Mount St Helens eruption anniversary: 40 years since May 18, 1980
Photo © Mike Doukas - USGS Cascades Volcano Observatory
Public Domain, https://commons.wikimedia.org/w/index.php?curid=680506

From the Editor

Les Hamilton

It will hardly come as a surprise to readers that the planned joint **EUMETSAT visit** for Werkgroep Kunstmanen and GEO members in early July has been cancelled. With much of Europe in lock-down, airlines inactive and the hospitality industry at a standstill, EUMETSAT had no option but to cancel the event. Here follows the text of the confirmation email sent to Ben Schellekens by EUMETSAT's Kim Hui Gaune.

Dear Ben,
I hope you are doing well.
I have to inform you, with regret, that considering the current situation, the GEO visit to EUMETSAT early July has to be cancelled.
We hope to be able to welcome the GEO Group again in the near future.
All the best,
Kim Hui Gaune

Some good has come of the lock-down however, with authors finding time on their hands to create articles for the Newsletter. Ed Murashie and David Taylor have pooled their resources to outline a project to view satellite imagery in Virtual Reality that may appeal to you, and there are two articles from John Tellick.

There is no leader article this issue as there have been no rally visits or other GEO activities to report. But Francis Bell remains in good health, and has provided a rather interesting Quarterly Question. Hopefully, as summer evolves, we will all be able to enjoy more freedoms, and GEO will be able to show its presence at rallies once more.

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Francis Bell

Quarterly Questions 55

My thanks to those individuals who responded to the last Quarterly Questions. It's reassuring to know that some people read the questions and take the trouble to send in their answers.

The previous Quarterly in fact had two questions, one relating to an image of a group of islands; the other a composite image of Antarctica. The island group shown in the first question was the Faeroe Islands, which are located in the Atlantic Ocean about 300 miles north of mainland Scotland. The pattern of the islands is quite distinct, hence they caught my eye as a satellite image.

The question relating to Antarctica showed a composite image of Antarctica but with a hole in the middle of it. The question asked why was there a hole in the middle of the image. The answer relates to the fact that it was a composite image which is made up of a large number of individual images, but none of the individual images included the South Pole because the strips of the Earth imaged by each satellite pass did not quite include the South Pole. When the images are put together in an attempt to cover the whole of the continent, the South Pole is just missing each time.

Many polar orbiting satellites orbit the earth about 16 times a day hence the Antarctic composite image is probably made up from 16 strips of images but each one just missing the pole so, when put together, the polar area is not covered. The resulting hole will not be a smooth circle but a polygon with perhaps 16 edges. However, the resolution of the image shown in the question was not fine enough to show the many straight edges to the hole but rather it look like smooth circle.

Quarterly Question 66

I notice that the last four Quarterly Questions have related to the identification of islands: they were, Easter Island, Gran Canaria, Bahrain and the Faroe Islands. This question is almost the opposite, and asks what point on the Earth's oceanic surface is farthest from any land?

In your answer give the Latitude and longitude of this point to the nearest whole degree or just say where it is.

To help you identify the location in question it is sometimes called Point Nemo (although it does have other names), and is positioned about 1,670
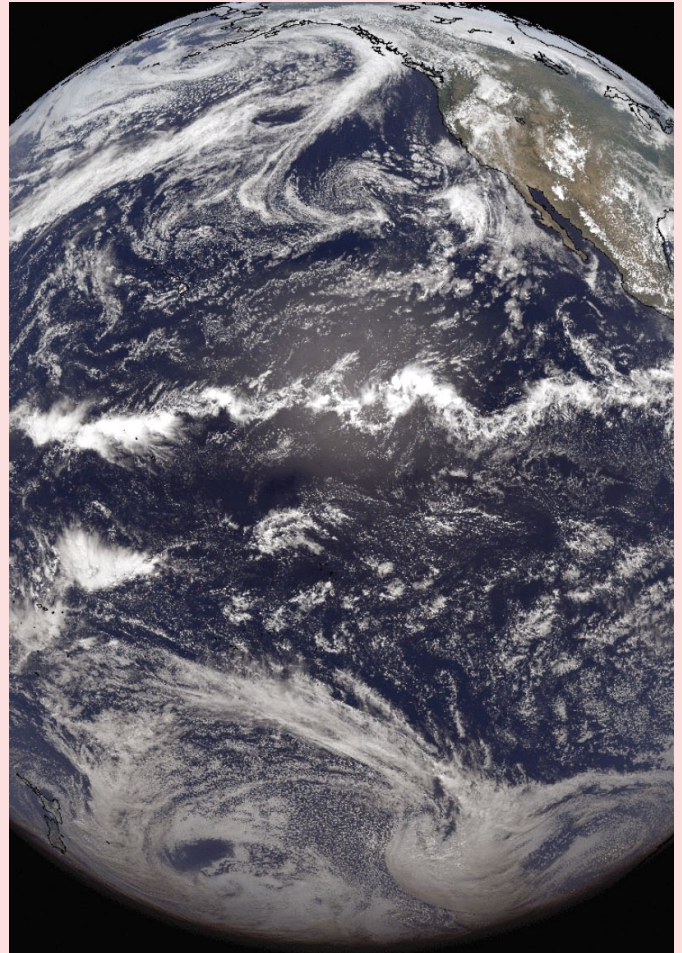
Point Nemo, the Oceanic Pole of Inaccessibility, lies within the confines of this 21:00 UT GOES-W image from June 1, 2020.
Image: NOAA

miles from land in any direction. Nearest landfalls are Ducie Island to its north (part of the Pitcairn Islands), Motu Nui to its northeast (part of the Easter Islands group) and Maher Island off the coast of Marie Byrd Land, Antarctica, to its south.

Here is the real issue in my mind related to the question:

'Why is this point so important to the international space industry?'

And a final part to this Quarterly Question: What is the English translation/meaning of the Latin word 'nemo'

Answers to Francis Bell by email to

francis@francisbell.com

before the copy deadline for our next Quarterly Newsletter (August 30, 2020).

Violent Puffs from Krakatau

NASA Earth Observatory
Story by Kathryn Hansen.

Anak Krakatau, imaged on April 13, 2020 by Landsat-8's OLI instrument.
NASA Earth Observatory image by Lauren Dauphin, using Landsat data from the U.S. Geological Survey.

Anak Krakatau maintains a mighty and sometimes menacing presence in the Sunda Strait between Java and Sumatra, with more than 50 known periods of eruptions in almost 2,000 years. The Indonesian volcano's latest burst of activity has produced numerous plumes and lava flows, including some relatively small but notable events in April.
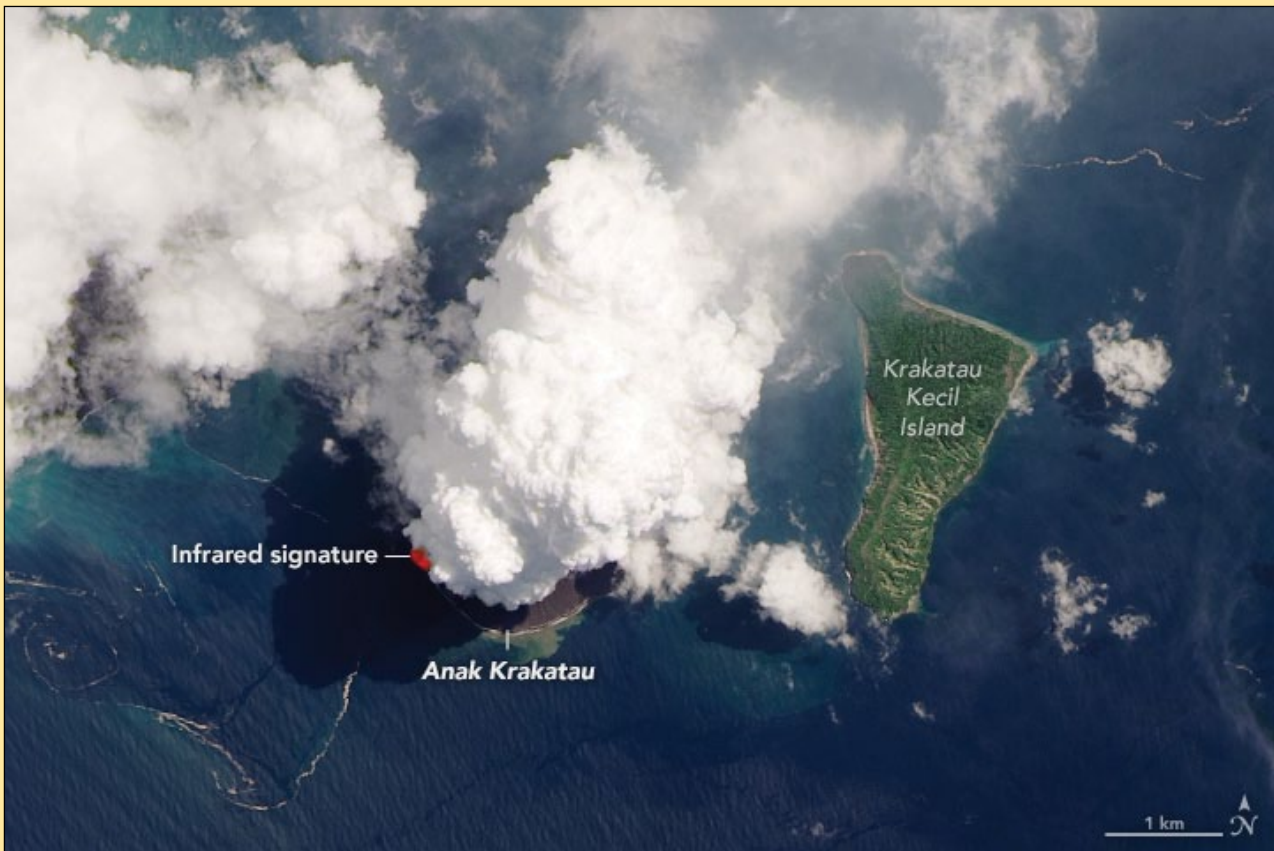
On April 13, 2020, the Operational Land Imager on **Landsat 8** acquired this natural-colour image of the volcano (OLI bands 4-3-2) as a plume towered over the peak. The image is overlain with the infrared signature detected by OLI of what is possibly molten rock.

'The location of the plume suggests that it is volcanic in origin,' said Verity Flower, a *Univrsities Space Research Association* volcanologist based at NASA's Goddard Space Flight Center. Flower and colleagues use the Multi-angle Imaging Spectroradiometer (MISR) sensor on NASA's Terra satellite to measure the height of volcanic plumes and to observe the shape, size, and light-absorbing properties of the particles within them. 'On April 12, I saw a similar feature in one of the angular MISR images with a plume-like feature above the volcano summit.'

Based on the colour of the plume, it is probably composed mostly of water vapour and gases. These small, reflective particles make a plume appear white. Conversely, larger and darker ash particles tend to look gray or brown in natural-colour images.

Note the darker part of the plume extending toward the north: it appears lower in altitude than the bright, billowy part of the plume directly over the peak. It is possible the heavier ash particles emitted are staying lower in the atmosphere and are being transported to the north by near-surface winds. In contrast, any water and gases within the plume, being less dense, would be transported higher and would condense rapidly in the atmosphere.

Indonesia's Center of Volcanology and Geological Hazard Mitigation (PVMBG) reported that incandescent rock had erupted onto the volcano's surface with "insignificant intensity" in the days prior to this image.

Anak Krakatau volcano has displayed these small eruptive bursts periodically through the last few years. However, it can also display more destructive activity such as tsunami-triggering eruptions.

According to the April 11 statement from PVMBG, the hazards from the volcano's recent activity included fountains of lava, lava flows, and ash rain within a radius of two kilometres around the crater. Thinner ash rain could extend even farther from the volcano, depending on the strength of winds.

Sentinel-1 Composite Image of English Channel Shipping Traffic
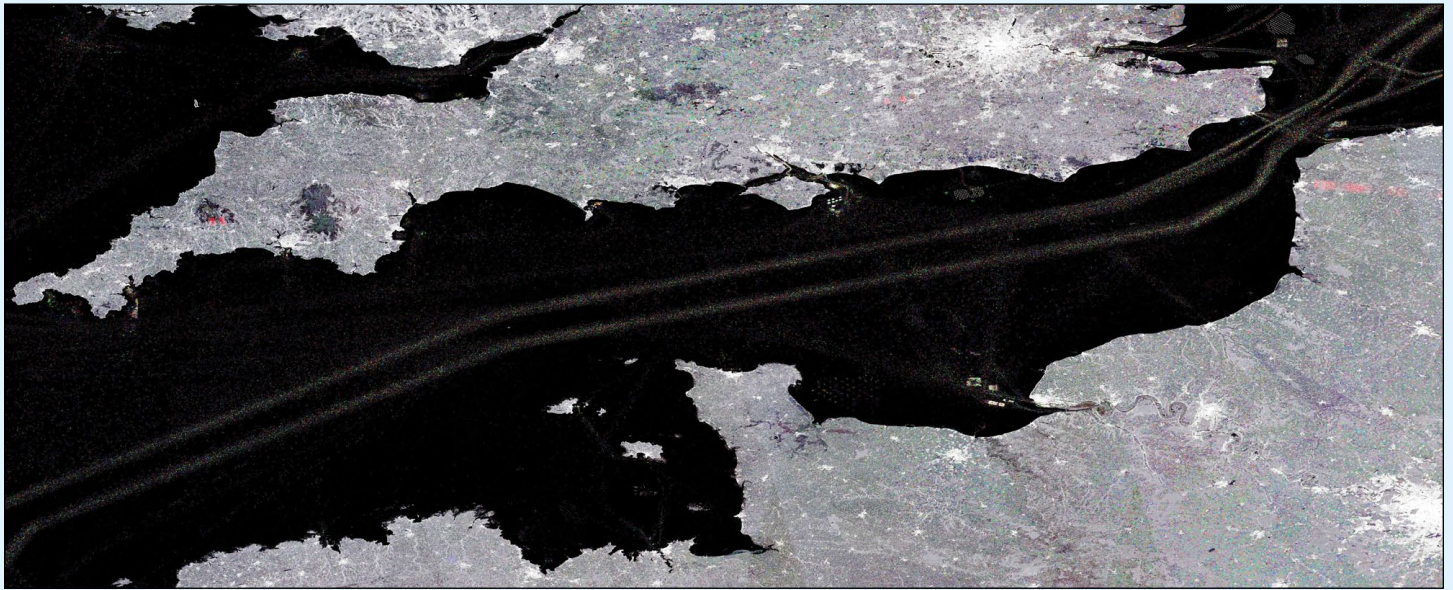
John Tellick

Figure 1 - English Channel Shipping Lanes as realised by the Copernicus Sentinel-1 Satellites
Copyright contains modified Copernicus Sentinel data (2016-18), processed by ESA, CC BY-SA 3.0 IGO

The two identical Copernicus Sentinel-1 satellites carry radar instruments which can see through clouds and rain and in the dark, to image the Earth's surface below. In figure 1, hundreds of radar images spanning 2016 to 2018 over the same area have been compressed into a single image to outline the English Channel's distinct shipping lanes.

.The sea surface reflects the radar signal away from the satellite, making water appear dark in the image. This contrasts metal objects, in this case ships, which appear as bright dots in the dark water. Boats that passed the English Channel in 2016 appear in blue, those from 2017 appear in green, and those from 2018 appear in red.

Owing to its narrowness, as well as its strategic connection of the Atlantic Ocean and the North Sea, the Channel is very busy with east-west ship traffic. Because of the volume of vessels passing through daily, a two-lane scheme is used, in order to avoid collisions. The two lanes can easily be detected in the image.

Many vessels crossing at the narrowest part of the English Channel can be seen in the far right of the image. Connecting Dover in England to Calais in northern France, the Strait of Dover is another major route, with over 400 vessels crossing every day. The shortest distance across the Channel is just 33 kilometres, making it possible to see the opposite coastline on a clear day.

The cities of London and Paris, other towns and buildings and even wind turbines in the English Channel are visible in white owing to the strong reflection of the radar signal.
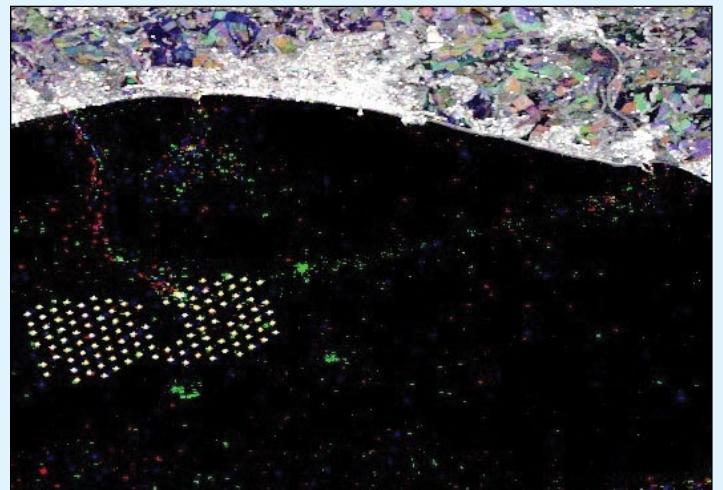
Figure 2
Detail from the main image showing the Rampion Wind Farm

For me, growing up on the Sussex coast in Lancing I'm familiar with that part of the UK and also the Strait of Dover looking across to France. A closer look at the full image of the Channel reveals that several of the offshore wind farms are very noticeable including the latest offshore wind farm to be built in the UK between Worthing and Brighton—the Rampion Wind Farm. Watching its construction on odd visits to the coast over many months was interesting with all the construction and support vessels just off the coast. Figure 2 shows the Rampion Wind Farm off the Sussex coast with construction supply vessel routes and cable laying vessel route.

The electricity cable from this wind farm comes ashore to the west of Lancing and then travels

across the South Downs in a trench for 27 kilometres—avoiding the use of pylons—to a sub station at Bolney, mid Sussex.

What can clearly been seen in the close-up image of the Rampion Wind Farm off the Sussex coast in figure 2, is the 'farm' itself and the building supply vessel routes from the ports of Shoreham (north) and Newhaven to the east. The route of the vessels involved with the laying of the electricity cable to Lancing can also be seen.

In the eastern close-up image below, earlier wind farm installations can be seen off the Kent and Essex coasts (figure 4).

This image also shows the enormous amount of shipping that passes through congested Strait of Dover, in addition to traffic between Dover and Calais.

Credit

Introductory Text comes from 'English Channel' on the European Space Agency website at

https://www.esa.int/ESA_Multimedia/ Images/2019/04/English_Channel
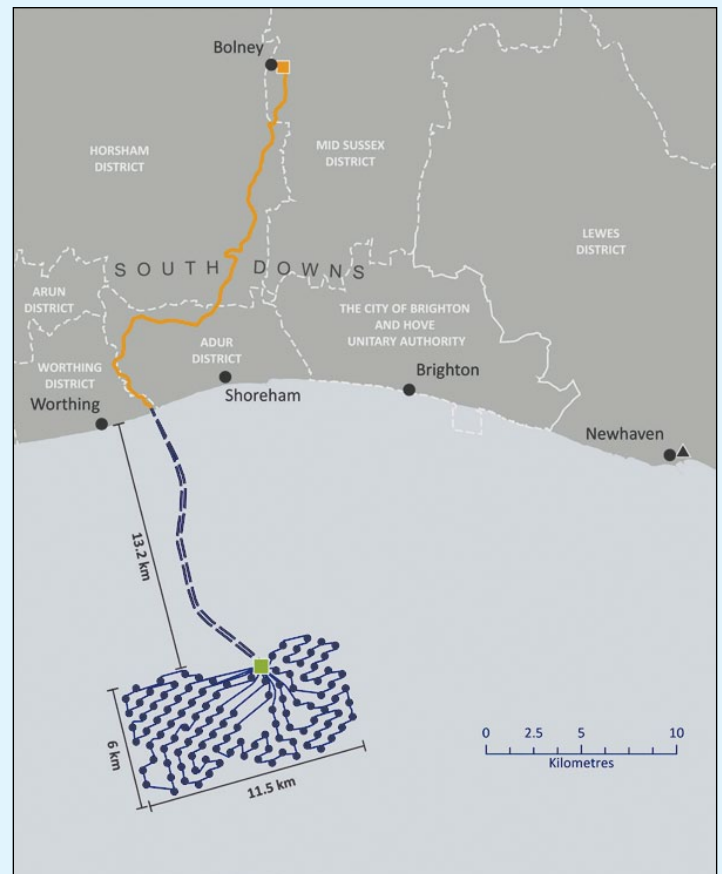
Figure 3 - The offshore and onshore electrical cable routes to the Rampion Wind Farm.
Image: Rampion Windfarm Tours
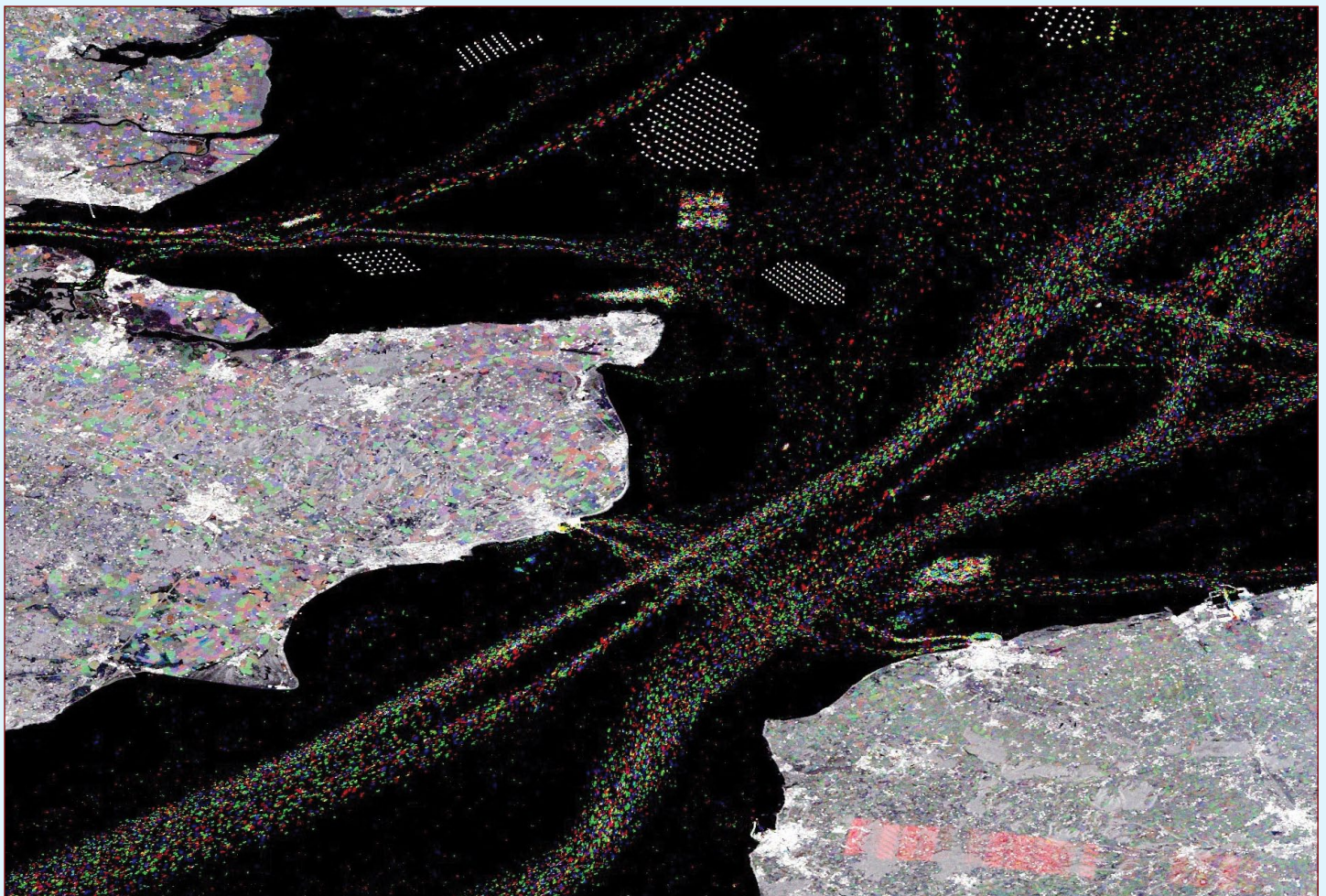
Figure 4 - Detail from the main image showing the congested shipping lanes between Dover and Calais
Copyright contains modified Copernicus Sentinel data (2016-18), processed by ESA, CC BY-SA 3.0 IGO

Dutch Tulip Fields come into Bloom

European Space Agency

While the COVID-19 virus pandemic is forcing everybody to stay at home, we bring you these beautiful views from space of the Dutch tulip fields coming into bloom. Captured by the Copernicus Sentinel-2 mission on April 20, 2020, this image shows the fields resplendent in an array of vibrant colours. Lasting just a few weeks, the beauty of these colours normally attracts millions of visitors from all over the world. Sadly, this is not the case this year, as the COVID-19 crisis means that people cannot travel and even locals are actively discouraged from visiting the fields.

The image features the area around the small town of Lisse, home to the world-famous showcase for floriculture, the Keukenhof flower park. The area, which lies close to the coast in the Dutch province of South Holland, is famed for producing bulbs which are exported all over the globe. The fields are only in bloom for a few short weeks. When the tulips reach full bloom, the farmers quickly remove their colourful heads to divert the flowers' energy back to the bulbs to help keep them strong.
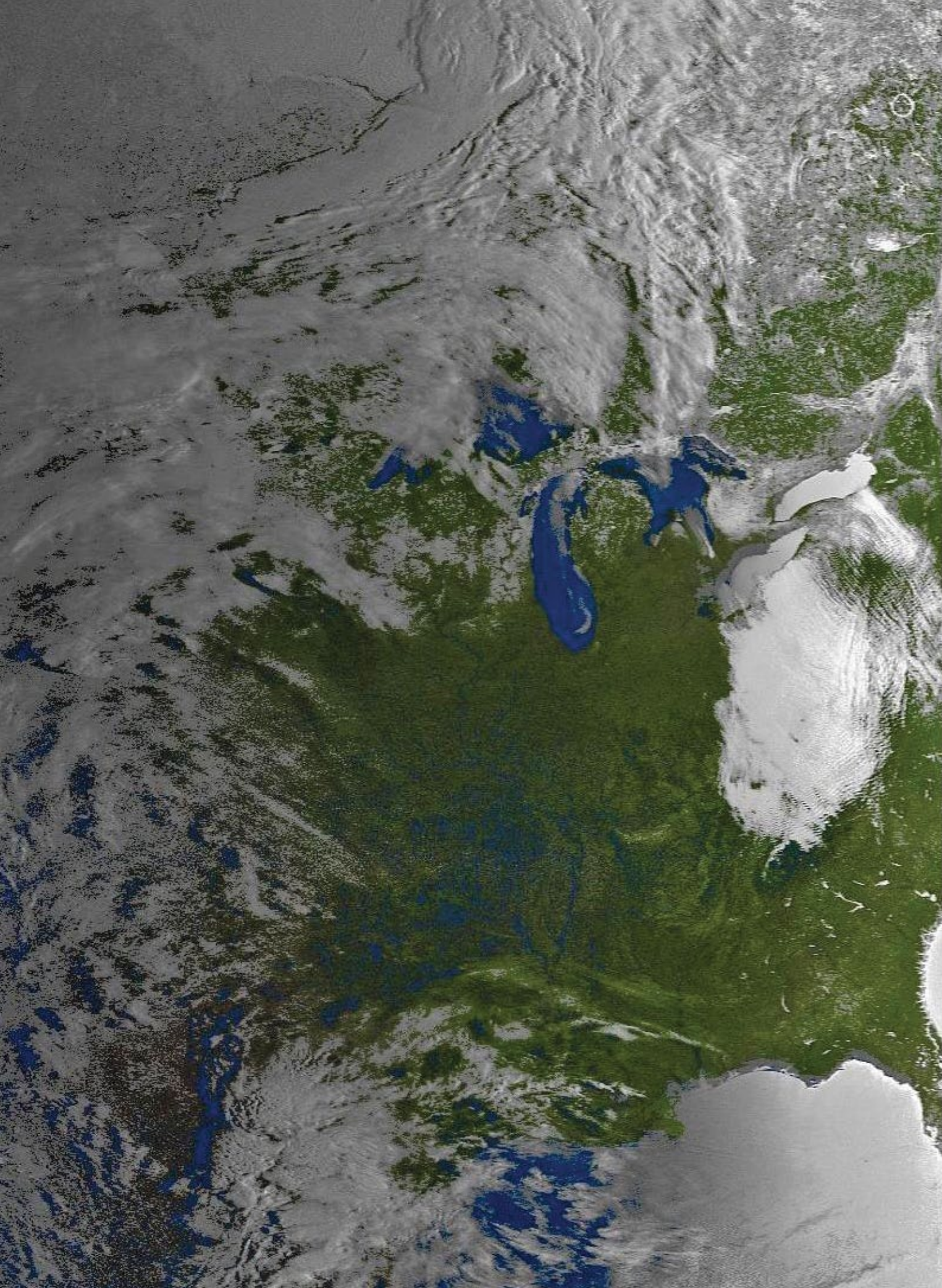
This morning NOAA 15 APT image obtained by Keith Fraser (Buffalo, NY) on March 7, 2020 shows interesting sun glint on Lakes Ontario and Erie. Also visible, at top right, is the Triassic Manicouagan impact crater, its ice glinting in the sun.

Viewing Weather Satellite Images Using Virtual Reality

Ed Murashie and David Taylor

Displaying satellite images has come a long way over the years. The first technique used was photographing the screen of a cathode ray tube (CRT) while the image was being received using a long exposure (figure 1). Later methods including using a facsimile machine like the Muirhead (figure 2), or even home-built photo-facsimile machines.

Soon after, standalone scan converter designs digitised the signal, stored it in memory and then read it out on a larger CRT [1] allowing the entire image to be quickly viewed. The quantum jump came with the invention of the personal computer and better printers, which allowed zooming, adding latitude and longitude grids, country outlines, the creation of animations and many other features.

3D viewing of satellites was bound to happen when technology caught up. One of the first approaches used two closely spaced polar satellite passes and stereo viewing glasses. The first computer technique used red/blue glasses with colour anaglyph images. MSA 3-D Anaglyph images are generated using the Infrared image to simulate cloud height and then shift and color the visible image accordingly. One program that has this capability is WXtoimg [2]. Another computer based approach is to drape satellite images over digital elevation model data and then the viewer's perspective is moved to any height and angle [3,4].

NOAA created its unique version of a 3D display, *Science on a Sphere* [5]. This is a system of computers and projectors that project images and movies on a six foot sphere, which has been installed in over 120 locations [6].

The next logical step is displaying satellite images using virtual reality. Using either HTC VIVE or Oculus VR glasses, the *Unity3D* software, a remapping program, and either of your received geostationary images or NOAA's website images [7], you can display the images in VR [8].

Figure 1 - The man on the left is looking through the camera mounted to the CRT as it is taking pictures.

Figure 2 - A muirhead fax machine from the 1960s

From here you have two options, you can either follow along using the step-by-step instructions below or watch a training video [9] to learn how.

Install the *HTC VIVE* and then enjoy a game or two.

Minimum PC requirements can be found at

> ***https://www.vive.com/eu/support/vive/category_howto/what-are-the-system-requirements.html***

An HP Pavillon gaming desktop model 690-0024 with its AMD Ryzen5-2400G processor and Radeon RX 580 was used in writing this article and making the tutorial video.

Installing Unity3D

- To start, point your web browser to ***https://unity.com/.***
- Click the blue **Get started** button ➔ **Individual tab** ➔ **Personal** ➔ **Get Started**.
- Click either **Start here** for new users or **Go here** for return users. We are going to click on the **Go here** button.
- Click **Accept terms** box ➔ **Unity Hub** ➔ **UnityHubSetup.exe**.
- If you see a warning screen, click **Yes** to allow the app to make changes to your device.
- Click **I Agree** to accept the service terms ➔ accept the default destination folder ➔ **Install** ➔ **Finish**.
- You may get a security warning about network access: if so, set the option you feel is safe and then **Accept** (or **Cancel** to disallow network access).
- Click **ADD** in the Unity Hub window ➔ **NEXT** to keep official version default selection (2019.3.9f1 at the time of writing.) ➔ **NEXT**.
- Two boxes should be checked, Microsoft Visual Studio Community 2019 for building scripts, and Documentation, click **NEXT** ➔ check box to accept the Visual Studio License Terms ➔ **DONE**.
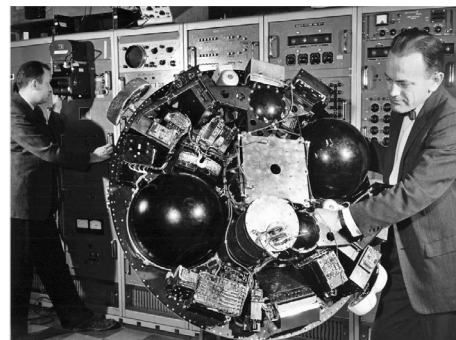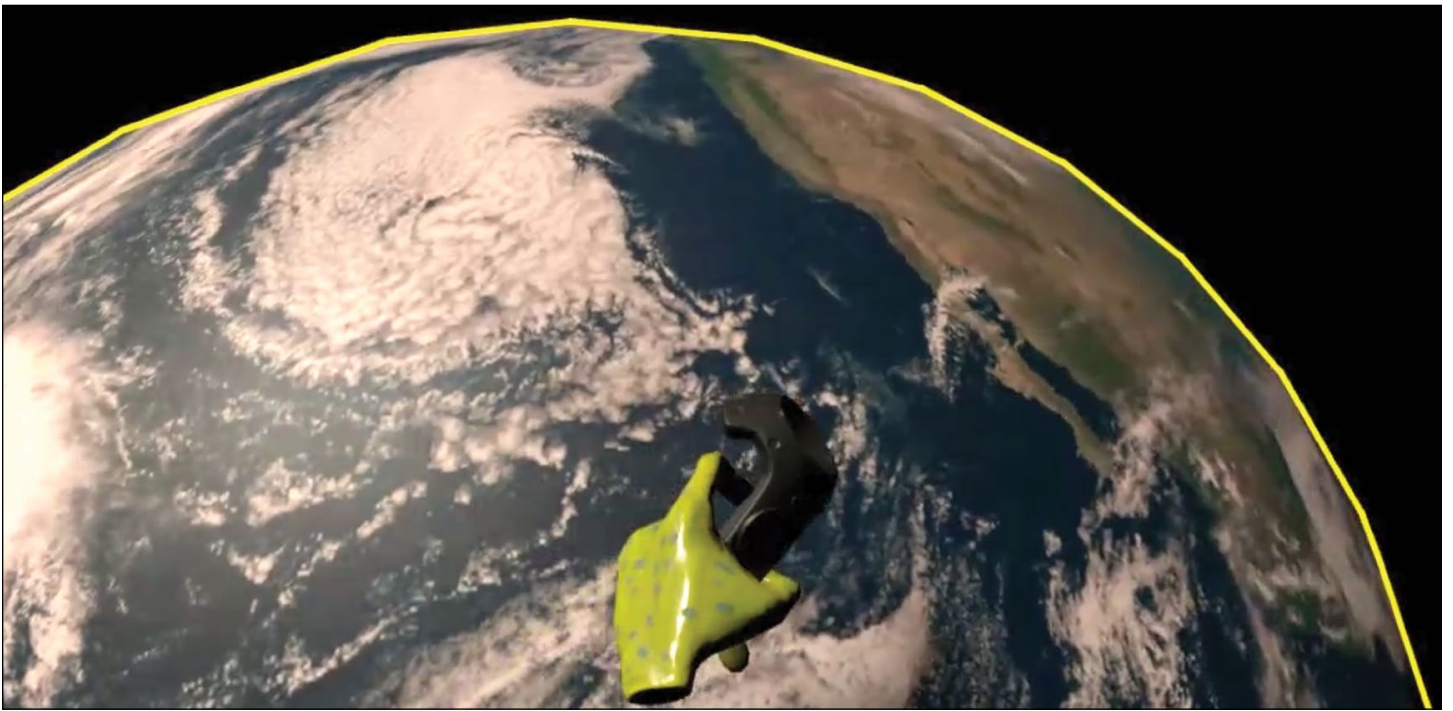
This is a frame from the sample movie downloadable from reference [8].

- Click **YES** if warning screen appears about allowing the app to make changes.
- Sit back and wait for the installation to finish.

Start a new project.

- Click on **Projects ➔ NEW ➔** Enter project name **➔ CREATE**.
- Click on the movie camera icon to left of the sun **➔ Delete Key** to delete default camera.

Import Steam VR Plugin

- Click the **Asset Store** tab at the top of the scene window.
- Enter **Steam VR** in the search box **➔** click on the **Steam VR Plugin ➔ Import** button.
- Click **Import** to keep the defaults in the SteamVR Plugin window
- Click **Accept All** in the Steam VR project setting window **➔ OK** to close.
  You made the right choice window.

Place a Player Steam VR object in the scene, change to a black background and add a 3D sphere

- Click the **Scene** tab at the top of the scene window **➔** enter **Player** in the Project window search box.
- Drag and drop a grey box with a blue both-direction arrow icon into the scene, anywhere.
- Enter **Position x=2, y=0, z=0** and **Rotation X=0, Y=270, Z=0** in the inspector window.
- Expand **Player menu** in the Hierarchy window **➔** expand **SteamVRObjects** menu **➔** click **VRCamera**.
- Click **Skybox** next to Clear Flags **➔ Solid Color ➔** click **Background color ➔** move sliders **R=0, G=0 and B=0** **➔** close the color selection window.
- In the Unity3D program menu click **Edit ➔ Project Settings ➔** verify that the **Virtual Reality Supported** box is checked **➔ close** the Project Settings window.
- Click the **Play** button at the top center **➔ Yes** at StreamVR actions warning **➔ Yes** to open the Input window **➔** **Yes** to use example 'actions.json' **➔ Save and generate ➔ Save** to save work **➔ Close** the SteamVR Input window.
- Click **GameObject** at the top **➔ 3D Object ➔ Sphere**.
- Change the **Position to X=0, Y=1, Z=0 ➔ Scale to X=2, Y=2, Z=2 ➔ Rotation is X=0, Y=1, Z=0**.

Remap satellite image to equirectangular projection and wrap around the sphere

- Download David Taylor's *MapToLinear* program [10] and the required runtime library bundle, if not already installed [11].
- Unzip both programs **➔Copy *MapToLinear.exe*** to a folder of your choice, avoiding 'Program Files' directories **➔** Run runtimes-setup.exe to install the runtime library.
- Download a geostationary satellite image, for example a GOES GRB image from
  https://www.star.nesdis.noaa.gov/GOES/index.php
  GOES-West or GOES-East **➔** Full Disk **➔** GeoColor 5425 x 5424px.
  (And of course, you can make use of images from any other geostationary satellite, to suit your interests).

- Open the image in an image viewing program like *IrFanView* and check the image dimensions.
- Rescale to 5424 pixels by 5424 lines if using a larger image ➔ Save the file ➔ Close the program.
- Click on **MapToLinear.exe** ➔ and drag-and-drop the image on to the program window to process it.
- Click **Scenes** folder under the Asset folder ➔drag and drop the remapped image into the Scenes window.
- Click on the image ➔change the **Max Size to 8192** and the **Compression to High Quality** ➔ **Apply**.
- Click on the **sphere** in the Scene window ➔ drag and drop the remapped image onto the sphere.
- Click **Play**, put on your VR googles and enjoy the view—but remember—don't walk into a wall!

This article and companion video can't possibly come close to conveying the experience you'll have viewing satellite images in virtual reality. You simply must try it!

References

1 A Digital Storage and Scan Converter for Weather Satellite Images, Part 1 pp 194-208, Matjaz Vidmar, YU3UMV
   https://www.americanradiohistory.com/Archive-DX/VHF-Communications/VHF-COMM.1982.4.pdf

2 *WXtoImg* User Guide
   http://leshamilton.co.uk/wxtoimg.htm

3 David Taylor's *Groundmap* program
   https://www.satsignal.eu/software/groundmap.htm

4 Creation of 3D images from HRPT Data
   http://www.alanbanks.org.uk/3D_HRPT_Images.php

5 Science on a Sphere NOAA)
   https://sos.noaa.gov/What_is_SOS/

6 Science On a SSAphere (Wikipedia)
   https://en.wikipedia.org/wiki/Science_On_a_SSAphere

7 GOES Image View
   https://www.star.nesdis.noaa.gov/GOES/index.php

8 An example 2D view of what the person wearing the VR goggles would see and **GRB2.exe**, a compiled *Unity3D* program ready to be run using *VIVE VR* goggles.
   https://www.dropbox.com/sh/m7a8pdtzutcb3k0/AADqdjL5nglWyIvXsymGGFqLa?dl=0 contains GRB1.mpg

9 Training Video
   https://www.dropbox.com/s/h29lprimpgw7uqr/Earth%20in%203D.mp4?dl=0

10 David Taylor's *MapToLinear* software
   https://www.satsignal.eu/software/MapToLinear.zip

11 David Taylor's Runtime Package
   https://www.satsignal.eu/software/runtime.html

The launch of Meteor M2-3 is delayed till 2021

Les Hamilton

Enthusiasts lamenting the end of LRPT transmissions from Russian meteorological satellite Meteor-M2-2 will be disappointed to learn that the anticipated launch of its successor, Meteor-M2-3 later this year, has now been delayed by twelve months.

On February 21, Russian News Agency TASS reported that Ilya Slobodskoy, a representative of the VNIIEM corporation—which develops and manufactures the satellite—had stated that meteorological satellite "Meteor-M" No. 2-3 is now scheduled to be launched from Russia's Far Eastern Vostochny spaceport in August 2021.

"The launch of Meteor-M satellite No 2-3 is expected in August 2021," said Slobodskoy, speaking at the 11th international conference of the Russian Association of Aviation and Space Insurers.

Earlier, the press service of *Roscosmos* informed TASS that Meteor-M2-3, which was planned to be put into orbit in 2020, will be launched in 2021. According to the state corporation, it was decided to conduct additional testing to ensure the integrity of the spacecraft.

Iceberg shattered

European Space Agency
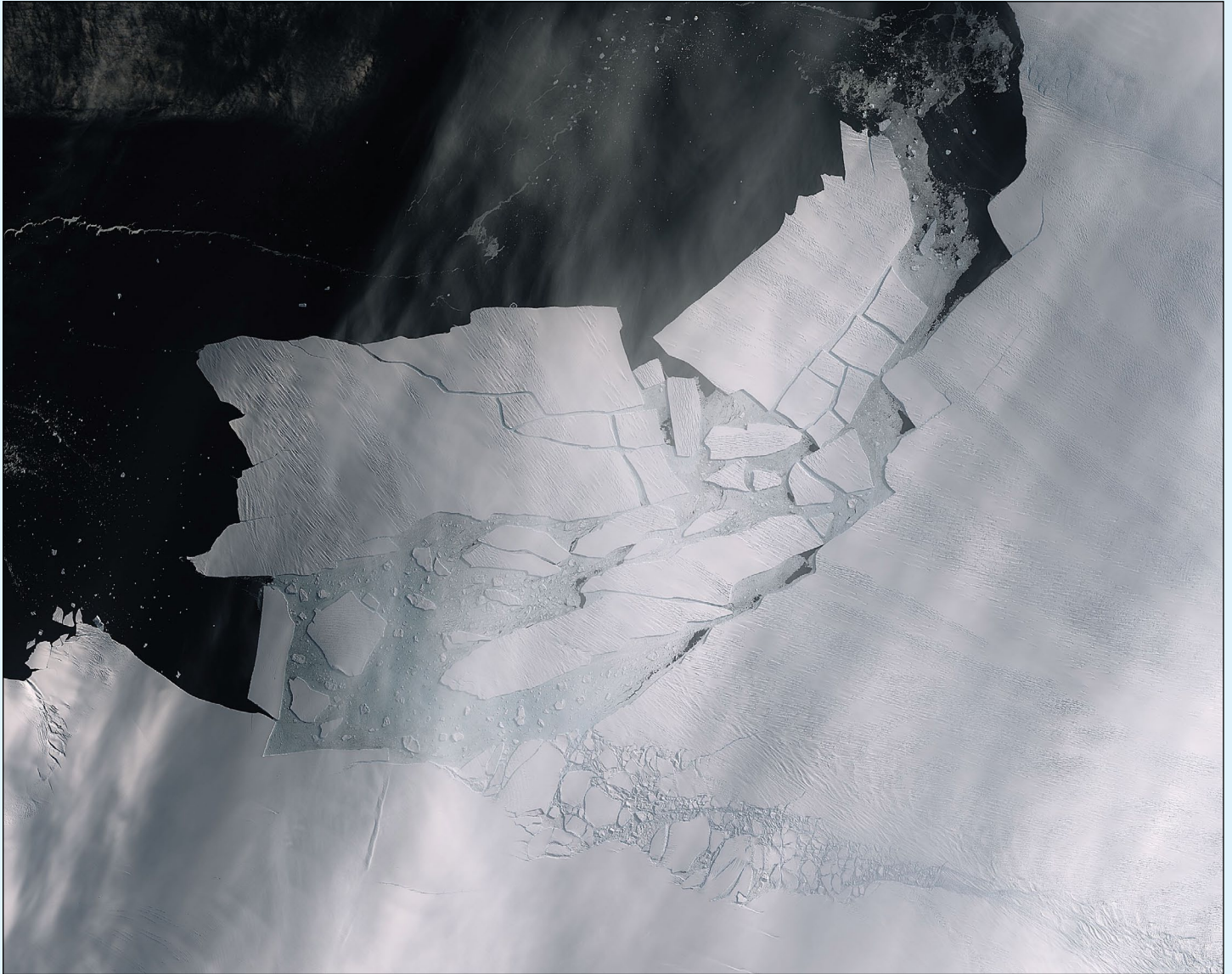
This Sentinel-1 image shows the fractured Pine Island Glacier iceberg
Image contains modified Copernicus Sentinel data (2020), processed by ESA, CC BY-SA 3.0 IGO

The Pine Island Glacier recently spawned an iceberg over 300 square kilometres in area—about the size of the island Malta. This huge berg very quickly broke into many pieces the largest of which has been named B-49. This almost cloud-free image, captured on February 11 by the Copernicus Sentinel-2 mission, shows the freshly broken bergs in detail.

Thanks to the combination of both optical and radar images from the Copernicus Sentinel satellite missions, two large rifts were spotted in Pine Island Glacier last year and scientists have been keeping a close eye on how quickly the cracks were growing.

This *YouTube* animation uses 57 radar images captured by the Copernicus Sentinel-1 mission between February 2019 and February 2020 (the last frame is from 10 February 2020) and shows just how quickly the emerging cracks grew and led to this calving event.

https://youtu.be/dYRcFPI2hhs

Pine Island Glacier, along with its neighbour Thwaites Glacier, connect the centre of the West Antarctic Ice Sheet with the ocean—together discharging significant quantities of ice into the ocean. These two glaciers have been losing ice over the last 25 years.

Owing to their extremely remote location, satellites play a critical role in measuring and monitoring Antarctic glaciology – revealing the timing and pace of glacial retreat in Antarctica. Since the early 1990s, the Pine Island Glacier's ice velocity has increased dramatically to values which exceed ten metres per day.

Easter Island

European Space Agency

The Copernicus Sentinel-2 mission captured this cloud-free image of Easter Island on April 7, 2019
© Contains modified Copernicus Sentinel data (2020), processed by ESA, Creative Commons CC BY-SA 3.0 IGO

The Copernicus Sentinel-2 mission takes us over one of the most remote islands in the world: Easter Island. Located in the Pacific Ocean, over 3500 km off the west coast of South America, this Chilean island is also known as Rapa Nui by its original inhabitants. The island was given its current name by Dutch navigator Jacob Roggeveen the day Europeans arrived, on Easter Sunday in 1772.

The island is famous for its monolithic stone statues, called Moai, said to honour the memory of the inhabitants' polynesian ancestors. There are nearly 1000 scattered around the island, usually positioned near fresh water. Many are located near the Rano Raraku volcano, on the southeast coast. The white edges along the southern coast show harsh waves colliding with the shore.

An interesting feature of the image is the ochre-orange colour of the Poike—the peninsula on the eastern end of the island. It is said that, in ancient times, the island was thickly vegetated. However, land clearing for cultivation, and the Polynesian rat, played roles in deforestation, leading to the erosion of the soil, particularly in the east.

Several reforestation projects have been attempted, including a eucalyptus plantation in the middle of the island, visible in dark green. The brown patch to the right of the plantation is probably a burn scar from a wildfire.

The majority of the island's inhabitants live in Hanga Roa, the main town and harbour on the west coast, clearly visible in the image. Interestingly, the long runway of the island's only airport was once designated as an emergency landing site for the US space shuttle.

At the very edge of the southwest tip of the island stands Ranu Kao, the island's largest volcano. Its shape is distinctive owing to its crater lake, one of only three natural bodies of water on Easter Island.

Many tourists are drawn here by Easter Island's mysterious history and isolated position. What is relatively unknown is the existence of two small beaches on the northeast coast. Anakena beach has white, coral sand, while the smaller Ovahe beach, surrounded by cliffs, has pink sand.
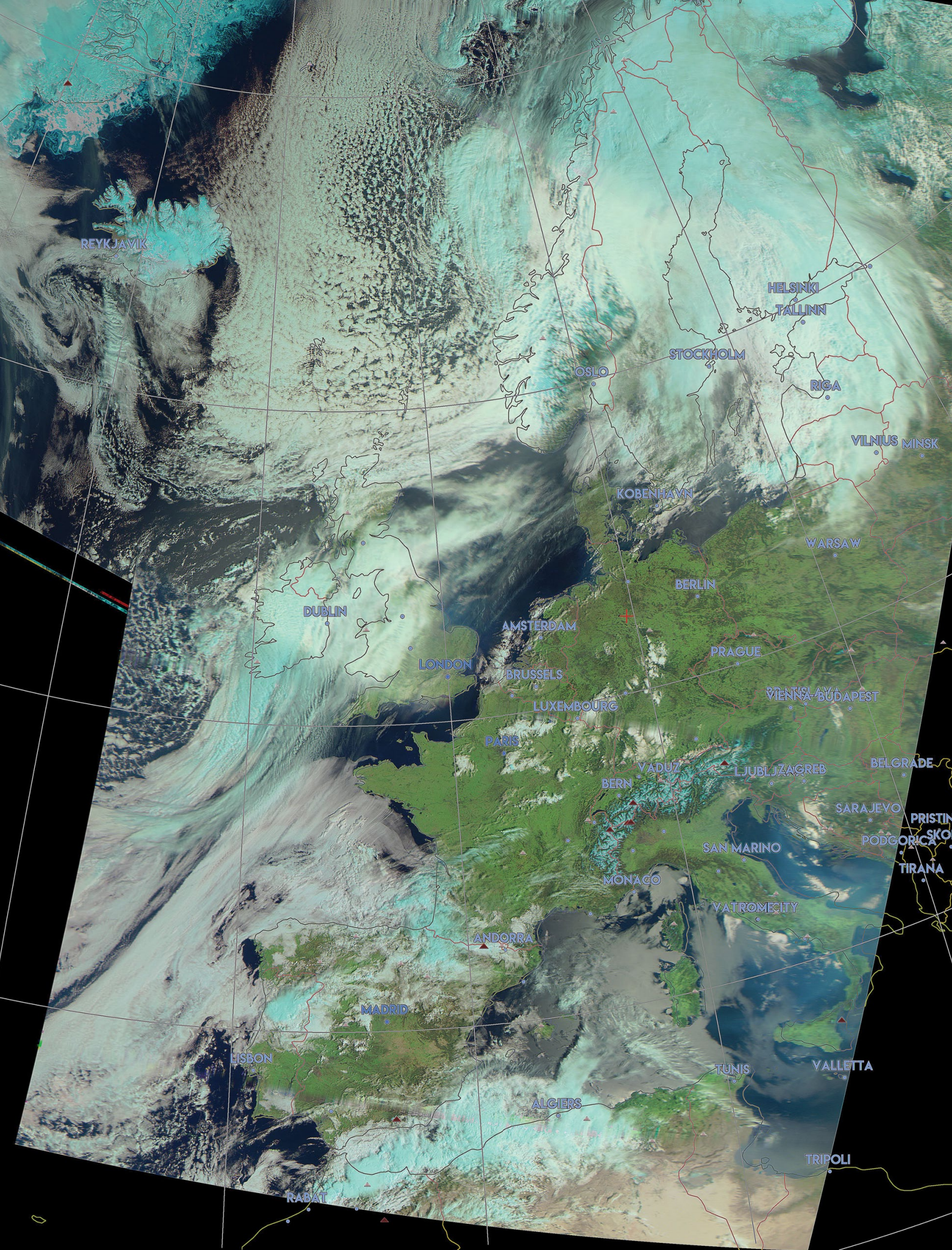
This Meteor M2 composite image was created by Joachim Scharrer using the MeteorGIS v 2.24 software system.
The RGB123 image, captured at 9.39 UT on April 12, 2020 is presented in UTM projection
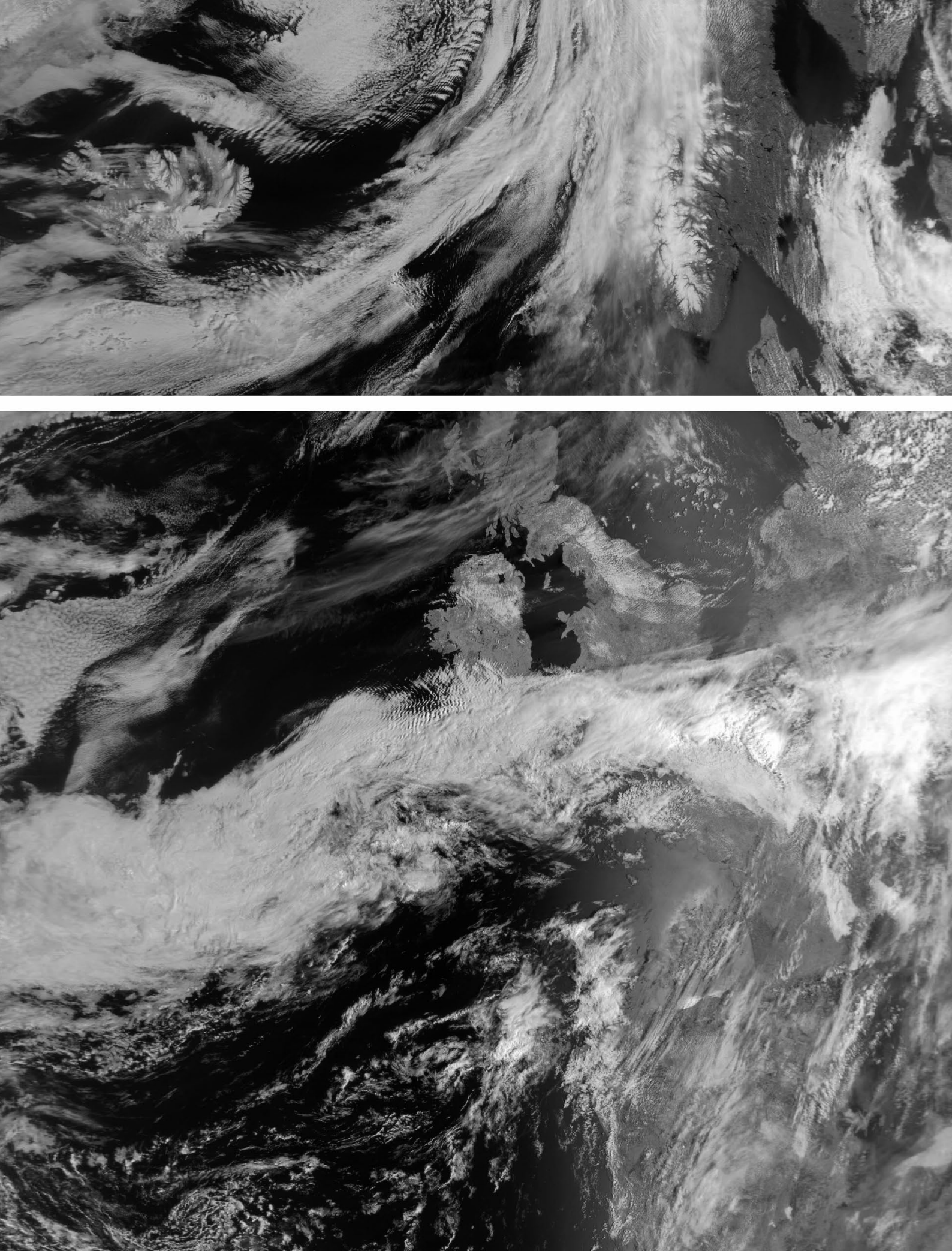
John Cooper provided this splendid Channel-3 LRPT image from Meteor M2, that he received on May 4, 2020.

Northwest Greenland

European Space Agency

ESA's Copernicus-3 satellite acquired this image of northwest Greenland on July 29, 2019.
This Sentinel 3 Image contains modified Copernicus Sentinel data (2019), processed by ESA, CC BY-SA 3.0 IGO

Lying in the North Atlantic Ocean, Greenland is the world's largest island and is home to the second largest ice sheet after Antarctica. Greenland's ice sheet covers more than 1.7 million square km and covers most of the island.

Ice sheets form in areas where snow that falls in winter does not melt entirely over the summer. Over thousands of years, layers of snow pile up into thick masses of ice, growing thicker and denser as the new snow and ice layers compress the older layers. Ice sheets are constantly in motion. Near the coast, most of the ice moves through relatively fast-moving outlets called ice streams, glaciers and ice shelves.

In the top centre of this image, captured on July 29, 2019, the Petermann glacier is visible. Petermann is one of the largest glaciers connecting the Greenland ice sheet with the Arctic Ocean. Upon reaching the sea, a number of these large outlet glaciers extend into the water with a floating 'ice tongue'. Icebergs occasionally break or 'calve' off these tongues.

In this image, sea ice and icebergs can be seen in the

Nares Strait—the waterway between Greenland and Canada's Ellesmere Island, visible top left in the image. On the tip of Ellesmere Island lies Alert—the northernmost known settlement in the world. Inhabited mainly by military and scientific personnel on rotation, Alert is about 800 km from the closest community, which is roughly the same distance between Alert and the North Pole.

Scientists have used data from Earth-observing satellites to monitor Greenland's ice sheet. According to a recent study, both Greenland and Antarctica are losing mass six times faster than they were in 1990s. Between 1992 and 2017, Greenland lost 3.8 trillion tonnes of ice, corresponding to around 10 mm contribution to global sea-level rise.

Melting ice sheets caused by rising temperatures and the subsequent rising of sea levels is a devastating consequence of climate change, especially for low-lying coastal areas. The continued satellite observations of the Greenland ice sheet are critical in understanding whether ice mass loss will continue to accelerate and the full implications of this anticipated change.

Mount St Helens

NASA Earth Observatory
Story by Kathryn Hansen

In May 1980, a satellite watched the mountain erupt.
Over the next 40 years, satellites have observed it recovering.

Mount St Helens as imaged by Landsat-8 on April 17, 2020
NASA Earth Observatory image by Joshua Stevens, Robert Simmon, and Jesse Allen, using Landsat data from USGS.

Forty years have passed since a tremendous blast at Mount St Helens—the deadliest eruption in United States history—transformed the landscape for hundreds of square miles in the Pacific Northwest. Satellite images acquired in the days around the eruption on May 18, 1980, helped scientists to understand the event; images acquired over the past four decades have given them insights into how a landscape recovers.

The image above, acquired with the Operational Land Imager (OLI) on **Landsat 8**, shows the volcano in southwest Washington on April 17, 2020. Seasonal snow still blankets its flanks despite the spring sunshine. By August, most of the snow on the mountain will melt. The image is the most recent, cloud-free view of the mountain from Landsat 8, which acquires images of any given place on Earth about once every two weeks.
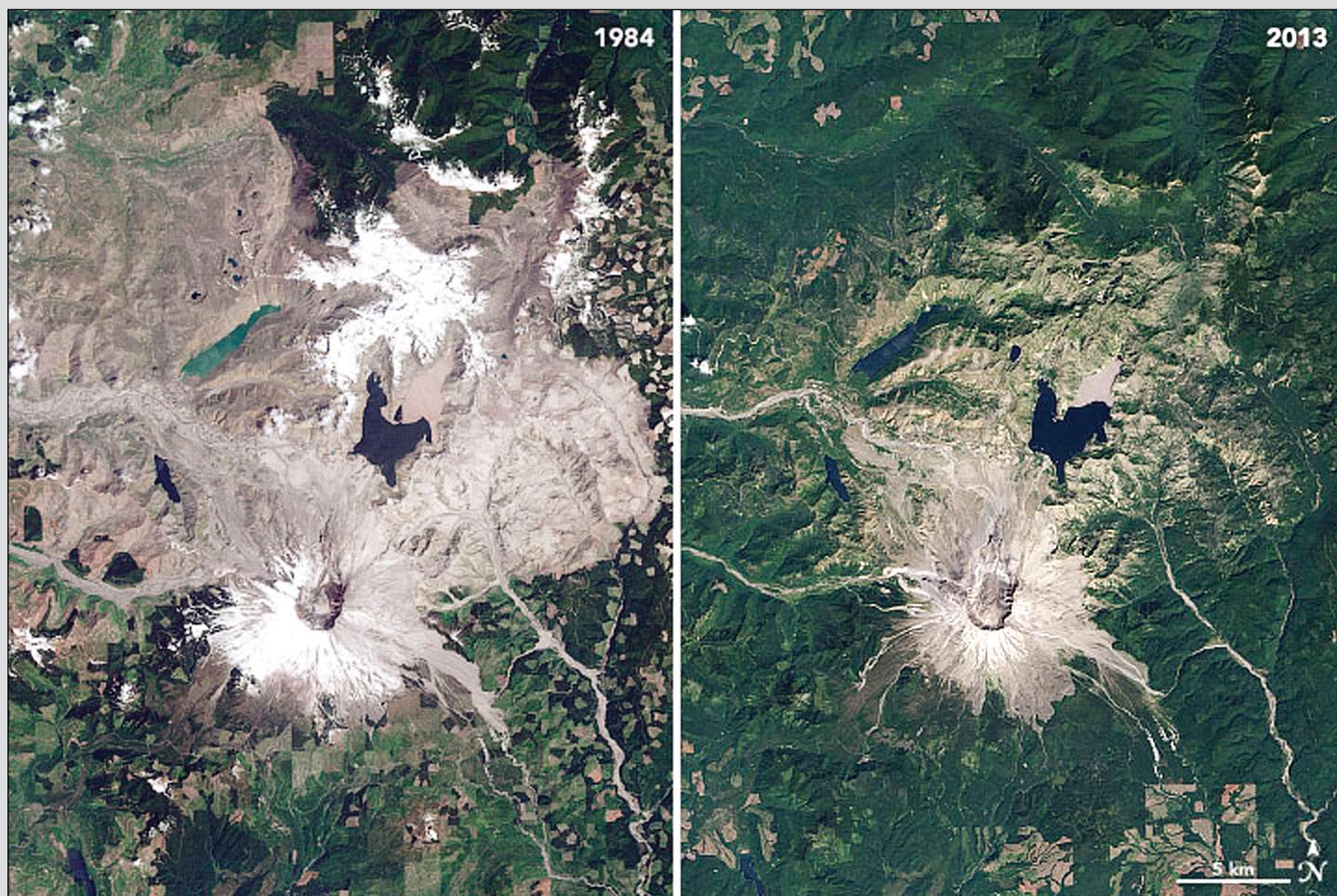
Comparison: Mount St Helens and its environs immediately after the eruption in 1984, and in 2013.
Earth Observatory images by Joshua Stevens, Robert Simmon, and Jesse Allen, using Landsat data from USGS.

Landsat satellites have been acquiring images of Mount St Helens for nearly five decades. The image pair above is from our World of Change series, which shows the scale of the eruption and the process of recovery. View the full series at

https://earthobservatory.nasa.gov/world-of-change/StHelens

to watch green plants and trees reclaim the land on the far outskirts of the volcano in the late 1980s and then closer to the mountain by the late 1990s. Change is still ongoing—plants are growing on the once sterile Pumice Plain north of the crater—but the changes can be slow and now appear less dramatic in annual images.

'*I think these long-time series will be useful for decades to come, possibly out to a century after the eruption, as change is very slow,*' said Steve Self, a professor at the University of California Berkeley.

The Geostationary Operational Environmental Satellite-3 (GOES-3) captured black and white images of the eruption as it happened forty years ago.

https://twitter.com/NWSSeattle/status/865193432771215360

Unlike Landsat satellites, which follow a predetermined ground track to collect imagery from around the entire planet, GOES satellites provide a constant view of the same area. This geostationary orbit is most valuable for weather monitoring. In this case, it was useful for watching an eruption unfold.

This animation, shared by the National Weather Service in Seattle, shows a series of GOES-3 images acquired on May 18, 1980. GOES-3 was operated by the National Oceanic and Atmospheric Administration (NOAA); NASA helps develop and launch the GOES series of satellites.

The GOES-3 images from that day were also analysed in research papers published by Self and colleague Rick Holasek.

'*The Mount St. Helens eruption was possibly the first time I saw satellite images from an eruption,*' Self said. '*I was very interested in these images because they gave a huge overview, and Rick and I had NASA support to explore this "new" technology.*'

Self noted the impressive density of the initial blast cloud, visible in the first three images of the animation, compared with those of the later phases, which sent pumice and ash flying as far as Idaho. The blast cloud rose quickly, reaching about 30 kilometres altitude in just four minutes.

Decades later, instruments on weather and research satellites are a routine but vital component of observing eruptions and their plumes. Scientists map the gases and particles in volcanic emissions to find out how they affect the air and climate. They also contribute to volcanic ash advisory centres in their predictions of the movement of volcanic clouds and, if necessary, the rerouting of aircraft.

Meteor M2-2 is still Transmitting AHRP Imagery

Further to our report in GEOQ 65 that Russia's Meteor M2-2 satellite had been put out of action following a collision with a micrometeorite, it now transpires that a degree of restoration has been accomplished. Alas this does not extend to the LRPT capability, but, during periods when the craft's solar panels are illuminated, there is sufficient power to operate the higher resolution AHRPT stream on 1700 MHz.

The image opposite is part of a Meteor M2-2 pass acquired from the east of The Netherlands by Harrie van Deursen of *Werkgroep Kunstmanen* at 13.50 UT on March 20 this year, and submitted to the *GEO-Subscribers* internet forum by Rob Alblas. The image was received using a home-made '*Werkgroep*' receiver and decoder, and is a colour composite image from channels 1, 2 and 3.
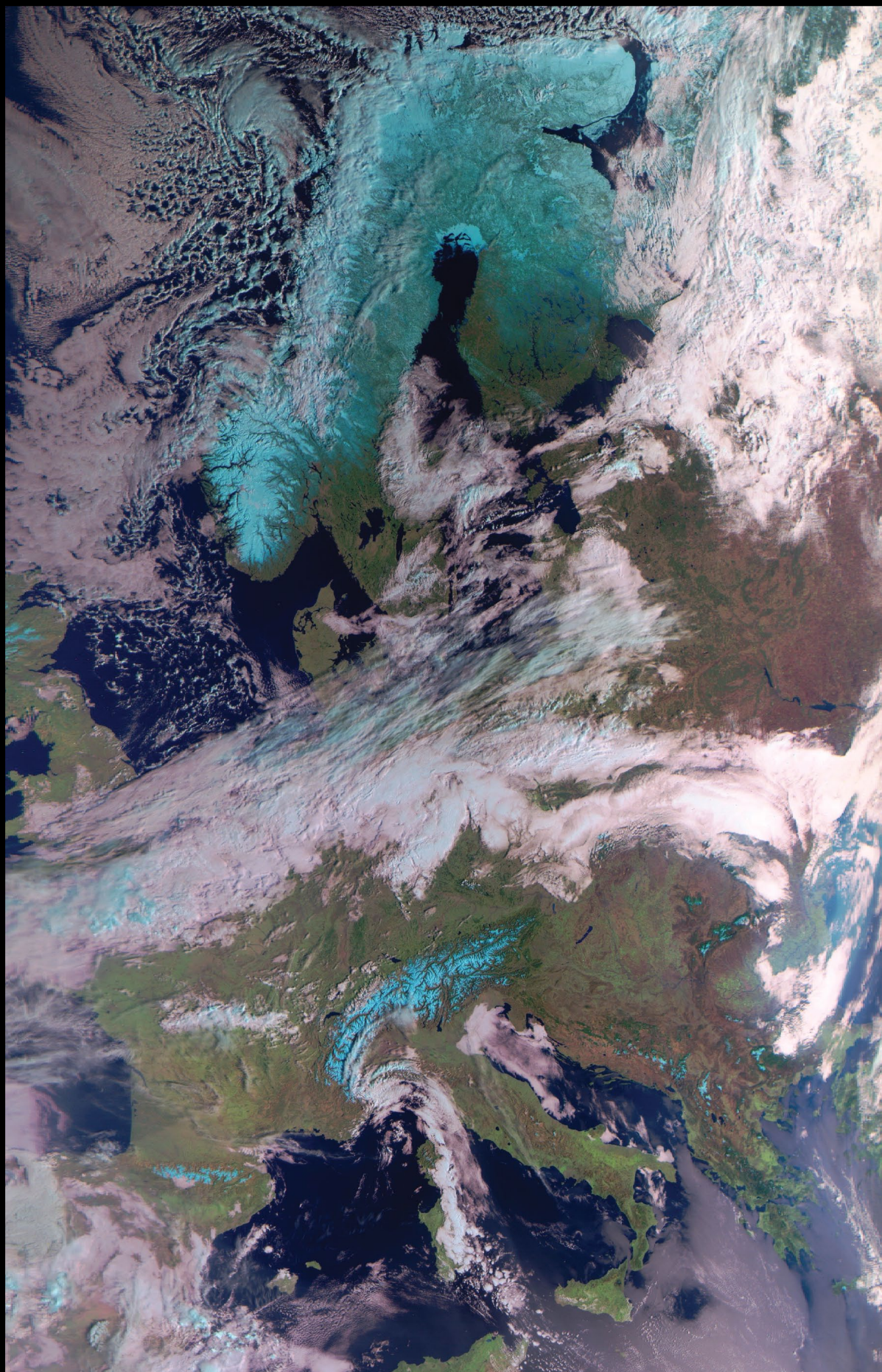
Greenland, Antarctica Melting Six Times Faster than in the 1990s

NASA / Jet Propulsion Laboratory

Observations from eleven satellite missions monitoring the Greenland and Antarctic ice sheets have revealed that they are losing ice six times faster than they were in the 1990s. If the current melting trend continues, the regions will be on track to match the 'worst-case' scenario of the Intergovernmental Panel on Climate Change (IPCC) of an extra 17 centimetres of sea level rise by 2100.

An aerial view of the icebergs near Kulusuk Island, off the southeastern coastline of Greenland, a region that is exhibiting an accelerated rate of ice loss.
Credits: NASA Goddard Space Flight Center

The findings, published online in the journal *Nature* from an international team of 89 polar scientists from 50 organisations, are the most comprehensive assessment to date of the changing ice sheets. The *Ice Sheet Mass Balance Intercomparison Exercise* team combined 26 surveys to calculate changes in the mass of the Greenland and Antarctic ice sheets between 1992 and 2018.

The assessment was supported by NASA and the European Space Agency. The surveys used measurements from satellites including NASA's **Ice, Cloud, and land Elevation Satellite** and the joint NASA-German Aerospace Center **Gravity Recovery and Climate Experiment**. Andrew Shepherd at the University of Leeds in England and Erik Ivins at NASA's Jet Propulsion Laboratory in Southern California led the study.

The team calculated that the two ice sheets together lost 81 billion tonnes per year in the 1990s, compared with 475 billion tons of ice per year in the 2010s—a sixfold increase. In total, Greenland and Antarctica have lost 6.4 trillion tons of ice since the 1990s, the resulting meltwater rising global sea levels by 17.8 millimetres. Together, the melting polar ice sheets are responsible for a third of all sea level rise. Of this total sea level rise, 60% resulted from Greenland's ice loss and 40% resulted from Antarctica's.

'Satellite observations of polar ice are essential for monitoring and predicting how climate change could affect ice losses and sea level rise,' stated Ivins. *'While computer simulations allow us to make projections from climate change scenarios, the satellite measurements provide prima facie, rather irrefutable, evidence.'*

The IPCC, in its Fifth Assessment Report issued in 2014, predicted global sea levels would rise 71 centimetres by 2100. The Ice Sheet Mass Balance Intercomparison Exercise team's studies show that ice loss from Antarctica and Greenland tracks with the IPCC's worst-case scenario.

Combined losses from both ice sheets peaked at 552 billion tons per year in 2010 and averaged 475 billion tons annually for the remainder of the decade. The peak loss coincided with several years of intense surface melting in Greenland, and last summer's Arctic heat wave means that 2019 will most likely set a new record for polar ice sheet loss. IPCC projections indicate the resulting sea level rise could put 400 million people at risk of annual coastal flooding by the end of the century.

'Every centimetre of sea level rise leads to coastal flooding and coastal erosion, disrupting people's lives around the planet,' said Shepherd.

As to what is leading to the ice loss, Antarctica's outlet glaciers are being melted by the ocean, which causes them to speed up. Whereas this accounts for the majority of Antarctica's ice loss, it accounts for half of Greenland's ice loss; the remainder is caused by rising air temperatures melting the surface of its ice sheet.
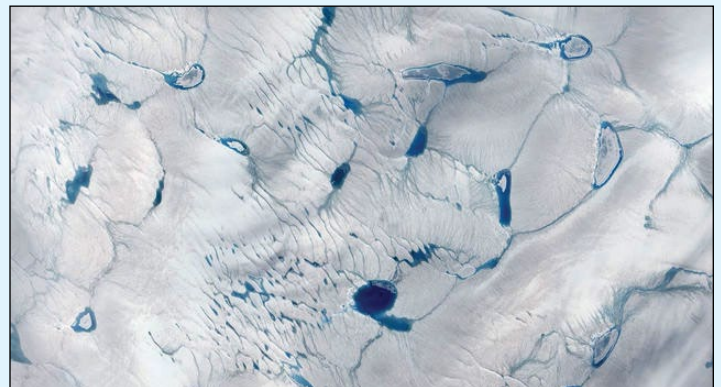
Pools of meltwater in southwestern Greenland's ice sheet as observed by a NASA satellite in 2016.
Credits: NASA Goddard Space Flight Center
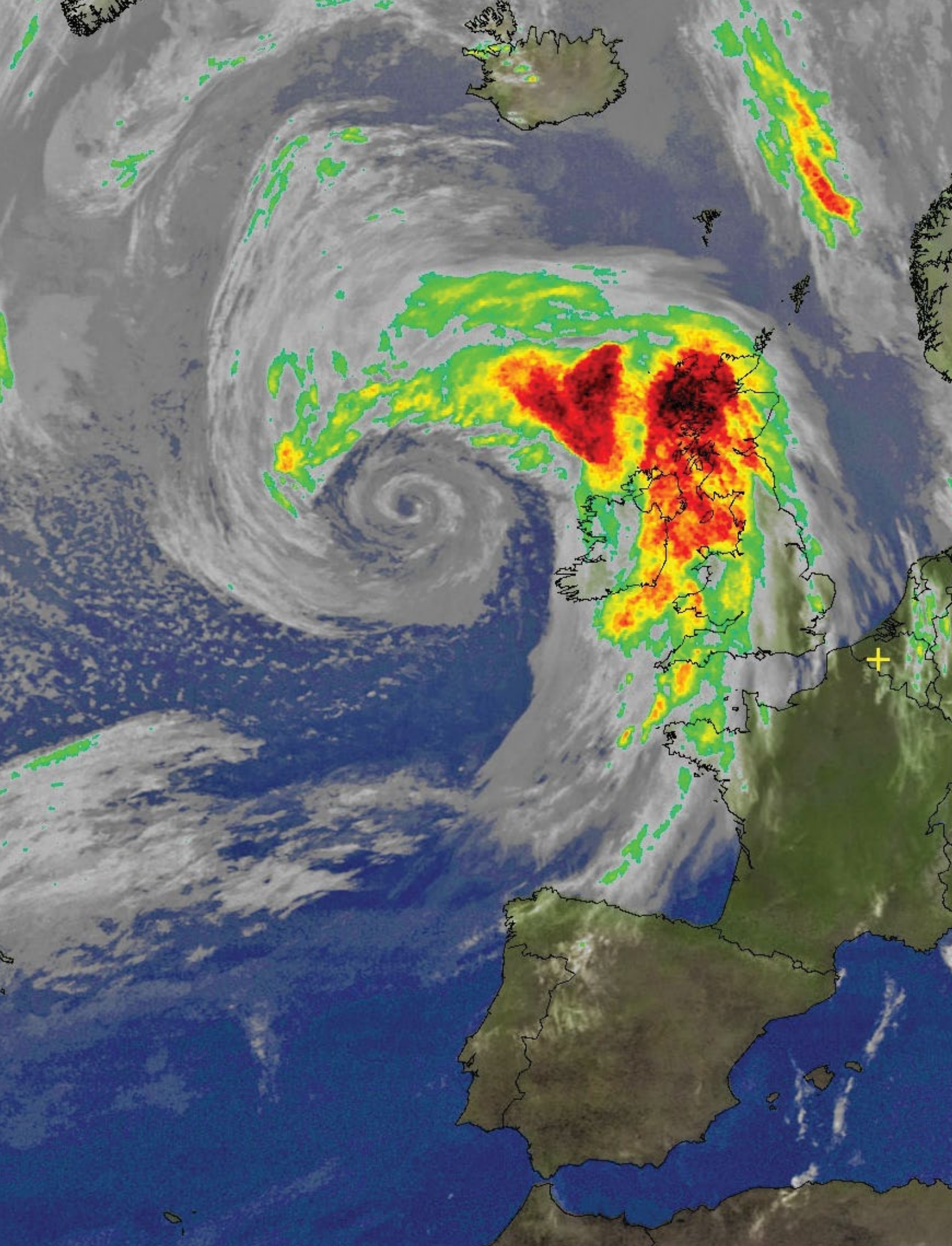
André T'Kindt sent in this NOAA 18 image that he captured at 23:19 UT on May 21 2020. It shows a deep, unseasonal Atlantic depression battering northwest Scotland. This *MCIR_with_precipitation with_overlay* composition from WxToImg clearly illustrates the intensity of the associated rainfall.

Sun/satellite/dish co-linearity – Solar Outage

John Tellick

Twice a year, as the Earth 'moves' between seasons, the sun will pass behind every geostationary satellite for a period of several days. This occurs at some time of day between around February and March as seen from a specific location on Earth. This means that, for a few days, receiving stations will experience a situation of sun/satellite/dish co-linearity. The avid EUMETCast enthusiasts among us are of course well experienced with this phenomenon and its effects through personal experience. But some explanation may be required for newcomers to the hobby.

During this springs 'outage period,' I found a website that gave a visual representation of solar outage which makes it perhaps more understandable than just prediction 'figures and timings.'

Those interested can visit the website at

https://www.satellite-calculations.com/

Many of us get our solar outage prediction timetable from David Taylor's *WXtrack* satellite prediction software—mine for this spring was:

Satellite solar outage list produced by WXtrack
Location: Surbiton at Lat: 51.38°N Lon: 0.23°W
Satellite: EUTELSAT 10A, separation <= 1.61°

Early Period Group				
Date	Begin	Peak	End	Closest
2020 Feb 26	11:25	11:27:53	11:30 UTC	1.54°
2020 Feb 27	11:23	11:27:43	11:32 UTC	1.16°
2020 Feb 28	11:21	11:27:32	11:33 UTC	0.79°
2020 Feb 29	11:21	11:27:20	11:33 UTC	0.41°
2020 Mar 01	11:20	11:27:09	11:33 UTC	0.03°
2020 Mar 02	11:20	11:26:56	11:33 UTC	0.36°
2020 Mar 03	11:20	11:26:44	11:32 UTC	0.74°
2020 Mar 04	11:21	11:26:31	11:31 UTC	1.12°
2020 Mar 05	11:23	11;26:17	11:28 UTC	1.51°

The list shows dates and times when the sun is in the beamwidth of the antenna, and may cause an outage because of solar noise entering the receiver.

However, the satellite-calculation website map shows the '**reduced carrier to noise ratio level cone**' as it passes your location in realtime giving the expected drop in carrier to noise level as the period of co-linearity passes. The contours of the cone range from: -6.46 dB at the centre of the cone to -1 dB at its outer margin, indicating the predicted drop in C/N ratio. Figure 2 illustrates my outage cone at the point of maximum co-linearity.

The sun is a giant and powerful source of RF radiation across a wide spectrum. And it is radiating this 'noise' all the time.
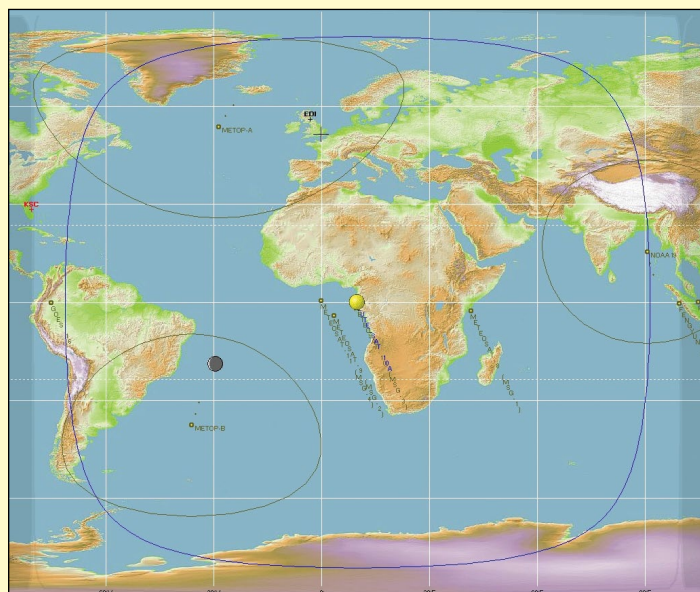

Figure 1 - The blue line in this WXtrack shows Eutelsat's theoretical global RF coverage.
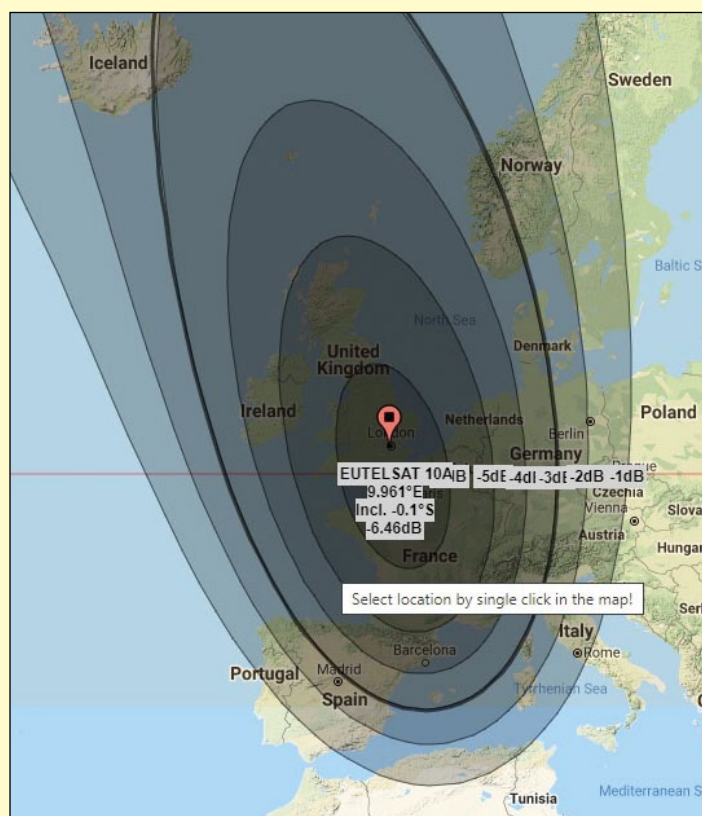
Figure 2 - Outage cone at the author's 'maximum' co-linearity

However this is only a problem to us during sun/satellite/dish co-linearity. The sun crosses our 'dish longitude' every day but, outside the co-linearity period, the sun is either below or above the beamwidth of our dish at that time, so no solar noise is focused onto our LNB.

Those of you who use the GEO/MSG-1/SatSignal internet Groups will often have noticed comments
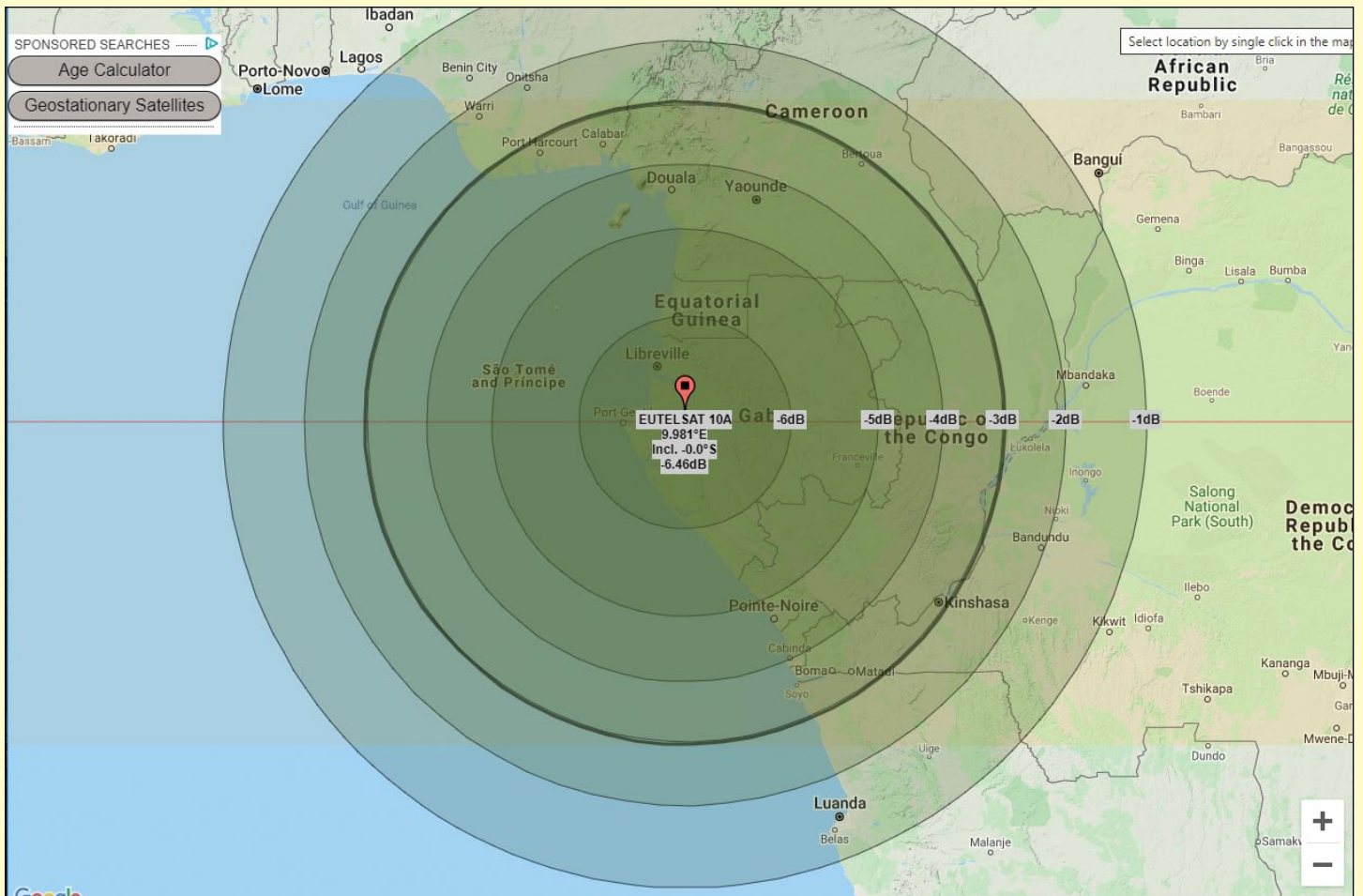
Figure 3 - The theoretical outage cone at the sub satellite point on the day of co-linearity shows degradation steps from -6 dB at the centre to -1 dB at the outer margin.
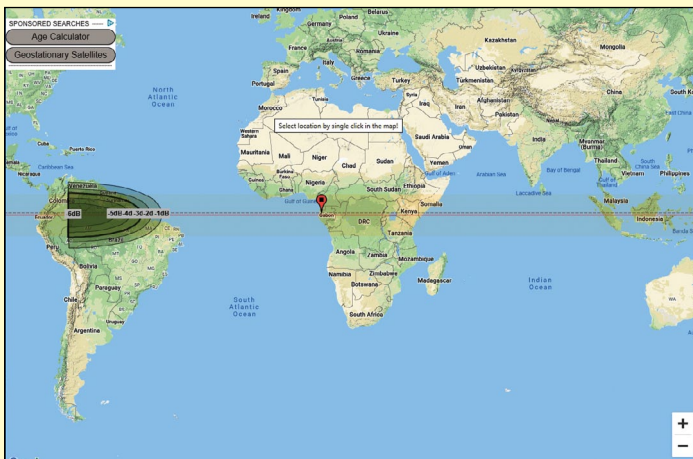

Figure 4
The start of Eutelsat 10-A's outage cone on the day when the sun was exactly above the Equator.

Figure 5
The end of Eutelsat 10-A's outage cone on the day when the sun was exactly above the Equator.

and recommendations about the importance of accurate alignment of a satellite dish and LNB.

We need to obtain the maximum level of signal with the least amount of 'noise'—Signal to Noise Ratio (SNR) or Carrier to Noise Ratio (C/N) or simply Es/No. This relationship between signal level and noise level determines the Link Margin of the receiving system. And a larger dish will give you more 'signal' level above the noise level leading to a higher (better) Link Margin.

Link Margin is a measurement that indicates how

much MER (Modulation Error Ratio) a digital channel can lose before it becomes impossible to 'lock' on to it. This happens when the Link Margin measurement is equal, very close to, or below zero. Then the decoder error corrector is not able to recover data lost at transmission.

MER: The Modulation Error Ratio or MER is a measure used to quantify the performance of a digital radio or digital TV transmitter, or the receiver in a communications system using digital modulation.

This is all getting a bit technical, but as we see above, the receiver requires a certain level of link margin to be able to 'receive' the signal.

And for EUMETCast reception, a further complication arises since EUMETCast's HVS-1 and HVS-2 data streams use a wider transmission bandwidth than the Basic Service, meaning that HVS-1 and HVS-2 require a _higher_ link margin than that required for the Basic Service.

Now, as we know, the sun appears to pass behind 'our geostationary satellite'—Eutelsat 10-A in the case of EUMETCast—twice a year. This is true for every geostationary satellite, although in actual fact it is the satellite passing in front of the sun as seen from Earth as it travels from west to east.

At this particular time our dish will see not only the wanted satellite but also the noisy sun behind it. The satellite signal remains at constant transmitted level, but added to this is the powerful sun's broadband 'radio transmission'—what we term 'noise'.

The 'noise signal' level increases relative to the wanted signal level and our signal to noise level drops—alarmingly so at maximum co-linearity.

This reduces the link margin towards or below the required level and we can lose our wanted signal: it all depends on how much 'extra' signal to noise level you had in the first place.

Satellite-Calculation Map Representations

I thought it would be interesting to see the outage cones for a geostationary satellite—in this case Eutelsat 10-A, not only from my location but from across the globe, specifically during the day when the sun was directly above the equator.

Figure 1 shows the extent of Eutelsat 10-A's theoretical global RF coverage as the blue line in David Taylor's WXtrack. [Note, Eutelsat 10-A, being a TV and data broadcast satellite, uses shaped, wide and spot beams to cover selected land areas at Ku-Band. It's not a global beam.]

Figure 2 shows the outage cone at my location at my 'maximum' (closest) co-linearity on March 1. The red line on the map shows the line of 'actual' co-linearity on that day.

Figure 3 shows the theoretical outage cone at the sub satellite point on the Equator at maximum co-linearity on March 20.

Figures 4 and 5 show the theoretical co-linearity outage cone at start and end of the day when the sun is above the Equator on March 20th.

Figure 6 shows the outage cone on last day of

Eutelsat 10-A's outages when the sun was at the same longitude of Eutelsat 10-A.

Figure 7 illustrates the start of my spring 2020 outage period. My location just clearing the -1 dB reduction contour at the end of that day's co-linearity.
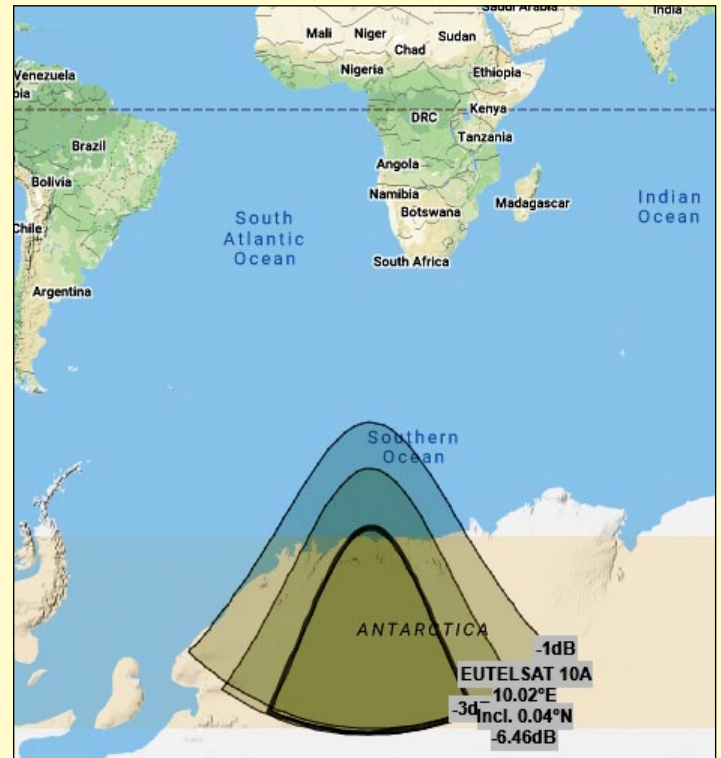

Figure 6
The final day of outages when the sun was at the same longitude of Eutelsat 10-A
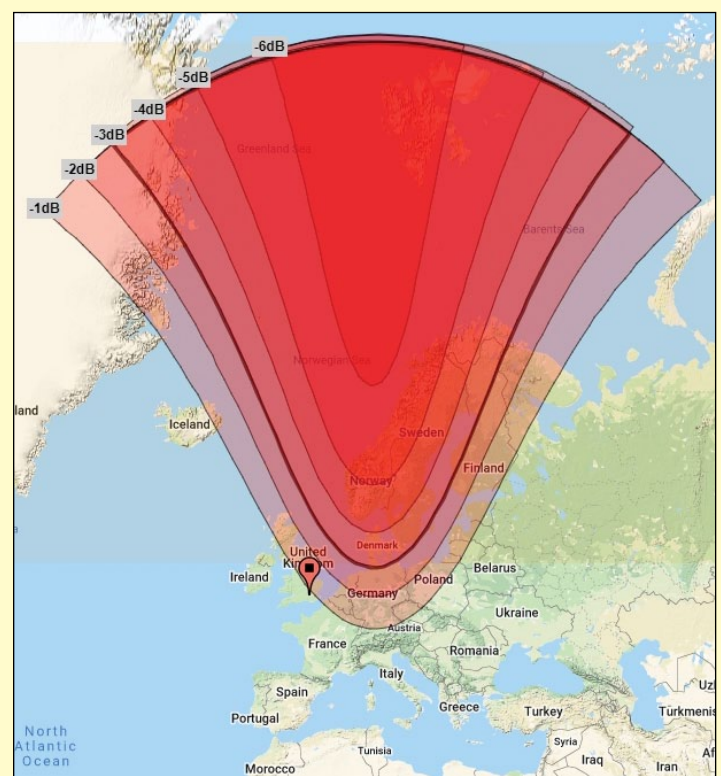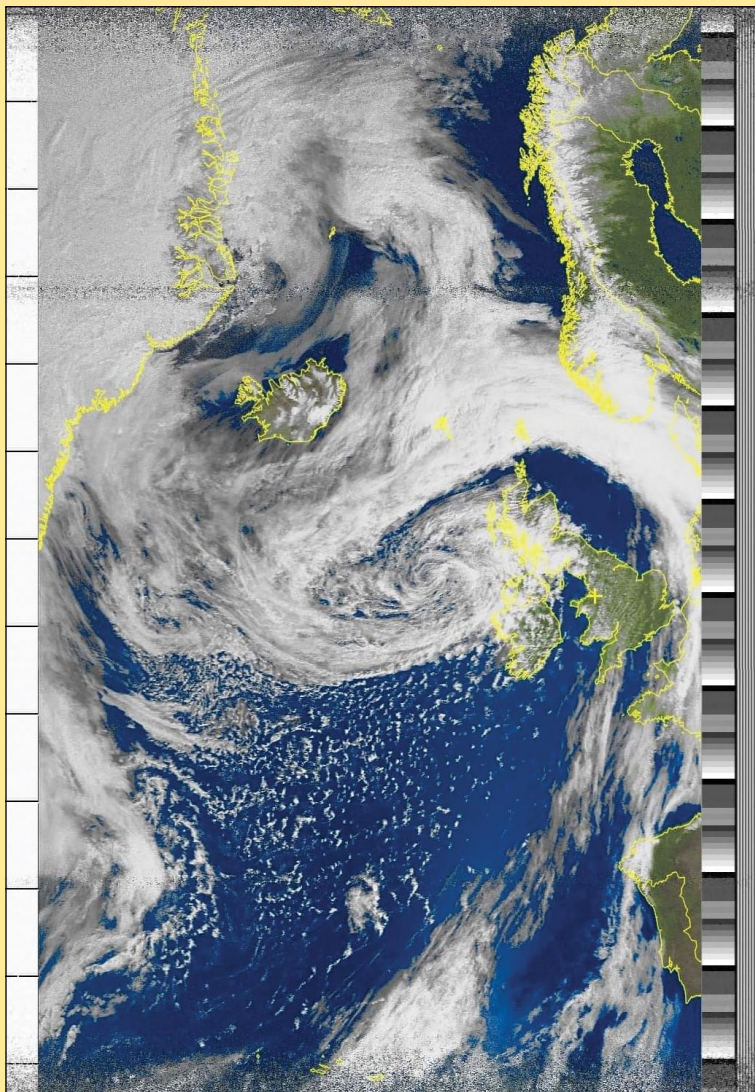

Figure 7
The end of the first day of the 2020 outage period at the author's location

What are you doing during 'Lock-Down'?

Les Hamilton

Rob Bale's smart looking QFH antenna, constructed in an evening from 'bits and bobs'

The first NOAA 18 image received on May 22 from the new QFH. There are over eleven minutes of excellent image between the facing at each extremity.

With the Covid-19 Lock-Down being only gradually lifted as I write this, and restrictions of some sort likely to remain in force for the forseeable future, what are you doing to occupy your time?

Have you done anything new or inventive on the weather satellite front?

If so, do feel free to contact the editor and share your experiences with our readers.

I recently received an email from Rob Bale, who was disappointed with his weather satellite reception and decided to build a new QFH antenna.

Rob stated: "I Made a QFH antenna last night out of some old bits and bobs I had lying around. The four top horizontal elements need to be a bit longer but I had trouble making the connection inside the 40 mm tube using choc blocks, and couldn't pull the wires back out again. I'll redo it later using solder.

"I was going to make one out of 10 mm copper tubing but thought I'd try this cheap design to see if there was any improvement in image quality before spending out on more expensive materials. The cost of this QFH was basically zero as I already had the stuff. Images are a vast improvement on my old antenna."

A-68A Holding it Together

NASA Earth Observatory
Story by Kathryn Hansen
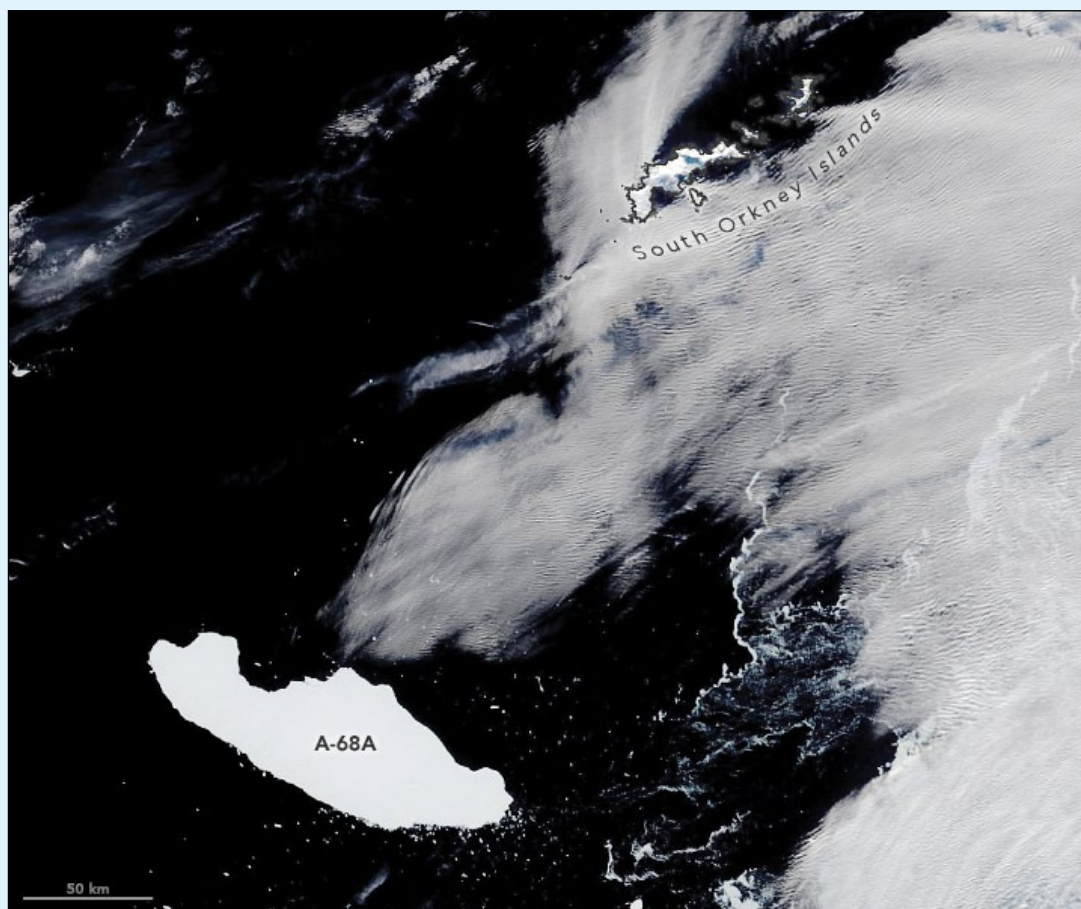
NASA Earth Observatory image by Lauren Dauphin, using MODIS data from NASA EOSDIS/LANCE and GIBS/Worldview.

Some Antarctic icebergs can persist for many years. A newborn child could go off to school, learn to drive, and become an adult all within the span of time it takes for some of the largest icebergs to break up and melt away. Iceberg A-68A—now just a few months shy of its third birthday—is a youngster compared to some. But this mammoth berg has already had an impressive journey.

On April 9, 2020, the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's *Terra* satellite acquired this image of A-68A floating about 230 kilometres west-southwest of the South Orkney Islands. The 150 km long iceberg appears to dwarf the 125 km long island chain.

In this image, A-68A is about 800 kilometres from where it broke away from the Larsen C Ice Shelf in July 2017. The journey, however, was not exactly direct. In its first year, it moved just 45 km as tides shuffled the Delaware-sized block of ice back and forth, occasionally smashing it against a rocky outcrop on the Antarctic Peninsula. The region's powerful currents eventually won, and the iceberg has since been winding its way north through the Southern Ocean.

A-68A seems to have hit the brakes in recent weeks, rotating without moving far. *NASA/UMBC* glaciologist Christopher Shuman thinks the berg could be caught up in a circulating gyre. Christopher Readinger, a scientist at the *US National Ice Center* (NIC), agrees that a gyre or smaller-scale eddy could explain the berg's motion. "*This is behaviour we've seen many times before with other bergs downstream of the peninsula*", stated Readinger. "*They just start circling for no apparent reason*."

Icebergs passing through this area are eventually kicked to the east when they encounter the powerful Antarctic Circumpolar Current, which funnels through the Drake Passage. From that point, the ice can whip north into the warmer waters of the South Atlantic—a region where icebergs melt, break down, and ultimately die. That has been the fate of many fragments of another iceberg, B-15. That Connecticut-sized berg was once the largest ever measured by satellites, but 20 years after breaking from the Ross Ice Shelf, only one piece is still large enough to be tracked by the NIC.
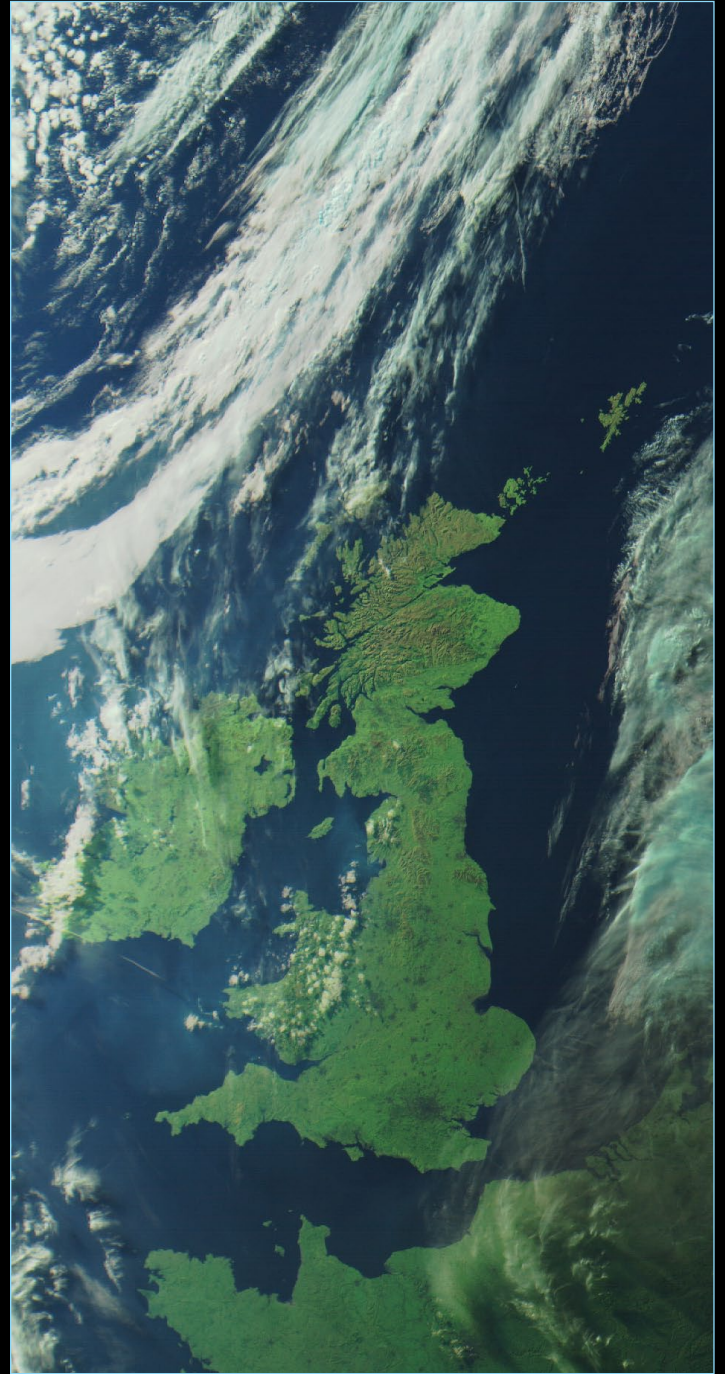
A-68A is not quite at that point. "*I'm surprised at how well it's sticking together*," Readinger said. "*It's been in warmer water for a few months now and it's not exactly a very thick berg, so I expect it will break up sometime soon, but it's showing no signs of that yet*."

Evening Imagery from Meteor M2

Les Hamilton
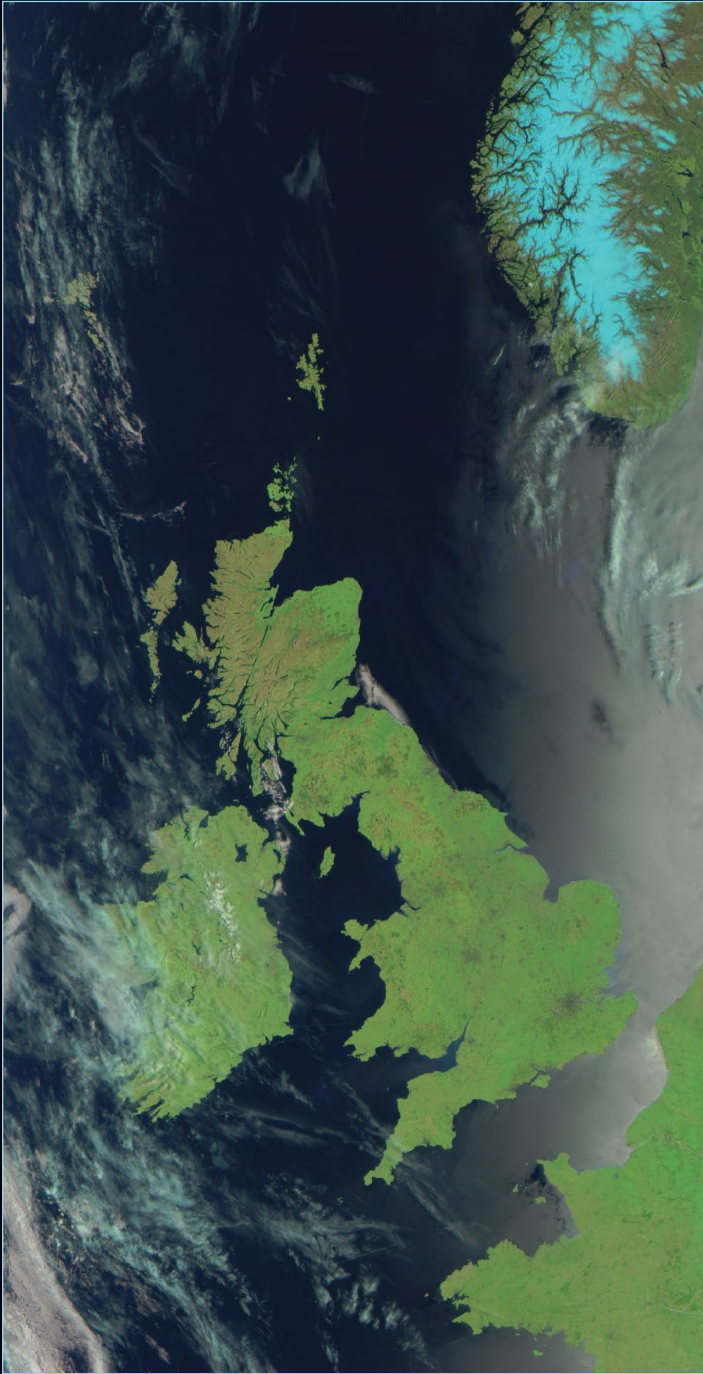
Meteor M2's mid-morning pass over the British Isles on May 31, 2020

Meteor M2's mid-evening pass over the British Isles on May 31, 2020

During the winter months Meteor M2 transmits channel-5 infrared imagery. But over the summer, this channel is replaced by the visible channel-3, which has in the past made meaningful colour composite evening images hard to come by because the satellite was always flying close to the day/night terminator.

No longer, though! Since Meteor M2's launch in 2014 its orbit has been gradually slipping forward into the daylight side of the terminator and since mid May this year, much brighter RGB123 images can be acquired in the evenings. This situation will continue to improve up to the summer solstice, and it should be possible to capture good evening imagery until at least mid July.

Both image segments shown above were acquired from Meteor M2 on May 31, 2020, the left one in the morning and the right-hand one in the evening.

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	System failure [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	Active [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 been compromised. AHRPT is still being transmitted when the solar panels are sunlit, but there is insufficient battery power to enable the LRPT stream..