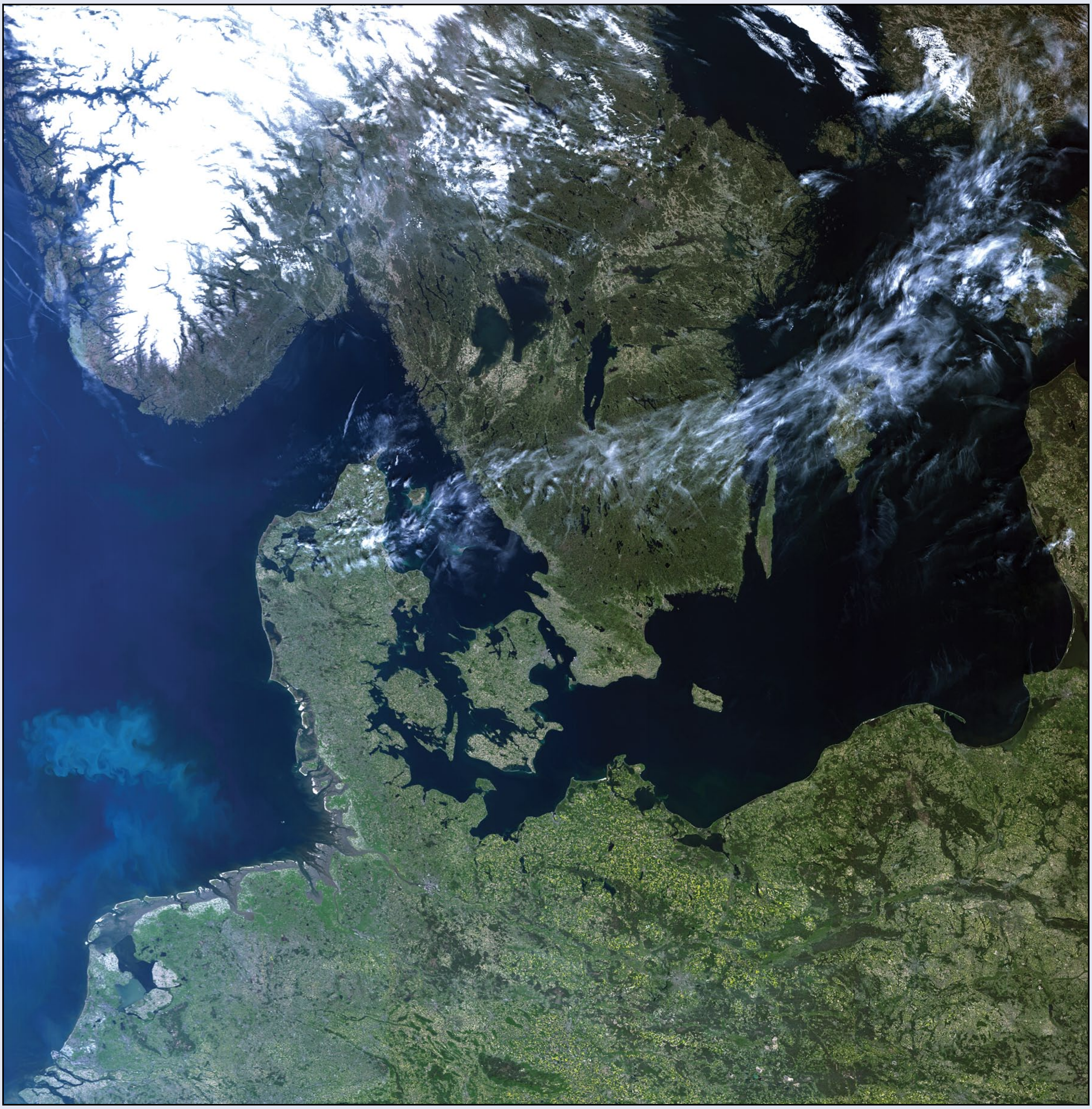
GEO Newsletter

Group for Earth Observation

Group for Earth Observation No 58 - June 2018

First Light for Sentinel 3B



The Copernicus Sentinel-3B satellite, launched from Russia's Plesetsk Cosmodrome on April 25, 2018, recorded this cloudless 300 metre resolution view of Northern Europe on May 8 using its 21-band *Ocean and Land Colour Instrument* (OLCI). Various types of ground cover can be seen, as well as snow on the highlands of Norway and a phytoplankton bloom in the North Sea.

Image: Copernicus Sentinel data (2018), edited by EUMETSAT, CC BY-SA 3.0 IGO

The GEO Report

Francis Bell

GEO has enjoyed the privilege of visiting EUMETSAT's Head Quarters in Darmstadt on a four yearly cycle, the last visit being in 2015. Each visit has been judged successful from both a technical information and a personal social perspective.

It has been suggested by a number of GEO members that it would be great to have a Darmstadt visit in 2019 which fits exactly with our four yearly cycle of visits.

In addition to visiting EUMETSAT's HQ, previous visits have included excursions to European Space Operations Centre (ESOC), again in Darmstadt, plus a visit to the EUMETSAT ground station communication unit at Usingen, just north of Frankfurt.

To be sure that it's worthwhile trying to organise a GEO visit to Darmstadt in 2019, I need to know if there is sufficient support by our members for such a visit. I would only be confident in trying to organise a visit if there were, say, 20 plus members attending. Personally I'm keen to visit and learn as much as possible about the EUMETCast High Volume Service plus other current developments.

If you are interested in visiting Darmstadt in 2019, please email me so that I can place your name on a provisional list. There will be no commitment by registering your name but it will give me an idea of the scale of our members interest. There will no specific charge for the visit but participants will have to be responsible for their own transport and accommodation costs.

Please note that no arrangement has yet been made with EUMETSAT, and a planned visit may be dependent on many factors relating to those organisations we wish to visit. However a starting point would be the dates of June 27-28, 2019. These dates correspond with the late June dates of our previous visits. Please let me know if you wish to be placed on a provisional list of GEO visitors and I will keep you in touch with potential arrangements.
Email me please, to:

francis@geo-web.org.uk

This GEO group photograph was taken outside EUMETSAT's HQ building in 2011.

Outside the EUMETSAT HQ building

EUMETSAT's media archive centre

GEO visitors in the central control room of EUMETSAT's satellite systems

GEO members in the presentation room at EUMETSAT's ground station

Some of the medium sized dishes at Usingen ground station

The GEO party enjoyed an informal dinner here, together with EUMETSAT staff, in the evening after a busy technical day.

From the Editor

Les Hamilton

It was particularly encouraging to receive an article for the *GEO Newsletter* from David Sale, recounting his experiences with both Meteor LRPT and NOAA APT reception in Australia. Though his article is by no means an in-depth tutorial on satellite reception, David certainly raises awareness of techniques and useful software, particularly on the Linux operating system, that readers might enjoy trying out.

As ever, we are always pleased to receive contributions from readers, be they articles or just interesting satellite images. These should continue to be sent to the Editor at

geoeditor@geo-web.org.uk

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Quarterly ? Question

Francis Bell

Question 57

My thanks to those members who contacted me with the answers to the previous Quarterly Question, which related to a recent satellite image of an erupting volcano in the Philippines. I asked for the name of the volcano and its association with any ring. The volcano is called 'Mayon Volcano' and it is associated with—or part of—the 'Pacific Ring of Fire',the ring of volcanoes which surround the Pacific Ocean. (more about Mayon on p 5)

Question 58

This new Quarterly Question is perhaps more political than geological. During my travels around the world I have occasionally visited an island which is divided by political boundaries, that is, the island is part of more than one nation. I have personally visited at least six such islands but I know there are others.

The question is: "Name as many islands as you can which are divided into—or are part of—different countries". List the islands and the countries concerned.

To start your researches examine Figures 1 and 2, which are satellite images of islands that are divided politically between different countries. Figure 1 is an island located in the Mediterranean Sea. It is approximately 140 miles long from east to west. Figure 2 is a colour composite image of a European island, measuring approximately 310 miles from northeast to southwest, with its western coast facing the Atlantic Ocean

Figure 1
Image © ESA

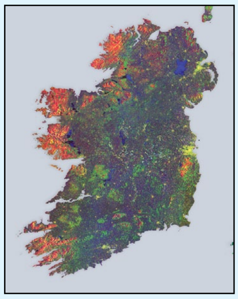


Figure 2
Image © ESA

Please send the names of these islands, plus a list of other islands and the countries between which they are divided, to

francis@geo-web.org.uk.

If you can do this by the end of August 2018 you will have appropriate recognition in the September issue of the *GEO Newsletter*: but a response at any time will be welcome and acknowledged.

I'm not sure how many islands qualify for inclusion in an answer, I suspect about ten, however I await your answers.

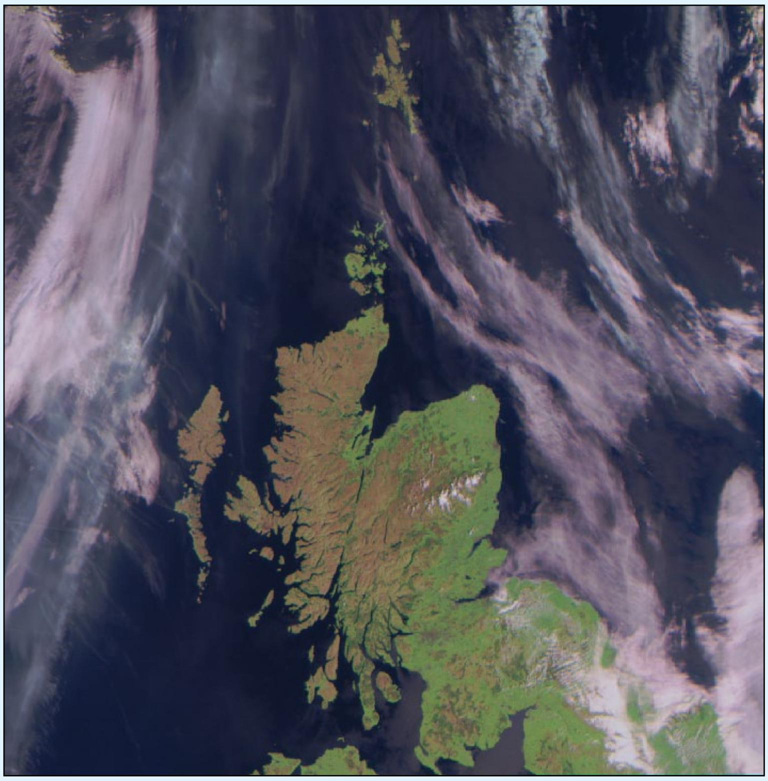
Meteor M2 News

Les Hamilton

In early May this year, Russia's Meteor M2 satellite started to exhibit signs of attitude control problems, firstly with partial images appearing on its LRPT stream on 137.9 MHz, before imaging ceased altogether between May 6 and 7, fuelling speculation that the satellite had suffered a fatal malfunction.

However, LRPT images started to reappear on May 8 and have done so consistently throughout the remainder of the month. Interestingly, though, the Meteor LRPT has since been transmitting channels 1, 2 and 3 (the visible and near infrared frequencies), allowing enthusiasts an extended opportunity to enjoy more realistic colour images.

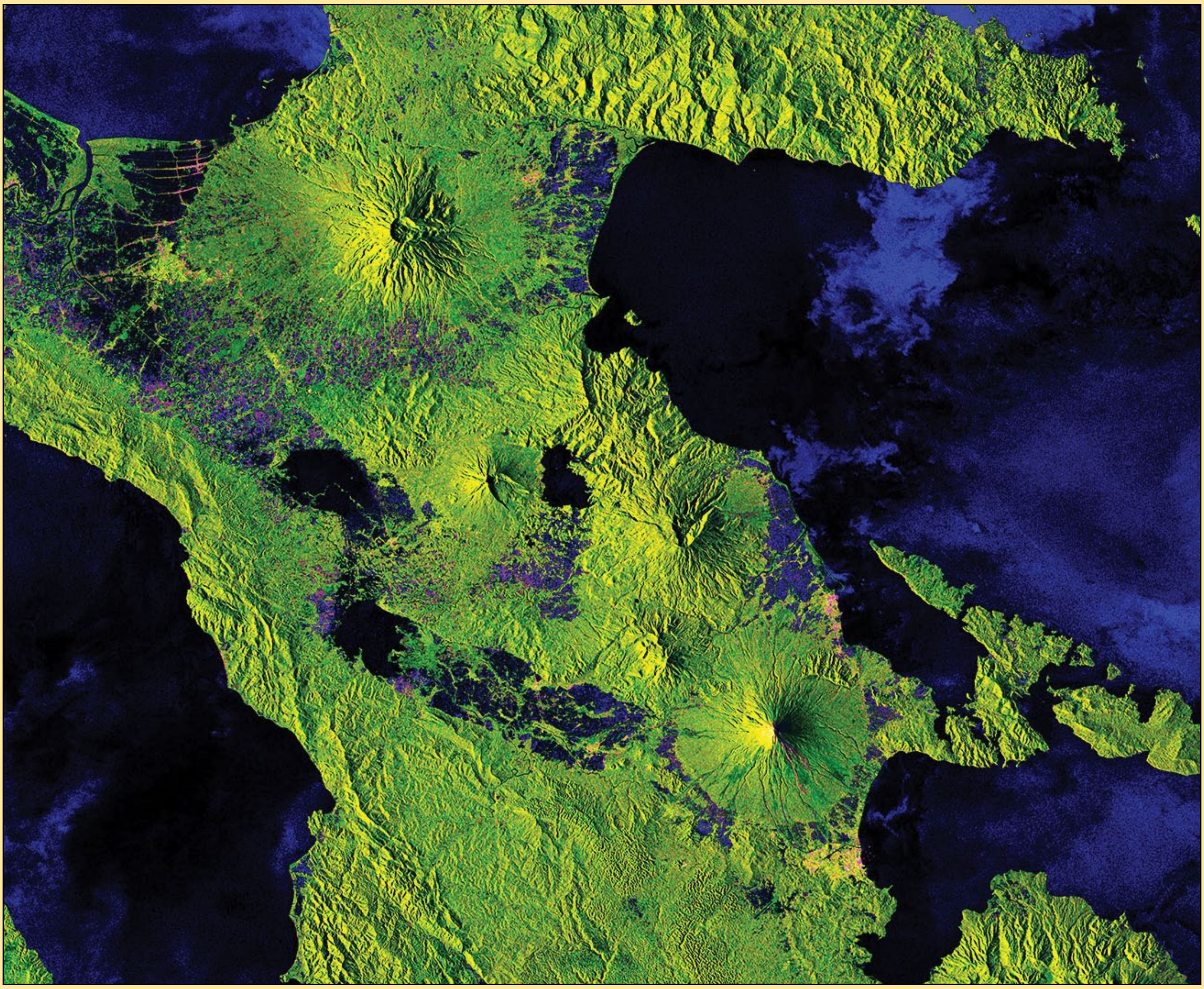
It was suggested that the channel 4 infrared sensor might have been damaged during the period of attitude loss, but Rob Alblas confirmed that it was still being disseminated on the HRPT transmissions.



The image opposite shows Scotland, including the Western Isles, Orkney and Shetland, in RGB123 rendition from Meteor M2, as acquired at 10.19 UT on May 28, 2018.

Mount Mayon, Philippines

European Space Agency



ESA's Sentinel 1B satellite captured this radar image of Philippines' Mount Mayon on January 16, 2018.

The Copernicus Sentinel-1B satellite takes us over one of the most active volcanos in the world: Mount Mayon on the island of Luzon in the Philippines. [It should be noted that the January eruption of Mount Mayon was the subject of our Newsletter's Quarterly Question 57 - Ed].

Luzon is the biggest island in the Philippines and home to most of the country's active volcanoes. This volcanism is associated with plate tectonic processes where the floor of the South China Sea is being drawn down into the mantle along the Manila Trench, located to the west of the island. The image just shows part of the southern end of this large island, but features no less than five volcanoes.

While Mount Mayon—the most southerly volcano in the image—is famous not only for being perfectly formed, but also for being one of the most active in the world, the other volcanoes in the image are actually either dormant or extinct. Dubbed a perfect volcano because of its symmetry, Mount Mayon has a classical conical shape, built up by many layers of hardened lava. It erupts frequently with the most recent eruption occurring in January this year.

This image was captured on January 16, 2018, and while satellite radar isn't typically used to detect hot lava flows, the way it has been processed reveals a pink line running down the southeast flank of the volcano that matches the flow of lava in optical images from satellites such as Sentinel-2. The predominant bright green in the image corresponds to vegetation, the lighter green and pink to towns and the blue to cultivated fields.

While the Sentinel-1 radar mission is used for a myriad of everyday applications, it is also used to detect ground movement, which is essential for monitoring shifts from earthquakes and volcanic uplift.

Netherlands Ice

European Space Agency

This Copernicus Sentinel-2 image from March 2, 2018 shows Amsterdam, and the IJmeer and Markermeer freshwater lakes, covered by a thin layer of ice. As famous as the Netherlands is for flowers, it's arguably equally renowned for ice skating. While the cold snap caused havoc throughout much of Europe, the Dutch were busy dusting off their skates and eager to hit the ice. The ice on these big lakes was much too thin to skate on, but some canals in Amsterdam were closed to boats to give the ice a chance to thicken and skaters took what is now a relatively rare opportunity to enjoy a national pastime.

A possible consequence of climate change, the Netherlands doesn't see the ice that it used to. The Royal Netherlands Meteorological Institute rates winters using an index: those scoring above 100 are considered cold. Between 1901 and 1980, there were seven winters above 200—very cold. The last time the index exceeded the magical 100 mark was in 1997. In fact, this was also the last time the weather was cold enough for the '*Elfstedentocht*': a 200 km skating race between 11 towns in the north of the country. In 2014, for the first time since measurements began, the index fell to zero.

While people enjoyed the ice below, this Sentinel-2 image, which is also featured on the Earth from Space video programme, allows us to view the beauty of this short-lived layer of ice from above.

http://www.esa.int/spaceinvideos/Videos/2018/03/Earth_from_Space_Netherlands_ice

The *koudegetal* (cold number), also referred to as the Hellmann number (H) after the German meteorologist Gustav Hellmann, is a measure of the cold during the five month interval between November 1 and the subsequent March 31. It is obtained by adding together all 24-hour average temperatures that are below freezing during this period, with omission of the minus sign. The coldest winter on record was 1947 (featured in the March Newsletter), which had a *koudegetal* of 348, closely followed by the severe winter of 1963 (337).

This is the complete scene imaged by Sentinel-2A on March 2, showing ice stretching from the Afsluitijk in the north through IJsselmeer and Merkermeer to the IJ near Amsterdam.
Image: Modified Copernicus data © ESA / Sentinel (2018)

Going for Atmospheric GOLD

NASA Earth Observatory

In late January 2018, NASA's *Global-scale Observations of the Limb and Disk* (GOLD) instrument was launched into space aboard a commercial satellite. GOLD is novel in two ways: it marks the first time that a NASA science mission is flying an instrument as a commercially hosted payload, and it is the first time scientists will monitor the daily and hourly weather of the uppermost parts of Earth's atmosphere where it meets the edge of space.

The instrument was launched on January 25 on an Ariane-5 rocket attached to SES-14, a communication satellite. On January 28, GOLD was briefly powered on to make sure it was working, then shut back down for the transit to orbit. The mission is being led by the University of Central Florida.

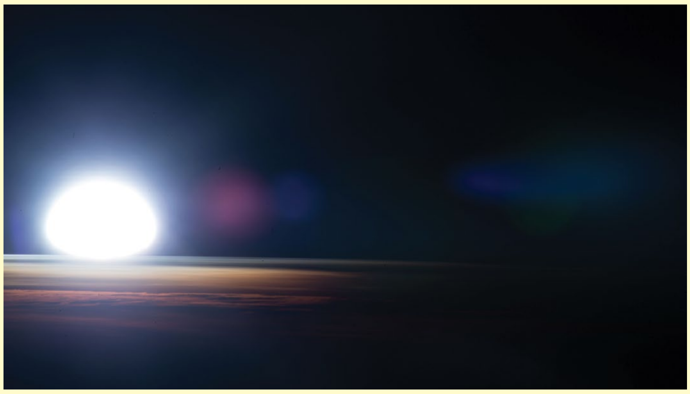
Space is teeming with fast-moving, charged particles and with electric and magnetic fields that guide their motion. At the boundary between Earth's atmosphere and space, the charged particles of the ionosphere coexist with the upper reaches of the neutral atmosphere, or thermosphere. The two commingle and influence one another constantly. This interplay is the focus of the GOLD mission.

"*The upper atmosphere is far more variable than previously imagined, but we don't understand the interactions between all the factors involved*," stated Richard Eastes, mission principal investigator at the University of Colorado. "*That's where GOLD comes in: For the first time, the mission gives us the big picture of how different drivers meet and influence each other.*"

Historically difficult to observe, this little understood region responds both to terrestrial weather in the lower atmosphere and the tumult of space weather above. It responds rapidly, too, undergoing dramatic change in as little as an hour.

Big events in the lower atmosphere, such as hurricanes and tsunamis, create waves that can travel all the way up to this interface to space, changing wind patterns and causing disruptions. From the space side, flurries of energised particles and solar storms carry electric and magnetic fields and have the potential to disrupt Earth's space environment. This combination of factors makes it difficult to predict changes in the ionosphere.

"*Space isn't just the home of astronauts and satellites; it affects our day-to-day lives*," said Sarah Jones, GOLD mission scientist at NASA's Goddard Space Flight Center. Low-Earth orbiting satellites and the International Space Station fly through the ionosphere. Communication signals, radio waves, and GPS signals also travel through this region. Sudden changes in the ionosphere can disrupt these space-based activities. GOLD seeks to understand what drives change in this critical region. The resulting data will improve forecasting models of the space weather events. This is the first mission that can provide observations fast enough to monitor in detail the hour-by-hour changes of space weather.



Astronaut photograph ISS054-E-5626 was acquired on December 25, 2017, with a Nikon D4 digital camera using a 600 millimeter lens, and is provided by the ISS Crew Earth Observations Facility and the Earth Science and Remote Sensing Unit, Johnson Space Center.

The GOLD satellite
Image: NASA

Roughly the size of a mini fridge, the 36 kg GOLD instrument is an imaging spectrograph that specifically measures far ultraviolet light, creating full-disk ultraviolet images of Earth from geostationary orbit above the Western Hemisphere. GOLD will collect observations with a 30-minute cadence, much higher than any mission that has come before it.

From these images, scientists can determine the temperature and relative amounts of different particles—such as atomic oxygen and molecular nitrogen—present in the neutral atmosphere, which is useful for determining how these neutral gases shape ionospheric conditions. These data will provide the first maps of the upper atmosphere's changing temperature and composition all over the Americas.

You can learn more about GOLD in this *YouTube* video
https://www.youtube.com/watch?v=BXiaN85Ck4M

Story by Lina Tran, NASA GSFC

GEO Outreach

Visit to the Kempton Amateur Radio and Computer Rally

Francis Bell

GEO has attended the Kempton Amateur Radio and Computer Rally for many years in the past with our display stand, demonstrations and verbal advice: this year was no exception for our April visit. The rally is always busy with members of the general public, some of whom know GEO but the majority learning about our hobby for the first time when visiting our stand with its displays.

In the past we have run live EUMETCast reception at this rally and it has always proved attractive to visitors. However, nowadays the reception requirement of a larger dish and very accurate alignment is too demanding for us to set everything up in the short time scale before the beginning of a rally. As an alternative, therefore, we show visitors the near equivalent by using recorded images, generally only about one day old. This is now our rally display policy for EUMETCast imagery. Our live demonstrations on the stand using a SDR dongle for local radio reception proved interesting to visitors.

All set up and raring to go! David Simmons (left) and Robert Coombes ready with our stand just a few moments before opening to the public.

David Simmons and Robert Coombes chatting with visitors to the GEO stand at the Kempton rally.

In addition to EUMETCast images we had available for display many other Earth images, some of them recorded via live home reception and others gathered from ESA, NOAA, NASA or other sources. In addition to viewing images we also carried on our stand GEO literature and interesting promotional materials from EUMETSAT plus their handouts, together with the potential sales of our SDR dongles.

Again this was a busy rally with visits from Amateur Radio friends and some GEO members visiting the stand again plus interest from many members of the general public.

My thank to David Simmons G1MAL and Robert Coombes for their help in running the GEO stand.

Visit GEO on Facebook

http://www.facebook.com/groupforearthobservation

Group for Earth Observation

and follow the dozens of links to NOAA, NASA, ESA, EUMETSAT and much more ...

Cloud Streets and Ice in the Barents Sea

NASA Earth Observatory

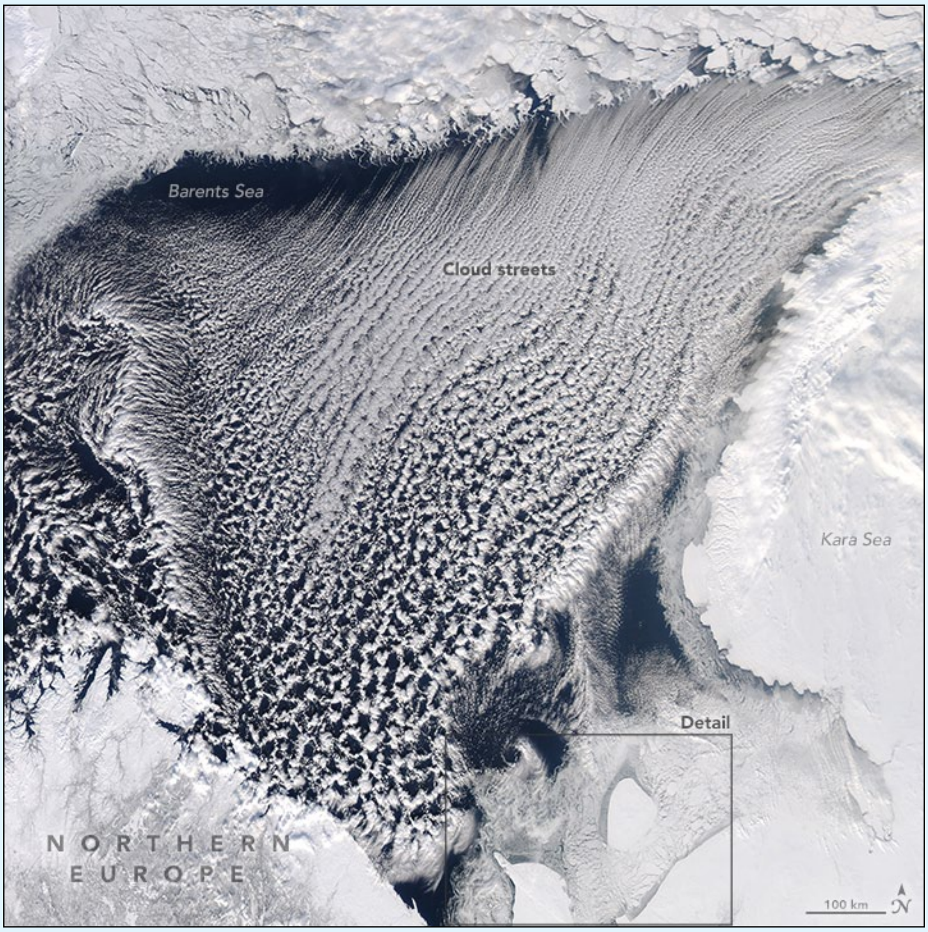
Sea ice in the Arctic Ocean grows each year throughout the autumn and winter and reaches its maximum extent some time between February and April. This year, sea ice peaked on March 17, 2018, at 14.48 million square kilometres, the second-lowest maximum on record. There was still enough ice, however, to cool the air and help produce cloud streets—long, parallel bands of cumulus clouds that commonly form this time of year when cold air blows over warmer water.

On March 15, 2018, two days before sea ice reached its maximum extent, the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's ***Aqua*** satellite acquired this image of cloud streets over the Barents Sea. According to the *National Snow and Ice Data Center*, this region had a late spurt of sea ice growth. When this image was acquired, cool air was blowing southward across the sea ice and over the comparatively warmer open water off northern Europe.

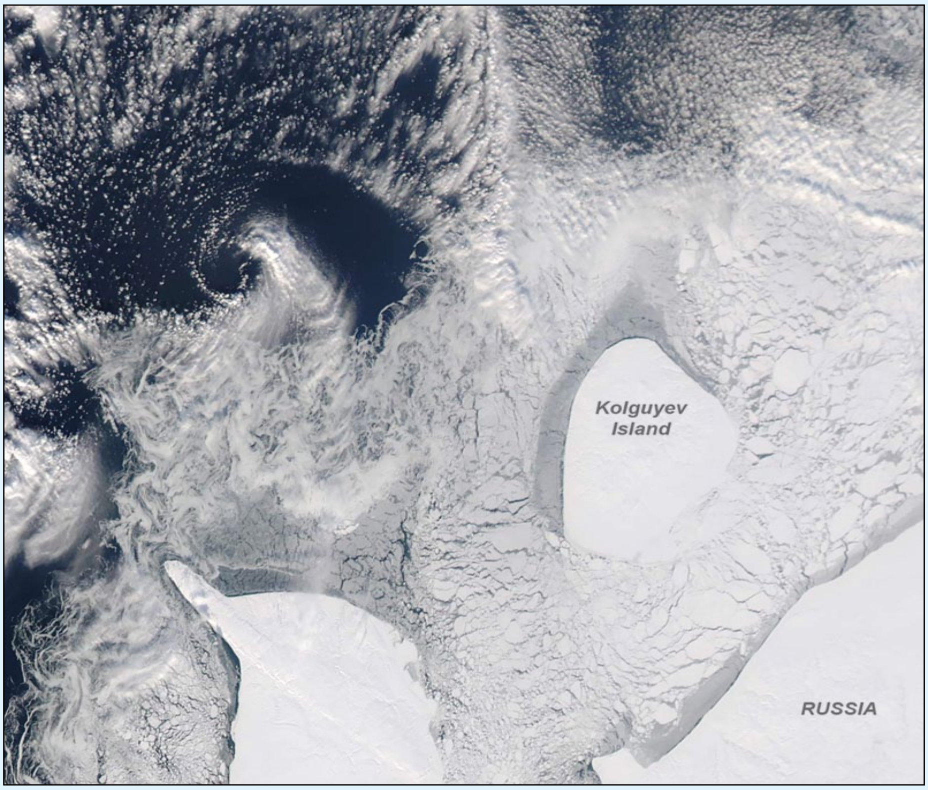
Ultimately, cloud streets are the visible result of nature trying to balance differences in energy. Columns of warmed air called thermals rise through the atmosphere, moving heat away from the sea surface. The air masses rise until they hit a warmer air layer (temperature inversion) which acts like a 'lid', causing the rising thermals to roll over and loop back on themselves forming parallel cylinders of rotating air. On the upper side of these cylinders (rising air), clouds form. Along the downward side (descending air), the skies are clear.

Notice, too, the variation in sea ice across the Barents and Kara seas. In contrast to the Barents, ice in the Kara Sea (east of the Novaya Zemlya archipelago) is still solid. The second image shows a detailed view of sea ice near Russia. Light gray areas that resemble shadows north of Kolguyev Island are likely to be due to sea ice that has been thinned by offshore winds.

Caption by Kathryn Hansen.

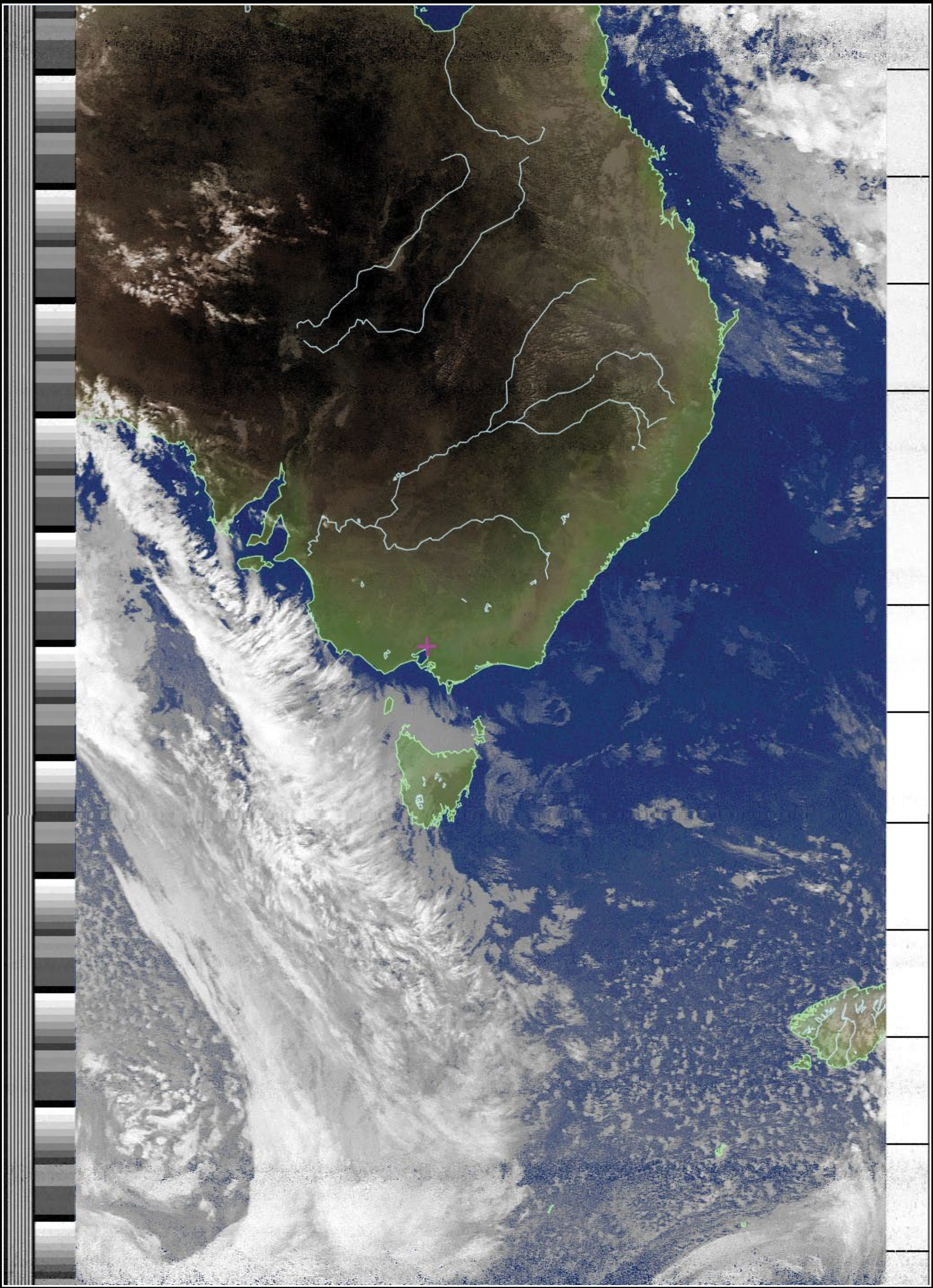


Cloud Streets over the Barents Sea



A close-up image of the Detail highlighted in the main image

NASA Earth Observatory images by Jeff Schmaltz, using MODIS data from LANCE/EOSDIS Rapid Response.



Ken Morgan sent in this splendid APT image of Australia, acquired on March 31, 2018 using a tall narrow QFH antenna, a *Timestep* Proscan receiver and the *WxtoImg* program. Ken asks us to note the two rivers that seem to end nowhere. I fact they empty into Lake Eyre, currently a dry salt lake, but which occasionally fills with water when rains feed these rivers. It was on Lake Eyre that Donald Campbell created a land speed record of 403 mph in his car '*Bluebird*' on July 17, 1964.

Shipping Responds to Arctic Ice Decline

NASA Earth Observatory

In late March 2018, scientists from the *National Snow and Ice Data Center* (NSIDC) and NASA reported that Arctic sea ice had reached its annual maximum extent. Once again, the ice cover was well below average. The four smallest maxima throughout the satellite record have all occurred in the past four years, continuing a decades-long trend of shrinking ice in the Arctic Ocean and surrounding waterways.

The annual maximum and minimum ice extents for the Arctic region have become steadily smaller over the past 40 years, and the percentage of thick, multi-year ice has been shrinking considerably. This thinning and retreating ice has opened the Arctic Ocean to new opportunities, but also serious environmental concerns. Shipping traffic fits into both categories.

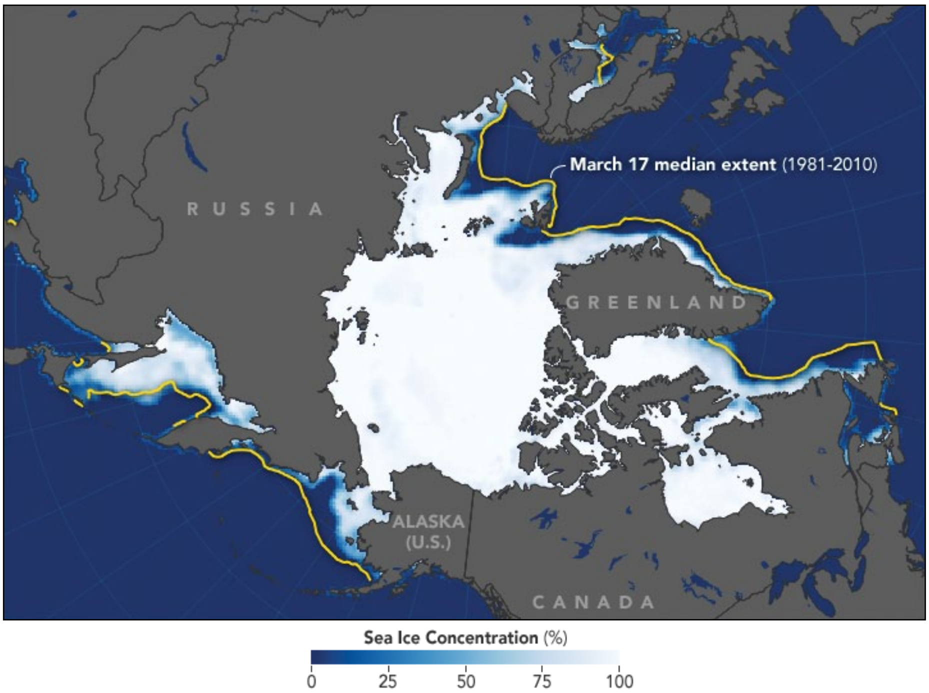


Figure 1 - Average concentration of Arctic sea ice on March 17, 2018

Figure 1 shows the average concentration of Arctic sea ice on March 17, 2018, when it reached its annual maximum. All white-shaded areas had an ice concentration of at least 15 percent (the minimum at which satellites give a reliable measurement), and span a total area that scientists refer to as the 'ice extent.' Ice cover peaked at 14.48 million km^2, the second lowest maximum on record and 1.16 million km^2 below the 1981 to 2010 average. The animated line plot (figure 2) shows Arctic sea ice extent for every March since 1979.

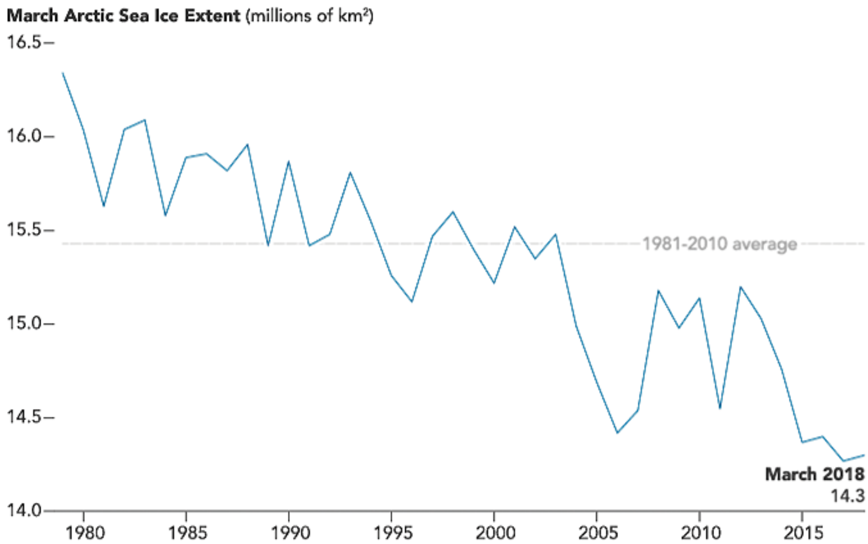


Figure 2 - Annual trend of March sea ice in the Arctic

The effects of declining sea ice have rippled throughout the Arctic region and the world. Plants, animals, plankton and people are being forced to adapt to warmer summers and winters, and to more open water. Atmospheric and ocean-circulation patterns are also changing, moving the jet streams and stirring up unusual weather in the high- and mid-latitudes.

The disappearing ice is also changing the shipping industry. In August 2017, a newly designed tanker with a hardened hull became the first merchant ship to sail across the Arctic Ocean without the aid of an icebreaker. The *Christophe de Margerie* travelled from Norway to South Korea in nineteen days, nearly a week faster than the traditional trip via the Mediterranean Sea and the Suez Canal.

It took just six months to top that feat. In February 2018, a tanker carrying liquid natural gas (the *Eduard Toll*) cruised through mid-winter ice cover from South Korea to Sabetta terminal (northern Russia) to France.

The map in figure 3 (page 13) shows unique ship visits to Arctic waters between September 1, 2009, and December 31, 2016. The map was created through a collaboration led by Paul Arthur Berkman, director of the science diplomacy centre at *Tufts University*, and Greg Fiske, a geospatial analyst at the *Woods Hole Research Center*. The team mapped

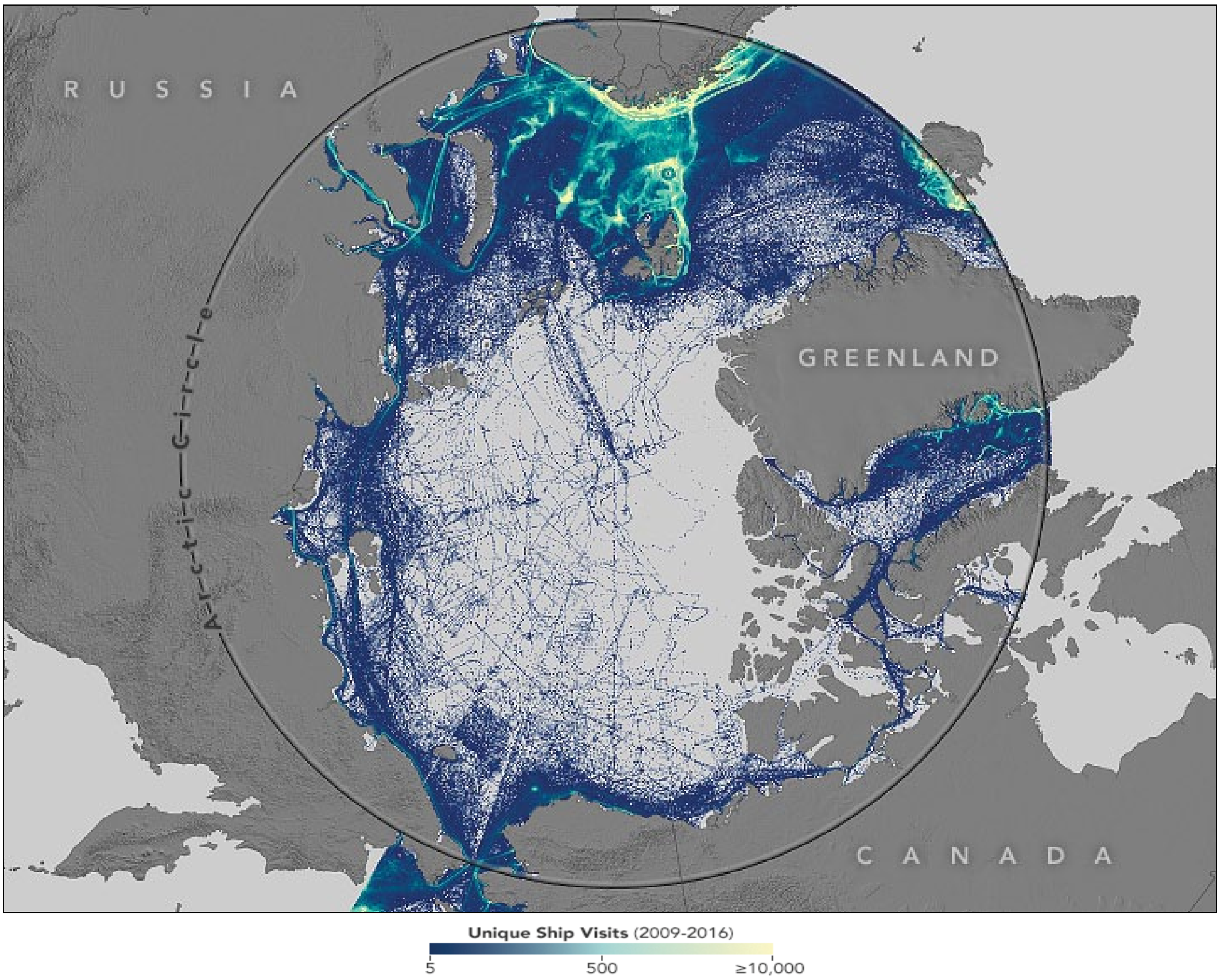


Figure 3 - Plot of unique ship visits to Arctic waters between September 1, 2009, and December 31, 2016

and analysed more than 120 million data points compiled by *SpaceQuest*, a company that designs microsatellites that can monitor the track *Automatic Identification System* (AIS) signals from ships.

Berkman, Fiske, and colleagues have found that the mean centre of shipping activity moved 300 kilometres north and east—closer to the North Pole—over the 7-year span. They were particularly surprised to find more small ships, such as fishing boats, penetrating farther into Arctic waters. The team also plotted the AIS ship tracks against sea ice data from NSIDC and found that ships are encountering ice more often and doing so farther north each year.

Russia, China, Canada, the United States, and Iceland are leading a body of nations preparing for more shipping activity in the Arctic. The Northwest Passage through Canada and the Northern Sea Route, or Northeast Passage, north of Russia and Siberia are both valued because they could significantly shorten ship transit times between Asia, Europe, and North America. But scientists and environmental advocates have serious concerns about pollution, oil spills, and disturbances to marine life, among other possible impacts. Then there is the danger to the lives of sailors plying icy waters with poor navigation charts.

Berkman is the coordinator and lead investigator of *Pan-Arctic Options*, an interdisciplinary, international effort to *'synthesize natural and social science research, leverage future scenario planning activities, and create geospatial maps, building common interests with practical governance options (without advocacy) that will promote sustainable development of the Arctic.'*

The group of researchers and policy specialists provides objective information that can guide the placement of infrastructure and the management of activities such as search and rescue and pollution response.

Whether open Arctic water is a boon for shipping, it remains bad news for the Arctic environment as we have known it. '*Arctic sea ice cover continues to be in a decreasing trend, and this is connected to the ongoing warming of the Arctic*,' said Claire Parkinson, a climate scientist at NASA's Goddard Space Flight Center. '*It's a two-way street: the warming means less ice is going to form, and more ice is going to melt. But also, because there is less ice, less of the Sun's radiation is reflected off of Earth, and this contributes to the warming*.'

Acknowledgements

- NASA Earth Observatory images (sea ice concentration and extent) by Joshua Stevens, using data from the National Snow and Ice Data Center.
- Ship traffic map provided by Greg Fiske, Woods Hole Research Center.
- Funding for the ship traffic analyses is provided by the National Science Foundation (NSF-OPP 1263819 and NSF-ICER 1660449).
- Story by Mike Carlowicz.

Space Storm Hunter installed on ISS

European Space Agency

the ASIM mounted on the European space laboratory Columbus
Copyright ESA–D. Ducros

On April 13 this year, the **Atmosphere-Space Interactions Monitor**, also known as the *Space Storm Hunter*, was installed on the outside the European space laboratory Columbus. Operators in Canada commanded the International Space Station's 16 metre long robotic arm to move the 314 kg facility from a *Dragon* spacecraft's cargo hold to its place of operation on the Columbus module.

Pointing straight down towards Earth, the Storm Hunter will observe lightning and powerful electrical bursts in the atmosphere that occur above thunderstorms, the so-called transient luminous events. The inner workings of these magnificent forces of nature are still unknown. The International Space Station offers a great vantage point to gather information about such events as it circles 400 kilometres above Earth and covers the areas where most thunderstorms appear.

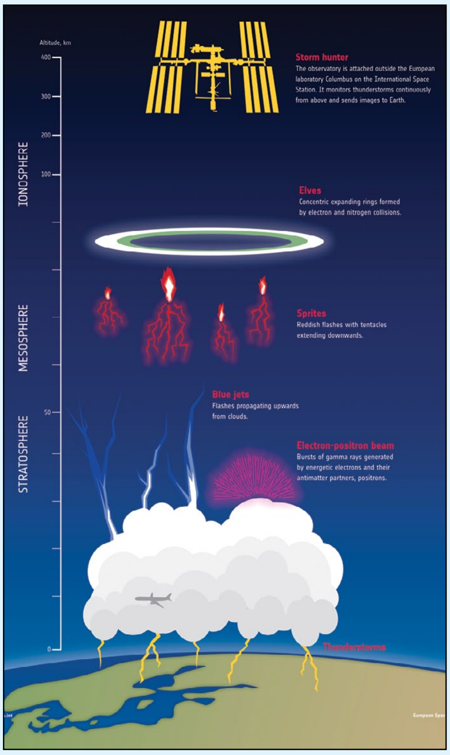
The first part to getting data is checking the communication channels. The Storm Hunter will send data over the International Space Station network beamed via communication satellites to a ground station in White Sands, USA; then on to the Space Station mission control in Houston; under the Atlantic ocean to the Columbus Control Centre near Munich, Germany; and finally to the Belgian user operations and support centre in Brussels.

The observatory carries two suites of instruments to capture optical images in infrared and ultraviolet, and x-ray and gamma-ray detectors. Sensors will measure light levels to determine if an image should be taken and the data sent back to Earth.

Setting the levels will be a matter of trial and error: setting the trigger too low will flood the network with images that are of no use; too high and some thunderstorms will not be recorded. The operators will collaborate with scientists at the Technical Institute of Denmark who are eagerly awaiting readings from the observatory, in order to find the best solution. Visual cameras will pinpoint areas of interest while photomultiplier tubes record the details of the lightning and transient luminous events. Other sensors are included to learn more about terrestrial gamma-ray flashes, and for high and low energy x-ray and gamma-ray bursts.

Each element of the Storm Hunter will be activated in turn, and tested to ensure it is working as expected. This is expected to take up to six weeks, during which the user control centre will be run continuously.

Anuschka Helderweirt, operations engineer at the Belgian operations centre, stated: 'We are thrilled to start operating these instruments in space, this is what the hours spent training, developing procedures and preparing for anomalies was for. We are ready to deliver some fascinating new scientific data.'



Storm hunter infographics
© ESA

Experiences with Meteor MN2 & NOAA APT

David Sale

The Past

A long, long time ago (30 years ago) in a galaxy far, far away (Melbourne, Australia), I came across an electronics article describing receiving weather images directly from polar orbiting satellites, specifically the NOAA and Meteor series. I had been receiving Wefax HF signals and this seemed a natural progression. While I was able to hear the satellites, my scanner only had an inadequate 5 kHz bandwidth. A dedicated receiver then cost the equivalent of $AUD600 in today's prices, well outside a uni-student's budget. And then other interests took over.

Fast forward to now and the scene has changed dramatically: shared data, software & information via the Internet, the rise of software-defined-radio with a lower cost, greater flexibility, and typically improved performance compared with hardware-only receivers. It is much easier to adjust the bandpass filter width using a PC, mouse and software than having to physically construct a hardware filter for each frequency and bandwidth of interest. Similarly, for the different modulation methods (AM, FM, SSB, xPSK, etc).

So it is this context that I came across another article describing the use of low cost RTL based SDR for APT reception. The software was **GQRX** (for receiving) and **xwxtoimg** (for decoding to an image). There was a delay obtaining images until I discovered that decimation needs to be used with **gqrx** to give a usable signal (improves the signal-noise ratio), and **xwxtoimg** requires a 11025 Hz sampling rate (not the fixed 48 kHz as written by **gqrx**). **Sox**, **ffmpeg** or **audacity** could then be used to re-sample. Once the correction was made, the image magically appeared.

My first antenna was a discone. This was at a low height, linearly polarised and gave mediocre quality (poor signal strength, and deep fades at higher elevations), but did give the occasional useful image.

A Lindenblad antenna was constructed specifically for the VHF weather satellites. It is considered easy to construct and moderately tolerant of measurement 'inaccuracies'. It did give an improved signal but exhibited partial fading every 12 degrees or so of elevation.

Later, a QFH (quadrifilar helical) antenna was constructed using RG-6 coax, and this provided a more consistent coverage (figure 1). It soon replaced the Lindenblad.

Figure 1
The author's prototype QFH with 2 ferrite cores

At this stage, APT reception was reasonably good. The next step was to try the Meteor MN2 LRPT signal. The main differences from APT are that the signal is digital rather than analogue and uses a wider bandwidth of 120 kHz vs 30 kHz (more noise). The end result is that the signal quality is more critical.

My first attempts using the QFH, RTL SDR, **meteor_qpsk_rx_rtl.py**, and **LRITofflineDecoder.exe** (+ WINE for Linux) weren't successful. As a last resort, I used a hand-held 4 element 2-metre yagi beam antenna and manually tracked the satellite. This worked well. The satellite was broadcasting in the 123 spectral mode (visible and near-IR frequencies) which gave a visually appealing image.

It has subsequently proved possible to receive images using the QFH. However, the elevation needs to exceed 25 degrees to have any chance of decoding a meaningful image. The advantage of the QFH is unattended reception.

The Present

There are some ongoing issues with Meteor MN2 image reception. The first is the 6 minute reset which appears to be an issue with the onboard JPEG compression used for LRPT. This is unavoidable. Consequently, the failure of the Meteor MN2-1 launch on 30/11/17 was a huge disappointment as it was hoped that this issue would be corrected in the new satellite. Hopefully, the next satellite (MN2-2) will be successfully launched later this year.

A second issue is periodic interference from NOAA 18 on 137.9125 MHz when the satellites are in close proximity. This occurs for a couple of days every few weeks and prevents acquiring any image data using the QFH, although the directional yagi can usually receive a partial image.

There is also some localised 'burst-mode' data transmission that interferes with my signal reception. The frequency range extends from 137.85 to 137.95 MHz, and the origin is somewhere south of my location. It lasts around 0.25 second and repeats from every few seconds to every few minutes. It manifests itself as black lines in both APT and LRPT images. It can't be avoided but the effects are reduced by using the yagi (directional) and at higher elevations (stronger signal).

Interference can also be emitted from LCD monitors (turn the monitor off for a few seconds to see the difference in the waterfall display) and laptop switch mode power supplies (run the laptop on batteries to see the difference). Obviously, turning the monitor off will improve the signal but won't be suitable for attended monitoring.

Using a different monitor (if there is a spare) and a USB extension lead (to distance the SDR receiver away from the laptop) can help.

Signal strength is particularly important for the LRPT signal. Adjacent trees do attenuate the VHF to some degree. The QFH is around 5 metres above ground and has a clear line-of-sight for the most of the satellite path. The hand-held yagi doesn't, but the higher gain compensates as well as choosing the best position for the satellite track.

There are also occasional issues with the data stream decoded using **meteor_qpsk_rx_rtl.py**. This decodes the SDR signal directly to a digital bitstream. However, sometimes the program fails to generate valid data, even with a strong signal. Fortunately, the **meteor_qpsk_rx_rtl.py** program also records the raw data in a wave file. Using **LrptRx.exe** on the wave file may give usable data (note that **LrptRx.exe** requires wave files using 16 bit samples).

The **LRPTofflineDecoder** software is a great program as it displays the image and constellation diagram graphically. However, it runs slowly, and even slower using WINE (Windows emulation for Linux). The alternative **medet** program runs natively and considerably faster (10 minutes vs 30 minutes) but only provides a console status, and doesn't process the 'raw' data from the **LrptRx** program (only the .s files from **meteor_qpsk_rx_rtl.py**).

Software Summary and Sources

Gqrx	SDR GUI program used to record FM APT data to a 48kHz WAVE file **http://gqrx.dk**
xwxtoimg	Decodes and displays APT image data from an 11 kHz WAVE file **https://pkgs.org/download/xwxapt**
meteor_qpsk_rx_rtl.py	Captures the Meteor signals as an 8-bit raw (.wav) and bitstream (.s) files. Also shows the signal constellation and FFT graphs. **https://www.dropbox.com/s/8kc89wriludrrb8/meteor_qpsk_rx_rtl.zip**
medet	Command line program to convert the bitstream to an image (.bmp) file. **https://github.com/artlav/meteor_decoder**
LrptRx.exe	Converts 16 bit raw data to bitstream data (requires WINE for Linux) **https://www.dropbox.com/s/qq1fjyitpa3j14o/software.zip**
LRPTofflineDecoder.exe	Converts bitstream data to an image (requires WINE for Linux) **www.radioscanner.ru/files/download/file17709/lrptofflinedecoder_2014.09.22.0010.zip**
LrptImageProcessor.exe	Corrects the Earth's curvature in the image. Also provides a variety of images based upon the different spectral bands (requires WINE for Linux) **http://satsignal.eu/software/LRPT-processor.html**
Gpredict	Satellite tracking & prediction program **https://github.com/csete/gpredict**
sox ffmpeg audacity	Utility programs that convert sample rates and sample size

The Images

The following represent some of the more interesting images received over the last nine months.

Figures 4 and 5 make a comparison between NOAA 18

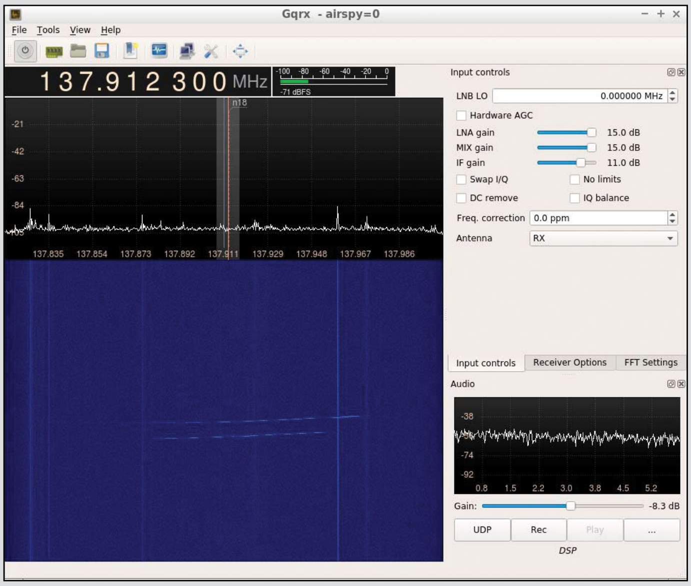


Figure 2 - GQRX showing the burst-mode interfering signal

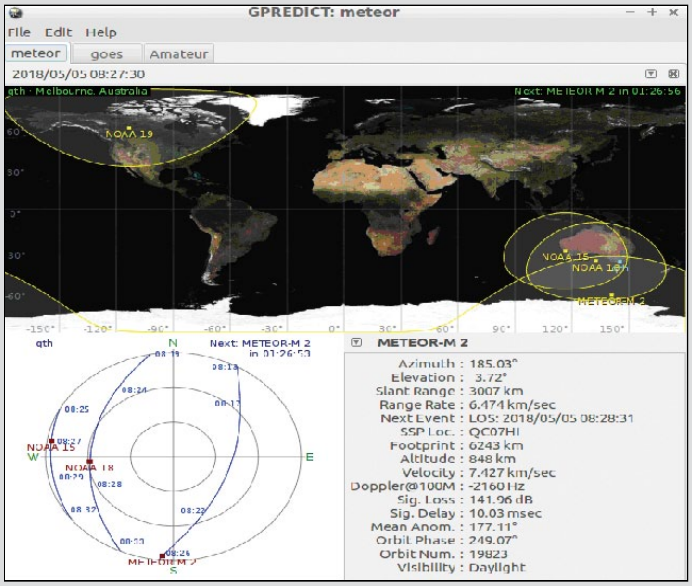


Figure 3

Screenshot of Gpredict with NOAA15, NOAA18 and Meteor MN2

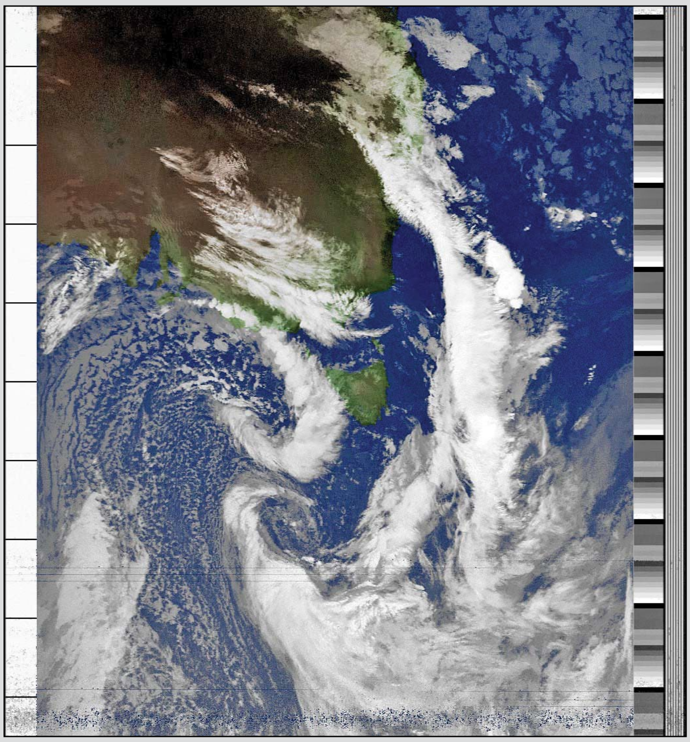


Figure 4 - A NOAA18 coloured IR image

(coloured IR) and a section of a Meteor MN2 image received one hour apart. They highlight the difference in resolution and viewing angle. In the lower quarter of the NOAA18 image are some fine black lines from the 'burst-mode' interference source. (The MN2 image was cropped to remove any dropouts.)

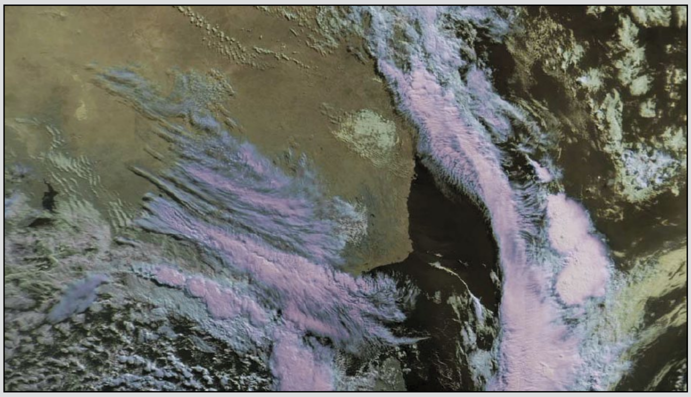


Figure 5
Section of Meteor MN2 LRPT 1 hour after NOAA18 image

Since the APT image is less sensitive to signal quality, the usable satellite pass duration is longer and the image covers a significant portion of Australia. The converse applies to the LRPT but the resolution is higher.

The second image (figure 6) is a section of the south-east coast of Australia, stretching from Melbourne to north of Sydney. Of interest is the band of clouds parallel with the eastern coastline. This seems to be due to the drier land breeze meeting the moist air over the sea. This turbulent interaction presumably increases condensation and hence cloud formation as the moist air is pushed upwards and cools.

Figure 6
Meteor MN2 LRPT image for south-east Australia

A second point of interest are the small snowfields in the south-east corner. Australia is a moderately warm continent and relatively flat—the highest peak is only 2200 m. This means that there are only a few snowfields suitable for skiing: the ski season only lasts a couple of months and, as a consequence, the cost of lift tickets and accommodation is high. It is still a popular activity for many Australians. The image illustrates the small snow covered area compared with the rest of Australia (for reference, Australia is twice the area of all of Europe, and 32 x the United Kingdom).

Figure 7 is a section between southern Victoria and Tasmania from a Meteor M N2 image. It shows what appear to be contrails from aircraft flying between Melbourne and Launceston or Hobart, both on the east coast of Tasmania. This is also a faint partial trail between Melbourne and Devonport (in the northwest corner of Tasmania).

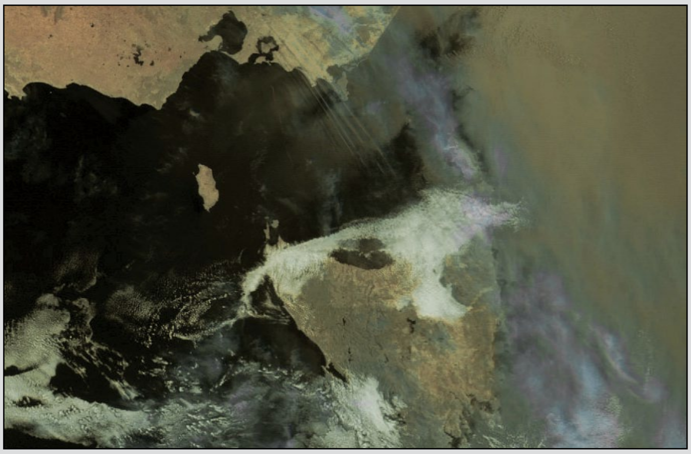


Figure 7
A Meteor MN2 LRPT image of Victoria
and Tasmania showing contrails

The distance between Melbourne and Launceston is a little over 500 km, around 40 minutes flying time. Therefore, there must have been negligible air movement in the upper atmosphere for the contrails to persist for this length of time.

Bushfires

Most of Australia experiences hot dry summers, and bushfires are a real danger. Part of risk mitigation is controlled burns. The idea is to burn sections of the forest using low intensity fires to remove the dead undergrowth during the cooler part of the year (typically autumn and spring). These sections can be up to several thousand hectares. Figure 8 shows two of the larger 'burn-offs' in the south-east corner of NSW and their smoke plumes over the Tasman Sea (the emulated '124' spectral bands give the best contrast). Figure 9 shows the fire incidents on the NSW rural fire service website around the same time as the satellite image (most are for 'hazard reduction').

The final image (figure 10) illustrates some of the Earth-observation data that can be obtained from the MN2 images. It is a false colour image that shows the dense forest areas in Victoria and Tasmania. Several lakes are evident with varying shades of blue (presumably due to temperature).

Also evident are 'green lines' towards the top of the image that are the Murray and Murrumbidgee river

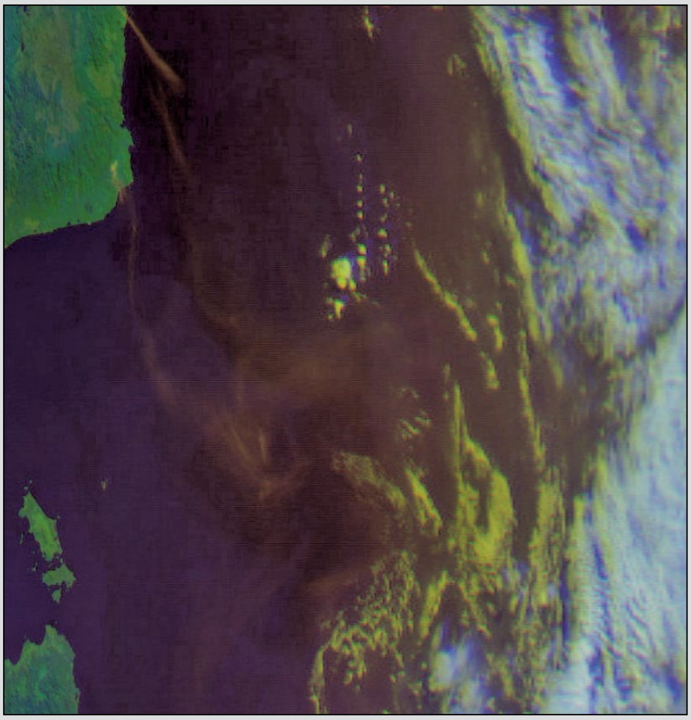


Figure 8
MN2 '124' image showing smoke plumes from 'burn-offs'

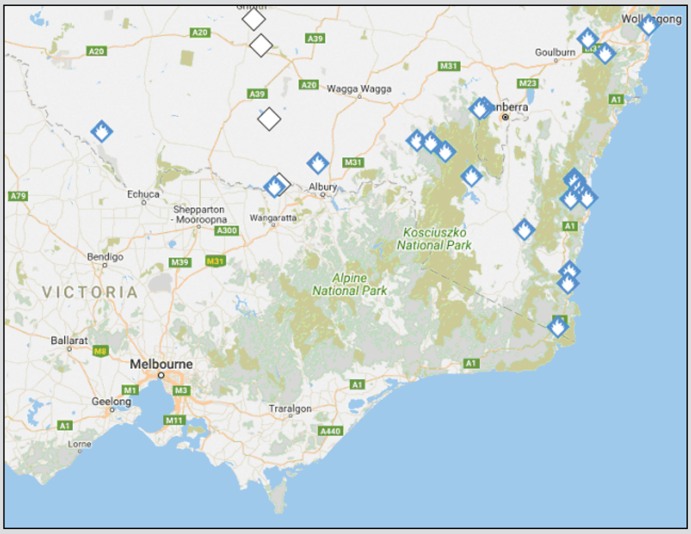


Figure 9
NSW fire services web site showing fires at the same time
(most are hazard reductions)

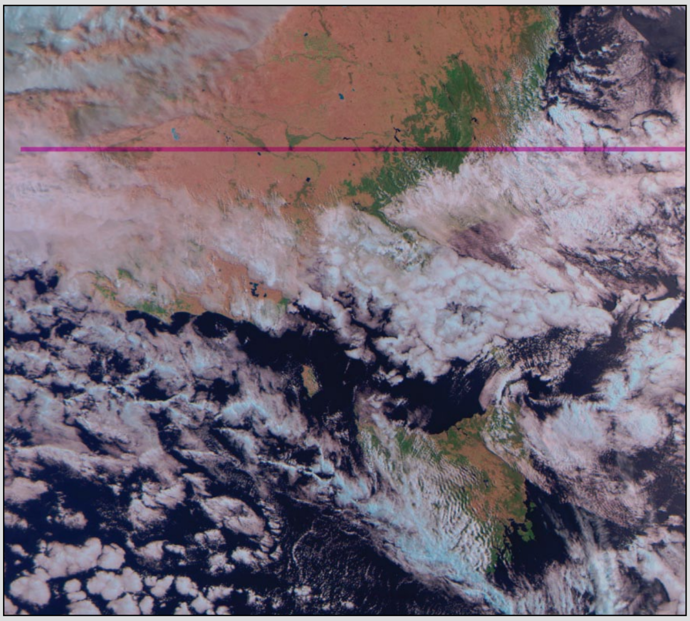


Figure 10
Meteor MN2 LRPT '123' spectral bands image
showing forests and river flood

systems. The Murray river is 2500 km long and drains the western side of the mountains heading west towards Adelaide. Much of this area is flat resulting in large flood plains when the rivers overflow.

The dominant eucalyptus species in the flood plains is the Red River Gum. It is tolerant to flooding and dry conditions once established, and can live over 500 years. However, it relies on the annual floods to germinate and grow. The construction of dams for irrigation has reduced most of the flooding and has negatively affected the tree population. 'Environmental' flows are now released to compensate.

The future

I'm planning a number of improvement ideas, but with no specific completion date.

- Use RSP1A: This should improve the signal quality. Unfortunately, the supplied software is still under extensive development and not very usable. The manufacturer does supply the API for the driver which permits writing an interface program for use with GQRX.
- VHF Antenna tracker: use automatic antenna tracking with a light weight yagi antenna. However, this won't correct the reset issue or NOAA 18 or the 'burst-mode' interference, and only there is only one suitable satellite. It's usefulness depends on the VHF transmission frequency and correcting the LRPT reset issue in the future MN2-2 (and MN2-3, etc) satellites.
- HRPT: this is the ultimate LEO solution as it avoids the JPEG buffer/LRPT reset issue, NOAA18 interference, and includes all spectral bands. There are multiple satellites available. However, it requires a high gain L-band (1.7 GHz) tracking antenna system. The high gain results in a narrow beam-width making manual tracking impractical. Some analysis has been conducted to determine a suitable antenna for a light-weight antenna rotator system. Unfortunately, the newer LEO satellites launch by USA and China don't use the L-band (they use the 8 GHz X-band instead).
- GEOS LRPT: There are several L-band LRPT geostationary satellites, and China is still periodically launching new satellites. The dish won't require tracking, and animations can be created as the viewpoint remains constant. The spatial resolution is the same as for APT but lower than for MN2 (4 km^2/pixel vs 1 km^2/pixel). This requires modifying a C-band dish.
- GEOS DVB-S2 (CMACAST & Himawari Cast) is another option using a C-band down converter, SDR and GNU radio. Initial testing hasn't been able to isolate the Himawari Cast transmission on the JCSat-2B satellite, so it remains a work-in-progress.

So there are many ideas to keep me busy. In the meantime, the process of receiving MN2 (and APT) continues to be a rewarding activity. Here's hoping for a successful MN2-2 deployment some time this year.

Twenty Years of NOAA 15 Reception

Francis Bell

Over a period of many years I have been recording images from the NOAA series of satellites, generally between about noon and late afternoon. The reason for this was domestic convenience, to satisfy my amateur interest without any special demands of weather forecasting or specific science projects.

Throughout this period I had noticed the overhead passes of NOAAs 15,18 and 19 coming progressively later in the day, almost taking them out of my rather gentle domestic observation time frame. I recently realised that a late afternoon satellite pass must be matched with an early morning pass. On checking the times I noticed that NOAA 15 was potentially overhead the UK at about 8.00 am BST. At this time of year, the south of England where I live enjoys pretty much full daylight at this hour, and as my favoured satellite images are recorded using visible light wavelengths it seemed to me to be worth trying for an early morning image. Figure 1 was my first result. On this occasion I used a turnstile antenna just propped up at ground level on my front lawn and a crystal controlled receiver which I had built myself about 18 years ago.

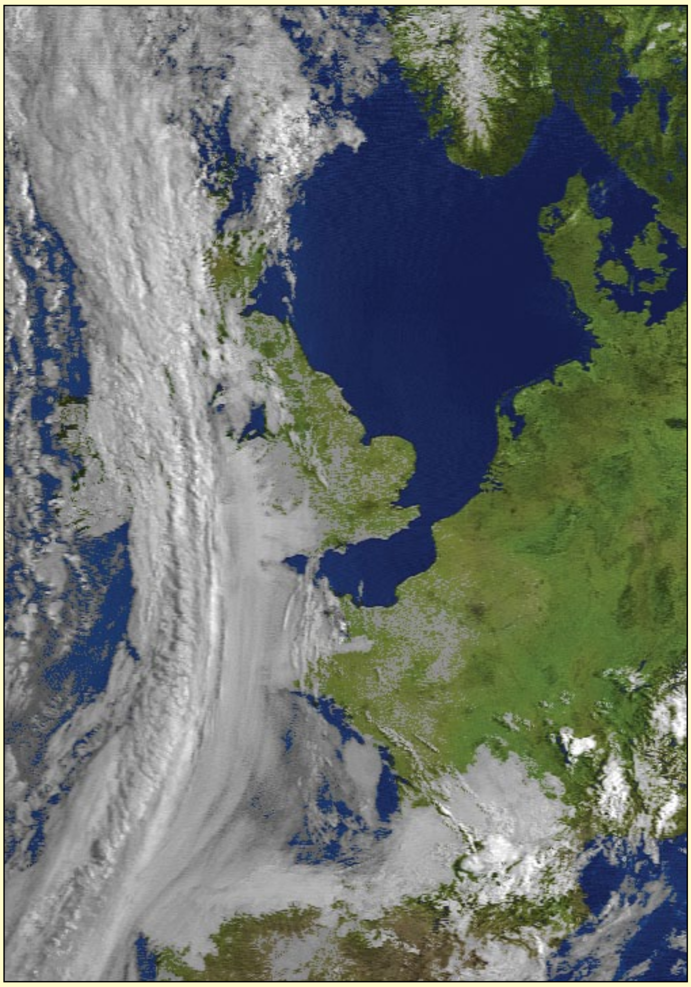


Figure 1 - This NOAA 15 image was recorded in the morning of May 7, 2018, the hottest May Bank Holiday day in the UK for at least 40 years.

In addition to my general interest in weather satellite reception there were two other reasons for me to try NOAA 15 at this time. I knew that my planned reception was within a few hours of the twentieth anniversary of NOAA 15's launch, so I thought that it would be great compliment to the satellite—as well as to the science and engineering behind its launch and operation—for me to receive and circulate a twentieth anniversary image from the satellite. Long my it continue its operation. Congratulations NOAA!

A second reason for wanting a weather satellite image of the UK and Europe was the UK weather forecast for the day in question. The forecast was for a hot day and it turned out to be the hottest May Bank Holiday Monday on record (about 40 years) for some parts of the UK, myself included, with a maximum temperature of 28 degrees C. To have a satellite image of the weather on this day was rewarding.

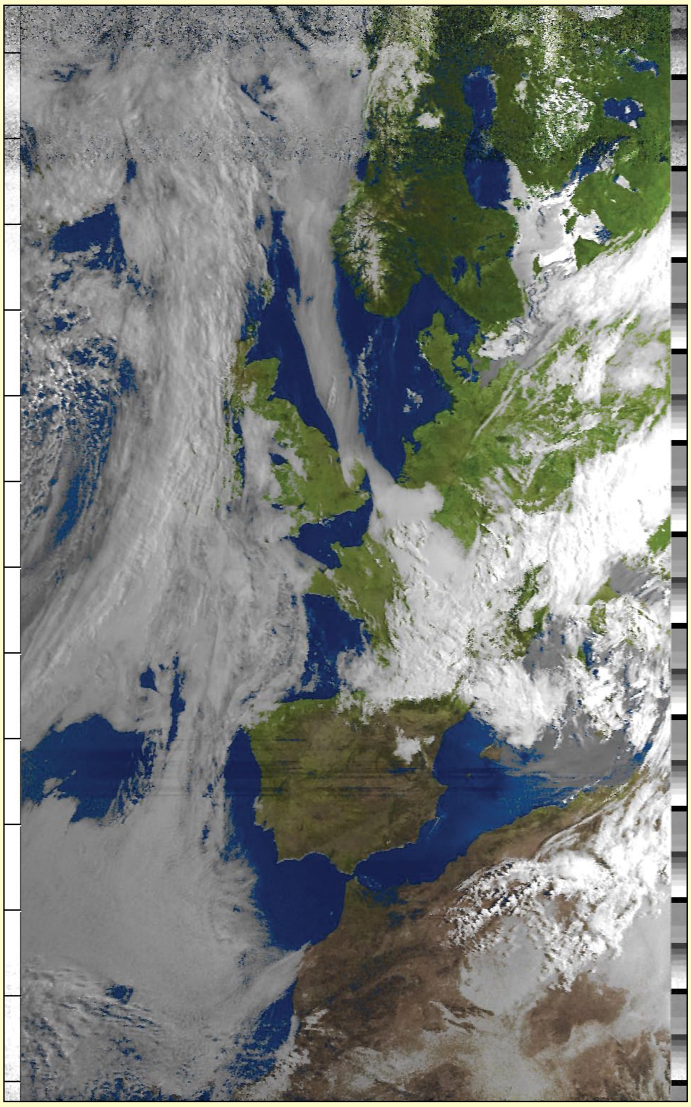


Figure 2 - This NOAA 15 pass was recorded at 07.13 UT on May 15. Not overhead illumination but OK considering the hour it was recorded.

Having recorded one image I thought I would put some effort into recording a longer pass using my elevated *Dartcom* turnstile antenna with a mast head preamplifier which has a clear view of the sky in most directions. Figure 2 is the result which I received some days later.

Further interest may be in the image recorded from the recently launched Sentinel-3B which was circulated by ESA recently.

Launched on April 25, 2018, the Sentinel-3B satellite has already delivered impressive first images from its ocean and land colour instrument, and now the radiometer carried on this latest Copernicus satellite has revealed its talents. Captured on May 9, 2018, figure 3 shows a low pressure system over the UK and Ireland, France, the Bay of Biscay, Spain and part of north Africa. Vegetation appears in red.

The Sentinel-3B satellite was launched from Russia to join its identical twin, Sentinel-3A, in orbit. This pairing of satellites increases coverage and data delivery for the European Union's Copernicus environment programme. Both Sentinel-3 satellites carry the same suite of instruments.

The Sea and Land Surface Temperature Radiometer (SLSTR) is particularly sophisticated, measuring energy radiating from Earth's surface in nine spectral bands, including visible and infrared. It also includes dedicated channels for measuring fires.

This early image came from its optical channels.

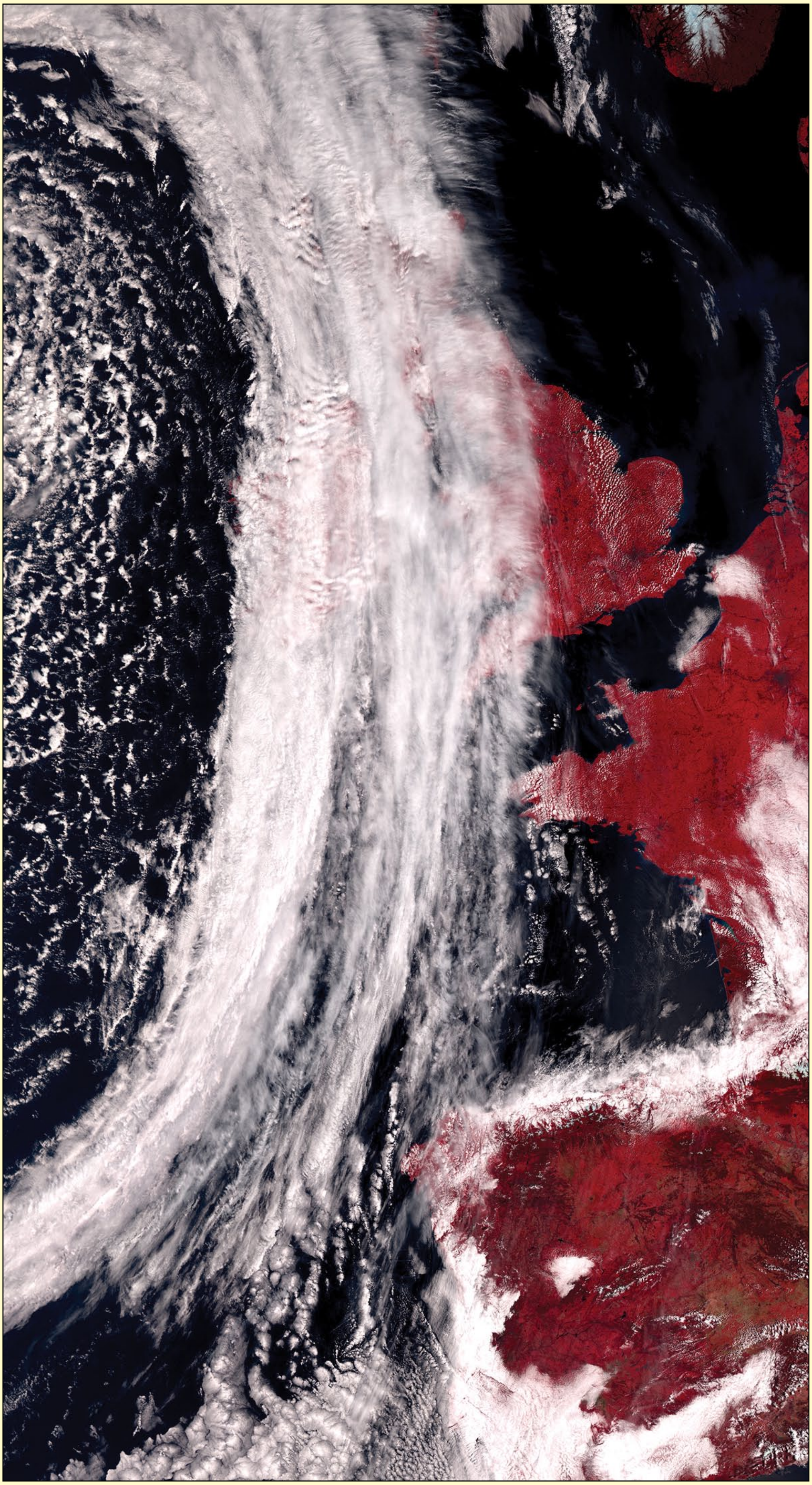
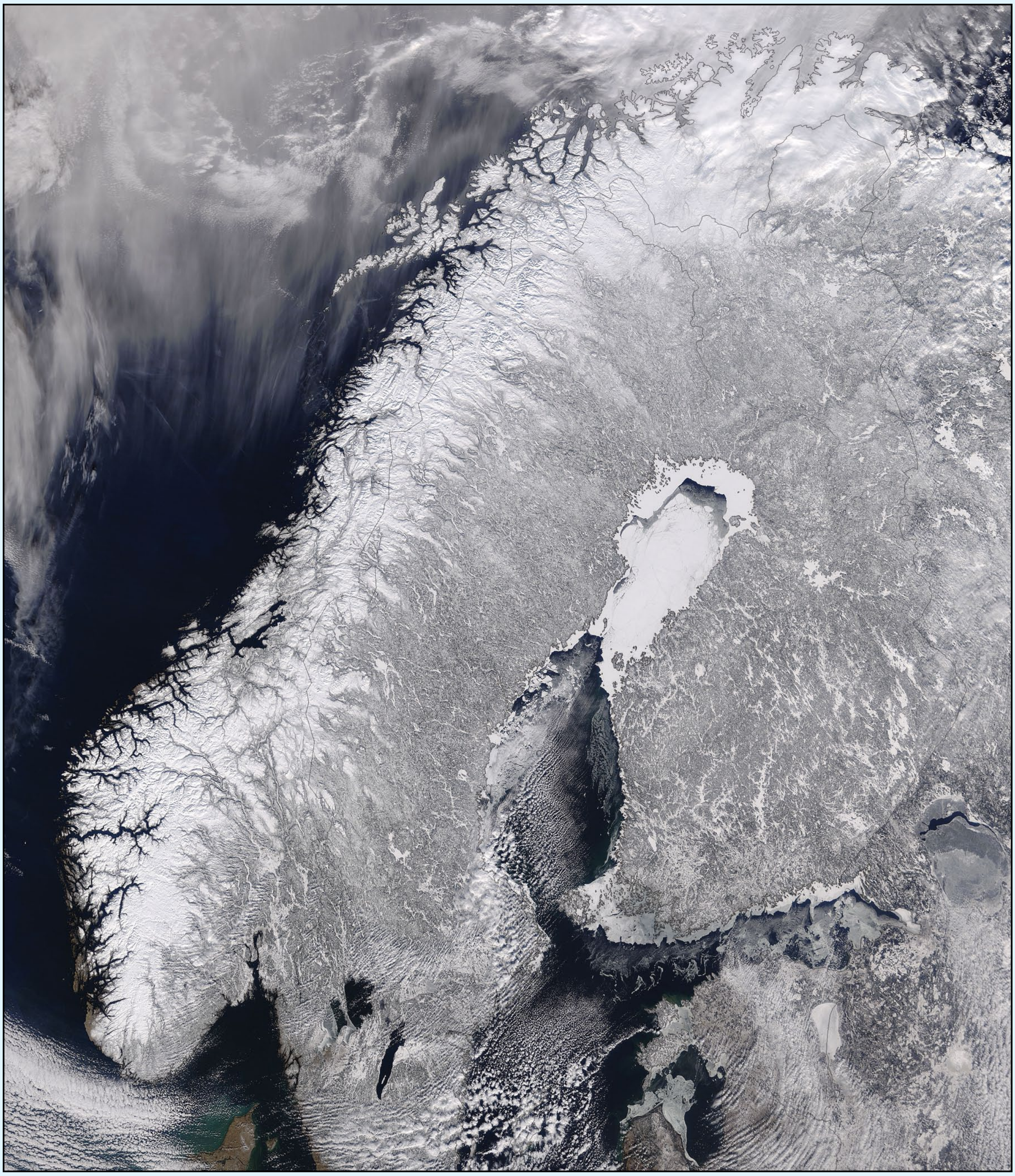


Figure 3 - This is a multi-channel image from Sentinel 3B taken 07.12 UTC 10 May 2018. This was one of the first images received from this new satellite and interestingly the area shown and the times are close to those for the NOAA 15 images shown in Figures 1 and 2.
Copyright contains modified Copernicus Sentinel data (2018), processed by EUMETSAT

Winter in Northern Scandinavia

MODIS Web



Northern Scandinavia, imaged by NASA's Terra satellite on March 16, 2018.
Image Credit: Jeff Schmaltz, MODIS Land Rapid Response Team, NASA GSFC

On March 16, 2018, the Moderate Resolution Imaging Spectroradiometer (MODIS) aboard NASA's ***Terra*** satellite acquired a true-colour image of a winter day across Northern Scandinavia.

The rugged landscape of the region, especially along the western edge of the peninsula, was carved by glaciers during the last ice age. The jagged inlets that characterise Norway's coast on the Norwegian Sea are known as fjords. Many of these fjords are steep and deep—some over 600 metres deep—and were created as thick glaciers slid slowly off the mountains and scoured troughs into the rocky landscape. Norway's longest and deepest fjord, Sognefjord, sits in the southwest coast, and is 1,308 metres deep.

Norway lies on the west of the Scandinavian Peninsula while Sweden sits in the east. The border between the two countries runs along the ridges of the Scandinavian Mountains. The Gulf of Bothnia, which lies between Sweden and Finland was covered with a layer of ice at the time this image was acquired.

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 members pictured beside one of the large dishes at Usingen, used for communication with EUMETSAT's satellites.
Photo: Francis Bell