Moon.