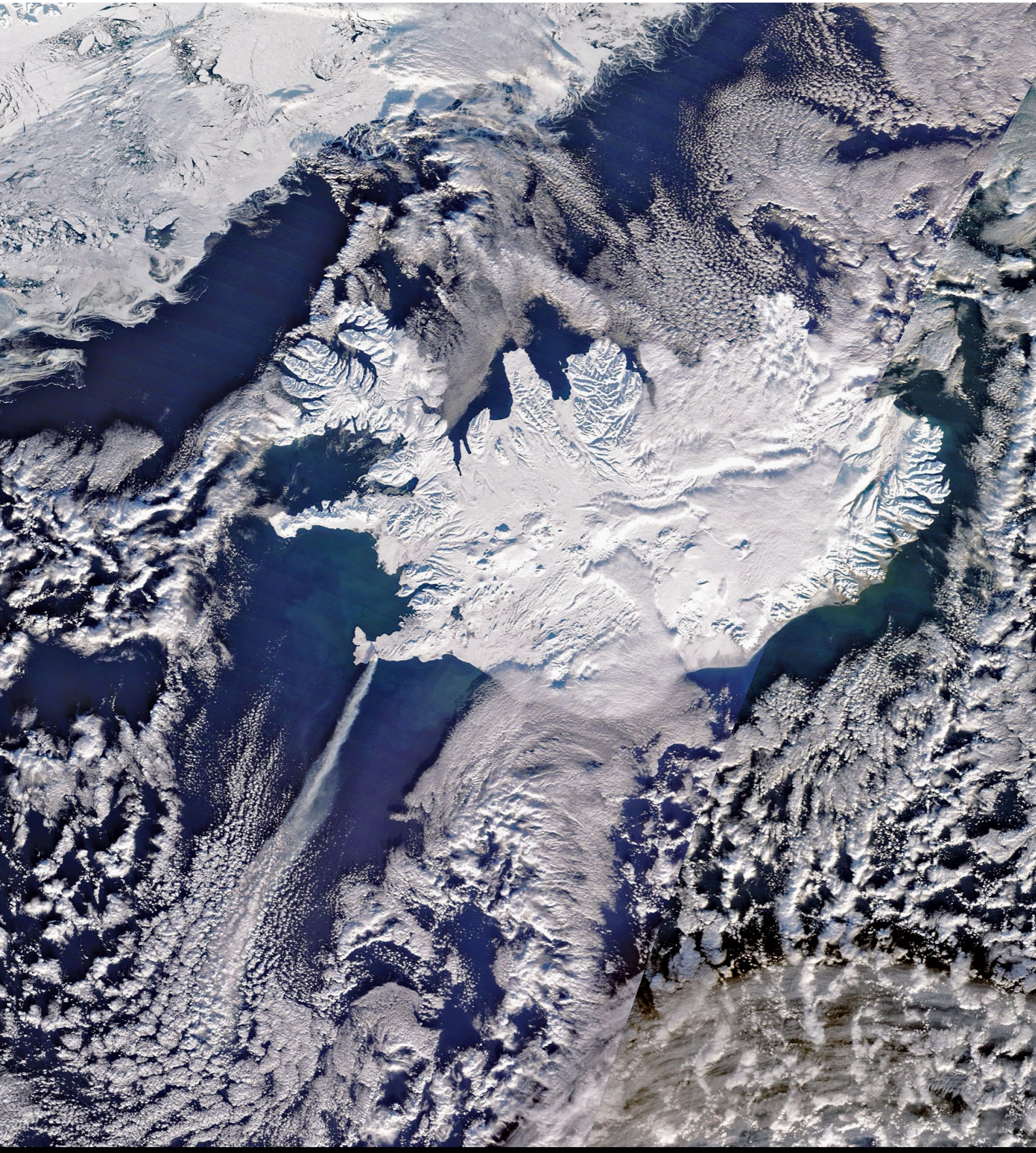
GEO Newsletter

Group for Earth Observation

Group for Earth Observation

No 81 - March 2024



The volcanic smoke plume from Iceland's Reykjanes peninsula shows clearly as it drifts over the ocean in this MODIS image from NASA's Terra Earth Observation Satellite on February 8, this year.
Image: NASA Worldview Snapshots (https://wvs.earthdata.nasa.gov)

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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/

Copy for the Newsletter

The Editor is always delighted to receive material for inclusion in the GEO Quarterly Newsletter. These can relate to any aspect of Earth Imaging, especially

- Technical articles concerning relevant hardware and software
- Construction projects
- Weather satellite images
- Reports on weather phenomena
- Descriptions of readers' satellite imaging stations
- Activities from overseas readers
- Letters to the Editor
- Problems and Queries for our experts to answer

Contributions should of course be original and be submitted to the editor by e-mail not later than the middle of the month preceding publication.

If your article submission contains embedded images and diagrams, please note that you must also submit copies of the original images as separate attachments: these are essential for page make-up purposes.

Materials for publication should be sent to the editor, Les Hamilton, at

geoeditor@geo-web.org.uk

GEO Quarterly Back-issue Archive

GEO Quarterly has been in continuous publication since 2004, and all previous issues are available on-line as PDF copies from:

https://leshamilton.co.uk/GEO/archive.htm

There is also a searchable index to all titles from previous years, and this can be downloaded from:

https://leshamilton.co.uk/soft/geoindex-setup.exe

From the Editor

Les Hamilton

The remarkable image on the front cover of this issue was captured by NASA's Terra satellite just a few hours after an early morning eruption from Iceland's Reykjanes Volcano on February 8, 2024, and shows a plume of gas and dust sweeping southward over the Atlantic Ocean. You can read about this eruption in the article on page 19.

As you read this issue of GEO Quarterly, it is anticipated that—if all goes to plan—a new Russian meteorological satellite, Meteor M Nº 2-4, should already be in orbit: launch, from Vostochny Cosmodrome, was scheduled for 05.43 UT on February 29. You can read ongoing information about this new craft at:

https://usradioguy.com/satellites/meteor-m-2-4-launch/

The current Meteor M Nº 2-3 commenced image transmissions within 24 hours of launch, so it is already worth looking out for it, most probably transmitting on the 137.10 MHz frequency.

Disappointingly, the launches of Meteor M Nº 2-5 and Meteor M Nº 2-6, previously expected to launch in 2024 and 2025 respectively, are reported now to be delayed for at least one year.

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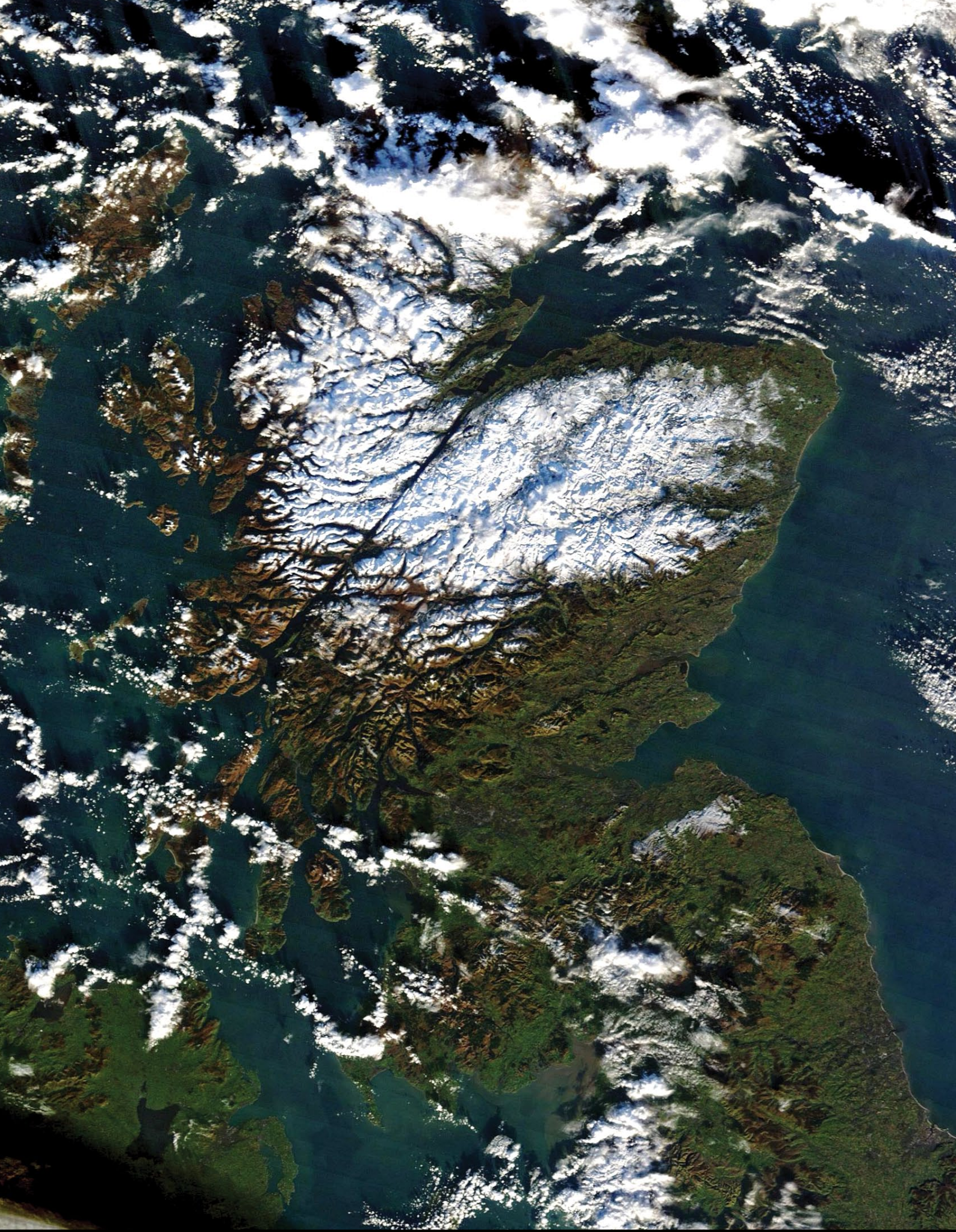


Clear Skies over Scotland on December 26, 2023 reveled sparkling new snowfall over the Highlands, as portreyed by the MODIS instrument aboard NASA's Terra Earth Observation Satellite
Image: NASA Worldview Snapshots (https://wvs.earthdata.nasa.gov)

Snow in Scotland

MODIS Web Image of the Day

Skies were clear over Scotland on December 26, 2023, allowing the Moderate Resolution Imaging Spectroradiometer to capture a false-colour image of snow blanketing the Scottish Highlands. This type of image combines both infrared and visible light (MODIS bands 7,2,1) to help separate snow (electric blue) from vegetation (bright green) and water (dark blue). Clouds usually appear white, although high cloud that contains ice may be tinted with light electric blue.

Despite warm weather and rain in the lowlands the previous day, fresh snowfall over the Highlands prompted the Met Office to officially declare a *White Christmas* in Scotland. Several ski resorts reported light snow between December 25 and 26, with the highest amounts (4 cm) at both Lecht and Cairngorm. Meanwhile, the Met Office recorded a high temperature of 13.6°C at Exeter Airport, England, making it the warmest December 25 in that location since 2016.

By December 27, the clear skies had clouded over as **Storm Gerrit** began to pound the United Kingdom. The Met Office ordered yellow warnings for rain, wind, and snow across much of Scotland, with warnings remaining in effect in Shetland until December 28. The Scottish Environment Protection Agency (SEPA) issued flood alerts and warnings across the country as high wind roared and heavy precipitation fell across the region. Train services and ferries were cancelled, and widespread power outages were reported across Scotland. Hundreds of cars and other vehicles were stuck on a the A9, due to heavy snow, many drivers being trappeed in their vehicles for as long as eight hours before winter weather response teams managed to reopen the road late in the dqy.

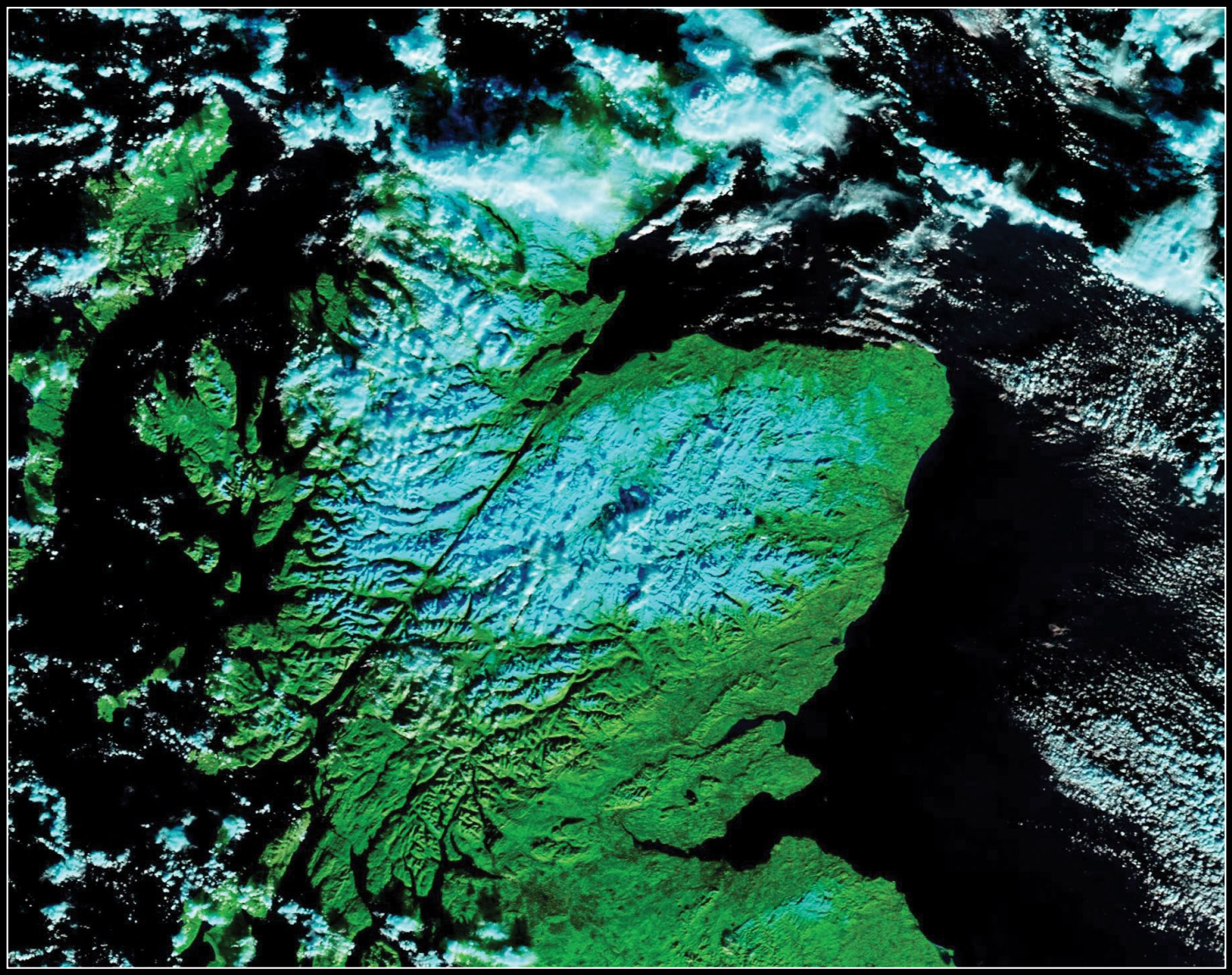
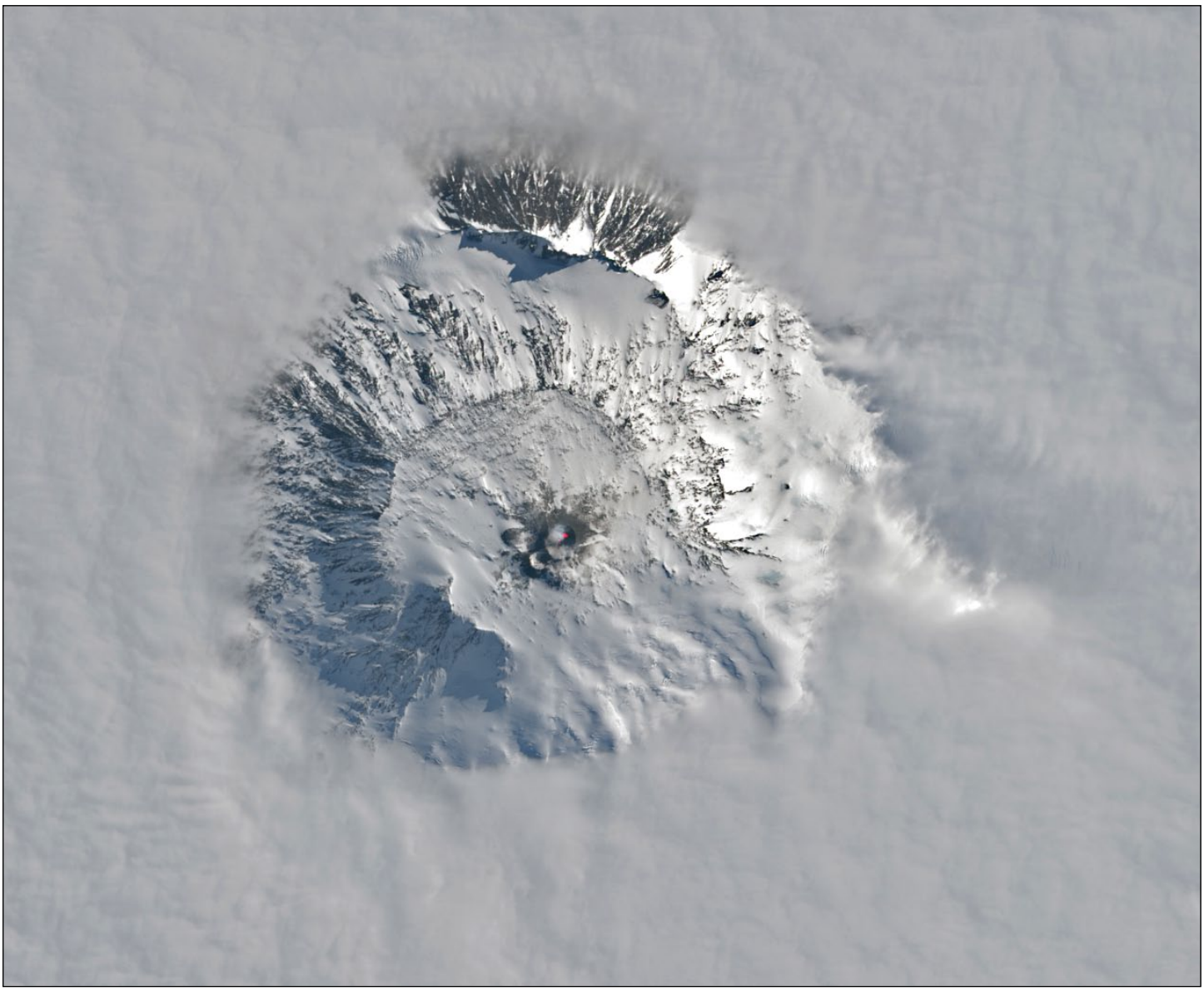


Image Credit: MODIS Land Rapid Response Team, NASA GSFC

Erebus Breaks Through

NASA Earth Observatory

Story by Lindsey Doermann



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

The summit crater of Mount Erebus, the world's southernmost active volcano, appeared above the clouds on a late-spring day in 2023. The OLI-2 (Operational Land Imager-2) on Landsat 9 captured this view of the stratovolcano on November 25.

Mount Erebus is one of several volcanoes forming Ross Island off the coast of West Antarctica. At 3,794 metres above sea level, it looms over McMurdo Station, located just 35 kilometres away. These volcanoes occur in a rift zone where extension has caused the crust to thin and allowed magma to migrate up through faults to the surface.

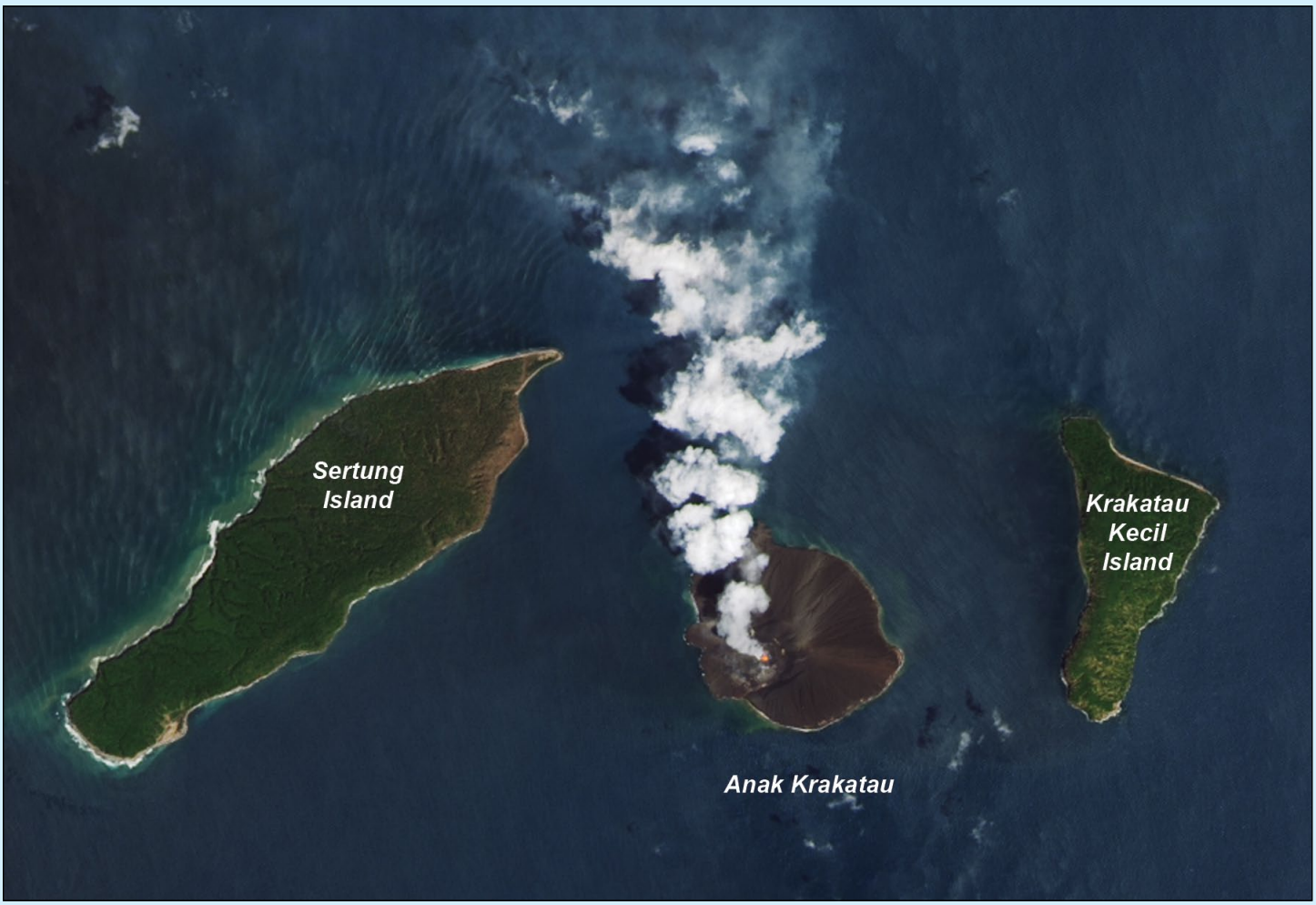
In this detailed view, the Landsat image includes the shortwave infrared signal (red) produced by heat from a lava lake in the summit crater. The lake has been active since at least 1972 and is one of only a few long-lived lava lakes on Earth. It constantly churns and occasionally spews bombs of molten rock in Strombolian eruptions. Geologists want to learn why an active lava lake has persisted here for so long. Recent research suggests one reason could be the magma's low water content, which makes it less volatile as it approaches the surface.

Erebus was active prior to the emergence of this lava lake, including in 1841 when British Royal Navy officer James Clark Ross first sighted it during his Antarctic exploration. Mount Erebus and neighbouring Mount Terror were named after warships retrofitted for use in that expedition and numerous other polar voyages.

Unrest at Anak Krakatau

NASA Eart5h Observatory

Story by Adam Voiland



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

Anak Krakatau is a small, unimposing volcanic island between the Indonesian islands of Java and Sumatra. However, its frequent blasts and explosions serve as a reminder of its mighty, and occasionally menacing, power.

The Operational Land Imager (OLI) on Landsat 8 captured this image of a volcanic plume drifting from the volcano on December 2, 2023. It includes an infrared signal (red) that was produced by the heat of molten rock in the crater near the island's summit.

Geologists have tallied 57 eruptive periods from this location since the beginning of the Holocene, roughly 11,700 years ago. The most recent eruptive period, which started in May 2021 and continued into December 2023, has featured frequent but generally mild Strombolian blasts of volcanic gases and ash particles. Materials ejected from the volcano's vent are typically lofted a few hundred metres above the summit, and small lava flows occasionally drain down the island's flanks and into the sea.

Beginning on November 26, 2023, geologists with the *Indonesian Centre for Volcanology and Geological Hazard Mitigation* began to report more intense explosions, with plumes of volcanic material rising up to 1,000 metres above the vent. Given the heightened unrest, the center warned the public to stay at least five kilometres from the crater. The *Volcanic Ash Advisory Center* in Darwin, Australia, also issued multiple warnings to the aviation community of elevated risks of ash in the area.

The volcano is infamous for producing an explosive eruption and powerful tsunami in 1883 that proved to be one of the deadliest and most destructive volcanic events in modern history. The blast obliterated the island of Krakatau, but fifty years later a new island—Anak Krakatau (meaning 'child of Krakatau' in Indonesian)—emerged from the sea. As recently as December 2018, hundreds of people died and thousands were injured on Java and Sumatra after part of Anak Krakatau's southwestern flank collapsed and produced a tsunami after a particularly powerful eruption.

Egypt's Toshka Lakes

MODIS Web Image of the Day

The Toshka Lakes on December 6, 2019

The Toshka Lakes on December 6, 2023

Image Credit: MODIS Land Rapid Response Team, NASA GSFC

Egypt's Toshka Lakes sit in natural depressions found in the vast, arid sands of the Sahara Desert. They were created in the 1980s and 1990s through diversion of water from Lake Nasser, the massive 550 kilometre long reservoir built on the Nile River between 1958 and 1970. As the depressions became flooded, four major lakes appeared amongst the desert sands.

Since they were created, these lakes have been dependent on overflow from Lake Nasser, with water levels rising in years of heavy rain and shrinking in years of drought. The Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Aqua satellite acquired two true-colour images, one on December 6, 2023, and another on December 6, 2019, that illustrate wide fluctuations in the Toshka Lakes.

In early 2019, lack of rainfall had nearly dried up the Toshka Lakes, leaving parched marks in the sand where they had once glittered with blue water. Abundant summer rainfall, especially in Sudan and South Sudan began to fall in that same year. The heavy rain filled the Nile which, in turn, raised water levels in Lake Nasser. Outflow from Lake Nasser began to regenerate the eastern portion of the Toshka lakes. This was the situation on December 6, 2019, and the image shows the newly-filled eastern lake while the others remain parched.

Beginning in 2020, record-breaking floods drenched Sudan, raising the water level in Lake Nasser to a record high. Flooding has occurred in Sudan and South Sudan every summer since 2019, resulting in serious difficulties for agriculture, livestock, and people living in the region, as well as increasing the overflow from Lake Nasser that feeds the Toshka Lakes. The water level in Lake Nasser reached another record high following the 2022 floods.

In 2023, floods began in September, initially destroying thousands of houses and damaging hundreds more. Additional flooding in late October caused the displacement of more than 1,000 people and killed at least ten people, according to *ReliefWeb*.

The image acquired on December 6, 2023, shows the impact of these multiple years of flooding on the Toshka Lakes. Not only are the original four lakes completely full, but new, smaller lakes have formed by filling depressions around them. Irrigated agricultural fields are visible between Lake Nasser (lower right) and the Toshka Lakes.

Yukon Delta

European Space Agency

Image contains modified Copernicus Sentinel 2 data (2017), processed by ESA, CC BY-SA 3.0 IGO

The Yukon River rises in British Columbia in Canada and flows through Yukon Territory before entering Alaska and finally draining into the Bering Sea. This image, recorded on 29 August 2017, shows how the river branches off into numerous channels that meander through the low-lying terrain on their way to the sea. The sandy colour of these channels and of the coastal water illustrates how much sediment the river was carrying to the sea at that time of year.

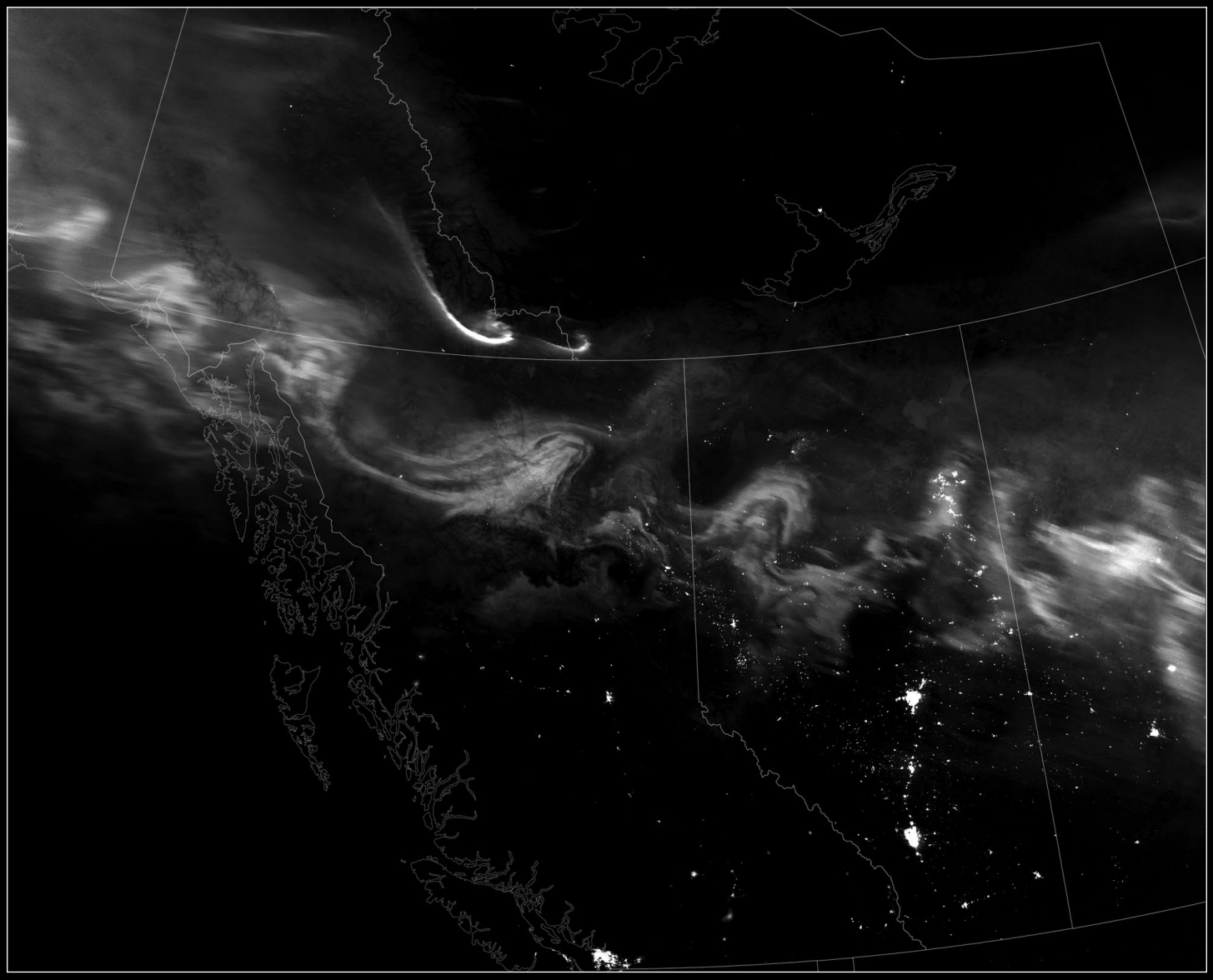
It is estimated that 95% of all sediment transported during an average year occurs between May and September. During the other seven months, concentrations of sediment and other water-quality constituents are low. However, scientists also believe that sediment flow has increased over the last few decades because permafrost is thawing in the Yukon River Basin and ice breakup occurs earlier in the year owing to warmer air temperatures. This is important because elevated concentrations can adversely affect aquatic life by obstructing fish gills, covering fish spawning sites, and altering habitat of bottom-dwelling organisms. Metals and organic contaminants also tend to absorb on to fine-grained sediment.

The Copernicus Sentinel-2 satellites each carry a high-resolution camera that images Earth's surface in 13 spectral bands. While the mission is mostly used to track changes in the way land is being used and to monitor the health of our vegetation, it also provides information on the condition of coastal waters.

Auroras Light Up the North

NASA Earth Observatory

Story by Lindsey Doermann



NASA Earth Observatory image by Lauren Dauphin, using VIIRS day-night band data from the Suomi National Polar-orbiting Partnership

A flurry of solar activity in mid-December 2023 sent energized particles crashing into Earth's magnetosphere, producing undulating auroras across northern latitudes of our planet. The VIIRS (Visible Infrared Imaging Radiometer Suite) on the **NOAA-NASA Suomi NPP** satellite captured this image of light from the aurora over western Canada in the early morning of December 17, 2023. The day-night band of VIIRS detects nighttime light in a range of wavelengths from green to near-infrared and uses filtering techniques to observe signals such as city lights, reflected moonlight, and auroras.

These auroras may have stemmed from several coronal mass ejections that were observed on December 14 and 15. Minor to moderate geomagnetic storm conditions were expected in the following days, according to NOAA's *Space Weather Prediction Center*. Coronal mass ejections contain large amounts of plasma from the Sun's corona and carry with them an embedded magnetic field. Interactions between these expulsions from the Sun and the upper atmosphere of Earth produce light that makes up colorful aurora displays.

The Sun's activity is ramping up as it approaches the peak of solar cycle 25, forecast to occur in or around July 2025. The Sun's magnetic field flips at the peak of these cycles, each of which lasts approximately 11 years. Scientists track fluctuations in solar activity in part by monitoring the number and location of sunspots—dark blotches on the Sun's surface that are the main source of solar eruptions.

The aurora seen here occurred several days after the strongest solar flare of this solar cycle so far. Whereas coronal mass ejections may take several days to travel to Earth, solar flares reach the planet in a matter of minutes and interfere with radio communications. Coronal mass ejections often, but not always, occur in tandem with solar flares.

A Lake Born out of an Earthquake

NASA Earth Observatory

Story by Lindsey Doermann

NASA Earth Observatory image by Wanmei Liang, using Landsat data from the U.S. Geological Survey. .

At their most deadly and destructive, earthquakes can topple buildings, crumple roads, and trigger tsunamis. They can also fundamentally reshape the landscape, reroute rivers, and even form new lakes.

The latter took place in the northwest corner of Tennessee in the early 19th century. Between December 1811 and February 1812, three earthquakes with magnitudes greater than 7 occurred in the New Madrid seismic zone, which encompasses southeastern Missouri, northeastern Arkansas, and neighboring parts of Tennessee and Kentucky. The last of these quakes, on February 7, 1812, centered near New Madrid, Missouri, was especially notable: It temporarily rerouted the Mississippi River, permanently dammed the Reelfoot River, and directed water to fill in a low-lying area to form Reelfoot Lake.

More than two centuries later, Reelfoot Lake remains a persistent feature on the Tennessee landscape. The OLI-2 (Operational Land Imager-2) on Landsat 9 captured this image of the lake, surrounding wetlands, and the nearby Mississippi River on November 27, 2023.

Rivers that run over fault lines are susceptible to being stopped abruptly and wrenched askew when the ground shifts. Earthquake-induced river avulsions (sudden changes of course) have been documented throughout history. In 2016, for example, the Kaikoura earthquake in New Zealand effectively dammed the Waiau Toa (Clarence River) and forced it into an entirely new channel.

In the case of the earthquake that formed Reelfoot Lake, lore has it that the shaking even made the Mississippi flow in reverse for a time. However, that may have been an illusion caused by earthquake-generated water waves travelling upriver. The shaking virtually destroyed the small Missouri town of New Madrid. Eyewitnesses near the epicenter also described trees being uprooted and the ground rising, falling, and cracking open. People in distant cities such as Boston, Detroit, and New Orleans reported having felt the shaking.

Some geologists consider the New Madrid seismic zone the most hazardous earthquake region east of the Rocky Mountains. Yet its history of large quakes and risk of future destructive activity remain sources of inquiry and debate. Geologists understand less about what causes earthquakes in the middle of tectonic plates than they do about ones at plate boundaries. What they do know is that seismic waves in the eastern U.S. travel much farther than they do in the west, so tremors of the same magnitude affect a larger area.

The Reelfoot Lake of today is a haven for boating, fishing, and watching wildlife. Bald cypress (Taxodium distichum) trees grow in marshy areas, while stumps from pre-flood forests are submerged in the water. The lake is surrounded by wetlands that comprise a state park and national wildlife refuge. Bald eagles and waterfowl overwinter in the area, while songbirds, frogs, and other aquatic life abound in the spring and summer.

Tropical Cyclone Jasper Brings Heavy Rainfall To Queensland

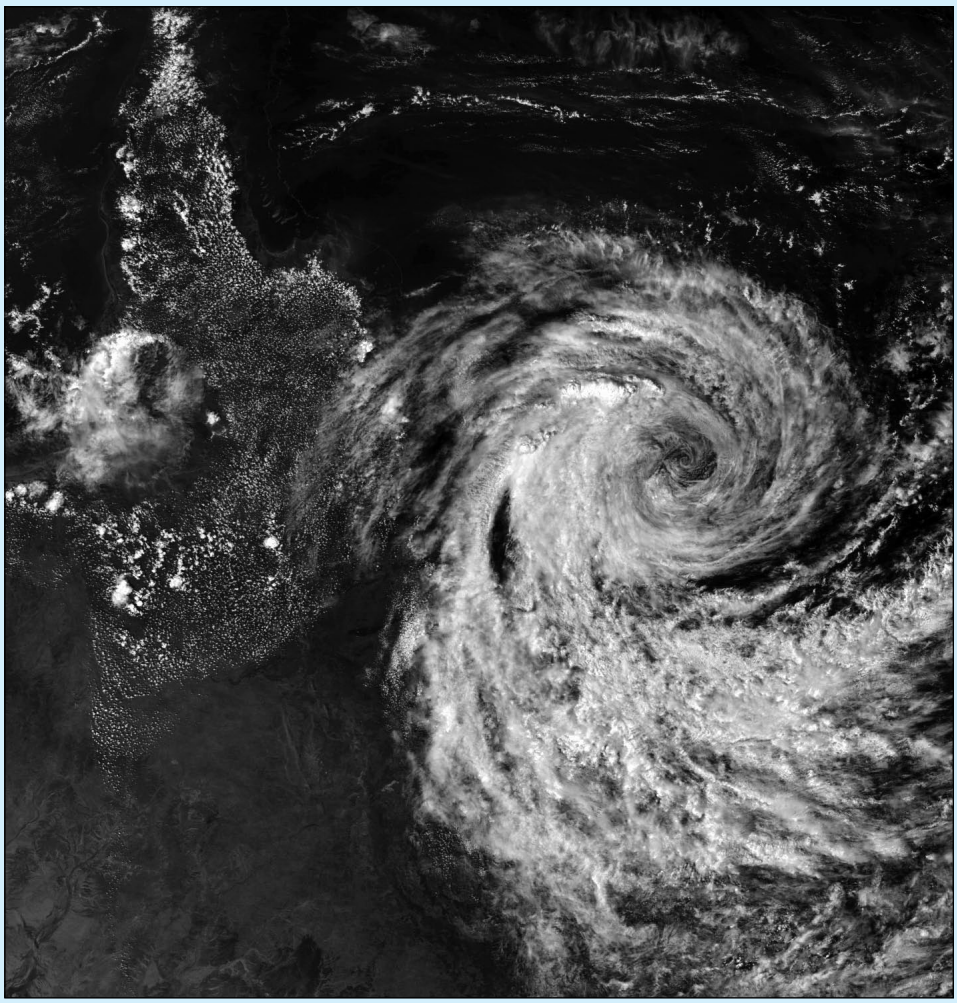
David Sale

Cyclone Jasper was the first cyclone in the Australian 'area of responsibility' for the 2023-2024 cyclone season. Category 1 was first assigned on December 5, 2023 when it was near the Solomon Islands and three days later it had strengthened to category 4 with wind speeds of up to 220 kilometres per hour. Fortunately, it had moved well into the Coral Sea by this time.

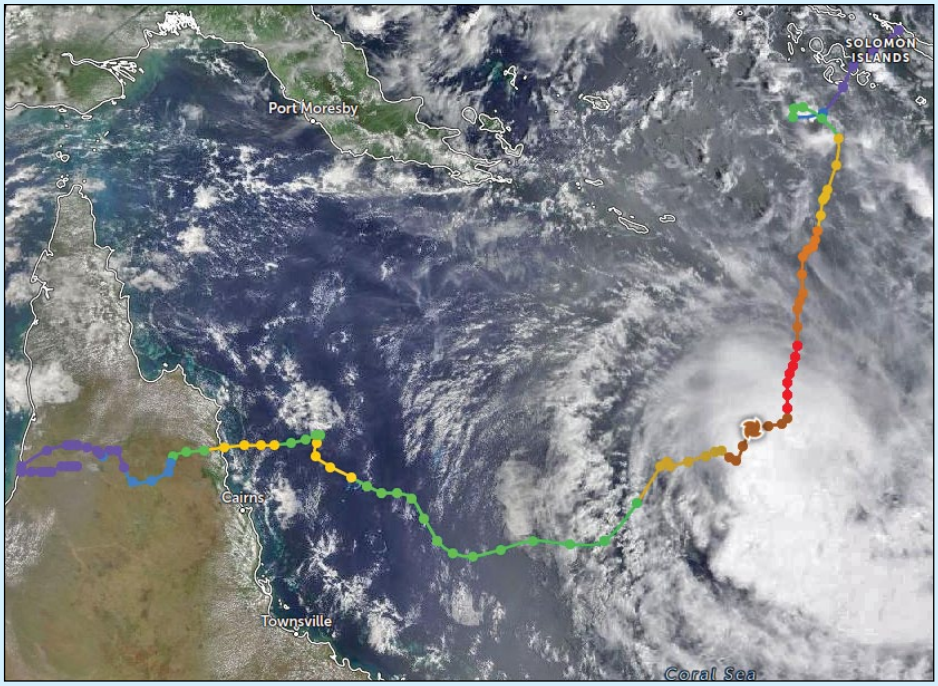
Jasper slowly dissipated as it approached the Queensland coast of Australia as a slow moving category 2 cyclone, soon after downgraded to category 1. Unfortunately, Jasper made landfall on December 13 and stalled over the Cape York Peninsula where its cyclonic circulation brought warm, moist northeasterly winds from the Coral Sea onshore, resulting in heavy precipitation along the coast for several days.

Notwithstanding the storm's downgrade, this resulted in considerable precipitation, with some areas recording in excess of 400 millimetres in a 24 hour period. The highest incidence was Mossman's 714 millimetres—a record 24 hour total for anywhere in Australia. And in many locations more than 1000 millimetres fell during a five day period, with Whyanbeel Valley recording 1934 millimetres. Indeed, the *Australian Bureau of Meteorology* reported that some isolated locations near Port Douglas and Cairns saw even greater amounts, in excess of 2000 millimetres.

Predictably, there were adverse consequences with extensive flooding in some areas. At one point, 40,000 people were without power. There was also a severe impact to the fruit growing industry (mangoes, papaya, banana, avocados) with a large amount of fruit lost just as it was ripening, and damage to the trees.



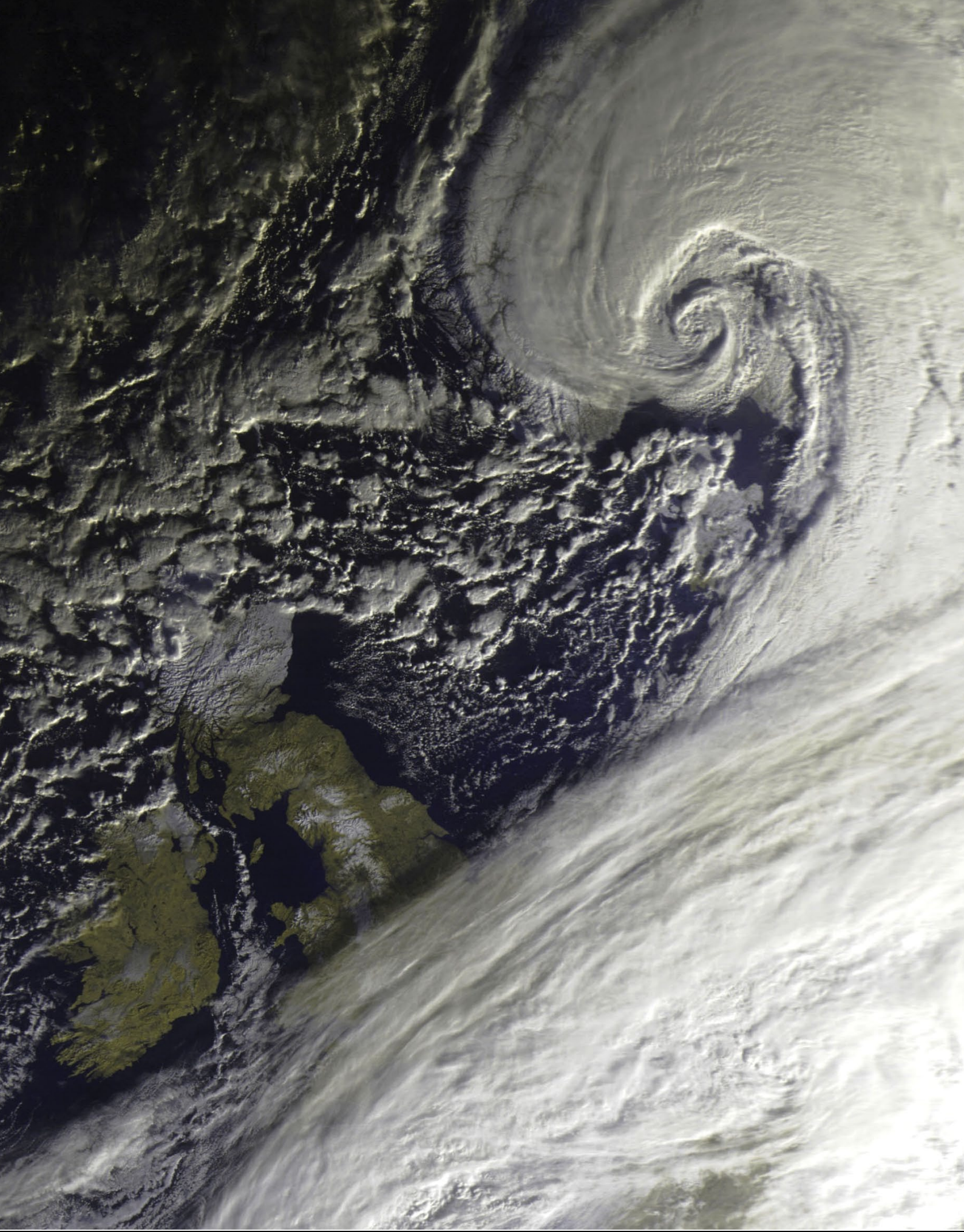
This Himawari Band-3 visible image of Cyclone Jasper was received as it approached Queensland on December 11, 2023
Credit: Himawaricast



Track plot of Cyclone Jasper (green=category 1, yellow=C2, orange=C3, red=C4)
Credit: Zoom Earth (https://zoom.earth/)

On 17 January 2024, the Copernicus Sentinel-2 mission captured this image of a lava flow in Iceland's Reykjanes Peninsula. The lava had reached the town of Grindavik, which had been previously evacuated. According to the Icelandic Met Office, on the same day, magma accumulation was continuing under the region with a likelihood that new eruptive fissures might open without warning.

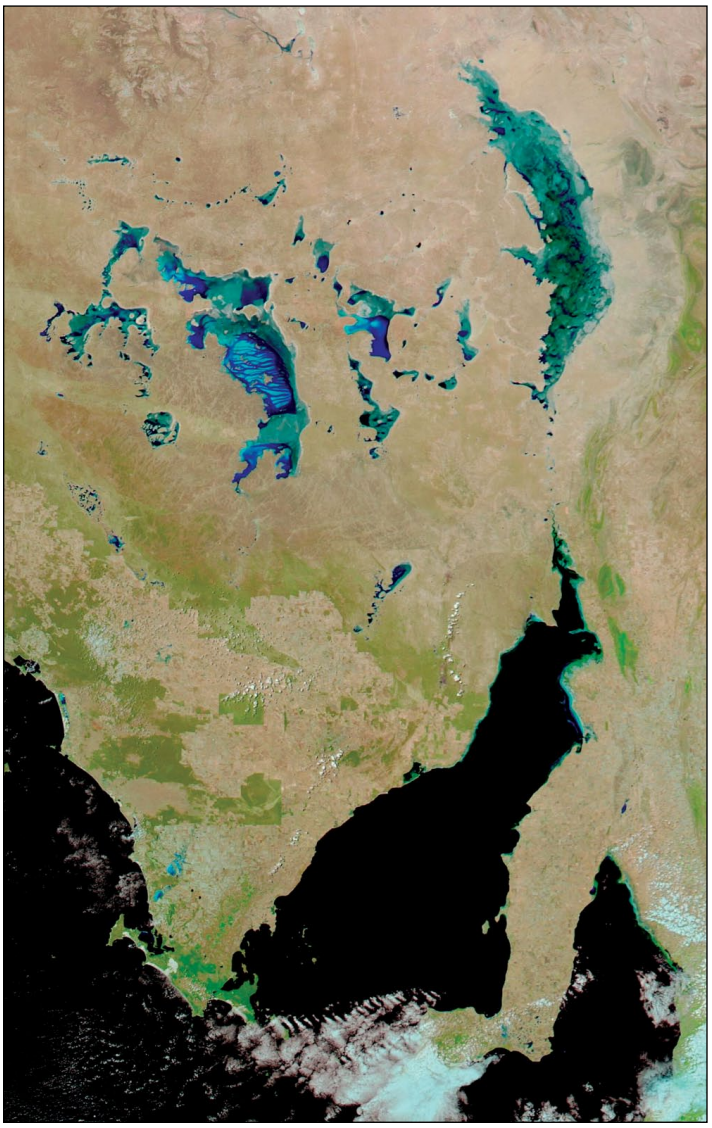
Image contains modified Copernicus Sentinel data (2024), processed by ESA, CC BY-SA 3.0 IGO



This stunningly beautiful image, captured in Aberdeen from Meteor M2-3 on the morning of January 17 this year, shows northern Scotland, covered deep in snow following two days of blizzards.

Water in South Australia's Salt Lakes

MODIS Web Image of the Week



Lakes Torrens and Gairdner on December 14, 2003

Lakes Torrens and Gairdner on December 4, 2003

Image Credit: MODIS Land Rapid Response Team, NASA GSFC

As forecasters warned of a 'hot and stormy' week across South Australia, a strong trough of low pressure dropped a deluge on a normally arid part of the state between December 6 and 13, 2023.

According to the *Weekly Australian Climate, Water and Agricultural Update* published on December 14, rainfall totals of up to 150 millimetres were recorded across South Australia during that week. South Australia is the driest of the Australian states, with less than half of it receiving more than 400 millimetres of rainfall in an entire year.

Lake Torrens and Lake Gairdner are located in some of the most arid land of South Australia, a region that receives an annual rainfall of only about 210 millimetres. Under typical conditions both lakes spend most of their days as large, dry salt pans. However, because they are so shallow, with depths of no greater than one metre, when strong rains fall, Lake Torrens and Lake Gairdner can rapidly fill with water. The December storms dropped enough rain to convert these salt pans into spectacular water-filled lakes.

The Moderate Resolution Imaging Spectroradiometer (MODIS) on board NASA's Aqua satellite acquired a false-colour image of freshly-filled Lake Torrens (east) and lake Gairdner (west) on December 14. This type of image uses both visible and infrared light (bands 1, 2 and 7) to help visualise specific features, such as separating deeper water (dark blue) from salt (bright blue) and moist salt (teal). Here, arid or sparsely vegetated land looks tan, while vegetation is green.

A second false-colour image of the same area was captured by Aqua MODIS on December 4, prior to the torrential rains. This image shows the lakes filled with salt, most of which appears quite dry (lightest blue). The deep waters of Spencer Gulf are seen in the lower right (southeast) section image and appear dark blue.

Iceberg A23a at the Tip of the Antarctic Peninsula

MODIS Web Image of the Day

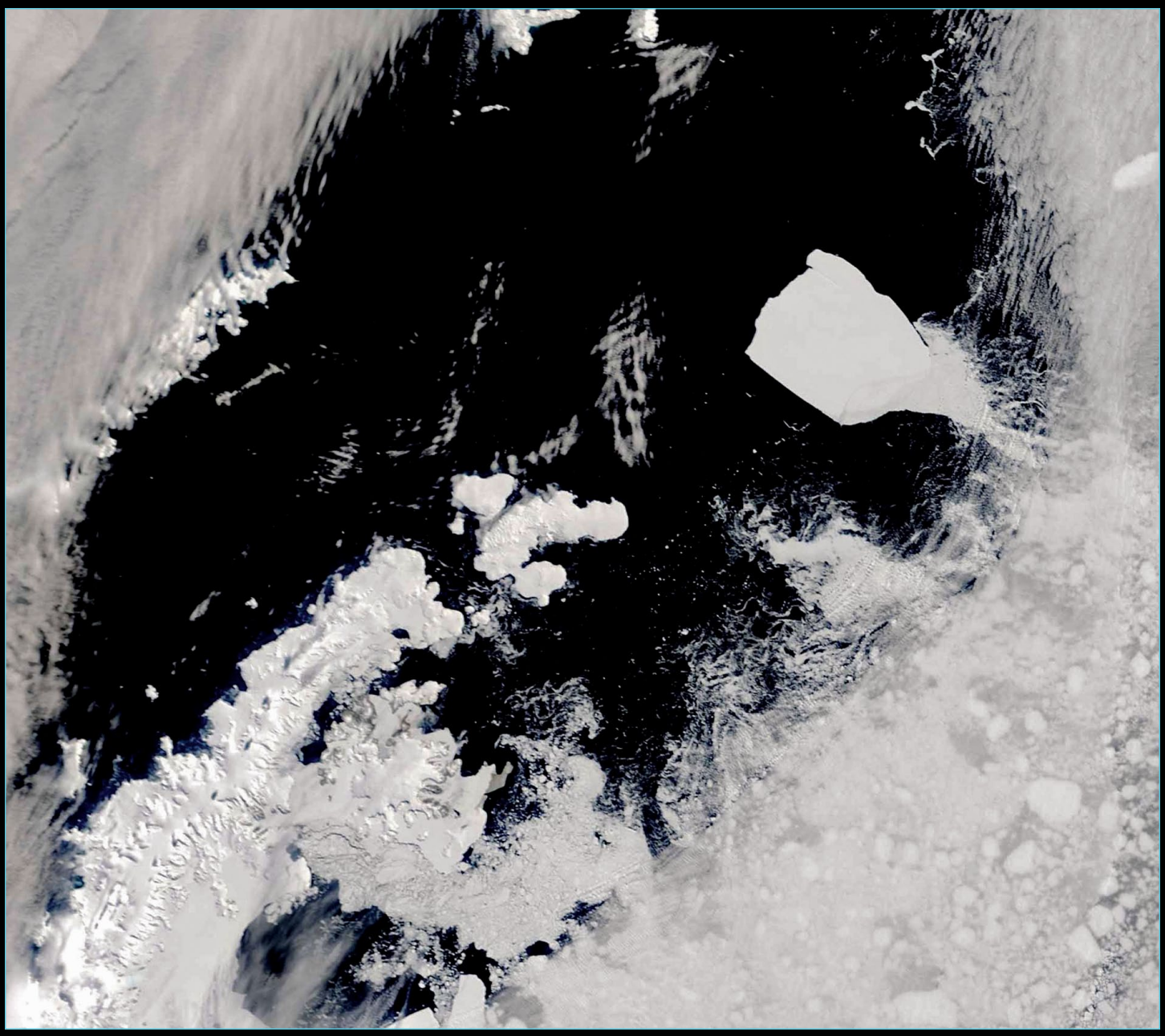


Image Credit: MODIS Land Rapid Response Team, NASA GSFC

On November 27, 2023, a break in the swirling cloud cover allowed a glimpse of the Earth's largest iceberg drifting past the tip of the Antarctic Peninsula. The Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite acquired this true-colour image of Iceberg A23a northeast of the Joinville Island group, which are the northernmost-group of islands on the Antarctic Peninsula, on that same day.

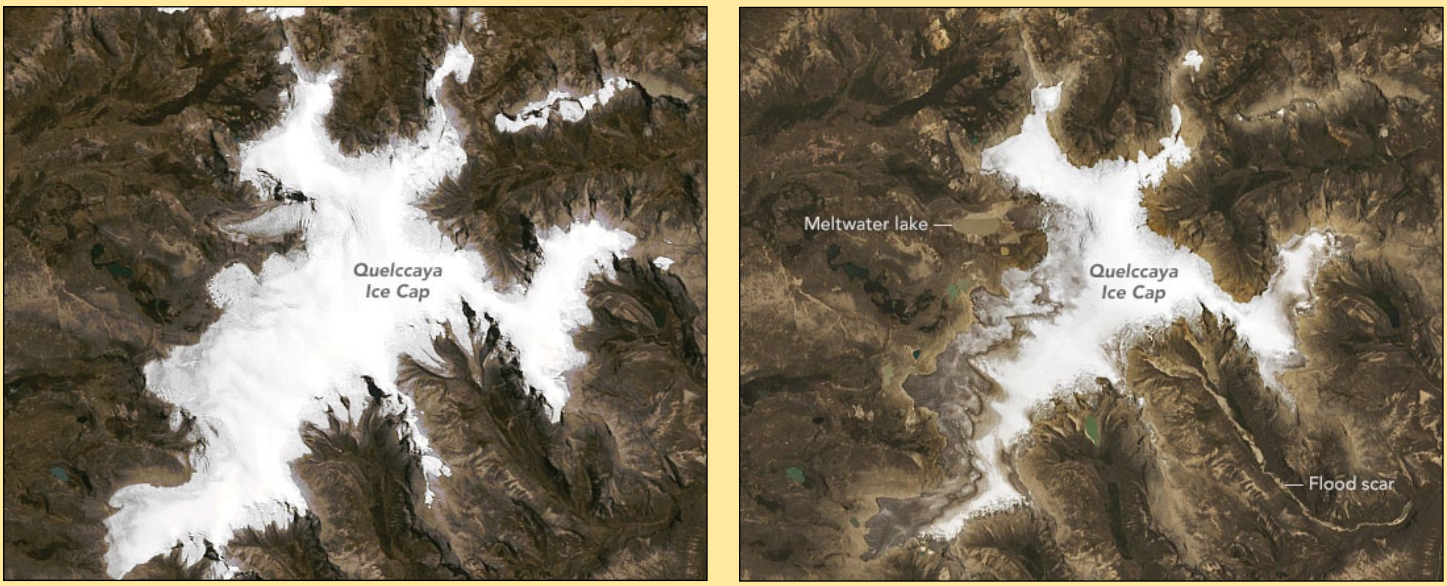
The massive iceberg calved from the Filchner Ice Shelf in 1986 but didn't drift far before it grounded in the Weddell Sea—and was stuck there for decades. Very slowly the massive iceberg lost a bit of mass here and there, until its long keel was finally able to loosen from the muddy bottom of the Weddell Sea and begin to drift. Scientists first spotted tiny movements in A23a's position in 2020, but only recently has it been caught by currents and started to drift quickly eastward towards the relatively warm waters of the South Atlantic Ocean.

A23a is estimated to measure about 400 meters thick and span an area of about 4,000 square kilometres. That's more than twice the area of Greater London, which covers 1,572 square kilometres.

Quelccaya Ice Cap Then and Now

NASA Earth Observatory

Story by Kathryn Hansen



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

The Quelccaya Ice Cap rests on a high-altitude plateau of the Andes Mountains in Peru. But like other tropical glaciers across the planet, the comparatively cold temperatures found at high altitudes are not enough to protect it from the grip of climate change.

This image pair shows the retreat of Quelccaya's ice edge between September 3, 1988 (left), and October 22, 2023 (right). They were acquired with the TM (Thematic Mapper) on Landsat 5 and the OLI (Operational Land Imager) on Landsat 8, respectively. Christopher Shuman, a University of Maryland, Baltimore County, glaciologist based at NASA's Goddard Space Flight Center, estimates that the ice area in 1988 spanned about 58 square kilometers: by 2023, it spanned just over 40 square kilometers.

Notice the accrual of meltwater lakes in the later image, particularly along the ice cap's western side. Many of these lake basins, carved by moving ice, have lost contact with the ice that formed them. The ice cap also feeds the Vilcanota River and Lake Sibinacocha (west of this image) and has long been an important water source for people living nearby and downstream.

Some of the lakes have already come and gone during the span of these images, including one that in November 2022 produced a glacial lake outburst flood (GLOF). Shuman detected the event in Landsat images showing the emptying of a lake on the ice cap's eastern side and a long path where the rushing floodwater had scoured the vegetation. The flood scar is still visible in this 2023 image.

Before Landsat satellites revealed the decadal changes, scientists already knew the ice cap was shrinking. Since 1974, Lonnie Thompson and colleagues from Ohio State University have been mounting expeditions to study Quelccaya up close.

'*Both ground-based and satellite images allow the documentation of the rates of glacier retreat, which now average about 14 meters per year,*' Thompson said. Thompson's team has shared Landsat images documenting the ice cap's retreat with local officials and indigenous people living near the ice cap.

As the planet's tropical glaciers are being lost, so are the temperature and climate records long preserved in their ice. Thompson's team has drilled ice cores from many tropical glaciers, including Quelccaya. By analyzing the layers in these cores, scientists can get a near-annual record of air temperatures and atmospheric composition dating back 1,800 years.

'Tropical glaciers might represent our only opportunity to capture global mean temperature changes through time, as well as how climate and the environment have changed in an area that represents 50 percent of the surface area of our planet and where over 50 percent of our 8 billion people live,' stated Thompson.

At Quelccaya, that record could be gone by the end of the 21st century—the expected timeframe for the ice cap's demise. '*The only proof of its existence will be the land-based and satellite images of what was once a magnificent ice cap located directly above the Amazon Basin.*'

Iceberg the loose

European Space Agency

After being grounded on the ocean floor for well over four decades, the largest iceberg in the world is on the loose.

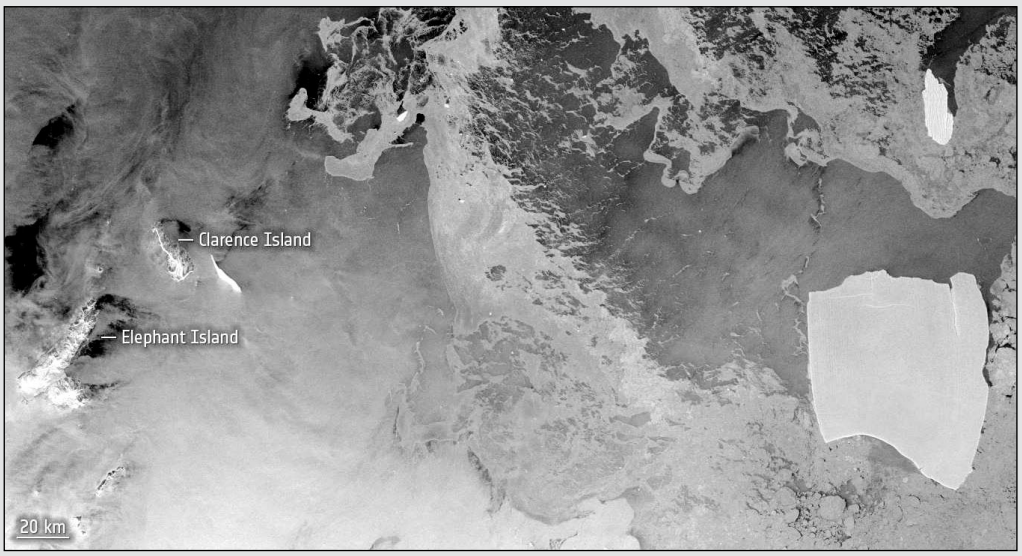
The iceberg, known as A23a, calved from the Filchner-Ronne ice shelf in West Antarctica in 1986 but quickly ran aground. By 2020, it had lost its grip on the sea floor and begun drifting in the Weddell Sea. Scientists say that it is not unusual for icebergs to become grounded, but over time they shrink enough to unground and float.

Now, however, driven by winds and currents, A23a has put a spurt on and is heading quickly away from Antarctic waters—as these images of Copernicus Sentinel-1 images show. The satellite images were acquired on November 2, November 14 and November 26, 2023.

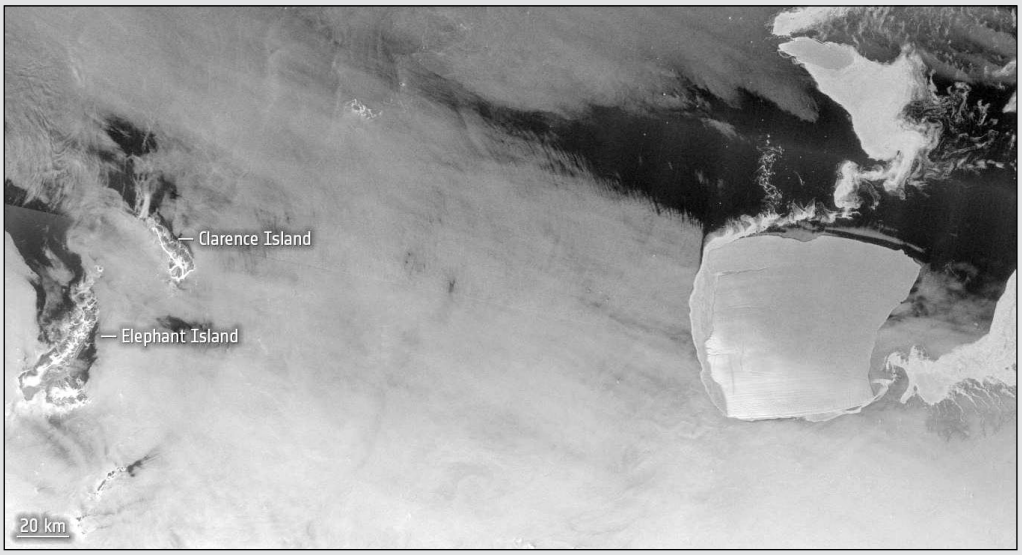
Like most icebergs from the Weddell sector, A23a is likely to end up in the South Atlantic on a path called iceberg alley.

Covering around 4000 square kilometres—more than four times the size of New York city—and around 400 metres thick, A23a is currently the world's biggest iceberg.

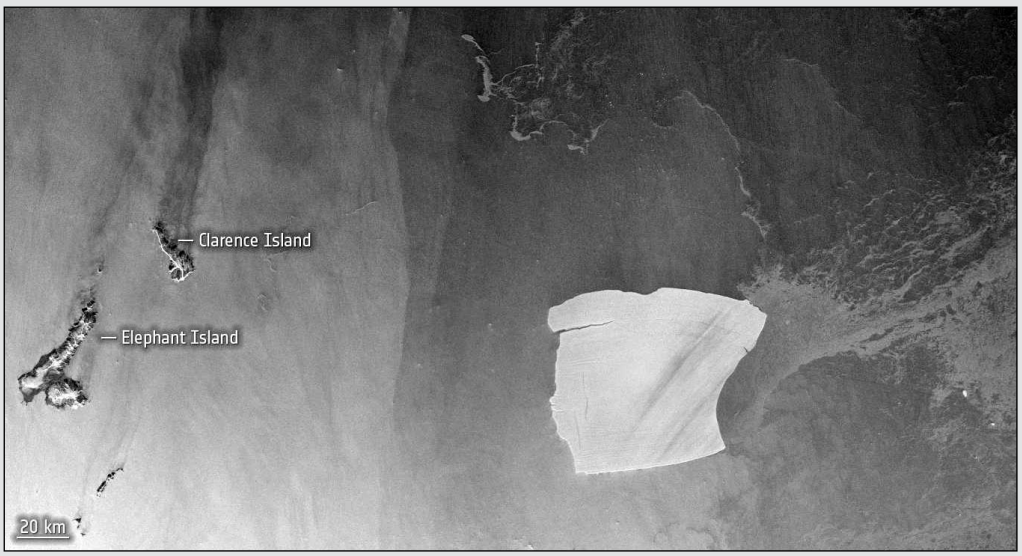
These Copernicus Sentinel-1 images also illustrate how the iceberg has rotated as it travelled between November 2 and November 26, 2023.



Iceberg A23a imaged on November 2, 2023



Iceberg A23a imaged on November 14, 2023



Iceberg A23a imaged on November 26, 2023

Third Reykjanes Volcanic Eruption in Iceland

NASA Earth Observatory

Story by Adam Voiland

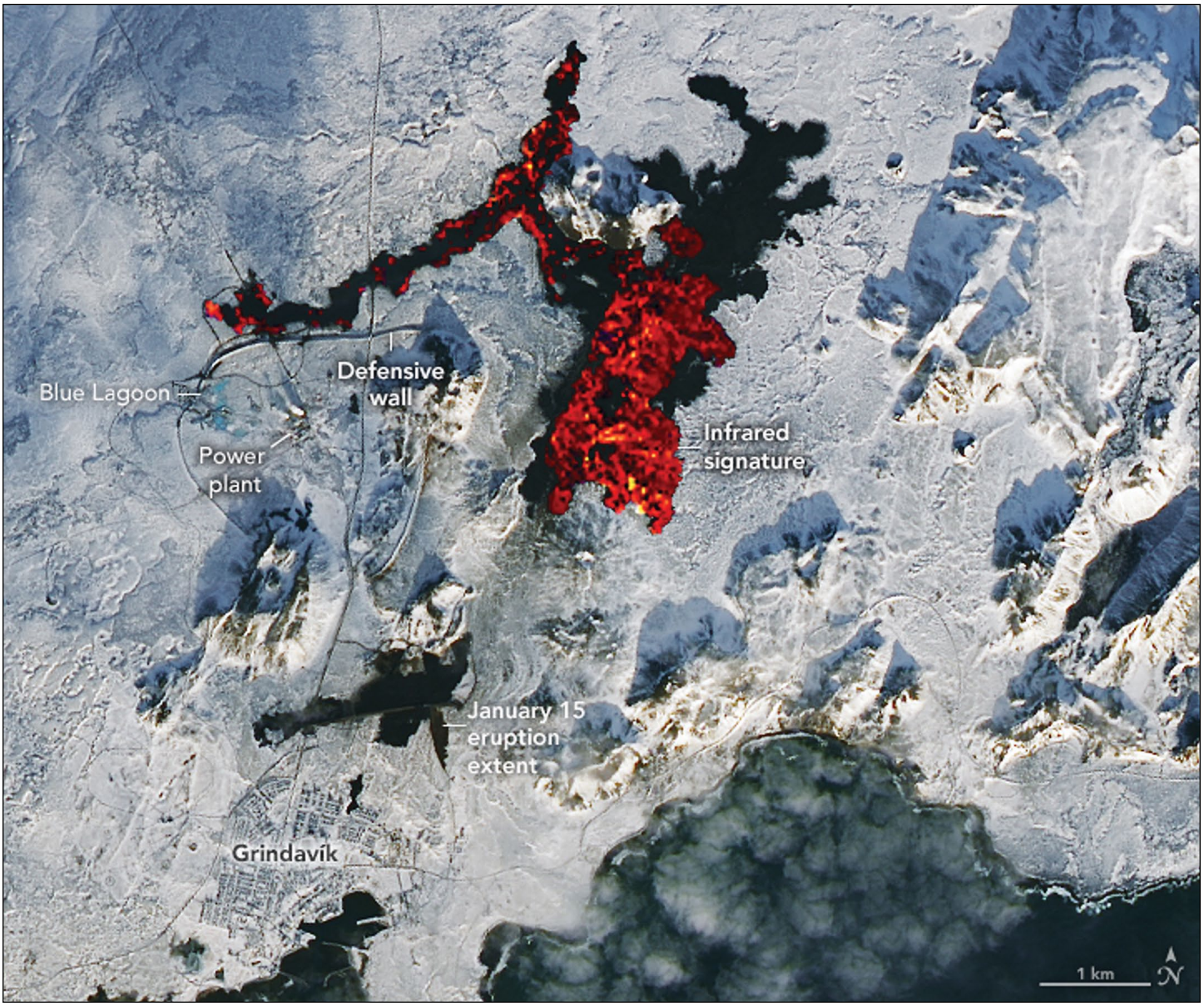


Figure 1 - Landsat-9 image showing details of the Reykjanes eruption
NASA Earth Observatory image by Lauren Dauphin, using data from GIBS/Worldview

After a lull in activity, fresh lava has once again poured from the Reykjanes peninsula in southwestern Iceland. This latest eruption—the third in the region since December 2023—began early on February 8, 2024, with lava spraying up to heights of 80 metres along a three kilometre long fissure near Mount Sýlingarfell. This small peak is north of the fishing village Grindavík and east of the Svartsengi power station and Blue Lagoon geothermal spa.

Figure 1 was acquired on February 10, 2024, by the OLI-2 (Operational Land Imager-2) on Landsat 9. Infrared and visible observations (bands 7-6-3) have been overlain on a natural-colour image to help distinguish the heat signature of the lava. Still recent but cooler lava, expelled near Grindavík in January, appears black.

The topography around the fissure means that much of the fresh lava flowed east into unpopulated areas rather than to the south toward Grindavík. Some lava also flowed west into the vicinity of the power plant and spa.

Earthen defensive walls protected both facilities, though lava did burn through a key hot water pipeline and two roads. According to the Icelandic *National Broadcasting Service RÚV*, authorities were in the process of restoring hot water to homes in the area after conducting repairs on the pipeline.

About seven hours after the eruption began, the MODIS (Moderate Resolution Imaging Spectroradiometer) on NASA's Terra satellite captured an image (figure 2) showing a plume of gas and ash streaming to the

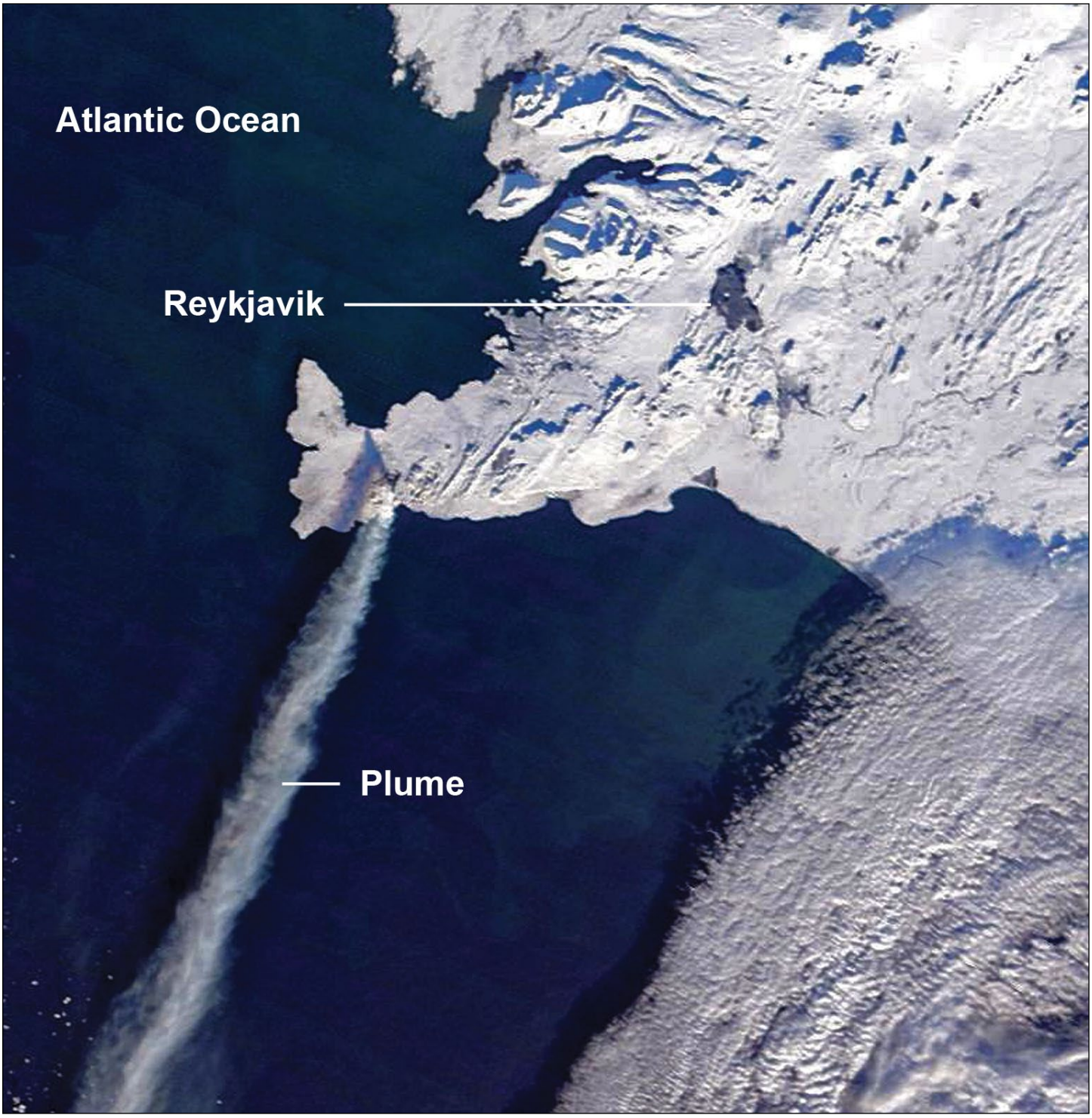


Figure 2 - Landsat-9 image showing details of the Reykjanes eruption plume
NASA Earth Observatory image by Lauren Dauphin, using MODIS data from NASA EOSDIS LANCE

southwest. This eruption was effusive—not explosive like the Eyjafjallajökull eruption in 2010—and the plume contained minimal ash, so did not cause any disruptions to either domestic or international flights.

Volcanic plumes like the one shown here typically contain water vapour, sulphur dioxide, carbon dioxide and small amounts of other volcanic gases. Researchers from the Icelandic Met Office and the University of Iceland have noted that, at times, magma has interacted with groundwater, adding to the amount of water vapour in the plume. After the initial burst of activity on February 8, the intensity of the eruption quickly faded, and in an update on February 9, the Icelandic Met Office reported that seismic sensors had stopped detecting volcanic tremors and that a recent drone flight showed no activity over the eruption site—signs that the latest eruption was ending.

However, on February 12, the agency reported that the land surface above an underground magma reservoir near Svartsengi had again begun to swell by between 0.5 and 1 centimetres per day, a rate similar to what was observed prior to other recent eruptions. “It is therefore highly likely that the cycle will continue in a few weeks with another dyke propagation and a volcanic eruption,” the agency stated.

The changing face of Cadman Ice Shelf

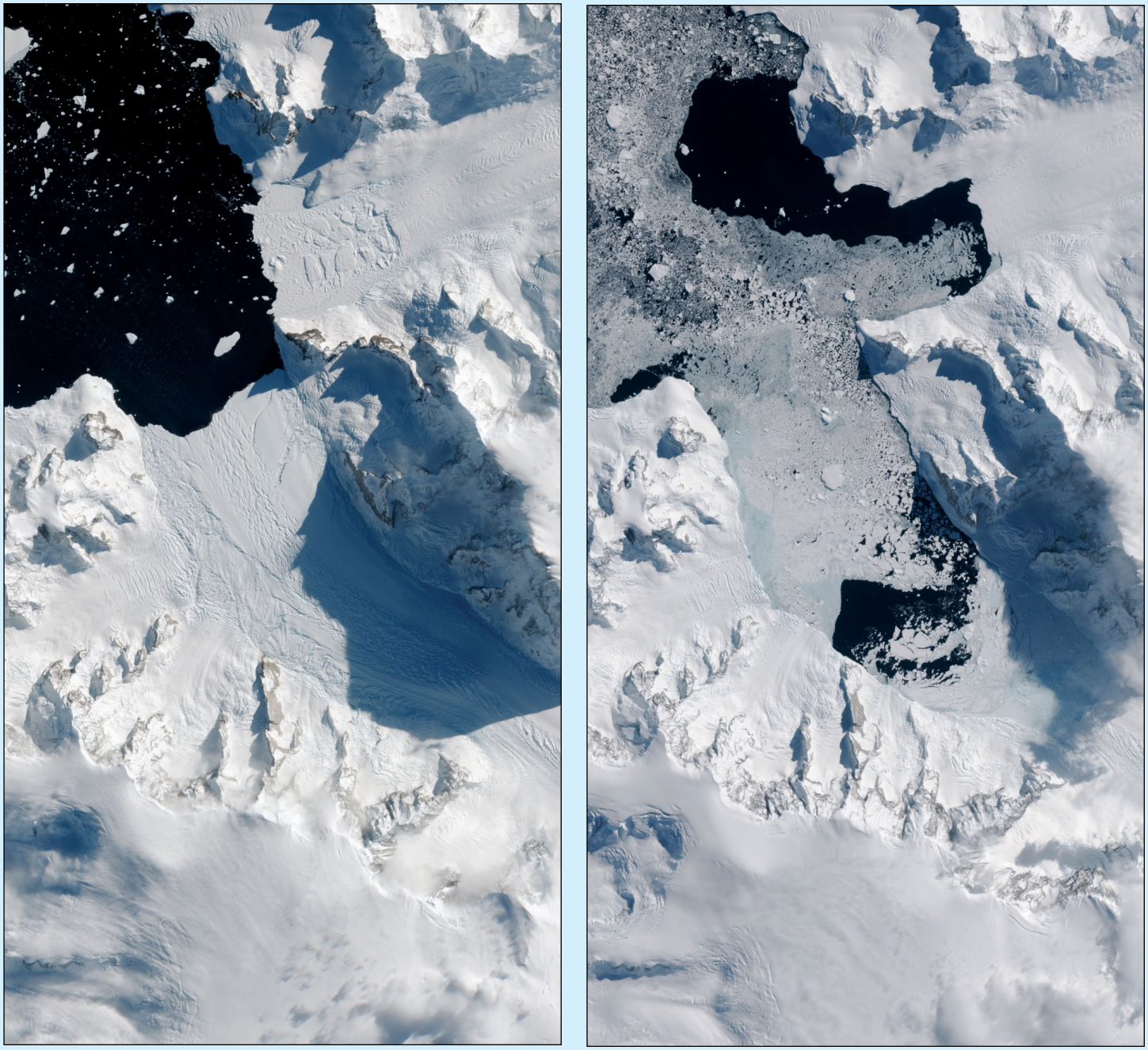
European Space Agency

Using satellite data, scientists have discovered that the ice shelf extending into the ocean from Cadman Glacier on the west Antarctic Peninsula collapsed leaving the glacier exposed to unusually warm ocean water, which caused the glacier to accelerate and retreat rapidly.

The research, published in Nature Communications, describes how a team of scientists, from the University of Leeds, Lancaster University, ENVEO, the University of Delaware and the British Antarctic Survey, used data from nine different satellite missions, including ESA's CryoSat and Europe's Copernicus Sentinel-1, along with in-situ measurements to map how the floating ice shelf and glacier changed.

They found that between November 2018 and May 2021, the glacier retreated a whopping eight kilometres, after being stable for around 50 years. They concluded that unusually high ocean water temperatures around the west Antarctic Peninsula during 2018–2019 had triggered the Cadman Glacier system to change dramatically.

Article continues overleaf ...



These side-by-side images use acquisitions from the Copernicus Sentinel-2 mission to show how the ice shelf changed between 28 February 2017, at left and 19 November 2023 on the right.

Images contains modified Copernicus Sentinel data (2023), processed by ESA, CC BY-SA 3.0 IGO

Benjamin Wallis, from the University of Leeds who led the research, explained:

'By tracking Cadman Glacier with satellites we saw that it started speeding up massively in 2018, and when we investigated ocean reanalysis data, we found that the waters nearby were up to 2°C warmer than average at that time. We think the warmer waters gradually started to eat away 'at the Cadman Ice Shelf from the early 2000s, but possibly from as early as the 1970s. The warmer water was not only on the surface of the ocean, but also deep in the water column. This warmer water may have reached to where the shelf was grounded on the sea floor. The result being that the ice shelf was melting from the bottom up, which we were able to observe using satellite data.'

Extending from glaciers on land, ice shelves float on the ocean surface and sometimes reach the ocean floor where then can be anchored, or grounded. Importantly, ice shelves act as a buttress, slowing the flow of the glacier towards the sea.

The Cadman Ice Shelf had become so thin that it was no longer able to hold back the glacier. In 2019, the shelf broke free from the grounding zone, in effect slipping anchor and enabling the Cadman Glacier to speed up and drain more ice into the sea. According to this new research, the Cadman Glacier is now in a state of 'substantial dynamic imbalance'.

The marine terminus: where the Cadman reaches the sea

The ice on the glacier has continued to thin, losing 20 metres a year, equivalent to a loss in height of a five-storey building annually. And around 2.16 billion tonnes of ice are draining from the Cadman Glacier into the ocean each year.

'Curiously, neighbouring glaciers on this part of the west Antarctic Peninsula did not react in the same way, which may hold important lessons for the way we can better project how climate change will continue to affect this important and sensitive polar region,' noted Benjamin Wallis.

The researchers say that what has happened to the Cadman Glacier can be seen as an example of a 'glaciological tipping point', where a system in a steady state can take one or two paths based on a change in an environmental parameter.

Such a tipping point was reached in 2018, resulting from the arrival of unusually warm ocean water which caused the ice shelf to unground. Reaching this tipping point caused Cadman Glacier to increase its ice discharge by 28% in 13 months.

Prof. Michael Meredith, from the British Antarctic Survey and one of the authors of the paper, stated:

'We have known for some time that the ocean around Antarctica is heating up rapidly, and that this poses a significant threat to glaciers and the ice sheet, with consequences for sea-level rise globally. What this new research shows is that apparently stable glaciers can switch very rapidly, becoming unstable almost without warning, and then thinning and retreating very strongly.

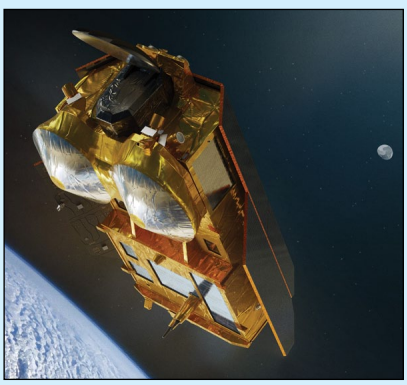
'This emphasises the need for a comprehensive ocean observing network around Antarctica, especially in regions close to glaciers that are especially hard to make measurements.'

ESA's Mark Drinkwater added:

'Again we see that the Antarctic is more susceptible to change than we thought a few years ago. It is imperative that we continue to monitor this fragile continent and surrounding oceans. We can only capture the full extent of such changes with pan-Antarctic measurements obtained by satellites over decades.

'Thankfully, we have missions such as CryoSat and Copernicus Sentinel-1 in orbit, but, importantly, we are developing new satellite missions such as the Copernicus Sentinel Expansion Mission Cristal and Sentinel-1 Next Generation to continue, to sustain, and enhance these types of measurements in the future.'

With a launch planned in 2027, the Copernicus Polar Ice and Snow Topography Altimeter, CRISTAL, mission will carry, for the first time, a dual-frequency radar altimeter, and microwave radiometer, that will measure and monitor sea-ice thickness, overlying snow depth and ice-sheet elevations.



Artistic impression of the Crystal craft
Image:ESA

Retreat at Klinaklini

NASA Earth Observatory

Story by Adam Voiland

Decades of satellite images of western Canada make it clear that the region's glaciers are shrinking and that the rate of ice loss is accelerating.

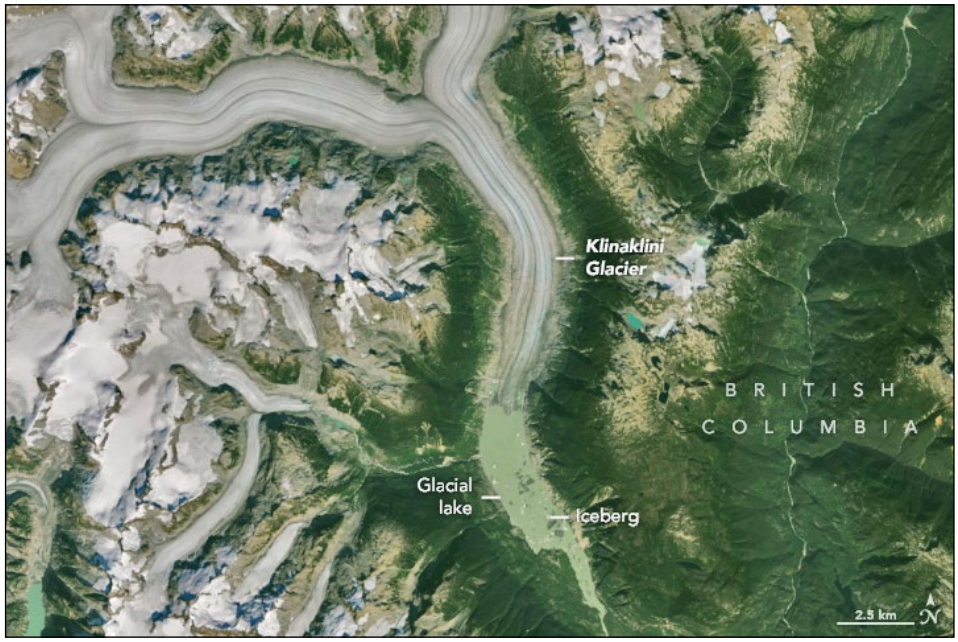
In 1984, there were 14,329 glaciers in British Columbia and Alberta that were large enough to detect with sensors on the Landsat 5 satellite. By 2020, nearly 8% of them—1,141 glaciers—had shrunk so much that newer Landsat sensors could no longer distinguish them, according to research conducted by University of Northern British Columbia glaciologists Alexandre Bevington and Brian Menounos.

'Clean' glaciers—those without much debris on them—went from losing an average of 49 square kilometres (km^2) per year between 1984 and 2010 to 340 km^2 per year between 2011 and 2020. In the same periods, the area spanned by water pooling at the ends of glaciers ballooned from about 9 km^2 to 49 km^2.

The **Klinaklini Glacier**, the largest glacier in western North America outside of Alaska, is part of this shrinking trend. The Coast Range glacier, found in the south of British Columbia, flows southward from the flanks of the 2864 metre Mount Silverthrone and 2658 metre Mount Somolenko into a forested valley roughly 300 metres above sea level.

The pair of images above shows how much Klinaklini has changed between September 26, 1984 (upper), and September 22, 2023 (lower). During this period, the glacier's terminus—sometimes called the snout or toe—retreated northward by more than five kilometres. In 1984, just a small glacial lake was present at the terminus. By 2023, the lake had grown to five kilometres long and two kilometres wide. It is now large and deep enough that icebergs float freely in it. The photograph at the top of page 23, which was taken by Menounos from a helicopter, is an view of the glacier as it appeared on September 1, 2017.

The Klinaklini Glacier in 1984
NASA Earth Observatory images by Wanmei Liang, using Landsat data from the U.S. Geological Survey



The Klinaklini Glacier in 2023
NASA Earth Observatory images by Wanmei Liang, using Landsat data from the U.S. Geological Survey

Klinaklini is also getting skinnier. Analysis of digital elevation models of the glacier derived from images acquired by the ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) on NASA's Terra satellite shows that Klinaklini's main stem thinned by nearly 200 metres between 2000 and 2019.

The meltwater that drains from the glacier flows first into the remote Klinaklini River, then into Knight Inlet and the Queen Charlotte Strait, before eventually debouching into the Pacific Ocean. The contribution of this one glacier to sea level rise is tiny, but the collective impact of the world's glaciers is important.

This photograph, taken from the air shows the glacier on September 1, 2017
Aerial photo courtesy of Brian Menounos (University of Northern British Columbia)

'If you take three or four decades of melt at a glacier in the Coast Range—even a big one like Klinaklini—the contribution to sea level rise is very small,' said Jeffrey Van Looy, a University of North Dakota glaciologist who analysed changes at five ice fields in southern British Columbia, including the Ha-Iltzuk Ice field that contains Klinaklini Glacier. 'But this is a region where we're talking about thousands of glaciers, and several ice fields are experiencing changes similar to this. And the same thing is happening globally. All that melting starts to add up.'

According to one recent estimate, glaciers—excluding the ice sheets on Greenland and Antarctica—lost an average of 267 gigatons of mass per year between 2000 and 2019, equivalent to 21 percent of the observed sea level rise during that period.

Van Looy's analysis of weather patterns found that rising temperatures and increases in rainfall, rather than snowfall, in the Ha-Iltzuk Ice field are fuelling the ice losses. More recent analysis by researchers from the University of Northern British Columbia showed the warming pattern continued into the 2020s. 'This is what climate change looks like,' said Van Looy.

'The total sea level rise potential of the western North America glaciers—if they melted entirely—is only about 2.6 millimetres,' said Menounos. Other important contributors to sea level rise, aside from the melting of glaciers on land, include the melting of ice sheets in Antarctica and Greenland, the thermal expansion of sea water as it warms, and changes to how much water is stored on land. Projections made available by NASA's *Sea Level Change Team* suggest that Port Hardy, a community 135 kilometres southwest of Klinaklini Glacier, will likely see about 8 millimetres of sea level rise by 2060 and 24 millimetres by 2100 under 'middle-of-the-road' emissions scenarios.

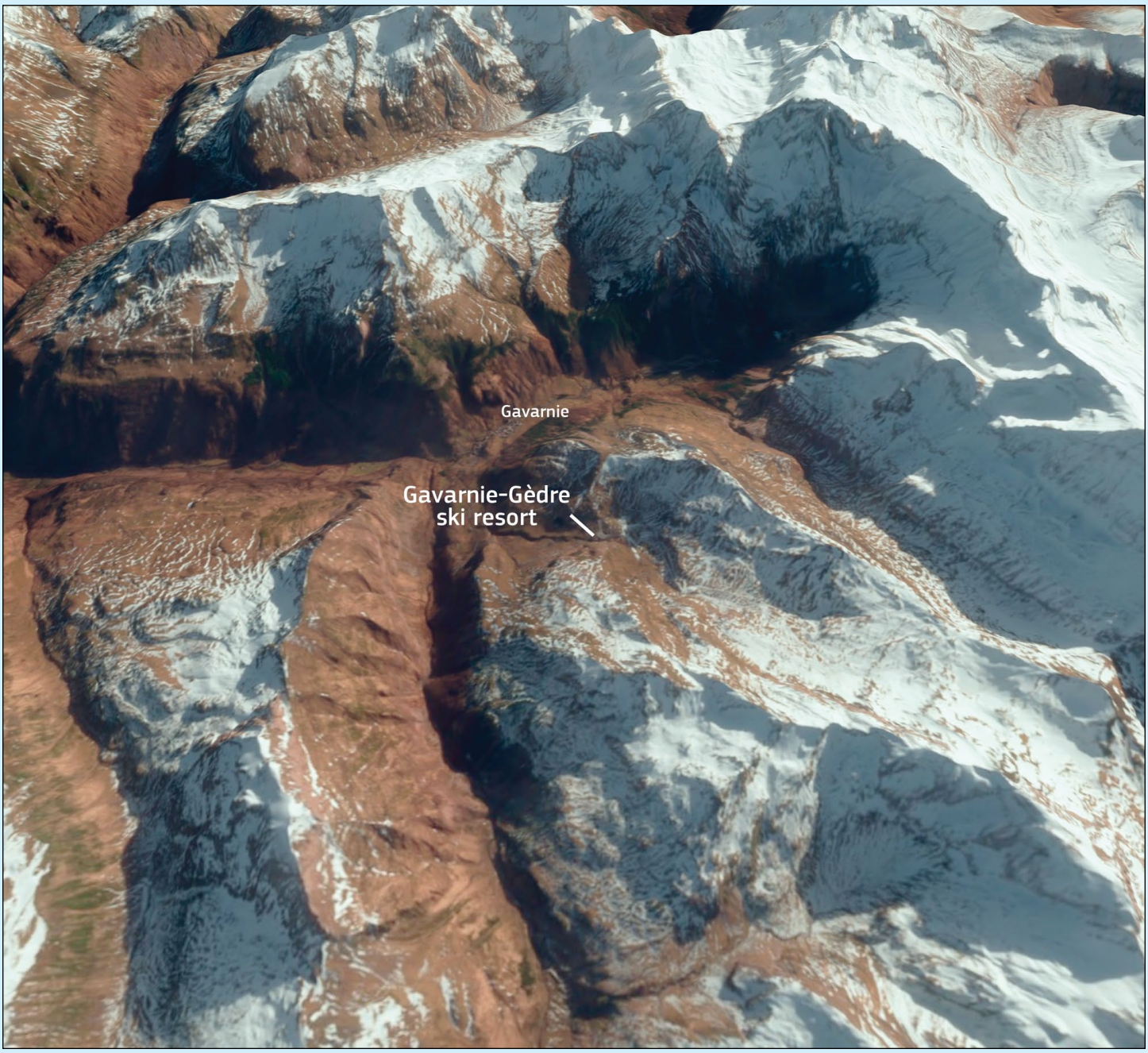
'The melting of these glaciers also raises important water resource issues since they provide cool, plentiful water when seasonal snow has melted during times of sustained droughts—like we're having now,' stated Menounos. 'Glacial meltwater is especially important for many fish-bearing rivers.'

The names of both the Klinaklini Glacier and Klinaklini River derive from the Kwak'wala word for eulachon grease, which is made from a small oily fish. Eulachon—sometimes called smelt, hooligan, oolichan, fathom fish, and salvation fish—have long been prized by First Nation communities because early spring spawning provides nutrition after long, cold winters.

While eulachon populations are considered stable in Alaska, more southerly populations in British Columbia and Washington state are threatened and moderately vulnerable to climate change, according to the Washington Department of Fish and Wildlife. The hatching of eulachon eggs is tied to peak spring flows on rivers; changing precipitation patterns, reduced snowpack, or earlier snowmelt associated with climate change could affect the eulachon life cycle.

Worrying lack of snow in the Pyrenees

Copernicus Image of the Day



Credit: European Union, Copernicus Sentinel-2 imagery

Like many other countries in Europe, France has experienced an unusually warm January this year, with temperatures remaining above 0ºC in the French Pyrenees region and, as a consequence, a lack of snow in the area. Some ski resorts have temporarily closed due to the almost complete absence of snow, while others have shut down completely for this year's ski season. This situation will impact the local economy, which relies heavily on winter tourism.

This image acquired by one of the Copernicus Sentinel-2 satellites shows the ski station of Gavarnie-Gèdre in the French Pyrenean on January 30, 2024. The ski station will remain provisionally closed because of the snow drought.

The Copernicus Sentinel-1 satellite, uses radar imaging to capture images of the Earth's surface, even in the presence of cloud cover or darkness. These images enable it to map and track changes in snow and ice cover, including the extent of glaciers, sea ice and snow cover on land.

Sentinel-2 and Sentinel-3 also provide high-resolution multispectral images used to map snow and ice cover. By monitoring snow and ice cover over time, scientists can better understand the effects of climate change and other environmental factors on these important ecosystems, while utilities can estimate future hydro-power potential production etc.

The Lovely Shape of Spirit Lake

NASA Earth Observatory

Story by Kathryn Hansen

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

Spirit Lake is resilient. The lake and once-popular tourist site in south-central Washington was nearly obliterated in May 1980 during the events that unfolded around the cataclysmic eruption of Mount St Helens. The lake survived, and it took on a lovely new shape.

The OLI (Operational Land Imager) on Landsat 8 acquired this image on April 26, 2023. A white blanket of snow contrasts with the dark-blue water, emphasizing the lake's heart-like shape when viewed from above.

Prior to the eruption, Spirit Lake had a smaller footprint that consisted of west and east arms connected by a narrow span of water—similar in shape to the top-half of a heart. Then, on May 18, 1980, the volcano's north flank let loose, producing the largest-known landslide in recorded history, followed by a lateral blast and shock wave as the eruption unfolded. The water in Spirit Lake was temporarily displaced but eventually flowed back into the basin.

A 'new' lake reformed atop the debris from the landslide. The fully heart-shaped lake was broader and shallower, and the elevation of its surface higher by nearly 60 metres. Some of the landslide debris formed a blockage, or natural dam, on the lake's southwest side. Without an outlet, water levels continued to rise until engineers constructed a drainage tunnel in 1985.

From the 1920s through the 1970s, Spirit Lake drew tourists to its shores. Cabins and lodges lined the lake, and people could swim, boat, and fish in its waters. Today, those lakeside features are buried in avalanche debris below the modern lake.

Fishing and swimming are now prohibited, and access is limited to preserve the site as a natural laboratory for studying the landscape's recovery. For example, scientists think that the trees uprooted by the volcanic blast and still floating in the lake, visible as the brown line in the detailed image above, have become an important part of the lake's ecosystem.

Cloud Vortices over the Atlantic

MODIS Image of the Day

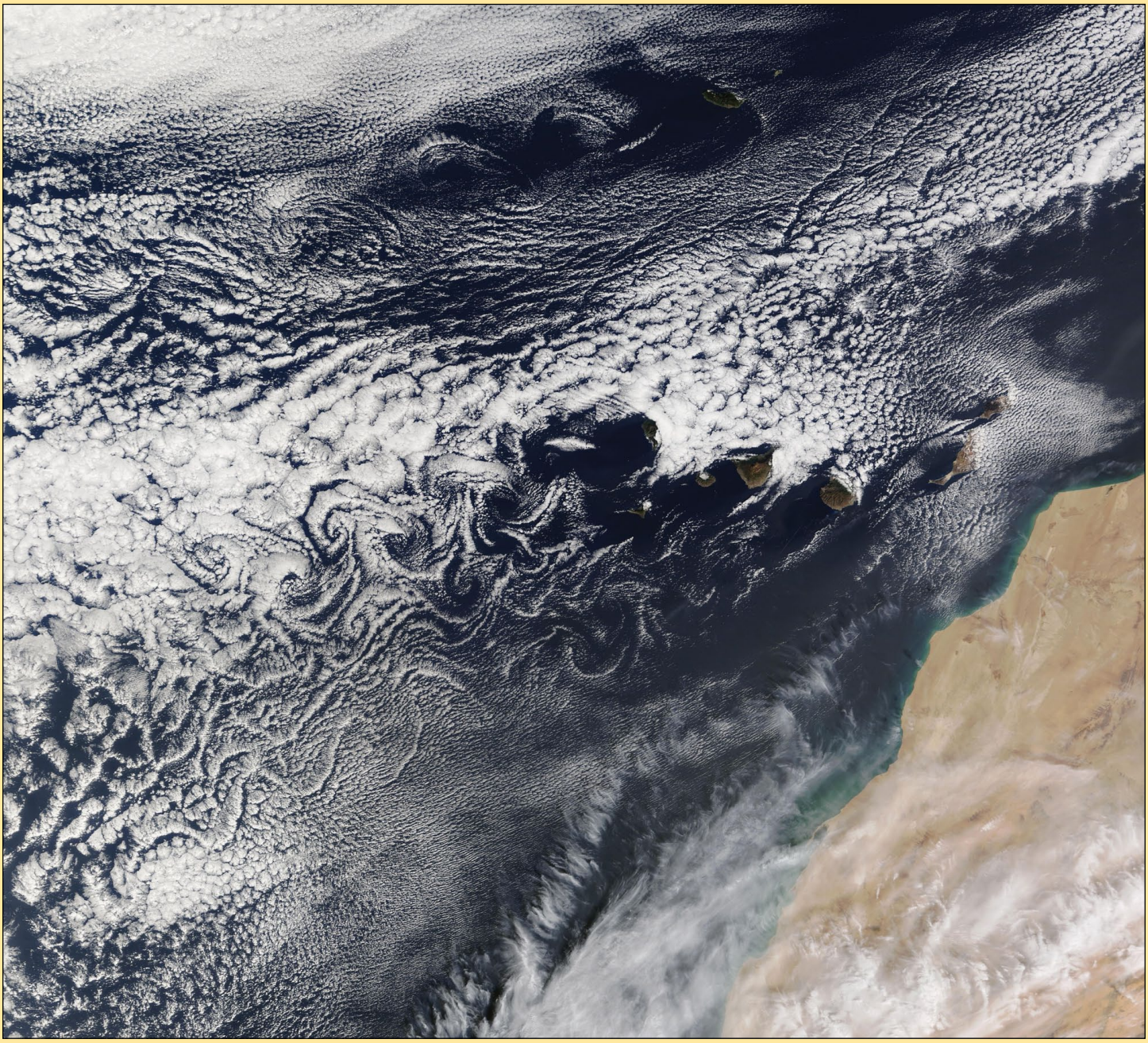


Image Credit: MODIS Land Rapid Response Team, NASA GSFC

Winds blowing past the Canary Islands created fascinating patterns in the clouds in late January 2024. The Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite acquired this true-colour image on January 22.

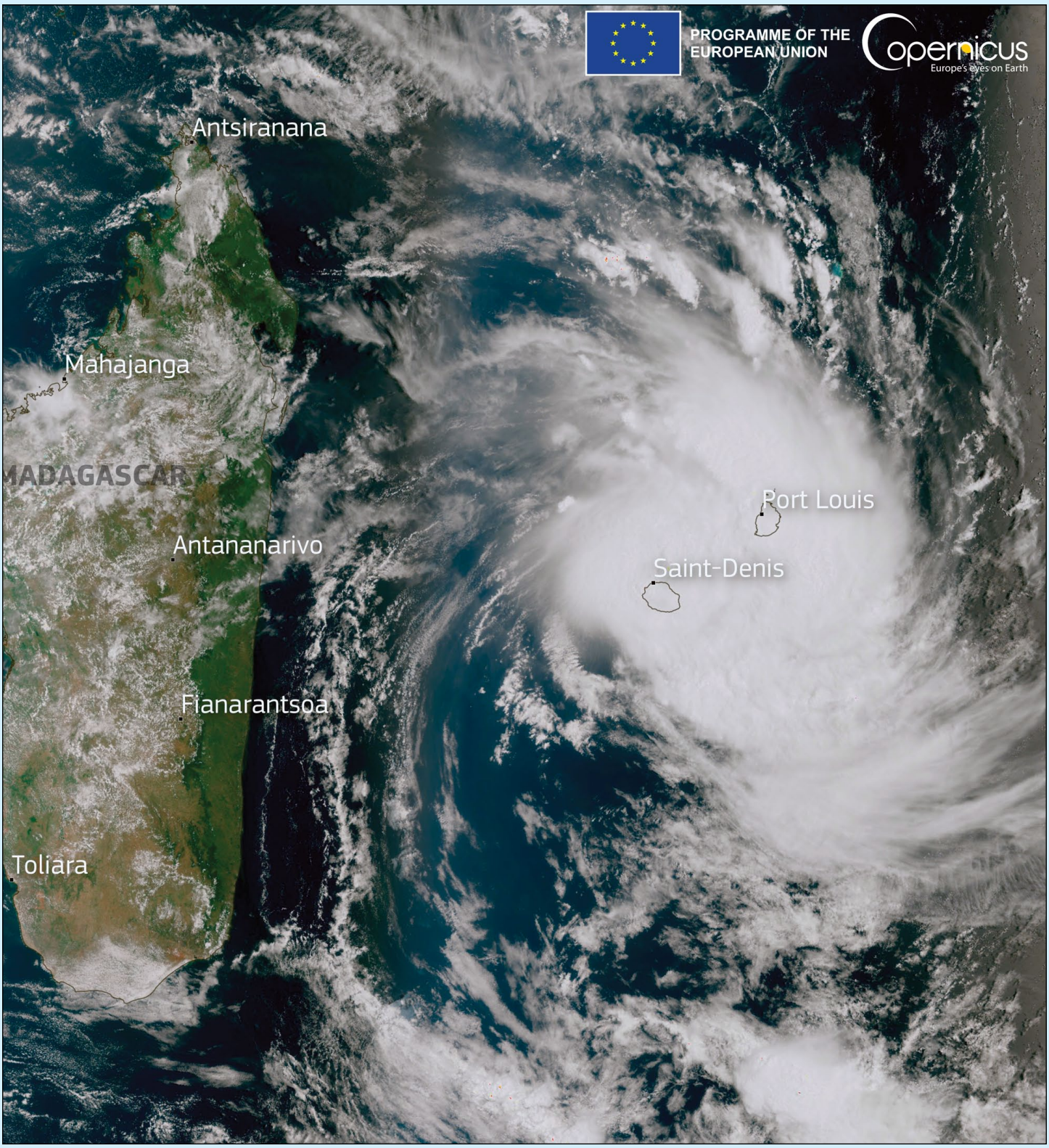
The cloud swirls downwind of the Canary Islands are called Von Kármán vortices, a distinctive pattern that can occur when a fluid passes a tall, isolated object. The fluid splits around the object, creating a swirling eddy downwind. Linear chains of these eddies are called von Kármán vortex streets. Fluids are materials that are capable of flowing and easily changing shape. While most people think of water as a fluid, air is also considered a fluid.

In this case, the Von Kármán vortices occurred as wind rushed past the tall volcanic peaks of the Canary Islands. Heavy clouds behind the islands were caught up in the swirling air, making the pattern easily visible from space. Located in the Atlantic Ocean off the western coast of Africa, the Canary Islands are a frequent location of such cloud patterns.

Fluid dynamicist Theodore von Kármán was the first to describe the conditions under which these turbulent patterns occur. Von Kármán was a professor of aeronautics at the California Institute of Technology and one of the principal founders of NASA's Jet Propulsion Laboratory.

Cyclone Belal hits La Reunion and Mauritius

Copernicus Image of the Day



Credit: European Union, Copernicus Sentinel-3 imagery

On 15 January 2024, Cyclone Belal hit Mauritius and the French island of La Réunion, bringing torrential rain and strong winds to the region. At least one casualty was reported in La Réunion, where a level three cyclone warning had been issued, and a quarter of the population had been left without electricity and drinking water. This image of Cyclone Belal was acquired by one of the Copernicus Sentinel-3 satellites on January 15, 2024 at 05:45 UTC while it passed through Saint-Denis and Port Louis.

The Zahara-El Gastor Water Reservoir has reached Critical Levels

Copernicus Image of the Day

Credit: European Union, Copernicus Sentinel-2 data

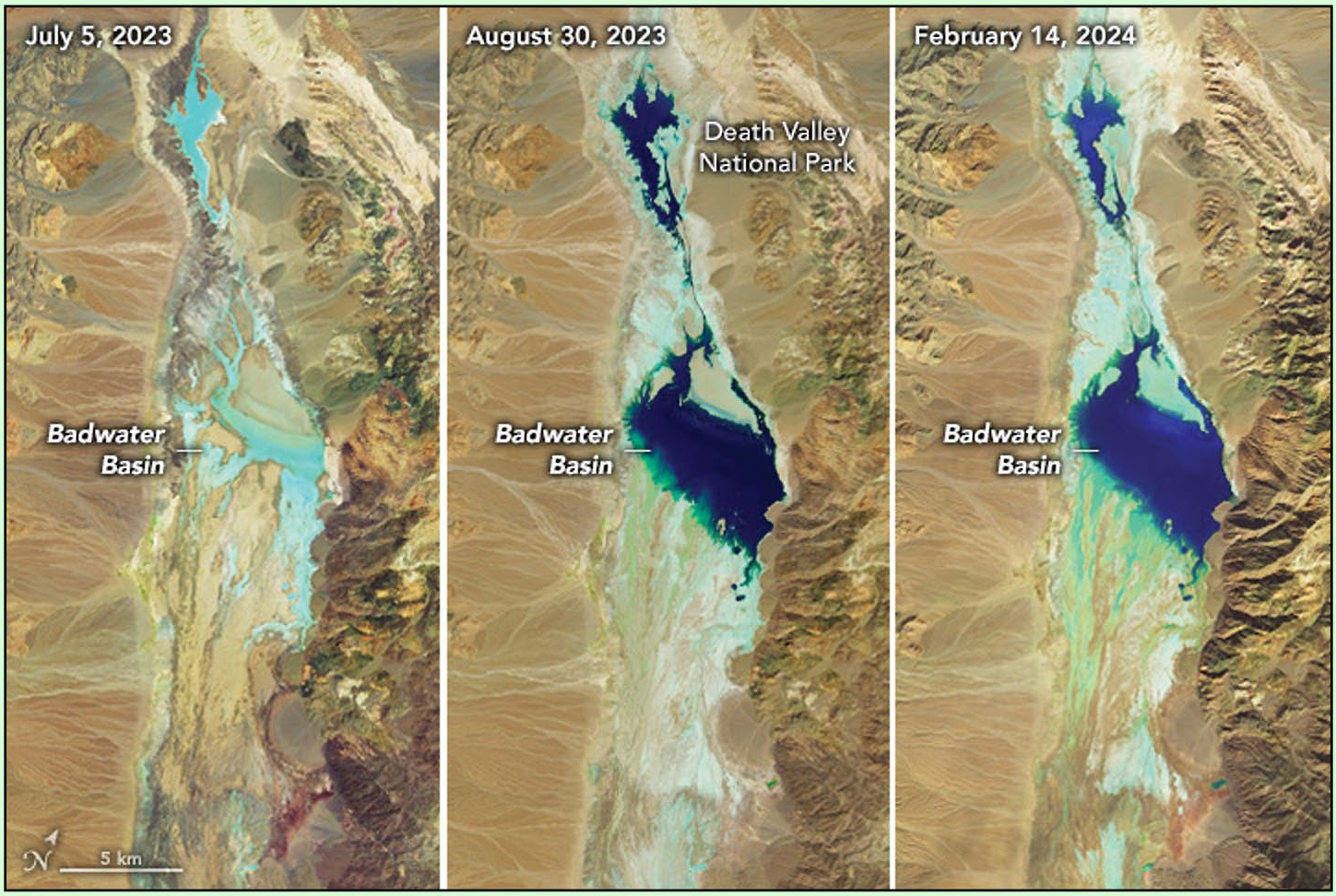
The Zahara-El Gastor reservoir in southern Spain is a vital source of water for agriculture and recreation. The critical drought affecting the province of Cádiz has left the reservoir at nearly 6% of its capacity, a worrying level that threatens access to water for surrounding communities. The lack of water is clearly visible in this Copernicus Sentinel-2 image of the Zahara reservoir acquired on February 2, 2024.

Open data retrieved by the Copernicus Sentinel satellites provide key information useful for accurately mapping lakes and reservoirs and extracting critical information about changes in their water levels.

Badwater Basin Refills

NASA Earth Observatory

Story by Lindsey Doermann



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

An ephemeral lake in Death Valley's Badwater Basin [1] is showing its staying power. After forming in August 2023, in the aftermath of Hurricane Hilary, the lake gradually shrank but persisted throughout the fall and winter. A potent atmospheric river refilled it during February 2024.

This series of images compares the desert basin before flooding (left) with its more-waterlogged state following each major storm. In both August 2023 (middle) and February 2024 (right), a shallow lake several kilometres across fills in the low-lying salt flat. The images were acquired by the OLI (Operational Land Imager) sensor on Landsat 8 (left and right) and the OLI-2 on Landsat 9 (middle). They are false-colour, shown with the OLI and OLI-2 band combination of 6-5-3, which emphasizes the presence of water in shades of blue.

The driest place in North America, Death Valley typically receives about 51 millimetres of rain per year. However, in the past six months alone, more than double that, 125 millimetres, fell at the National Park's official weather gauge at Furnace Creek. Two events were responsible for most of that precipitation. According to park officials, the remnants of Hurricane Hilary delivered 66 millimetres on August 20, 2023, and an atmospheric river supplied another 45 millimetres between February 4–7, 2024.

Following the August deluge, '*most of us thought the lake would be gone by October*,' said Death Valley National Park ranger Abby Wines in a news release. '*We were shocked to see it still here after almost six months.*' That was before the rains returned in February.

After the early February atmospheric river moved through, observers on the ground saw the lake continue to expand as water drained into the area. On February 11, park ranger Matthew Lamar noted: *'The Amargosa River [which feeds the basin from the south] is really flowing, and we've noticed the water level continue to rise over the last couple of days as waters make their way to the basin.'*

Snow-capped hills are reflected in the ephemeral waters of Badwater Lake
Photo by K. Skilling/National Park Service

Basin is endorheic, meaning that water flows into but not out of it. Typically, evaporation far outpaces inputs, rendering the lake ephemeral. But in the past six months, the influxes have changed the equation.

Based on satellite imagery, the lake appears to have grown to a similar size in February 2024 as it did in August 2023, thereby extending its months-long tenure. This comes as welcome news to visitors, who have enjoyed witnessing stunning reflections of the surrounding peaks in its calm waters.

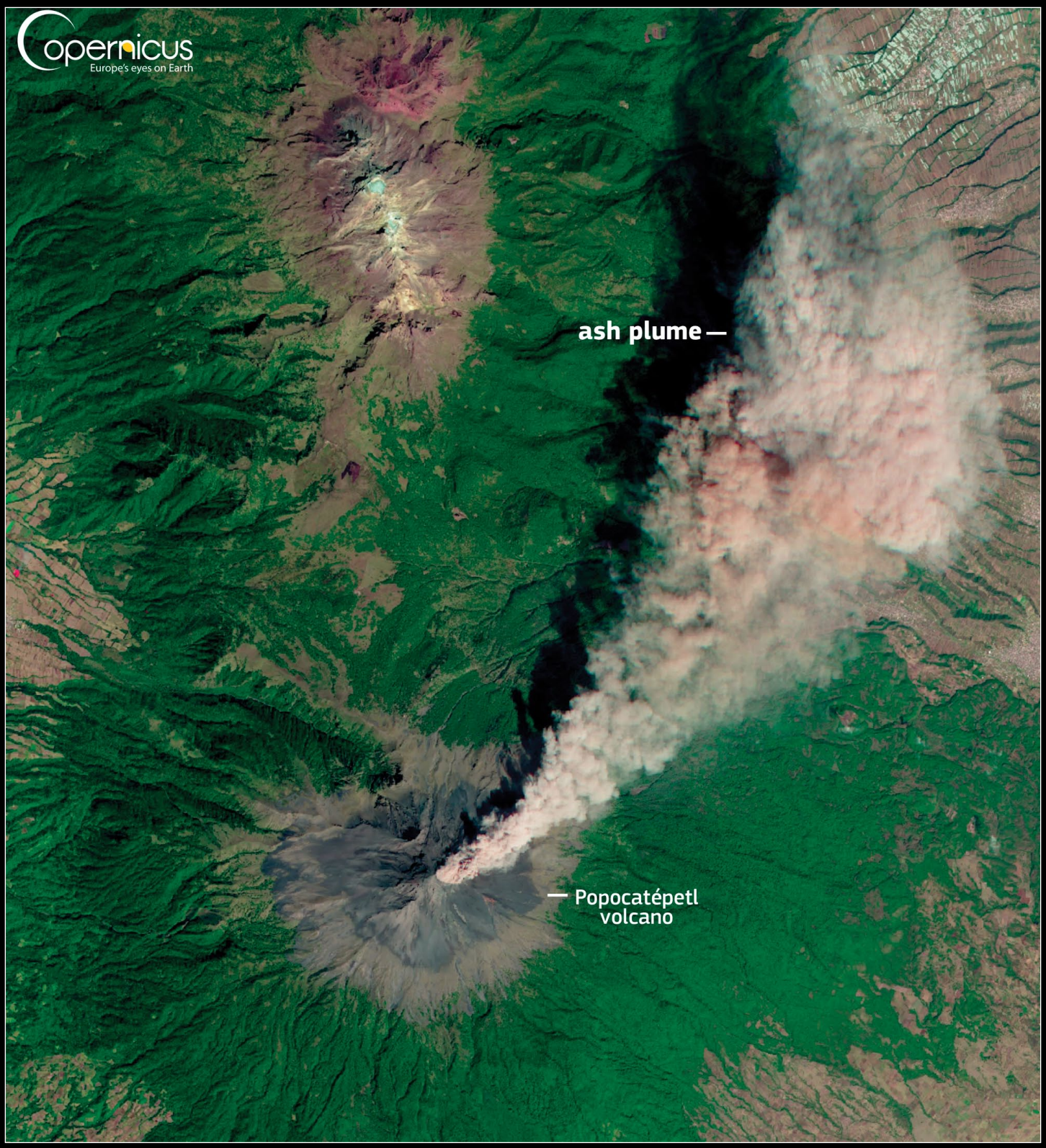
As of February 14, the lake is 30 centimetres deep in places, according to park officials, and it is uncertain how long this will last. Past appearances of the lake are rare and offer little insight into the current situation: when a lake formed in 2005, for example, it reportedly lasted about one week. It is also too early to know how the precipitation will affect the wildflower season, which runs from late-February to mid-April.

Reference

1 Floodwaters in Badwater Basin - GEO Quarterly No 80, page 26

Volcanic activity at the Popocatepétl Volcano

Copernicus Image of the Day



Credit: European Union, Copernicus Sentinel-2 imagery

Popocatépetl is a stratovolcano in central Mexico, formed by the subduction of the Cocos Plate beneath the North American Plate. Its eruptions are predominantly explosive, driven by the build-up of gas pressure in the magma chamber. It is closely monitored due to its proximity to densely populated areas such as Mexico City and La Puebla. The activity of the Popocatepetl increased during February and this image, acquired on February 10 by one of the Copernicus Sentinel-2 satellites, shows a massive ash plume drifting some twenty kilometres to the northeast.

The Copernicus Sentinel satellites support the surveillance of volcanoes worldwide, proving particularly adapted to monitoring volcanoes located in remote regions.

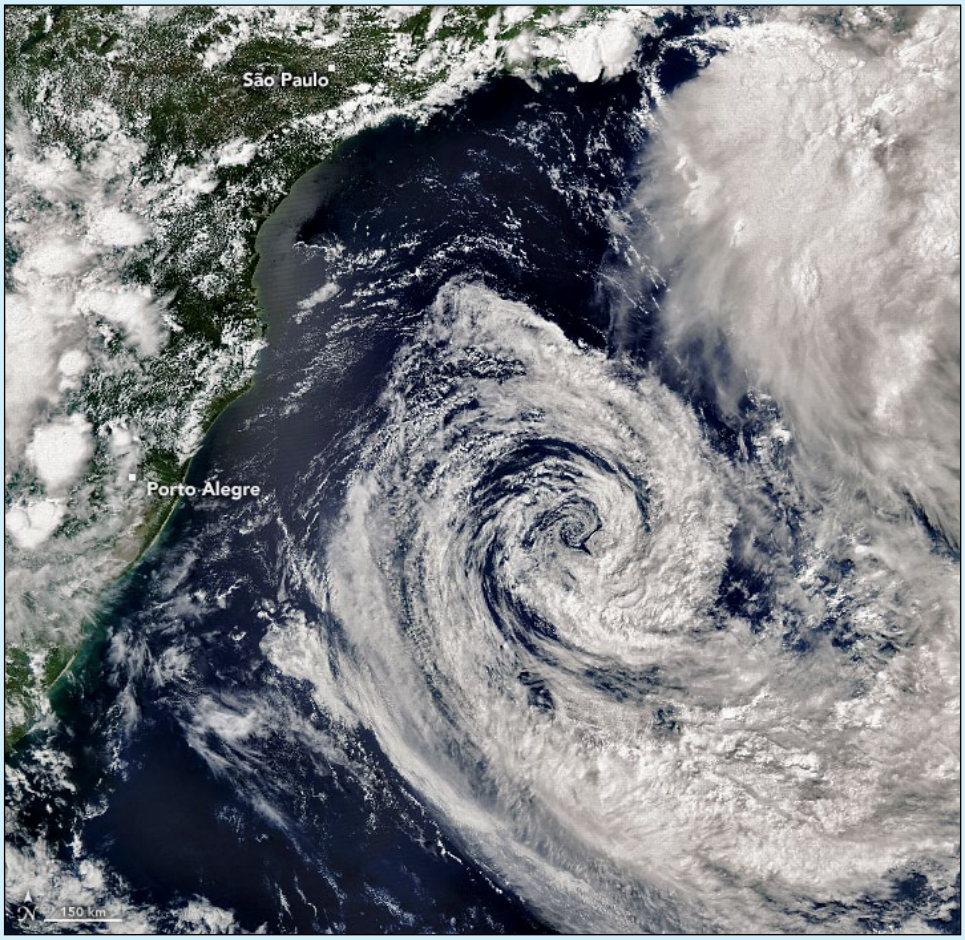
A Rare Tropical Storm in the South Atlantic

NASA Earth Observatory

Story by Emily Cassidy

Tropical storms seldom roam in the South Atlantic Ocean. But in mid-February 2024, one such storm did form off the coast of Brazil.

The disturbance began to develop as a stalled front of low pressure on February 15. According to researchers at NOAA's *Cooperative Institute for Meteorological Satellite Studies* (CIMSS), the front developed into a subtropical depression on February 16 after being fed by a plume of tropical moisture that plunged south. The depression continued to intensify and move south, and at 9 pm local time on February 18 (00:00 Universal Time on February 19) the *Brazilian Navy Hydrographic Center* upgraded it to Tropical Storm Akará. At the time, the storm carried sustained winds of up to 64 kilometres per hour.



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

The MODIS (Moderate Resolution Imaging Spectroradiometer) instrument on NASA's Aqua satellite captured this image of Akará around 2:20 pm local time (17:20 Universal Time) on February 19, 2024, when its centre was about 900 kilometres southeast of São Paulo.

Until the start of the 21st century, tropical cyclones in the South Atlantic were undocumented. According to meteorologists at *Yale Climate Connections*, wind shear was often too high for storm formation, and easterly waves from northern Africa—which seed cyclones and hurricanes in the Atlantic—are not a regular occurrence south of the equator.

In 2004, a rare tropical cyclone formed in this region and eventually made landfall in Brazil's southern state of Santa Catarina. The *National Hurricane Center* in Miami estimated the storm to be a category-1 hurricane (named Catarina), making it the first hurricane observed in the South Atlantic during the satellite record. At the time, the *Brazilian Center for Weather Prediction* did not operate any anemometers in the area or have any hurricane hunter aircraft to fly through the storm. All estimates were based on satellite data only.

After Catarina, forecasters paid closer attention to storm development in the South Atlantic. Since 2015, three other tropical storms have been recorded in the basin: Tropical Storm Iba in 2019, Tropical Storm 01Q in 2021, and now Akará in 2024.

Warm sea surface temperatures most likely contributed to Akará's formation. According to *Yale Climate Connections*: "Sea surface temperatures in the vicinity of Akará on Monday were around 0.5°C warmer than average, at around 26°C, or what's typically considered to be the minimum threshold for tropical development." This unusually warm water is more typical of temperatures in early summer, they noted, continuing a trend of warm sea surface temperatures that has persisted for months.

Akará was expected to remain well offshore and not have major impacts on land, aside from high surf along the coast south of Rio de Janeiro. Forecasts showed the storm weakening as it headed south over cooler waters.

Editor's Note

For a full explanation as to why South Atlantic Hurricanes rarely form, see Peter Wakelin's article: "Why are south Atlantic Hurricanes so Rare?" in GEO Quarterly No 2 (2004), available from the on-line back-issue archive.

Winter on the Tibetan Plateau

MODIS Web Image of the Day

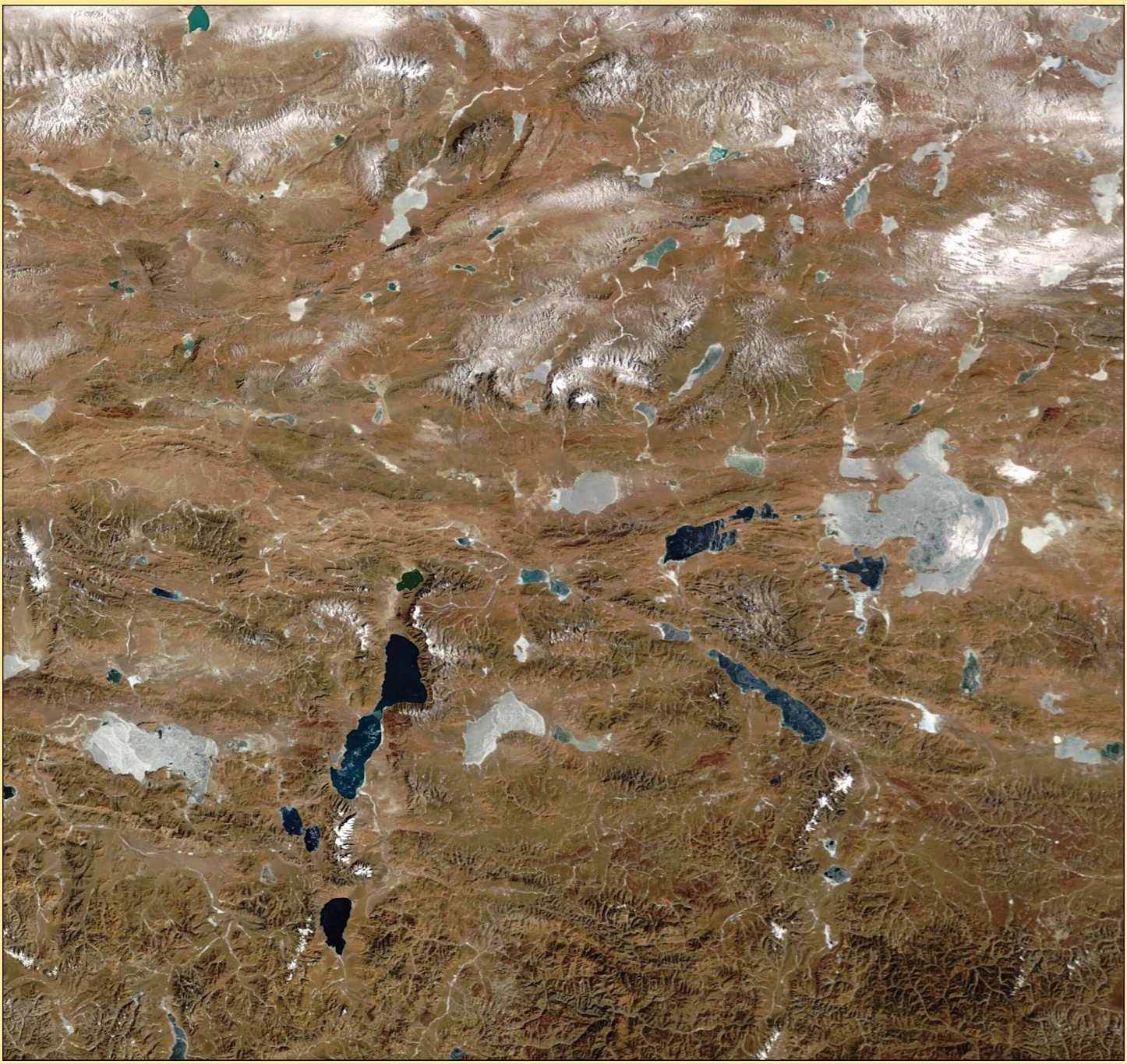


Image Credit: MODIS Land Rapid Response Team, NASA GSFC

On February 10, 2024, crystal-clear skies over the Tibetan Plateau allowed the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite to capture a true-colour image of winter at the 'Roof of the World'.

Sitting north of the Himalayas and south of the Kunlun Mountains, the Tibetan plateau stretches more than 1000 kilometres from north to south and 2500 kilometres from east to west. It has earned its nickname because of its extremely high elevation, which averages more than 4,500 metres. In the north and northwest, elevations rise to 5,000 metres.

This high plateau is home to more than 1,500 lakes of assorted sizes and characteristics. Many are quite saline, while others are filled with fresh water. Some are fed by glaciers while some give rise to many of Asia's major rivers, including the Ganges, Yangtze and Mekong.

Frigid winter temperatures cause freshwater lakes and rivers to ice over completely, and these appear white in this image.

More saline lakes are partially frozen, while a few very deep and salty lakes remain ice-free and shine like sapphires in the winter landscape.

Currently Active Satellites and Freqencies

Polar APT Satellites				
Satellite	**Frequency**	**Status**	**Format**	**Image Quality**
NOAA 15	137.6200 MHz	On	APT	Intermittent sync problem
NOAA 18	137.9125 MHz	On	APT	Good
NOAA 19	137.1000 MHz	On	APT	Good
Meteor M N2	137.1000 MHz	On	LRPT	Failed
Meteor M N2-3	137.9000 MHz	Off	LRPT	Variable [1]

Polar HRPT/AHRPT Satellites				
Satellite	**Frequency**	**Mode**	**Format**	**Image Quality**
NOAA 15	1702.5 MHz	Omni	HRPT	sync problem
NOAA 18	1707.0 MHz	RHCP	HRPT	Good
NOAA 19	1698.0 MHz	RHCP	HRPT	Good
Feng Yun 3C	1701.4 MHz	RHCP	AHRPT	Inactive [2]
Feng Yun 3D	7820.0 MHz	RHCP	AHRPT	Active {2}
Feng Yun 3E	7860.0 Mz	RHCP	AHRPT	Commissioning
Metop B	1701.3 MHz	RHCP	AHRPT	Good
Metop C	1701.3 MHz	RHCP	AHRPT	Good
Meteor M N2-2	1700.0 MHz	RHCP	AHRPT	Active [8]
Meteor M N2-3	1700.0 MHz	RHCP	AHRPT	Active

Geostationary Satellites				
Satellite	**Transmission Mode(s)**		**Position**	**Status**
Meteosat 9	HRIT (digital)		45.5°E	IODC - On
Meteosat 10	HRIT (digital)	LRIT (digital)	0°W	Off [4]
Meteosat 11	HRIT (digital)	LRIT (digital)	9.5°E	On [3]
MTG-I1			0.4°W	Commissioning
GOES-13	GVAR 1685.7 MHz	LRIT 1691.0 MHz	61.6°E	[5]
GOES-14	GVAR 1685.7 MHz	LRIT 1691.0 MHz	105°W	Standby
GOES-15 (W)	GVAR 1685.7 MHz	LRIT 1691.0 MHz	135°W	Off (in storage)
GOES-16 (E)	GRB 1686.6 MHz	HRIT 1694.1 MHz	75.2°W	On [7]
GOES-17	GRB 1686.6 MHz	HRIT 1694.1 MHz	104.7°W	Off
GOES 18	GRB 1686.6 MHz	HRIT 1694.1 MHz	137.0°W	On [7]
Himawari-8	No direct download	Data is only available via the HimawariCast service	140.7°E	On
Himawari-9	No direct download		140.7°E	On
Feng Yun 2E	SVISSR (digital)	LRIT (digital)	86.5°E	Off
Feng Yun 2F	SVISSR (digital)	LRIT (digital)	112.5°E	Standby
Feng Yun 2G	SVISSR (digital)	LRIT (digital)	105.0°E	On
Feng Yun 2H	SVISSR (digital)	LRIT (digital)	79.0°E	On
Feng Yun 4A	HRIT (digital)	LRIT (digital)	99.5°E	On
Feng Yun 4B	HRIT (digital)	LRIT (digital)	105°E	On

Notes

1 Currently, M2-3 transmits on 137.9 MHz but has on occasions switched to 137.1 MHz. Transmission is currently on a Symbol Rate of 72,000 baud, though 80,000 baud has been used in trials.
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 prime Rapid Scanning Service (RSS) satellite.
5 Repurposed for use by the US Space Force
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 GOES Rebroadcast (GRB) provides the primary relay of full resolution, calibrated, near-real-time direct broadcast space relay of Level Ib data from each instrument and Level 2 data from the Geostationary Lightning Mapper (GLM). GRB replaces the GOES VARiable (GVAR) service.
8 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.
9 Japanese satellites MTSAT-1R (Himawari-6) and MTSAT-2 (Himawari-7) are no longer active and are probably retired. Current Japanese operational geostationary satellites are Himawari-8 and Himawari-9.