



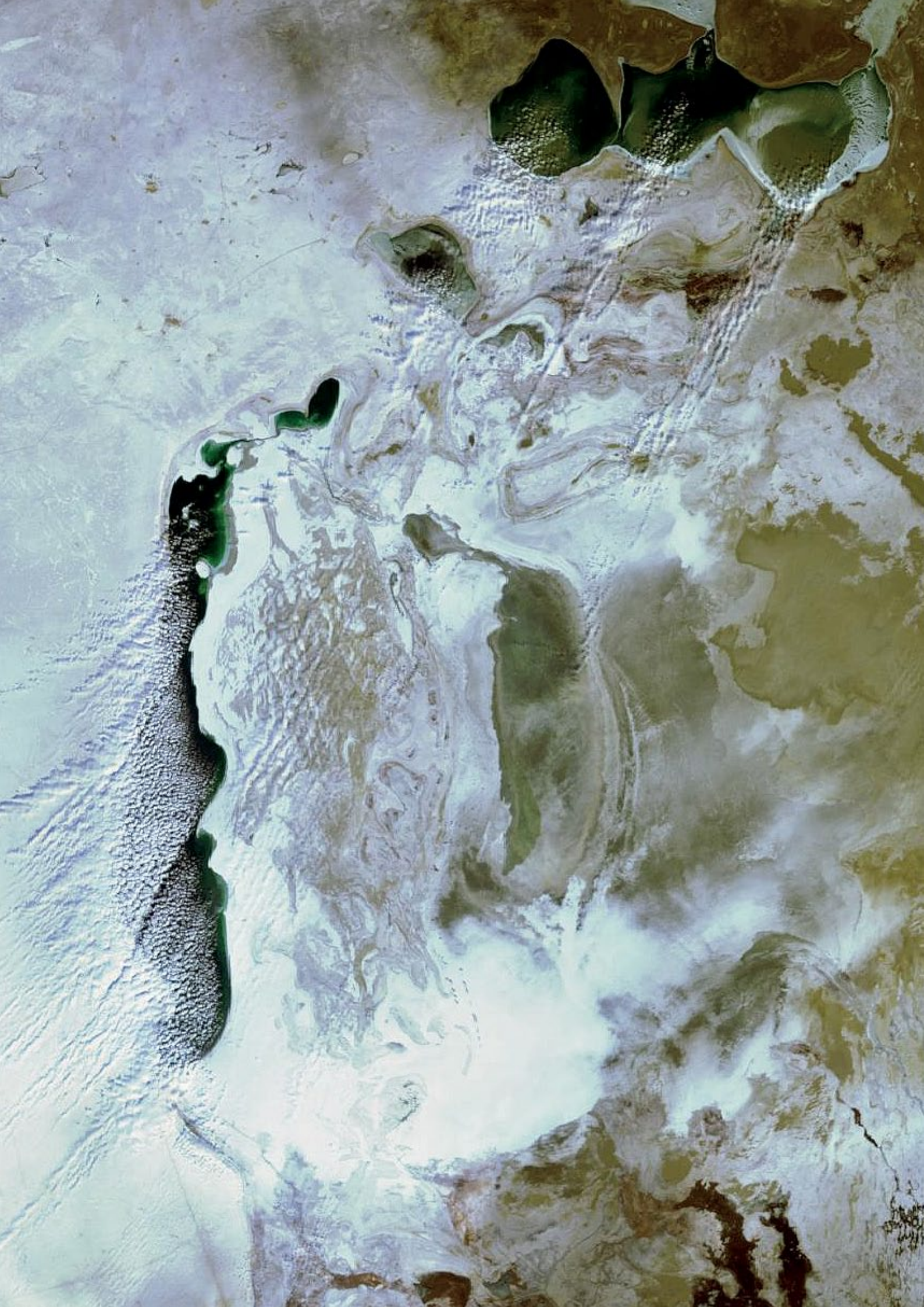
Inside this issue . .

This issue of GEOQ marks a major reappraisal of the satellite imagery currently available. With ESA's Copernicus mission now well established, both Sentinel 2A and Sentinel 3A satellites are now fully commissioned and providing amazing colour imagery of Earth. Our pages are replete with prime examples of the output of both satellites. The image at left, from Sentinel 2A, clearly picks out shipping in the Strait of Gibraltar.

Imagery from both these satellites is available via EUMETCast, and many of our readers are already enjoying this option. But don't despair if you are not a EUMETCast user: you can now to obtain the very same products from the Internet.

The emphasis this issue is on Sentinel 2A, with an article which describes how to obtain the data, and another which introduces you to new software from David Taylor which can process the files into colour images.

Other topics covered include NASA's Operation IceBridge, Mapping the speed of glaciers, Kerguelen island, Snow on the summits of Hawaii, and an eruption at Erta Ale in Ethiopia.



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Editorial

Les Hamilton

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This issue of *GEO Quarterly* could justifiably be described as a 'Sentinel Special' edition as our pages are replete with full-colour images from both Sentinel-2A and Sentinel-3A. Apart from the EUMETCast data streams, data from both the above satellites is now freely available from the internet.

To start you off, we concentrate on Sentinel-2A, which provides stunning images at a resolution of just ten metres per pixel. The front cover illustrates the detail available by revealing shipping in the Strait of Gibraltar. Such imagery is available from the *Land Viewer* website, described in our article on page 28.

Readers who enjoy creating coloured satellite images from scratch can download individual channel data for Sentinel-2A and combine them using new software from David Taylor. An extensive guide to this relatively simple procedure is to be found on page 31.

David Taylor has produced a 'starter' guide to *EUMETCastView*, software for viewing images disseminated via EUMETCast, including those from Sentinel-3A. At the end of last year I spread the word to quite a number of parties that I hoped someone would produce a guide for this rather complex program. Disappointingly, no-one obliged, and I am grateful to David Taylor—who has far better things to do—who stepped in at short notice to produce the article you can read on page 41.

**Copy deadline for the June issue of GEO
Quarterly is Sunday, May 28, 2017.**

Contents

GEO Report	Francis Bell	2
Cover Image Details		2
International Space Station Images	Francis Bell	3
Quarterly Question	Francis Bell	5
Panama Canal	David Taylor	7
Sentinel 3A Images UK and Netherlands	Gerard Boon	10
Operation Ice Bridge	NASA Earth Observatory	12
Ship Wave Cloud Formations	NASA Earth Observatory	15
Mapping the Speed of Ice in Earth's Glaciers	NASA Earth Observatory	16
ISS Images the Namib Sand Sea	NASA Earth Observatory	19
Kerguelen Island	Les Hamilton	21
Snow-Capped Summits in Hawaii	NASA Earth Observatory	24
Cloud Vortices off Cheju Do, South Korea	Modis-Web	25
Land Viewer	Les Hamilton	28
SentineltoJPEG Image Creation Software	Les Hamilton	31
Muted La Nina follows Potent El Nino	NASA Earth Observatory	40
EUMETCastView	David Taylor	41
French Storms	John Tellick	46
From Drought to Overflow	European Space Agency	49
Blue Jets	John Tellick	50
Snow and Ice above Katmai	NASA Earth Observatory	51
Sicilian Snow	John Tellick	52
Fission Eruptions on Erta Ale	NASA Earth Observatory	53
Satellite Status		55
GEO Helplines and Internet Discussion Groups		56
GEO Membership Application Form		57
GEO Shop Catalogue and Price List		58

The GEO Report



Francis Bell

I'm looking forward to the coming year, perusing my interests in Earth observation further, triggered by the availability of the high resolution satellite images from the new Sentinel satellites. As usual I'm lagging a little behind with the technology relating to the reception of these new images, but with the help and advice from our talented GEO members and the ever helpful EUMETSAT 'Ops' team, I hope to regularly receive for myself a selection of these ultra high resolution Earth images.

There are superb examples of these Sentinel images included elsewhere in this Quarterly, and a comparison can be made between the ground resolution of Sentinel images which are several orders of magnitude higher than the ISS's HDTV images which I have used in the Quarterly Question. However, this will not diminish my interest in the ISS and in receiving their HDTV from time to time.

Symposium 2017?

My report in the previous GEO Quarterly asked readers for suggestions relating to a venue for our GEO annual meeting. I have only received three responses, hence a decision is still pending on this topic and the issue about a possible annual meeting has yet to be resolved. I have been in touch with EUMETSAT and they are quite willing to send one of their senior staff to our meeting bringing us up to date with the latest image reception but, because of their current increased workload related to the Sentinel programme, they would prefer to send a representative to our meeting rather than hold the meeting at their HQ.

One interesting idea suggested by a member is to overlap our own meeting, or run it in parallel, with the RSGB's annual conference at Milton Keynes in October 2017. I am currently researching this suggestion.

Widening the Management Team

Likewise there was a poor response about widening the GEO Management Team (MT) membership to include an individual interested in promoting the educational interests in Earth observation, plus another to promote technical interests in the reception of satellite images. Our current MT believe that one or two addition people promoting these areas would be of great benefit to both current and potentially new members. The invitation for addition people to broaden our membership is ongoing—please respond if you can.

Membership Numbers

I will ask our membership secretary to give us a broad report about membership numbers for our next Quarterly publication, but in the meantime I think total membership is about 276 (as of November last year). Of course I would like to see this number double, not just for the sake of numbers but primarily to bring new interests and skills into our fast moving hobby of Earth observation.

Finances

I usually produce a financial report for our annual meeting but, because the time and place for a 2017 meeting is still

unresolved, I will produce a financial report for publication in our next Quarterly. In the meantime we are financially secure, mainly due to the reserves created by shop sales over the past years.

Future Events

30th April 2017

The West London Radio and Electronics Show is to be held at Kempton Park, West London on April 30, 2017. GEO have again booked a stand at this popular busy show and I hope to meet up with many GEO members there.

On June 14, GEO will be giving an evening presentation at the Farnborough Amateur Radio Club's meeting.

October 14-15 is the weekend of the RSGB's annual convention, which will be held at Kents Hill Park Conference Centre, Milton Keynes. Watch the RSGB web site for details of this event as they become available. GEO hopes, for the first time, to have a presence at this event with a stand, perhaps even contributing to the programme of presentations. However, these details still have to be arranged.

On November 5, GEO will again be attending the West London Radio and Electronics Show at Kempton with our stand.

Cover Image Details

Front Cover

The 10-metre resolving power of ESA's **Sentinel 2A** satellite is evident in this image of the Strait of Gibraltar, where shipping in the strait is clearly discernible. The image dates from September 24, 2016.

Modified Copernicus data © ESA / Sentinel (2016)

Inside Front Cover

This image showing striking detail of the Aral Sea and its environs is a vignette taken from a **Suomi-NPP** image acquired by Mike Stevens on November 24, 2016.

Image © EUMETSAT 2016

Inside Back Cover

Gerard Boon acquired this **Sentinel 2A** image of the Maasvlaakte harbour at the mouth of the Nieuwe Maas near Rotterdam on December 27, 2016. The resolution is quite staggering, this image section measuring approximately 12 kilometres from north to south.

Image © EUMETSAT 2016

Back Cover

Peter Kinghorn recently started receiving **Sentinel 3A** data via EUMETCast, and submitted this superb image of Kamchatka that he acquired on January 18, 2017. The snow-covered mountains stand out starkly under the oblique illumination.

Image © EUMETSAT 2017

International Space Station Images

Francis Bell

In the corner of my study I still have a 15 year old computer which, although not today's state of the art technology, still works perfectly well and has a high speed Internet connection. Occasionally, just out of curiosity, I turn on this computer which by default connects to the website transmitting the International Space Station's (ISS) High Definition Television (HDTV) images. The web site I usually use is

<http://www.ustream.tv/channel/iss-hdev-payload>

This site constantly transmits live images from the experimental HDTV cameras on the ISS. If you want to receive these camera images for yourself go to the above website or an attractive alternative, which is

https://www.nasa.gov/multimedia/nasatv/iss_ustream.html

This alternative site not only transmits Earth images but also occasionally sends images from inside the ISS and, if your lucky, some audio between the space station and ground control.

There are several HDTV cameras involved in these experimental transmissions and from time to time the position of the cameras can be changed. Currently there seems to a camera giving a forward view from the space station, another giving a rear view

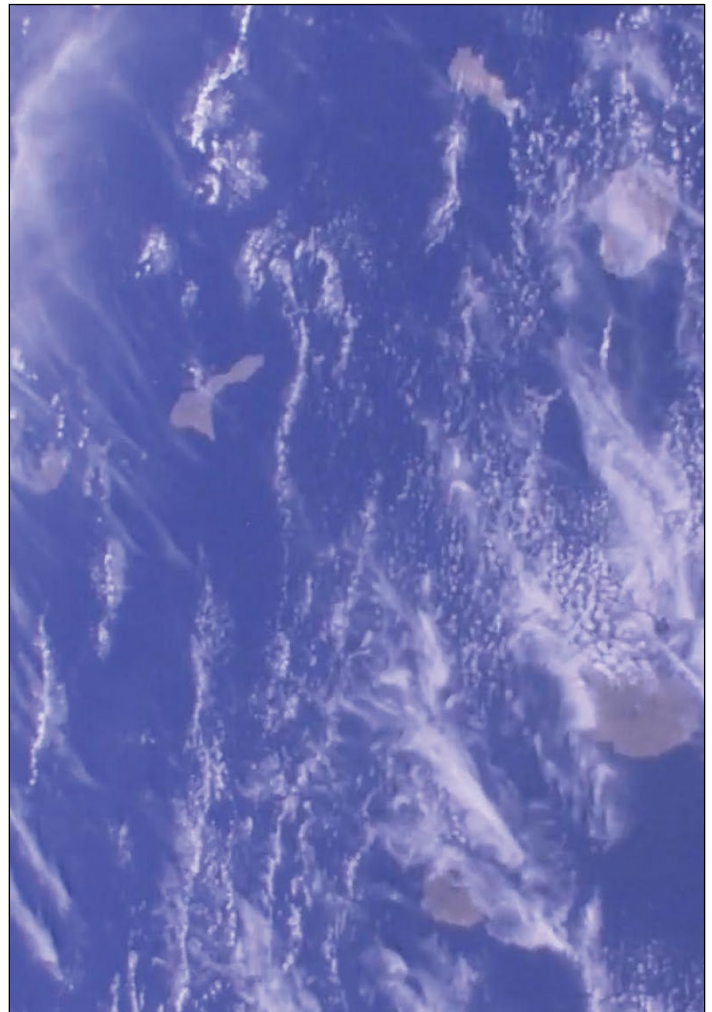
and one offering a vertical view directly below the space station. Although I like all the views offered by all the cameras I prefer the image from the vertical view camera because of the higher definition compared with the more distant views from the other cameras, which often involve the Earth's horizon and deep space.

When attempting to view these images it must be recognised that there is constant switching between the operational cameras, hence there is no guarantee that at any moment my favoured vertical camera will be in use. It also has to be recognised that half the ISS's orbit will be in darkness, and from time to time the transmissions stop because of communication links or other technical reasons. This means that I cannot predict whether the ISS is transmitting images which might interest me, so my option is reduced to turning on the system and viewing whatever it is offering me at that moment.

It so happened that, when I turned on my system one day in February 2017, I was greeted with images from the ISS's vertical viewing camera; so I quickly checked the location of the space station from its orbital prediction which showed it to be crossing eastern Brazil, then the central Atlantic and on to overfly the



This is a near north / south image of the **Canary Islands** with mainland Africa to the right. I picked this image partly for nostalgic reasons having visited four of the major islands in the group during several holidays over the past few years. Currently I'm particularly interested in the island of Lanzarote with its volcanic lunar like landscape, hence an invitation to anyone who has a high resolution image of this island please send it to me or our editor for potential publication in our next Quarterly.



This image shows the **Cape Verde Islands** just visible among traces of what looks like high level clouds. This island group is located in the Atlantic ocean about 200 miles off the coast of Senegal. A recent Sentinel 2A image of the main island, São Domingos, appears on page 19.

Strait of Gibraltar. This part of the orbit was in full daylight with only a little cloud present, so I recorded some of the pleasing images I received, three of which are shown below. To record the images I press the 'Print Screen' key on my keyboard and then paste the image in to the program 'Paint'. I also use the program 'IrfanView64' to view the images. If anyone knows a better way of recording and processing ISS images please let me know as I'm always on a learning curve in these matters.

[If you are using the *IrfanView* program, forget about *Paint*. Just paste your 'PrintScreen' image directly into *IrfanView* and save it - Ed]

Having been alerted to the vertical image views being transmitted by the space station, I continued to take an interest in the transmissions for the next two orbits and recorded some more images, two of which are the subject of the Quarterly Question.

Please remember that when viewing images from the ISS cameras that their orientation could be in any direction, and not particularly related to a defined compass direction. North is not necessarily at the top of an original image; however, subsequent processing can orientate the image to an almost conventional view, which I certainly prefer.

The scale of the images from the vertical viewing camera seems to be approximately 200 miles square.

The Outer Banks

The image to the right shows the Atlantic coast of the USA state of North Carolina. I think the area is called the Outer Banks for obvious reasons. I have flown over this area in a commercial aircraft and photographed some of the area. I was surprised how busy it was for an exposed coastal region with recreational harbours and marinas lining much of the outer coast. Just to the south and not quite appearing in the image is town of Wilmington the location for the Wright brothers first aircraft flight.



Quarterly ? Question

Francis Bell

Quarterly Question 52

The previous Quarterly Question asked for the identification of two major European cities from two satellite images, one from a camera on board the ISS, the other from the Earth observation satellite EnviSat. My thanks to those GEO members who responded to the question and gave me their answers.

All those who responded were correct and identified Lisbon, the capital city of Portugal and St. Petersburg, which was once the capital of Russia. I was reminded that St. Petersburg previously had other names: Petrograd (1914-24) and Leningrad (1924-91).

The image showing St Petersburg also showed much of the Gulf of Finland which is an inlet of the larger Baltic Sea. Also identifiable in this second image were Helsinki, the capital city of Finland, and Tallinn the capital of Estonia.

I know that one GEO member was initially confused by the different scales of the two images in spite of the scales being quoted; however, there will be no such issue with this quarter's question because, although again there are two images featured in the question, both are from the same camera on the ISS and hence have the same scale.

Quarterly Question 53

This Quarterly Question relates two images I captured live from an ISS HDTV camera. In each case the challenge is to identify the main body of water shown in each image. To help with the identification, the following background information might be useful. The scale of each image should be the same at about 200 miles (320 kilometres) across. The images appear on page 5.

Further help may be the fact that in figure 1, the tropic of Cancer (not shown) just touches the bottom of the image. Another clue here might be the fact that in spite of the



Figure 1 - Note that the two land masses to the left and right are joined beyond the image's range.

casual assumption that there are two land masses shown, in fact the land to the left and to the right are joined out of the image's range. There are some small islands shown in the image but the two main land masses are conjoined. I guess for some historical reason the name of the sea area and the name of the left part of the land mass seems to conflict with the name on the country to which they currently belong. It is often the case that my interest in an image of a particular area is reinforced if I have been there, in this case I spent two days in the region and still have the hat to prove it!

Figure 2 was also recorded from the ISS, this time while it was overflying North America's Great Lakes. I have to say it took me some time to identify exactly which lake was shown in the image because the image's orientation was a little unconventional and some of the lake's outline was masked by ice cover—the image was received in February 2017. To give you a further idea of scale, the image shows about half the area of the Great Lake in question. To make identification a little easier the original image has been rotated 90 degrees to show an approximately conventional north-south orientation.

Answers please, to

francis@geo-web.org.uk

before Sunday, May 28. All you need give is the name of the main body of water in each image but interesting additional background details would also be welcome.

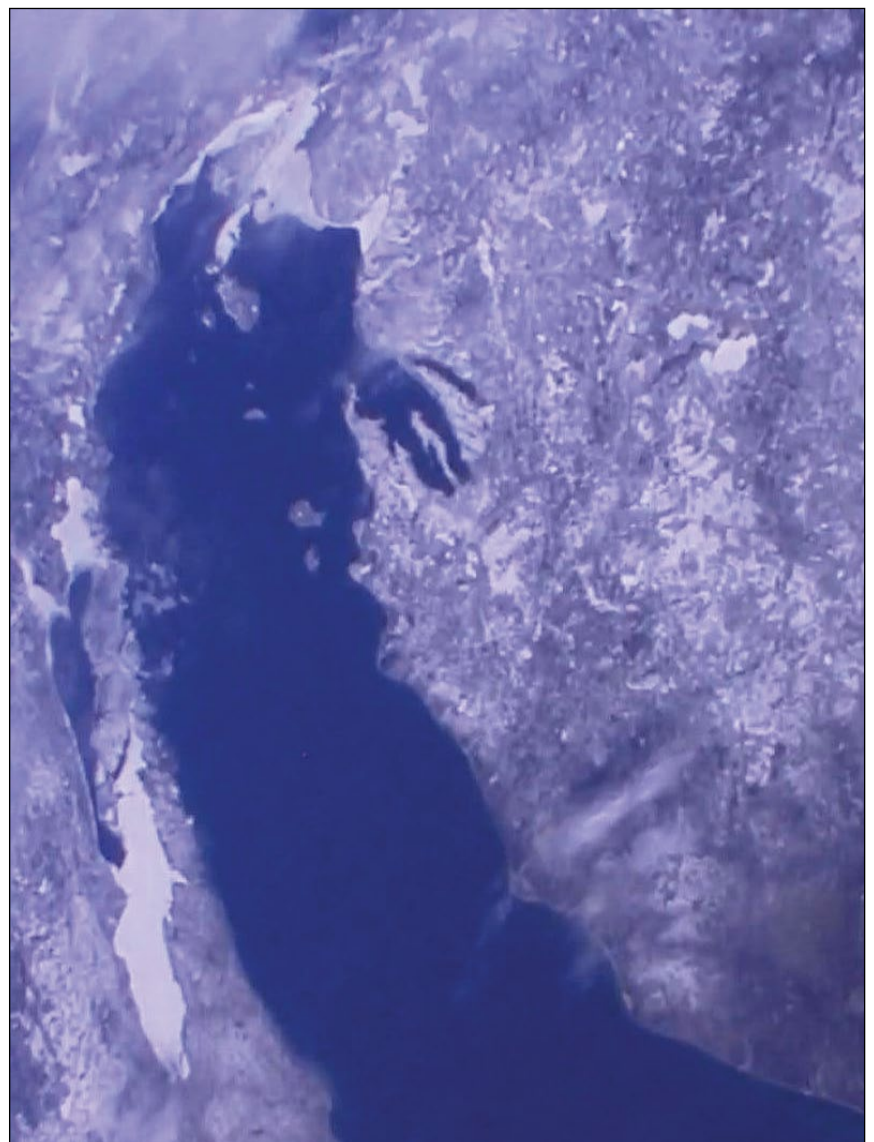
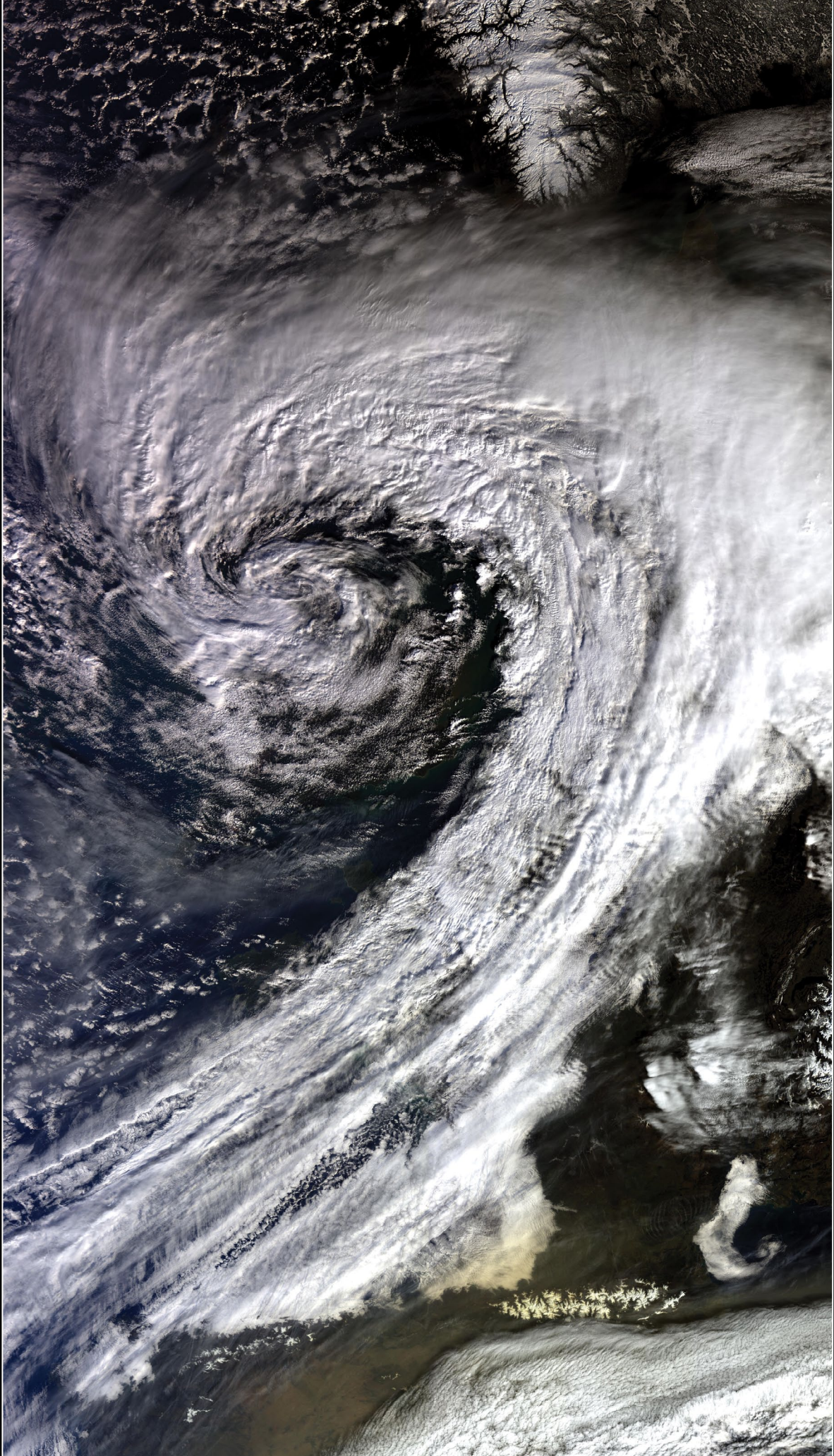


Figure 2 - This image has been rotated to yield an approximate N/S orientation.



This image of **Storm Doris** was acquired by the **Copernicus Sentinel-3** satellite between 10:21 and 10:27 UT on the morning of February 23, 2017 as the storm was at its height across the British Isles. England sits entirely within the 'eye' of the storm while Southern Norway (top) and the snow-clad Pyrenees (bottom) give scale to the scene.

Image: Modified Copernicus data © ESA / Sentinel (2017)

Panama Canal

David Taylor

Noting Francis Bell's request for images of specific targets in the December issue, I thought readers would be interested in these images of the Panama Canal, acquired by ESA's Sentinel-2A satellite last year.

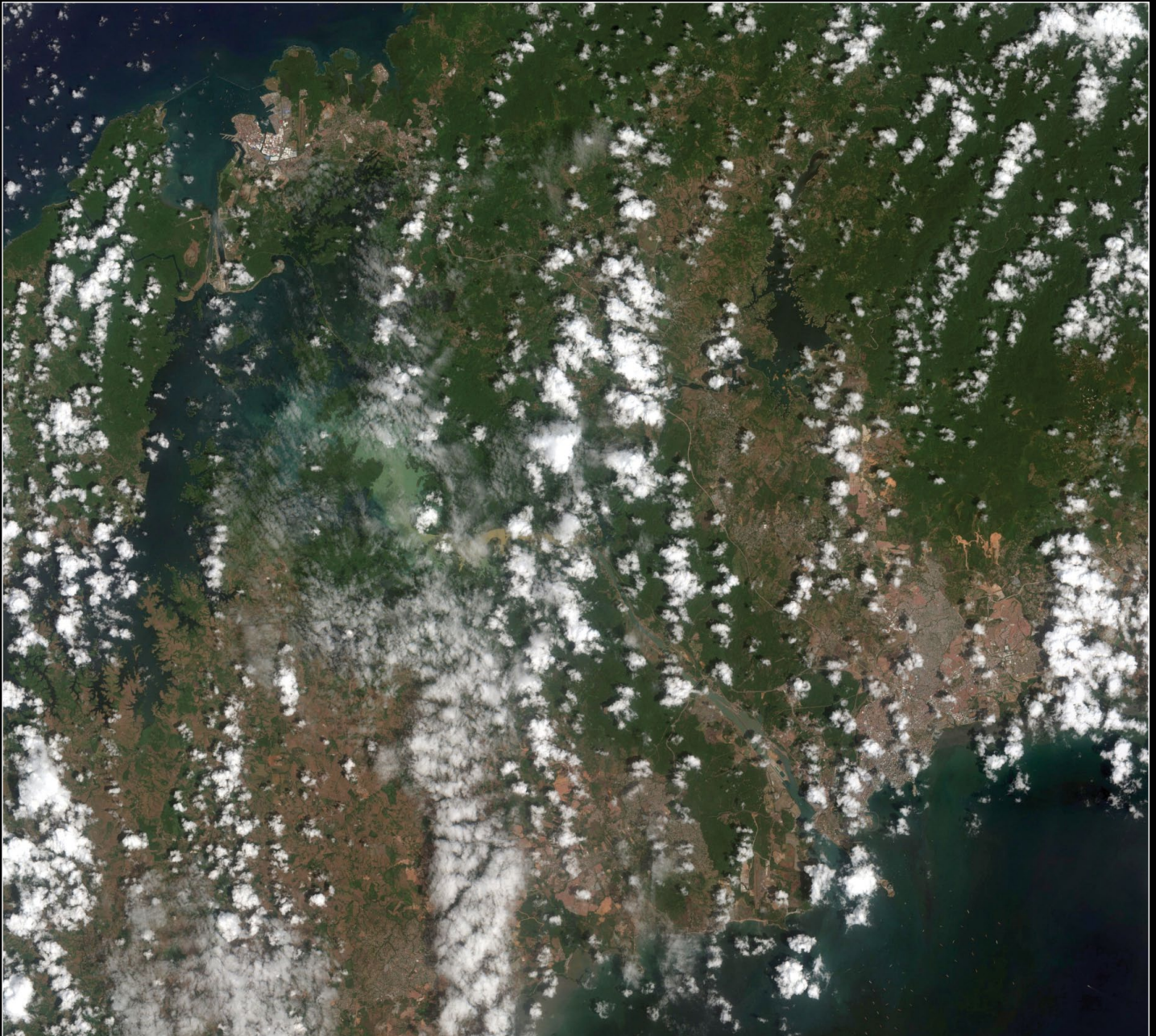
I had actually created these images before I saw that Francis had requested them, as my wife was taking a trip which included the Panama Canal and many of the interesting neighbouring locations. The images were first downloaded from the *Land Viewer* website of California-based company *EOS Data Analytics* at

<https://lv.eosda.com>

as three separate files corresponding the red, green and blue bands on the OLCI sensor on the Copernicus

Sentinel 2A satellite. These were then combined in my Sentinel2toJPEG program to produce a full-colour JPEG image as described by Les Hamilton elsewhere in this issue.

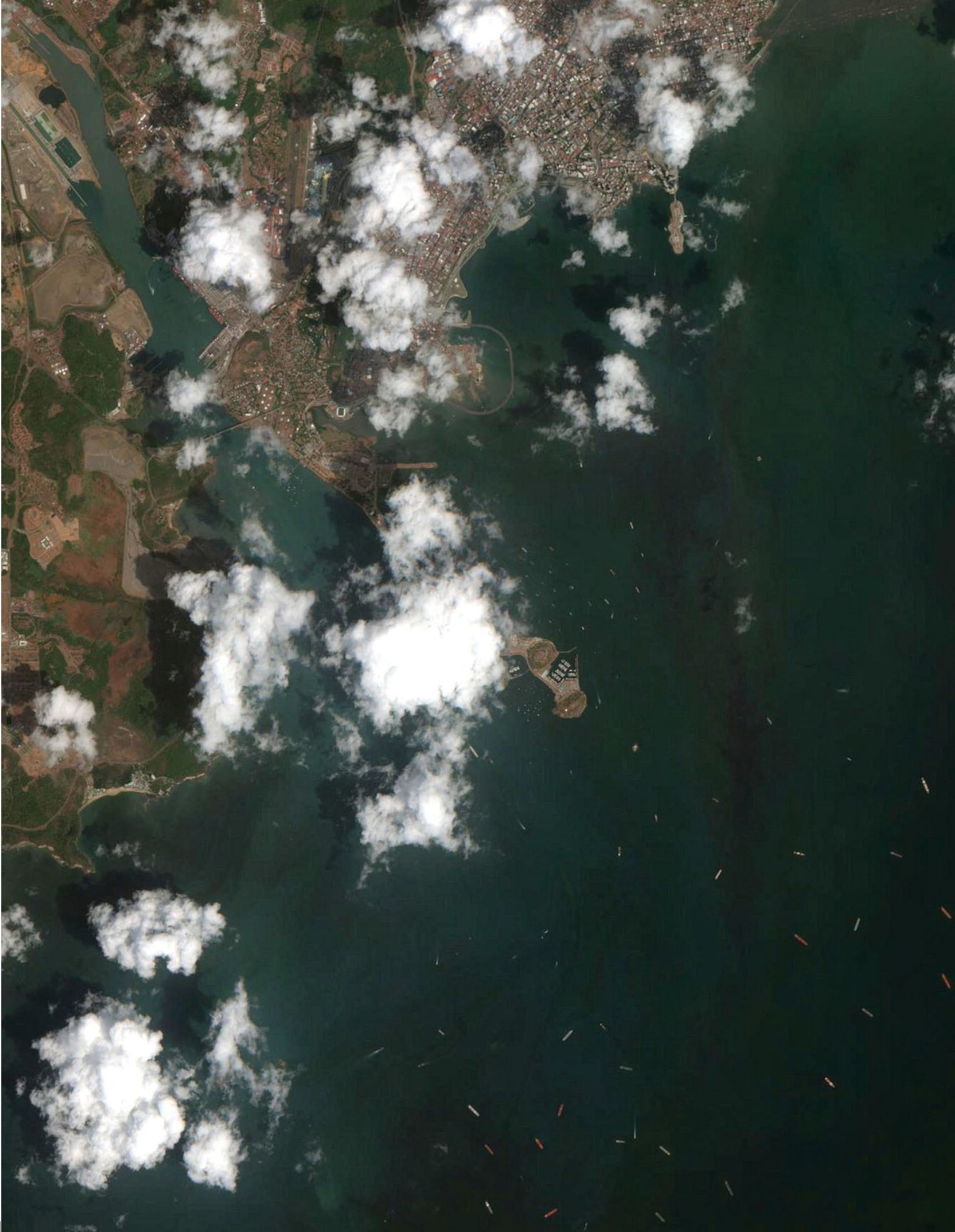
As two separate tiles were needed for the north and south parts of the image, I used Autopano Pro (as Les suggested) and produced a single large image from which the three images shown were cropped. On the originals of the two detailed images of the lock areas for the canal, you can easily see ships of a variety of colours either waiting to enter or sailing off after passing through the canal. I guess that everyone knows that you travel from west to east on the canal when sailing from the Atlantic to the Pacific (shouldn't it be the other way round?).



This image of the Panama Canal zone was created from two Sentinel 2A tiles using *Autopano Pro* stitching software.
Modified Copernicus data © ESA / Sentinel (2016), processed by David Taylor



Detail showing the northeastern (Gatun) end of the Panama Canal as imaged by the Sentinel 2A satellite.
Modified Copernicus data © ESA / Sentinel (2016), processed by David Taylor



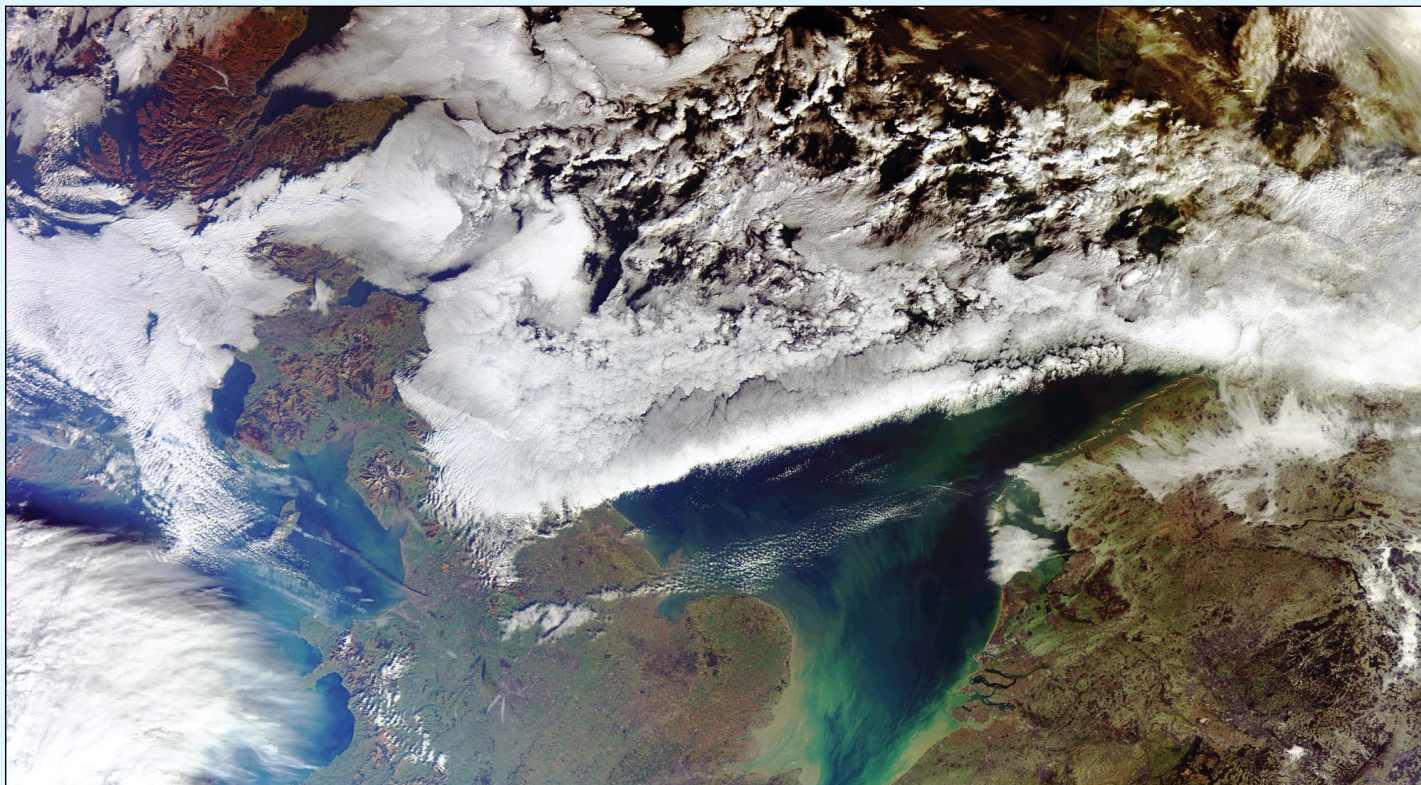
The southwestern (Perdo Miguel and Mirflores) end of the 65 kilometre long Panama Canal is seen in this 10 metre/pixel Sentinel 2A image, as shipping abounds in the waters of Panama Bay. Also visible is the Bridge of the Americas a little above left-centre, and Panama City at top right.
Modified Copernicus data © ESA / Sentinel (2016), processed by David Taylor

Sentinel 3A Images UK and Netherlands

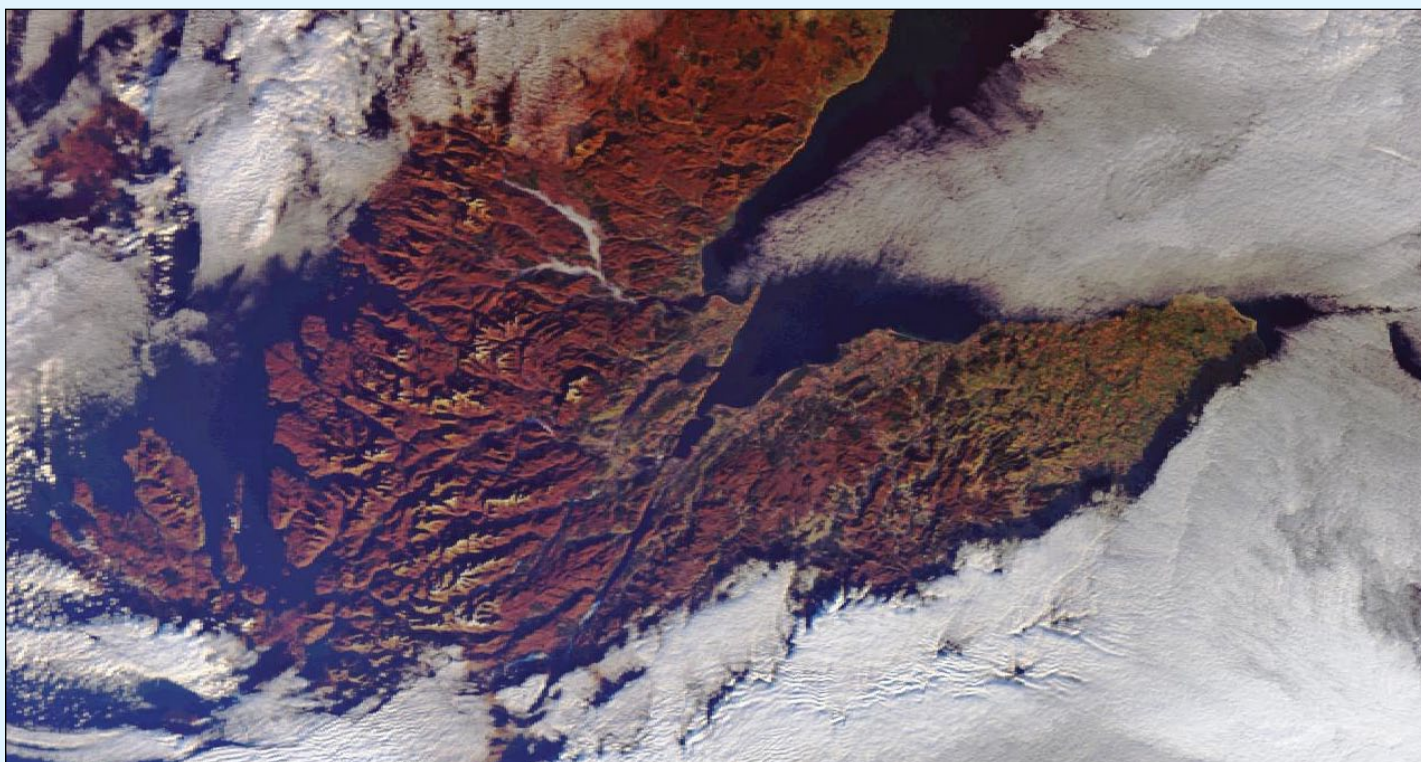
Gerard Boon

This image is a high resolution segment of Sentinel 3A dating from December 4, 2016. It was received with an Ayecka SR1 connected to an *iMac* running Windows 7 32-bit using *BootCamp* assistant. Data from the EUMETCast HVS service was acquired by Tellicast 12.2.1 software followed by further image segment processing using Hugo van Ruyskensvelde's EUMETCastView v 1.1.7.

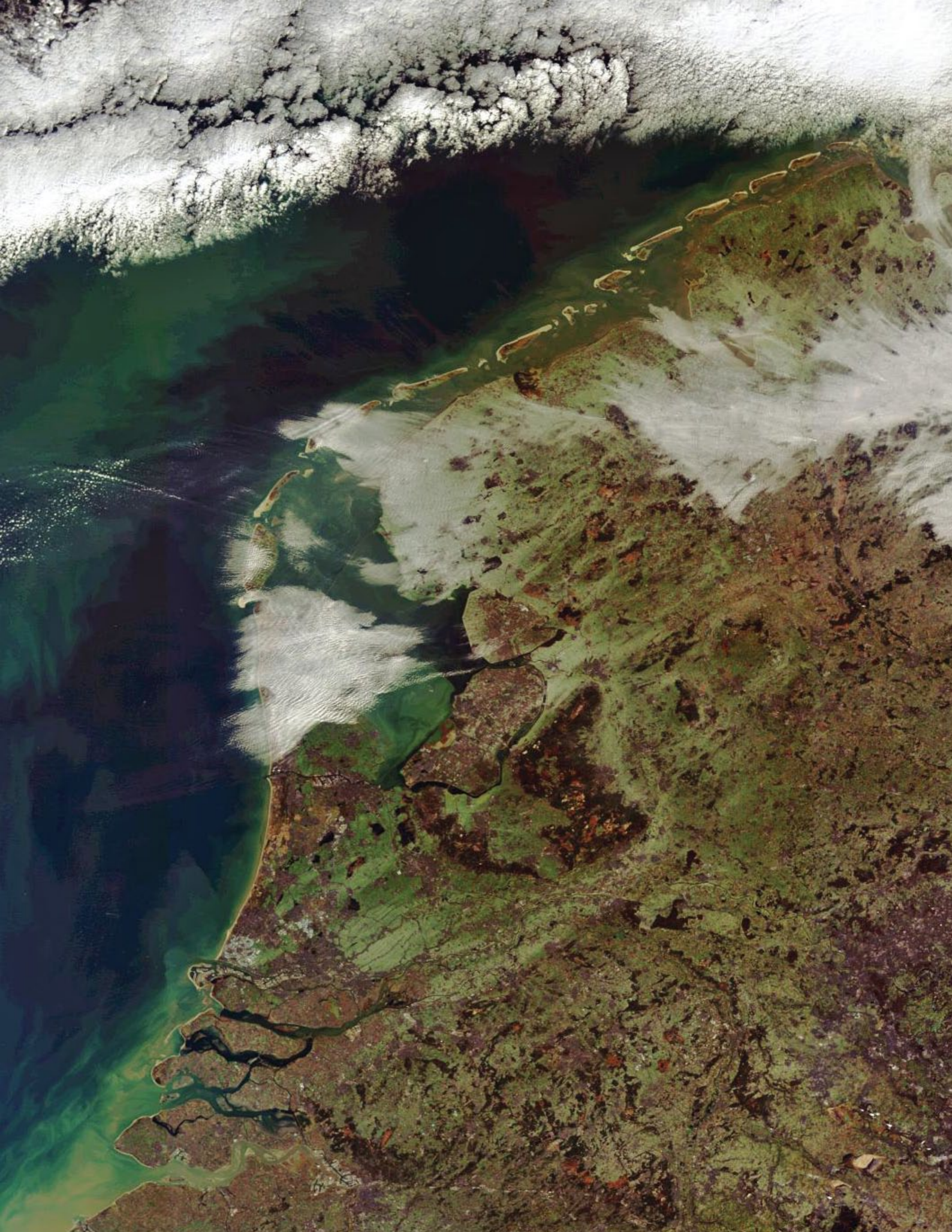
I also use David Taylor's software for MSG-1 and AVHRR but the discussions on the forums regarding scripts, Python and Linux are beyond me. So far the images are limited with regards to tweaking, *SNAP* provided by EUMETSAT is great and works natively on a *Mac* but the learning curve is steep and I have yet to attempt stitching segments together. So a big 'Thank You' to Hugo for EUMETCastView.



The original Sentinel 3A segment showing much of Great Britain and the Netherlands
Image © EUMETSAT 2016



The resolution of Sentinel 3A is evident in this segment of the main image showing Scotland's northwest highlands.
Image © EUMETSAT 2016



This is another section from the Sentinel 3A image, showing the Netherlands.
Image © EUMETSAT 2016

Operation Ice Bridge

Greenland's lesser-known glaciers

NASA Earth Observatory

Scientists and crew with NASA's *Operation IceBridge*, which makes annual aerial surveys of polar ice, made another series of science flights over the Arctic between late August and mid September 2016. These late-summer flights followed a previous series during April and May. Data from the start and end of the summer melt allows scientists to observe how each season affects the Greenland Ice Sheet.

'Earlier in *IceBridge's* history, we only surveyed the elevation of these glaciers once a year,' stated *IceBridge* deputy project scientist Joe MacGregor. 'But these glaciers experience the climate year-round. Now we're starting to complete the picture of what happens to them as the year goes on—especially after most of the summer melting has already occurred—so that we can measure their cumulative response to that melt.'

The image opposite, taken during a high-priority flight that *IceBridge* carried on August 29, shows Helheim Glacier, with its characteristic wishbone-shaped channels, as seen from about six kilometres altitude. Helheim is one of Greenland's largest and fastest-melting glaciers. During the first week of the summer land ice campaign, *IceBridge* has also flown over glaciers along Greenland's northwest, southeast and southwest coasts, and also over lines that the *Ice, Cloud, and land Elevation Satellite* (ICESat) flew over Greenland during its 2003-2009 period of operations, to observe how ice elevation has evolved since then. Future flights will cover critical areas in central and southern Greenland, such as the world's fastest glacier, Jakobshavn Isbræ.

The photographs overleaf show some glaciers observed from the *HU-25A Guardian* aircraft on September 2, 2016. The upper photograph shows the Brückner and Heim glaciers, where they flow into Johan Petersen Fjord in southeastern Greenland. The lower photograph



Helheim Glacier, with its characteristic wishbone-shaped channels, as seen from about 6,000 metres in the sky.

Credits: NASA/Operation IceBridge

shows a tributary of Heimdal glacier. The dark brown thread through the centre is a medial moraine—a ridge of debris that forms where ice from two glaciers merge. The *IceBridge* team also surveyed glaciers draining ice from Greenland's western side. The images provide a visual reference to help researchers understand better the data collected by other instruments during the flights.

Data collected during *IceBridge* campaigns have contributed to a range of discoveries since the mission began eight years ago. Under the snow and ice, scientists have mapped a canyon and observed an aquifer. They have estimated the extent of frozen and thawed areas on the bottom of the ice sheet, and have observed variations in the thickness of Arctic sea ice.

For this short, end-of-summer campaign, the *IceBridge* scientists are flying aboard an *HU-25A Guardian*

aircraft from NASA's *Langley Research Center* in Hampton, Virginia. The *Guardian* is a version of an early-generation *Falcon 20* business jet, modified for service with the US Coast Guard and later acquired by NASA. The plane carries a laser instrument that measures changes in the ice elevation, a high-resolution camera system to image the surface, and an instrument to infer the surface temperature. Due to the *Guardian's* limited range, the flights were curtailed to just 3.5 hours long, compared with the 8-hour missions carried during *IceBridge's* spring Arctic campaign, but the team flew twice daily whenever possible.

Operation *IceBridge* maintains the continuity of polar measurements between ICESat satellites. The original ICESat mission having ended in 2009, and its successor satellite not scheduled for launch until 2018.



The Brückner and Heim glaciers where they flowing into Johan Petersen Fjord in southeastern Greenland
Image: Jeremy Harbeck/NASA Goddard



The dark brown streak across this photograph is a medial moraine in a tributary of the Heimdal glacier
Image: Jeremy Harbeck/NASA Goddard

GEO Outreach

Visit to the Harwell Radio Rally in Didcot

Francis Bell



The GEO stand at the HARS Didcot rally. The photograph was taken at the start of the day as the first wave of visitors approached the stand.

GEO already have a number of rallies and presentations to amateur radio groups—and other interest groups—lined up for 2017. These events tend to be in the southeast of England because it's difficult and expensive for myself, often with David Simmons, to extend the areas we are prepared to cover for these events. However, I know there are other willing GEO members in other parts of the country ready to support such activities so, if you know of any technical interest group which is looking for a presentation related to GEO's activities and technical achievements I recommend you to contact us with potential details. You could contact a member of the GEO Management Team directly: see the inside cover of this publication or consult our website at this URL

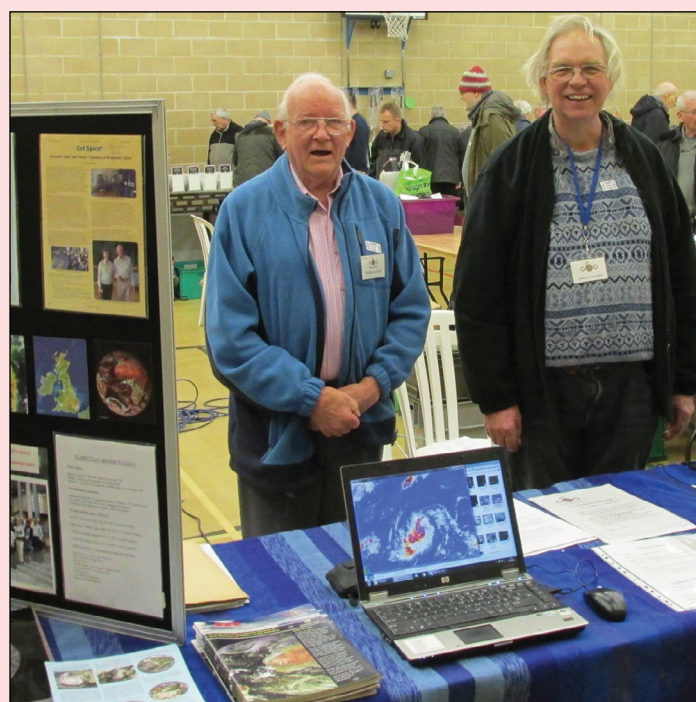
<http://www.geo-web.org.uk/contacts.php>

A recent rally, held at Didcot on Sunday, February 12, 2017, was hosted by the *Harwell Amateur Radio Society*, Oxfordshire. This was not our first attendance at this venue, which takes place in a local sports centre. As usual the rally filled most of the centre's main sports hall with stands, as well as several squash courts and other areas. The GEO stand was located in the busy main sports hall, where we displayed our own literature, promotional materials from EUMETSAT and set up three computers running slide shows showing polar orbiting and geostationary weather satellite images. Most of the time just two of our Management Team, myself and David Simmons, manning the stand. But briefly, during the day, that number increased when we welcomed GEO Shop Manager Nigel Evans and his wife Michele.

It proved to be a busy day, particularly between 10.00 am and 1.00 pm, but visitors then coordinated their departure earlier than usual, I suspect because of the cold weather outside. It's always rewarding to meet people, and as usual visitors to the stand had a wide spectrum of interests. Without exception they seemed

knowledgeable in their own areas but also keen to learn about GEO and the potential which our membership offered: together with the inevitable enquiries about us making a presentation to their own clubs or groups.

It was a most satisfying day and I owe a big 'thank-you' to David Simmons for giving up a day of his time to be with us on the GEO stand.

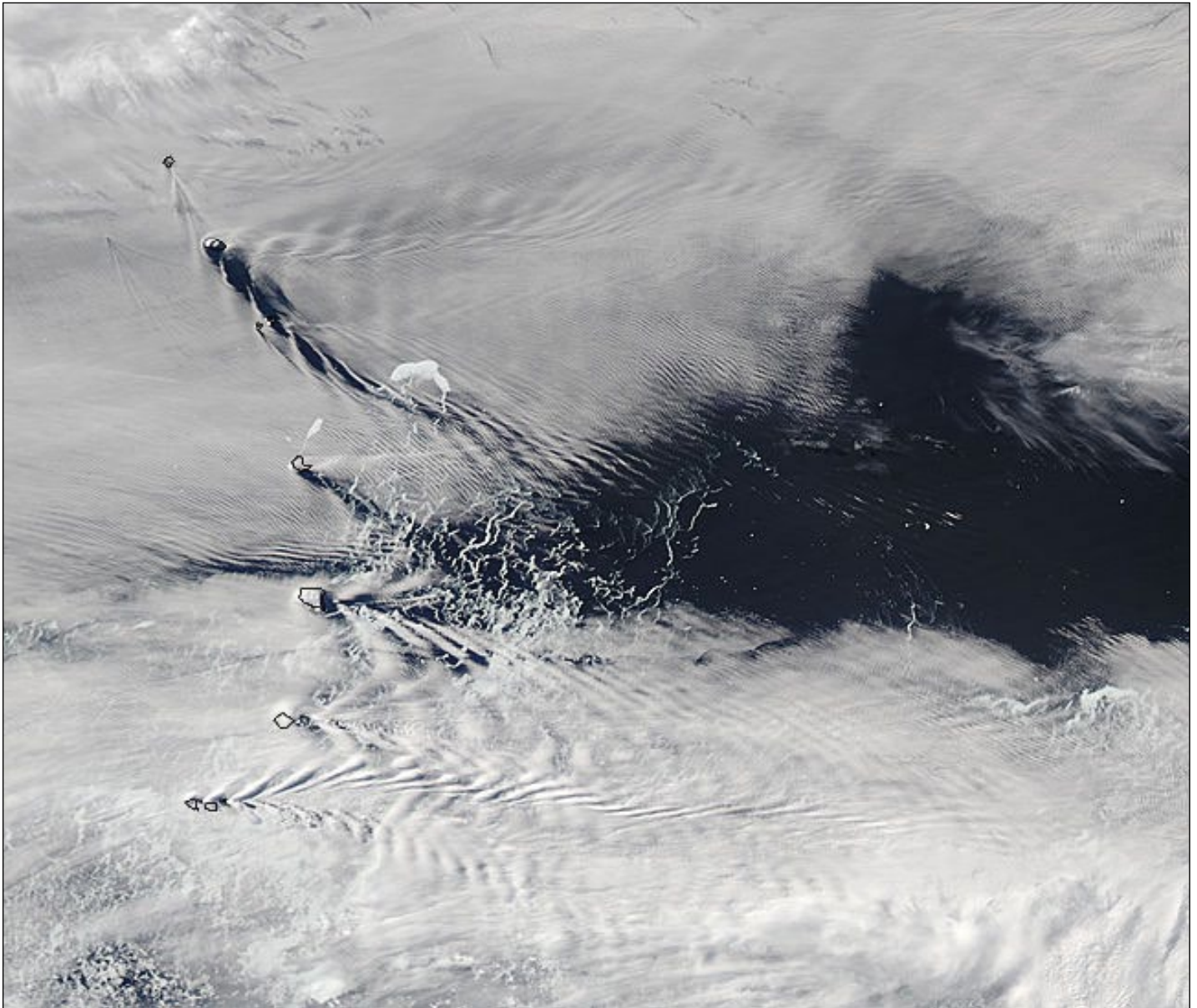


David Simmons, right and Francis Bell manning the GEO stand at the HARS rally, Didcot.

Ship-Wave Cloud Formations

induced by the South Sandwich Islands

NASA Earth Observatory



Ship Waves spawned by the South Sandwich Islands on November 15, 2016
 Image: Jeff Schmaltz, MODIS Land Rapid Response Team, NASA GSFC

Sometimes, when viewed from space, the South Sandwich Islands can appear much like a fleet of fishing boats cutting through foamy waves. Appearances can be deceiving, however. In reality, the 'moving islands' are merely an illusion created by low clouds and strong winds blowing past the rugged—and solidly stationary—lands. The Moderate Resolution Imaging Spectroradiometer (MODIS) aboard NASA's *Aqua* satellite captured such a moment as it passed over the southern Atlantic Ocean on November 15, 2016 and acquired this true-colour image.

When strong winds slam into tall, immobile objects (called 'bluff bodies'), the wind flow is disrupted, creating turbulence in the motion of the air as it passes by the object. On a clear day, such turbulence would remain unseen. But when the sky is filled with clouds, the motion of the wind moves the

cloud cover, making it visible to the human eye. The resulting patterns of turbulence can take many forms, including V-shaped waves that appear to be similar to wakes behind moving ships.

The South Sandwich Islands sit in a location where westerly winds blow frequently and with substantial strength. Cloud cover is frequent, with only slightly more than a thousand hours of sunshine annually on average. The islands are volcanic in origin, with tall mountains and rugged terrain—making them formidable bluff bodies. These features combine to make the appearance of these ship-wave shaped clouds, a common occurrence in this remote location.

Reference

Ship Waves - GEO Quarterly 11, page 10 (2006)

Mapping the Speed of Ice

in Earth's glaciers

NASA Earth Observatory

Earth's ice is changing: from mountain glaciers to ice sheets to ice shelves. For the most part, land-based ice has been shrinking, and the very definition of a 'glacial pace' has changed within our lifetimes. Now researchers have the tools to see those changes every few weeks and at scales as small as 5 metres.

Using freely available data from the **Landsat 8** satellite, scientists are working to provide a near-real-time view of every large glacier and ice sheet on Earth. A group of scientists from the National Snow and Ice Data Center (NSIDC), the University of Alaska-Fairbanks, the University of Bristol, and the Jet Propulsion Laboratory (JPL) have started the *Global Land Ice Velocity Extraction* project (*GoLIVE*), a NASA-funded effort to better understand how ice flow is changing worldwide.

'We are now able to map how the skin of the ice is moving,' said Ted Scambos, senior research scientist at NSIDC and lead for the *GoLIVE* project. *'From now on, we're going to be able to track all of the different types of changes in glaciers. There's so much science to extract from the data.'*

The effort was described at the 2016 fall meeting of the American Geophysical Union.

Evidence strongly suggests that the loss of ice from glaciers and ice sheets has been the largest contributor to sea level rise over the past three decades, with waters rising at a global average rate of 3.3 millimetres per year. By examining changes in ice flow in combination with data on ocean and atmospheric changes, the researchers hope to determine what causes ice masses to change and how much ice will flow into the ocean. The satellite-based approach is particularly valuable in remote landscapes, where ground- and airplane-based observations are expensive, dangerous, and intermittent.

In Alaska and Canada's Yukon Territory, for instance, most glaciers

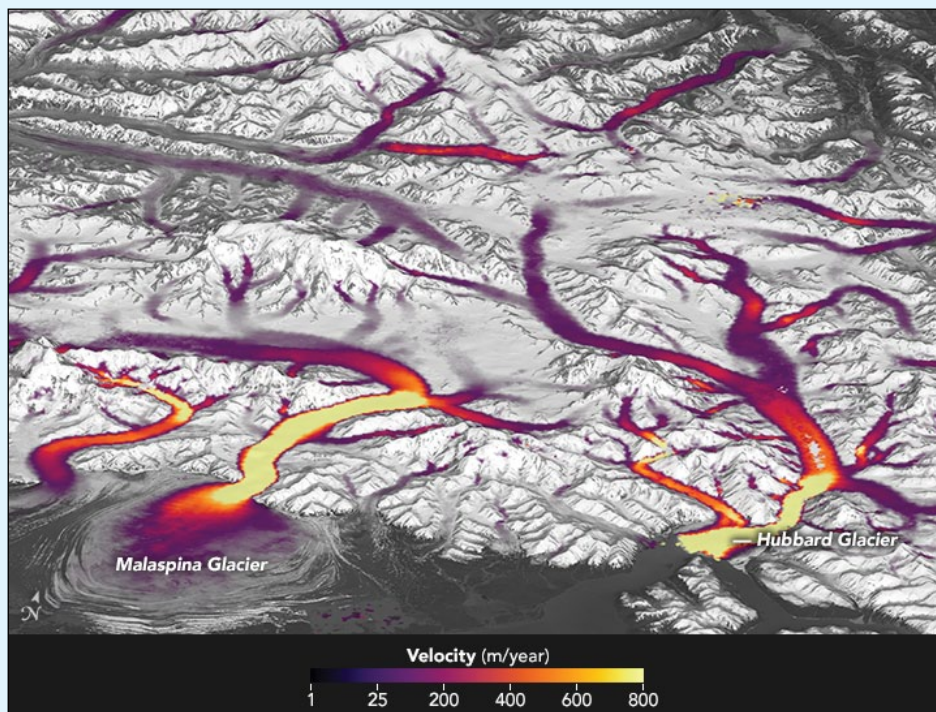


Figure 1 - Ice velocity in southeastern Alaska

are so remote that speedup events can go unnoticed for months until a pilot flies over the region and reports disrupted ice. Figure 1, based on an analysis by *GoLIVE* investigators, shows the velocity of ice in southeastern Alaska near Malaspina and Hubbard glaciers.

'By measuring ice flow all the time, we can identify a surge as it starts, providing an entirely new way to follow this phenomenon,' stated Mark Fahnestock of the University of Alaska. *'We can also follow large seasonal swings in tidewater glaciers as they respond to their environment. Scientists need to see all of this variability in order to identify trends.'*

Automation has been key to this ice velocity mapping effort. **Landsat 8** collects images of roughly 700 sunlit parcels of the planet's surface every day, and during the course of 16 days, the satellite observes the entire land surface of Earth in multiple visible and infrared wavelengths. This means that scientists can view changes in the same spot on Earth every 16 days (or 32, 48, 64, etc. days as cloud cover allows).

This also means that there is a huge amount of data to process and analyse. Between 2013 and 2016, **Landsat 8** collected thousands of images from Antarctica alone. The globes in figure 2 illustrate how many times **Landsat 8** passed over a given icy parcel in 2015 alone. As many as 150 to 200 images were collected over the brightest yellow and green areas, while purple areas had just a handful of useful images because of frequent cloud cover and fewer orbital passes. Due to the nature of the satellite's polar orbit, areas in the far north and south can be imaged more frequently (when there is sunlight).

The imaging system aboard **Landsat 8** is far more sensitive than previous Landsat sensors, distinguishing far more subtle differences in shading and surface texture. The *GoLIVE* team has written software that allows researchers to follow these subtle features, like bumps or dune-like patterns on ice surfaces. By comparing images of the same location on different dates, researchers can track individual features and determine the speed of the surface flow.

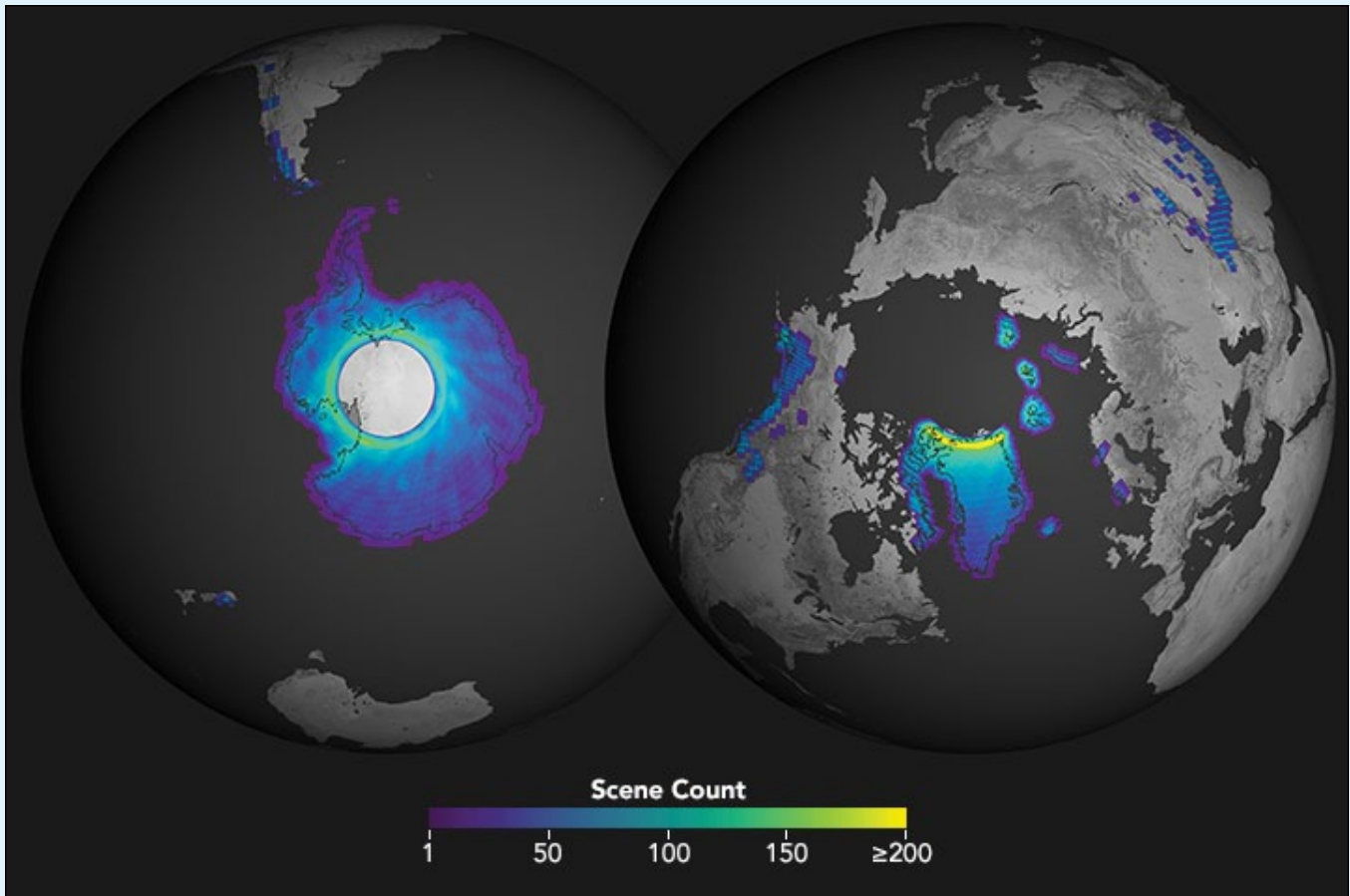


Figure 2 - Frequency of Landsat 8 passes over Antarctica in 2015

‘The question is: how sensitive are these ice sheets to changes in the atmosphere and the ocean?’ said Alex Gardner of JPL. ‘We could wait and see, or we could look to the past to help inform what is most likely to happen in the future.’

Gardner has been looking closely at Antarctica, with ice velocities represented in the map below (figure 3). He is working to combine the new **Landsat 8** ice-flow data with prior maps of the continent’s glacier flow in the hope of understanding decadal changes across the entirety of the ice sheet. Almost 2,000 cubic kilometres of ice flow into the Southern Ocean from Antarctica each year.

Twila Moon, an ice scientist at the University of Bristol, is using the global maps to expand her research in Greenland. With the new database, she can study the movements of more than 240 glaciers, nearly all of the outlets from the ice sheet. And with **Landsat 8** making an overpass every 16 days, she has the opportunity to detect seasonal changes and cyclical patterns.

While most glaciers speed up in the warmer summer months, Moon has found several that slow down dramatically in the mid- to late-summer.

‘We can group these glaciers by looking at the similarities in their behaviour,’ Moon said. ‘It’s providing an opportunity to get at the underlying drivers of why they change.’

With measurements of what the seasonal shifts do to glacier speed, scientists can extrapolate what might happen to those glaciers as global temperatures continue to climb.

You can view a speeded-up animation showing the motion of Greenland’s Heimdal Glacier on *YouTube* at

<https://www.youtube.com/watch?v=EahiP3Qa7QY>

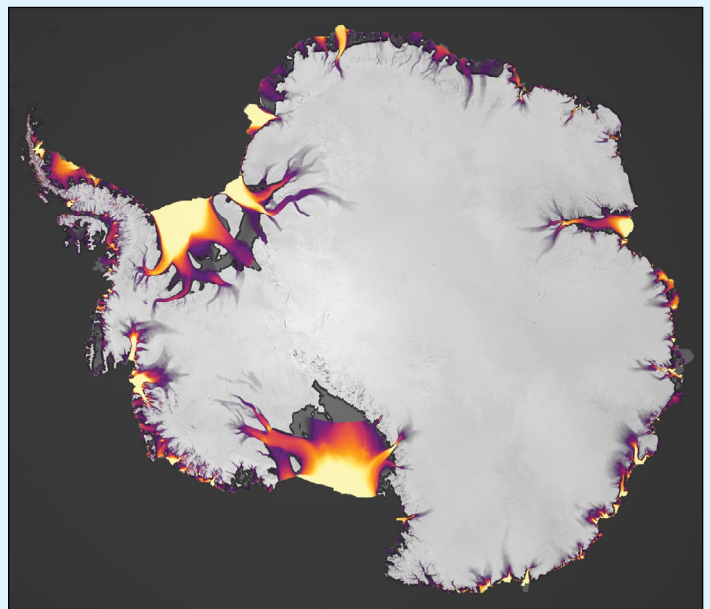


Figure 3 - Ice velocities in Antarctica
(For colour key, see figure 1)

NASA Earth Observatory images by Joshua Stevens, using Landsat-derived ice velocity data courtesy of Alex Gardner, NASA Jet Propulsion Laboratory/California Institute of Technology and ASTER GDEM data from the NASA/GSFC/METI/ERSDAC/JAROS, and U.S./Japan ASTER Science Team.

Caption by Kate Ramsayer and Mike Carlowicz.

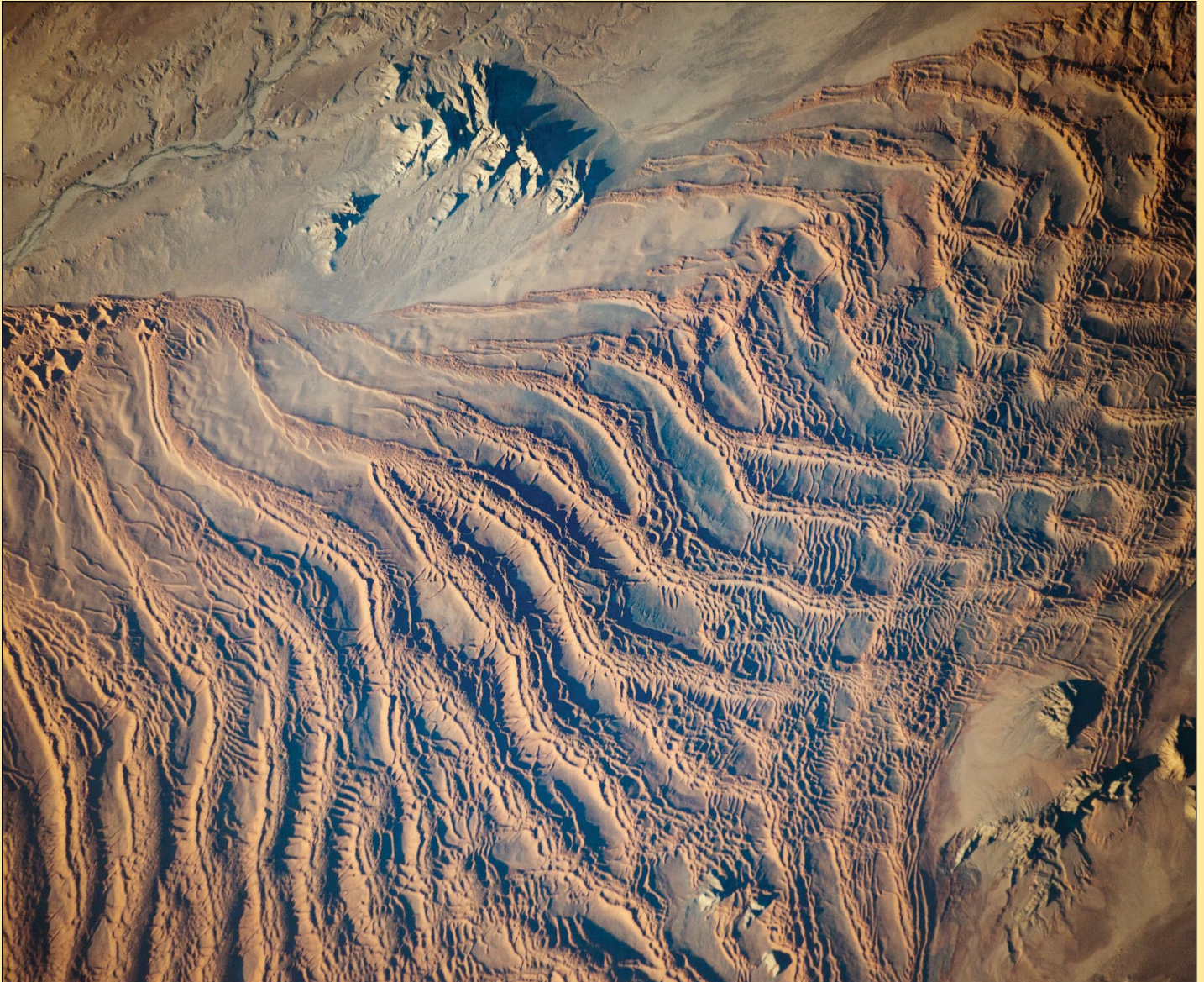


This Sentinel 2A image depicts São Domingos, the main island of the Republic of Cabo Verde (Cape Verde), acquired on February 6, 2017. The island measures 55 kilometres from north to south, and its capital city, Praia, can be seen clearly at the far south.

Image: Modified Copernicus data © ESA / Sentinel (2016)

ISS IMAGES THE NABIB SAND SEA

NASA Earth Observatory



An astronaut aboard the International Space Station (ISS) used a long lens to document what crews have termed one of the most spectacular features of the planet: the linear sand dunes of the Namib Sand Sea.

Looking inland (from an ISS position over the South Atlantic) near sunset, the highest linear dunes show smaller linear dunes riding along their crests. Linear dunes are generally aligned parallel to the formative wind—in this case, strong winds from the south. Southerly winds explain the parallel north-aligned linear dunes on the left side of the image.

But this simple pattern is disrupted near the Tsondab valley, which acts as a funnel for winds from the east. These less frequent but strong winter winds are channelled down the valley and usually carry large amounts of sand, similar to the *Santa Ana* winds in California. These strong easterly winds significantly deflect all the linear dunes near the valley so that they point downwind.

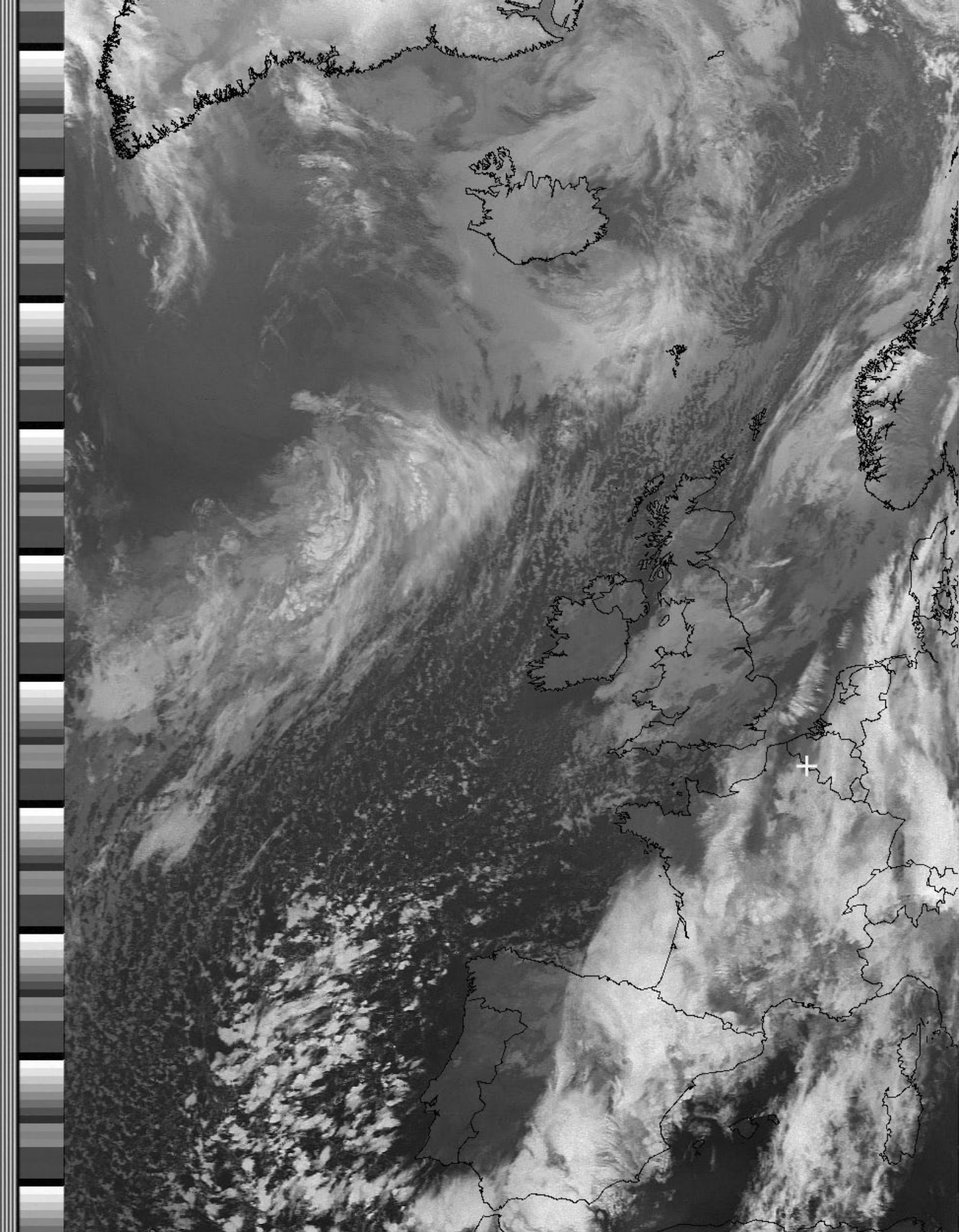
Further inland (right), the north-pointing and west-pointing patterns appear superimposed, making a rectangular pattern.

Because the Namib Desert is very old—dating from the time when the cold, desert-forming Benguela ocean current started to flow about 37 million years ago—wind patterns and dune patterns have shifted over time. North-oriented dunes have shifted north and east with drier climates and stronger winds, overriding but not removing earlier dune chains, thus creating the rectangular dune network we see today.

The Tsondab, an ephemeral dry river in the west of Namibia, is blocked by linear dunes (just outside the left margin of the image) 100 kilometres from the Atlantic Ocean. Research has shown that, during wetter times, it did reach the ocean. The name Tsondab means ‘that which is running is suddenly stopped’ in the local Khoisan language.

Along the edge of the dune-free Tsondab River valley, you can see star dunes, which are smaller and display multiple arms (top left).

Astronaut photograph ISS047-E-23405 was taken by a member of the Expedition 47 crew on March 27, 2016, with a Nikon D4 digital camera using a 500 millimetre lens, and is provided by the ISS Crew Earth Observations Facility and the Earth Science and Remote Sensing Unit, Johnson Space Center. Caption by M. Justin Wilkinson, Texas State University, Jacobs Contract at NASA-JSC.



André T'Kindt submitted this finely detailed NOAA 18 APT image he decoded from the satellite's 18.17 UT pass on November 22, 2016, and which shows the British Isles in a ridge of high pressure which drove freezing winds south over the North Sea.

Kerguelen Island

Les Hamilton

Formed over millions of years by a series of lava flows, the Kerguelen Archipelago is a group of islands located in the southern Indian Ocean roughly midway between Africa, Australia, and Antarctica. The Kerguelen Islands experience a fierce climate, with incessant, howling winds accompanied by rain or snow nearly every day. At a latitude of about 49° south, they lie in the path of the 'Furious Fifties', the belt of westerly winds that whips around the Southern Hemisphere, mostly unimpeded by land.

These islands are among the most isolated places of Earth, being located 450 kilometres northwest of the uninhabited Heard Island and McDonald Islands and more than three thousand kilometres from the nearest populated location, on Madagascar. The Kerguelen islands, along with the Crozet Islands and the Amsterdam and Saint Paul Islands were officially

annexed by France in 1893 and were included as possessions in the French constitution in 1924: they are now part of the *French Southern and Antarctic Lands* and are administered as a separate district.

The main island, Grande Terre, its perimeter carved by fjords, has an area of 6,675 km² and is surrounded by an archipelago of 300 smaller islands and islets with a total area of 7,215 km². The climate is raw and chilly throughout the year with frequent high winds and the surrounding seas are generally rough though they do remain ice-free all year. There are no indigenous inhabitants, but France has maintained a permanent presence of between 50 and 100 scientists, engineers and researchers since 1950. There is also a French satellite tracking station. There are no airports on the islands, so all travel and transport from the outside world is conducted by ship.



Figure 1 - A rare cloud-free image of Kerguelen island, acquired by NASA's Terra satellite on October 28, 2016
Image: LANCE Rapid Response/NASA/GSFC

The islands were officially discovered by the French navigator Yves-Joseph de Kerguelen-Trémarec on February 12, 1772 and, the following day, Charles de Boisgüehenneuc landed and claimed the island for the French crown. A number of other expeditions briefly visited the islands, including that of Captain James Cook in December 1776. Following their discovery, the archipelago was regularly visited by whalers and sealers (mostly British, American and Norwegian) who hunted the resident populations of whales and seals to the point of near extinction.

In 1825, the British sealer John Nunn and three crew members from the *Favourite*, were shipwrecked on Kerguelen for almost three years until they were rescued in 1827. Nunn related his experiences in a book: *Narrative of the Wreck of the 'Favourite' on the Island of Desolation*. During their time on Kerguelen, the men built a wooden cottage in which to live (figure 2) and a cart for collecting and transporting king penguin eggs, which formed an important part of their diet (figure 3).

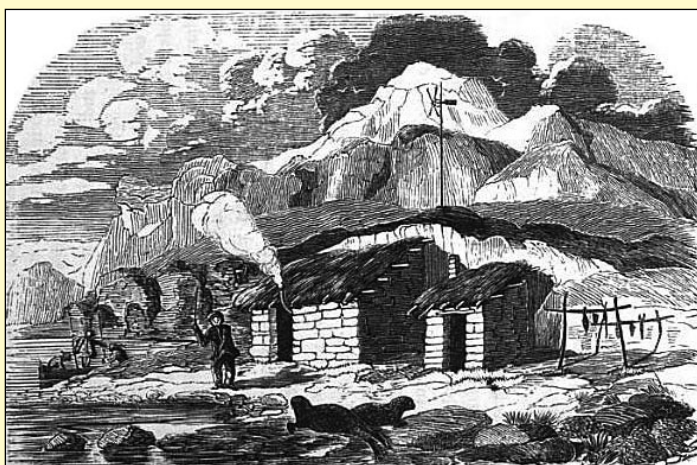


Figure 2 - Hope Cottage, an engraving from John Nunn's book showing the refuge they built on Courbet Peninsula in 1825.

Source: Wikimedia Commons

Grand Terre

The main island of the archipelago is called La Grande Terre, and measures 150 kilometres from east to west and 120 km from north to south. The scientific base is known as Port-aux-Français, and is located on the eastern shore of the Gulf of Morbihan. Facilities there include scientific-research buildings, a satellite tracking station, dormitories, a hospital, a library, a gymnasium, a pub, and the chapel of Notre-Dame des Vents.

The highest point is Mont Ross in the Gallieni Massif, thought to be Kerguelen's youngest volcano, which rises along the southern coast of the island to an elevation of 1850 metres. No eruptive activity has been recorded in historic times although some fumaroles are still active in the southwest of Grande-Terre.

Glaciers are scattered across the island and the Cook Ice Cap—France's largest glacier with an area of about 403 km²—lies to its west-centre. Overall, the glaciers of the Kerguelen Islands cover just over 500 km². Grande Terre has numerous bays, inlets, fjords, and coves, as well as several peninsulas and promontories.

Economy

The French supply ship Marion Dufresne makes regular calls at the Kerguelen Islands and typically carries a small contingent of tourists. Principal activities on the Islands focus on scientific research—mostly Earth sciences and

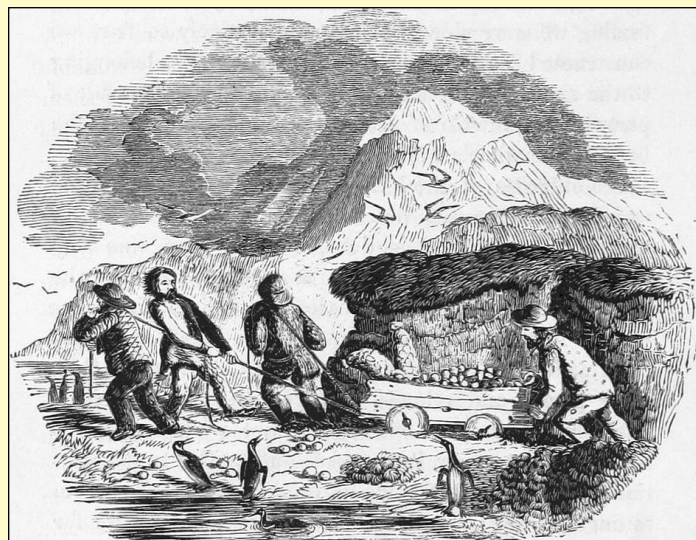


Figure 3 - The Egg Cart, another engraving from Nunn's book.

Source: Wikimedia Commons

biology. A former sounding rocket range to the east of Port-aux-Français is currently the site of a SuperDARN radar.

Since 1992, the French Centre National d'Études Spatiales (CNES) has operated a satellite and rocket tracking station which lies four kilometres east of Port-aux-Français. CNES needed a tracking station in the Southern Hemisphere, and the French government required it to be located on French territory, rather than in a populated, but foreign, place like Australia or New Zealand.

Agricultural activities were limited until 2007 to raising sheep (about 3,500 Bizet sheep—a breed of sheep that is rare in mainland France) on Longue Island for consumption by the occupants of the base, as well as small quantities of vegetables in a greenhouse within the immediate vicinity of the main French base. There are also feral rabbits and sheep that can be hunted, as well as wild birds.

There are also five fishing boats and vessels, owned by fishermen on Réunion Island (a department of France about 3,500 km to the north) who are licensed to fish within the archipelago's Exclusive Economic Zone.

Climate

Kerguelen's climate is oceanic, cold and extremely windswept and is classified as tundra. The average temperature in the warmest month is below 10 °C, comparable with Alaska's Aleutian Islands, Iceland, the



Figure 4 - The south rim of Cook Glacier and Mount Ross on Kerguelen Island

Photo: B.navez (1983) / Wikimedia



Figure 3 - Port-aux-Français, the French Station located at Golfe du Morbihan on Grand Terre in the Kerguelen Archipelago
Image: Daniel Delille / Wikimedia

northern Kamchatka Peninsula, Labrador and Tierra del Fuego. All climate readings come from the Port-aux-Français base, which has one of the more favourable climates in Kerguelen due to its proximity to the coast and its location in a gulf sheltered from the wind.

The average annual temperature is 4.9 °C with an annual range of around 6 °C. The warmest months of the year include January and February, with average temperatures between 7.8 and 8.2 °C. The coldest month of the year is August with an average temperature of 2.1 °C. Annual high temperatures rarely achieve 20 °C, while temperatures in winter have never been recorded below -10 °C at sea level.

Kerguelen receives frequent precipitation, with snow throughout the year as well as rain. Port-aux-Français receives a modest 708 millimetres of precipitation per year, compared to the west coast which receives an estimated three times as much. The mountains are frequently covered in snow but can thaw very quickly in rain. Over the course of several decades, many permanent glaciers have shown signs of retreat, with some smaller ones having disappeared completely.

The west coast receives almost continuous wind at an average speed of 35 km/hour, due to the islands' location between the *Roaring Forties* and the *Furious Fifties*. Wind speeds of 150 km/hour are common and can even reach 200 km/hour.

Flora and Fauna

Despite the challenging climate, several animals and birds make their homes at Kerguelen or use it as a stopping over point in their migrations or during breeding. Among the indigenous wildlife on the Kerguelen Islands are several species of penguins, elephant and fur seals, plus dozens of species of sea birds, including terns and albatrosses. It is the sea that makes this 'wildlife sanctuary' possible because the islands are located along the *Antarctic Convergence Zone*, where the icy waters of the Southern Ocean meet the warmer waters of the Indian Ocean. The waters in this mixing area are very rich in nutrients, which support the phytoplankton which are the foundation of the ocean food web.

Plant life in this rocky landscape is mainly limited to tussock grass (*Poa cookii*), mosses (*Azorella selago* and *Acaena adscendens*), lichens and the famous Kerguelen cabbage (*Pringlea antiscorbutica*). This latter species, belongs to the brassica family (as does the common cabbage), and has evolved a unique method of cross-pollination which relies on the wind, since there are no flying insects on the island. The leaves of the cabbage contain a pale-yellow, highly pungent essential oil which is rich in ascorbic acid (vitamin C) which made it a useful dietary supplement against scurvy for early sailors.



Kerguelen Cabbage

Photo: Wikimedia Commons / Share Alike 3.0

The wildlife on Kerguelen is particularly vulnerable to introduced species and one particular problem has been cats. The main island is home to a well-established feral cat population, descended from ships' cats, which survive on a diet of sea birds and the feral rabbits that were introduced to the islands by the whalers. All these cats are black-and-white because the original three cats on the island were black-and-white.

There are also populations of moufflon sheep (*Ovis aries musimon*) and reindeer introduced by the French. The reindeer have now become wild, and impossible to remove from the island and probably number in excess of 3,000 head.

Tourism

Tourists can book a cabin in the base support ship *Marion Dufresne* for €8,300 per person for a double cabin, or €16,500 for a single cabin. There are apparently four trips open to tourists per year. The trip leaves from Réunion and takes about 28 days

Acknowledgements

Much of the information contained in this article was gleaned from Wikipedia, and from reports from NASA Earth Observatory.

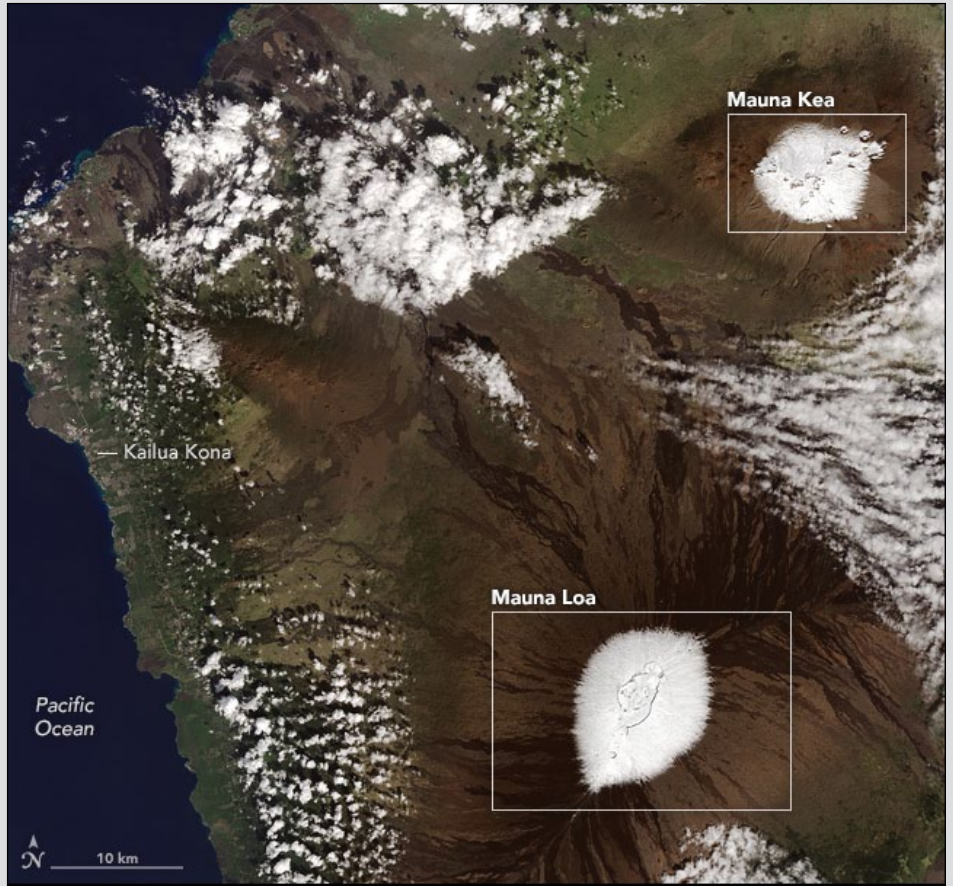
Snow-Capped Summits in Hawaii

NASA Earth Observatory

Snow may not be the first thing that comes to mind when you think of the Hawaiian Islands. But nearly every year, the volcanic peaks of Mauna Kea and Mauna Loa become temporarily dusted with white. The Operational Land Imager (OLI) on the **Landsat 8** satellite captured these natural-colour images of the snowy peaks on December 25, 2016. A storm a week earlier brought not only snow, but bouts of thunder and lightning. While snow in Hawaii is not unusual, and can even fall in summer, thundersnow is less common.

The storm was reportedly associated with a Kona low. This low-pressure system brought a change in wind direction, such that winds that typically blow out of the northeast shifted to blow from the southwest. The winds from the leeward or 'Kona' side drew moisture from the warm, tropical Pacific that ultimately fell as snow over the high elevations.

Detailed views give a closer look at the snowy summits. Mauna Kea rises to 4,205 meters (35 meters higher than Mauna Loa) and is one of Hawaii's older dormant volcanoes, with steep, irregular terrain marked by numerous cones. Mauna Loa, in contrast, is relatively active and topped with three circular depressions that compose the Moku'aweoweo caldera. Mauna Loa is less steep, with gentle slopes



Snow capping Mauna Loa and Mauna Kea, Hawaii on Christmas Day 2016. NASA Earth Observatory images by Jesse Allen, using Landsat data from the US Geological Survey

that block the view of its snow capped summit from sea level. Satellites offer views of both summits. Natural-colour visible imagery from satellites, however, can be obscured by the

presence of clouds. That was the case earlier in December when a storm was reported to have dropped more than 60 cm of snow on the peaks.



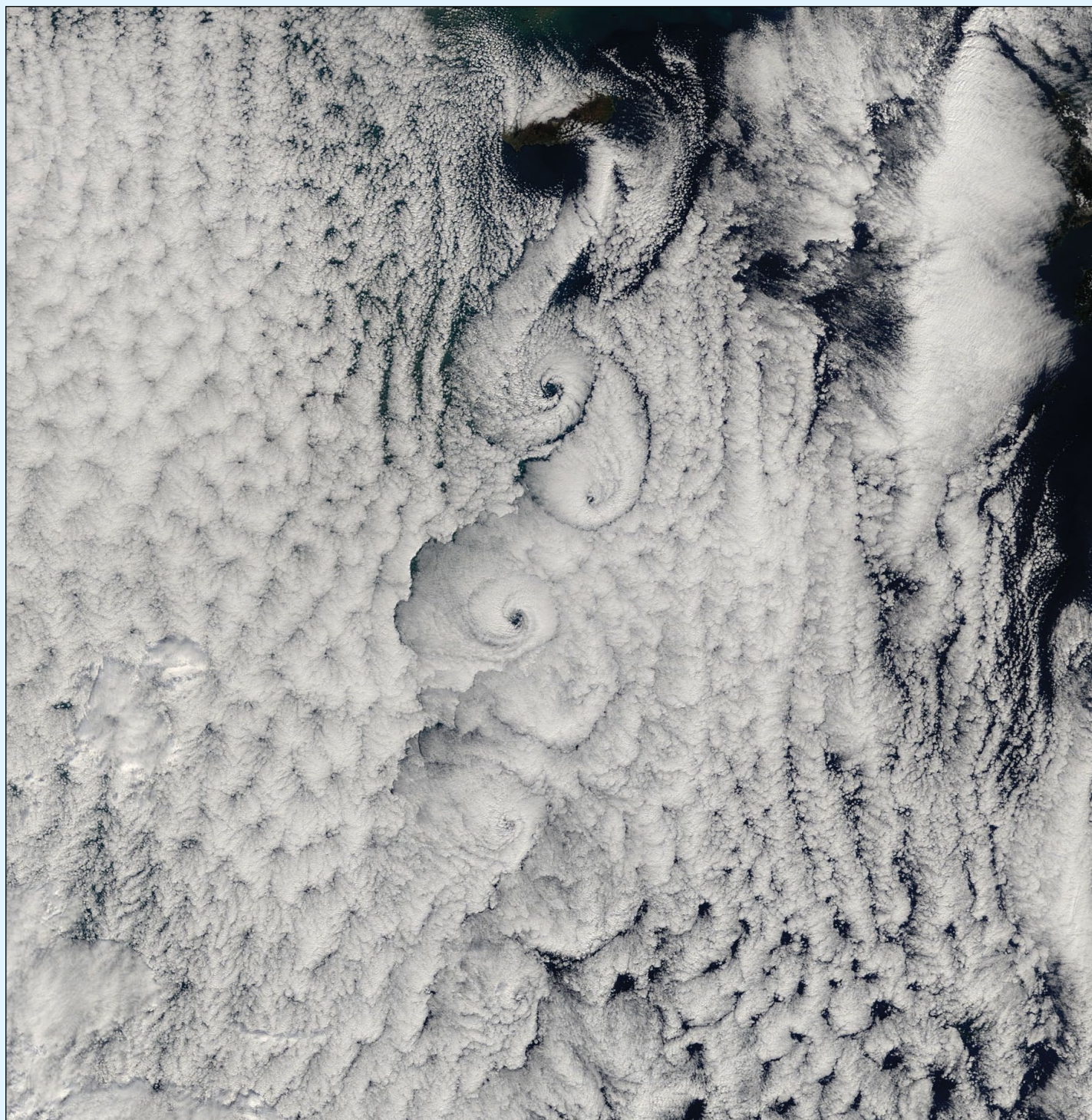
The summit of Mauna Kea showing its numerous cones
Image: NASA



Moku'aweoweo caldera Mauna Loa
Image: NASA

Cloud vortices off Cheju Do, South Korea

MODIS-Web Image of the Day

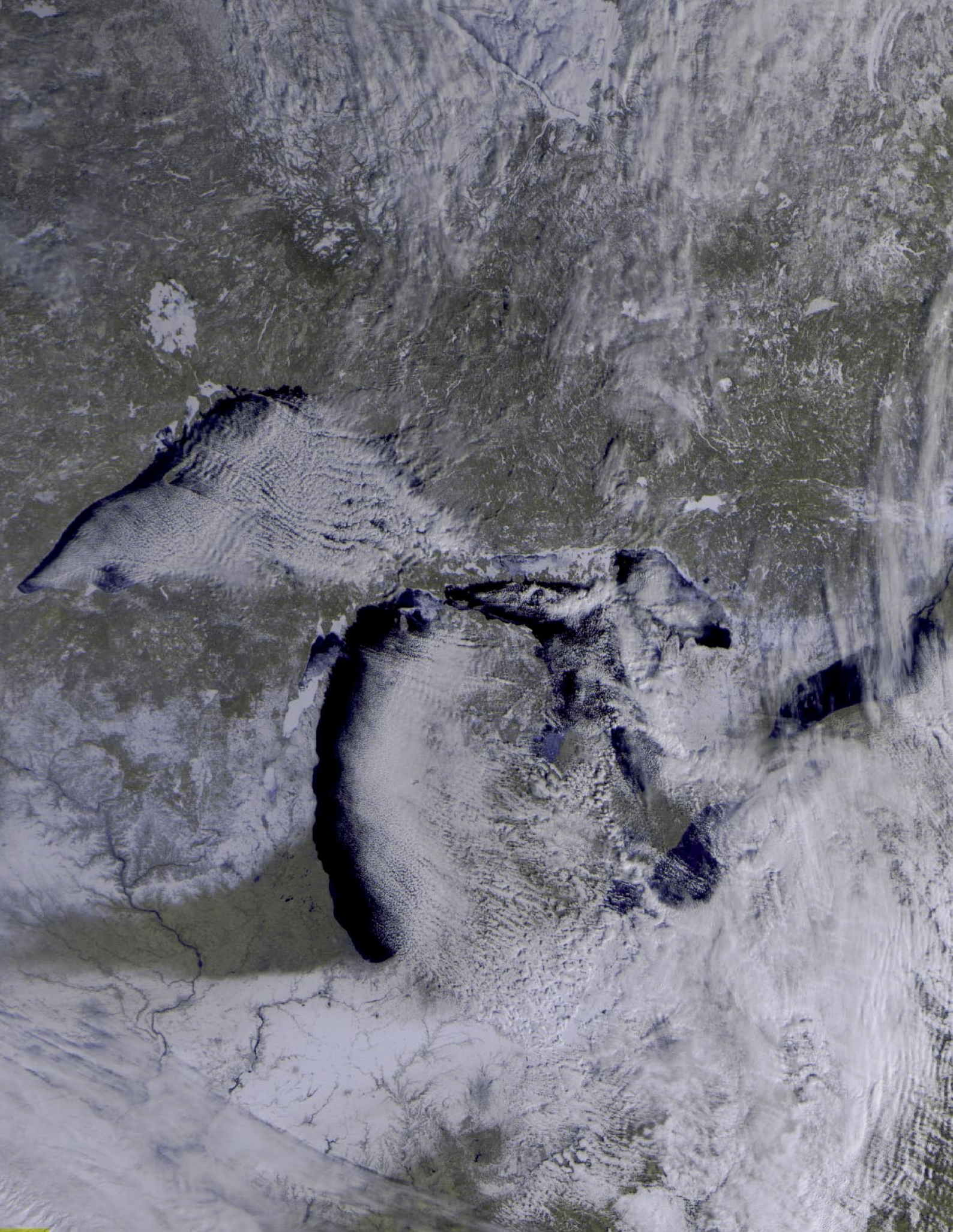


NASA's *Terra* satellite captured this image of Van Karman vortices being shed by the island of Cheju Do, South Korea
Image Credit: Jeff Schmaltz, MODIS Land Rapid Response Team, NASA GSFC

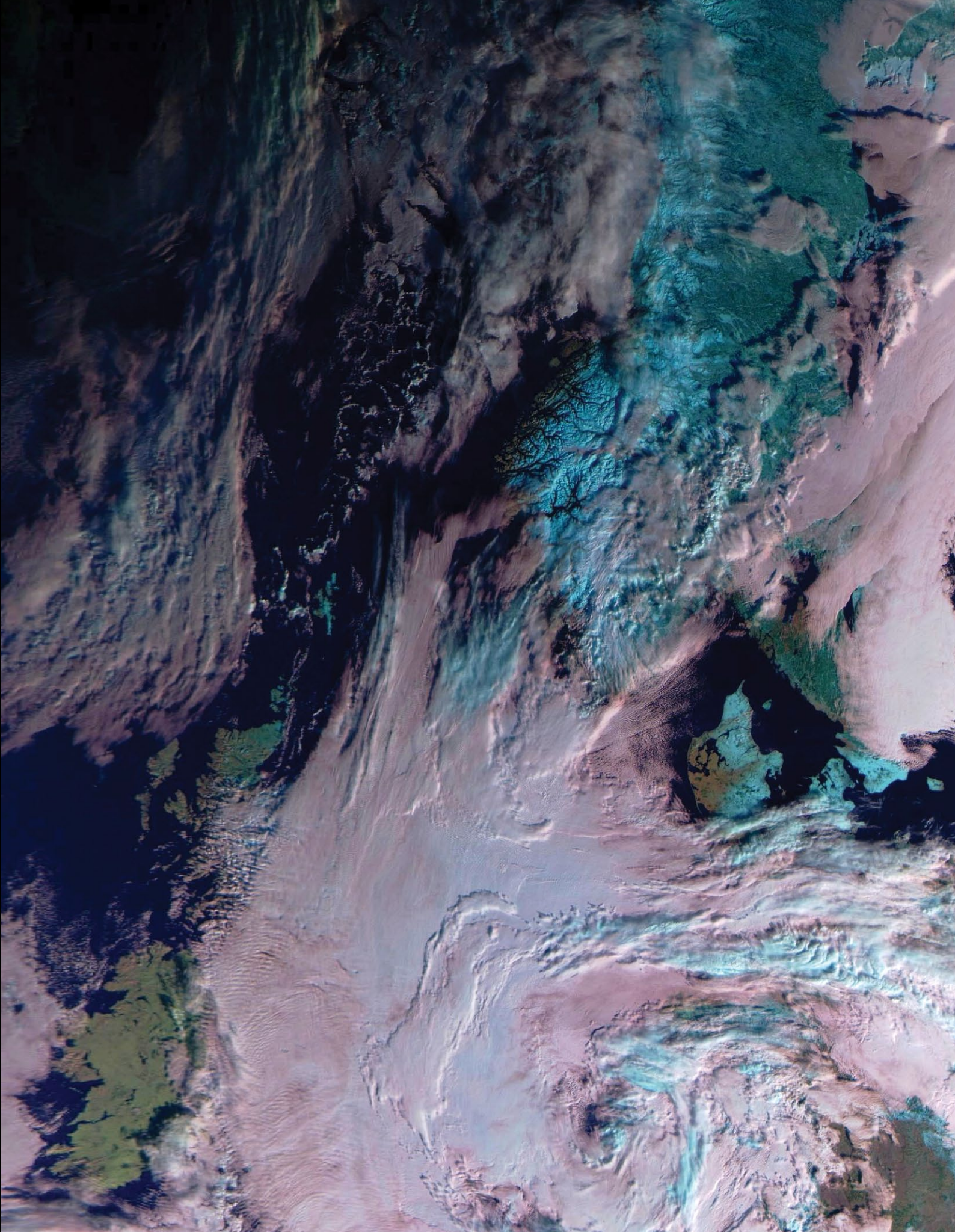
On January 31, 2017, the Moderate Resolution Imaging Spectroradiometer (MODIS) flying aboard NASA's *Terra* satellite captured a stunning true-colour image of cloud vortices induced by the island of Cheju Do, South Korea.

The swirling patterns are being formed by the turbulence created when southward-flowing air strikes the broad face of Mount Halla—a tall, broad-faced mountain that rises to 1,950 metres. The turbulent wind causes the clouds to flow in the large, spinning eddies seen in this image.

Known as von Karman vortex streets, such patterns occur in many situations, such as the vibration of a car antenna at specific speeds, or wind impacting buildings. The size and shape of the eddies formed by the unsteady flow of a fluid around blunt bodies can be predicted with good accuracy via mathematical formulas, and this aspect of fluid dynamics is important in science, meteorology, and engineering. Only when clouds are present, however, is this beautiful pattern visible in the atmosphere.



This image of North America's Great Lakes comes from a February 9 **Meteor M2** image posted on the GEO-Subscribers **YAHOO** Group by Jeff Kelly.



Periodically, Russia's **Meteor M2** satellite transmits three visible light channels, as here, on February 11. This segment comes from an image submitted by Enrico Gobbetti, and the cyan colouration highlights areas covered by snow, frost or ice.

LAND VIEWER

Inspect Sentinel 2A imagery at 10 metre/pixel resolution

Les Hamilton

ESA's *Sentinel-2A* satellite, launched in June 2015, has the capability of imaging the Earth at a resolution of ten metres per pixel. Thanks to cloud-based GIS analysis service *EOS Data Analytics*, it is now possible for anyone to inspect the Earth's surface in exquisite detail by means of their Land Viewer website at

<https://lv.eosda.com/>

Visit this URL and click the prominent 'Open Land Viewer' button.

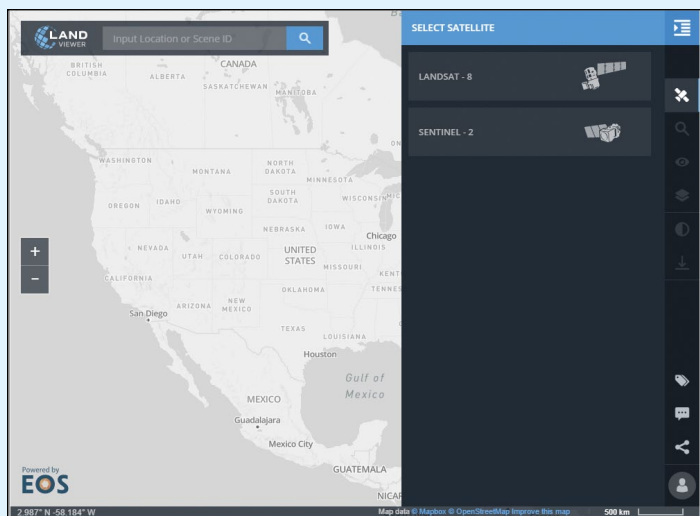


Figure 1 - The opening Land Viewer screen

Land Viewer's opening screen (figure 1) displays two panels: a scrollable/zoomable map of the Earth and 'Select Satellite'. To use the software, select the desired satellite (which, from the perspective of this article is *Sentinel-2A*), then drag/zoom the map to the desired location with the mouse. Zooming can also be achieved using the +/- buttons at the left of the display or by a wheel-mouse.

As soon as you select a satellite, a grid is superimposed over the map (though it is not visible until you have zoomed in three times). This grid, based on the NATO *Military Grid Reference System* [1], consists of 100 kilometre squares, each of which may relate to a tile of Sentinel-2A imagery. Figure 2 shows this grid overlain upon The Netherlands.

Click on a square to highlight it (figure 3) and a panel of images will appear in the right-hand panel. Be patient as it may take several seconds for the images to download. The default images shown all contain excellent land detail with at maximum, 10% cloud cover. Grid squares wholly over the sea do not contain imagery.

Finally, click on the image of choice to load it into the grid square (figure 4). You can zoom into this image and scroll around as described above. You can hide the right-hand panel and view this image full-screen by clicking the 'Toggle Panel' icon at the right of the screen.

Program Options

Once you have loaded a satellite image, the column of icons to the right of the right-hand panel all become active.

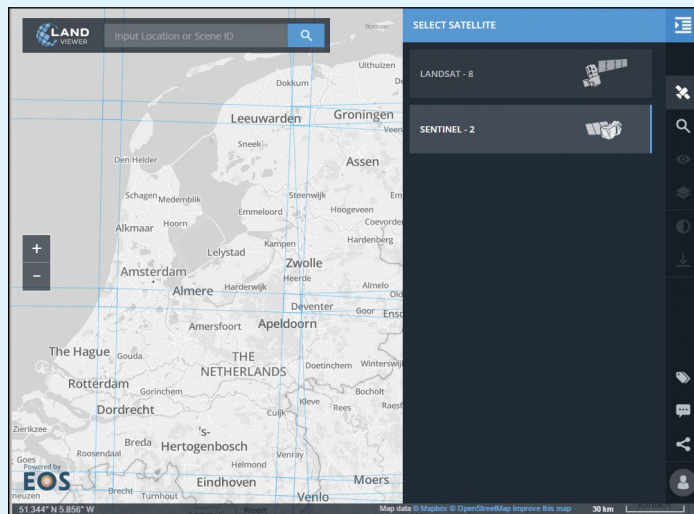


Figure 2 - The grid that is displayed as soon as a satellite is selected

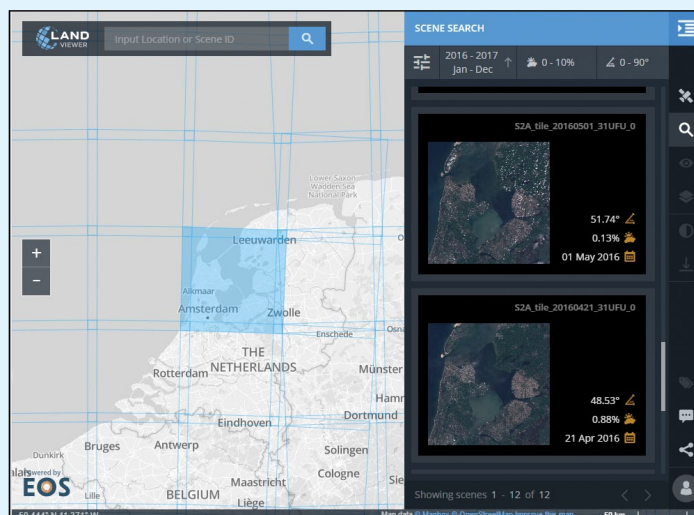


Figure 3 - Select the Tile of interest

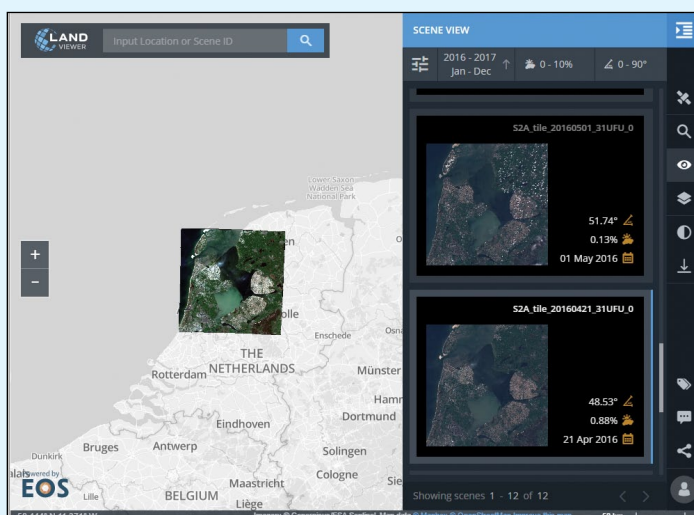


Figure 4 - Select an image from the scrollable side panel

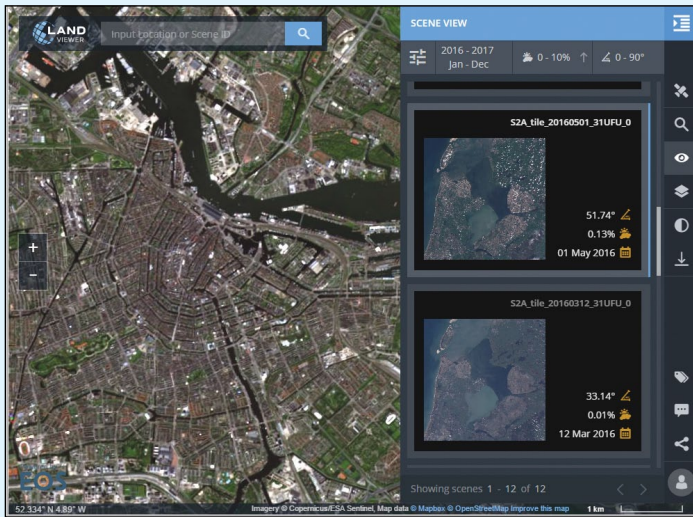


Figure 5 - A zoom into the Amsterdam canal system

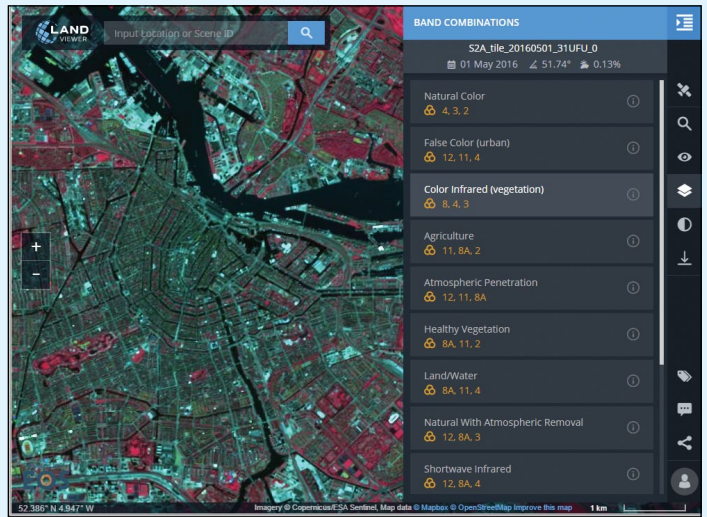









Figure 6 - The same scene with channel 8 replacing the red component

-  **Satellite:** Select between *Landsat-8* and *Sentinel-2A* data.
-  **Scene Search:** removes any image displayed on the map and displays the grid
-  **Scene View:** displays the selected thumbnail image on the map and hides the grid
-  **Band Combinations:** by default, a true colour image is displayed by combining channels 2, 3 and 4 (the blue, green and red channels from the satellite). But Sentinel-2 images in thirteen distinct frequency ranges, and this option allows you to vary the combinations used. Figure 6 shows channels 3, 4 and 8 in combination (vegetation).
-  **Contrast and Stretching:** a panel appears with controls that allow you to adjust the contrast of the displayed scene.
-  **Scene Downloading:** this reveals the Download Options from which you can download full-resolution original images. As explained in the following article, David Taylor has developed software that can, specifically, combine the red, green and blue *Sentinel 2A* tiles into a coloured image. To download, hover the mouse over the 'B02 - Blue' option and a down-pointing arrow appears at the right: click this to start the download. Repeat for the 'B03 - Green' and 'B04 - Red' bands. All three can be downloaded simultaneously.
-  **Labels:** Clicking this icon adds labels to the image, as appropriate. Applied to figure 7, main roads in the city are highlighted along with the caption 'Amsterdam'. Figure 8 shows how the full tile responds to the 'Labels' button.

Other Options

The final three buttons offer, respectively:

- Feedback on the map
- Map sharing
- Log in/out

Although you must log in to use *Land Viewer*, usage is free.

Locating Areas of Interest

It goes without saying that, with 10-metre resolution available, the main value of *Sentinel 2A* images comes when you zoom in to small regions: cities, oceanic islands, mountains, lakes and man-made structures all provide fascinating viewing.

But how can you locate a tiny island, St Helena for example, which is simply a tiny dot in a vast expanse of ocean? At the

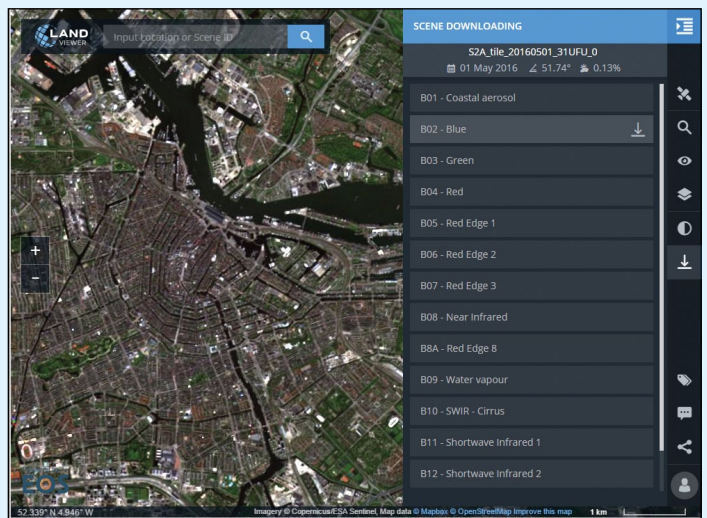


Figure 7 - The download screen showing the blue tile selected

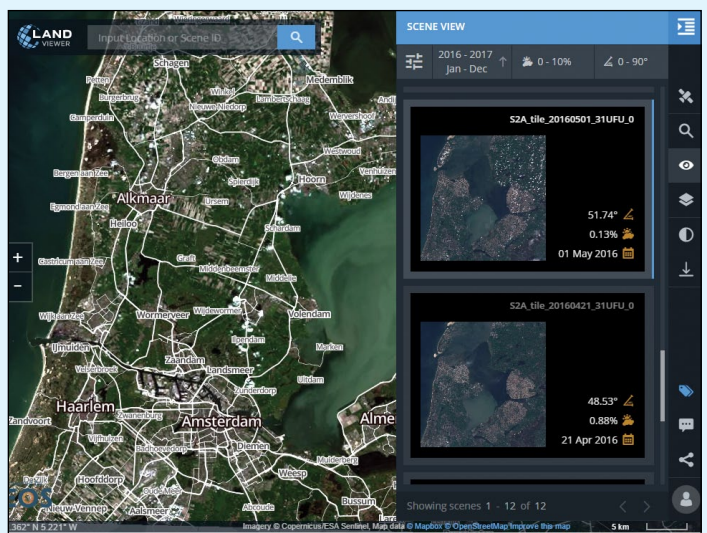
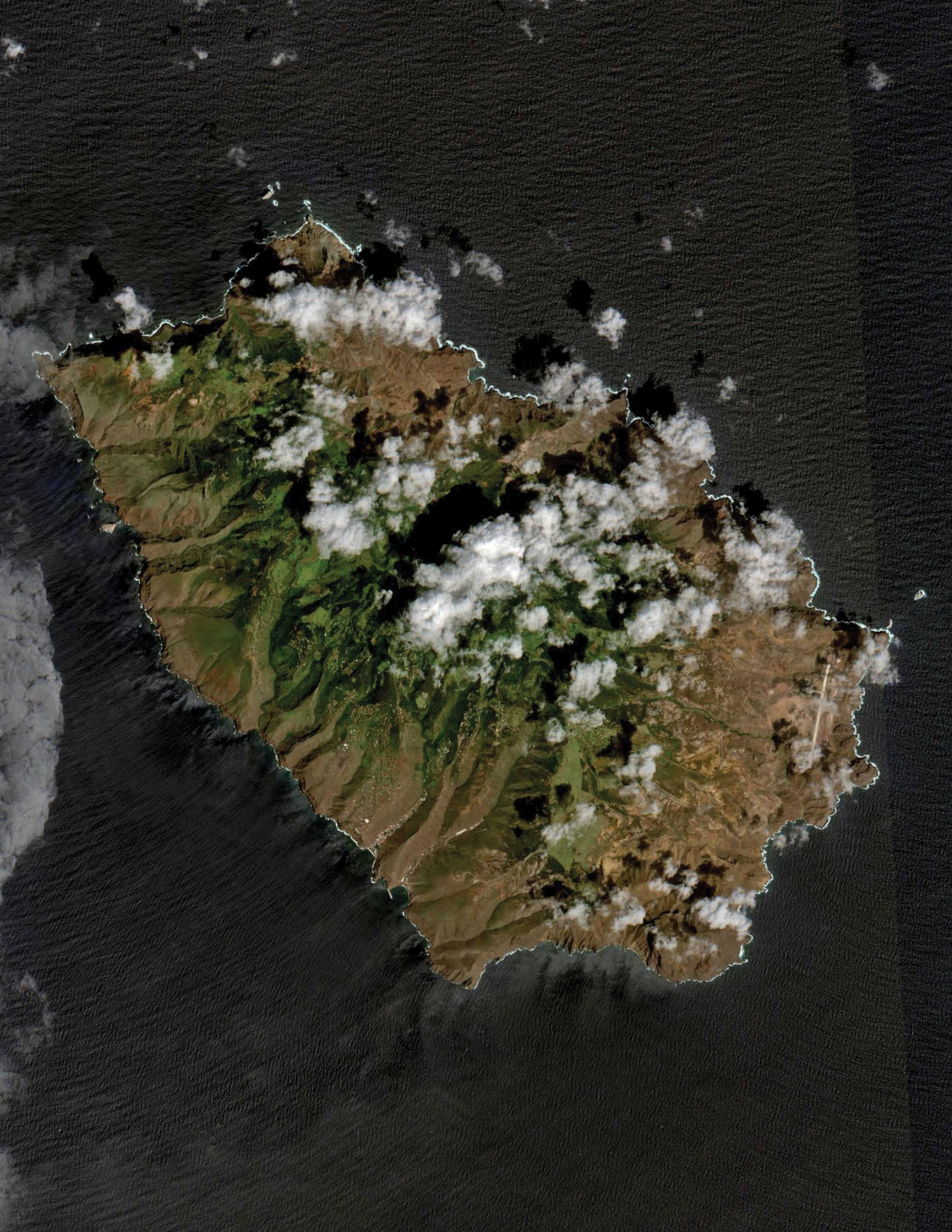


Figure 8 - Labelling applied to the entire tile

bottom left margin of the *Land Viewer* screen is a display of the latitude and longitude of the cursor. These change as you scan the map with your mouse. I started by looking up the coordinates of St Helens on the internet than placed the cursor as close to this on the World Map. Successive double-clicks on this spot to zoom into the map coupled with repositioning of the cursor each time soon brought St Helena into view. The result can be seen overleaf.

Reference

- 1 https://en.wikipedia.org/wiki/Military_Grid_Reference_System



The Atlantic Island of St Helena, imaged by ESA's Sentinel-2A satellite on April 2, 2016. The island measures just 16 × 10 kilometres.
Image: Modified Copernicus data © ESA / Sentinel (2016)

Sentinel2toJPEG

New software for creating Sentinel 2A colour images

Les Hamilton

As explained in the previous article, high-resolution imagery from ESA's *Sentinel-2A* satellite is now available on the *Land Viewer* internet site. It is perfectly feasible to view image tiles within *Land Viewer*, but wouldn't it be much more satisfying to be able to download the individual red, green and blue data channels and combine them into colour composites yourself? Well, now you can!

David Taylor has produced the **Sentinel2toJPEG** program which, in addition to allowing the user to create colour composite images of individual *Sentinel* tiles, also affords control over the extent of histogram equalisation and gamma correction, as well as the ability to define cropping areas. The software is available in both 32- and 64-bit versions.

Sentinel Tiles

Segments of imagery from *Sentinel 2A* passes are available as 'tiles', each of which contains a scene measuring 100 × 100 km. These tiles correspond with squares on the NATO *Military Grid Reference System*, which covers the entire surface of Earth. Not all tiles contain *Sentinel* imagery however: many of those above land and some (but not all) small oceanic islands do so. Of the thirteen spectral bands sensed by *Sentinel 2A*, those for blue (490 nm), green (560 nm) and red (665 nm) are realised at the maximum 10 metres per pixel ground resolution of the satellite's multi-spectral instrument (MSI). It is these three channels that are processed by **Sentinel2toJPEG**.

Once you have selected a tile, download the three RGB images as explained in the preceding article. Although every tile has a specific descriptor which includes the date and tile name, the files you download always have the following basic names:

B02.jp (blue)
B03.jp (green)
B04.jp (red)

David Taylor recommends that you should immediately rename these by prefixing them with the tile descriptor. For the Amsterdam tile used earlier, this would give:

S2A_tile_20160501_31UFO_0-B02.jp
S2A_tile_20160501_31UFO_0-B03.jp
S2A_tile_20160501_31UFO_0-B04.jp

I prefer to name images after a prominent feature in the tile itself, e.g.

Gibraltar_20160924-B02.jp
Gibraltar_20160924-B03.jp
Gibraltar_20160924-B04.jp

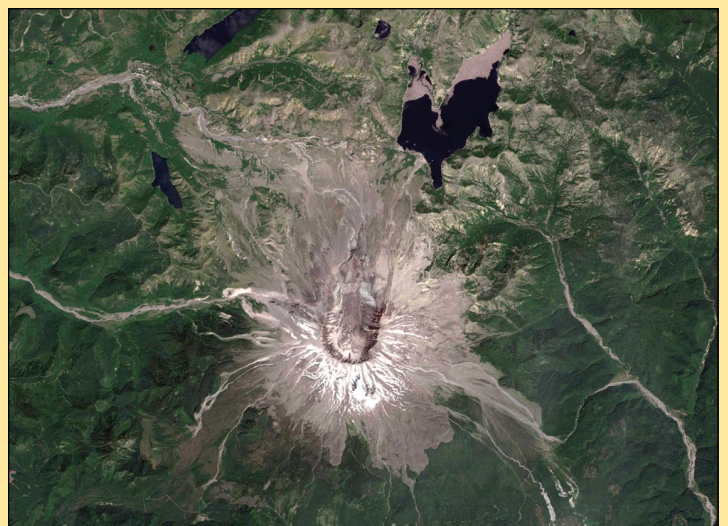
The choice is yours. But it is vital that the names are identical, with the sole exception of the respective suffixes 'B02.jp', 'B03.jp' and 'B04.jp'. Without these, the software cannot identify the three channels correctly, and processing will not take place.



Bay of Gibraltar on September 24 - Gibraltar is the peninsula on the east
Modified Copernicus data © ESA / Sentinel (2016)



The south end of Lake Mead with the Hoover Dam
Modified Copernicus data © ESA / Sentinel (2016)

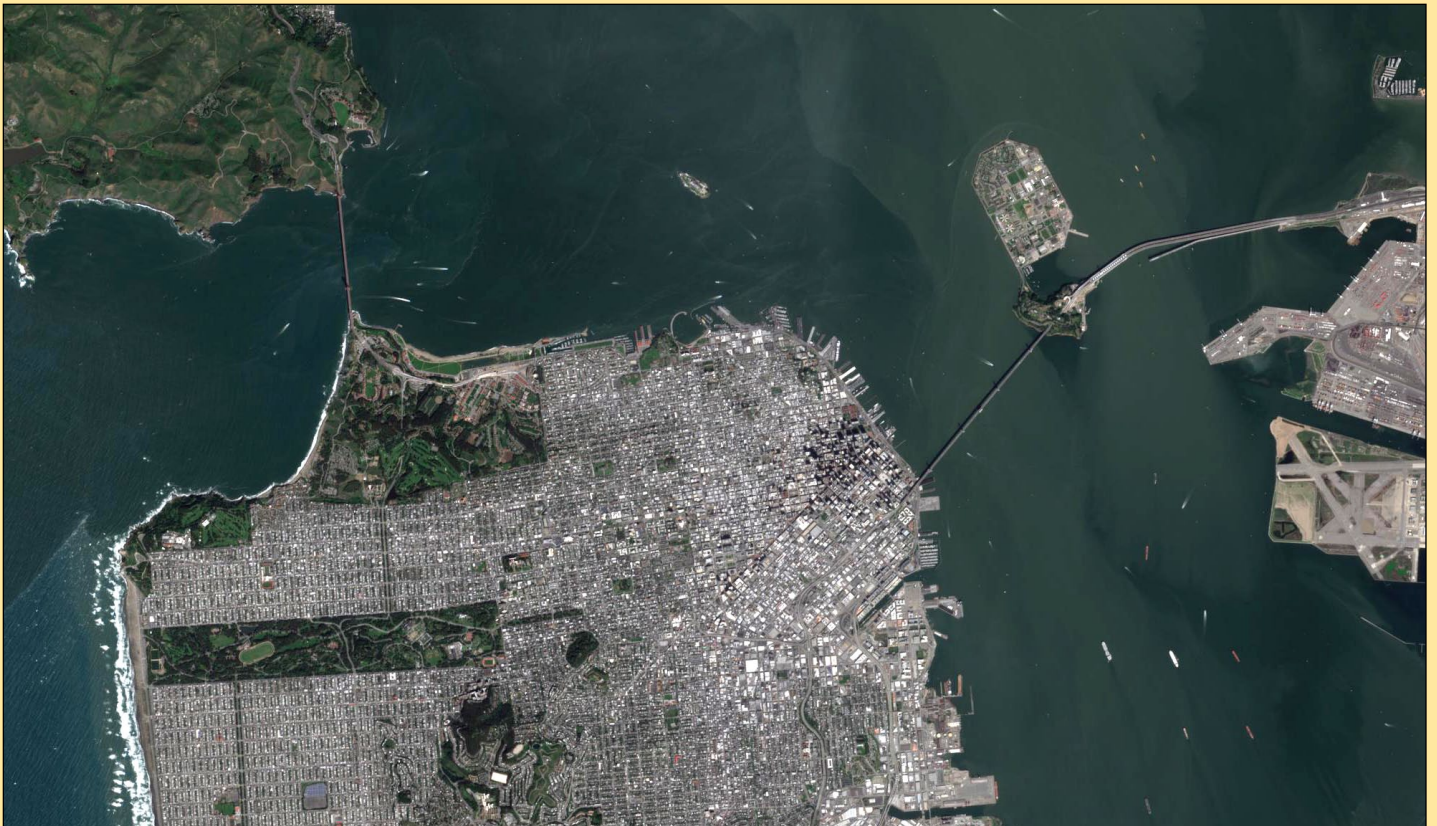


Mount Saint Helens in Washington State
Modified Copernicus data © ESA / Sentinel (2016)

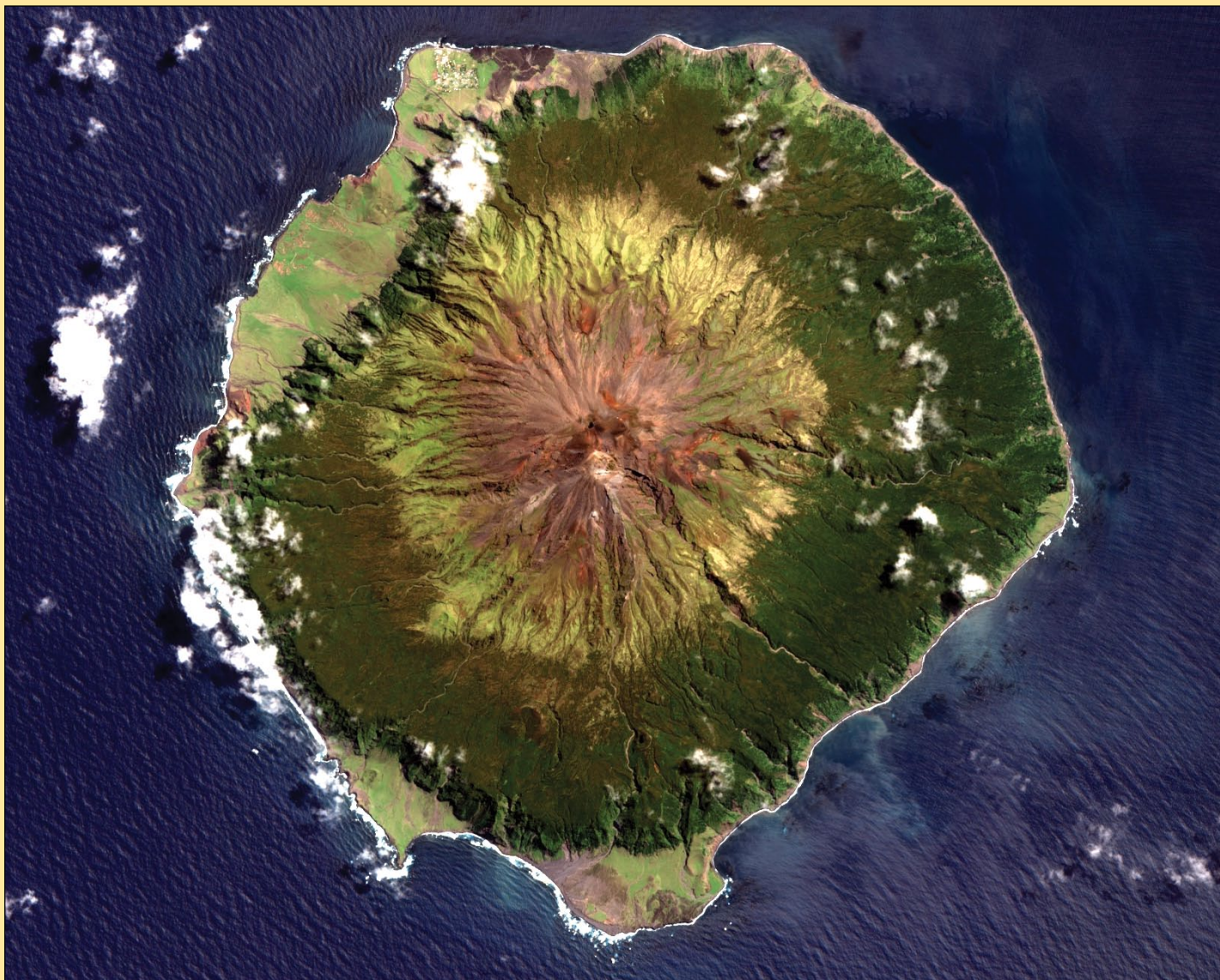
... continued on page 33



The cross-Channel Ferry terminal at the port of Zeebrugge, Belgium.
Modified Copernicus data © ESA / Sentinel (2016)



San Francisco Bay on March 26, 2016, with the Golden Gate bridge at left and Alcatraz the small Island to its right.
Modified Copernicus data © ESA / Sentinel (2016)



The volcanic South Atlantic island of Tristan da Cunha, only 12 kilometres wide and with a population of 265 hardy souls.
 Modified Copernicus data © ESA / Sentinel (2016)

The files you download are losslessly coded in the JPEG2000 [1] format, one, alas, that most current viewing and graphics programs do not recognise. Hence the impetus to create a software package that would not merely load these tiles, but could combine them into a true colour images like the segments illustrated on these pages. You can read David’s own web article on this topic at

<http://www.satsignal.eu/wxsat/Sentinel/Sentinel-2A.html>

Sentinel tiles measure 10980 pixels in both dimensions, which works out at a nominal resolution of 10 kilometres per pixel at nadir. Consequently, the files you download are large, even with JPEG2000 compression, and typically measure between 90 MB and 130 MB each. This means that processing is a relatively lengthy process, and even with a fairly fast computer, Sentinel2toJPEG will take around ninety seconds to produce an image from a set of three Sentinel 2A JPEG2000 image tiles.

The Sentinel2toJPEG Software

This program comes as a zip file which contains both the 32- and 64-bit versions. Also included is a copy of the essential *FreeImage.dll* library file for each version.

The first time you attempt to run the 64-bit version of Sentinel2toJPEG, you may be confronted by an error message stating that the library file VCOMP120.DLL is missing.

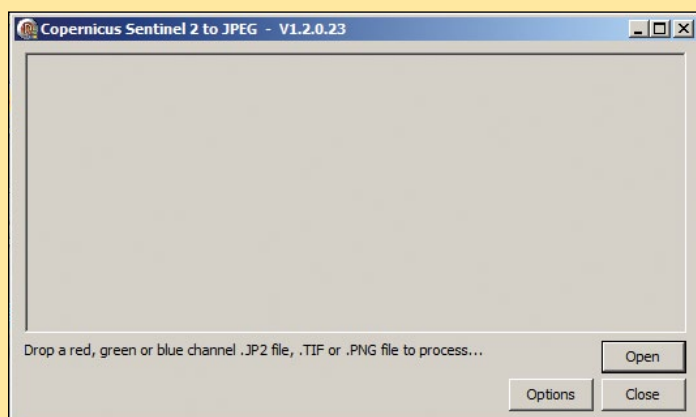


Figure 1 - The Sentinel2toJPEG program interface

If so, you must download and install Microsoft’s *Visual C++ Redistributable Package for Visual Studio 2013* from

<https://www.microsoft.com/en-us/download/details.aspx?id=40784>

The 32-bit version does not require this file.

This new software comes with a refreshingly simple interface which can be resized from full-screen right down to the size of a postage stamp: and the only controls are the three buttons you can see in figure 1.

	Windows 10 64-bit 4 core Intel i5-4460 8 GB RAM		Windows 7 64-bit 4-core AMD A6-6310 8 GB RAM		Windows 7 64-bit 2-core Intel i7-620M 4 GB RAM		Windows 7 64-bit 2-core Intel Duo E4600 4 GB RAM	
	32-bit	64-bit	32-bit	64-bit	32-bit	64-bit	32 bit	64 bit
3 × JPEG2000 files	96.6 sec	86.2 sec	201.1 sec	192.8 sec	116.1 sec	105.2 sec	190.6 sec	180.4 sec
1 × 48-bit PNG file	12.3 sec	10.9 sec	27.2 sec	25.1 sec	15.5 sec	14.4 sec	22.9 sec	23.2 sec
1 × 48-bit TIFF file	6.4 sec	6.2 sec	14.4 sec	14.3 sec	12.8 sec	12.7 sec	12.6 sec	13.4 sec
3 × Landsat TIFF files	4.0 sec	4.0 sec	8.3 sec	8.7 sec	5.9 sec	6.3 sec	10.54 sec	10.2 sec

Table 1
Comparative processing times for both versions of Sentinel2toJPEG on various computers

To process your first *Sentinel* image, just load any one of the *Sentinel* RGB files, either by dragging it on to the interface, or by clicking the ‘Open’ button and navigating to its folder and double-clicking the one of your choice. Note that you only have to load one of the three files: the software will then automatically load all three (the open dialogue normally displays only the ‘Blue’ B02 tile. However, if you load the ‘Near Infrared’ B08 tile, this shows up as well - see Appendix on page 32).

From this point you will face a delay until the image is ready. The bulk of this time is required to decipher the wavelet-based coding within the JPEG2000 files: once that is achieved, the final RGB image follows swiftly and is automatically saved in standard jpg format in the same folder as the original files. Do not panic if a ‘Program not responding’ message appears in the title bar: this may occur because the program is hogging the computer’s resources—but processing is continuing. Just be patient for a while and check the progress messages at the lower left of the **Sentinel2toJPEG** interface as it decodes the red, green and blue images in sequence. Table 1 shows timings for various processes using both the 32-bit and 64-bit versions of **Sentinel2toJPEG**.

I have tested both the 32- and 64-bit versions of **Sentinel2toJPEG** using four different computer systems, one running *Windows 10 Home* and three *Windows 7 Home*. The top line of the table shows the times taken to completely process the same set of three JPEG2000 files. The 64-bit version of the software is marginally faster than the 32-bit compilation, but the overall processing time depends mainly on the speed of the processor (all other things being equal).

ThreeJP2toPNG48

If you wish to process a particular set of JPEG2000 files several times—to optimise gamma and histogram stretching for example—this could turn out to be a lengthy exercise.

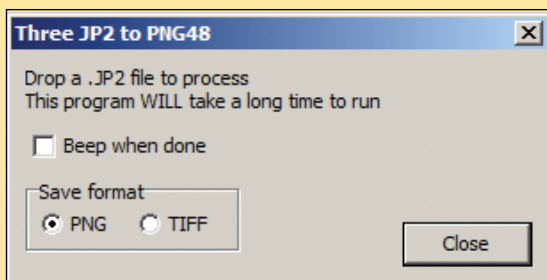


Figure 2 - The ThreeJP2toPNG48 interface

The solution to this problem comes via a small ‘helper’ application named **ThreeJP2toPNG48**. This utility can process a set of JPEG2000 files into a single 48-bit PNG file, a common format that can be read quickly (or, if you prefer, as a 48-bit TIFF file). Although it can take several

minutes to create these files, both the PNG and TIFF files process rapidly in **Sentinel2toJPEG**: see Table 1 for details.

Options

When you click the ‘Options’ button on the program interface, the *Sentinel2 Reader Setup* panel appears. Figure 3 displays the default settings.

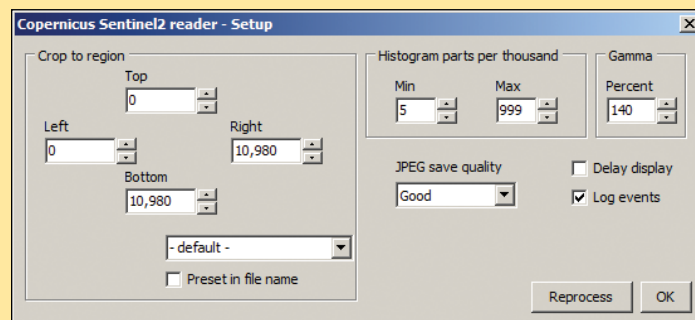


Figure 3 - The default Setup panel

Here you find options to process a cropped section of a *Sentinel* tile, crop the extremities of its histogram and adjust the gamma to optimise the brightness of the processed image.

Crop to Region

When processing an image—such as that of Tristan da Cunha shown on the previous page—the area of interest is an island just twelve kilometres wide in an image tile stretching one hundred kilometres along each side. The first time I processed this *Sentinel* tile, I ended up with the image shown in figure 4, where the island is highlighted in the white square.

If you wish to image a specific region regularly, it would be much more manageable if the software could process just the immediate area of interest and save that alone. This is what the ‘Crop to Region’ options are designed to achieve.

On completion of tile processing in **Sentinel2toJPEG**—once the ‘Saved as’ message appears at the lower left of the screen—the X- and Y-coordinates of the position of the cursor above the final image are shown in the bottom left-hand corner of the display. By scrolling the image and positioning the cursor successively above, left, below and to the right of the area required, appropriate Y-values can be established and entered into the ‘top’ and ‘bottom’ fields of the *Setup* panel; similarly, the X-values can be entered into the ‘left’ and ‘right’ fields (figure 5). Now, when the tile is reprocessed, only the desired area appears on screen, and in the saved image.

The **Sentinel2toJPEG** zip archive contains a file named ‘Sentinel2toJPEG-sample.ini’ which contains a list of presets for the program, Tristan da Cunha among them. If you copy this file into the *Sentinel2toJPEG* folder and

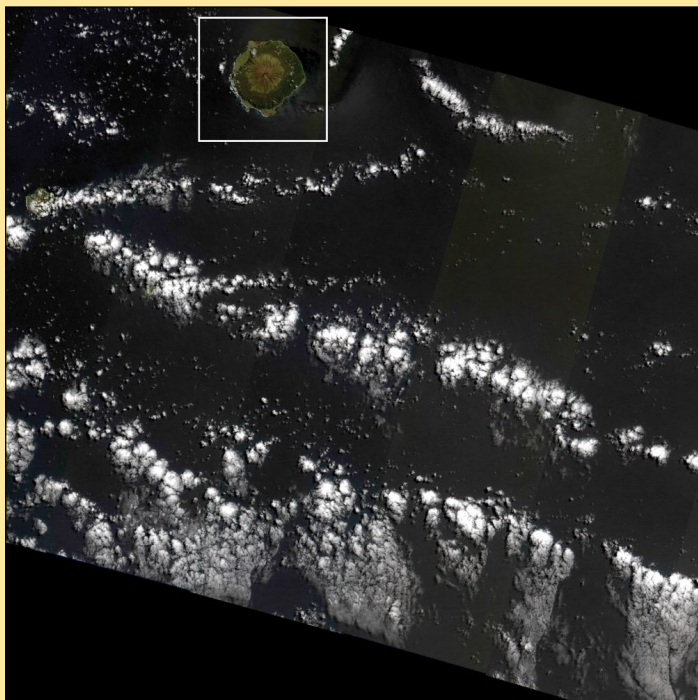


Figure 4 - The complete Sentinel 2 tile containing Tristan da Cunha with the volcanic island highlighted in the white square.

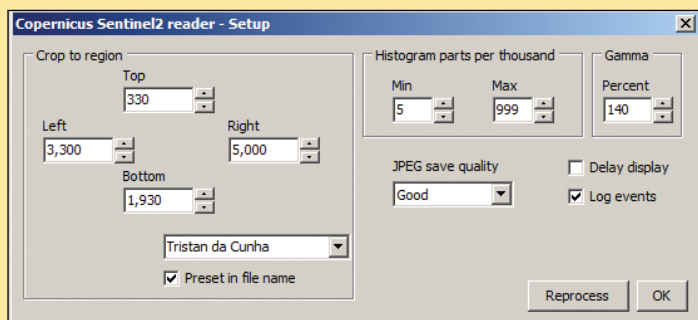


Figure 5 - Tristan da Cunha crop parameters

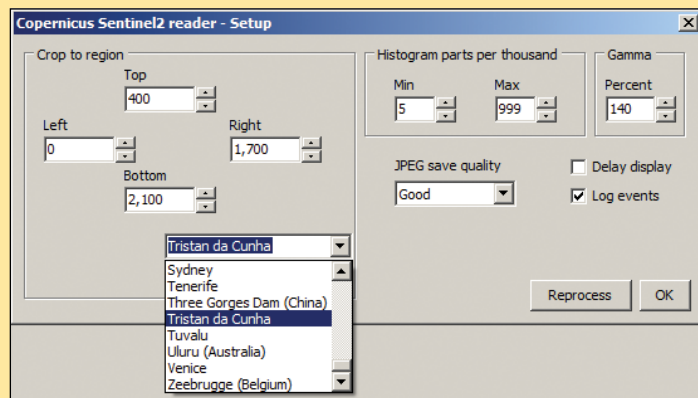


Figure 6 - The crop drop-down list

rename it to 'Sentinel2toJPEG.ini', a drop-down list containing all these presets becomes available. This is simply a text file, which you can edit in any way you wish. Just ensure that the [CROP] line is present at the start of the list otherwise the program will not recognise the entries.

Reprocess

Provided you do not close the Sentinel2toJPEG program, the 'Reprocess' button allows you to make alterations to the 'Histogram' and 'Gamma' settings and quickly process the same Sentinel tile multiple times (this saves having to keep reloading the files). This can be a great help in producing images with the optimum range of tones and brightness.

Setting the Crop to Default Values

If, after setting a cropping preset, you wish to prepare an image of a complete tile, the crop values can be returned to their defaults by clicking '- default -', the top item in the drop-down menu.'

Delay Display

This option, when ticked, prevents the red, green and blue images from appearing on screen during the processing operation. Only the final RGB composite is displayed. This could be of benefit if your processor struggles handling the three JPEG2000 files.

Note that this change requires that the program be closed down and run afresh (a warning message appears).

Log Events

If this box is ticked, the program produces a log file that details precisely how long is taken over each task during the processing of an RGB image. Again, a restart is required to enable a change in status.

JPEG Save Quality

This selector allows three save options: normal, good and superb. Personally, I can only just detect the difference between these, but of course the better the quality the larger the file size. If file size is important, the 'normal' option will serve you well.

Troubleshooting

As you build up a list of presets for Sentinel2toJPEG, a time may come when you discover that a particular preset no longer works as expected: the main area of interest could lie off-centre or, if quite small, off screen altogether.

This had me puzzled for a while until I looked more closely at Land Viewer. Although a given tile will most commonly offer just one Sentinel image on a given date, sometimes there are two: one each from the satellite's northbound and southbound passes. As the satellite track will differ for each pass, the exact location of features within the tile will alter slightly between the two image. Not serious, but something to be aware of.

Creating Composite Images

Frequently, a feature of interest such as a city or island straddles the boundaries of two or even four Sentinel tiles. A typical case is the island Majorca, illustrated in figure 7.

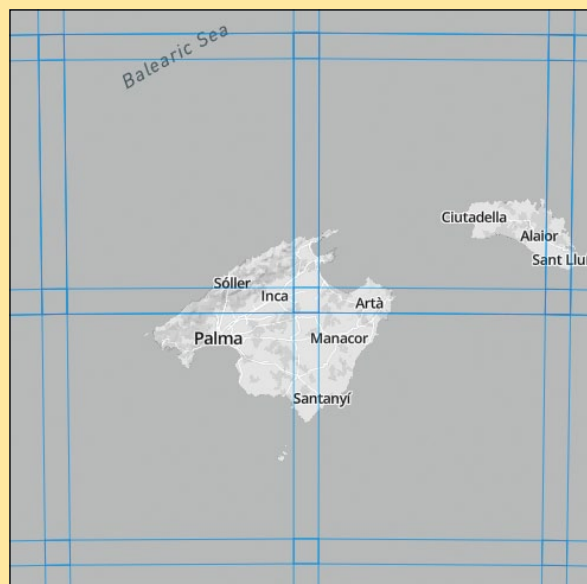


Figure 7 - Majorca straddles four Sentinel tiles

A glance at the figure shows that there is considerable overlap between adjacent tiles, approximately nine percent, in fact: so joining the four sections should be feasible.

For my first effort, I searched for the appropriate set of four tiles from the same *Sentinel* pass (not always possible) and discovered what I required on August 26, 2016. I prepared appropriate presets for the four sections and prepared the coloured composite images, which proved easy to slide together in Photoshop. But there was a problem: the brightness characteristics of the four segments were slightly different, as is clear in the resulting composite image of Majorca (figure 8).

Many photographers these days are in the habit of stitching together series of photographs to create panoramic views. I do this with *Autopano Pro* [2]. Because this software caches its workspace on the hard drive, it easily copes with the full-size tile images, saving the bother of creating presets for the four quadrants of Majorca. The program also intelligently compensates for any differences in illumination between photographs. To my delight, my first effort was perfect: there was absolutely no indication of the joins (figure 9). Because the original images were rather bright for my taste, both those illustrated were initially processed with a gamma value of 100.

Locating Small Target Areas

One of the problems of locating the correct tile for small islands is that they are hard to spot until you



Figure 8

The initial Majorca composite image, compiled using *Photoshop*, which showed brightness variations between quadrants.

zoom a long way into the world map. This was true of Tristan da Cunha, for example. But there is an easy way to locate it because, at the very bottom left of the *Land Viewer* screen there is a display line showing the latitude and longitude beneath the mouse cursor. I looked up the latitude/longitude of Tristan da Cunha in *Wikipedia* and moved the mouse as close to this as possible. There was as yet no sign of the island but, by successively zooming the map and correcting the mouse to these coordinates, it eventually came into view, allowing me to select the appropriate tile.

... continued on page 38



Figure 9 - The Majorca composite image, compiled using *Autopano Pro*, which produced a perfectly balanced result.

Modified Copernicus data © ESA / Sentinel (2016)



The Caribbean holiday island of Aruba, imaged by Sentinel 2A on May 16, 2016
Modified Copernicus data © ESA / Sentinel (2016)

But a word of caution: whether this is an arcane American way of denoting coordinates, or is simply an error, I do not know. But the coordinates at the foot of the screen are always suffixed by 'N' for latitude and 'W' for longitude: never 'S' or 'E'. Latitudes south of the equator are negative and those north positive; longitudes west of Greenwich are always negative and those to the east of it positive.

So, the correct location of Tristan da Cunha is:
Latitude 37°04' south, Longitude 12°19' west

Land Viewer quotes it as:

Latitude -37.15°N, Longitude -12.26°W

I know this is absolutely bonkers, but that's the way it works (at present anyway).

As yet, all small islands in the ocean have not been viewed by *Sentinel 2A* (e.g. Ascension island), so these are worth looking out for as the image bank builds up in future.

Landsat-8 Images

Finally, as an 'optional extra', you can also process the Landsat-8 tiles offered by *Land Viewer*. These, however, have a ground resolution of only 30 metres/pixel. The process is similar, but Landsat tiles are in TIFF format and you must load them into **Sentinel2toJPEG** by dragging, or using the 'All files (*.*)' option.

Appendix - Near Infrared Sentinel Tiles

A recent addition to David Taylor's **Sentinel2toJPEG** software is the option to substitute the near-infrared band (842 nm)—the only other of the thirteen offering 10-metre resolution—for the red component of composite images. Download the following files

B03.jp (blue)

B04.jp (green)

B08.jp (red)

and proceed as before. If you have also downloaded the B04.jp file, be sure that it's the B08.jp file that you drag/load into the program.

The resulting images show vegetation cover in shades of red, which can be useful for analysing the terrain in an image. It is recommended that the gamma be lowered into the range 80-100 for optimum rendition. Figure 10 compares the true-colour RGB432 image with the infrared RGB843 one for largely cultivated terrain.

References

- 1 JPEG2000
https://en.wikipedia.org/wiki/JPEG_2000
- 2 Autopano Pro
<http://www.kolor.com/autopano/>

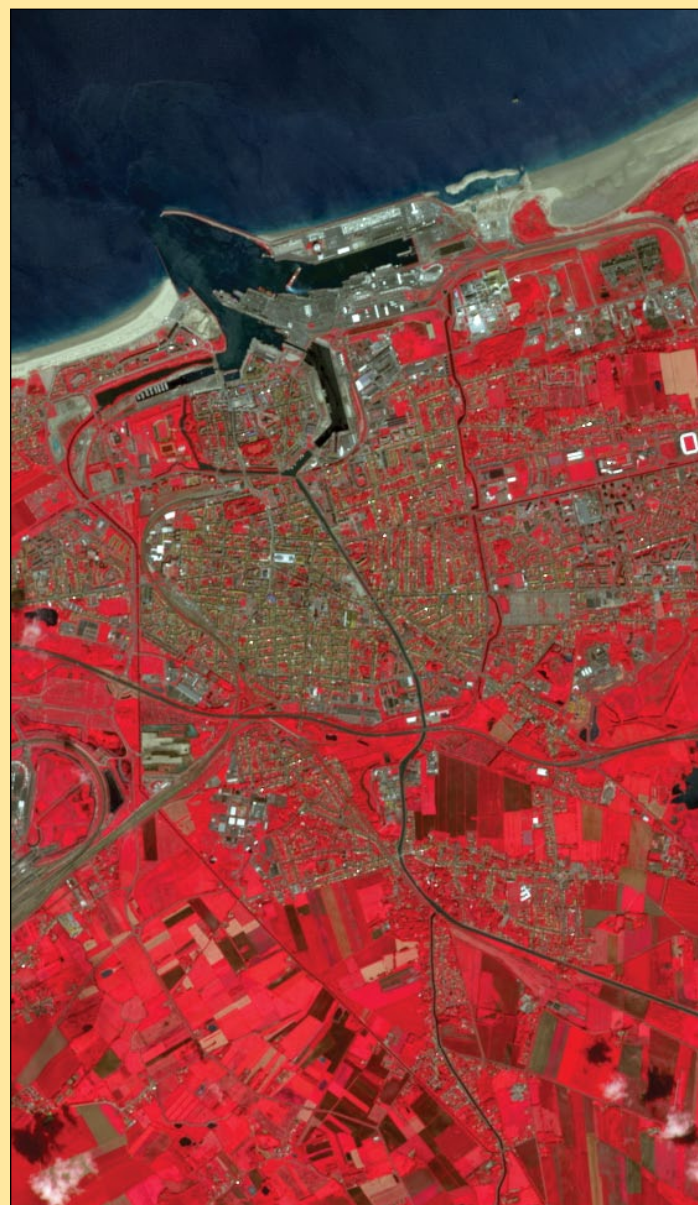
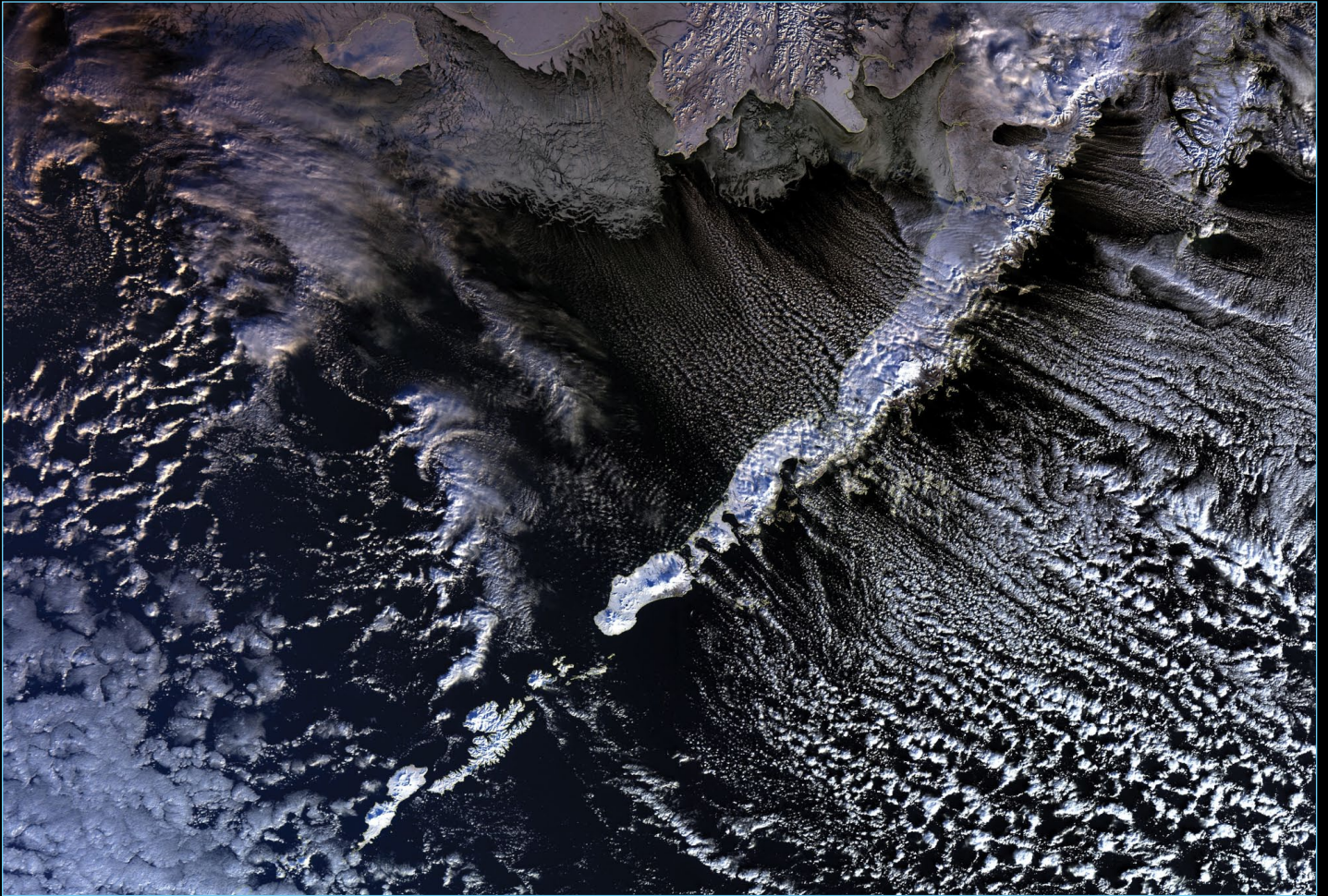


Figure 10 - The French port of Calais and its hinterland, imaged by Sentinel 2A on June 23, 2016. The two images illustrate the true-colour RGB432 band combination (left) and the vegetation RGB843 version (right), where rectangular fields of crops show in shades of red.

Modified Copernicus data © ESA / Sentinel (2016)



This Sentinel 3A segment acquired on January 21, 2017 by Peter Kinghorn depicts the Aleutian Islands south of Alaska
Image © EUMETSAT 2017



This Sentinel 3A segment acquired on January 22, 2017 by Peter Kinghorn shows the plain of the River Ganges
Image © EUMETSAT 2017

Muted La Niña Follows Potent El Niño

NASA Earth Observatory

One year ago, the central and eastern parts of the tropical Pacific Ocean were pulsing with heat, a result of one of the most intense El Niño events on record. One year later, La Niña has been relatively quiet, and she does not seem to be staying for long.

La Niña is the cool sister pattern to El Niño. While El Niño knocks down the easterly trade winds and sashes warm water from the western Pacific to the Americas, La Niña pulls up cool water from the depths of the eastern Pacific, energises the easterlies, and pushes the warm water back toward Asia. Regions that are often drenched with rain and snow during El Niño often go dry during La Niña events—and vice versa—as atmospheric circulation and jet streams shift with the changing heat and moisture supply from the vast Pacific Ocean.

The maps in figure 1 compare sea surface height anomalies in the Pacific Ocean as observed by NASA scientists on November 4, 2016, near the peak of the current La Niña, and on January 18, 2016, near the peak of last winter's El Niño.

The measurements were made by altimeters on the **Jason-2** and **Jason-3** satellites, and show averaged sea surface height anomalies. Shades of red indicate areas where the ocean stood higher than the normal sea level: surface height is a good proxy for temperature because warmer water expands to fill more volume. Shades of blue show where sea level and temperatures were lower than average (water contraction). Normal sea-level conditions appear in white.

In a report issued in December 2016, the *NOAA Climate Prediction Center* described the latest La Niña as 'weak', and probably changing to neutral conditions in early 2017. La Niña conditions—with surface water temperatures at least 0.5° Celsius below normal in the central and eastern Pacific (in the 'Niño 3.4' region between 170° to 120° west longitude)—began to surface in July and August 2016. During last year's El Niño, surface water temperatures were as much as 2.5°C above the 1981-2010 norm. During the current La Niña, temperatures have not dropped more than 1°C below normal.

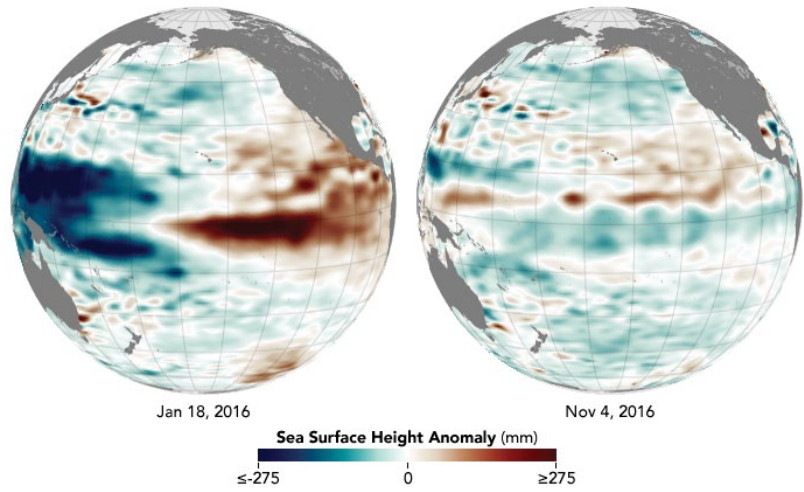


Figure 1

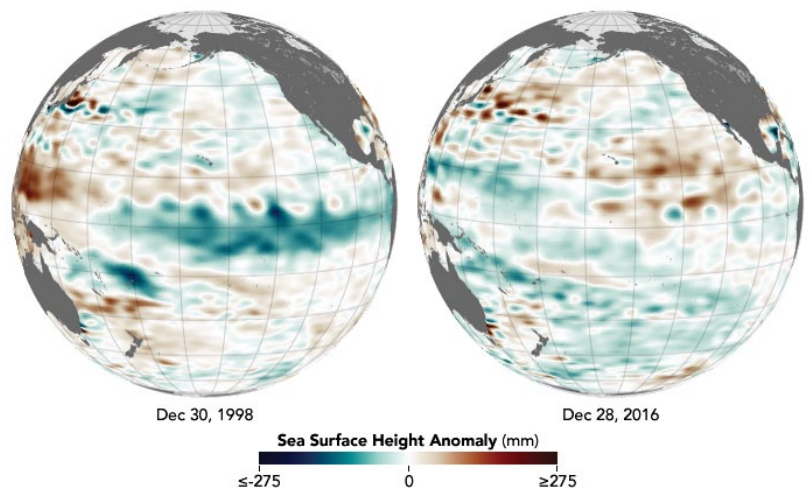


Figure 2

'Last year's Niño was huge in area, duration, and magnitude,' said Bill Patzert, a climatologist at NASA's Jet Propulsion Laboratory. 'My take is that, because it lasted so long and covered such a large area, it damped the return of the strong trade winds needed for a healthy Niña. Note the strong positive heat content north of the equator—the entire tropical Pacific between Central America and Hawaii—that lingered into the fall.'

The patterns following the great El Niño of 2015–16 have been starkly different from what occurred after the last major event. In 1997-98, very warm El Niño conditions persisted for roughly 13 months, but were then followed by roughly 32 months of well-below-normal (La Niña) water temperatures in the eastern Pacific. In 2015–2016, water temperatures and sea surface heights were above normal for 19 months, first weakly

and then with great gusto in late 2015. But this event has been followed by just five months of weak La Niña conditions that are already fading.

The maps in figure 2 compare conditions in December 2016 with December 1998, one of the strongest La Niña events on record. The data come from **Jason-3** and from the **TOPEX-Poseidon** mission.

Mike Halpert, deputy director of the *NOAA Climate Prediction Center*, noted that the current pattern is somewhat similar to 1982–83, when another strong El Niño was followed by a relatively modest La Niña.

'Just when you think you have seen everything and think you know what to expect, something happens that you just can't explain,' he noted. 'There are many rhythms and natural variabilities, and nature will always keep it interesting.'

Introducing Hugo Van Ruyskensvelde's **EUMETCastView**

David Taylor

EUMETCastView is an open source program created by Hugo Van Ruyskensvelde, which allows the user to view and manipulate data disseminated by the EUMETCast service. Data included are

- AVHRR images from NOAA-19 and Metops-A and -B
- VIIRS images from SUOMI-NPP
- OLCI EFR and ERR images from Sentinel-3A, and
- HRIT/LRIT images from the Meteosat, FengYun, GOES and Himawari-8 geostationary satellites.

Installation

The home page currently flags version 1.1.6 as the latest build but in fact version, **EUMETCastView_Windows_64bit_v1_2_0.zip** is currently available, from

<https://github.com/hvanruys/EUMETCastView/releases/>

There is no setup as such. Simply extract the Zip archive to a location of your choice, taking care to keep the directory structure intact. Note that this is a 64-bit program, and there is no 32-bit version yet available. The directory structure created on unzipping the EUMETCastView archive is shown below.

After decompressing the Zip archive, I copied the directory tree of: *DeployEUMETCastViewer* into the following directory in my working tools:

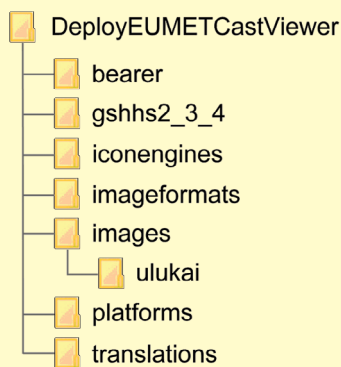


Figure 1 - The Directory Tree

Note that this cannot be placed inside *C:\Program Files* as the program needs to write files to its own directory. When a new version comes out, I can then rename *EUMETCastViewer* to, for example, *EUMETCastViewer.1.2.0* so that I have a local copy of the personalised .INI files which control the program's configuration. I may copy these .INI files to the new version's directory to save having to repeat all the setup process a second time.

Setup Screen

On opening the program you are taken to what I call the Setup View (figure 2). This is divided into three areas:

- On the left is a vertical column of icons which allow you to switch between the five views: setup, geostationary, polar map view, polar globe view, image view. The orange-handled spanner at the bottom of the column allows you to show or hide the toolbox.
- Next to the right is the toolbox which allows control of the other functions according to the mode in use.
- Finally, there is a big setup panel. You need to customise a number of elements herein, particularly the segment directories on the right-hand side, to tell the program where to look for images. You can see that I have *D:/MSG/Images/VIIRS/* and a number of others selected. The program will understand the usual *{yyyy}mm{ddd}* structure below these directories. From the TLE list, check the boxes for the satellites which interest you. I found that the default 'number of segments' was rather low for my taste, so I upped it to the maximum which appears to be 200.

continued on page 43

C:\Tools\ EUMETCastViewer

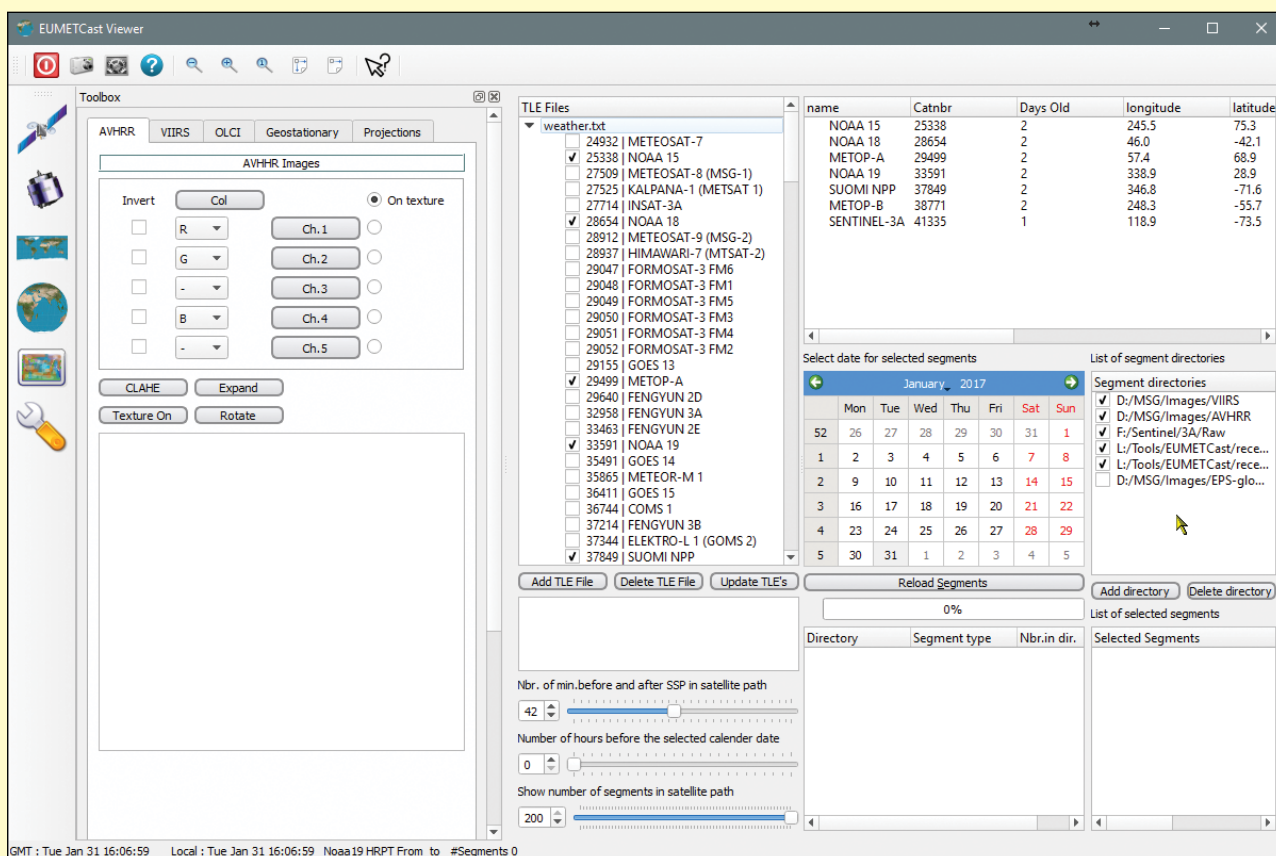


Figure 2 - The EUMETCastView Setup Screen

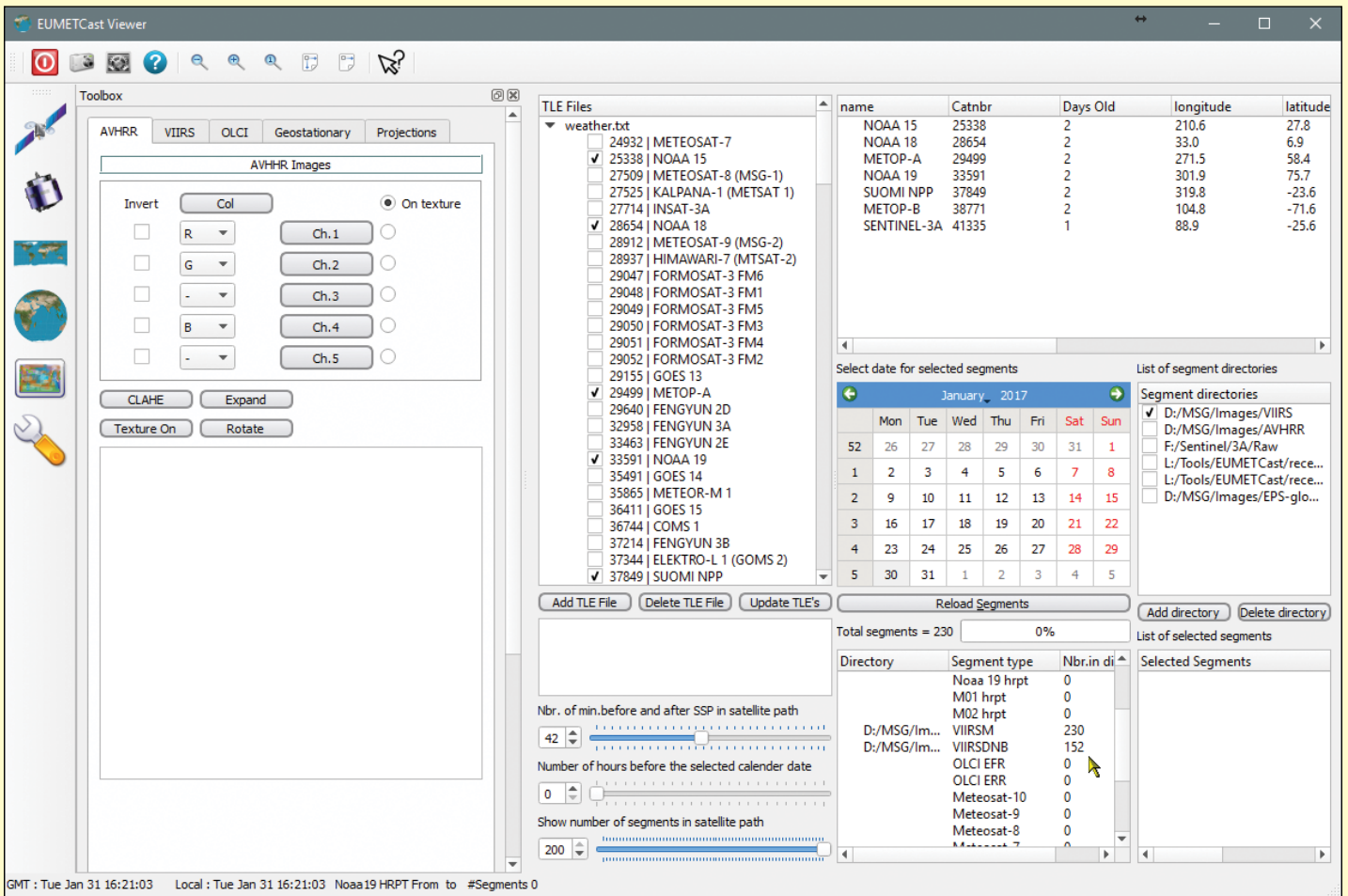


Figure 3 - The EUMETCastView Setup Screen after selecting a date.

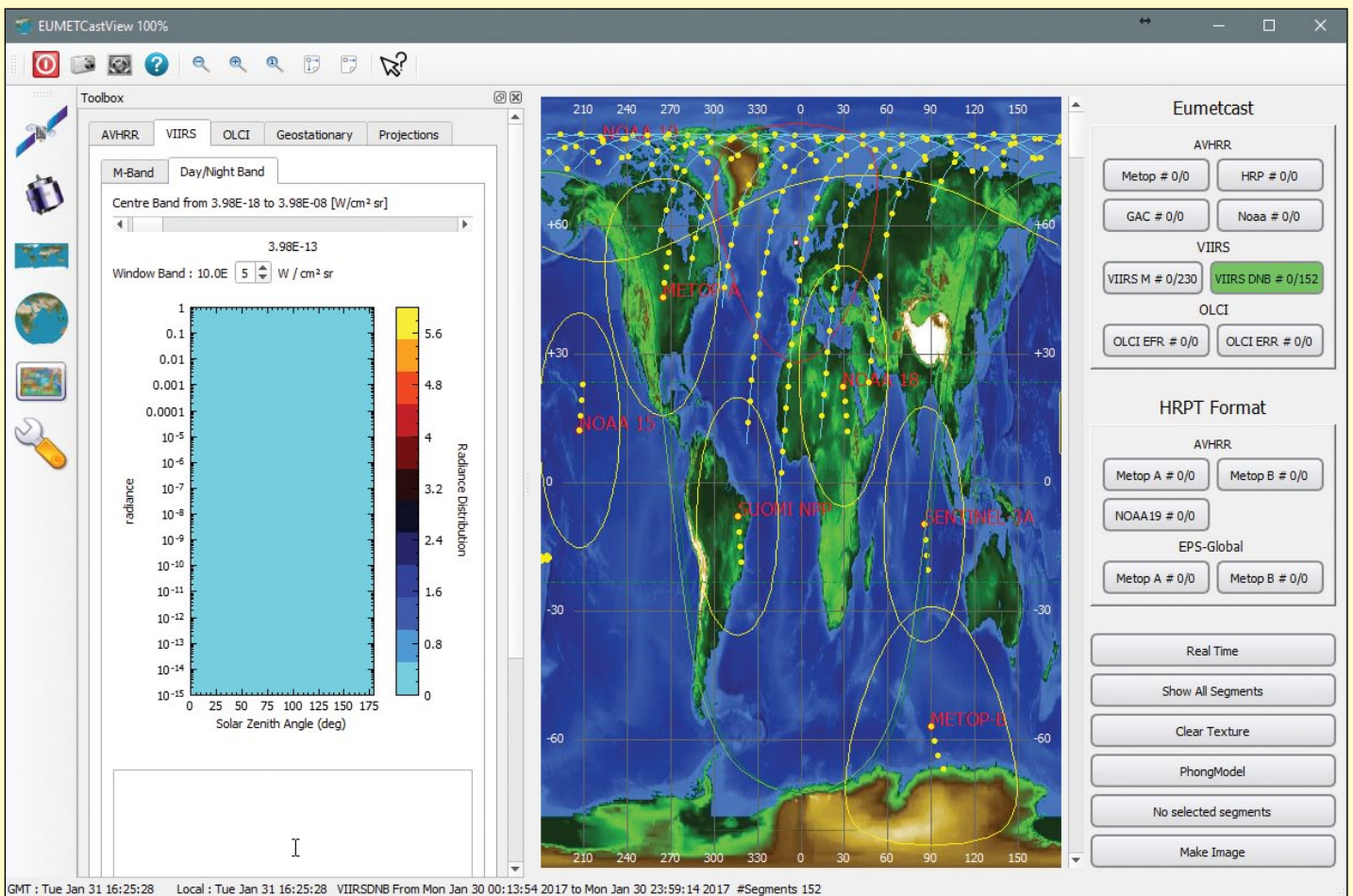


Figure 4 - The Plate Carrée map view for polar orbiting satellite selection

Navigating the program would be so much easier if, as with so much software, the author gave pop-up hints on various buttons and icons.

Now click on the date of interest. Note that, following selection of the date (in this case 2017-Jan-30), some 152 DNB (day-night-band) files were found (figure 3).

Geostationary Satellite Selection

I've never used this option as the *MSG Toolset Plus* suite gives me everything I need.

Polar Orbiter Selection - Map View

There are two ways to select which passes, or segments of a pass, you want to process. Both are graphical, one on a Plate Carrée projection, and the other on a globe view. The former is illustrated in figure 4, but I find that the globe view suits my needs better.

Polar Orbiter Selection - Globe View

Now you can see why you might want to limit the number of segments! Drag the globe with the mouse to bring the region of interest into view, and zoom with the mouse wheel (figure 5). Place the mouse cursor somewhere near the centre of one of the tiles, and right-click to select the tile. Suppose I wanted to look at the UK—I've made a guess and selected three tiles covering that region (figure 6).

And no! I don't know what the blue rectangle is for....

Image View

Now click the large **Make Image** button at the bottom-right of the panel. With the three tiles selected it took about four seconds for my PC to complete making the image. Now switch to the **Image View**, the icon below the globe in the left panel. You may need to scroll the image with the (rather faint and nonstandard) scroll bars to see anything, but scrolling to the bottom-right of the image I did find a recognisable coast outline - the north end of the Adriatic sea (figure 7).

By playing with the **Centre Band** and **Window Band** adjustments you can see more detail (figure 8), or just the brightest spots (figure 7).

Projections

By scrolling a little further (after making the image brighter) I found the south coast of the UK (figure 9).

Now switch to the **Projections** tab in the Toolbox. Figure 10 shows one I happen to have used before, showing parts of southeast England and the Netherlands.

By pressing on the **Create Map** button (at lower left) the image you just created

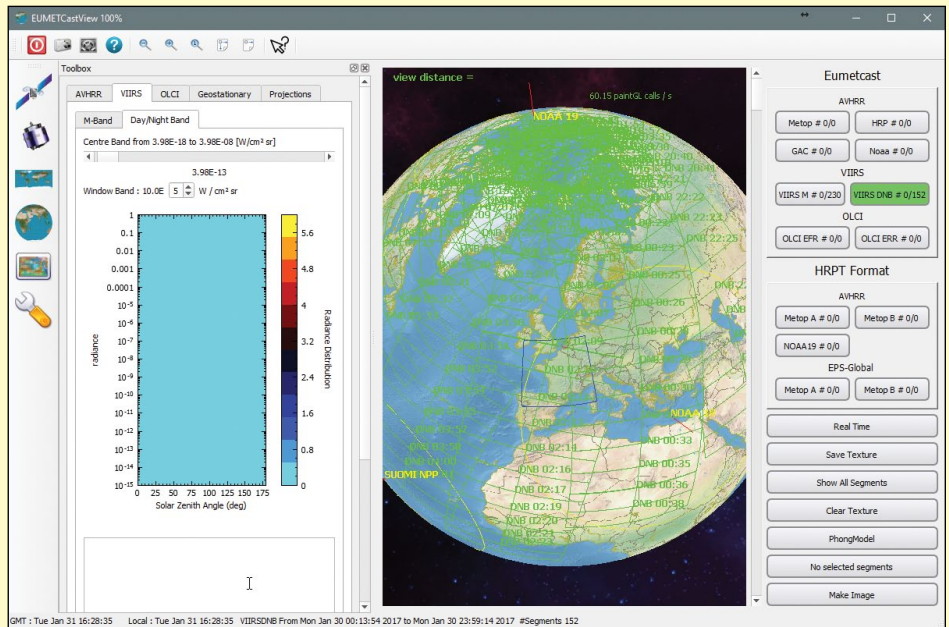


Figure 5 - The Polar map view: zooming in to the region of interest

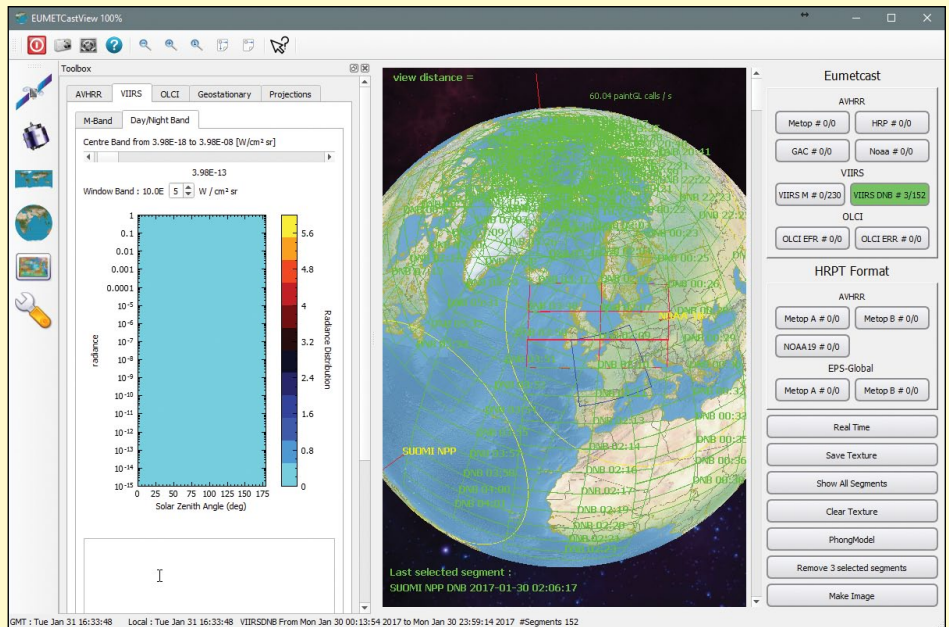


Figure 6 - The Polar map view: selecting tiles

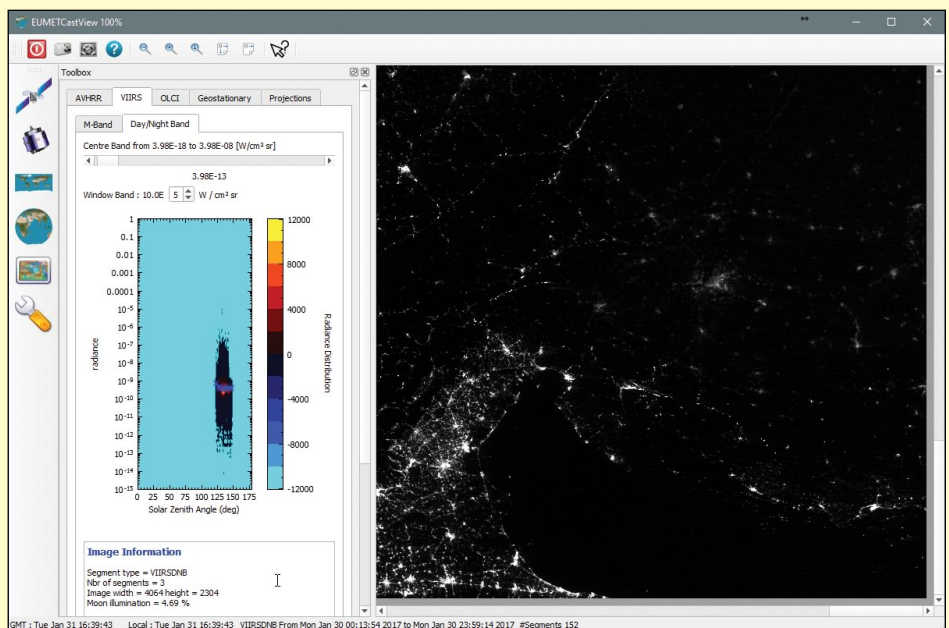


Figure 7 - A Suomi NPP day-night image showing the cities of Venice and Chioggia as prominent white spots on the northwest coast of the Adriatic Sea.



Figure 8 - The same Suomi-NPP day-night image

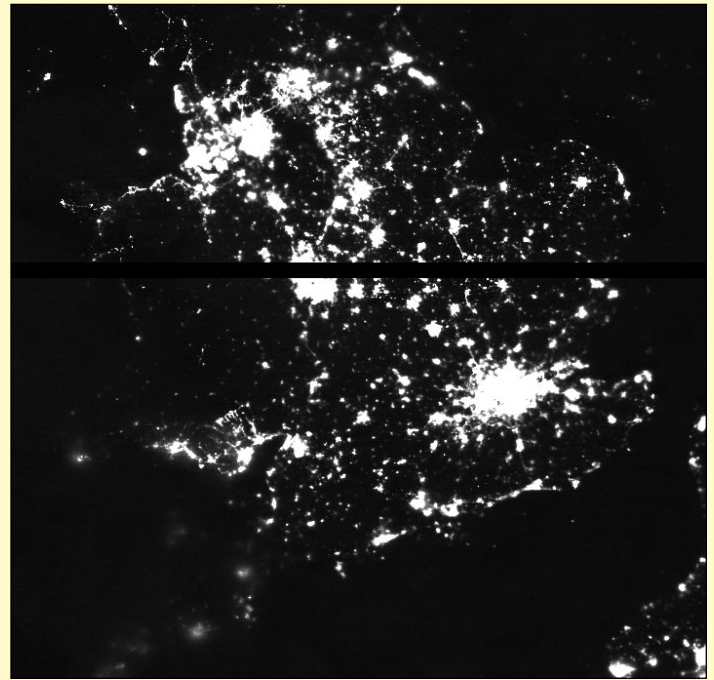


Figure 9 - Scrolling through the image reveals the UK

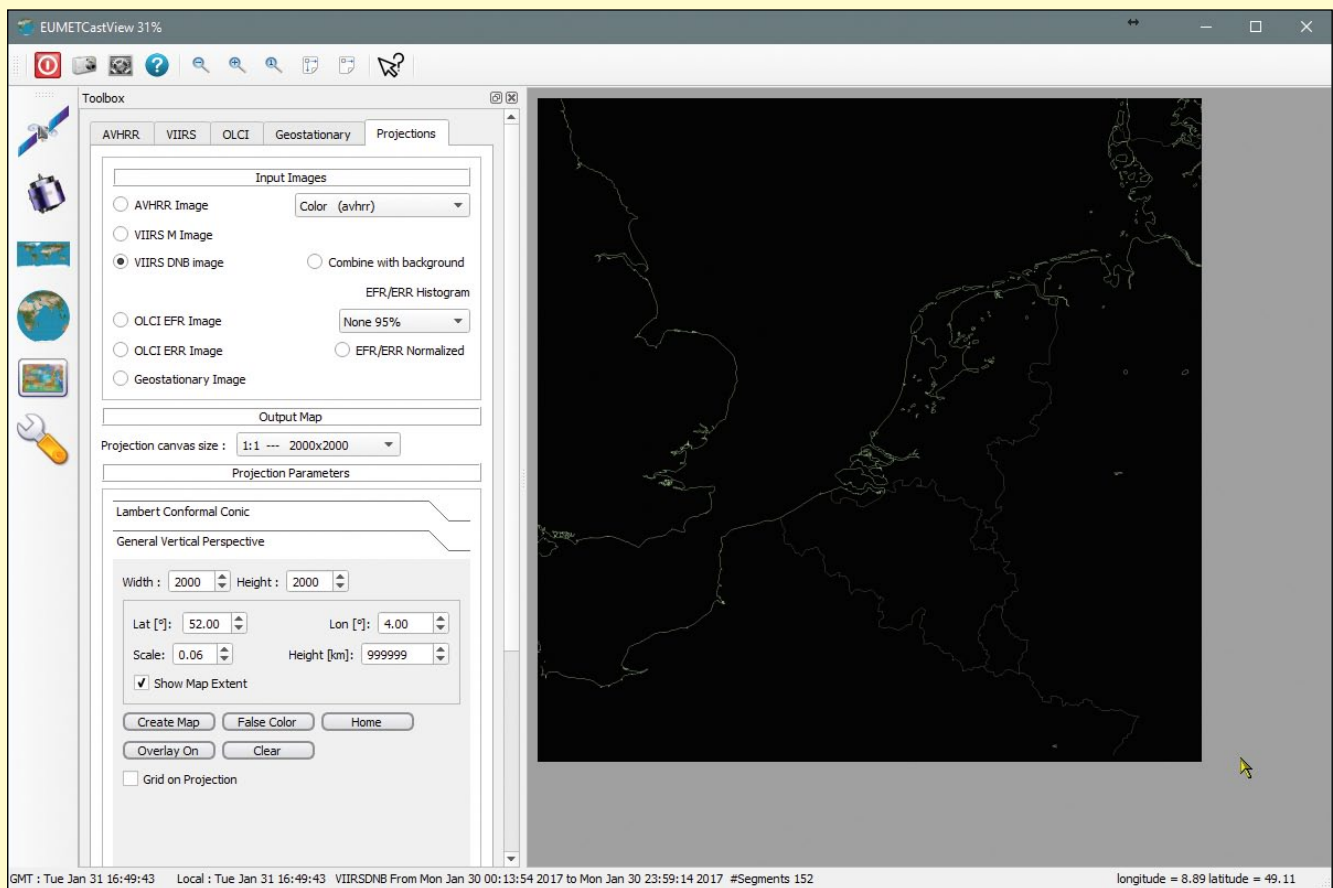


Figure 10 - A projection including southeast England and The Netherlands

will be re-projected on to the mapping you have chosen. Neat, eh? You can even see lights from the oil rigs in the North Sea (figure 11).

Saving Images

To save an image, use the **Camera Icon** in the top toolbar—it's the second one along from the left, next to the **Power** (program exit) button. Images are saved in the program's directory unless you choose otherwise. It is well worth visiting the EUMETCastViewer home page at

<http://hvanruys.github.io/>

where you will find a selection of images which illustrate the program's capabilities, as well as some hints on its use.

Concluding Remarks

This article is not intended as a comprehensive review of the EUMETCast Viewer, but just a 'first look' to help the newcomer begin exploring its features to view some more unusual data.

It is to be hoped that readers more experienced in using EUMETCastView will feel encouraged to prepare further articles detailing with this software in greater depth.



Figure 11 - The Suomi-NPP satellite imaged this scene in its day-night band on January 30, 2017. Not only are the illuminations of major cities prominent but you can even see evidence of shipping and North Sea oil activity.

Image © EUMETSAT 2017

FRENCH STORMS

John Tellick

Following the long period of high pressure over western Europe and the southern half of the UK throughout much of January, which blocked the advance of Atlantic depressions, the first few days of February saw a whole collection of Atlantic lows heading in our direction. A strong jet stream, blowing over the north Atlantic at around 300 kph at this time, helped to spawn these storms and direct them eastwards towards Europe.

The first storm mid-week, centred west of Ireland, was deflected by the fading high pressure to the east and caused rain and gales in Ireland and the western part of the UK before tracking off to the northwest for a couple of days.

The following storm was far more intense and early warnings were issued to southern parts of the UK and the English Channel for possibly damaging winds, all dependent on the storm's eventual track: it could go a bit further north or south.

The storm, thankfully, tracked quite a bit further south, and the Atlantic coast of France, Portugal and parts of Spain bore the brunt of the winds which caused considerable structural damage: trees and electricity pylons came down, leaving some 250,000 French residents without electricity on February 3rd and 4th. *Météo France* reported wind speeds of up to 148 kilometres per hour on the coast and warned that in some places they could reach 160 kph. The Mediterranean island of Corsica registered a 155 kph gust across its northern cape, while Santander in northern Spain also felt the storm with winds up to 104 kph.

On February 1, the European Space Agency's *Sentinel 3* satellite measured significant wave heights of about 16 metres off the coast of France, which is extraordinary, even for the typically stormy winter season in the North Atlantic basin. Individual waves were likely higher than that.

As the storms in western France became stronger, weather agency *Météo France* urged residents not to travel and to remain indoors, further adding that they should keep off roofs and be vigilant about the risks of falling trees. Because of the violence of the winds and the ensuing flood risks, the western Departments of Charente, Charente-Maritime, and Gironde were all placed on red alert. In addition, there were warnings of 'very strong waves' on the northern coasts of Brittany and Normandy, where storm surges were producing wave peaks of up to twelve metres, bringing the risk of 'marine submersion'.

No sooner had this storm passed but another tracked across France on February 5th narrowly missing southern England – again.

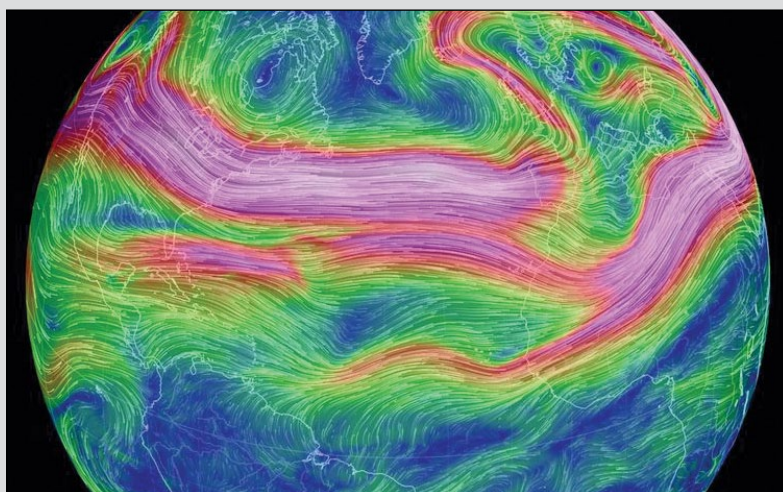


Figure 1 - The north Atlantic Jet Stream on February 1

Image: earth.nullschool.net

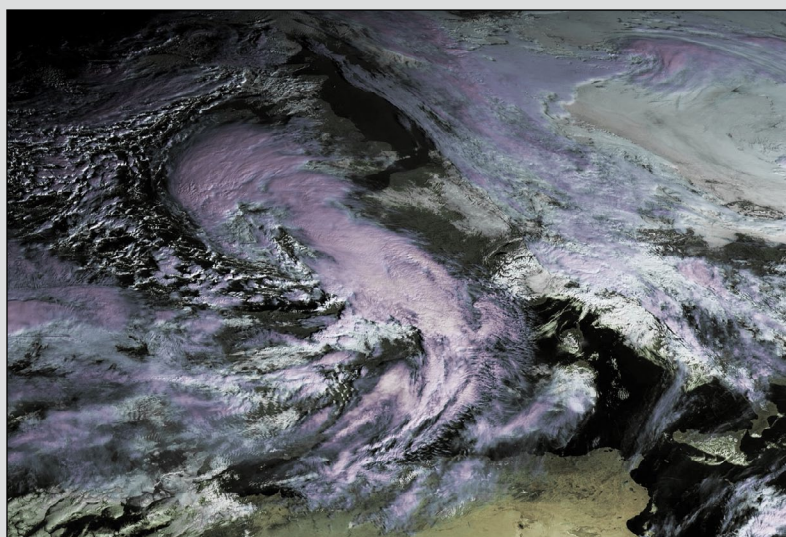


Figure 2 - The storm approaches France on February 3

Image © EUMETSAT 2017

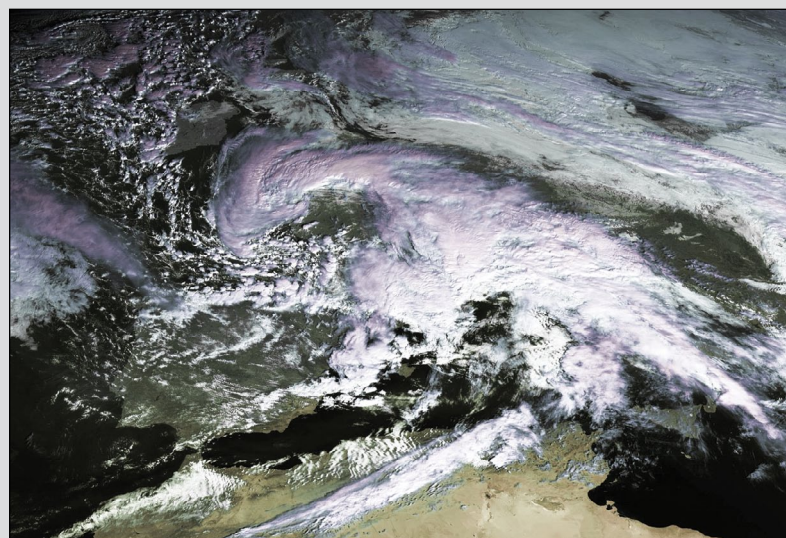
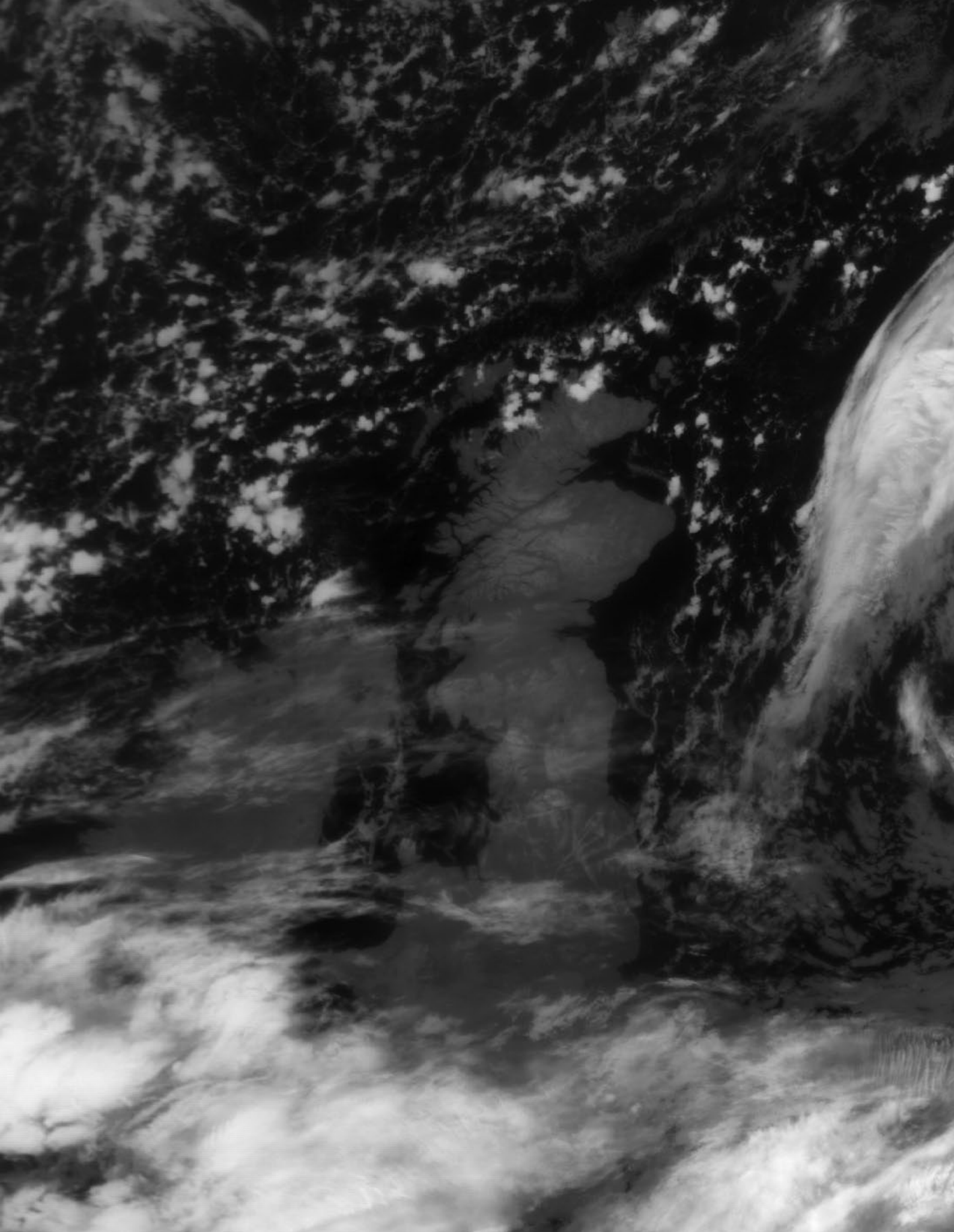


Figure 3 - The storm centred over France on February 5

Image © EUMETSAT 2017



It's mid-evening on November 20, 2016 and winter is already biting hard over Scotland. This infrared LRPT image comes from the 20.02 UT pass of Russia's Meteor N2 satellite, showing the entire country fully in the grip of a hard frost. By daybreak the following morning, the temperature had dropped to minus 8°C or lower almost everywhere.



Mike Stevens submitted this remarkable Sentinel 3A image that he acquired on January 3, this year.
Image © EUMETSAT 2017

From Drought to Overflow

European Space Agency



Lake Oroville and the Oroville Dam were imaged by the Copernicus Sentinel-2A satellite on December 21, 2016 (left) and January 30, 2017. Copyright contains modified Copernicus Sentinel data (2016–17), processed by ESA

Almost 200 000 people were evacuated from their homes in early February after channels draining the Oroville Dam in northern California were damaged because of unusually heavy rain.

Images captured by the Copernicus **Sentinel-2A** satellite on December 21, 2016 and again on January 30, 2017 show the remarkable difference in the height of the dam water. Far more of the shoreline is exposed in the earlier image, for example. There are a couple of islands visible to the north of the dam in the first image which were almost entirely submerged following the rains. The comparison also shows that the water was much lighter

in colour in December and much darker in January owing to sediment washed into the dam. The ‘spillway’ appears dry in the first image but water can be seen clearly gushing down it in the later image. This is the first time that water had ever run down the spillway. In turn, damage to this spillway caused by excessive water led to fears about safety and the area being evacuated.

With a height of 235 metres, Oroville is the highest dam and second largest reservoir in the USA. It provides an important water supply and is used to generate hydroelectricity. Until the recent rains it had been a defining image of the state’s drought.

Blue Jets

Studied from the International Space Station

John Tellick

For years, their existence has been debated: elusive electrical discharges in the upper atmosphere that sport names such as red sprites, blue jets, pixies and elves. Reported by pilots, they are difficult to study as they occur above thunderstorms.

During his 2015 mission aboard the International Space Station, ESA's Danish astronaut, Andreas Mogensen, was asked to use

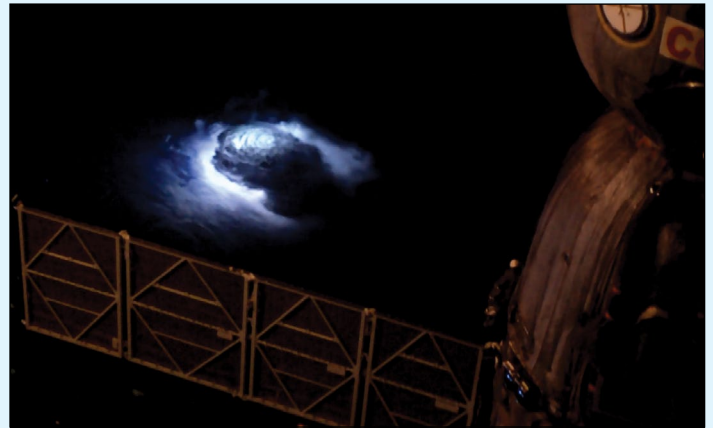


Andreas Mogensen
Photo: ESA

the most sensitive camera available to take photographs as he flew above thunderstorms to look for these elusive features. Denmark's National Space Institute has now published the results [1], which confirm many kilometre-wide blue flashes around 18 kilometres altitude, including a pulsating blue jet reaching 40 km. A video recorded by Andreas as he flew over the Bay of Bengal at 28 800 kph on the Station shows the electrical phenomena clearly - a first of its kind [2]. ESA has produced a short video in which Mogensen describes his experiences [3].

Satellites had probed these events but their viewing angle is not ideal for gathering data on the scale of the blue jets and smaller blue discharges. In contrast, the ISS's lower orbit is ideally placed to capture the sprites and jets.

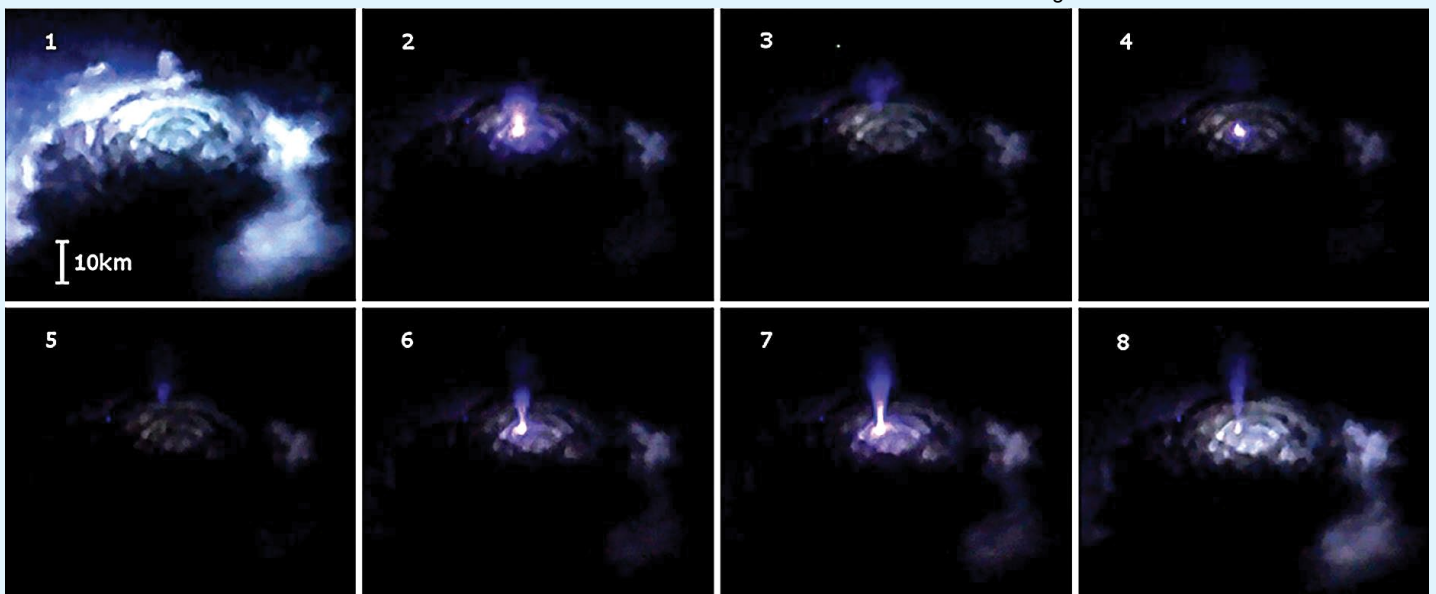
Andreas aimed for cloud turrets—cloud pillars extending into the upper atmosphere—and shot a 160 second video showing 245 blue flashes from the top of a turret that drifted from the Bay of Bengal's thunderstorm. The image sequence below was compiled from frames from Andreas' video.



A spectacular Blue Jet photographed from the ISS
Credit: ESA / Andreas Mortensen



A cumulonimbus turret over Africa photographed by an astronaut on the International Space Station
Image: NASA



This sequence of photographs illustrates the progression of a Blue Jet lightning strike extending upwards from a storm cloud over the Bay of Bengal
Credit: ESA / Chanron et. al, 2017.



ESA astronaut Tim Peake took this image circling Earth 400 kilometres up in the International Space Station.
Image: ESA

British astronaut Tim Peake also observed and photographed Blue Jets during his stay aboard the ISS in 2016, the image above being one of his best examples. Tim commented: “Sometimes looking down on Earth at night can be kinda spooky.”

The image shows lightning strikes illuminating clouds over Western Australia during a thunderstorm. The Space Station travels at 28 800 kph, so takes only 90 minutes to complete an orbit of Earth. Astronauts often spot thunderstorms and are impressed by how much lightning they observe.

Although this picture was taken in Tim’s free time, the Station is used for research into elusive phenomena in the upper

atmosphere during thunderstorms—red sprites, blue jets and elves. Some of the most violent electric discharges are very difficult to capture from the ground because of the atmosphere’s blocking effect. From space, astronauts can judge for themselves where to aim the camera and where to zoom in and follow interesting regions for researchers.

The blue discharges and jets are examples of a little-understood part of our atmosphere. Electrical storms reach well into the stratosphere and have implications for how our atmosphere protects us from radiation.

These experiments confirm that the ISS is a suitable base for observing these phenomena. As a follow-up, the *Atmosphere-Space Interactions Monitor* [4], a climate observatory for the International Space Station being developed for ESA, will be prepared for launch later this year for installation outside Europe’s *Columbus* laboratory to monitor thunderstorms continuously in order to gather more information about such ‘transient luminous events’.

Following his flight, Andreas Mogensen concluded:

“It is not every day that you get to capture a new weather phenomenon on film, so I am very pleased with the result—but even more so that researchers will be able to investigate these intriguing thunderstorms in more detail soon.”

Acknowledgements

Most of the text in this article comes from the European Space Agency website.

References

- 1 <http://onlinelibrary.wiley.com/doi/10.1002/2016GL071311/full>
- 2 https://youtu.be/dY5F_gEexAY
- 3 <https://www.youtube.com/watch?v=r50Un4LPTM4>
- 4 www.asim.dk

Snow and Ash Above Katmai

NASA Earth Observatory

A plume of volcanic ash hangs over the Gulf of Alaska in this natural-colour image. The plume is not, however, the product of an active volcano: it is re-suspended ash dating back to the 1912 eruption of Novarupta, according to the Alaska Volcano Observatory. High winds previously stirred up ash in the area in October 2015.

Novarupta is a young volcano that was created as recently as 1912, and is located on the Alaska Peninsula within *Katmai National Park and Preserve*, about 470 km southwest of Anchorage. Formed during the largest volcanic eruption of the 20th century, Novarupta released thirty times the volume of magma as the 1980 eruption of Mount St Helens.

The Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA’s *Terra* satellite captured this image on December 2, 2016.



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

Sicilian Snow

John Tellick

Mount Etna is Europe's tallest and most active volcano, with an eruptive history reaching back more than 2,000 years. It seems to be in nearly constant activity, with intermittent short pauses. The eruptions can be relatively quiet, with tremors accompanying gas and ash plumes, but at times Etna can produce spectacular explosive eruptions. Though generally mild in nature, these eruptions can produce glowing lava fountains that rise high above the summit craters.

Following the reception on February 5, 2017 of a NOAA 19 image of snow-topped Mount Etna, not that unusual in winter, ESA later published a false-colour Sentinel 2A image of part of Sicily captured earlier on January 8 showing heavy snowfall.

I was surprised to find, during a quick search, that Mount Etna regularly receives considerable winter snowfall with the opportunity for winter sports activities at two ski resorts: Linguaglossa (Etna North) and Nicolosi (Etna South).

The Sentinel image depicts a period of unusual cold and snowfall across parts of southern Europe. As a consequence, the mountains of Sicily are visible in white across the northern part of the island. While Italy's northern regions experienced little snowfall this winter, the central and southern areas have seen abnormally cold conditions and snowfall in mountainous areas.

Mount Etna, an active volcano, is visible at upper right of the Sentinel image. Positioned over the zone where the African plate collides with and slips under the Eurasian plate, Etna's frequent eruptions are often accompanied by large lava flows, smoke and ash.

Sentinel-2 provides optical data for land and vegetation monitoring. Its main instrument has 13 spectral bands, and this false-colour image was processed including the near-infrared channel—which explains why vegetation appears as red.

The varying shades of red and other colours across the entire image indicate how sensitive the instrument is to differences in chlorophyll content. This is used to provide key information on plant health: brighter reds indicate healthier vegetation.

Sentinel-2 is a two-satellite mission for Europe's Copernicus programme. The first satellite was launched in June 2015 and its Sentinel-2B twin is set for launch from French Guiana on March 7 this year, at 01:49 GMT.

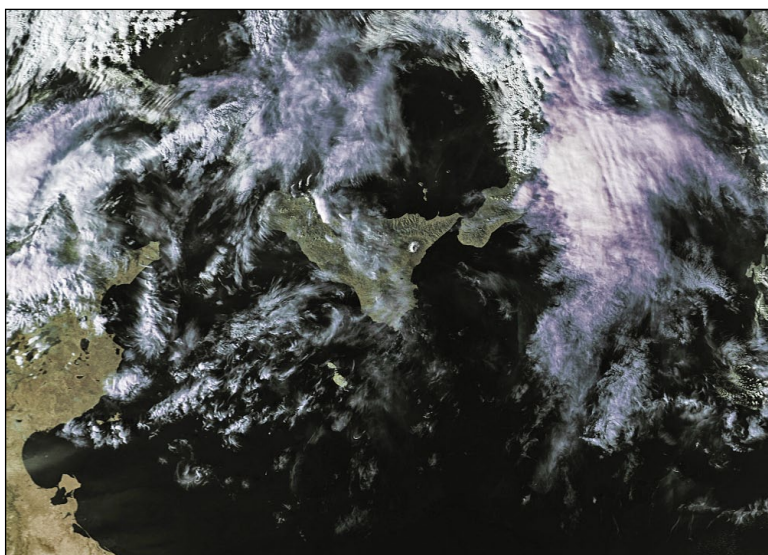
Live Mount Etna Webcams

www.skylinewebcams.com/en/webcam/italia/sicilia/catania/vulcano-etna-sud.html

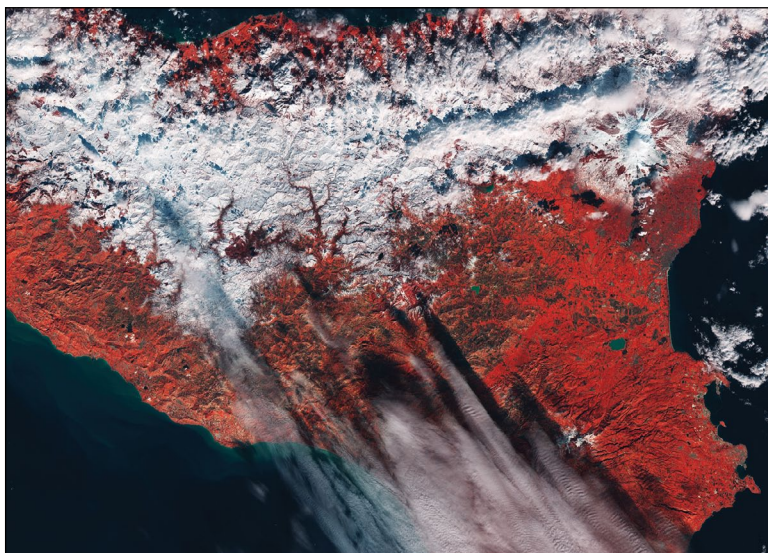
www.skylinewebcams.com/en/webcam/italia/sicilia/catania/vulcano-etna-nord.html



Mount Etna with the city of Catania in the foreground
Photo: BenAveling / Wikimedia Commons



NOAA 19 images Mount Etna on February 5, 2017
Image © EUMETSAT 2017



Part of Sicily with Mount Etna visible at upper right
© Contains modified Copernicus Sentinel data (2017), processed by ESA

Fissure Eruptions on Erta Ale

NASA Earth Observatory



In Ethiopia's Afar Depression, three tectonic plates are tearing apart in spectacular fashion. As the plates separate, several active volcanoes have emerged along the seams. One of the most active is Erta Ale, a shield volcano near the Ethiopian border with Eritrea. It is known as the 'smoking mountain' and the 'gateway to hell' in the Afar language.

Erta Ale has a long-lived lava lake that has gurgled and spattered in its caldera for decades, but the most recent bout of activity involves the southeast flank of the gently sloping mountain. According to reports posted by *Volcano Discovery*, new fissures opened up on January 21, 2017, about 7 kilometres from the summit caldera, spilling large quantities of lava. Meanwhile, at

least one of the lava lakes has experienced large changes in the level of its lava that have led to overflows and intense spattering.

This image was captured by the Operational Land Imager (OLI) sensor on Landsat 8 on January 26, 2017, and is a composite of natural colour (OLI bands 4-3-2) and shortwave infrared (OLI band 7). Shortwave infrared radiation (SWIR) is invisible to the naked eye, but strong SWIR signals indicate increased temperatures. Infrared hot spots representing two distinct lava flows are visible. Plumes of volcanic gases and steam can be seen drifting northward from the lava lakes.

NASA Earth Observatory image by Joshua Stevens, using Landsat data from the US Geological Survey. Caption by Adam Voiland.



Here's another stunning image from Mike Stevens who is clearly enjoying his experiences with Sentinel 3A imagery. This image, dating from February 9, showcases the Bahamas, Turks and Caicos Islands, Haiti, Cuba and Jamaica

Image © EUMETSAT 2017

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	137.1000 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	---	AHRPT	[2]
Feng Yun 3B	1704.5 MHz	---	AHRPT	[2]
Feng Yun 3C	1704.5 MHz	---	AHRPT	[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 (E)	GVAR 1685.7 MHz	LRIT 1691.0 MHz	75°W	On ^[5]
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]
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	104.0°E	On
Feng Yun 2F	SVISSR	LRIT	112.0°E	On
Feng Yun 2G	SVISSR	LRIT	86.5°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 13 and GOES 15 also transmit 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.

Internet Discussion Groups

There are a numerous Internet-based discussion groups of interest to weather satellite enthusiasts. The home page for each group provides an email address through which you can request membership. Even a blank email containing the word 'subscribe' in its Subject line is all that is required.

GEO-Subscribers

This is GEO's own group, where members can exchange information and post queries relating to any aspect related to weather satellite reception (hardware, software, antennas etc), Earth observation satellites and any GEO-related matter.

<https://groups.yahoo.com/neo/groups/GEO-Subscribers/info>

Satsignal

An end-user self-help group for users of David Taylor's Satellite Software Tools (SatSignal, WXtrack, GeoSatSignal, HRPT Reader, GroundMap, MSG Data Manager, AVHRR Manager and the ATOVS Reader).

<https://groups.yahoo.com/neo/groups/SatSignal/info>

MSG-1

A forum dedicated to Meteosat Second Generation (MSG), where members share information about the EUMETCast reception hardware and software.

<https://groups.yahoo.com/neo/groups/MSG-1/info>

Weather Satellite Reports

If there is a single Internet Forum that is relevant to all weather satellite enthusiasts, it must surely be Douglas Deans' Weather Satellite reports.

Here you will find every conceivable type of information about weather satellites, whether polar or geostationary, APT, HRPT, LRIT, or EUMETCast, updated every Monday.

You can read the bulletins from this URL

<https://groups.yahoo.com/neo/groups/weather-satellite-reports/info>

or, even better, elect to have the reports sent to you by email every Monday.

EUMETCast On-Line Registration Guide

If you require to register as a first-time user for any of the free EUMETCast data streams such as MSG, NOAA AVHRR, Metop etc., or need to renew an existing subscription, this must be done on-line.

GEO has produced a step-by-step guide to the entire process at

<http://www.geo-web.org.uk/eumreg.php>

This guide also contains a direct link to the official EUMETCast on-line registration form, which can otherwise prove somewhat tricky to locate.

Copy for GEO Quarterly

Original contributions relating to any aspect of Earth Imaging should be submitted in electronic format (although handwritten and typed copy will be accepted).

Please note that **major articles** which contain a large number of illustrations should be submitted **as early as possible before copy deadline**, to give time for preparation prior to publication.

Please note that it is preferred that satellite images are provided **without added grid lines, country outlines or captions** unless these are considered essential for illustrative purposes in an accompanying article.

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Materials for publication may be sent to the editor,

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8 Deeside Place
Aberdeen AB15 7PW
Scotland

The most efficient way to do this is by **email attachments** to the following address

geoeditor@geo-web.org.uk

Particularly large attachments (8 MB and above) can be transmitted via *Hightail*

<https://www.hightail.com/>

or from a link to your Drop Box.

GEO Helplines

Douglas Deans, Dunblane, Scotland.

All aspects of weather satellites from APT, HRPT to Meteosat-9 DVB/EUMETCast systems.

- telephone:(01786) 82 28 28
- e-mail: dsdeans@btinternet.com

John Tellick, Surrey, England.

Meteosat advice: registering for the various MSG services, hardware and software installation and troubleshooting. John will also field general queries about any aspect of receiving weather satellite transmissions.

- telephone: (0208) 390 3315
- e-mail: info@geo-web.org.uk

Geoff Morris, Flintshire, NE Wales.

Geoff has lots of experience with aerial, coax connectors, mounting hardware etc. and has also done a lot of work with the orbiting satellites. Geoff has been a EUMETCast Meteosat user for some time and is familiar with David Taylor's MSG software. He should be able to share his experiences with newcomers to this branch of the hobby.

- Tel: (01244) 818252
- e-mail: gw3atz@btopenworld.com

Guy Martin, Kent, England.

Guy is prepared to advise anyone who wishing to receive MSG/Metop using Windows 2000 or XP. Can also help with networking and ADSL router setup.

- gmartin@electroweb.co.uk

Hector Cintron, Puerto Rico, USA.

Hector is prepared to field enquiries on HRPT, APT, EMWIN and NOAAPORT

- Phone: 787-774-8657
- e-mail: n1tkk@hwic.net

Email contact can of course be made at any time, but we would ask you to respect privacy by restricting telephone contact to the period 7.00 - 9.00 pm in the evenings.

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- UK residents may pay by means of a **personal cheque** or **Postal Order** made payable to 'Group for Earth Observation'
- Payment by **direct bank transfer** can be arranged. Please email members@geo-web.org.uk for BIC and IBAN details.

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Email Address (please print very clearly)

Address

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I sign below to confirm that I have no objection to my membership details being held on a computer database and understand that these details will be used *exclusively* for internal GEO administrator purposes.

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Callsign

Country

Signature

Telephone Number

FAX

Date

Your subscription is valid for two years from your date of application and entitles you to all the privileges of membership of the Group for Earth Observation, including four issues of GEO Quarterly. Please note that your subscription will commence with the issue of GEO Quarterly that is current at the time of your application. Back issues, where available, may be ordered from the GEO Shop.

Please send your completed form to:

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 Loughborough LE12 6PP, UK

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If you prefer not to remove this page from your Quarterly, a photocopy or scan of this Membership Form is perfectly acceptable

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For our full range, visit **GEO Shop** at
<http://www.geo-web.org.uk/shop.php>



Ayecka-SR1 DVB-S2 VCM USB Receiver

This advanced DVB-S2 VCM Receiver has been extensively tested by both EUMETSAT and GEO, and has proved to be exceptionally suitable for trouble-free reception of the EUMETCast DVB-S2 transmissions that became standard from the start of 2015.



The price includes a USB cable, wall power supply, shipping and *Paypal* fees.

UK members price - £375.00
EU members price - £385.00

NEWSKY RTL2832U/R820T2 SDR DAB USB MCX Socket Special Dongle for reception of NOAA APT and Meteor M2 LRPT



- Frequency range: (*100) 700 kHz - 1864 MHz
- MCX Socket
- Active Crystal Oscillator
- Reinforced Socket

This stick does not come with SDR software or instructions.



UK members price - £20.00
EU members price - £25.00

TechniSat SatFinder Antenna Alignment Meter



This sensitive meter is a great help in setting up and aligning the dish for maximum signal. The meter comes with full instructions.

UK members price - £26.50
UK non-member's price - £29.50

Current Price List

	Members' Prices			Prices for non-Members		
	UK	EU	RoW	UK	EU	RoW
Ayecka SR1 DVB-S2 Receiver	375.00	385.00	390.00	-----	-----	-----
Edimax USB 2.0 Fast Ethernet Adapter	15.00	17.00	18.00	-----	-----	-----
DVB-S USB 2102 Receiver	60.60	67.00	-----	70.60	77.00	-----
SDR Dongle kit for APT/LRPT	20.00	25.00	26.00	-----	-----	-----
Technisat Satfinder Alignment Meter	26.50	29.50	-----	29.50	32.50	-----
GEO Quarterly Back Issues (subject to availability)	3.80	4.60	5.60	n/a	n/a	n/a
GEO Quarterly (PDF on CD) 2004-2016 (Annual compilations - state year)	8.00	8.80	9.30	n/a	n/a	n/a
GEO Membership - 2-year subscription	15.00	15.00	15.00	15.00	15.00	10.00

(4 PDF magazines and one printed magazine per year)

All prices are in £ sterling and include postage and packaging

Ordering and Shipping

We will ship by post, so please allow a few days for items to arrive in Europe and perhaps a few weeks for the Rest of the World.

Orders should be sent by email to

geoonlinestore@gmail.com

or made through the GEO Website at

<http://www.geo-web.org.uk/shop.php>

Goods are normally shipped within 28 days, subject to availability.



Not yet a GEO Member?

GEO can provide most of the items advertised (with the exception of GEO Quarterly back-issues and CDs) to both members and non members: but non-members cannot benefit from the discounted members prices.

Why not join GEO and take advantage of the discounted prices we can offer you as a member?

Annual Subscription Rate for all regions in now £15 (UK)

For this you will receive 4 electronic (PDF) copies of GEO Quarterly Magazine. In addition, you will be mailed a **printed version** of the December magazine.

GEO Quarterly - Back Issues (Only available to GEO Members)



Paper copies of back issues of GEO Quarterly may be available, but it is advisable to check before ordering.

UK members price - £3.80

Annual compilations of GEO Quarterly back issues in PDF format are available on CD. Be sure to state the year of each annual compilation that you wish to order.

UK members price - £8.00

Inverto-Black-Ultra High-Performance LNBS



GEO currently recommends these LNBS for EUMETCast reception. We are currently **not stocking** this item but it is available at **Amazon**.

<http://www.amazon.co.uk/gp/product/B0010NAEKI/>

Twin LNB 40mm 0,2dB £15.50
Single satellite LNB £ 9.95

Edimax USB 2.0 Fast Ethernet Adapter



This adapter enables you to add a *second* network connection for your PC/Laptop, to connect to the Ayecka SR1 Traffic port, thereby relieving loading on the home network. Typically, you would assign this adapter with an IP address on the same network as the SR1 i.e 192.168.10.103. Data from the SR1 passes directly to the PC whilst its internet connection remains on your usual home network 192.168.1.xxx (Management Port).

UK members price - £15.00
UK non-members price - £17.00



