GEO Newsletter

Group for Earth Observation

Group for Earth Observation No 57 - March 2018

The north of Scotland has suffered one of its most severe winters for years with huge accumulations of snow falling on the mountain ranges. In this image from NASA's Terra satellite, acquired on February 21, 2018, most of Scotland is cloud-free, highlighting the snow cover on both the Northwest Highlands and the Cairngorms/

The GEO Report

Francis Bell

Welcome to the new format and presentation of our GEO Quarterly and my report. We have said before the production and posting of our printed Quarterly is very expensive, compounded by diminishing copy contributions, thus making it difficult for the editor to produce a worthwhile Quarterly without having to research material himself. Hence the decision has been made to use a more flexible approach via the website, which incurs few costs.

The printing and posting of our printed Quarterly came to about £3,000 for each edition. Now relieved from this financial commitment, the decision was made to abolish the membership subscription: that is, after completing the joining protocol new membership is free and existing members may continue with their membership without annual renewals. New members are most welcome. The hope is that we can all continue to exchange our experiences of satellite reception to mutual benefit. The details and time scales for membership renewals still have to be established by our GEO Management Team.

In the background of free membership there is an expectation that our membership numbers will increase, and that communication will increasingly be via the Internet/Email rather than just personal contact. It has been pointed out to me more than once—quite independently—that if we wish to regularly communicate with people on our personal list these individuals must specifically opt into the system of GEO emails rather than receiving them as unsolicited communications. Apparently this will become law in mid 2018.

GEO's management is currently looking into these protocols and will advise members when the new rules become clearer. My personal expectation is that we will be asking our members to specifically confirm that they wish to receive appropriate communications from us: however, the protocols for this have still to be established for our group.

MSG3 or MSG4?

Recently, during last February, I experienced a few days of frustration with my EUMETCast receiving systems. Quite suddenly and unexpectedly the system stopped receiving regular Earth images, even though all the meter readings indicated that everything was working. Rather eccentrically, the only images I did occasionally receive were relayed from the NOAA GOES-W satellite, but there was nothing showing Europe or Africa. I checked and double checked both dishes, receives and cables. Except for an intermittent fault in a coax connector, which I corrected, everything was in order. But still no images!

Agh! My 'Road to Damascus'! Somehow, I remembered a similar experience about three years ago when EUMETCast switched its regular service from one satellite to another. Perhaps this had happened again without me knowing. To check this using my *SatSignal* software, I clicked on the advanced system setup menu and changed the satellite from MSG3 to MSG4. Magic: within a minute I was once more receiving the images I was hoping for and everything seemed to be working perfectly.

The lesson here for me, and I guess others, is to be more attentive to notices from EUMETSAT relating to current satellite operations, hence avoiding this mistake for a third time. If this transmission switch happens again, which I expect it will, I will try to issue some form of notice, so our GEO members will then have a double chance of recognising a change in EUMETCast transmissions.

Symposium 2018

I have only received a very small number of responses to my enquiries relating to those members who would be interested in having a group meeting in 2018. As a result of this apparent lack of interest, nothing is planned for this year, but I most sincerely hope that we can visit EUMETSAT HQ in Darmstadt next year. In the past these visits have been well supported by GEO members and we have always experienced great hospitality, informative presentations and centre tours: however, such a repeat visit next year does depend on the cooperation of a very busy EUMETSAT.

Rallies

GEO will definitely have a stand at the South London Radio and Computer Rally, to be held at Kempton Park on April 15, 2018. This is usually a busy rally which I judge to be worthwhile for both those running stands and the many visitors. Visit their website for more information.

www.radiofairs.co.uk

Other meetings

It is possible that we will also attend the Newbury Radio Rally on Sunday June 24, 2018, which is a popular outdoor event held on the Newbury race course. Visit their website for more information.

www.nadars.org.uk

Another possible idea is to ask for a stand at the RSGB's three day annual meeting in the autumn but this idea still has to be researched. It could be attractive, sharing a busy event with many amateur radio people attending. I understand that AMSAT-UK had a presence at the equivalent meeting last year.

Sales

The *GEO Shop* no longer stocks Software Defined Radio (SDR) dongles. As an alternative I have a few available together with a connecting cable for a price of £20, which includes postage. These dongles cover a frequency range of about 500 kHz to 2 GHz with various modulations and bandwidths. Their use is very flexible and suitable for satellite APT reception and perhaps also HRPT, but I have no experience here. If you want to buy a dongle send an email to:

francis@francisbell.com

Footnote

If any reader is currently experimenting with HRPT reception using an SDR dongle, we would be most interested to hear from you. It would be good to learn of even rudimentary success: sufficient to hint that such reception could be possible. Any contributions in this field will be welcome by myself, the Editor, and members of the *GEO Subscribers* YAHOO Group.

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From the Editor

Les Hamilton

Welcome to the first issue of the new, rebranded *GEO Quarterly*. For reasons explained by Francis Bell on page 2, it is no longer possibly, financially, to produce printed magazines. It is also not feasible for me to continue single-handedly generating some 30 or so pages of relevant content every quarter: so our electronic publication will now be called *GEO Newsletter*.

But we do still wish to keep in touch with our readers, even if may sometimes only be to the extent of an 8 or 10 page document from time to time. It's frequency will depend on material submitted, but we would hope to be able to continue publishing the *GEO Newsletter* every quarter, as previously.

To place the recent winter in perspective, I have reprinted a 2002 article from the late Cedric Roberts, which detailed the far worse scenario experienced for three long months in early 1947.

As ever, we value contributions of images and articles from readers, however small these may be, and these should continue to be sent to me at

geoeditor@geo-web.org.uk

(or to any other Management Team Member).

Contents

Quarterly Question

Francis Bell

Quarterly Question 56

My thanks to those members who responded to Quarterly Question 56, which related to a photograph taken by UK astronaut Tim Peake while he was on the International Space Station (ISS) about two years ago. I understand that the photograph was taken with a hand-held camera rather than an image created by a dedicated onboard instrument, hence the slightly oblique view of the Earth shown in the photograph. The photograph showed the city of Istanbul in the centre of the image with the Sea of Marmara to the south and the Bosporus seaway connection to the Black Sea towards the top with at least two bridges visible spanning this waterway. Hence the answer to the question, asking for the name of the city, was 'Istanbul'.

Additionally, my thanks to the member who corrected me about the famous mosque in Istanbul which I referred to as the 'Golden Mosque'. It is in fact called the 'Blue Mosque'. I must have named this mosque in anticipation of my next foreign expedition to India where a visit to the Golden Temple at Amritsar is anticipated.

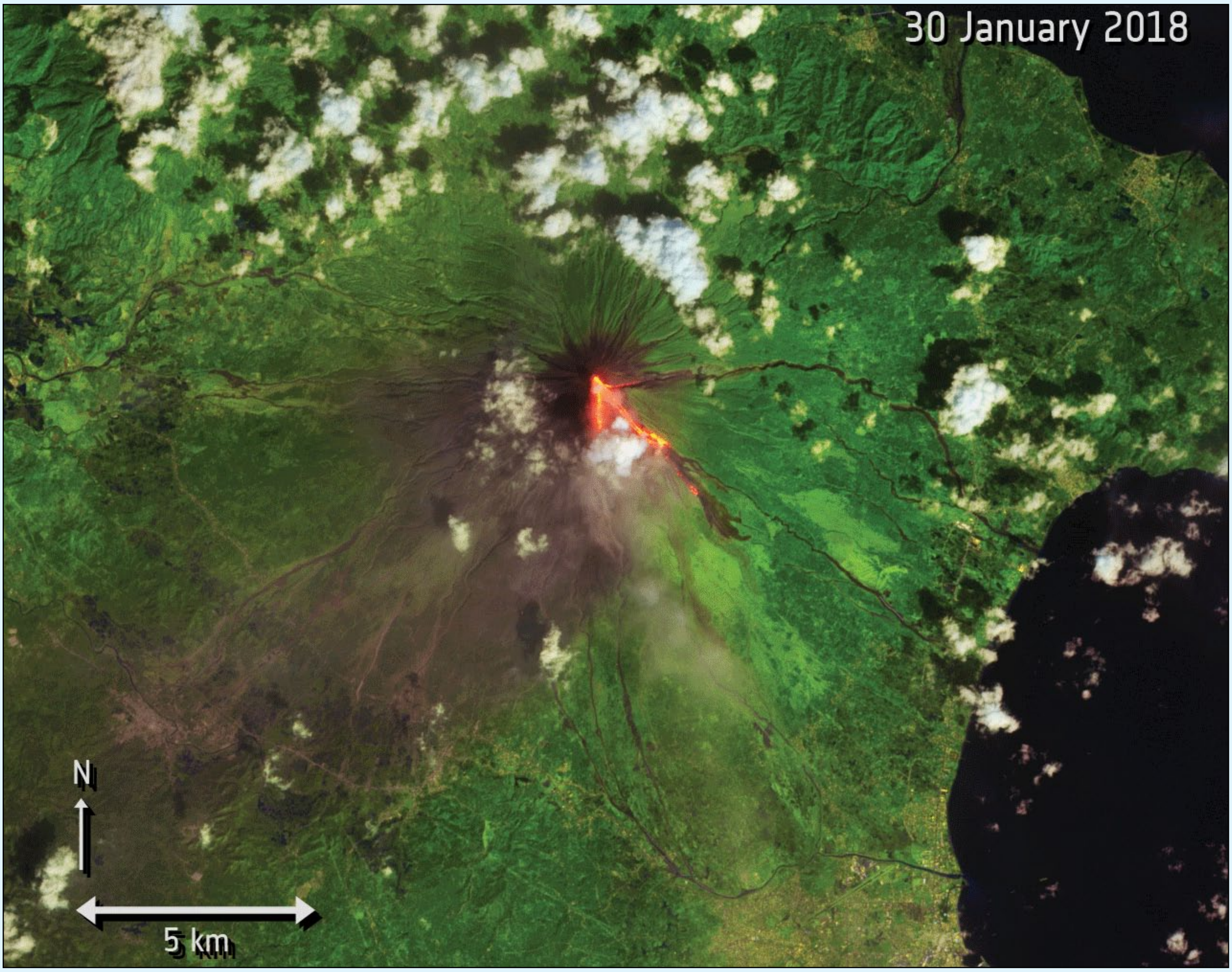


Figure 1 - This is an Earth image recorded by Sentinel-2 highlighting an active volcano with red lava streams running from its summit. The Quarterly Question is to name this volcano. See the adjacent text for more information.
Image: modified Copernicus Sentinel data (2017), processed by ESA

Quarterly Question 57

This question come in two parts, and was prompted by Earth images I regularly receive from ESA. The date when Figure 1 was recorded is overlaid on it, together with an indication of scale. The image was recorded by the Copernicus Sentinel-2 satellite on January 30, 2018 using the visible light, and shows a volcanic eruption with flowing red lava. Because of the anticipated consequences of this eruption ESA quickly issued an appropriate alert warning of the event on February 1.

Question No 1 is quite straightforward. Name the erupting volcano shown on the ESA image (Figure 1) and this additional question: "With which 'Ring' is this volcano associated?"

Without additional information it would be very difficult to locate and name this volcano because the scale is quite small and there is little coastal outline to act as a guide, hence some addition information may be necessary.

The volcano is located on one of the main islands of the Philippines, the same island that also hosts the country's capital city Manila. The caption associated with Figure 2 will be of great help because it names a city from which a conventional photograph of the same volcano was taken, although at that time it was not erupting.

During my personal travels I have visited a number of countries with volcanoes, and I'm always impressed that, throughout much of the world, not far below my feet at high pressure, lies molten rock trying to force its way to the surface. The dynamics and convection of this material changes our planet's magnetic field on a daily basis and in the longer term influences climate change in which ice ages come and go.

Figure 2 - This is a conventional photograph of the subject volcano taken about 8 km from the volcano's peak. The photographer was located on the edge of Legazpi City, in the Philippines (visible at bottom right of the ESA image).

Figure 3 - This old volcanic peak, one of many in the area, was photographed by Francis Bell in 2011 while travelling between Indonesian islands separating the Flores Sea and the Savu Sea. It is believed to be one of the volcanoes of East Nusa, Tenggar in the 'East Flores Regency' of Indonesia. The many volcanic peaks in this area are connected to the Quarterly Question because they form part of the 'Ring' associated with the volcano in the Philippines.

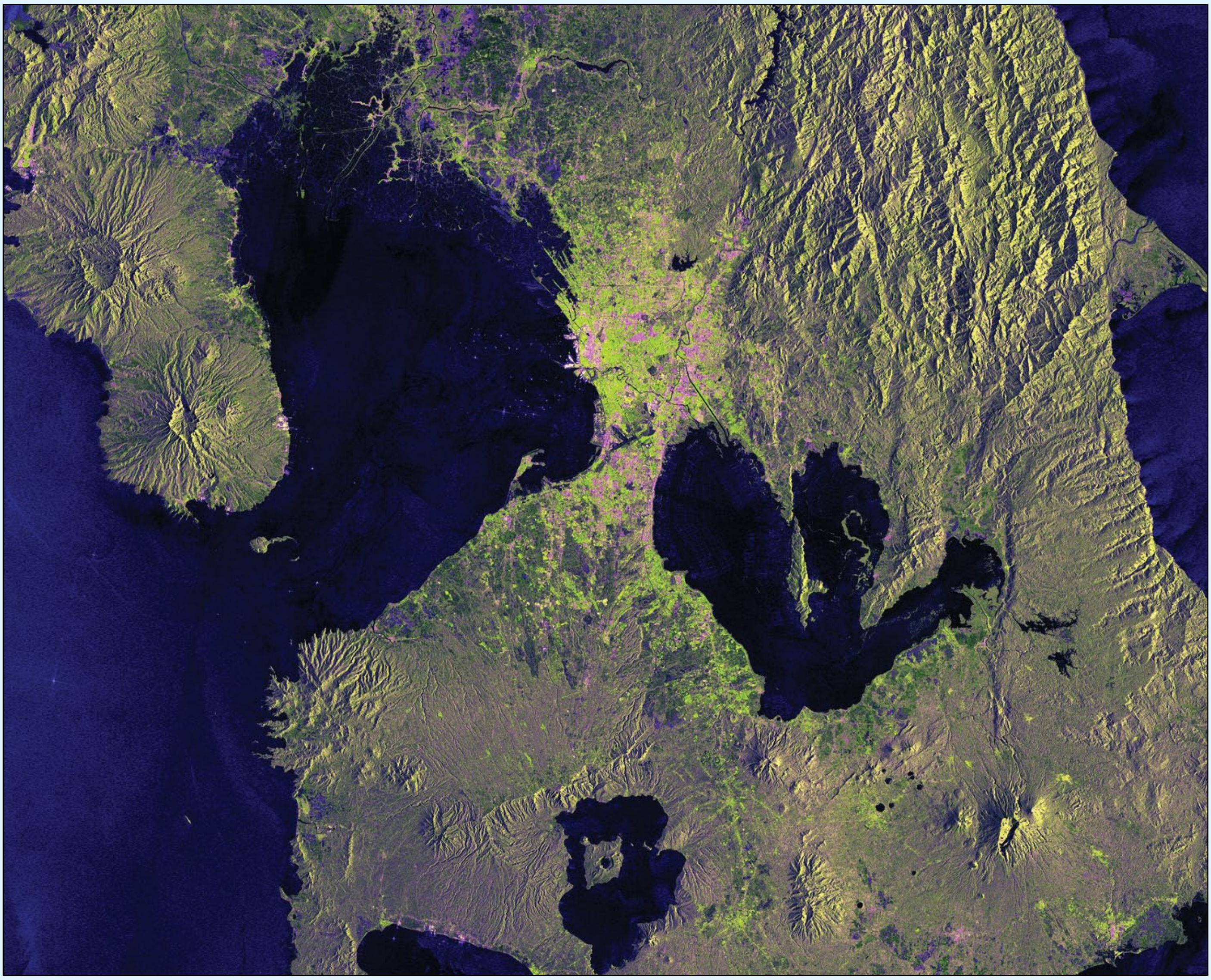


Figure 4 - This is a satellite image showing Manila the capital of the Philippines with two volcanoes visible to the upper left. The scale of the image is approximately 100 km across and vertical.
Image: Modified Copernicus Sentinel data (2016), processed by ESA

My visits to active volcanoes include *Vesuvius* and *Etna* in Italy, *Tiede* in Tenerife and *Fuji* in Japan. However, I think I have been most impressed with the sight of volcanoes when travelling between some of the islands of Indonesia. In 2011 I was aboard a ship which cruised between some of these islands, and on some occasions there was an impressive 360° view with many conical shaped volcanoes lining the horizon. One of my photographs is shown in Figure 3.

Question No 2 was prompted by an image that I found during my researches relating to the first Quarterly Question. In my text to the first question I correctly stated that the erupting volcano is on the main island of the Philippines, which hosts the country's capital of Manila.

This second image (figure 4) is a Sentinel-1A multi-spectral wavelength radar image, and clearly shows the Philippine's capital Manila slightly above centre. Manila is the most densely populated city in the world and lies on the eastern shore of Manila Bay in the South China Sea. To the east of the city lies the largest lake in the Philippines, Laguna de Baý.

But interestingly, to the upper left of the image can be seen two distinctive conical shaped volcanoes.

The second Question is therefore to name these two volcanoes.

A Reminder of the Questions

Question No 1

"What is the name of the active volcano shown in the ESA Sentinel-2 image (figure 1) and what is its relationship with a 'ring'?

Question No 2

"What are the names of the two volcanoes in figure 4".

Answers by email to Francis Bell please, at

francis@geo-web.org.uk

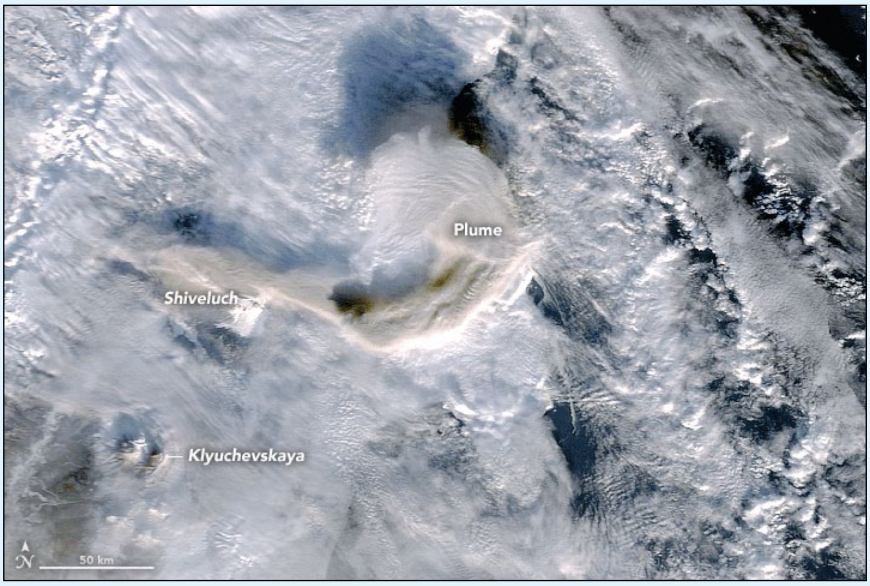
by June 1, 2018.

Plumes Over the Kamchatka Peninsula

A NASA Earth Observatory Report

Sitting along the northwest rim of the Pacific *Ring of Fire*, Kamchatka is one of the most volcanically active parcels of land in the world. At least 300 volcanoes dot the peninsula, and at least 29 of them are active.

Two of those volcanoes were busily puffing away in early January 2018. The Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite caught a glimpse of plumes rising from Shiveluch and Klyuchevskaya on January 9. The plume from Shiveluch stretched for at least 100 kilometres. Note the long shadows, which are caused by high peaks and thick clouds and the low, oblique angle of the Sun in the winter sky.



Plumes rising from Shiveluch and Klyuchevskaya on January 9, 2011.

On January 10, the Operational Land Imager (OLI) on Landsat 8 got clear, close-up views of the area around Klyuchevskaya.

Shiveluch is one of the largest and most active volcanoes on the Kamchatka Peninsula, with at least 60 eruptions in the past 10,000 years. The current eruption has been ongoing since 1999. On January 10, 2018, the Kamchatka Volcanic Eruption Response Team reported that volcanic explosions had lofted ash 10 to 11 kilometres into the atmosphere. The aviation threat level was briefly raised to code red, but was lowered to orange by the end of the day. Volcanic emissions can pose a hazard to aeroplane engines, which can stall or fail when choked with smoke and ash.

By comparison, Klyuchevskaya was relatively docile on January 10, emitting a small plume of gas, steam, and ash. The volcano is the tallest and most active on the peninsula, and the latest eruption has been ongoing since August 2015. More than 100 eruptions have occurred at Klyuchevskaya in the past 3,000 years, with 12 eruptions since 2000.

On January 10, the Operational Land Imager (OLI) on Landsat 8 acquired this clear, close-up view of the area around Klyuchevskaya.

NASA Earth Observatory images by Joshua Stevens and Jeff Schmaltz, using Landsat data from the U.S. Geological Survey and MODIS data from LANCE/EOSDIS Rapid Response. Story by Michael Carlowicz.

Russia's Meteor M2-1 Launch Failure

Les Hamilton

On November 28, 2017, a Russian government-operated Soyuz-2 booster launched the 45 million dollar **Meteor-M No. 2-1** meteorological satellite from the nation's new far-east Vostochny spaceport in the Amur Oblast. All the initial stages of the rocket flight progressed smoothly until, 9 minutes 23 seconds into the launch, the Fregat upper stage initiated sequence to insert the spacecraft into orbit. Alas, that proved to be the last that was heard from the mission.

Meteor M2-1 satellite
Image: Roscosmos

Following extensive investigations into the loss of Meteor and the mission's associated payload of 18 smaller research and commercial satellites for the US, Japan, Canada, Germany and other nations, Russian authorities conceded that the high-profile failure occurred because scientists had programmed the Fregat with incorrect coordinates for Vostochny.

Ever since the 1950's, the Russians had been launching their satellites from the Baikonur Cosmodrome in the south of Kazakhstan. Following the collapse of the Soviet Union, Russia has been leasing the facility from Kazakhstan. Now preferring to launch satellites from home territory, Russia has been constructing its own, brand new five billion dollar cosmodrome at Vostochny in the southeast of the country since 2011.

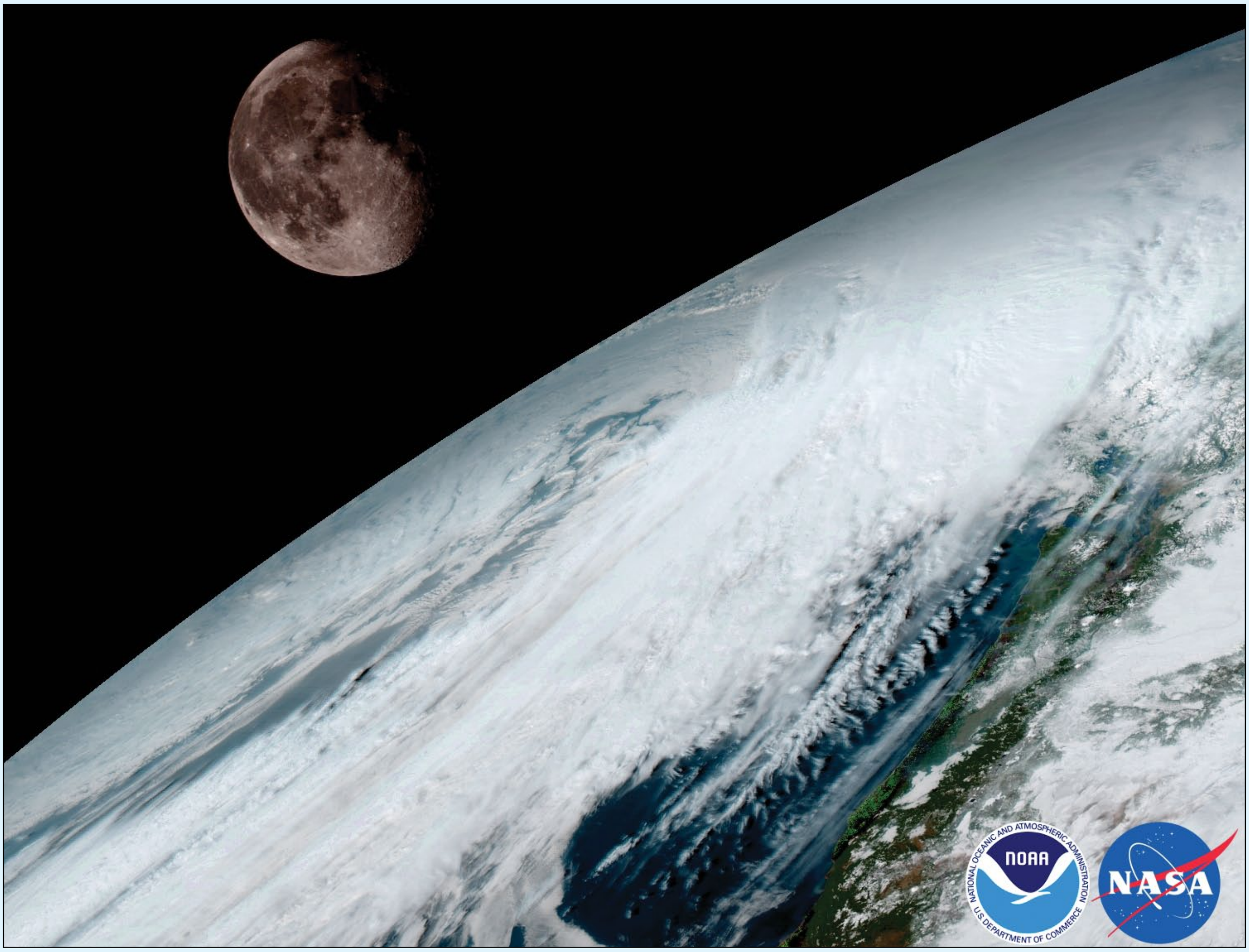
Initially, a spokesman for Russian space agency *Roscosmos* stated that: "the first scheduled communication session with the Fregat has failed to establish contact with the satellite due to its absence from the designated orbit".

After some days it was established that the failure was not due to any malfunction of the booster itself but rather to human error. Apparently, the software aboard the Fregat had been programmed, not with the coordinates of Vostochny, but with those of Baikonur. Consequently, the on-board computers, sensing incorrectly that the Fregat was in the 'wrong' inclination to launch its payload, applied what it considered to be the appropriate 'correction'. The attitude of the payload was thus adjusted, and ended up being deposited somewhere in the North Atlantic Ocean.

Meteor M2-1 undergoing leakproof testing prior to mating with the Fregat launcher
Image: Roscosmos

The Soyuz launcher bearing Meteor-M2-1 on the launchpad
Image: Roscosmos

The launch of the successor to Meteor M2, the next satellite in the series, will now be Meteor M2-2, which is scheduled for a launch late this year. Let's keep our fingers crossed that lessons have been learned, and that the next launch will be successful.



GOES-16: Moon over Planet Earth

Image Credit: NOAA, NASA

Launched on November 19, 2017 from Cape Canaveral Air Force Station, the satellite now known as GOES-16 observes planet Earth from a geostationary orbit 22,300 miles above the equator. Its Advanced Baseline Imager captured this contrasting view of Earth and a gibbous Moon on January 15. The stark and airless Moon is not really the focus of GOES-16, though. Capable of providing a high resolution full disk image of Earth every 15 minutes, in 16 spectral channels, the new generation satellite's instrumentation is geared to provide sharper, more detailed views of Earth's dynamic weather systems and enable more accurate weather forecasting. Like previous GOES weather satellites, GOES-16 will use the moon over our fair planet as a calibration target.

Currently Active Satellites and Frequencies

Polar APT/LRPT Satellites			
Satellite	Frequency	Status	Image Quality
NOAA 15	137.6200 MHz	On	Good
NOAA 18	137.9125 MHz	On	Good
NOAA 19	137.1000 MHz	On	Good [1]
Meteor M N1	137.0968 MHz	Off	Dead [7]
Meteor M N2	137.9000 MHz	On	Good

Polar HRPT/AHRPT Satellites				
Satellite	Frequency	Mode	Format	Image Quality
NOAA 15	1702.5 MHz	Omni	HRPT	Weak
NOAA 18	1707.0 MHz	RHCP	HRPT	Good
NOAA 19	1698.0 MHz	RHCP	HRPT	Good
Feng Yun 1D	1700.4 MHz	RHCP	CHRPT	None: Device failure
Feng Yun 3A	1704.5 MHz	RHCP	AHRPT	Off [2]
Feng Yun 3B	1704.5 MHz	RHCP	AHRPT	Active [2]
Feng Yun 3C	1701.4 MHz	RHCP	AHRPT	Active [2]
Metop A	1701.3 MHz	RHCP	AHRPT	Good
Metop B	1701.3 MHz	RHCP	AHRPT	Good
Meteor M N1	1700.00 MHz	RHCP	AHRPT	Dead? [7]
Meteor M N2	1700.0 MHz	RHCP	AHRPT	Good

Geostationary Satellites				
Satellite	Transmission Mode(s)		Position	Status
Meteosat 7	HRIT 1691 MHz / WEFAX 1691 MHz		57.5°E	On
Meteosat 8	HRIT (digital)	---	3.5°E	Standby [3]
Meteosat 9	HRIT (digital)	LRIT (digital)	9.5°E	On [4]
Meteosat 10	HRIT (digital)	LRIT (digital)	0°W	On
GOES-13	GVAR 1685.7 MHz	LRIT 1691.0 MHz	75°W	Backup East
GOES-14	GVAR 1685.7 MHz	LRIT 1691.0 MHz	105°W	Standby
GOES-15 (W)	GVAR 1685.7 MHz	LRIT 1691.0 MHz	135°W	On [5]
GOES-16 (E)	GRB 1686.6 MHz	HRIT 1694.1 MHz	75°W	On[8]
MTSAT-1R	HRIT 1687.1 MHz	LRIT 1691.0 MHz	140°E	Standby
MTSAT-2	HRIT 1687.1 MHz	LRIT 1691.0 MHz	145°E	On
Feng Yun 2D	SVISSR	LRIT	86.5°E	Off [6]
Feng Yun 2E	SVISSR	LRIT	86.5°E	On
Feng Yun 2F	SVISSR	LRIT	112.5°E	On
Feng Yun 2G	SVISSR	LRIT	105.5°E	On

Notes

1. LRPT Signals from Meteor M N2 may cause interference to NOAA 19 transmissions when the two footprints overlap.
2. These satellites employ a non-standard AHRPT format and cannot be received with conventional receiving equipment.
3. Meteosat operational backup satellite
4. Meteosat Rapid Scanning Service (RSS)
5. GOES 15 also transmits EMWIN on 1692.70 MHz
6. There has been no imagery from Feng Yun 2D since June 30, 2015. Since Feng Yun 2G is operating from the same position (86.5°E), it is likely that FY-2D is now in standby as a backup satellite.
7. On March 20, 2016, Meteor M1 suffered a catastrophic attitude loss, frequently pointing its sensors towards the sun. The following day all signals ceased and it seems highly probable that this satellite is now incapable of imaging the Earth.
8. GOES Rebroadcast (GRB) provides the primary relay of full resolution, calibrated, near-real-time direct broadcast space relay of Level 1b data from each instrument and Level 2 data from the Geostationary Lightning Mapper (GLM). GRB replaces the GOES VARiable (GVAR) service.

GEO Outreach

Visit to the Harwell Radio and Electronics Rally

Francis Bell

GEO attended its first radio and electronics rally of the year at Didcot, Oxfordshire on February 11. If you are not familiar with the location of Didcot, it is situated about three miles from the village of Harwell which is noted for the world of high technology and nuclear physics not to mention a new office of the European Space Agency (ESA). Based in this village is the amateur radio group *Harwell Amateur Radio Society* (HARS) and it was this organisation which ran the rally in Didcot Leisure Centre.

GEO have attended this rally in previous years, but I judge this year's event to have been the busiest ever with 140 display stands covering amateur radio, computing and other high technology interests. Our GEO stand had on display recorded satellite images, plus recent animations from geostationary satellites together with a selection of high resolution images relayed by ESA as well as literature and personal advice relating to weather satellite reception at home.

Part of the main hall at the HARS showing some of the 140 stands plus some of the visitors.

There was particular interest during the day relating to the live reception of NOAA and Russian polar orbiting satellites on 137 MHz FM using a Software Defined Radio (SDR) dongle: in fact so much interest that the few SDR dongles we had available were soon sold. After that, enthusiasts were directed to our GEO shop to buy their dongle.

Between the opening time of 10.00 a.m. and 2.00 p.m. we were very busy with visitors to our stand. Some people were very knowledgeable about their own specialist areas: for example, a test pilot for new aircraft or computer systems—but with others less knowledgeable but enjoying the potential experience of live personal reception of satellite images—which is what many GEO members do best! During the day we enrolled six new members to our GEO group.

Future planned rallies include a definite booking for a stand at the South London Radio and Computer Rally at Kempton Park on April 15, 2018, together with other possible events during the year but which still have to be confirmed. If any reader belongs to a radio group or is involved with planning a rally/show, depending on details perhaps GEO could contribute in some way to such an event.

My personal thanks go to David Simmons for attending this rally with me. David's knowledge and experience with SDR was particularly valued by many of the visitors to our stand.

A view of our GEO stand at the HARS rally.

Atlantic Ship Tracks

Les Hamilton

The European Space Agency (ESA) recently released a fascinating image showing ship tracks over the Atlantic Ocean to the west of the United Kingdom. The subject of Ship Tracks was covered in an article in the June 2005 issue of GEO Quarterly, which it seems timely to reproduce below.

The Formation of Cloud

To understand how ship trails arise, it is necessary first to detail how 'normal' cloud forms in Earth's atmosphere. Ship trails are, after all, just one particular form of cloud, albeit man-induced.

Earth's atmosphere contains water vapour but this does not automatically condense into liquid droplets to form clouds, even when the temperature is well below freezing. Cloud formation depends on the presence of aerosols—suspensions of tiny, microscopic solid and liquid particles dispersed throughout the atmosphere.

Cloud-forming aerosols originate, in the main, from natural sources like sea salt, volcanic ash, desert dust and biomass burning but also, increasingly, through the burning of fossil fuels by man. Aerosol particles often contain substances that dissolve easily in water (such as sea salt, sulphur dioxide etc.) and it is these that provide the cloud condensation nuclei (CCN) around which water molecules condense. If the air were devoid of aerosol particles, cloud, mist and fog would never form at all and the sky would be forever clear and cloudless!

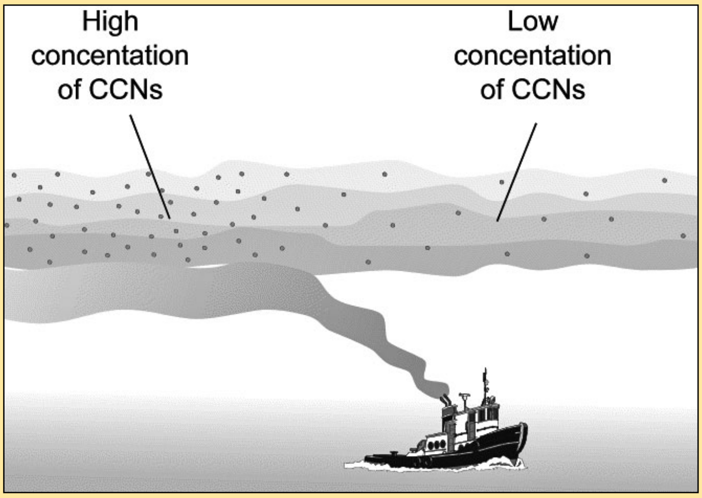


Figure 2 - Formation of Cloud Condensation Nuclei (CCN)

A layer of moist air, relatively depleted in condensation nuclei, is trapped beneath a high pressure inversion. The ship's exhaust fumes can rise to the upper reaches of the trapped airmass but no farther, greatly increasing the concentration of condensation nuclei present. The increased numbers of tiny water droplets produced in the air-mass makes it more reflective, giving rise to the phenomenon of 'ship trails' in satellite images.

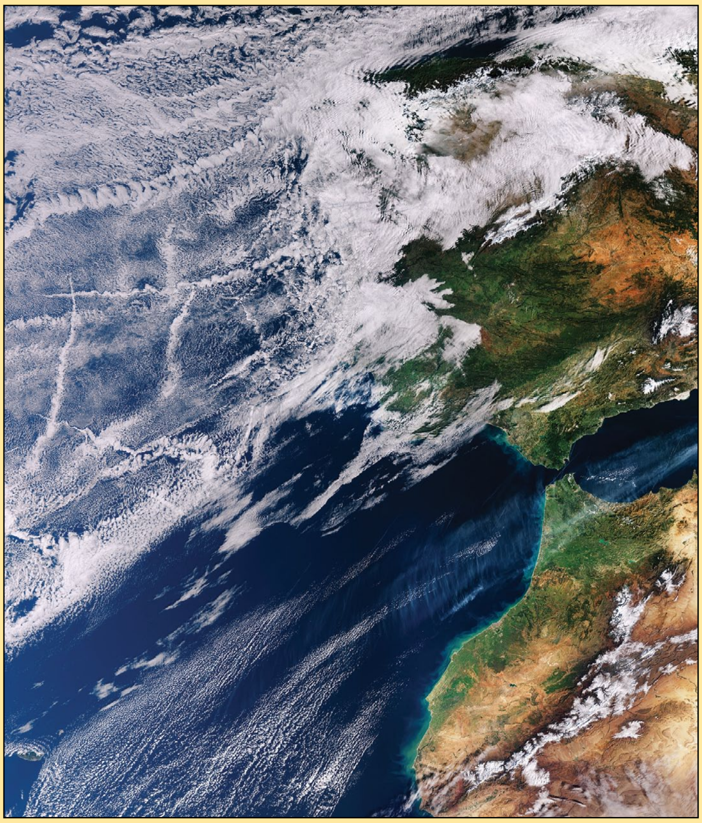


Figure 1 - Ship trails west of Ireland

When do Ship Trails Form?

Ship trails generally form in the still, moist air commonly associated with anticyclonic conditions, when the sea is overlain with a stable layer of air at a similar temperature to that of the water itself. This layer may on occasions already contain thin cloud or mist but it is in effect supersaturated and lacks sufficient CCNs to generate full scale cloud.

When ships pass through this region, fine aerosol particles from their exhausts float up through the moist layer of air where they become additional CCNs (figure 2). This means that water vapour in the air now contains many more nuclei upon which to condense and these produce new cloud droplets where few may have existed before. The outcome is that the cloud becomes more reflective to sunlight.

As a ship crosses the ocean its exhaust issues a continual stream of CCNs in its wake. Consequently, its path shows up as a trail of shallow stratus clouds—a 'ship trail'. This cloud streamer often stretches for hundreds of kilometres and can extend tens of kilometres in width.

Generally speaking, the faster a ship travels, the narrower, longer, and less diffuse its ship trail will be. Slower ships leave shorter, wider, and more diffuse trails. It is worth noting that ship trails often reflect the direction and speed of local winds as much as the direction and speed of the ship itself.

Ship trails normally persist for many hours and sometimes remain visible for days on end provided that the air mass surrounding them remains relatively undisturbed.

Ship trails show up well in satellite images, even those from low-resolution APT transmissions. The trails show up most strongly in reflected radiation (NOAA channels 1, 2 and 3) where they appear as bright lines that can be distinguished clearly from any surrounding clouds. The same trails are usually all but invisible in the radiated infrared from NOAA channels 4 and 5 because the temperature of the sea and surrounding air are very similar.

What Conditions Favour Ship trails?

Persistent ship trails often form beneath a low-level temperature inversion where humidity is high and low-level stratus or stratocumulus cloud may already exist.

Such conditions are most likely to occur during conditions of high pressure, when the lower atmosphere can become especially calm due to a layer of warmer air lying approximately 500 meters above the sea surface. This effectively places a 'cap' over the cooler moist air below, trapping pollutants and water vapour alike. In general, ships vent their exhausts into still, relatively clean marine air that suffers minimal convective turbulence and which is near-saturated and generally depleted in CCNs. Under these conditions exhaust fumes are able to rise only as far as the top of the cool air-mass where particulates greatly increase the number of CCNs present (figure 2). The result is the formation of many tiny water droplets, too small to produce precipitation, but which form relatively low-elevation clouds that resemble larger versions of aeroplane contrails. Unlike contrails, ship trails last for many hours.

Aircraft Contrails

Enthusiasts spotting these cloud trails on their satellite images for the first time often mistake them for aeroplane contrails.

Contrails (condensation trails) produced by jet aircraft normally form at altitudes of eight kilometres and more, where the temperature is around -40°C. Under these conditions, water vapour in the exhaust can change directly into ice crystals (without forming liquid water at all), a process that does not require nuclei such as dust particles.

Aeroplane contrails can be observed in satellite images, but show up most strongly in NOAA infrared channels 4 and 5—the very ones where ship trails are least likely to be visible. Contrails are much colder than the terrain beneath them and this temperature differential shows up sharply in these radiant infrared channels. Of course, contrails (and their shadows) also show up by reflected radiation, but are so narrow (a few hundred metres only) that they rarely appear in APT images. They can, however, be readily identified in many HRPT images.

Temperature Inversions

Under normal conditions, air temperature decreases with altitude. That's why high mountains retain snow even during summer. A temperature inversion is a situation where this temperature decrease is interrupted by the presence of a layer of warmer air at higher altitude.

An inversion is an extremely stable layer of the atmosphere which acts rather like a lid. Rising currents of air within the lower cool air mass lose their buoyancy when they reach the warmer, less dense inversion layer: they cannot rise any higher and are forced to spread laterally. Any pollutant particles released into the lower layer become trapped there because normal convective mixing of the atmosphere is prevented.

Phenomena associated with temperature inversions are valley fog (where surrounding mountain peaks may be bathed in sunshine) and red sunsets (caused by the build-up of pollution particles).

What causes an Inversion?

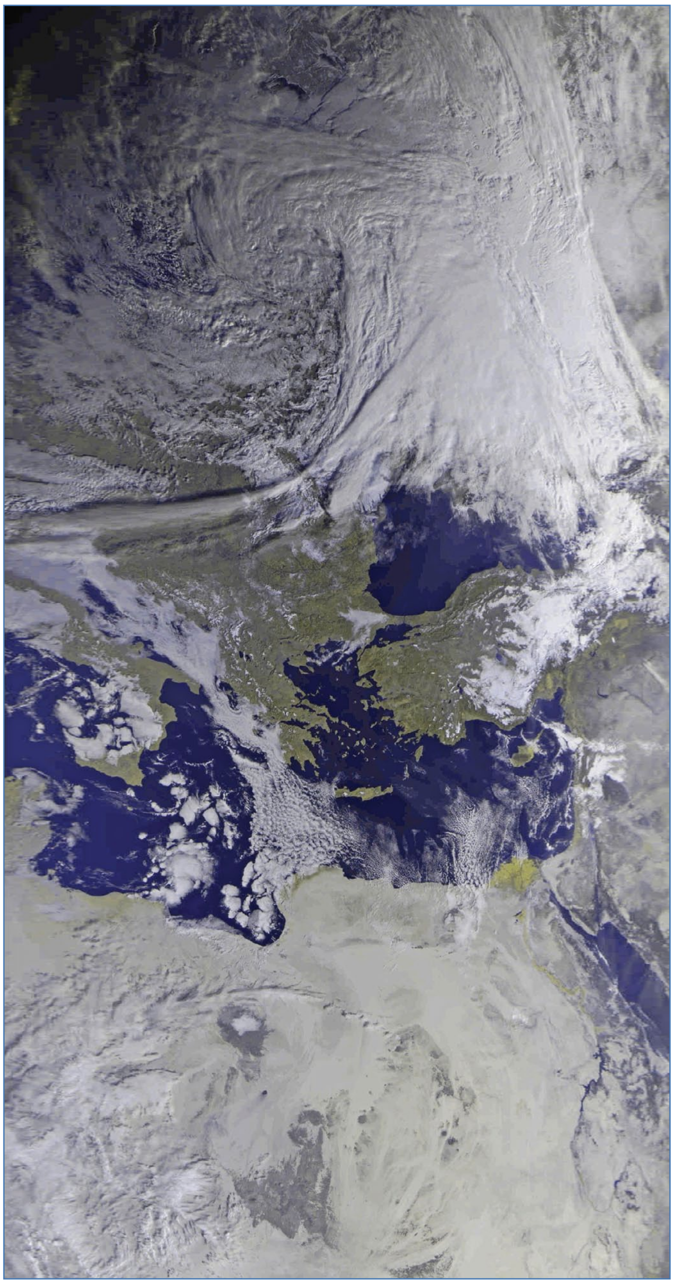
Temperature inversions are produced in a variety of ways. A familiar but usually short-lived example occurs in secluded mountain valleys where overnight radiative cooling of the ground produces low-level air that is colder than the air above. If the cooling is sufficient, valley fog may form although the mountain peaks, surrounded in the warmer inversion layer, remain clear. This inversion ends when the morning sun warms the lower levels once more.

The type of inversion that results in ship tracks is of longer duration, and is found within a region of high pressure. High pressure is caused by descending air and as the air descends it becomes compressed and experiences adiabatic warming.

This increases its buoyancy, eventually arresting its descent and isolating a cooler, denser layer of air below it. This is known as a 'subsidence inversion'. As high pressure systems often combine temperature inversion conditions with low wind speeds, they can persist for a long time, and provide ideal conditions for the formation of ship trails.

Perfect LRPT from Meteor M2

On January 30 this year, Enrico Gobbetti was pleasantly surprised to discover that Meteor M2 had transmitted two LRPT images without the customary breaks in transmission every six minutes or so. The image below is from the 07:44 UT pass that morning.



Alas, this situation did not last long and members in North America reported that the image breaks were present as usual in their images later that day.

Enrico queried what happened with the Russian authorities and was informed that the image breaks result when an internal buffer aboard Meteor overflows. This is most likely when the Earth below the satellite is free of continuous clouds and snow cover, making the image data more diverse and saturated. Apparently, on January 30, because the scene was largely cloudy and did not exhibit a great contrast range, the captured image could be sufficiently compressed to prevent the internal buffer from overflowing.

The Winter of 1947 in Halesowen, West Midlands

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Most readers who experienced the severe weather of late February and early March, brought by the '*Beast from the East'*, can be forgiven for thinking this is the worst ever winter to hit the British Isles.

Not so! A mere flea-bite compared with the severity of the weather in early 1947, as recounted for the RIG Journal in 2002 by the late Cedric Roberts. His article, describing three months of continuously horrendous weather, is reproduced below.

This article relates to the three months from January through March 1947, a period of 90 days, which represented one of the most severe spells of weather encountered in England for very many years, possibly since the 17th century! Not only was there searing cold, but also exceptionally heavy falls of snow totalling more than two metres, awesome indeed for the U.K.

January 1947

January 1947 began fairly mild and wet, the first five days experiencing 17 mm of rain, but cooler air from the continent brought a heavy fall of snow early on the 6th, and 9 cm lay on the ground by dawn on the 7th. During that day the snow turned to sleet then rain, and by the morning of the 9th most of the lying snow had become very patchy. The weather then turned much milder under mainly westerly winds, with rain on most days until the 17th when it became fine and sunny.

But cooler conditions returned on the 18th, although it was not until the 20th that night frosts again set in. By the 22nd much colder northeasterly winds were bringing frequent snow showers, leading to a full snow cover of 2.5 cm on the 23rd. Further heavy snow showers on the 25th and 26th brought the level snow cover to 13.5 cm. Heavy snowfall continued during the following two days as winds gusting to 28 knots caused widespread drifting

Figure 1 - Walking to work along paths between the snowdrifts.

up to depths of 2 metres in many rural areas while persistent frost kept daytime maxima at or below 0°C for the remainder of the month.

The gusting southeasterly winds piled up ever deeper drifts, and many minor roads became almost impassable. Overnight temperatures tumbled to -10°C in the air and -13.3°C on the snow, and by the end of January, level snow lay 14 cm deep with drifts of up to 2.5 metres in isolated and open areas. Table 1 summarises the principal features of the month's weather. Thus ended the start of what was to be a memorable and extremely trying spell of severe winter weather.

	January	February	March	Jan-Mar 1947	Jan-Mar Mean
Falling snow / sleet (day)	16	19	13	48	14.4
Lying snow (day)	13	28	19	60	9.4
Air-frost (day)	13	27	15	55	30.8
Ground frost (day)	24	28	16	68	51.1
Days with precipitation	22	21	24	67	59.6
Precipitation total (mm)	70.2	55.5	151.7	277.4	196.1
Sunshine total (hour)	46.0	15.2	70.1	131.3	160.3
Sunless days	13	22	12	47	35.1
Warmest day (°C)	12.8	4.4	12.2	12.8	12.0
Coldest day (°C)	-5.6	-3.9	-1.7	-5.6	-0.4
Coldest night (°C)	-10.0	-8.9	-8.3	-10.0	-7.5
Snow-surface minimum (°C)	-13.3	-20.0	-16.1	-20.0	-11.6
Warmest night (°C)	8.9	0.0	8.9	8.9	9.3
Mean maximum (°C)	4.0	-0.7	6.3	3.2	7.0
Mean minimum (°C)	-1.3	-3.8	0.7	-1.5	1.3
Mean daily temperature(°C)	1.3	-2.3	3.5	0.9	4.1

Table 1 - Summary of the salient statistics for the period January to March 1947.

Figure 2 - A bus almost buried by drifting snow.

Measuring Snow-Depth

Due to the very strong and gusting winds that blew for practically the whole month, it became necessary to make very careful estimates of snow-depth, due to the widespread and deep drifting which had occurred. Several measurements were taken across the plot, melt water was measured and converted, while a board was placed on a clear patch to estimate fresh falls. In addition, estimates were made on the farmland adjacent to the site to give a further idea of falls in 'open' areas. All depths of snow relate to the plot or its immediate environs. Conditions in open country could, and did, vary considerably and this is commented upon in the text.

February 1947

February was ushered in with brisk southeasterly winds and sub-zero temperatures, though no fresh snow fell on the first. However, further heavy snowfall began at around 4 a.m. on the 2nd and continuing fresh falls of snow and snow grains during the subsequent five days brought the 'level' snow to a depth of 19 cm with drifts over 4 metres in places. Winds remained in an easterly quarter throughout and gusted to 40 knots, causing severe wind-chill and blowing snow back into drifts as soon as attempts were made at clearance. By now most local roads were blocked and their clearance was becoming futile.

During that first week temperatures rose no higher than 1.1°C and fell at night to -4.4°C in the air and -6.7°C over the snowfield, with winds regularly gusting around the 30 knot mark and peaking at 40 knots. With the continued falls of snow, permanent frost and continuously overcast skies, Britain was akin to the Antarctic. From early on the 4th, there ensued a period of sub-zero temperatures lasting the best part of 100 hours and it was not until the 9th that daytime maxima reached 1°C; and this rise lasted barely 48 hours. To add to the depression felt by many struggling in to work or school (neither factories, schools nor shops closed), the skies remained totally overcast by day and night until the 15th, apart from a one hour break on the 6th when we had our first glimpse of the sun for the month.

From February 11, persistent frost occurred, totalling in excess of 320 hours of sub-zero conditions with the daytime temperature reaching no higher than -3.9°C on the 17th. In addition, three days, the 3rd, 7th and 10th saw freezing fog at 9 a.m., with thick fog at other times on a further six occasions (smokeless zones had not yet arrived). Throughout this spell winds had been gusting regularly to levels between 20 and 30 knots, bringing severe windchill, widespread drifting and reduced visibility due to blowing snow. By the 23rd level snow had reached 23 cm though drifting, which was widespread and severe, resulted in all roads (and railways) which passed through cuttings being totally filled and blocked. In several places drifts were deep enough to cover hedges and reach the window-sills on the upper floors of houses. The only way from the front door to the 'road' in many cases was to dig a tunnel beneath the snow, akin to that from an igloo. By this date we had experienced snow or sleet on 15 days and sunshine on just two.

Figure 3 - Tunnelling through the snow

February 24 was the first really sunny day of the month with 7.1 hours, but the clear skies sent the temperature plummeting, resulting in an overnight air frost of -8.9°C, while the snow surface temperatures plunged to -20.0°C. Despite this respite, snow or sleet continued to fall, and only four days during the second half of the month escaped solid precipitation. At no time during the month did night time minima rise above zero, and the mean daily temperatures were positive on only three days overall.

By the end of February the countryside was in chaos, as were many towns and cities. Fuel was in very short supply since the railways were strike-ridden and impassable, as were almost all roads (we did not have any motorways then). In truth, everywhere was practically at a standstill. People had to walk to work or school, an easier task in the immediate post-war years as almost everyone lived very near to their place of work; the ‘commuter-age’ was fortunately still decades in the future.

Figure 4 - Heavy drifting on the A456

Rationing meant that people were ‘adequately’ but not well fed, and the biting cold without central heating or sufficient fuel meant only one room in the house being heated, with the bedrooms like iceboxes. I remember ink freezing on a table under my bedroom window, and getting into bed was like slipping between a couple of sheets of ice.

And so, to draw the threads for February together, snow lay on 28 days to a maximum ‘level’ depth in the enclosure of 27 cm and locally drifting to almost 4 metres. Air frost occurred every night bar one (when it struggled up to zero). There was precipitation on 21 days, while 22 days were sunless, during a month when the total sunshine totalled just a shade over 15 hours. Wind-chill regularly reached -13°C and sometimes -15°C. The nation was ‘shell-shocked’, but March was to bring even worse privations.

March 1947

Although February 1947 produced some dramatic and extreme conditions, March was to throw even more severe weather at us, including blizzard conditions, glazed ice, a gale, severe wind-chill and widespread flooding.

Figure 5 - Snowdrifts blocking the A456

The month opened in relative calm, March 1 showing little more than scattered snow showers and almost 8 hours of bright sunshine. It did, however remain bitterly cold, with a day maximum of 2.2°C and a night minimum of -6.1°C as winds gusting to 30 knots produced severe wind-chill somewhat ameliorating the effects of the bright sunshine. Following two further dry days with quite widespread fog, a brisk northeasterly wind on March 4 heralded the arrival of blizzard conditions that brought level snow to a depth of 27 cm with drifts as deep as 5 metres in places. Roads and railways again succumbed as snow piled in as fast as it was cleared.

Continuing heavy snow falls the following day increased the ‘level’ snow depth to 42 cm, a total that continued to increase during moderate to heavy falls from the 6th to the 9th. Most of the country was again at a standstill and wartime ‘bulldozers’ were brought out in attempts to open roads to isolated towns and villages. It was the second week into March before my own village road was opened from Halesowen, and then only by cutting a single path.

On March 12, freezing rain began to fall, coating everything in sheets of ice and making conditions treacherous, putting a 5 to 6 cm layer of ice on top of the snow surface. Additional heavy glazing occurred on the 14th only to have a further layer of snow added after heavy falls on the afternoon and evening of the 15th. Under these conditions the deep layer of snow was so solid that it was possible to walk on its surface, which in many cases left one standing above hedgerows, fences and road signposts.

The final air-frost of the month occurred on the 15th and the following day saw a complete change, with the daytime maximum rising to 8.3°C after early morning fog. By late evening a full gale was blowing, gusting to 66 knots and for almost 11 hours, the mean wind speed remained in excess of gale force. The gale was accompanied (fortunately) by rain, not snow, though anxiety now began to mount with the prospect of flooding if the thaw were rapid, in view of the immense volume of snow around.

Figure 6 - Digging through snow drifts to keep the A456 Kidderminster to Birmingham road open.

Rain and fresh to strong winds persisted throughout the following seven days, eating into the lying snow as a change in wind direction to a westerly quarter heralded much higher temperatures. By March 22 these were peaking at 11.1°C, warm days, frost-free nights and ample rain removing almost all of the main volume of lying snow.

The final ten days of March were exceptionally wet with 36.3 mm of rain. This and the water resulting from the melting snow caused widespread flooding along the river valleys, a fact mentioned regularly during the floods occurring the autumn before last (i.e. 2000).

Figure 7 - Flooding near Worcester

The inhabitants of Bewdley would have been horrified to find that the river Severn floodwater reached the garage forecourt near the railway bridge over the A456 Birmingham-Bewdley road. The resulting flooding along the Severn—and most other rivers—was so severe that it set records which in many places still stand today.

The 1947 winter was now well and truly over, and March had added to the mass of statistics thrown up by this spell of quite amazing weather, statistics which appear in Table 1. The rainfall total of 151.7 mm is a March record not exceeded to this day, with precipitation on 24 days, 11 of which experienced 5 mm or more of precipitation. Hail occurred on 3 days with fog at 9 a.m. on eight days.

Summary

During the first three months of 1947 snow lay on the ground for 60 days in all, with the deepest ‘level’ snow amounting to 42 cm on the March 6. Just prior to the final thaw, drifts extended up to, and in cases over 5 metres in road and railway cuttings and on high ground. Over the period the heaviest single fall amounted to 17 cm on March 12 during a final blizzard accompanied by glazed ice. The final two columns of Table 1 highlight the statistics for this 3-month spell, with the 30-year mean (1971-2000) included by way of comparison.

Sub-zero temperatures occurred over 32 days, a total in excess of 768 hours of frost, the longest continuous spell lasting from February 11 to February 23, more than 320 hours. One gale, on March 16, blew with gusts up to 66 knots and gale force gusts were noted on 21 days in all. These figures well illustrate the problems which were encountered, both through the severe wind-chill and by blowing snow re-filling all freshly cleared roads and railways.

The entire severe spell had lasted 57 days, 60 if we include the initial short spell at the start of January. That ends this rather detailed look at the winter of 1947 seen entirely through my own eyes, with comments made where it thought likely to enhance the data being quoted. I do hope that this has proved of some interest, especially to those who were not born at the time, or were too young to ‘appreciate’ the conditions.

Figures 1,2,3,6,7 kindly supplied by the *Birmingham Evening Dispatch*; Figures 4,5, by the author

This RGB123 image segment from Meteor-M2, acquired on February 12 this year by Enrico Gobbetti, shows northern Scotland in particular beset by heavy snow showers. The cyan colouring indicates lying snow on the ground.