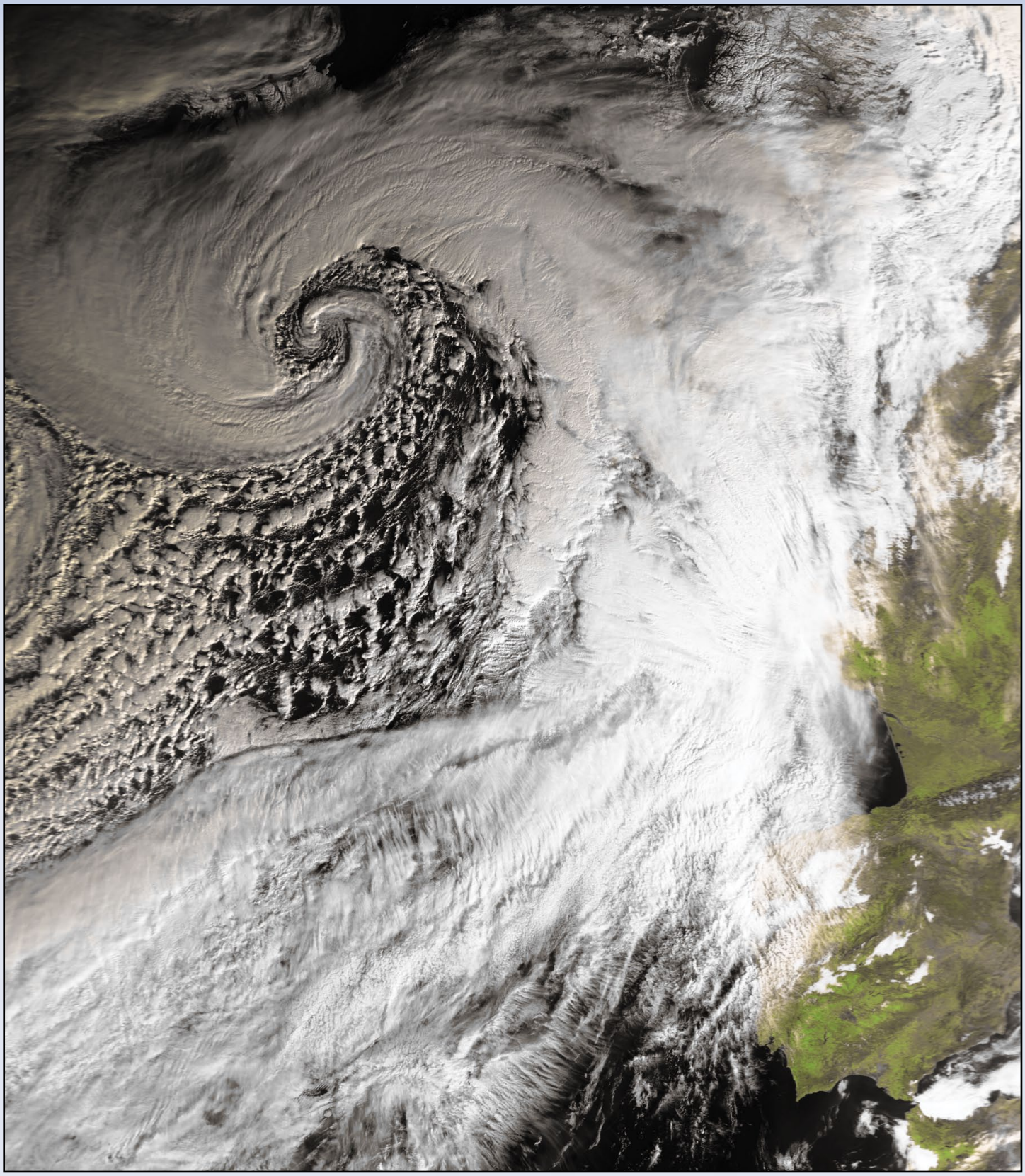
GEO Newsletter

Group for Earth Observation

Group for Earth Observation

No 65 - March 2020



This was the scene viewed by the European Metop-B satellite in late morning on February 15 this year as **Storm Denis** engulfed the British Isles, bringing gales of 120 kph and causing widespread flooding as some parts of the country received more than a full month's rainfall in just 48 hours.

Image: NOAA CLASS Archive

Useful User Groups

Weather Satellite Reports

This group provided weekly reports, updates and news on the operational aspects of weather satellites.

https://groups.io/g/weather-satellite-reports

SatSignal

This end-user self help group is for users of David Taylor's Satellite Software Tools, including the orbit predictor WXtrack, the file decoders GeoSatSignal and SatSignal, the HRPT Reader program, the remapper GroundMap, and the manager programs - MSG Data Manager, GOES-ABI Manager, AVHRR Manager etc.

https://groups.io/g/SatSignal

MSG-1

This forum provides a dedicated area for sharing information about hardware and software for receiving and processing EUMETCast data.

https://groups.io/g/MSG-1

GEO-Subscribers

This is the official group is for subscribers of the Group for Earth Observation (GEO), aimed at enthusiasts wishing to exchange information relating to either GEO or Earth Observation satellites.

https://groups.io/g/GEO-Subscribers/

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http://www.facebook.com/groupforearthobservation

From the Editor

Les Hamilton

The past few months have been remarkable in terms of the extremes of weather experienced world-wide: from severe forest fires followed by torrential rainfall in Australia, record high temperatures in the Antarctic, and a succession of severe Atlantic storms that have beset the UK and western Europe. Much of the British Isles has experienced severe gales accompanied by torrential rains that have resulted in widespread flooding on an unprecedented scale. It has proved to be the wettest February on record, with some areas enduring more than a full months rainfall in a single weekend.

Russia is not having the best of fortune with its Meteor M2 satellite programme. Following the loss of Meteor M2-1 following a failed launch in November 2017, and more recently the loss of Meteor M2-2 last December, following a collision with a micrometeorite. The original Meteor M2 is the only member of its class still active although there are hopes that Meteor M2-3 will launch before the end of this year.

On a happier note we can look forward to summer as interest mounts towards the GEO/Werkgroep Kunstmanen trip to EUMETSAT HQ in Darmstadt on July 2/3. Francis Bell outlines the details on pages 3-4. Readers still contemplating taking part have till the end of March to make their provisional registrations.

David Taylor, well known to most readers as a prolific software author, has compiled a new version of his *LRPT Image Processor* for creating products from the Meteor M2 Russian satellite. The software was originally made available, gratis, a few years ago, but now has a new feature: the ability to add accurate country outlines to the images. You can read my review from page 13 while, for completeness, David Taylor's original article is reprinted from page 23.

Contents

Francis Bell

Your chance to join our Group Visit to EUMETSAT and ESOC in Darmstadt July 2020

EUMETSAT Headquarters in Darmstadt
Photo © EUMETSAT

Our group visit to EUMETSAT's HQ in Darmstadt Germany is confirmed for the date of 2nd July 2020. This is to be a joint visit by both GEO members and members of the Dutch group Werkgroep Kunstmanen. Both groups will accept requests to join the planned visit but if you live in the UK I suggest that you register with Francis Bell (details below). Continental residents should register with Ben Schellekens of Workgroups Kunstmanen, who lives in The Netherlands. His email address is

ben@towerhouse.nl

If you do wish to be included in the visiting group, I suggest that you register as soon as possible in case we are limited by number for the size of group that EUMETSAT can accommodate. A positive start has already been made relating to the itinerary for our visit.

Below is the current plan for Thursday July 2, which will be a full day at EUMETSAT's HQ. We hope on July 3 to visit the European Space Operations Centre (ESOC). At the time of writing I do not have a specific programme for that day, but if it turns out to be as interesting as on our previous visits to ESOC, it should turn out to be great day.

If you wish to join us for this Darmstadt visit, please register by email to

francis@francisbell.com

as soon as you are able, and by March 31 at the latest, as there may eventually be an upper limit to the numbers who are allowed to visit. A number of UK GEO members have already registered with me and I will keep in touch with them as necessary. Remember, there are no specific charges for these visits but there may be some small administrative background costs to be covered—not more than 10 or 20 euros each. Personal travel arrangements are left with the individuals because we will be coming from so many directions

I expect we will all need overnight accommodation and in the past some of us have used the Ibis Hotel which is about a 15 minute walk to the EUMETSAT HQ buildings. I hope to use this hotel myself again this year and its contact details are given below.

Ibis Hotel (also named ETAP Hotel)
Kasinostrasse 4
64293 Darmstadt
Germany
Tel:- +49 6151 3973720
Email address:- h3521@accor.com

On the web, search for 'Ibis Hotel Darmstadt Germany'

Price guidance

When I enquired in January 2020, prices were, for one person in a twin room, £51 per night and or two people in a twin room £60 per night.

EUMETSAT Headquarters viewed from the air
Photo © EUMETSAT

EUMETSAT's official Group Photograph of the delegated who attended the inaugural 2007 visit to their HQ
Image © EUMETSAT

Joint GEO/Werkgroep Kunstmanen visit to EUMETSAT

Agenda

July 2, 2020 in the EUMETSAT Briefing Gallery

09:00 - 17:00 (Registration at 08:30)

09:00 - 09:05	Welcome address
09:05 - 09:15	Overview of current satellite operations
09:15 - 09:45	Overview of the MTG mission
09:45 - 10:15	Overview of the EPS-SG mission
10:15 - 10:30	User preparation for MTG and EPS-SG
10:30 - 10:50	Coffee break
10:50 - 11:30	Data access evolution 0 EUMETCast
11:30 - 12:00	Data access evolution - New data services
12:00 - 13:30	Group mphotograph and lunch break
13:30 - 15:00	Data reception systems
15:00 - 15:20	Cofee break
15:20 - 15:35	Update on User Service Activities
15:35 - 16:10	Presentation of selected case studies
16:10	Wrap up
16:15 - 17:00	Tour of Mission Control Centre

ESOC Visit - July 3, 2020.

This visit is confirmed for a party of 20 to 30 visitors with the initial session located in ESOC's meeting room.

The check-in time for this event is 10.00 a.m. but, because of security, we will try to be there a little earlier.

The day's agenda in not fixed but is anticipated to be approximately as follows.

- A general introduction to ESA/ESOC
- A number of presentations by their Earth Observation division. Note that if there are any particular requests to cover such topics as climate change or environmental issues, these may possibly be covered if agreed in time.
- After the presentations/discussions a tour of the buildings will be on offer.
- Refreshment and coffee breaks are likely to be included somewhere but no details are available at this time.
- If any of our visitors has a particular topic they would like to see as a presentation, or other information, then let this be known and ESOC may be able to cover it.

  Send anay requests, which we will try to progress, to

francis@francisbell.com
or
ben@towerhouse. nl

The ESOC buildings are about a 20 minute walk from the Ibis Hotel mentioned above.

GEO Accounts for the Year ending November 2019

The accounts for the past year are quite straightforward because there has been little income or expenditure during the year. Currently there are no membership charges for GEO, hence no income for us but almost equally we have quite low running costs.

The major cost of printing and distributing our Quarterly publication no longer applies: instead we publish our Quarterly 'News Letter' via the website. However, running the website with its associated emailing facilities does have some costs.

We have two bank accounts which in the past have dealt with membership monies and shop business separately. Looking into the future the two accounts may now be judged unnecessary and will soon be amalgamated into a single account.

The accounts for 2019

Bank Account Number 2

Opening balance	£13,805
Expenditure	£325
Closing balance	£13,480

These expenses relate to running the website and some costs incurred in attending rallies.

Bank Account Number 1

Opening balance	£258
Expenditure	£208
Closing balance	£50

These expenses include subscription to the '**Groups.Io**' web user group, Companies House plus other small items.

It should be noted that our donation to the Dundee Satellite Station will be shown in next year's accounts because the bank transfer took place in December 2019. Our combined accounts currently have a total value of £8,440. Perhaps we have some small stock items but they are not valued for the purpose of the accounts. We are currently reviewing the cost of running the website because the general opinion indicates they are too high for our current requirements. However, it must be noted that this is not a criticism of our website, which I judge to be of outstanding quality and informative. Congratulations to our webmaster and those who contribute to our GEO website.

Rallies

GEO has only one booking for a forthcoming rally or show and that is the '**London Computer and Amateur Radio Rally**' to be held at Kempton Park, SW London on Sunday, April 19, 2020. Please attend this rally if you can as it's always great to meet established GEO members again, while new faces are always welcome. There is a small entrance fee, about £3.00 I think. On the stand we hope to be running live EUMETCast, showing archived satellite images and giving away substantial amounts of EUMETSAT promotional material which has been specifically provided by them.

Quarterly Question

Francis Bell

Question 64

My thanks to those members/readers who responded to the last Quarterly Question. The question related to a satellite image showing part of the Persian Gulf and specifically showed the island country of Bahrain.

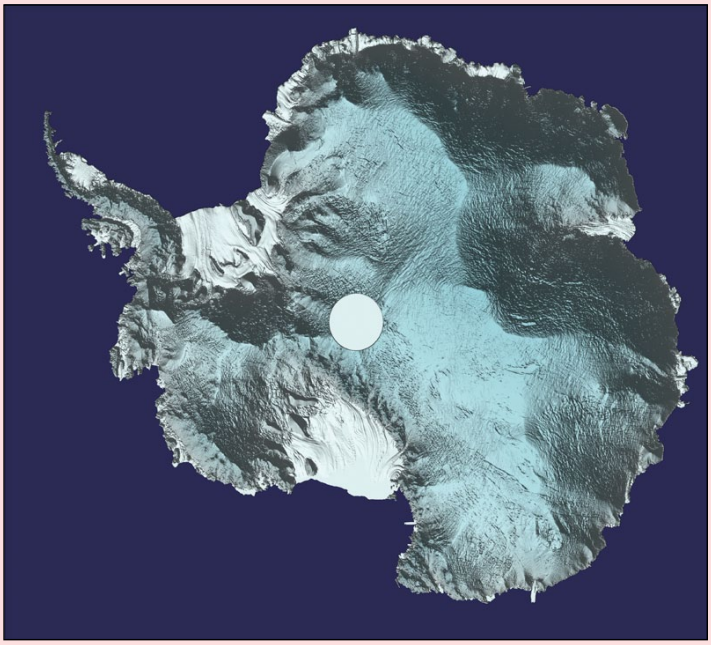
I was particularly interested in this image because Bahrain has been newsworthy recently because of the oil issues in the area relating to the potential disputes between Iran and the USA, plus some European countries including the UK.

I also like to ask a question about a country which I have visited. I'm not sure if in this case 'visited' is quite the correct expression but I have been in transit through Bahrain's international airport a number of times in the past (the 1990s) while flying between the UK and Goa, India. In those past days a refuelling stop was necessary for this long distance flight but nowadays long haul aircraft can achieve this particular route none stop.

Question 65a

This Quarterly Question relates to the image of Antarctica reproduced below, which is a composite from a number of radar images taken over the continent by a polar orbiting NOAA Earth Observation satellite about three years ago. It is important to note that this is a composite image, where several images from different satellite passes, but using the same instruments, have been combined into a single image of Antarctica.

Question 65a is this: Why is there a white hole in the centre of this composite image?



cntinued on page 7

If you feel ‘inclined’ to answer the question, you should consider orbital geometry rather than any instrument failure on the satellite which just missed part of a possible image. For acknowledgement of answers in the next newsletter please submit you answer, by May 20, 2020, by email to:

francis@francisbell.com

Question 65b

An image I recently encountered really appealed to me, and I decided to use it for a ‘bonus’ additional Quarterly Question

This Question should be quite straightforward. Name the island group shown in the satellite image opposite. The image was taken by a Copernicus Sentinel- 2 satellite on January 10, 2020 using the visible spectrum. I think that, without any further information, it would be difficult to name the islands, so have included ithe following edited text which I extracted from Wikipedia and ESA.

“The islands are particularly known for their dramatic landscape, grass-roofed houses and treeless moorlands. The islands boast over 1000 km of coastline, and because of their elongated shape one can never be more than five km from the ocean from any point of the islands

These islands are a North Atlantic archipelago located 320 kilometres north-northwest of Scotland, and about halfway between Norway and Iceland. It is an autonomous territory within the Kingdom of Denmark. They have a total area of about 1,400 square kilometres with a population of 51,783 as of June 2019.

The terrain is rugged; the climate is sub polar oceanic climate, windy, wet, cloudy, and cool. Temperatures average above freezing throughout the year because of the Gulf Stream and summers normally hover around 12°C. Average winter temperatures are 5 °C. The northerly latitude location also results in perpetual civil twilight during summer nights and very short winter days.

Between 1035 and 1814 these islands were part of the Kingdom of Norway, which was in a personal union with Denmark from 1450.

© contains modified Copernicus Sentinel data (2018), processed by ESA, CC BY-SA 3.0 IGO©

In 1814, the Treaty of Kiel transferred Norway to the king of Sweden, on the winning side of the Napoleonic wars, whereas the king of Denmark, on the losing side, retained these islands, along with the two other historical Norwegian island possessions in the North Atlantic. These islands shown in the image have been a self-governing part of the Kingdom of Denmark since 1948.

The islands control most of their domestic affairs. Those that remain the responsibility of Denmark include military defence, policing, and the justice department, currency, and foreign affairs. However, as they are not part of the same customs area as Denmark, the islands have an independent trade policy and can establish trade agreements with other states. The islands also have representation in the Nordic Council as members of the Danish delegation. The islands have their own national teams competing in certain sports.

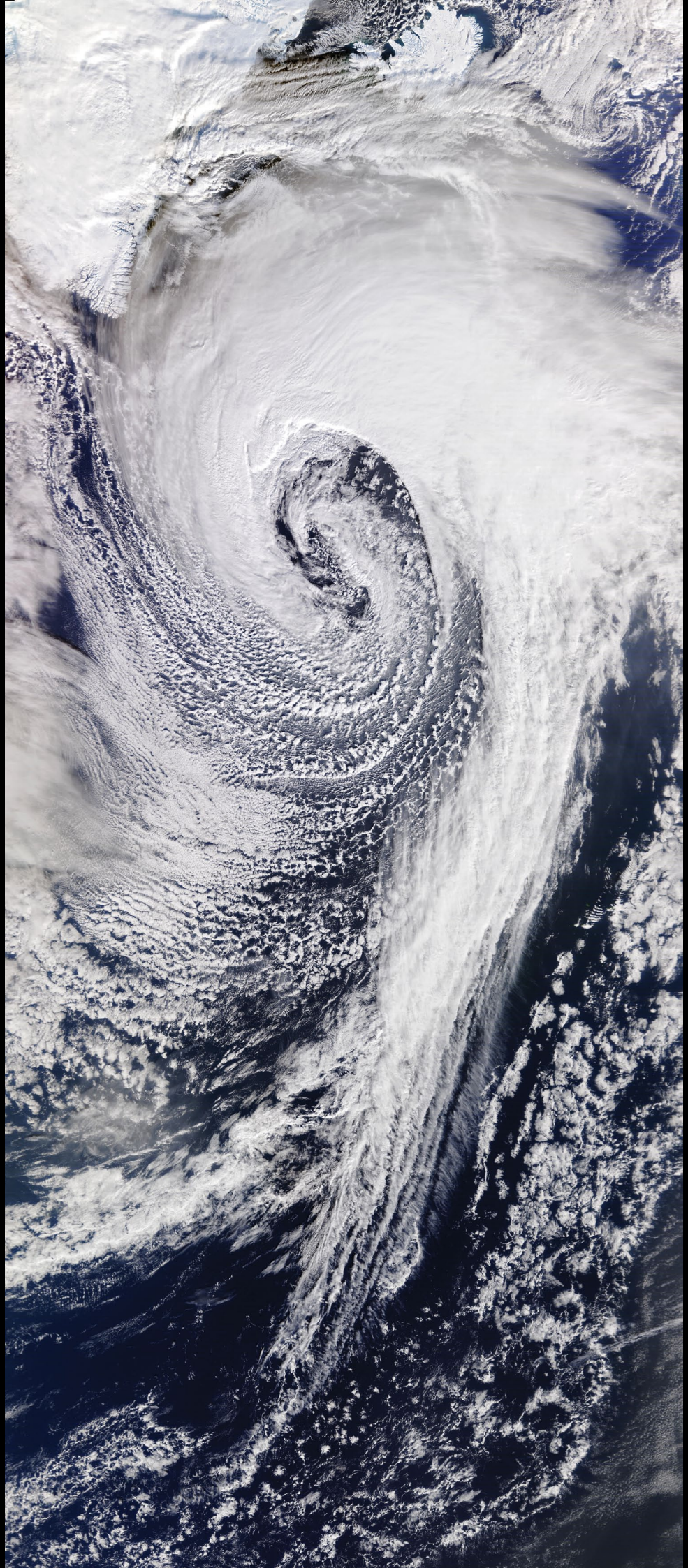
Please send your answer, by May 20, 2020 to

francis@francisbell.com

Storm Denis

The MODIS instrument aboard NASA's *Terra* satellite captured this fine image of storm Denis over the Atlantic Ocean on February 13, 2020, two days before it unleased gale-force winds and torrential rainfall over much of the UK

Image: LANCE, Rapid Response, Global Imagery Browse Services (GIBS), Worldview



Meteor-M 2-2 critically damaged by a micrometeorite

No further APT and AHRPT imagery expected from this satellite

Les Hamilton

Readers who had been enjoying imagery from Russia's latest meteorological satellite, Meteor M 2-2, had a nasty surprise on December 18, 2019 when transmissions abruptly ceased. A few days later, Roscosmos (Russia's State Corporation for Space Activities) explained as follows:

An abnormal situation was recorded on the Meteor-M spacecraft No. 2-2, associated with an external impact (presumed to be a micrometeorite) on its structure. As a result, Meteor's orbit was compromised and all on-board systems not involved in ensuring its functioning were turned off.

The *RIA Novosti* news agency issued further clarification on December 24, in the following report:

Meteor-M 2-2 has suffered a collision with a micrometeorite, which caused a change to the satellite's orbit and resulted in it temporarily losing its orientation. Following the emergency, power to all systems aboard the satellite were automatically turned off until it came within the range of Russian tracking stations.

Work then started to damp Meteor's angular velocity and return it to its standard operations orientation in order to be able to receive telemetry and target information. Now that the connection has been restored, regular control sessions are being conducted with the reception of telemetry information and data from the target equipment.

Technical details of what happened

According to ***space-track.org***, the specialised website of the US Air Force, on the night of December 17-18 (between 23:08 and 06:06 Moscow time) the perigee of Meteor's orbit fell by 2.4 kilometres (from 806.5 to 804.1 kilometres) while its apogee fell by 0.1 kilometre (from 821.8 km to 821.7 km).

The instruments aboard Meteor M2-2 were housed in a pressurised environment in which circulating gases acted as a coolant and heat transfer agent. It is conjectured that, during depressurisation of this chamber, the escaping gases provided thrust that sent the satellite into a spin and altered its orbit. At the same time, the instrumentation became prone to overheating because of loss of coolant.

Meteor-M 2-2

The satellite was launched from Vostochny in July 2019 by a Soyuz-2.1b launch vehicle with the Frigate booster and, following completion of flight tests on December 7, *Roscosmos* announced the spacecraft to be was fully operational.

Meteor M2-2
Image: Roscosmos

There are currently three Meteor-M series satellites in orbit. The first, Meteor-M1 is no longer fully operational and does not disseminate imagery although some of its additional scientific equipment is still in operation.

The second satellite in the series is Meteor M2, which is still fully operational despite now having exceeded its optimum design lifetime. Its successor, Meteor M2-1 was lost due to a launch failure in 2017 and it seems that the latest member of the series, Meteor M2-2, has been rendered incapable of delivering any further LRPT/AHRPT imagery. We must now await the launches of Meteor M2-3, scheduled for this year and Meteor M2-4 which could be launched in 2012.

On January 17, 2010, Roscosmos admitted that although they had regained control over Meteor M2-2 there was particular concern over the condition of the satellite's batteries, which were quickly becoming overheated and switching over to the backup units. This meant that could be only short-term power-ups as the battery life was reduced tenfold.

Meteor M 2-2 prior to launch
Image © RIA Novosti / Pavel Lvov

Unfortunately, the power supply situation no longer allows the 137 MHz transmitter to be used even though it is still technically in working order, and as a result there will be no future LRPT/HRPT transmissions.

The following is an extract from a report on the 'Hackaday' website by Dan Mahoney, which adds further insight into the matter.

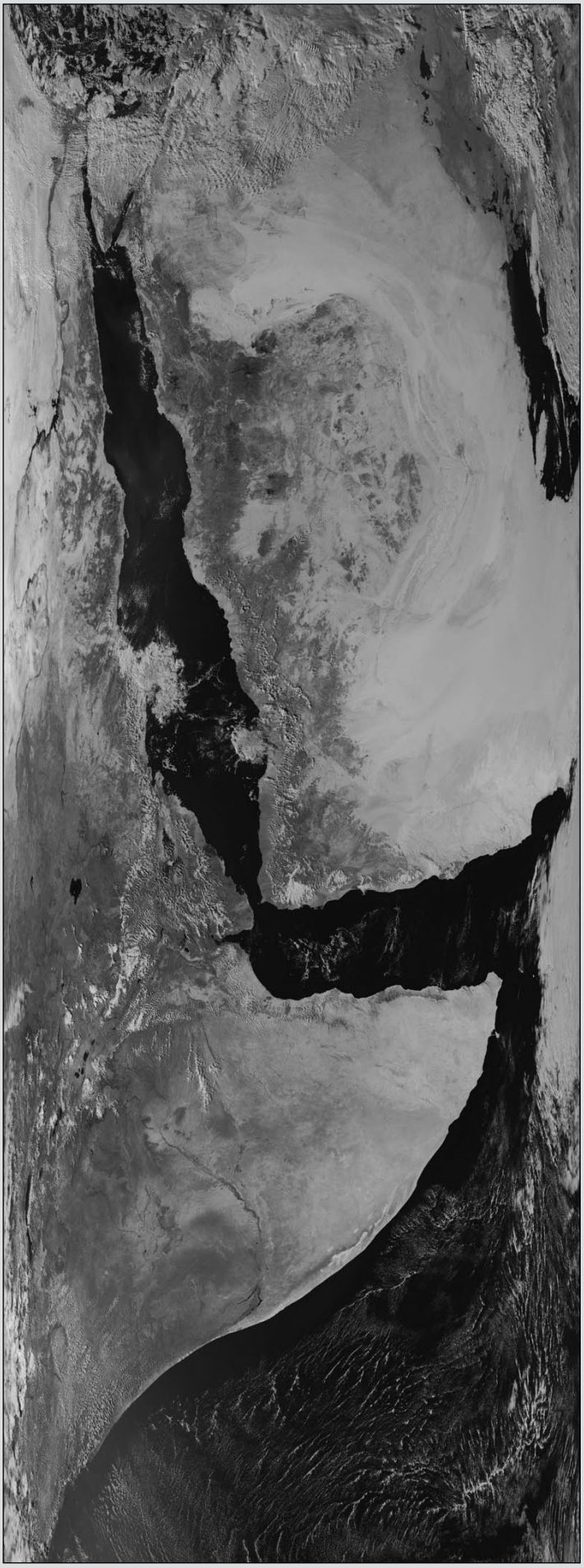
As is often the case, an amateur radio operator was among the first to notice the problem with Meteor M2-2. Dmitry Pashkov (R4UAB), a satellite monitoring fan, had been capturing images from weather satellites for years. But when he tried to find Meteor-M 2-2 on December 18, 2019, all he got was dead air. It seemed like the satellite was gone, and once he announced his findings, it wasn't long before other satellite watchers pieced together a story, one that would eventually be confirmed by *Roscosmos*, the Russian space agency.

Based on the data, it appears that Meteor-M 2-2 was struck by a micrometeoroid—either a natural chunk of space rock or some piece of man-made debris. The SUV-sized satellite was sent spinning violently out of control by the impact. It immediately put itself into a safe mode to protect its instrumentation and give ground controllers time to regain control, which they eventually did. Subsequent analysis of the orbital data revealed that the satellite had also lost two kilometres of orbital altitude immediately after the impact.

Such a violent disruption of a satellite as big as Meteor-M 2-2 would imply a large, very energetic collision. But that would probably break the satellite into multiple pieces, and there's no evidence that anything like that happened. That means the impactor was small, which appears at odds with the outsized effect it had on the spacecraft. That leaves operators considering whether the impact penetrated a pressurised part of the satellite's hull. That could explain the drastic change in attitude and altitude.

Unfortunately, it could also mean the end of Meteor-M2-2's mission. Many of the instruments aboard the satellite require constant temperatures to work, and the electronics controlling the bird may now be exposed to the vacuum of space. Roscosmos has regained control of the spacecraft and damped down its spin, and there are even reports that an X-band signal from the satellite has been detected.

With a depressurized hull, the spacecraft is most likely doomed to follow in the sad footsteps of its predecessors. It's yet another in a long string of failed or marginal weather satellites, the passing of each of which is mourned by the satellite monitoring community. There are still plenty of satellites up there providing realtime weather and climate imagery, but the likely loss of Meteor-M 2-2 shows just how dangerous it can be up there.



This X-band image from Meteor M2-2 appeared on the @MeteoOleg Twitter feed on December 26, 2019, with the caption 'Meteor M N2-2 still alive. Now in X-band 61.44MS/s QPSK in 8128MHz (MSU-MR instrument) '

Smoke and flames in Australia

European Space Agency

Detail of bush fires burning some 200 kilometres south of Sydney, New South Wales, during January 2020.

Ferocious bushfires have been sweeping across Australia since September 2019, fuelled by record-breaking temperatures, drought and wind. The country has always experienced fires, but this season has been horrific. As of January 9, 2020, a staggering 10 million hectares of land have been burned, at least 24 people have been killed and it has been reported that almost half a billion animals have perished.

The Copernicus Sentinel-2 mission has been used to image the fires. The Sentinel-2 satellites each carry just one instrument—a high-resolution multispectral imager with 13 spectral bands. The smoke, flames and burn scars can be seen clearly in the full image—on the following page—which was captured on 31 December 2019. The large brownish areas of burned vegetation provide an idea of the size of the area affected by the fires. The brown 'strip' running through the image has a width of approximately 50 kilometres and stretches for at least 100 km along the Australian east coast. Jervis Bay is prominent at the top of the image. The image zoom above reveal starkly the extent of the flames.

Adding Country Boundaries and Station Data to Meteor LRPT Imagery

Les Hamilton

Overview

In GEO Quarterly No 47 (2015) David Taylor introduced his *LRPT Image Processor* software which was designed to analyse the three data channels disseminated by Russia's Meteor M2 satellite and derive a number of geographically rectified products from them.

What this software has been unable to achieve—until now—is the addition of country boundaries and station data overlays to the Meteor images.

This updated version of *LRPT Image Processor* can be downloaded from David Taylor's website at

https://satsignal.eu/software/LRPT-processor.html

At the present time the only active Russian weather satellite is Meteor M2, currently transmitting channels 1, 2 and 5. By feeding all three data channels into *LRPT Image Processor*, either as an RGB125 image (figure 1) or individual greyscale channel images, derived products can be created.

One of the more useful derived products is the false colour image produced by assigning channel-1 to red and channel-2 to both green and blue (figure 2). Partly due to low solar illumination at this time

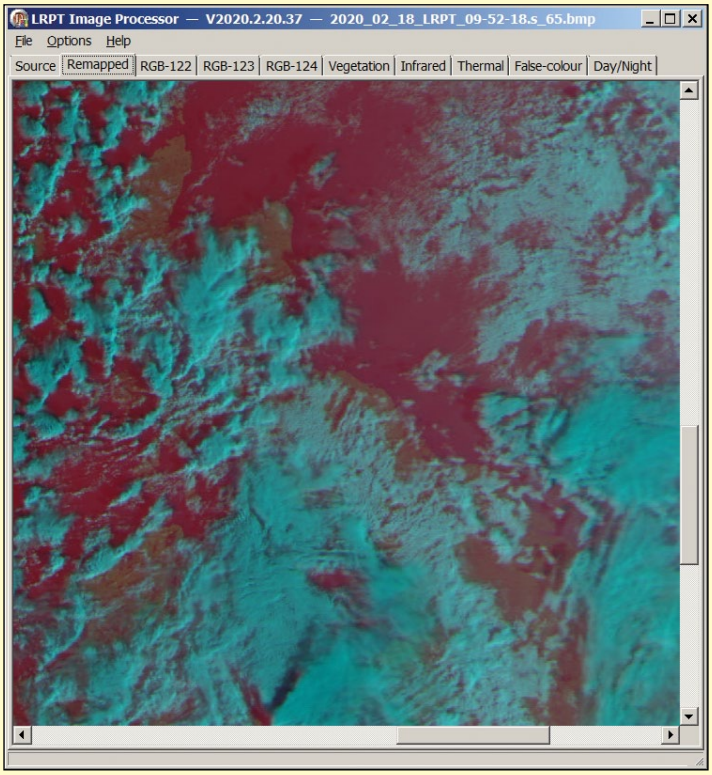


Figure 1
This RGB125 image segment is taken from the 09.50 UT Meteor M2 pass on February 18, 2019

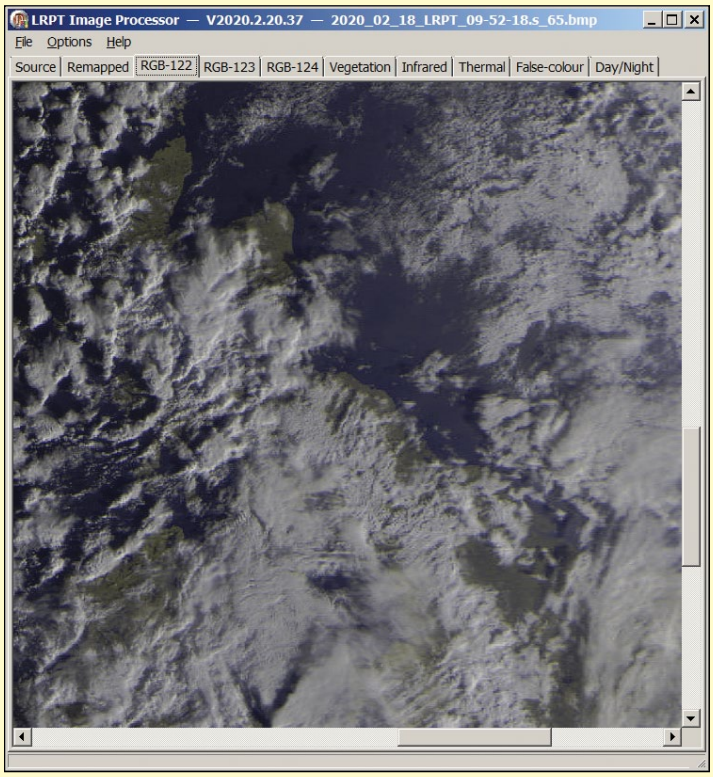


Figure 2
Following processing with LRPT Image Processor, this is the false-colour RGB122 version of the same image.

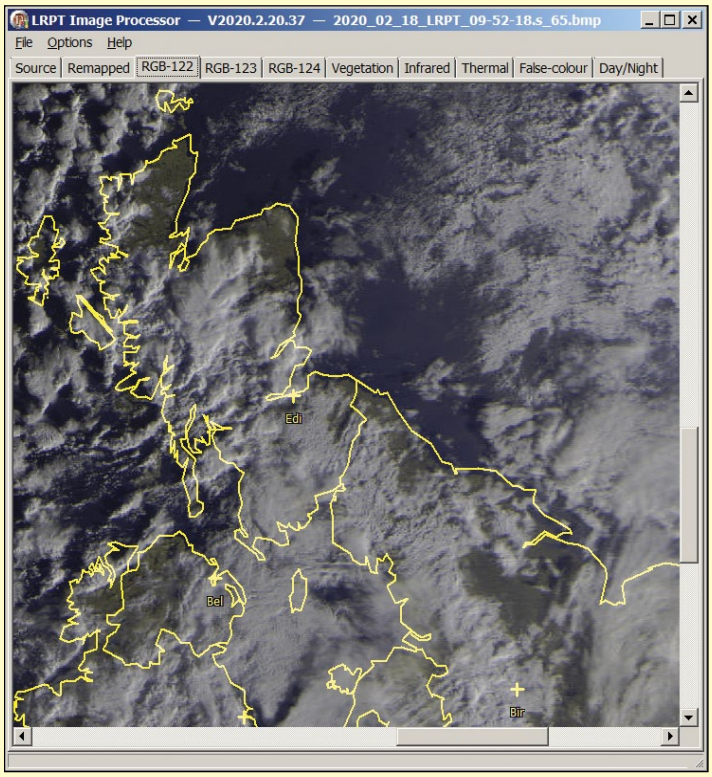


Figure 3
The original image is rather dark and partly obscured by cloud. The addition of country outlines clarifies the area imaged.

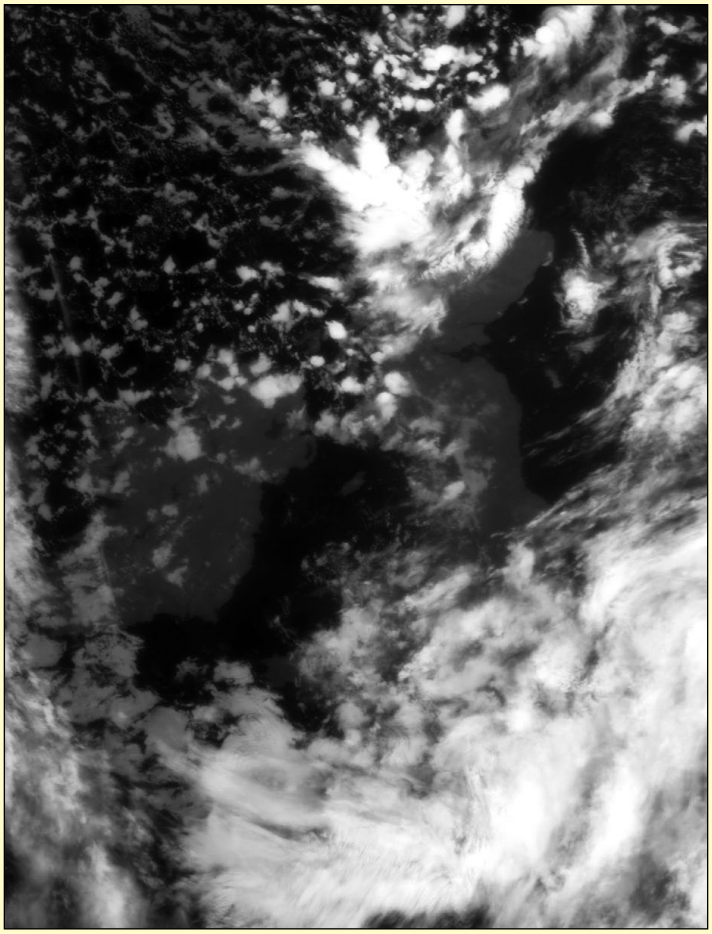


Figure 4
This infrared image (channel 5) comes from the February 17 evening pass of Meteor M2.

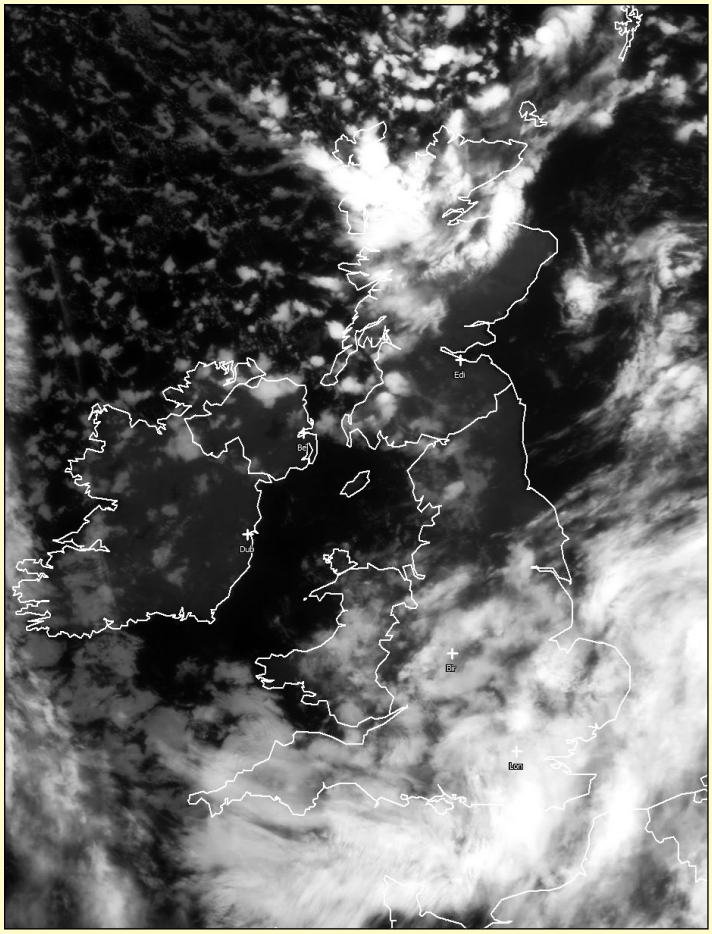


Figure 5
This is the same evening Meteor M2 pass, rectified in LRPT Image Processor, which also added the country outlines.

of year, but also to cloud cover, the image does not show land features clearly, and the addition of country boundaries gives a more satisfying impression (figure 3). Figures 4 and 5 illustrate how the overnight infrared channel can also benefit from the application of country boundaries.

The New Features

Depending on the settings in its 'ini' file, Oleg Bekrenov's *LRPT Decoder* can generate not only composite RGB125 Meteor images (figure 1) but also greyscale images of each of the three individual data channels. If these three greyscale images are present, *LRPT Image Processor* will combine them to form its products: if only an RGB125 or RGB123 image is present, the software will extract the individual data from these. To be certain that *LRPT Decoder* generates greyscale BMP Meteor images, its minimalist ini file should read as below:

```
[IN]
mode=72k      ; current PSK Symbol Rate for M2
[OUT]
rgb=125.bmp ; Current channels being transmitted
mono=bmp     ; Single channel BMPs in greyscale
logs=no       ; inhibits developer's log files
```

Each original image generated by Oleg's *LRPT Decoder* is accompanied by a 'stat' text file which contains essential data for superimposing country boundaries accurately on the images, in particular the start time of decoding (Moscow time). A typical set of three Meteor BMP images, each with accompanying 'stat' file, is illustrated in figure 6. All six files have the same stem filename, and differ only in the final channel code: 64 (channel-1), 65 (channel-2) and 68 (channel-5). To avoid any confusion when accessing these files through *LRPT Image Processor's* Load Dialog, they are listed only by the stem filename, in this case: 2020_02_18_LRPT_09-52-19. Selecting any one from these three will load the full set into the software.

Overlays

The current setup file for *LRPT Image Processor* contains two datafiles: **Countries.dat** which creates the country boundaries and **Stations.dat** which adds markers for principal cities, points of interest, and EUMETSAT ground stations.

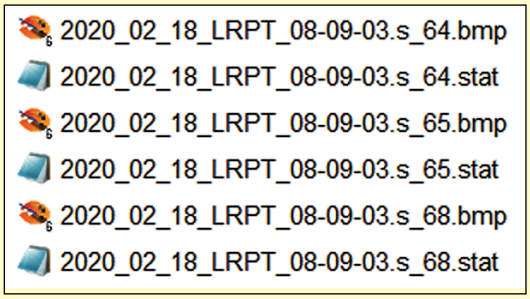


Figure 6
A typical set of Meteor M2 greyscale-BMP channel files

These overlays are initialised by right-clicking over a generated image to reveal the pop-up menu shown in figure 7. Click on 'Boundaries' to toggle the overlays on or off. Note that these overlays do not automatically save with the images. To save images with overlays intact you must, additionally, check the 'Save with overlay' option on the Setup panel (figure 8). A recent Meteor M2 image is reproduced on page 16 both with and without country boundaries to illustrate the effect (figures 9a/b).

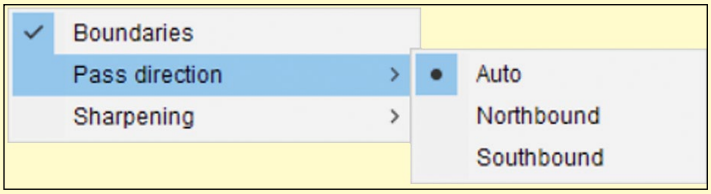


Figure 7
A right-click of the mouse over the generated images reveals this menu for controlling boundary data, image attitude and sharpening.

Overlay Accuracy

To ensure the best possible registration of country boundaries it is vital that *LRPT Image Processor* has access to the most up-to-date set of Keplerian elements. The *Setup* panel includes a 'Browse' option for the location of a file of **Keplerian orbital elements** for Meteor M2: most commonly the file 'weather.txt' from *Celestrak*. Browse to a folder containing this file (not the file itself) and the software will do the rest. One of the safest options is to use the element file within your favoured tracking software, as this will be updated regularly through use.

The most likely candidates are David Taylor's own *WXtrack* and Sebastian Stoff's *Orbitron*. Figure 8 shows, for my own system, the Kepler path set to the 'tle' folder in *Orbitron*. If you don't run a tracking program, you can download an element set from

https://celestrak.com/NORAD/elements/weather.txt

and store it in a folder of your choice: this element file will actually work perfectly from within the *LRPT Image Processor* folder itself.

Registration of country boundaries is generally very accurate, but if necessary they can be nudged into better alignment by means of your keyboard's arrow keys (and Shift+arrow keys for larger movement). But it is advisable to update the Keplerian elements at least once weekly to minimise this. In the *Orbitron* tracking program which I use to control my reception of the Meteor satellites, I have set it to automatically update the Keplers at 2-day intervals.

There is also a choice of colour for the outlines: the 'Colour' button on the Setup panel opens a colour palette which you can click to make your choice.

RGB123 Mode

When *LRPT Image Processor* was originally released in 2015, Meteor M2 transmitted visible channels 1 and 2 alongside infrared channel-5 continuously all year long. The only deviation from this occurred when the infrared channel was occasionally deactivated for one or two days and replaced by channel-3 (presumably for decontamination of the infrared sensor).

text continues on page 18

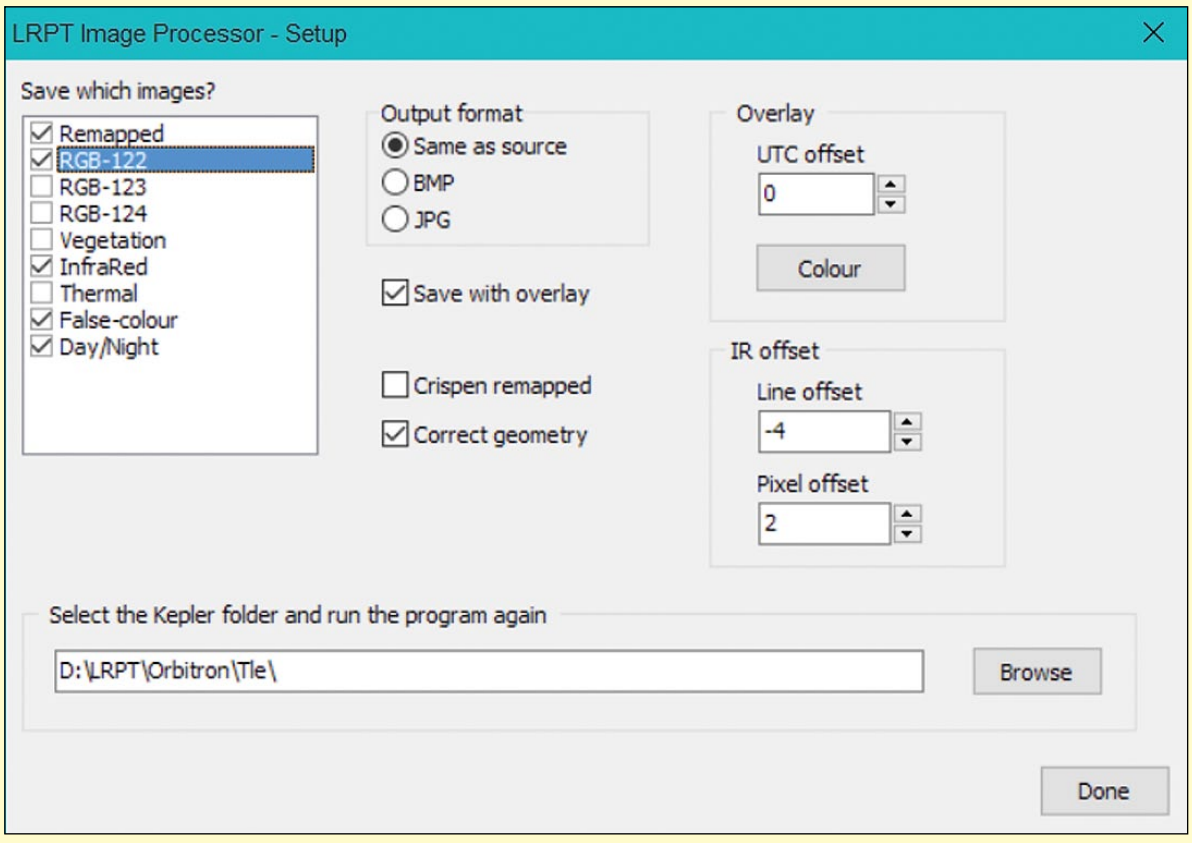


Figure 8
The Options-->Setup window in LRPT Image Processor

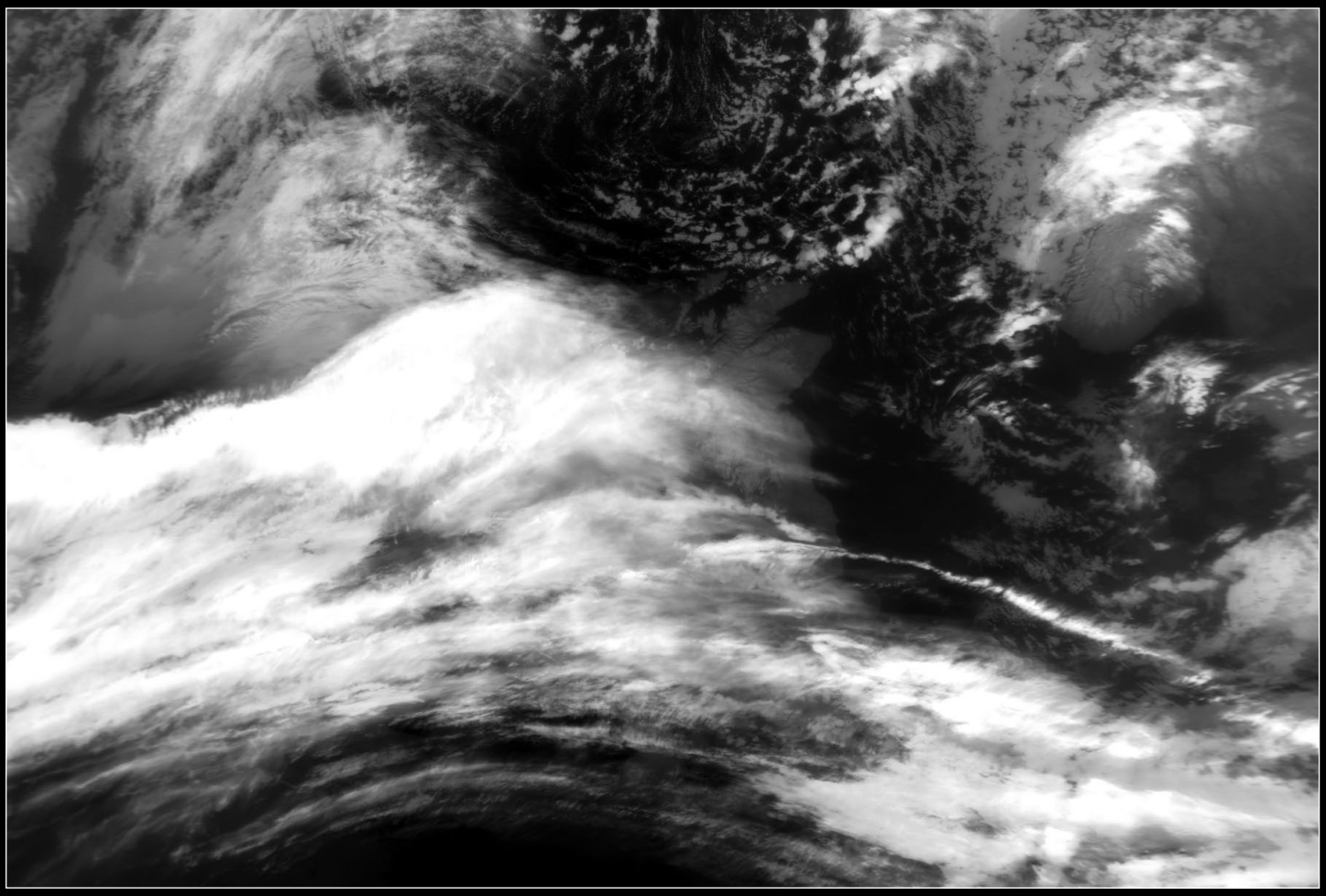


Figure 9a - This IR image comes from the 19:40 UT pass of Meteor M2 on February 23, 2020, processed in LRPT Image Processor.

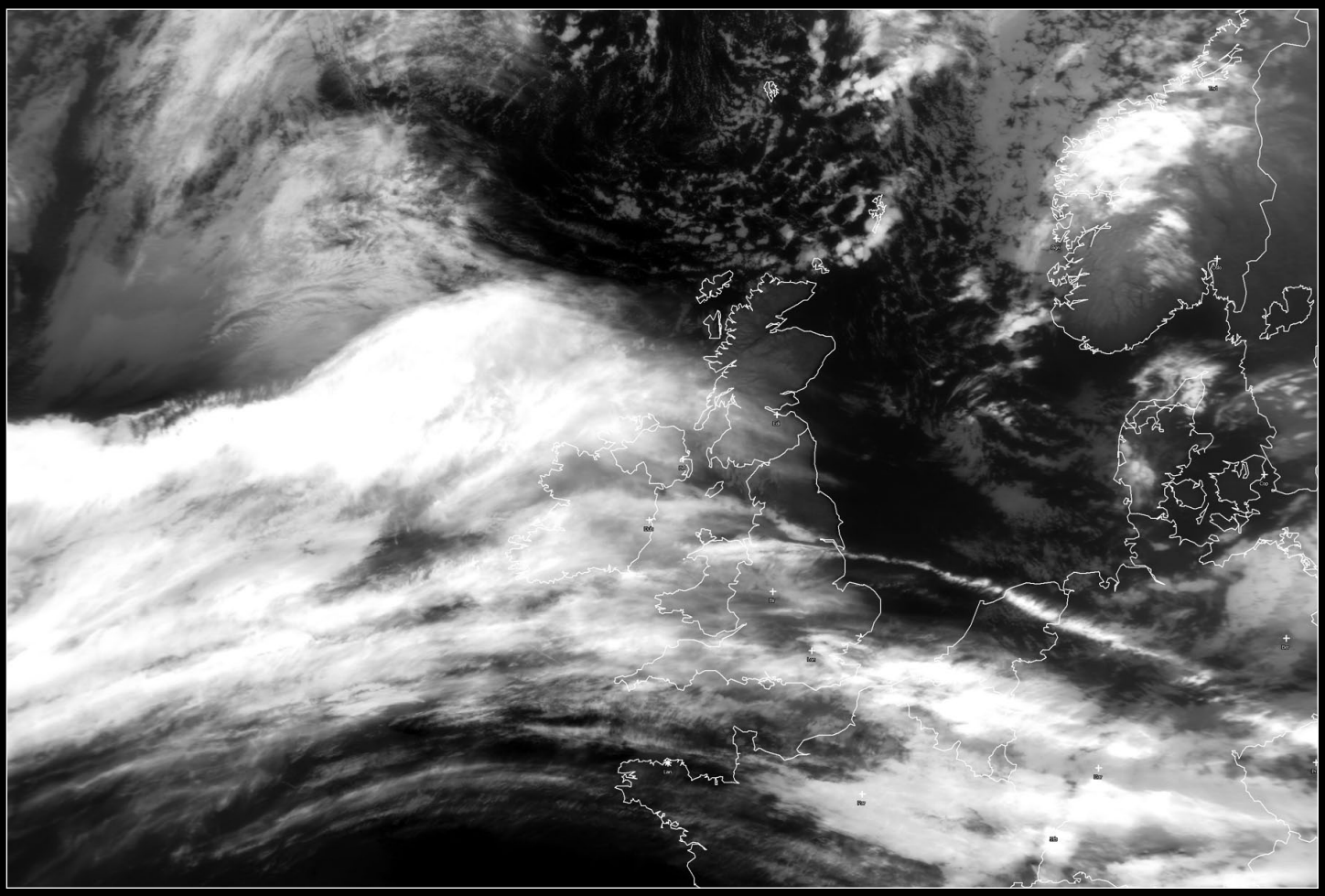


Figure 9b - This is the same image with country boundaries added.
Note that there are no colour options for boundaries over images on the Infrared tab as these are greyscale images.

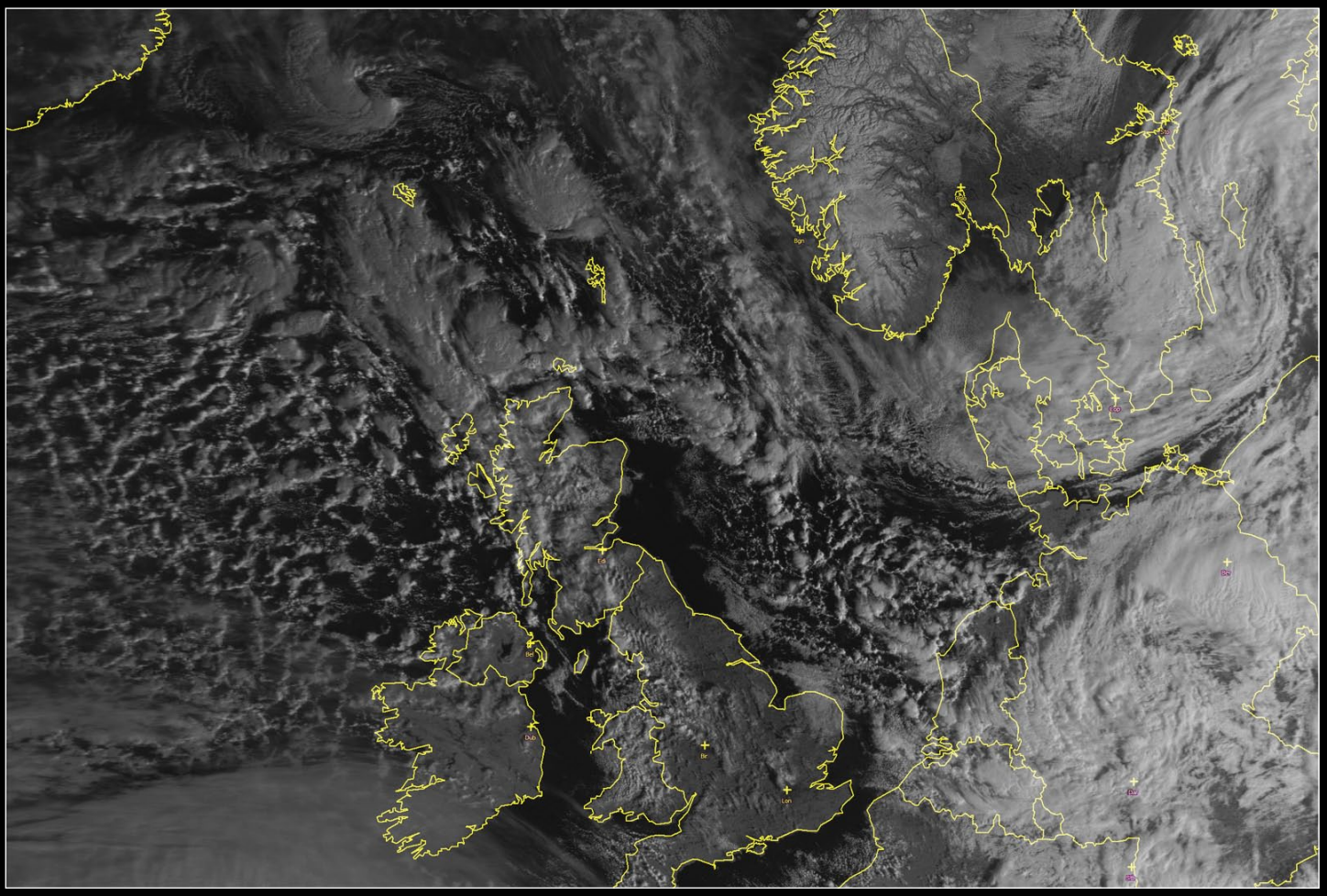


Figure 10a - This is the greyscaled False-Colour Meteor M2 image from the 08:50 UT pass on February 26, 2010.

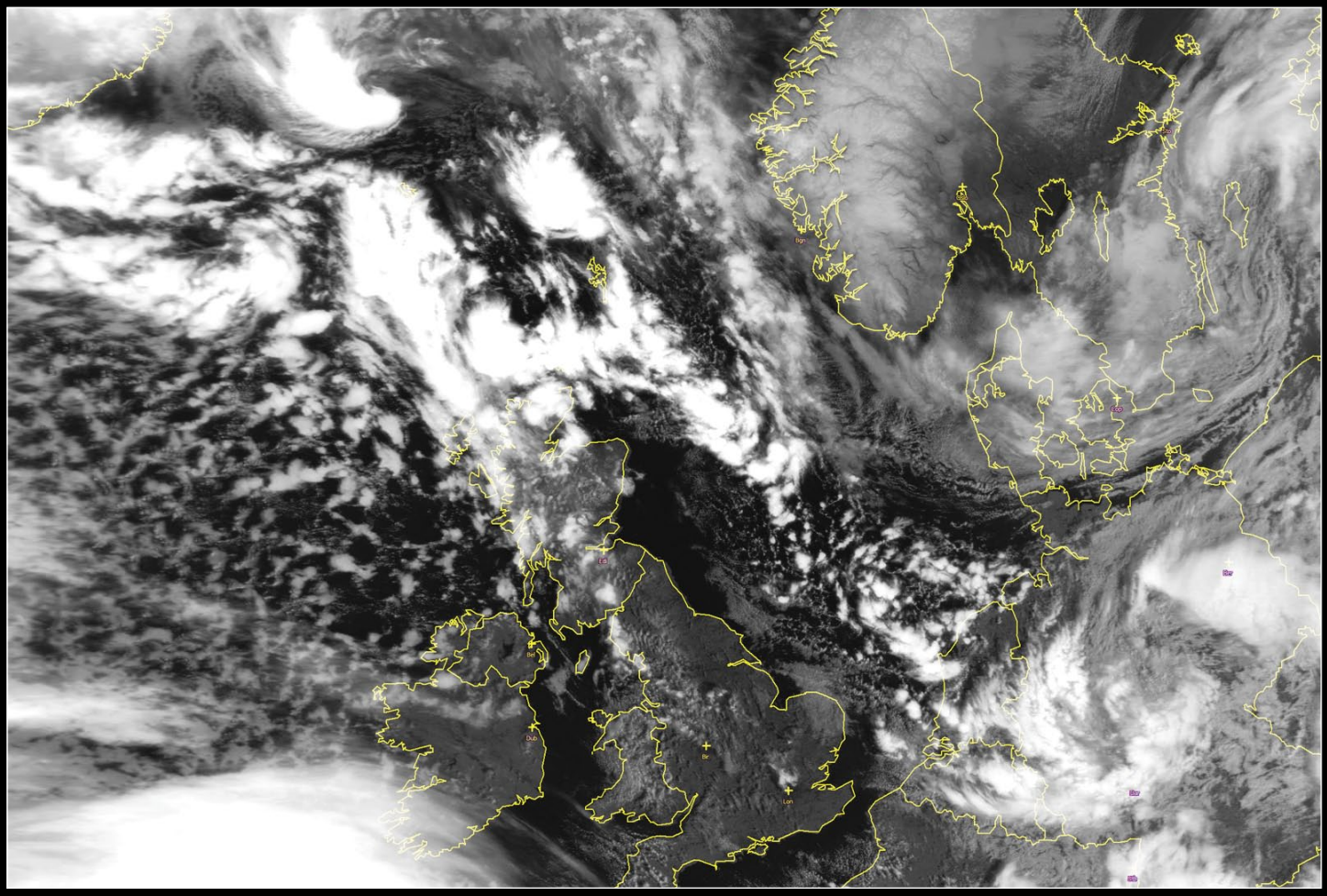


Figure 10b - This is the composite Day-Night image from the same Meteor M2 pass where detail from the infrared channel has been added to the above image to provide enhanced detail in the darker areas.

However, starting in 2018, *Roscosmos* began 'resting' the infrared LRPT transmission for several months at a time, allowing enthusiasts access to regular RGB123 visible-light imagery. This lasted for three months (from May to August) in 2018, and was increased to six months (from April to October) in 2019. This has now been catered for with a new RGB123 tab on the program interface and an option on the Setup panel (figure 8). Hopefully Meteor M2 will continue disseminating channel-3 this summer.

Day/Night Mode

Another innovation in the software is what is termed Day/Night mode, in which a greyscaled version of the false-colour image and the infrared image are combined. David Taylor explains:

> *"My intention in the new Day/Night mode was to enhance dark winter-time false-colour images by adding infra-red content into the dark areas. The Day/Night image aims to combine the infra-red and visible images so that cloud is shown in night areas, together with the brighter visible image detail where the clouds are thinner or absent.*
>
> *"I had hoped to use the colouring in the false-colour images to continue, but in practice this produced some artefacts: so it's actually a monochrome version of the false-colour image that's combined with the infrared image. You can view this as either the false-colour providing more detail to the infra-red, or the infra-red providing more detail to the false-colour, as you wish."*

Although the oriinal idea was for the infrared image to lighten the dark areas of false-colour image, I have found that it also adds enhanced land detail to infrared images.

The February 26 Meteor M2 pass reproduced on page 17, shows both the greyscaled 'false-colour' image alongside the processed 'day/night' image (figures 10a/b).

Finally

It is only fair to point out that *LRPT Image Processor* is free, unsupported software and, as such, David Taylor is unable to field queries about it.

However, he has kindly agreed that we can reprint his original article, which should answer any queries that first-time users in particular may have about how to use the software.

You can read David Taylor's original article about *LRPT Image Processor*, starting on page 23 of this Newsletter.

Support for Ayecka SR1 Users

Nigel Evans

I recently heard from a GEO shop customer living in Germany who had tried to restore his SR1, had got in a mess and needed support. His SR1 is now in my possession and I hopefully can restore it for our German friend as Baruch from *Ayeka* showed me how to do a full factory reset.

Although the GEO Shop is now closed, I am still willing to provide some support to members.

In the case of our German friend, I suggested that rather than throw his SR1 in the bin, his only risk should I be unable to get his SR1 working again would be the postage cost to the UK. I do make a small charge to cover postage and time for the restore if successful. I make no charge of the unit is clearly 'dead on arrival', which has only ever occurred twice.

Also, there must be SR1s out there gathering dust too. As I do get the odd enquiry for these, I would be prepared to help find these new homes. I can be contacted by email at either:

nigel.m0nde@gmail.com

or

shop@geo-web.org.uk

An Atmospheric Phenomenon

Rob Denton sent us this photograph taken by a neighbour of his. It appears to show a thin wisp of cloud, in an otherwise clear sky, sporting a brilliant flash of colour. If any reader understands the cause of this phenomenon, the editor will be pleased to hear from you. Emails, please to

geoeditor@geo-web.org.uk

News from Dundee Satellite Receiving Station

Now a commercial entity known as Dundee Satellite Station Ltd (DSRS)

Introduction by Francis Bell

Members of GEO and those who read our last Quarterly News Letter will know that GEO have tried to be supportive of the satellite project based at Dundee University, which has recently been faced with closure due to NERC withdrawing its financial support. The project at the University has now been closed but is being re-established at a new site nearby. I asked the project leaders to send us a very brief report about their progress in re-establishing their satellite ground station. I was delighted to receive the following report from Neil Lonie, plus a number of photographs.

The closure last year of the well known DSRS facility, first begun in 1966 by Peter Baylis and John Brush, along with students at the School of Engineering in the University of Dundee, was a body blow to remote sensing observation science in Scotland, the UK and beyond.

After NERC withdrew funding from the Station (it had begun funding it from ca. 1976 until 2019) the University's senior management claimed it could no longer afford the Station or the personnel and forced its closure. However, several of the personnel, along with long-time supporters of the facility, began a campaign to rescue the equipment and antennas, and relocate the Station to a new site to recommence operations.

Dishes awaiting transfer to the new station on Errol Airfield

As such, Dundee Satellite Station Ltd was formed, now run by Dr Paul Crawford (RF Engineer) and Mr Neil Lonie (Station Manager and Operations Engineer). Faced with the realities of creating the necessary income stream to fund the running costs, DSS Ltd will operate as a commercial entity providing ground station support for small satellites, for example. This

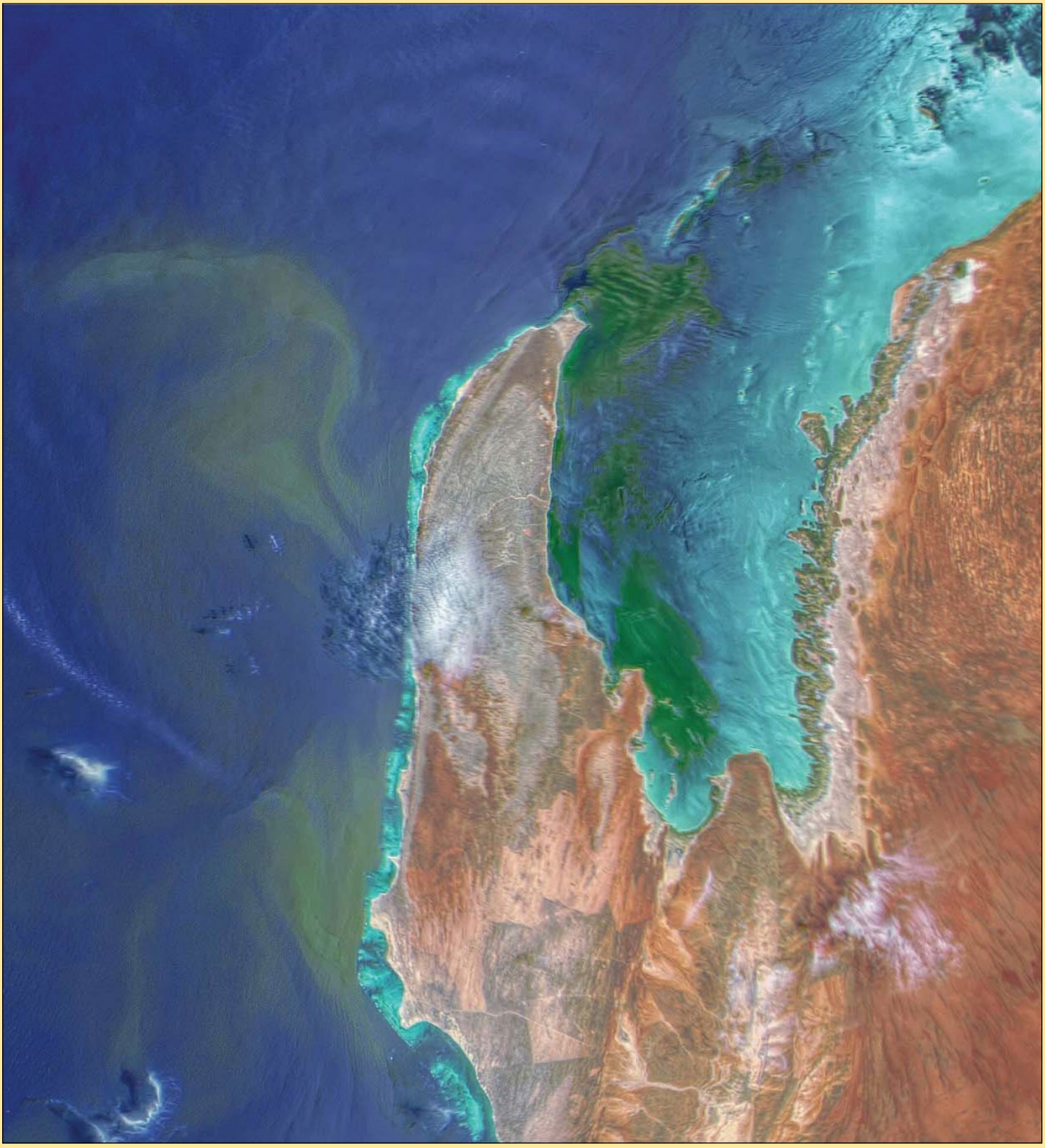
The tracking 3.7 metre dish with VHF antenna which will be the first antenna established at Errol Airfield

should also generate profits that will allow the pursuit of research and development projects with universities and other organisations, and also provide some free Earth Observation data and imagery to both amateur users and professional remote sensing scientists.

DSS Ltd has recently received (13th February) planning permission from Perth & Kinross Council to relocate its antennas to the former RAF Errol Airfield, just west of Dundee, where the "antenna farm" will be re-established. This will require the installation of an on-site operations/ maintenance building to support the antennas, with all the requisite antenna mount hardware, power, networking and site security infrastructure to be constructed as well, of course.

The ongoing *Gofundme campaign* to help fund the antennas and facilities to be used for EO data collection has raised on-line to date, some £14,200, while additional

An aerial view over Errol airfield, where planning permission has been give for establishing the new Dundee Satellite Station



A recent image of Exmouth Gulf Australia from a prototype ocean colour satellite supported by the Dundee station

outside donations bring that amount even higher, with an end goal of £65,000. The very kind and substantial donation from the GEO Organisation is currently being held in reserve until the commercial antennas are functioning, when it can then be used towards establishing EO data reception once more to “keep the weather free” and provide daily data and imagery, as had been done by DSRS.

Discussions are underway between the Centre for Remote Environments at the University of Dundee, the Satellite Oceanographer of NASA at NASA Goddard and DSS Ltd, and the GEO funds may also assist with a related research project using data from a new prototype ocean-colour observation satellite. The project area would be South Georgia Island and the surrounding South Atlantic region. An attached sample image showing Exmouth Bay, Australia gives an idea.

Neil Lonie, Dundee Satellite Station Ltd

Web: www.DundeeSat.co.uk

Email: ntlonie@dundeesat.co.uk

The Island Shaped like a Horseshoe

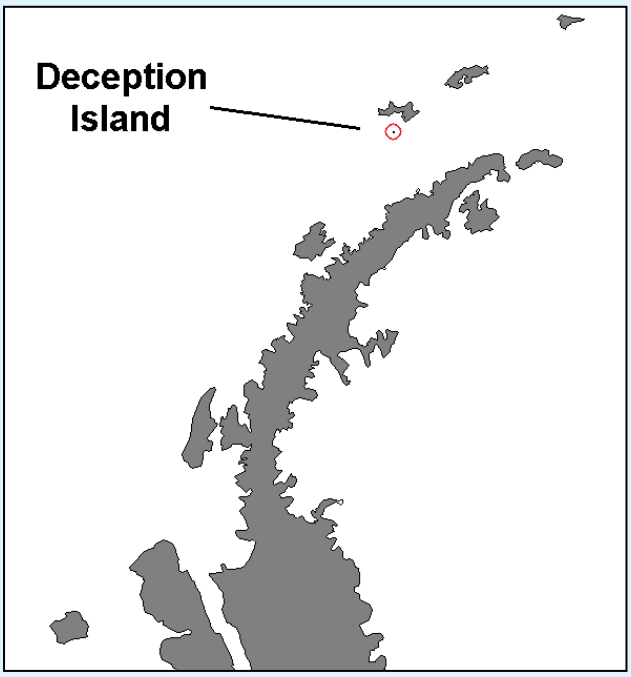
NASA Earth Observatory

Story by Kasha Patel

Approximately 4,000 years ago, a volcano in the Southern Ocean launched between 30 and 60 cubic kilometres of rock and magma into the sky. The eruption had the same severity as the cataclysmic 1991 eruption of Mount Pinatubo and was the biggest eruption around Antarctica in the past 12,000 years.

As the volcano's magma chamber emptied, the sudden drop in pressure inside the volcano caused the top to collapse and form a caldera eight to ten kilometres in diameter. A collapse of this magnitude is large enough to induce multiple, intense high-magnitude earthquakes, according to researchers.

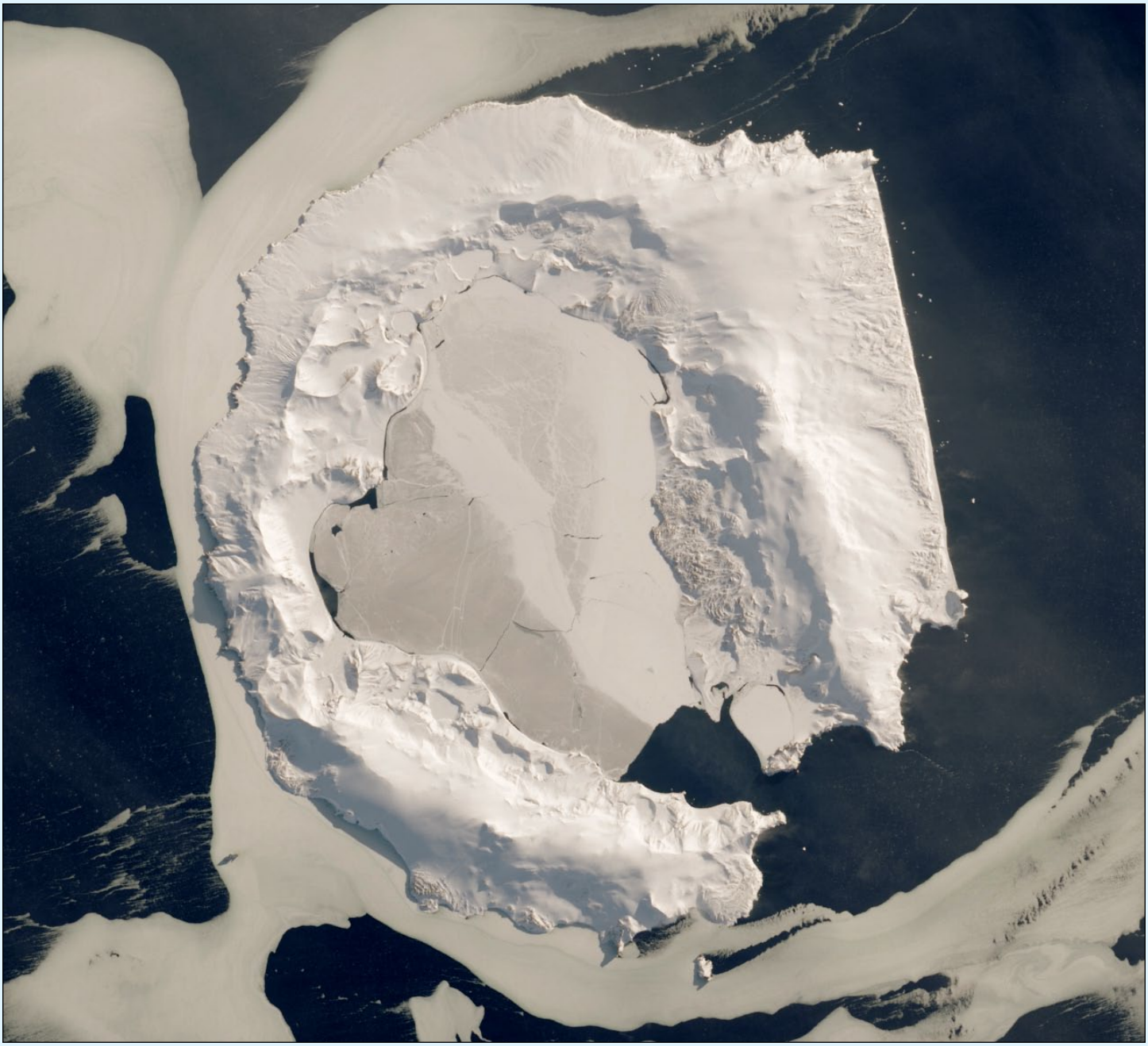
In the process, the caldera gave the island its unusual horseshoe shape. When explorer Nathaniel Palmer approached the island in 1820, he named it *Deception Island* on account of its deceptive appearance; it appeared as a normal island from most directions, but from the southeast a narrow passage revealed a harbour (the flooded caldera) that explorers could sail into.



Location of Deception Island off the Antarctic Peninsula

Deception Island viewed from Landsat-8 on March 23, 2018

NASA Earth Observatory images by Lauren Dauphin, using Landsat data from the U.S. Geological Survey.



Deception Island viewed from Landsat-8 on September 121, 2017.
NASA Earth Observatory images by Lauren Dauphin, using Landsat data from the U.S. Geological Survey.

The natural-colour image on page 21 shows Deception Island in early autumn, as observed by the Operational Land Imager aboard Landsat 8 on March 23, 2018, when the top of the volcano was visible. The image above, taken on September 21, 2017, shows the volcano and caldera covered in snow and ice.

Deception Island is one of two active volcanoes around Antarctica, and has erupted more than twenty times since the 19th century. The most recent eruptions occurred between 1967 and 1970, and seismic activity has occurred as recently as 2014-2015. Deception Island remains one of the only places in the world where ships can sail directly into the centre of a restless volcano.

Despite the island's eruptive history, its harbour—Port Foster—is considered one of the safest in Antarctica due to the absence of large glaciers. At the beginning of the 19th century, people began visiting the island to hunt seals, a popular commercial frenzy at the time. When the seals were hunted almost to extinction by the early 1900s, seafarers switched to whaling and set up operations at Whalers Bay on the east side of the port.

Today, Deception Island is home to scientific research stations, although some have been wiped away by past volcanic activity. The island is also a popular place for tourists, who can haul out on the beach and sit in geothermal baths. Visitors can also see one of the world's largest rookeries of chinstrap penguins located on the island.

Enhance your Meteor M2 Experience with

LRPT Image Processor

David Taylor

Program Background

Like many other readers, I had been dabbling with Meteor M2 imagery in recent months, and quickly became aware of one feature that currently available software lacked: the ability to combine the three Meteor LRPT channels into realistic false-coloured images.

Those of you who download NOAA HRPT imagery will be well aware that excellent results can be formed by combining channels 1, 2 and 4, to create the 'classic' RGB124 coloured images. In theory, this can also be achieved for Meteor as the frequency ranges of the two satellites' channels are almost identical, as illustrated in the tables below.

NOAA	
Channel 1	0.58 - 0.68 µm
Channel 2	0.725 - 1.00 µm
Channel 4	10.30 - 11.30 µm

Meteor M2	
Channel 1	0.50 - 0.70 µm
Channel 2	0.70 - 1.10 µm
Channel 5	10.55 - 11.50 µm

One problem is that Meteor M2 transmits its channel-5 image with the warmer areas as light tones and cold regions in dark tones, displaying dark clouds and light coloured land. NOAA reverses this prior to transmission, providing images with the more familiar light cloud features and darker land and sea.

A second problem is that I have yet to find calibration data for digital level to brightness temperature, so I have had to estimate this by comparison with other satellite data.

Meteor RGB125 images

If you select the three Meteor LRPT channels as red, green and blue respectively in Oleg's *LrptOffLineDecoder*, you end up with images like the one shown in figure 1, where there is a strong red bias, especially in the seas. But because these images contain the complete sets of values for all three LRPT channels, it is a straightforward matter to tease them apart with software and recombine them in more interesting interpretive ways.

LRPT Image Processor

This was the rationale behind the development of *LRPT Image Processor*, a simple program that converts Meteor RGB125 images into a number of more useful formats. Some of these are simply combinations of the original channels, while others result from the application of Colour Lookup Tables (CLUTs) to produce more realistic false-colour images.

LRPT Image Processor can be downloaded from

https://www.satsignal.eu/software/LRPT-processor.html

and is free to use. No registration is required.

To install *LRPT Image Processor*, extract all the files from the ZIP archive into a directory outside the **C:\Program Files** tree: I suggest **C:\Tools\SatSignal\LRPTprocessor**.

Usage

LRPT Image Processor can remove the edge compression present in the raw scan data from *Meteor-M N2* LRPT data (and does so by default), to create a Meteor RGB122 image, pseudo-NOAA RGB124 image, vegetation image, infrared image, thermal image and a false-colour image based on

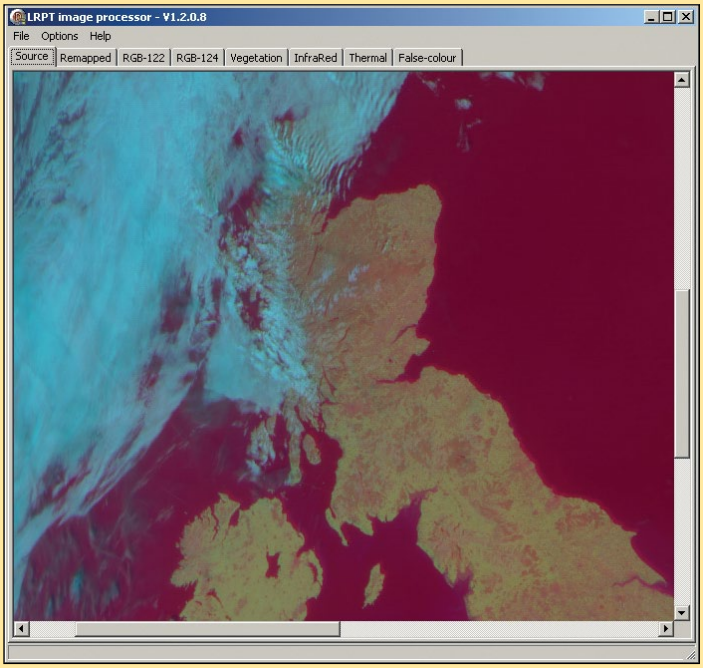


Figure 1 - The original RGB125 Meteor M2 Image from April 21, 2015

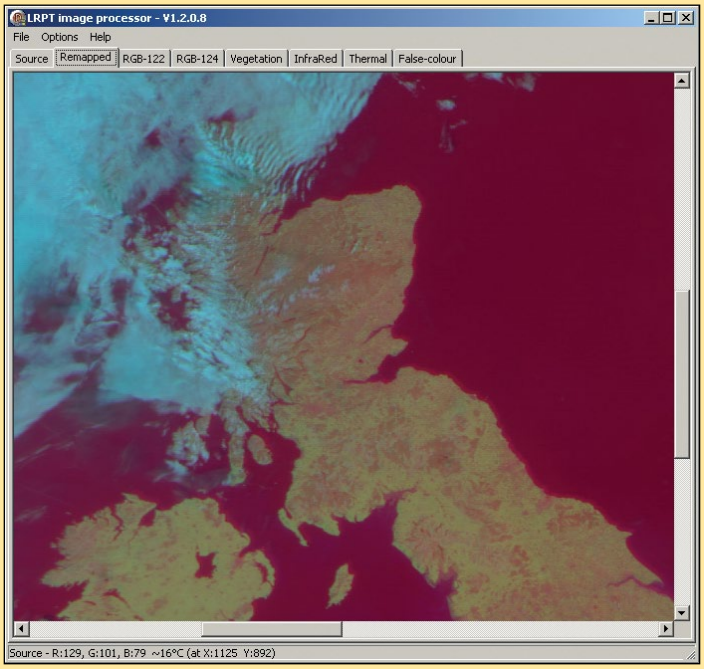


Figure 2 - The Geometrically Corrected RGB125 Meteor M2 Image

a provided 256×256 CLUT. The thermal components do rely on you initially saving an RGB125 Meteor image from *LrptOffLineDecoder*, where

channel 1 (0.5 - 0.7 µm)	=>	Red
channel 2 (0.7 - 1.1 µm)	=>	Green
channel 5 (10.5 - 11.5 µm)	=>	Blue

You can load such an image, in either BMP or JPG format, into *LRPT Image Processor* from the command-line, by using drag-and-drop on to the program interface, or via the *File|Open*

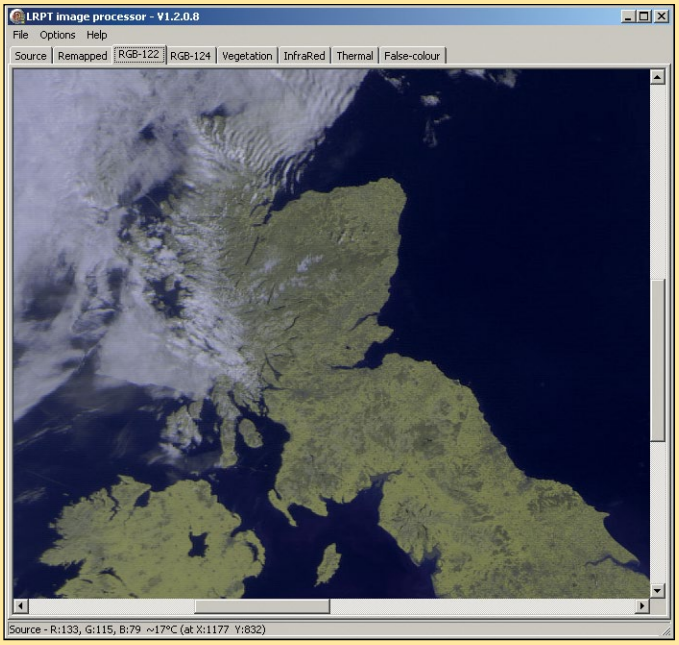


Figure 3 - The standard Meteor RGB122 image

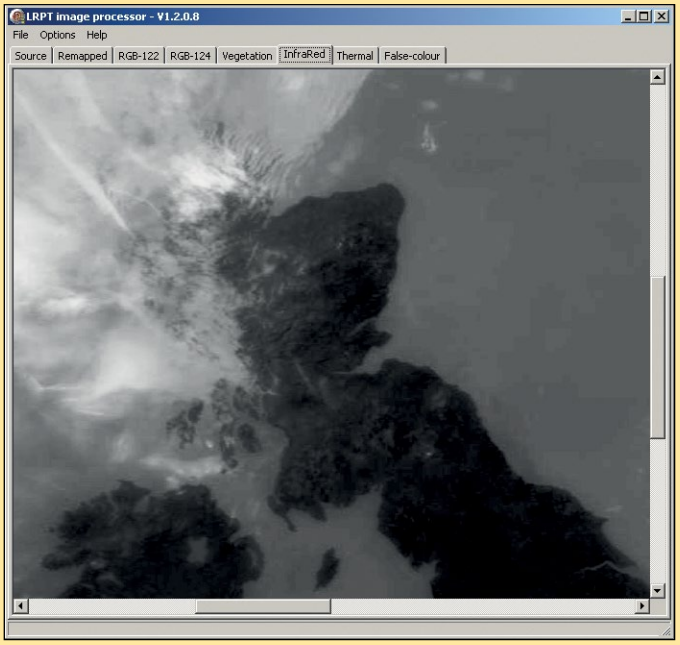


Figure 6 - Infrared image derived by inverting Meteor channel 5

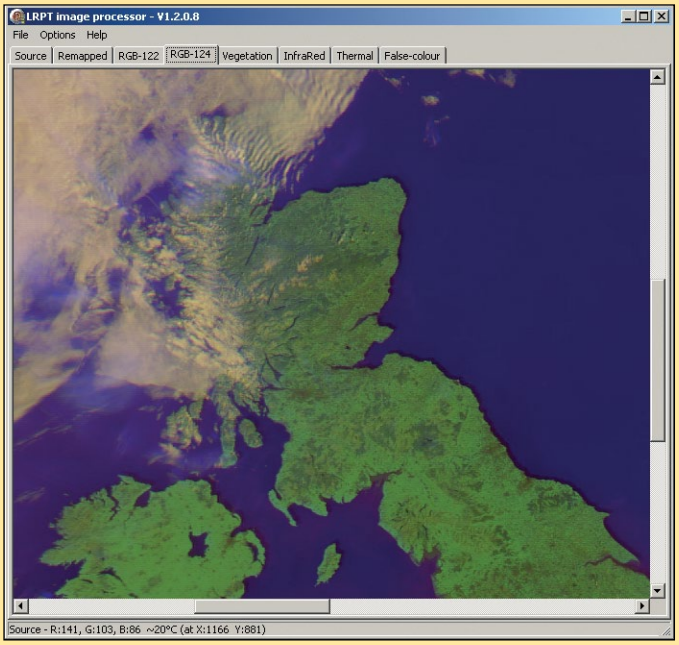


Figure 4 - Mimicking NOAA's RGB124 image

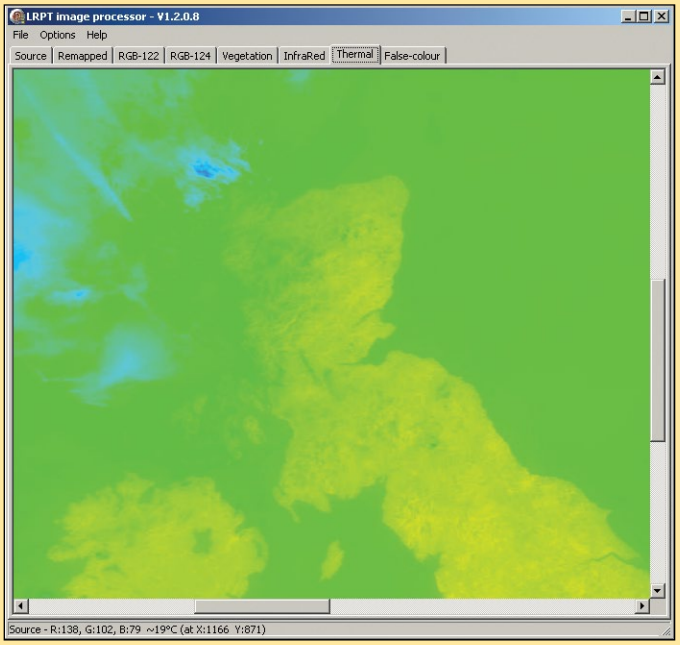


Figure 7 - The Thermal image

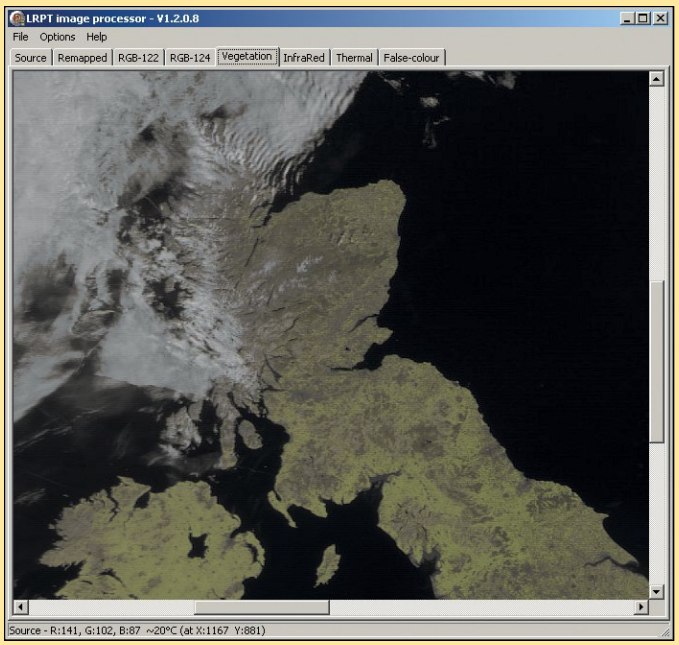


Figure 5 - Vegetation Index derived from channels 1 and 2

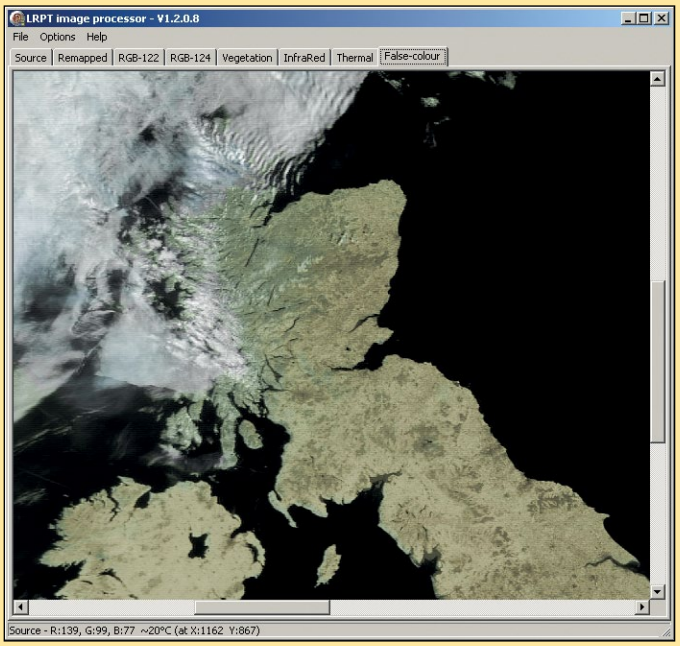


Figure 8 - The False-colour Image created by applying the *TempToColourHLS* CLUT

menu. After a short delay while processing takes place, all the images generated are automatically saved in the same directory as the input image, and in the same format (BMP or JPG). These images can be inspected individually by clicking on the various tabs at the top of the screen. Initially, because each image is shown at full resolution, only a small section appears on screen. But a left-click over the image toggles it between full size and fit-to-screen.

Histogram Equalisation

As readers who regularly acquire Meteor M2 imagery will be well aware, the infrared images from Meteor's channel-5 often show very low contrast. When *LRPT Processor's* 'InfraRed' tab is displayed, a right-click over the image reveals a pop-up menu that provides four histogram equalisation options ranging from 'none' to 'strong' (figure 9). Lower levels of equalisation improve detail in light coloured areas (clouds) while higher levels reveal progressively more detail in darker regions (land). The four levels of equalisation are compared in figure 10.

The 'False-colour' tab also allows a choice of histogram equalisation and sharpening, both accessed by a right- mouse click (figure 12). Note that the sharpening will also make the compression in the original data more obvious.

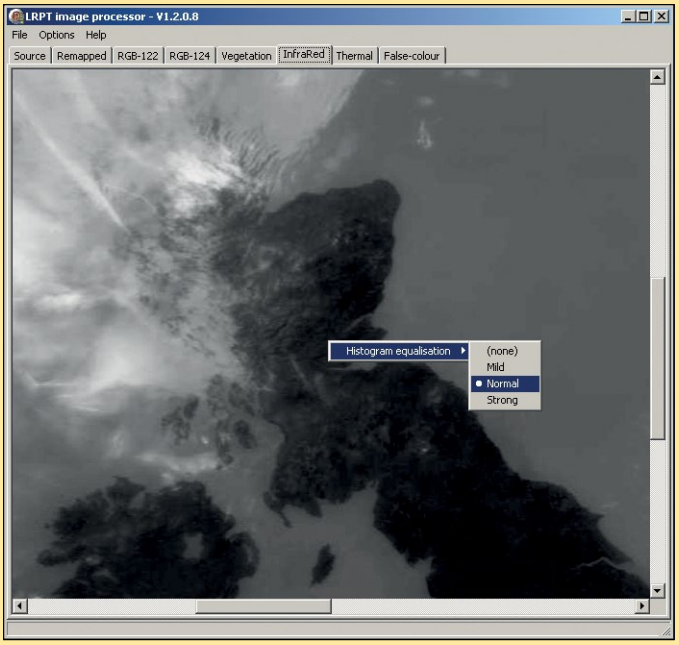


Figure 9 - The right-click histogram equalise menu that operates on the Infrared tab.

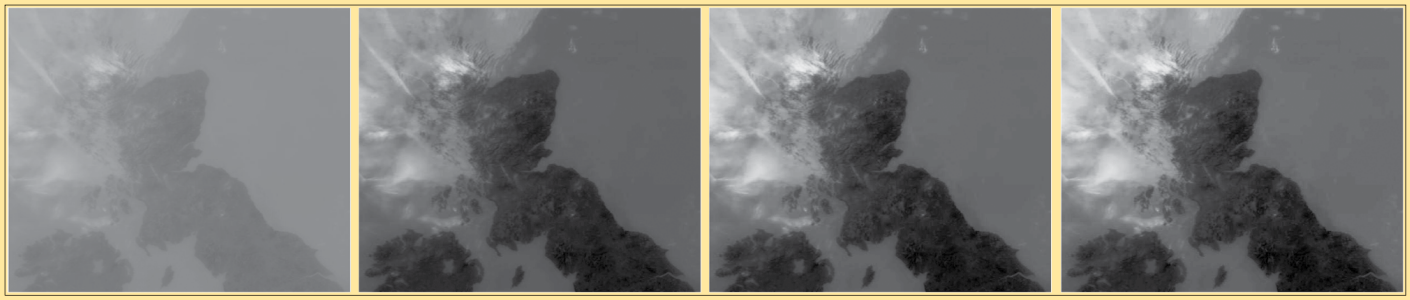


Figure 10 - The Histogram Equalise options available on the Infrared Tab (from left to right): None, Mild, Normal and Strong.

The Options Menu

The '*Options*' menu allows you to

- Rotate an image: used for flipping imagery from northbound passes into an upright position.
- Select a CLUT, which determines the appearance of the image in the 'False-colour' tab.
- Reveal the 'Setup' panel.

This final option allows the user to select which of the seven images displayed on *LRPT Processor's* tabs are actually saved when the software is activated, whether or not to apply geometrical correction to the images, and the preferred output format (figure 11).

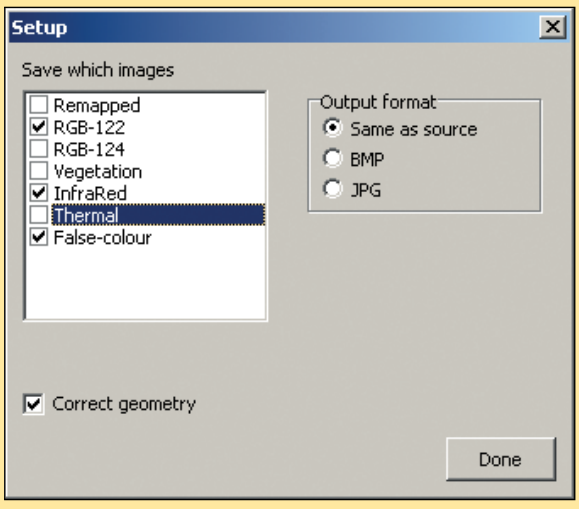


Figure 11 - The LRPT Processor 'Setup' panel.

The program has been developed in *Embarcadero's Delphi* using *Windows-8.1/64*, but I would expect it to work on *Windows XP-SP3* and later. *Windows-XP/64* and *Vista/64* may not work as expected (and these operating systems are not supported). It will also work in Linux, under WINE.

To run LRPT Processor, my *Runtime Library Bundle* must also be installed. It can be downloaded from

https://www.satsignal.eu/software/runtime.html

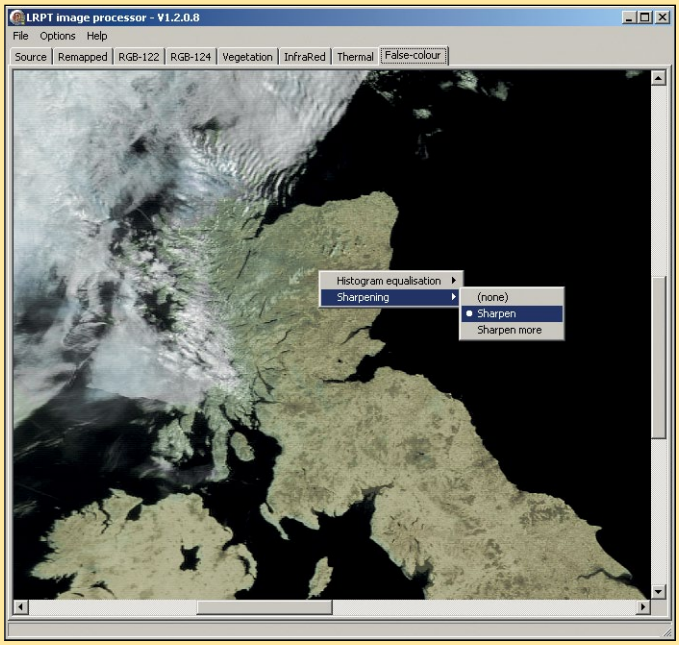


Figure 12 - The sharpening menu on the 'False-colour' tab.

Flevoland, the Netherlands

European Space Agency

Composite Sentinel-1 radar image of the Dutch province of Flevoland
© Contains modified Copernicus Sentinel data (2018), processed by ESA

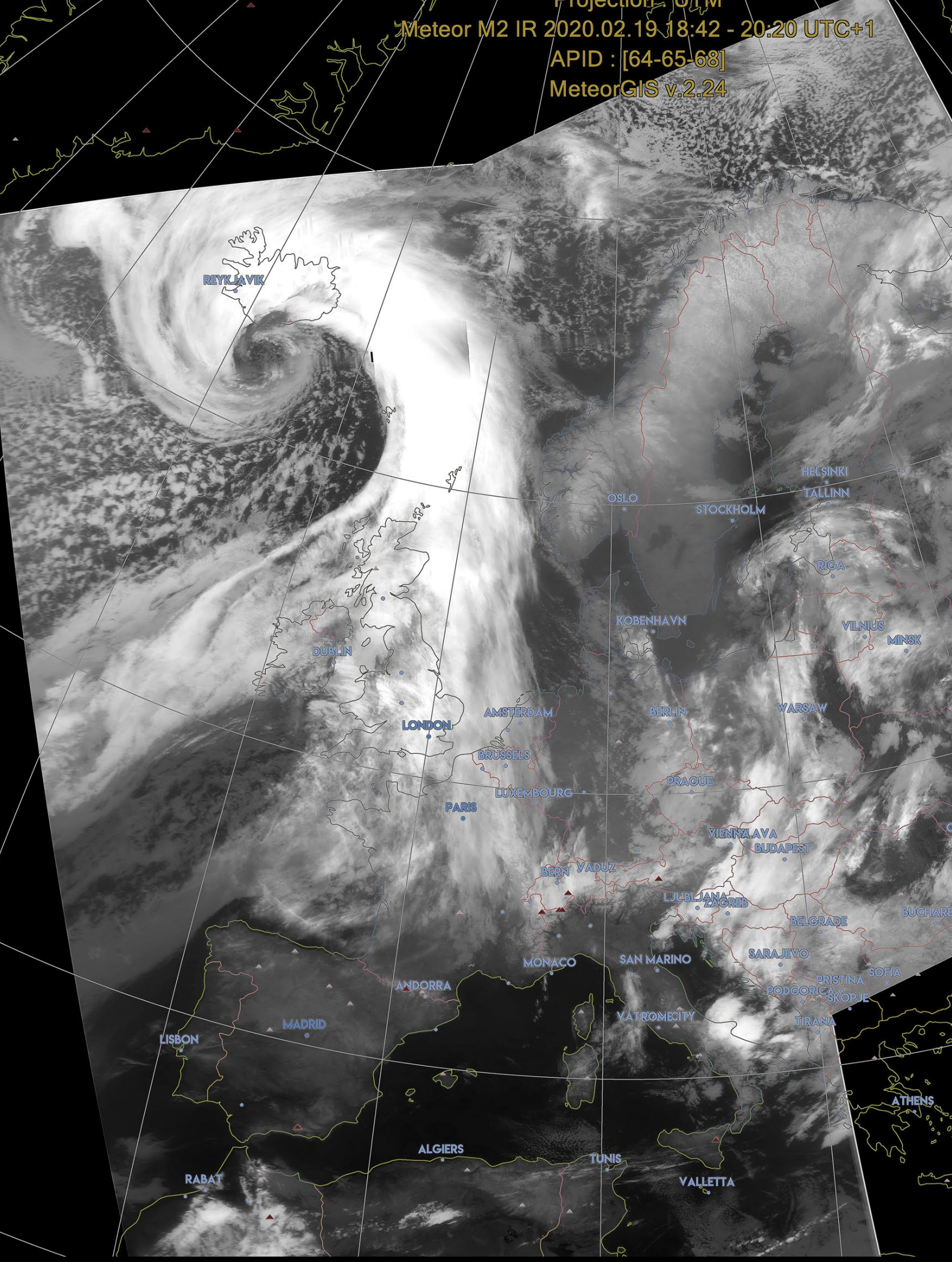
The Copernicus Sentinel-1 mission takes us over part of the Dutch province of Flevoland—the newest province in the Netherlands and one of the largest land reclamation projects in the world.

With almost a third of the country lying below sea level, the Netherlands is famously known as a 'low country,' and has a long history of land reclamation. After a major flood in 1953 it was decided to tame the Zuiderzee, a large, shallow inlet of the North Sea, to improve flood protection and also create additional land for agricultural use. The project entailed the creation of land known as polders. The 'Noordoostpolder,' or the Northeast polder is the focus of this image. Over the years, the region has developed to become home to a modern and innovative agricultural industry. The province produces predominantly apples, cereals, potatoes and flowers—with each colourful patch in the image representing a different crop.

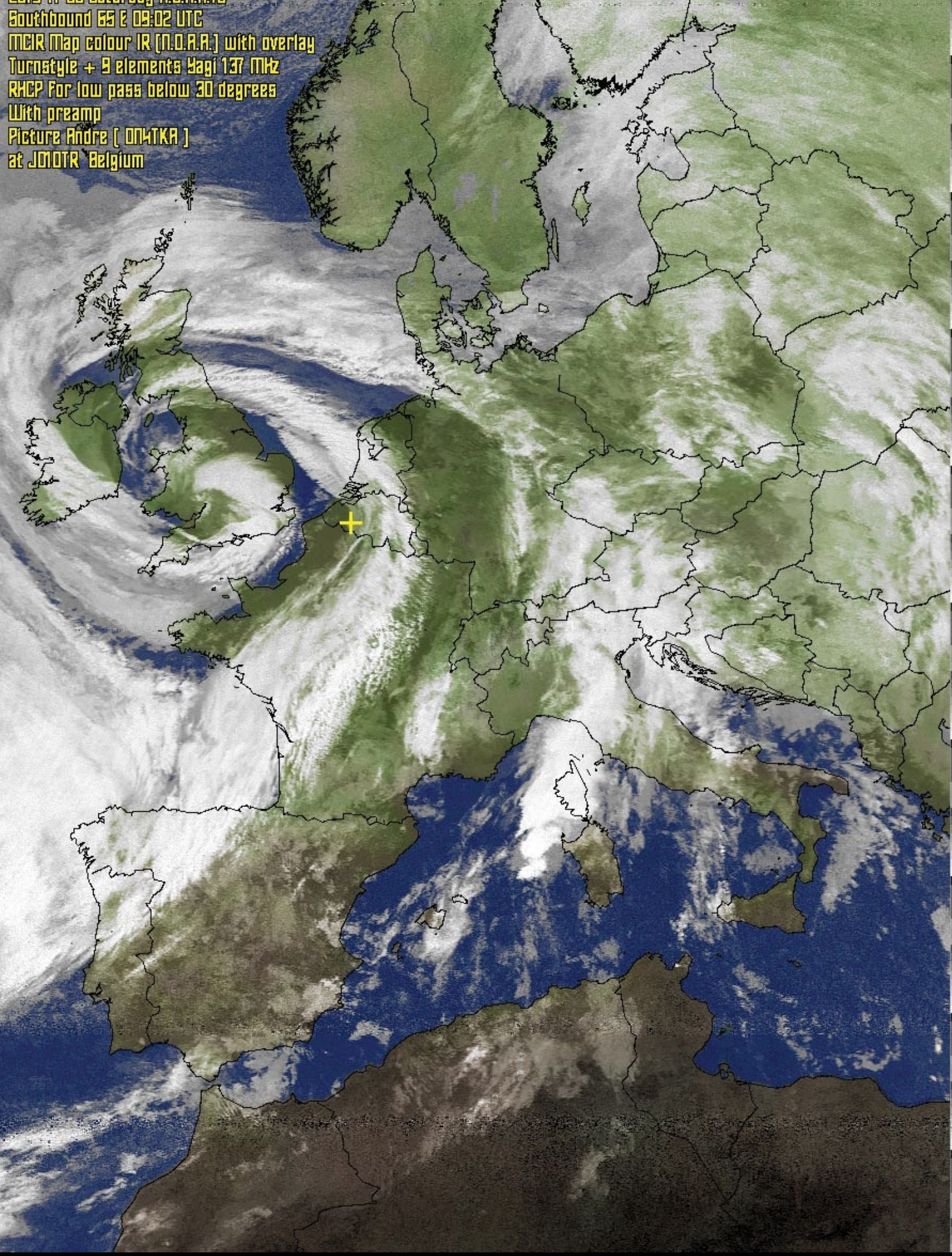
This image combines three radar acquisitions from the Copernicus Sentinel-1 mission taken about two months apart to show change in crop and land conditions over time. The first image from May 8, 2018 is associated with red, the second from July 7 depicts changes in green, and the third from September 5 has been linked to blue.

Along the dykes of the Ijsselmeer, west of the Noordoostpolder, lies one of the largest wind farms in the Netherlands. The strong, almost star-shaped, reflections that can be seen near the shore are around 86 wind turbines. The wind farm is said to generate approximately 1.4 billion kWh of clean renewable energy per year, comparable to the power consumption of over 400 000 households.

Images acquired with radar are interpreted by studying the intensity of the backscatter radar signal, which is related to the roughness of the ground. Cities and towns are visible in white owing to the stronger reflection of the signal. Emmeloord can be seen in the centre of the Noordoostpolder, as well as several farms that appear as bright white dots along the roads.



Joachim Scharrer sent in this composite Meteor M2 infrared image from his GIS system, showing a spectacular depression over Iceland on February 19, 2020.



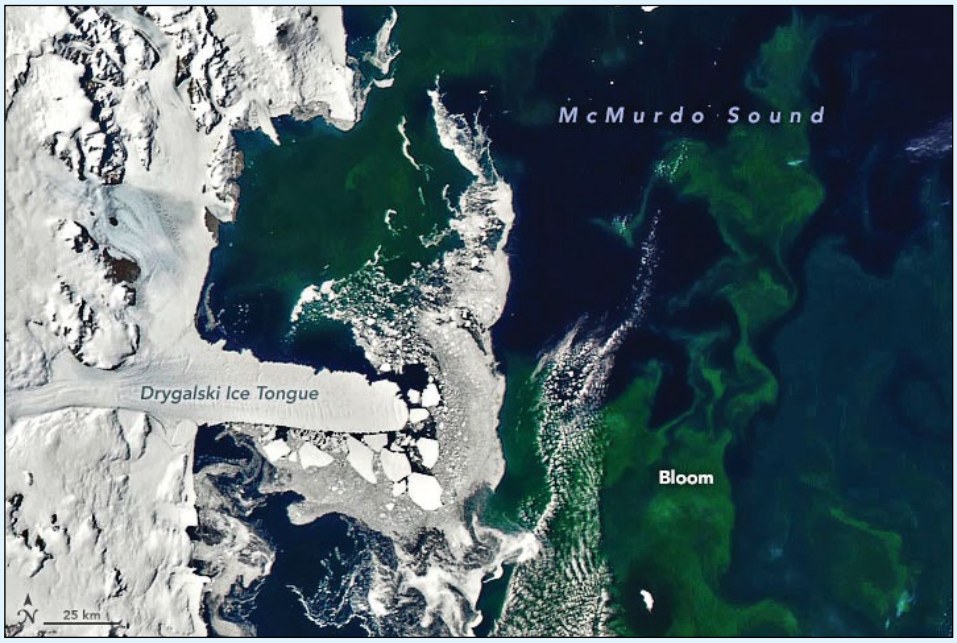
André T'Kindt submitted this interesting NOAA 18 APT image showing a November Atlantic Storm engulfing the UK on November 3, 2019.

Bloom in McMurdo Sound

NASA Earth Observatory
Text by Kathryn Hansen

There is plenty of plant-like life around Antarctica; you just have to know when and where to look. During the austral spring and summer, coastal waters sometimes swirl with vibrant green colour—the surface expression of a huge phytoplankton bloom.

The floating, microscopic plant-like organisms were abundant in Terra Nova Bay and McMurdo Sound on January 21, 2020, when the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Aqua satellite acquired this image. Such colorful swirls in coastal waters are sometimes caused by sediments stirred up by waves and currents. But scientists say the source of the colour this month has a biological origin.



NASA's *Aqua* satellite observed this antarctic plankton bloom on January 21, 2020.
NASA Earth Observatory image by Joshua Stevens, using MODIS data from NASA EOSDIS/LANCE and GIBS/Worldview

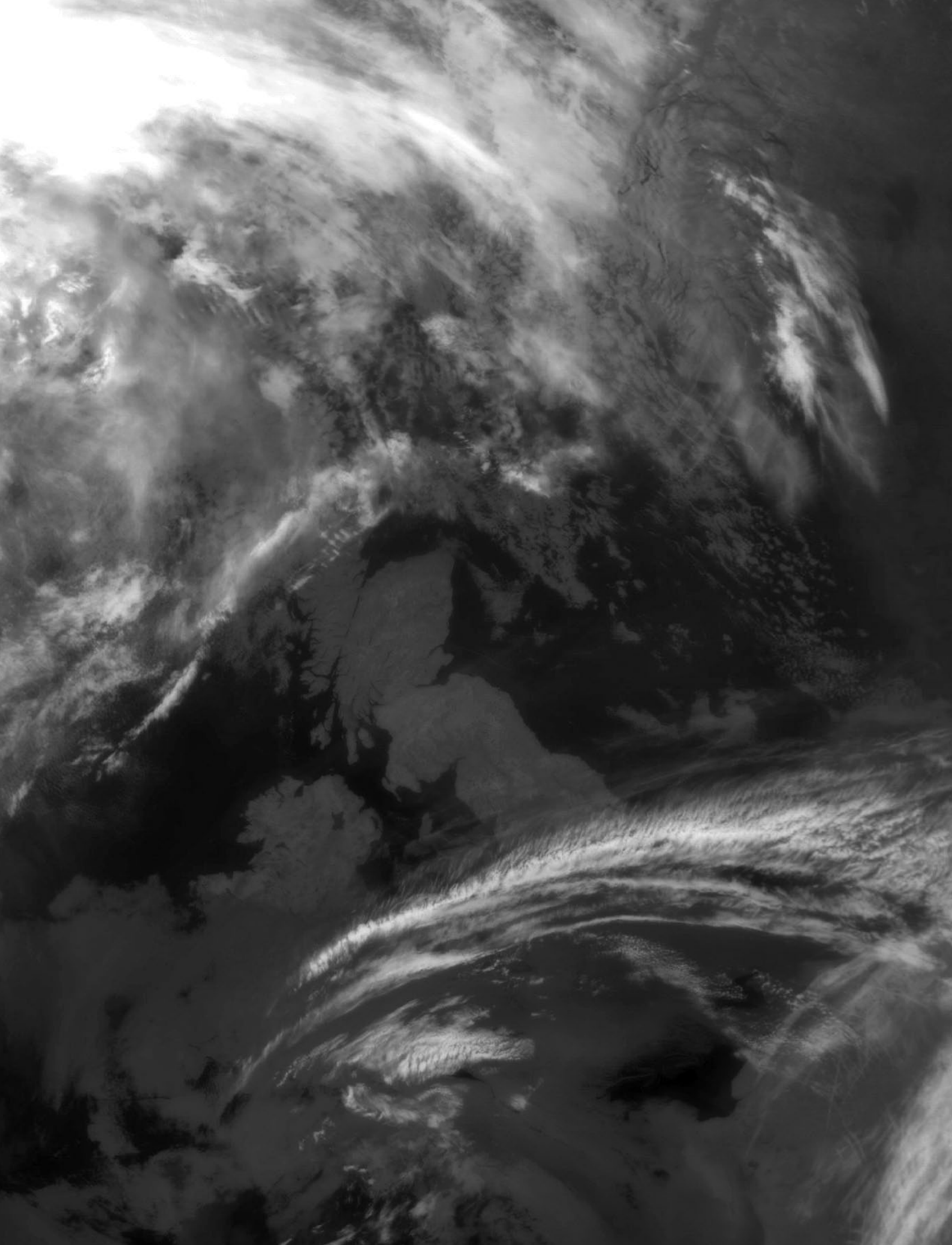
'It is definitely a phytoplankton bloom,' said Kevin Arrigo, a biological oceanographer at Stanford University. *'They tend to form every year in Terra Nova Bay around January.'*

Robert Dunbar, a fellow researcher at Stanford, agrees that the colour is a phytoplankton bloom. *'These kinds of features are common in Antarctica's coastal polynyas in summer and late summer.'*

Pancake ice in the Antarctic
Photo: Robert Dunbar

Polynyas are areas where winds sustain a persistent opening in the sea ice. Sunlight and near-surface nutrients are plentiful in these areas, making them havens for phytoplankton. Blooms can even occur in polynyas in late summer when the water is covered by thin, new frazil crystals and pancake ice. Research by Dunbar and colleagues has shown that late summer blooms can accumulate in this ice and turn it green. The phenomenon—most widespread in February and March—is visible in the photograph at left, shot by Dunbar in 2018.

Even in the satellite image from late January 2020, some of the bloom appears be associated with the sea ice, primarily north of the Drygalski ice tongue. Still, a significant amount of the bloom shows up farther out in McMurdo Sound and could just be a typical summer bloom.



Somewhat unusually, New Year's Eve 2019 was mild and without wind, perfect conditions for the thousands of revellers who welcomed in the New Year. This Meteor M2 infrared image acquired on that day shows most of Northern Ireland, Scotland, and northern England under starry skies completely free of cloud.

Widespread Melt on the George VI Ice Shelf

NASA Earth Observatory

Story by Kathryn Hansen

Even in frigid Antarctica, summer warmth can turn ice into water. At the peak of the 2019-2020 melt season, jewel-toned ponds of meltwater spanned a vast area on the George VI ice shelf—a huge slab of floating glacier ice attached to the western side of the Antarctic Peninsula.

These images were acquired on January 19, 2020, by the Operational Land Imager on **Landsat 8**, and is the only complete view of such a widespread surface melt event on the George VI Ice Shelf during the nearly 50-year-long Landsat record. Alison Banwell, a glaciologist at the University of Colorado Boulder, who currently has a three-year fieldwork project on the shelf, noticed the melt in images acquired by the European Space Agency's **Sentinel-2** satellite, stated: "This is the biggest melt event we know to have occurred on the George VI ice shelf".

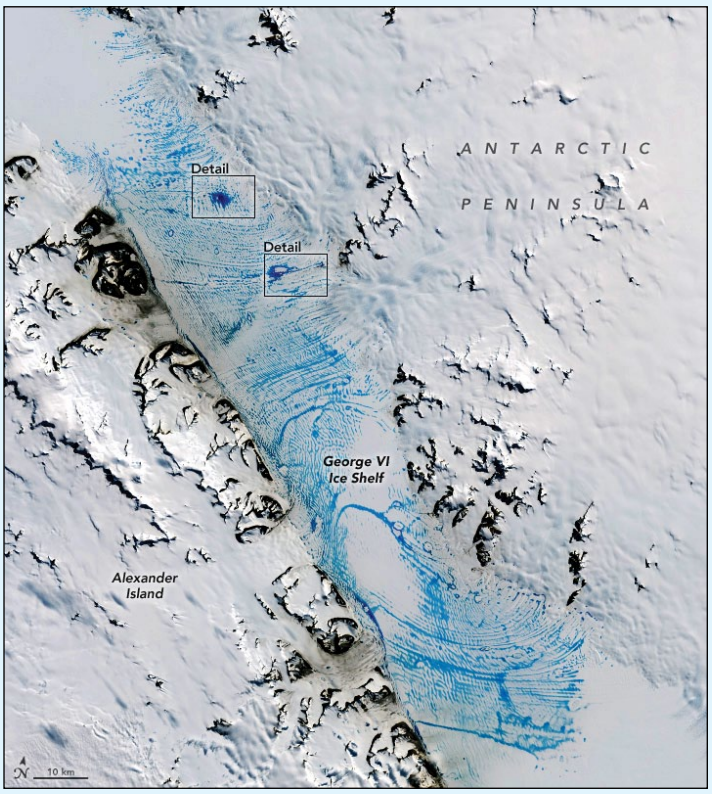
That's not to say that melting hasn't happened here before. Satellite images, often partially obscured by clouds, show periodic melt since it was first visible in Landsat imagery in January 1973. However, none seem to cover such a large area. The extent of the melt in the January 2020 image is impressive, spanning a length of about 140 kilometres. It is most likely the product of multiple days of melting.

The exact reason for the extensive melt on George VI shelf this year is currently unclear. Previous melting had been caused by wind patterns that brought warm air close to the surface, and by excessive cloudiness that trapped longwave radiation and reflected it back on to the ice. Whatever the reason, the warmth probably extends beyond the George VI ice shelf.

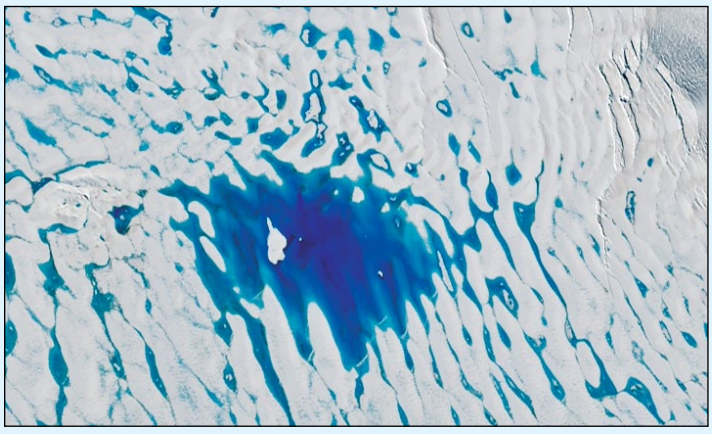
"What's worrying is that (if George VI looks like this) other ice shelves on the peninsula probably have plenty of meltwater too," stated Banwell. "And those ice shelves are less stable." At the time, clouds prevented satellites from getting a good look at the other ice shelves.

Banwell explained that when melt ponds in surface depressions on an ice shelf, it changes the distribution of stress placed on the ice. Ponded water can then drain down through cracks in the ice, again shifting the distribution of stress on the shelf and helping to destabilise it. Banwell's research has shown that the drainage of some 2500 lakes via a chain reaction process preceded the collapse of the Larsen B ice shelf in 2002 on the peninsula's eastern side.

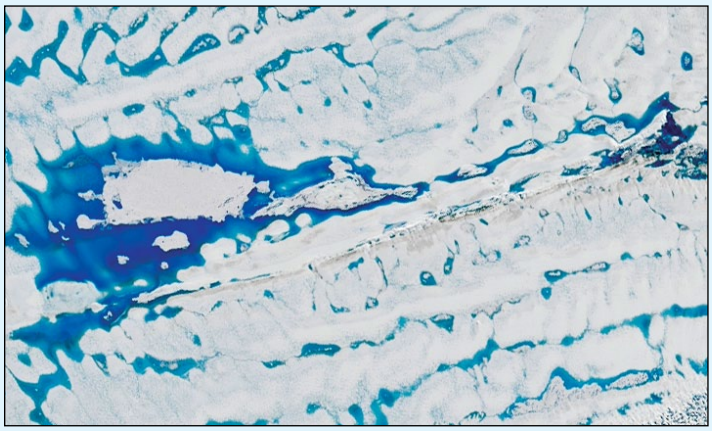
George VI is less likely to see that fate. Unlike most ice shelves that fan out over the open ocean, George VI is sandwiched between the Antarctic Peninsula and Alexander Island. With the flow of ice compressed between these two landmasses, the shelf sees smaller flexes and is more stable than other ice shelves. According to Banwell, "George VI is quite stable and can probably support a lot of melt without collapsing."



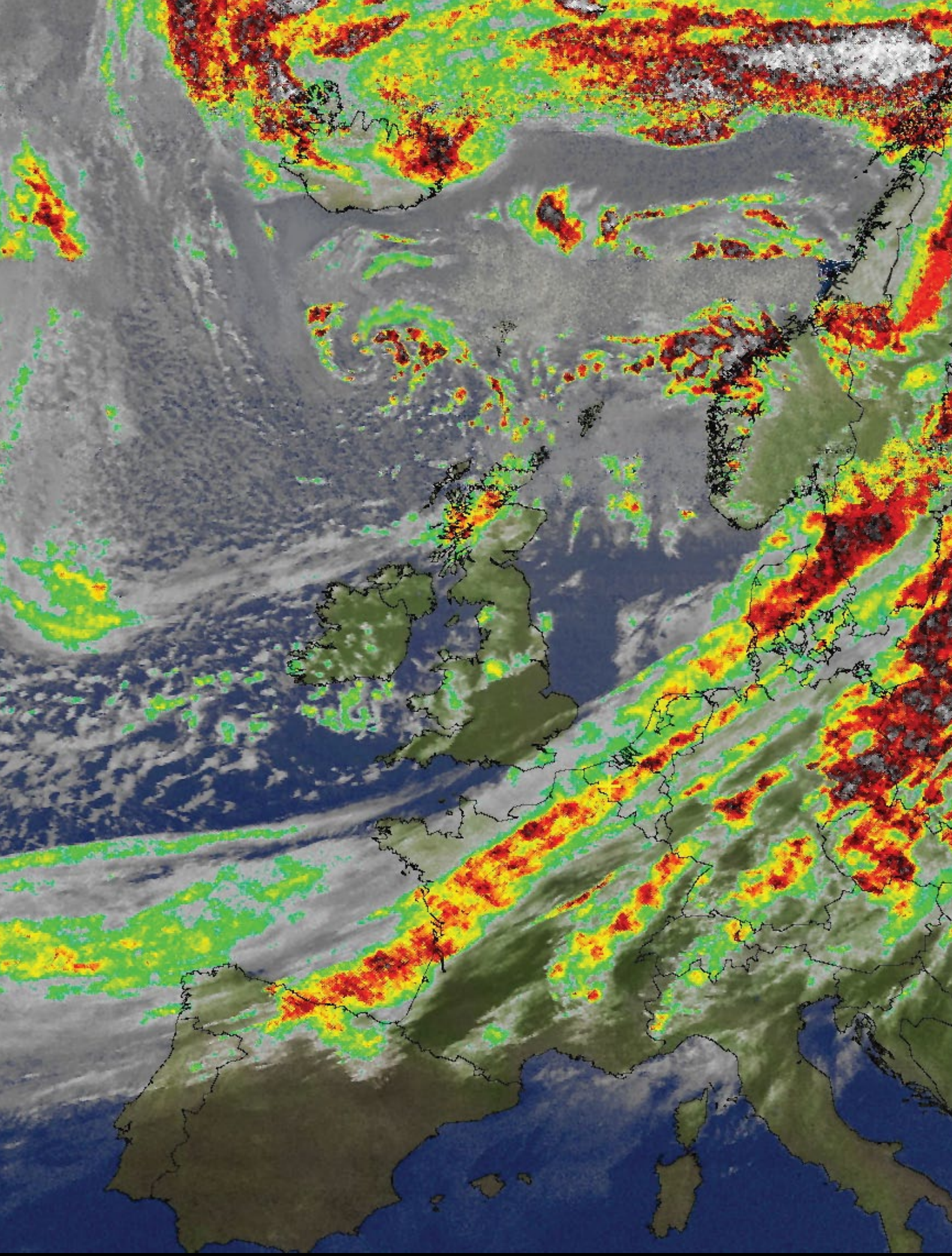
NASA Earth Observatory images by Lauren Dauphin, using Landsat data from the U.S. Geological Survey.



Detail 1



Detail 2



This NOAA 18 APT image with precipitation overlay from André T'Kindt dramatically shows the bands of intense rainfall as **Storm Denis** leaves a battered and badly flooded England in its wake on February 16, 2010.

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 [8]
Meteor M N2	137.1000 MHz	On	Good
Meteor M N2-2	137.9000 MHz	Off	Failed [12]

Polar HRPT/AHRPT Satellites				
Satellite	Frequency	Mode	Format	Image Quality
NOAA 15	1702.5 MHz	Omni	HRPT	Weak
NOAA 18	1707.0 MHz	RHCP	HRPT	Good
NOAA 19	1698.0 MHz	RHCP	HRPT	Good
Feng Yun 1D	1700.4 MHz	RHCP	CHRPT	None: Device failure
Feng Yun 3A	1704.5 MHz	RHCP	AHRPT	Inactive [2,10]
Feng Yun 3B	1704.5 MHz	RHCP	AHRPT	Active [2]
Feng Yun 3C	1701.4 MHz	RHCP	AHRPT	Active [2]
Metop A	1701.3 MHz	RHCP	AHRPT	Good
Metop B	1701.3 MHz	RHCP	AHRPT	Good
Metop C	1701.3 MHz	RHCP	AHRPT	Commissioning
Meteor M N1	1700.00 MHz	RHCP	AHRPT	Dead [8]
Meteor M N2	1700.0 MHz	RHCP	AHRPT	Good
Meteor M N2-2	1700.0 MHz	RHCP	AHRPT	System failure [12]

Geostationary Satellites				
Satellite	Transmission Mode(s)		Position	Status
Meteosat 8	HRIT (digital)	LRIT (digital)	41.5°E	IODC
Meteosat 9	HRIT (digital)	LRIT (digital)	3.5°E	On [5]
Meteosat 10	HRIT (digital)	LRIT (digital)	9.5°E	Off [4]
Meteosat 11	HRIT (digital)	LRIT (digital)	0°W	On [3]
GOES-13	GVAR 1685.7 MHz	LRIT 1691.0 MHz	60°W	Off
GOES-14	GVAR 1685.7 MHz	LRIT 1691.0 MHz	105°W	Standby
GOES-15 (W)	GVAR 1685.7 MHz	LRIT 1691.0 MHz	128°W	On [6]
GOES-16 (E)	GRB 1686.6 MHz	HRIT 1694.1 MHz	75.2°W	On[6,9]
GOES-17	GRB 1686.6 MHz	HRIT 1694.1 MHz	137.2°W	[11]
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	123.5°E	Backup/Off [7]
Feng Yun 2E	SVISSR	LRIT	86.5°E	On
Feng Yun 2F	SVISSR	LRIT	112.5°E	Standby
Feng Yun 2G	SVISSR	LRIT	99.5°E	On
Feng Yun 2H	SVISSR	LRIT	86.5²E	
Feng Yun 4A	HRIT (digital)	LRIT (digital)	99.5°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 prime Full Earth Scan (FES) satellite
4 Meteosat backup Full Earth Scan (FES) satellite
5 Meteosat prime Rapid Scanning Service (RSS) satellite.
6 GOES 15 also transmits EMWIN on 1692.700 MHz
GOES 16 also transmits EMWIN on 1694.100 MHz
GOES 17 also transmits EMWIN
7 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.
8 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.
9 GOES Rebroadcast (GRB) provides the primary relay of full resolution, calibrated, near-real-time direct broadcast space relay of Level 1b data from each instrument and Level 2 data from the Geostationary Lightning Mapper (GLM). GRB replaces the GOES VARiable (GVAR) service.
10 Although Feng Yun 3A's status is recorded on the wmo-sat website as 'inactive (end of operation)', it continues (as of June 2018) to transmit imagery.
11 GOES 17 is expected to start operations during January 2019.
12 Following a collision with a micrometeorite, the power system aboard Meteor M2-2 has all but failed and is no longer capable of powering the AHRPT/LRPT instrument.