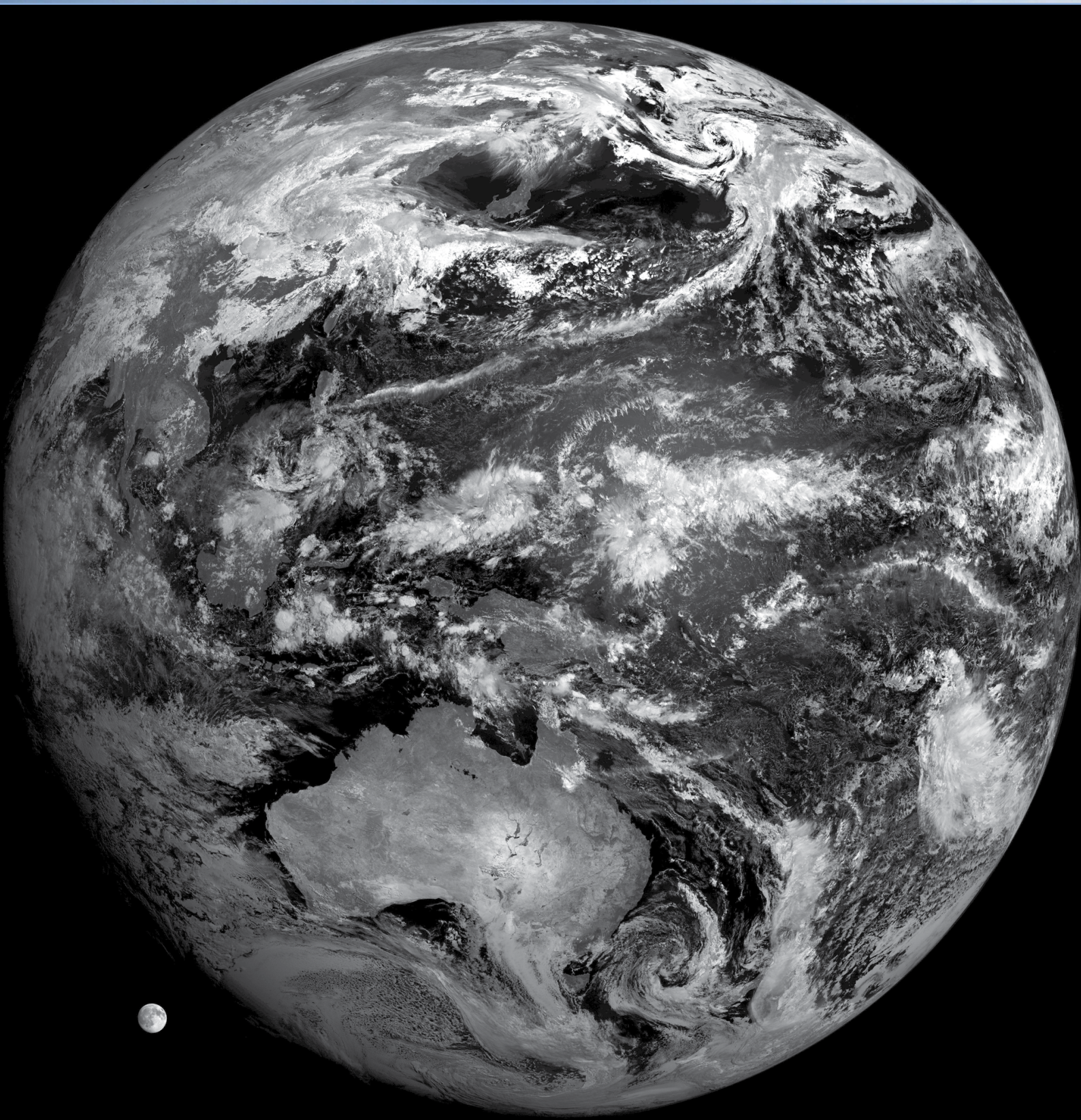
GEO Newsletter

Group for Earth Observation

Group for Earth Observation

No 78 - June 2023



On May 4 this year, Japan's Himawari 9 satellite captured this image of Earth which includes the Moon at lower left. Refer to the Editorial for more details

GEO MANAGEMENT TEAM

General Information

John Tellick,

email: information@geo-web.org.uk

GEO Newsletter Editor

Les Hamilton,

email: geoeditor@geo-web.org.uk

Technical Consultant (Hardware)

David Simmons

email: tech@geo-web.org.uk

Webmaster and Website Matters

Vacancy

e-mail: webmaster@geo-web.org.uk

Management Team

David Anderson

Rob Denton

Nigel Evans: nigel.m0nde@gmail.com

Clive Finnis

Carol Finnis

Peter Green

David Simmons

David Taylor

Useful User Groups

Weather Satellite Reports

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

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

SatSignal

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

https://groups.io/g/SatSignal

MSG-1

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

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

GEO-Subscribers

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

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

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Group for Earth Observation

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From the Editor

Les Hamilton

The cover of this issue of the Newsletter carries a remarkable image acquired by Japan's Himawari 9 satellite, which includes the Moon (shown full size opposite). David Taylor spotted a similar image from Simon Proud posted on Twitter, and used his own EUMETCast data to select band 6 (2.3 μm), which showed the brightest lunar image. This was processed in his MSG Data Manager to 8-bit JPEG followed by a little contrast and sharpening adjustment in Paint Shop Pro.

At last there is news of a new Meteor satellite. Both the Meteor M 2-3 satellite and its Fregat launcher were delivered to Vostochny cosmodrome earlier this year, and there are high hopes of a July launch. You can read all the latest information in Carl Reinemann's article on page 4. Should there be updated information on the launch after this Newsletter is published, you will find it on Carl's web page:

https://usradioguy.com/satellites/meteor-m-no-2-3/

Contents

Meteor M No 2-3

Possibility of a late July launch

Carl Reinemann - https://usradioguy.com/

After years of delay there are at last signs that the launch of Russia's Meteor M No 2-3 satellite could be imminent as, on April 28 this year, a launch date of July 28 was assigned. This not to say that this is by any means guaranteed as the Meteor program has been continuously plagued by uncertainty: custom-designed to observe oceans with a high-resolution phased-array radar Meteor M N2-3 has in fact been in storage since 2016!

Historic Background

The Russian Meteor M Satellite program, which aims to monitor weather patterns and provide accurate climate data, was initially launched in 2014 with the successful launch of Meteor M2. But since then, the Meteor programme has been plagued by technical issues and bureaucratic obstacles as well as launch failures and software malfunctions. In November 2017, the launch of the Meteor-M N-1 satellite failed due to a programming error which caused the payload to ditch into the North Atlantic ocean.

The repeated delays to the Meteor M program have caused concern among scientists and meteorologists who rely on the data provided by these satellites to make accurate weather predictions. This delay has also affected Russia's ability to provide climate data to the international community and participate in global climate research initiatives.

By the middle of 2020, the launch of Meteor M2-3 was delayed by 12 months till the end of 2021, at which time it was planned to launch Meteor M2-4 in early 2022 and Meteor M2-5 in the first half of 2023. But all these dates lapsed as the launch date of Meteor M 2-3 continued to advance, with proposed launch dates in February, March and June this year. At the time of writing, a date of July 28th has been set.

Interestingly enough, in my search for information, I contacted a private space tourist company that offers ground tours for rocket launch viewing in Russia. Even they could not give me a date for the launch of Meteor M2-3, just telling me, 'it will launch when the rubles say it will'.

Latest Developments

In February this year, the Fregat Upper Stage for the Soyuz launch vehicle was delivered to Vostochny Cosmodrone in the Amur Oblast in Russia's Far East, and the Meteor-M No 2-3 satellite was delivered for installation in the aero shell along with other satellites that are hitching a ride. Compared

The upper-stage Fregat being delivered to Vostochny cosmodrome in February 2023
Image: Roscosmos

Meteor-M № 2-3 arriving at the Vostochny Cosmodrome
Image: Roscosmos

One of the Meteor M2 satellites undergoing testing prior to mating with its Fregat launcher
Image: Roscosmos

with earlier Meteor-M craft, the new satellite is additionally equipped with an onboard radar system based on an active phased antenna array, and heliogeophysical instruments (a short-wave reflected radiation meter and a radio frequency mass spectrometer). These will ensure all-weather radar monitoring of the Northern Sea Route and expand the range of controlled heliogeophysical parameters.

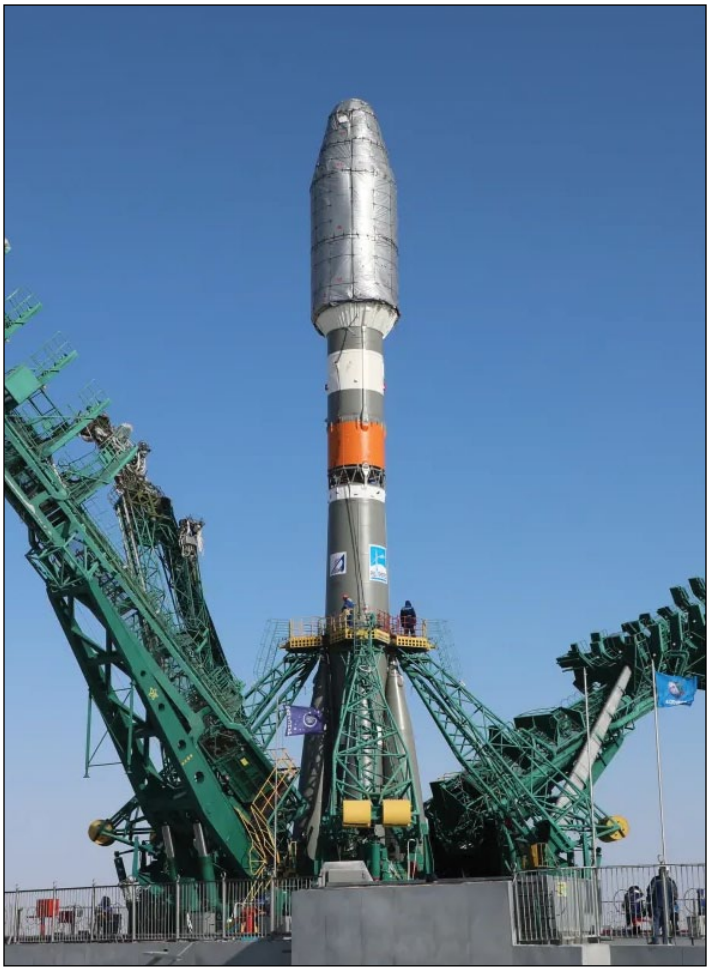
April Update

An update from the Vostochny Cosmodrome in mid April announced that their Launch Schedule for Meteor-M No.2-3 aboard the Soyuz 2.1b launcher had again been delayed, with an anticipated July 28, 2023 launch date. The actual time of the launch was not specified, but if and when the launch does take place, it will be from Cosmodrome Site 1S at the Vostochny Cosmodrome, Siberia, Russian Federation.

As is usual these days, the launcher payload will include numerous other satellites as well. Many of these are small '*Cube Sats'* and/or '*Nano Sats*'. Two cubesats, Yarilo No 3 and Yarilo No 4, are solar research microsats developed by the Bauman Moscow State Technical University which will be manoeuvred using solar sails. Interestingly they will be transmitting on 433 MHz.

I will continue to post updated information on this launch on my **USRadioGuy website** at the URL below:

https://usradioguy.com/satellites/meteor-m-no-2-3/



A Soyuz/Fregat launcher on its launchpad
Image: Roscosmos

Cyclone Mocha

Copernicus Image of the Day

This image, acquired by the Copernicus Sentinel-3 satellites on May 14, 2023, shows **Cyclone Mocha** before it made landfall along the coasts of Bangladesh and Myanmar.

Mocha struck the Bay of Bengal coastlines as a category-4 equivalent cyclone, bringing heavy rain, winds of up to 195 km/h, and coastal flooding. Myanmar, particularly the western Rakhine state, experienced significant destruction, with up to 90% of the capital city, Sittwe destroyed. The storm's impact included power outages, fallen trees, disrupted telecommunications, and damage to camps for displaced Rohingya.

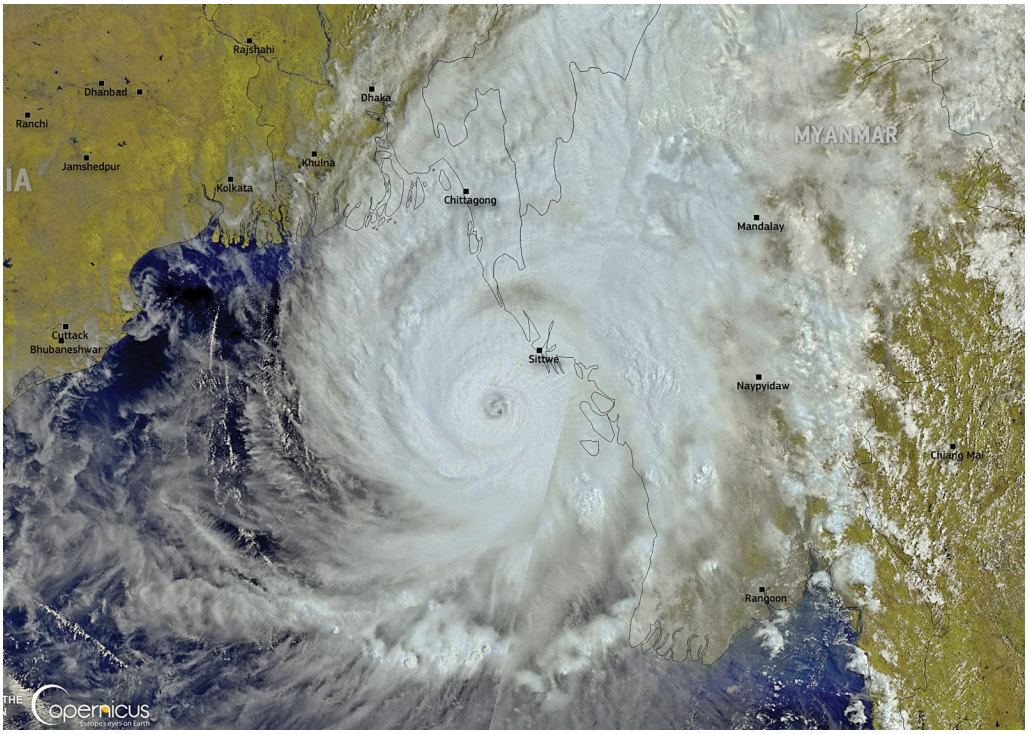


Image: European Union, Copernicus Sentinel-3 imagery

Antarctic Sea Ice Reaches Another Record Low

NASA Earth Observatory

Story by Kathyrn Hansen

In February 2023, sea ice around Antarctica reached the lowest extent ever observed since the start of the satellite record in 1979. But despite several recent years of low extents, the long-term trend for sea ice in southern polar waters is essentially flat: it is the declines in sea ice at the other pole—in the Arctic—that are pushing the global sea ice trend downward.

Sea ice around Antarctica reached its lowest extent on February 21, 2023, at 1.79 million square kilometers (691,000 square miles). That's 130,000 square kilometres below the previous record-low reached on February 25, 2022—a difference that equates to an area about the size of New York state. It marks the second time that scientists have observed the ice shrinking below two million square kilometres.

The map in figure 1 shows the ice extent on the day of its record low. To determine extent, scientists project satellite observations of sea ice on to a grid and then add up the total area of each cell that is at least 15% ice-covered. The yellow outline shows the median sea ice extent for February from 1981–2010. A median is the middle value: that is, half of the extents were larger than the yellow line and half were smaller.

Amid year-to-year variability, sea ice trends in the Antarctic prior to 2016 were generally headed slightly upward in all months. Since then, several years hit new record lows, including 2017, 2022, and now 2023.

> *"There is some discussion about the Antarctic sea ice undergoing a regime-shift since 2016 toward a generally lower extent, and that maybe this could be a response to global warming; that is, the warming signal is starting to be seen in the Antarctic sea ice above the year-to-year variability,"* said Walt Meier, a sea ice scientist at the National Snow and Ice Data Center (NSIDC). *"But it is hard to say at this point if it is a real shift and response to warming, or just a temporal multi-year variation."*

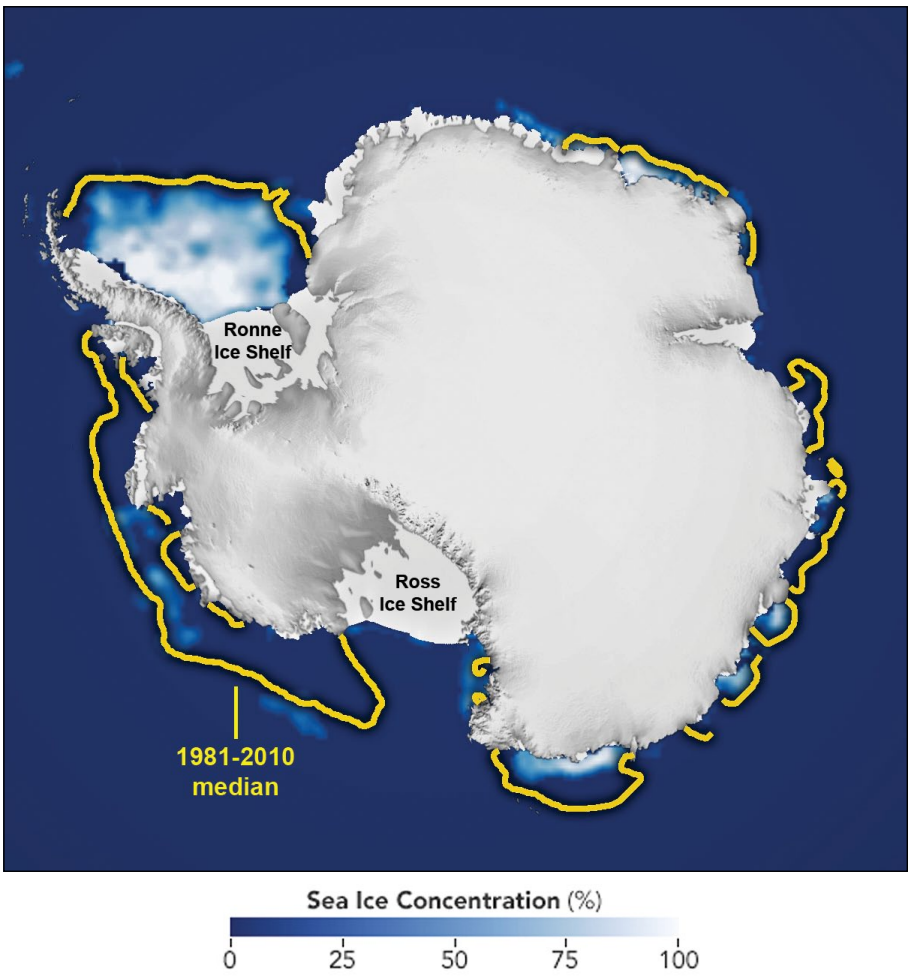


Figure 1
Antarctic Sea Ice at its record low on February 21, 2023
NASA Earth Observatory images by Lauren Dauphin, using data from the National Snow and Ice Data Center.

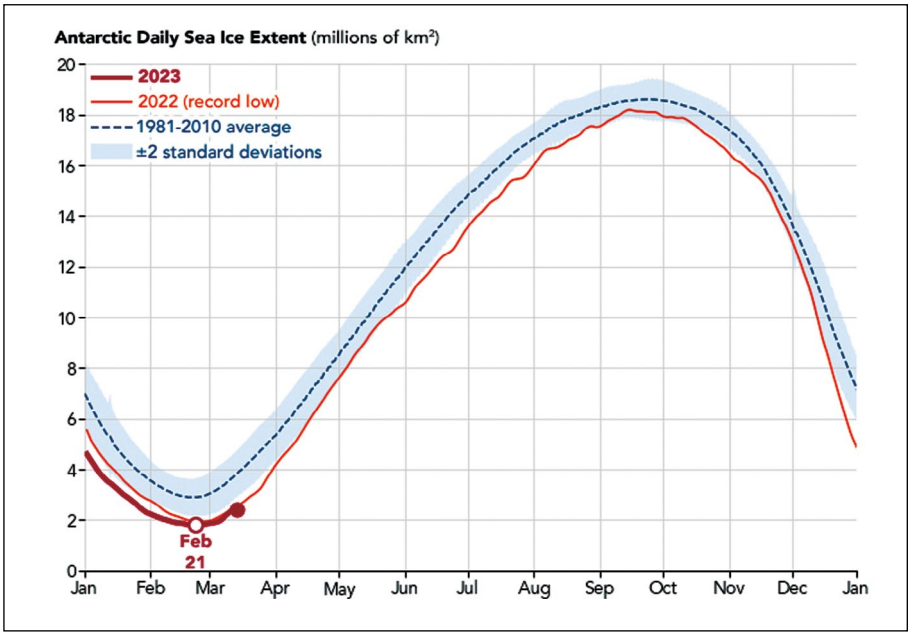
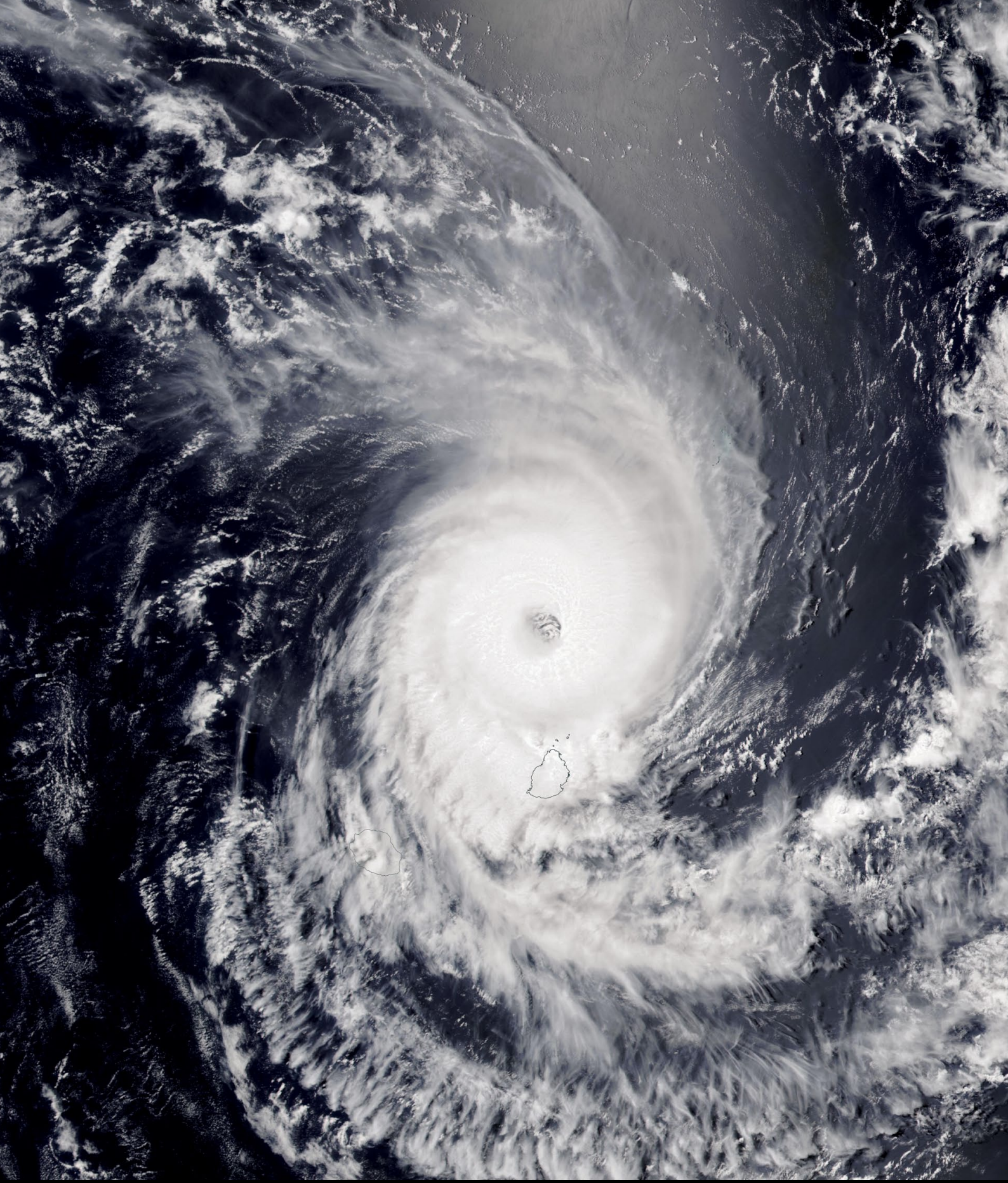


Figure 2
Antarctic Sea Ice Trends over the years



The NOAA 20 satellite captured this image of Tropical Cyclone Freddy skirting the islands of Mauritius and Réunion in the Indian Ocean on February 20, 2023.

Freddy, which initially developed off the North Australian coast on February 6, 2023, spent a record 32 days traversing the entire Indian Ocean, becoming the **longest-lived tropical cyclone ever recorded**. During its zig-zag travels, Freddy made repeat visits to both Madagascar, Mozambique and Malawi before being finally being downgraded over Zimbabwe on March 14.

Image: NASA Worldview Snapshots (https://wvs.earthdata.nasa.gov)

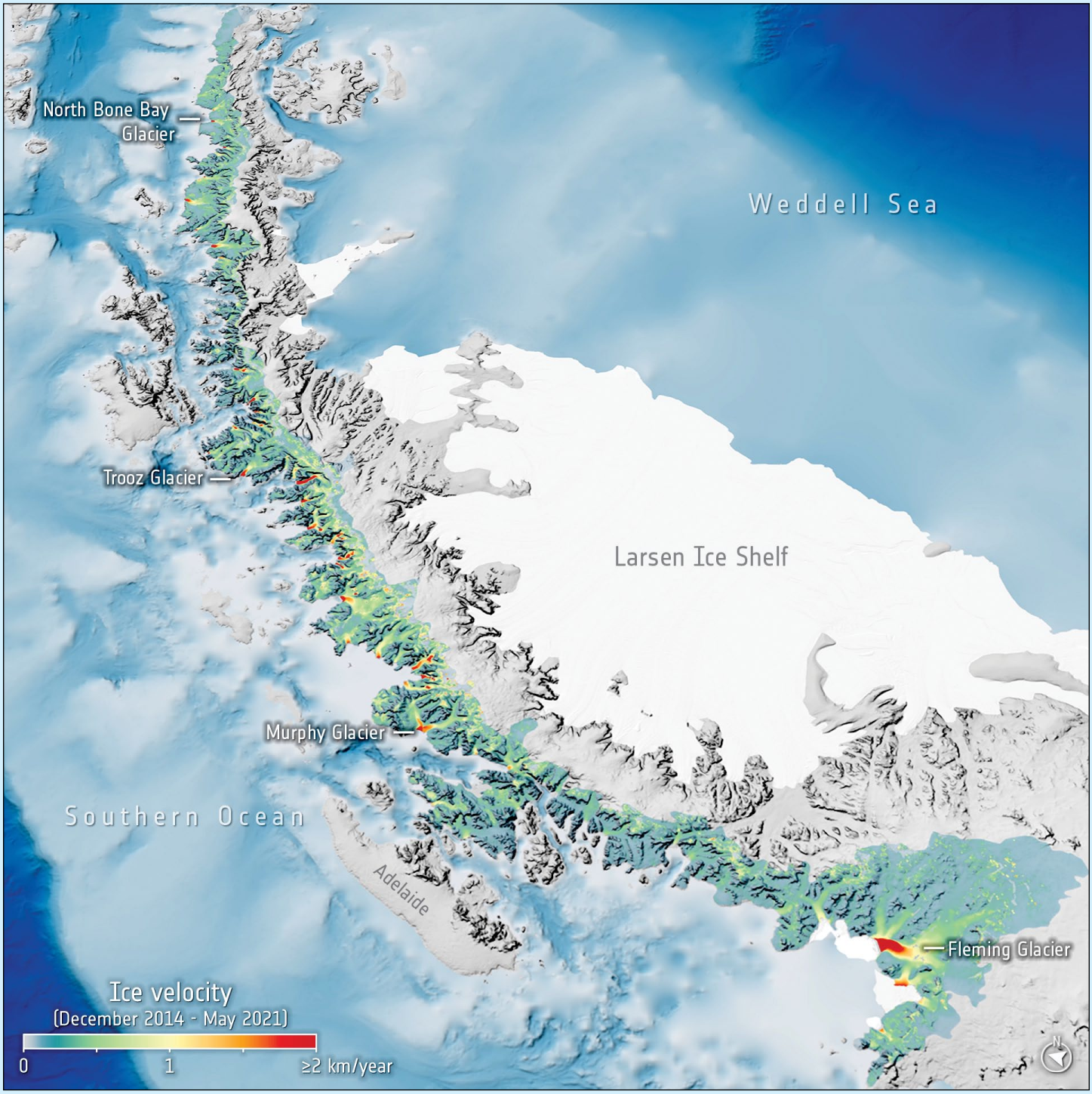
Antarctic Peninsula Glaciers on the Run

European Space Agency

Like many places, the Antarctic Peninsula is falling victim to rising temperatures. However, when scientists used radar images from the Copernicus Sentinel-1 mission acquired between 2014 and 2021, they were taken aback to discover just how the fast 105 glaciers on the west coast are flowing in the summer months.

The Antarctic Peninsula is the most northern and warmest region of Antarctica, and with a 1000 kilometre long mountainous spine, it is home to a rich marine ecosystem. The peninsula holds enough ice to raise global sea levels by around seven centimetres, and is rapidly changing in response to the climate crisis.

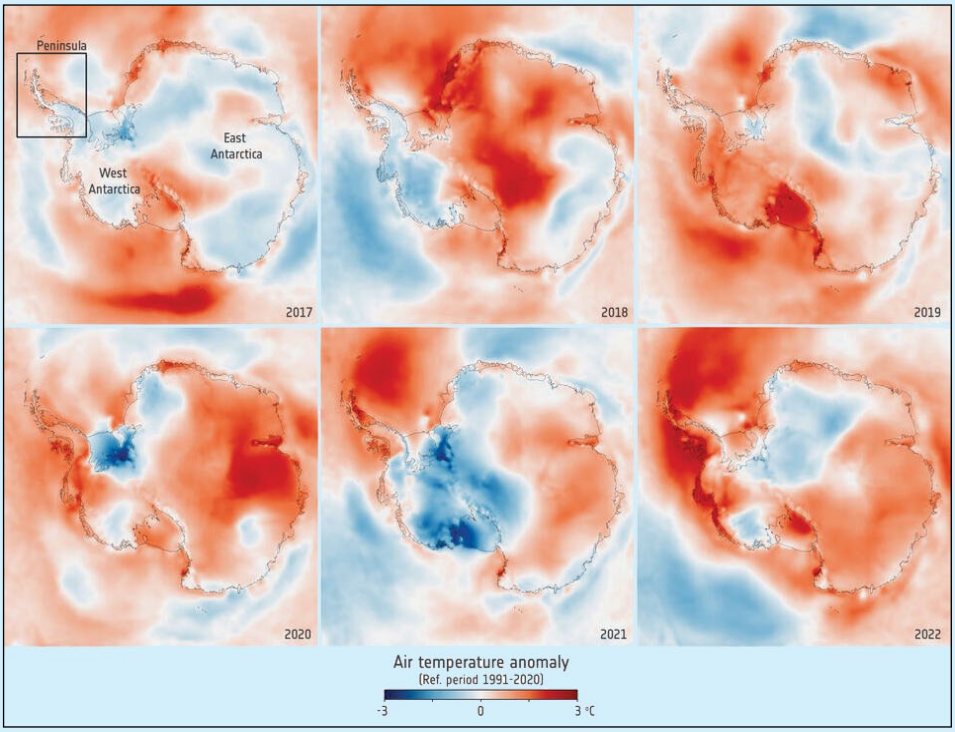
Along the west coast of the peninsula, over one hundred large glaciers drain ice from the ice sheet directly into the Southern Ocean. A team of scientists from the University of Leeds in the UK and the Utrecht University in the Netherlands have processed over 10,000 Copernicus Sentinel-1 radar images to measure the speed of these glaciers on the Peninsula's west coast over the six-year period between 2014 and 2021.



© Image contains modified Copernicus Sentinel data (2014–2021), processed by University of Leeds/ESA

A recent paper published in the journal *Nature Geoscience* [1] describes how they found that the glaciers experiencing the most seasonal change actually flow over 22% faster in summer than in winter, with all glaciers in this region speeding up by 12% on average. This new discovery of faster summer ice speeds had not been seen before in this region of Antarctica.

Climate models of snow melt and ocean temperature were used to investigate what was driving this summer speed-up. The data showed that the glacier speed-up occurs at the same time as water from melting snow and warmer ocean temperatures are present in the summer, showing how glaciers in this region of Antarctica can respond quickly to changes in the environment.



Antarctica air temperature anomaly 2017-2022

Ben Wallis, from the University of Leeds, said:

"What's exciting about this study is that it shows how sensitive glaciers in Antarctica are to the environment. We've known for a long time that glaciers in Greenland have a seasonal behaviour, but it's only now that satellite data has shown similar behaviour in Antarctica.

"Originally, we didn't plan to focus on the west coast of the Peninsula, but after seeing some interesting signals on Breguet Glacier, we investigated further and found summertime speed-ups were widespread along the whole coast."

Anna Hogg, also from the University of Leeds, added:

"These results show that it is essential to account for short-term seasonal change in glacier speeds when measuring how much ice is being lost from Antarctica and contributing to global sea-level rise.

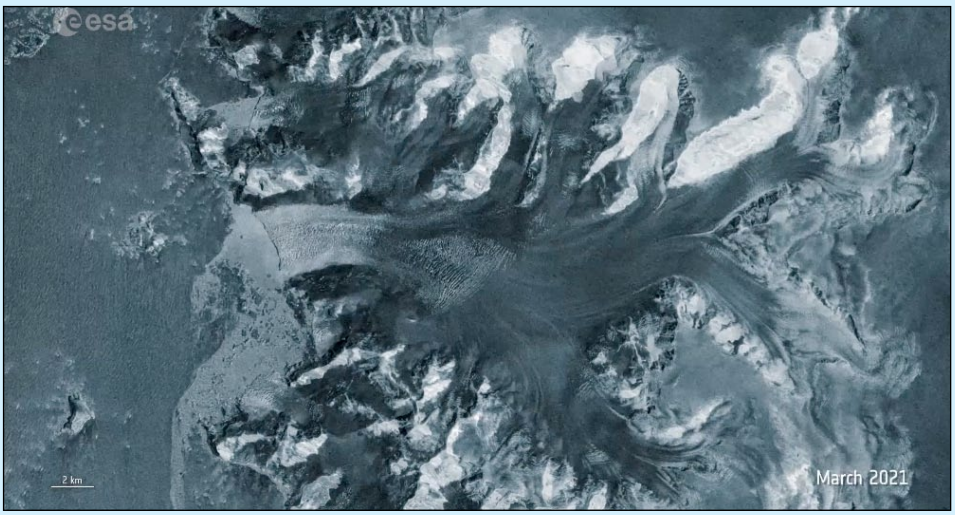
"The Antarctic Peninsula has seen some of the most rapid warming of any region on Earth. Continuing work like this will help glaciologists monitor how quickly change is occurring, enabling accurate assessments of how Earth's ice will respond to climate change."

Thanks to its ability to acquire images regardless of day or night and in all weather conditions, the Copernicus Sentinel-1 radar mission is key to monitoring ice change in the polar regions. While there are still two more Sentinel-1 satellites to launch in this family to continue the work of the first two satellites, other satellites in a new family of Copernicus Sentinel Expansion Missions are being built that will take polar monitoring farther into the future.

ESA's Craig Donlon noted: *"This study highlights how high-resolution satellite images can help us monitor how the environment is changing in remote regions. Future satellites, such as the family of Copernicus Sentinel Expansion Missions, promise to bring enhanced continuity and capabilities that will spearhead further insight into the characteristics and processes governing ice mass balance and sea-level rise."*

Reference

1 Widespread seasonal speed-up of west Antarctic Peninsula glaciers from 2014 to 2021 https://www.nature.com/articles/s41561-023-01131-4



Radar image of the Trooz Glacier on the Antarctic Penisula in 2021
Image: ESA

You can view a video of the Trooz glacier in motion at the link below.

https://dlmultimedia.esa.int/download/public/videos/2023/02/053/2302_053_AR_EN.mp4

Nishinoshima Island, Japan

European Space Agency

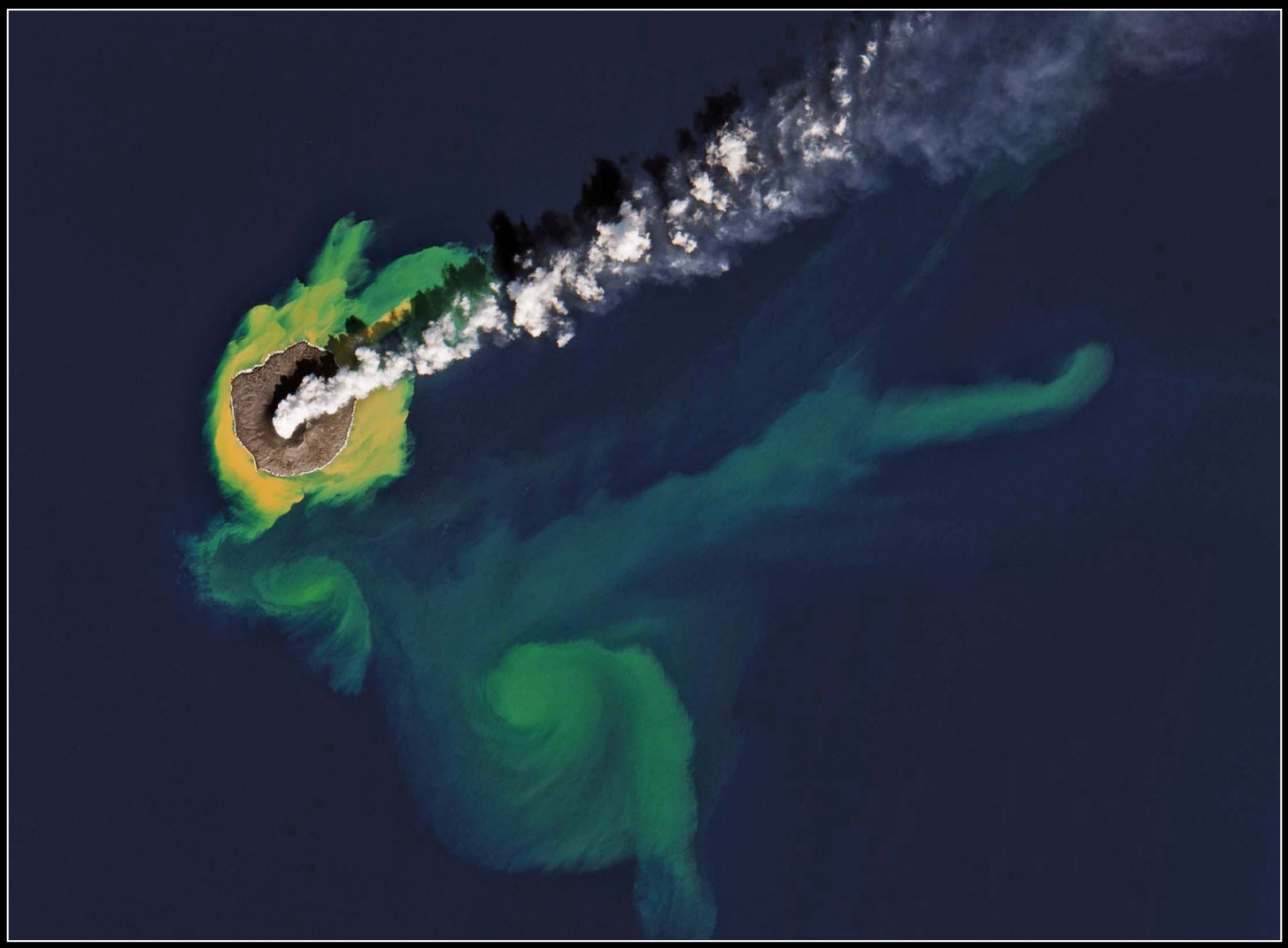


Image contains modified Copernicus Sentinel data (2021), processed by ESA, CC BY-SA 3.0 IGO

This Copernicus Sentinel-2 image features the Japanese island of Nishinoshima, in the northwest Pacific Ocean. One of the Ogasawara Islands, Nishinoshima is a small uninhabited volcanic island roughly 1000 kilometre south of Tokyo. Volcanic activity along the western edge of the Pacific Ring of Fire gave rise to this island, which is in fact the tip of a submerged volcano.

Until 1974, only a part of the ridge of the otherwise submerged caldera was visible, and the island was about 700 metres long and 200 metres wide. Since then, Nishinoshima has experienced alternating periods of explosive activity and calm, but lava from various eruptions over the years has led to the island growing bigger. In this image, acquired in January 2021, the island measured around 2.3 kilometres in the north-south direction and 2 kilometres in the east-west direction.

The yellowish discolouration of the water around the island is due to volcanic minerals, gas and seafloor sediment that is being stirred up by the volcanic activity. It stretches for about 10 kilometre to the southeast, where ocean currents turn it into bright green swirls.

A plume of gas and steam can be seen rising from the volcano and drifting northeast over the Pacific Ocean. As the plume rises higher, the steam condenses and forms clouds.

Volcanic plumes are of particular concern to the airline industry because ash can contaminate oxygen supplies and damage jet engines. Atmospheric sensors on satellites can identify the gases and aerosols released by eruptions, quantify their wider environmental impact and can help provide early warnings to the aviation industry.

Satellite data can also be used to better understand volcanic activity. Optical and radar instruments can image lava flows, mudslides, ground fissures and earthquakes, and be used to assess damage.

Saving a Forest of One

NASA Earth Observatory

Story by Adam Voiland

When viewed from hundreds of kilometres above Earth, this patch of aspen foliage in south-central Utah looks somewhat ordinary (figure 1). But the leaves belong to a colony that is actually quite extraordinary. More than 40,000 genetically identical trees are connected by a common root system, and are part of a single massive organism, a male **quaking aspen** (*Populus tremuloides*), that scientists have named Pando, which means 'I spread' in Latin.

In the fall image (figure 2), acquired with the Operational Land Imager-2 (OLI-2) on Landsat 9, Pando's yellow leaves are visible for about 200 metres on either side of State Route 25 just west of Fish Lake. The darker green forested areas surrounding it are dominated by evergreen trees, including spruce and fir. Many of the other yellow areas in the image are aspen stands that are not part of Pando.

Pando's trees and root system span 106 acres (43 hectares) and weigh 5900 tonnes. That is roughly the size of 80 American football fields and the weight of 15 jumbo jets, making Pando among the largest and heaviest land organisms on the planet. (Offshore, sea grass and coral reefs also grow to vast sizes, but most likely do not carry the immense weight of Pando.)

The precise age of Pando's root system is difficult to determine. But scientists think the aspen seed that started the plant sprouted several thousand years ago, perhaps even as long as 14,000 years ago as ice retreated from the Fish Lake Valley after the height of the last glacial maximum. Since sprouting, that seed has grown and spread by sending up new shoots every spring from its root system. These shoots—sometimes called suckers or ramets—are recognised as trees as they grow to maturity. They typically persist for about 100 to 150 years before dying back, even as Pando sends up more shoots and lives on.

Figure 1 - Pando, imaged on August 11, 2021 by Landsat 9
NASA Earth Observatory image by Lauren Dauphin using Landsat data from the U.S. Geological Survey

Figure 2 - Pando, imaged on September 28, 2021 by Landsat 9
NASA Earth Observatory image by Lauren Dauphin using Landsat data from the U.S. Geological Survey

But Pando has not been well in recent decades.

'It's dying,' said ecologist Paul Rogers, the director of the Western Aspen Alliance at Utah State University. '*Mule deer—and to a smaller degree cattle—frequent this area in such numbers that they are grazing on the young shoots and stopping them from getting*

Figure 3 - This photograph shows more growth of young stems on the inside (left side) of one section of fencing
Photo by Paul C. Rogers (Western Aspen Alliance)

established. If you think of Pando as a village, it's a village full of old people with very few children growing up to take their place.'

Rogers and a colleague from Utah State University first reported in 2018 that Pando was in trouble. Field measurements and a series of historical aerial photographs made clear that the forest had thinned considerably since the 1930s. In that study, and in an update published in 2022, Rogers reported that the only parts of Pando that were showing signs of regrowth were the parts that were fenced off from deer and cattle. The photograph above, taken by Rogers, shows more growth of young stems on the inside (left side) of one section of fencing.

However, Rogers wonders about how large a role fences should play in trying to save Pando. '*Is fencing Pando off like a zoo animal the right solution'* he asked. '*We also need to look at things like predation and what can be done to keep deer populations at more sustainable levels to address the problem in a more comprehensive way.*"

For Rogers, the challenges and management questions don't end at Pando's edges. '*Pando, though charismatic and fascinating, is a microcosm for much bigger, more global issues,*' he said. '*We have to think not just about Pando, but about how we keep aspens—forests more broadly—all over the world healthy and thriving as the climate changes and people put increasing pressure on ecosystems.*'

That is going to require a change in perspective that expands far beyond Pando or this one part of Utah, he added. "This Landsat image is a reminder of how small even one of the world's largest organisms is from a planetary perspective. We're going to need monitoring and conservation of aspen forests on a global scale.'

Smoke from Canadian Fires reaches Europe

Copernicus Image of the Day

Canada is currently experiencing an extremely severe fire season, which is having far-reaching consequences. The smoke plume generated by the fires has not only blanketed the skies over North America but has also begun to reach as far as northern Europe on 23 May. A notable instance occurred on 25 May, when one of the Copernicus Sentinel-3 satellites captured the smoke cloud over Norway, Sweden, and Denmark.

Data from the Copernicus Atmosphere Monitoring Service provide high-resolution forecasts of air quality in Europe.

Credit: European Union, Copernicus Sentinel-3 imagery

Mayotte's Lagoon

NASA Earth Observatory

Story by Emily Cassidy

Millions of years ago, during the Miocene Epoch, a series of volcanic eruptions created a chain of islands in the Indian Ocean between Madagascar and the African mainland. These islands are now known as the Comoros archipelago.

The oldest and easternmost islands in the archipelago comprise a territory known as Mayotte. Mayotte consists of two principal islands, the main island (known as Grande Terre) and a smaller island to the east, known as Pamandzi or Petite Terre.

The image shown in figure 1, captured by the Operational Land Imager (OLI) on Landsat 8, shows the main island in the centre of an outer ring of barrier reefs and small islets, which form a lagoon rich in marine biodiversity. Corals and mangroves fringe the coasts of the main island.

Mayotte's lagoon is home to a diversity of marine life, including corals, clownfish, and green sea turtles. But overfishing and coral bleaching threaten the health of the ecosystem. A 2022 study of corals in the western Indian Ocean found that the Comoros islands corals were at risk of collapse in response to warming water temperatures. A marine park, which covers all of Mayotte and surrounding waters, was established in 2010 to protect its aquatic life.

A string of volcanic mountains span the length of the main island. The tallest peak is Mount Bénara, altitude 660 metres and just south of it stands the island's second-tallest summit, Mount Choungui (593 metres) (figure 2). Both of these mountains are home to several species of birds that are vulnerable to extinction, including the yellow-billed Comoros olive pigeon (*Columba pollenii*) and the glossy black Mayotte drongo (*Dicrurus waldenii*).

Geologic activity continues to shape these islands. Although the islands went many years without significant earthquakes and volcanic eruptions,

Figure 1 - Landsat 8 image of Mayott and its encircling lagoon
NASA Earth Observatory images by Lauren Dauphin
Using Landsat data from the U.S. Geological Survey

Figure 2 - Landsat 8 image of Mayott and its encircling atoll
NASA Earth Observatory images by Lauren Dauphin
Using Landsat data from the U.S. Geological Survey

multiple earthquakes a day shook Mayotte between May 2018 and July 2019, and more than a dozen in that year were of magnitude five or more. Landslides and other natural hazards followed the earthquakes. The cause, scientists discovered, was the birth of an undersea volcanic ridge and edifice, just 5 kilometres east of Pamandzi. Using data from the global navigation satellite system (GNSS), scientists learned that this seismic activity caused the main island of Mayotte to shift eastward by between 21 and 25 centimetres and sink approximately 10 to 19 centimetres.

The capital of Mayotte, Mamoudzou, is located on the eastern coast of the main island and looks across a two kilometre channel to Pamandzi. Most of Mayotte's population of 310,000 live on the main island, but the airport is located on southern tip of Pamandzi, shown in **figure 3**.

A lake on Pamandzi, called Dziana Dzaha, stands out as a bright green oval in the north. Dziana Dzaha is a crater lake with salt concentrations higher than those of seawater. The salty, oxygen-poor lake is considered a modern analogue to environments of the Precambrian, when multi-cellular life began to form. Researchers have studied the lake to understand the types of microbes that flourish in extreme environments.

Figure 3 - Landsat 8 image of Mayott and its encircling atoll
NASA Earth Observatory images by Lauren Dauphin
Using Landsat data from the U.S. Geological Survey

Unseasonal high Temperatures in Greenland

Les Hamilton

Readers in the UK and western Europe will recall the intense cold snap in early March this year when Arctic air swept south bringing the heaviest snowfalls and coldest freezing temperatures for this month in over a decade. By contrast, southwest Greenland was experiencing a most unseasonable heatwave, with air temperatures more than 20°C above the historical average for this time of year. On March 4, when the Sentinel-2 image below showing Nuuk, the Greenlandic capital, was acquired, the temperature reached a record of 15.1°C, the highest March temperature ever recorded in this area of Greenland.

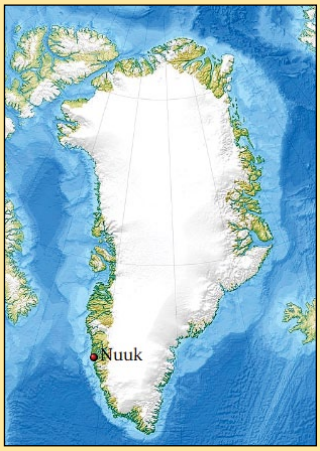


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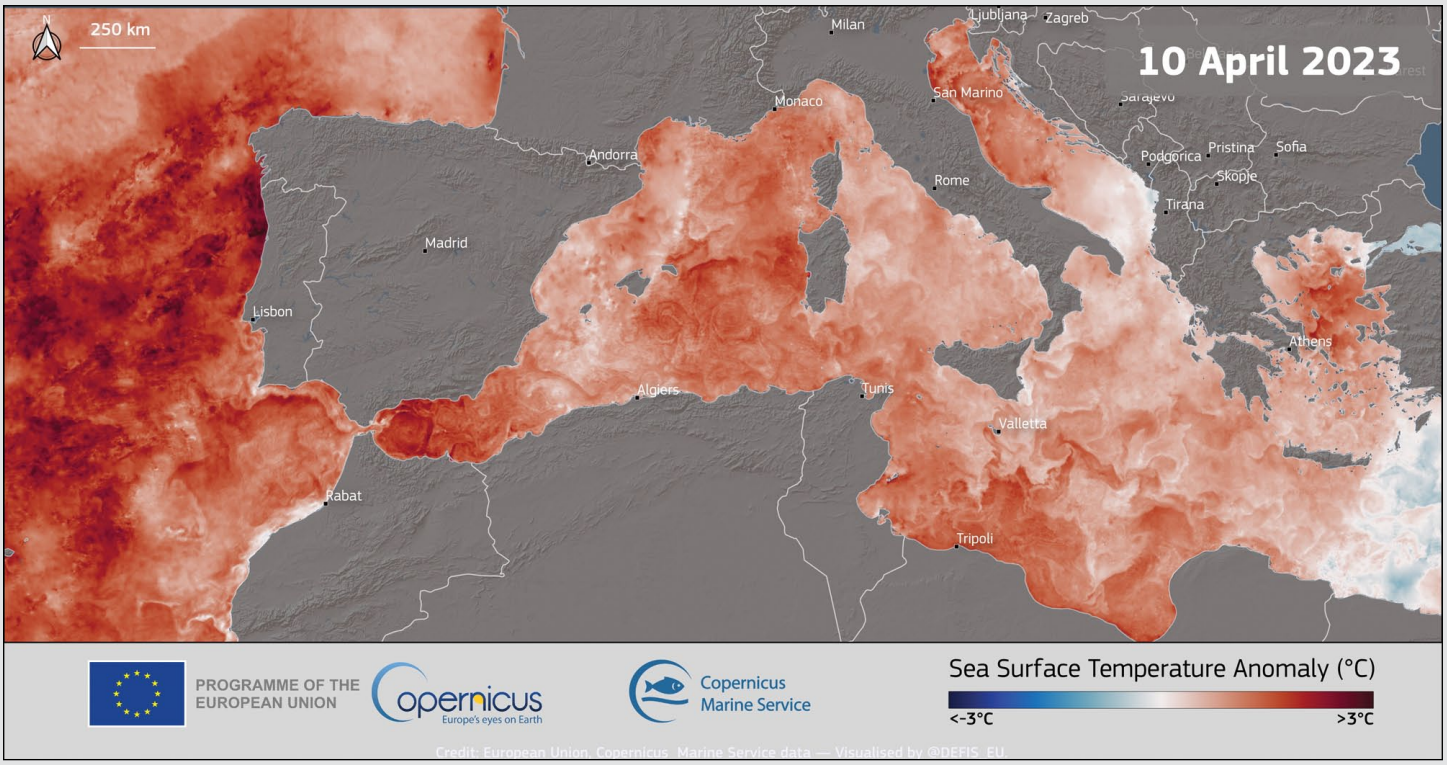
Image Credit: European Union, Copernicus Sentinel-2 imagery

There was a heavy overnight snowfall over northern Scotland on March 7, 2023

Unprecedented Sea Surface Temperatures of Global Oceans

Copernicus Image of the Day



Credit: European Union, Copernicus Marine Service data

This image illustrates the Sea Surface Temperature (SST) anomaly in the Mediterranean Sea and off the Atlantic coasts of the Iberian Peninsula and North Africa, using data from the Copernicus Marine Service. The visualisation highlights that the SST anomalies reached around +3°C above the reference value on 10 April.

These findings echo preliminary data from the United States' National Oceanic and Atmospheric Administration (NOAA), which revealed that the global average Sea Surface Temperature has hit an all-time high (since satellite records began). In particular, the ocean's surface reached a temperature of 21.1°C at the beginning of April, beating the previous high of 21°C set in 2016.

Great Salt Lake level rises after record-breaking snowfall

Copernicus Image of the Day

This image, acquired by one of the Copernicus Sentinel-2 satellites on April 10, 2023, shows the Great Salt Lake in Utah, USA.

The Great Salt Lake was at its lowest level ever in November 2022 as a result of months of record-breaking drought. However, thanks to a record snow pack since early 2023, the lake rose by over one metre in just a few days. The statewide average snow pack in the area reached 76.2 cm, beating the previous record of 73.2 cm recorded in 1952.

Copernicus satellite data enables the monitoring of snow cover around the globe and contributes to hydrological monitoring by providing valuable information on the state of water resources.

Credit: European Union, Copernicus Sentinel-2 imagery

Shrinking Lake Urmia

MODIS Web Image of the Day

Seated near the Zagros Mountain range in northwestern Iran, Lake Urmia was once the second-largest lake in the Middle East, supporting a rich ecosystem filled with fish, birds, and plants, and held shores studded with tourist centres and hotels. Concerns about how excessive water use and drought might affect the lake were expressed as early as the 1970s. Only eight permanent rivers flow into the lake, and more than 50 dams have been constructed on those rivers, severely reducing water flow into the lake.

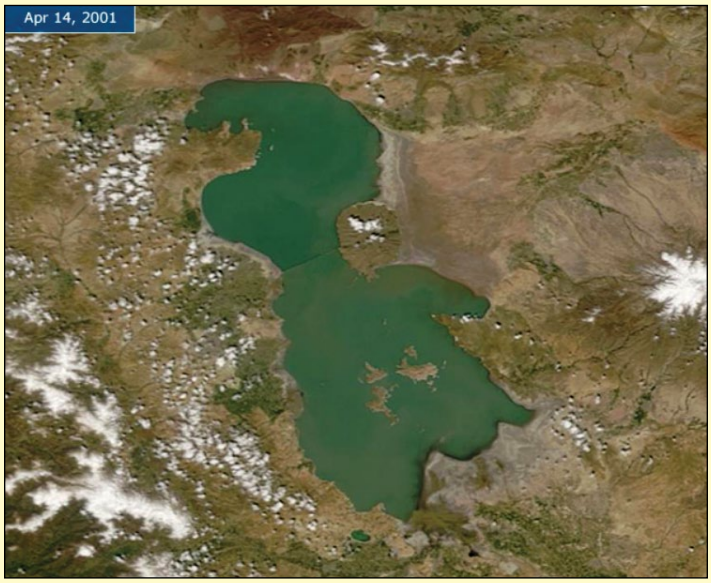
In 2015, estimates from satellite imagery showed that the lake had lost about 88% of its size between 2006 and 2015. In 2016, Scientific American published an interview with Iranian botanist Hossein Akhani, who described the changes he had seen over years visiting the lake.

In 1987, he first visited to perform studies in the saline waters of Lake Urmia. When asked when he realised that the lake was shrinking, he replied,

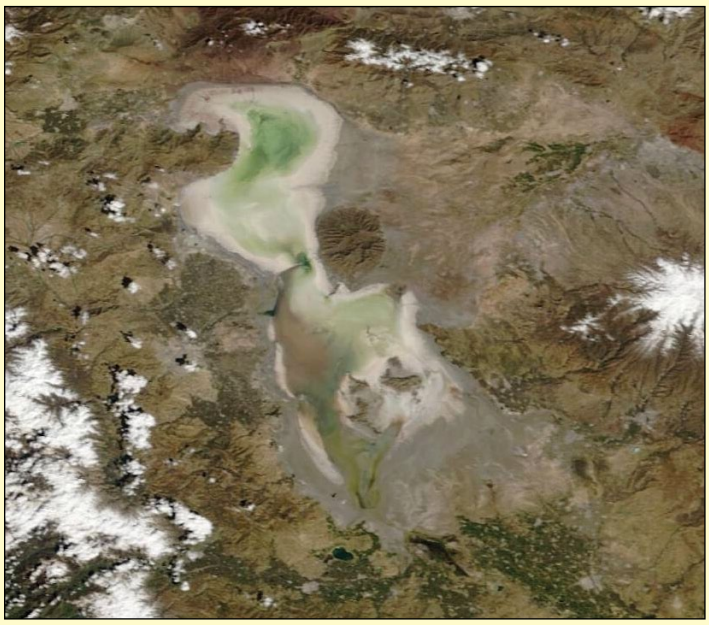
> *"In 2001, when I visited the northeastern part of the lake to collect plants, I saw that the lake wss receding and there were many areas where the salt was exposed to earth. It was completely different from what I saw in 1987."*

Lake Urmia has continued to shrink, and today is barely a mineral-encrusted remnant of its former self. The complete loss of this lake would be tragic in many ways, from the flamingos who feed on the unique crustaceans that live in the saline waters, to the loss of biodiverse wetlands, to the damage to agriculture in the basin. In addition, the mineral crust and bottom sediments contain not only salt, but heavy toxic metals used in industry and toxic agricultural substances. As the lakebed becomes exposed and desiccated, these may become airborne and pose a risk to the environment and people.

In response to the shrinking of this valuable resource, the Urmia Lake Restoration National Committee (ULRNC) was established in 2013 to study and fund a response to slow water loss and try to restore at least some water to the lake. In 2016, the Committee approved more than 80 projects in the basin, including release of water from dams and plans to create a canal to bring water into Urmia. In mid-February 2023, a long-delayed project designed to divert water from the Kanisib Dam in the West Azarbaijan province finally began to carry water. The project consists of a 40 kilometre long tunnel and 17 kilometre long canal, and promises to bring at least a little water to the shriveling lake.



Lake Urmia, imaged by NASA's Terra satellite on April 14, 2001
Image: MODIS Land Rapid Response Team, NASA GSFC



Lake Urmia, imaged by NASA's Terra satellite on March 29, 2023
Image: MODIS Land Rapid Response Team, NASA GSFC

The Moderate Resolution Imaging Spectroradiometer (MODIS) on board NASA's Terra satellite acquired two true-colour images of Lake Urmia, one on March 29, 2023, and an earlier one on April 14, 2001. The two images illustrate the dramatic changes over time. In the center of each image is a dark round area. This is an inactive volcano. At one time, Lake Urmia completely surrounded the volcano, so that visitors would have to take a boat to reach it. Even in the earlier 2001 image, waters had already receded so dramatically that the volcano would be easily accessible by any tourist, with no risk of getting their shoes damp.

Heavy Rains Hit Drought-Stricken Horn of Africa

NASA Earth Observatory

Story by Emily Cassidy

Flash flooding from heavy rains killed dozens and affected 300,000 people in Ethiopia and Somalia in March 2023. The damaging flooding came after the region had experienced almost three years of extreme drought.

In the first 25 days of March, parts of Ethiopia received 5 to 10 centimetres more rain than is usual for the period, according to a report from **Crop Monitor**. The Crop Monitor is part of the **Group on Earth Observations Global Agricultural Monitoring Initiative** (GEOGLAM), which uses satellite data and modelling to produce early warning reports for food shortages.

The above-average rainfall ushered in an early start to the long **Gu Rains**, which occur in March, April, and May in Eastern Africa. These long rains typically contribute up to 60% of the total annual rainfall to the Horn of Africa and play a big role in agricultural productivity.

> *"Normally, the long rains begin in Kenya and move north to Ethiopia and Somalia,"* said Caroline Wainwright, a climate scientist at Cardiff University in the United Kingdom. *"But this year, the rains started concurrently, and the final two weeks of March were incredibly wet in all three countries."*

Moderate to heavy rains in the Ethiopian highlands overtopped banks of the Shabelle and Juba rivers. Homes, schools, and health facilities were destroyed along the banks of the two rivers, in southern Somalia and eastern Ethiopia, according to the **United Nations Office for the Coordination of Humanitarian Affairs** (UN OCHA).

Figure 1 - This MODIS image from NASA's Terra satellite shows the Shabelle River in the Somali region of Ethiopia on March 11, prior to the flooding
NASA Earth Observatory image by Lauren Dauphin, using MODIS data from NASA EOSDIS LANCE and GIBS/Worldview.

Figure 2 - The same region as imaged by NASA's Terra satellite following the rains on April 9, showing the flooding
NASA Earth Observatory image by Lauren Dauphin, using MODIS data from NASA EOSDIS LANCE and GIBS/Worldview

Flooding along the Shabelle River in the Somali region of Ethiopia can be seen in the figure 2, acquired by the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite. The image is false colour which makes the water (dark blue) stand out from its surroundings. Vegetation is green and bare ground is brown. Figure 1 shows the same area on March 11, 2023. In the photograph on the following page, taken by an astronaut aboard the International Space Station on April 1, 2023, sediment-rich floodwater can be seen overtopping the banks of the Shabelle River near the Ethiopia-Somalia border.

Astronaut photograph ISS069-E-422 was acquired on April 1, 2023, with a Nikon D5 digital camera using an 400 millimetre lens and is provided by the ISS Crew Earth Observations Facility and the Earth Science and Remote Sensing Unit, Johnson Space Center. The image was taken by a member of the Expedition 69 crew.

The Horn of Africa has seen almost three years of some of worst drought conditions in history, according to the **Famine and Early Warning Systems Network** (FEWS NET). Ethiopia and Somalia have experienced five failed rainy seasons since late 2020, which have displaced 1.4 million Somalis and killed 3.8 million livestock. During this time the Shabelle-Juba river basins saw their lowest rainfall totals since 1981.

"This flooding doesn't just undo three years of drought," stated Wainwright.

Her recent research into the drivers and impacts of rainfall variability in East Africa found that, from the mid-1980s to 2010, the long rains have been getting drier. In fact, the research team's analysis of climate projections found that the short rains could deliver more rainfall than the long rains by 2030–2040.

More than 1,000 hectares of cropland have been swamped by recent rains, challenging the agricultural economies in Ethiopia and Somalia. Agriculture employs 67% and 80% of people in these countries, respectively, and much of the farmland in the region is rain-fed. Although rainfall can provide some relief, intense rainfall following extensive drought can wash away crops and topsoil. Most of the farms in the area also lack the infrastructure to store water for future use.

Even with the unexpectedly early and heavy rains this March, climate models project that the long rains this year will be drier than normal and drought conditions are likely to continue.

Cloud Streets over Labrador Sea

MODIS Web Image of the Day

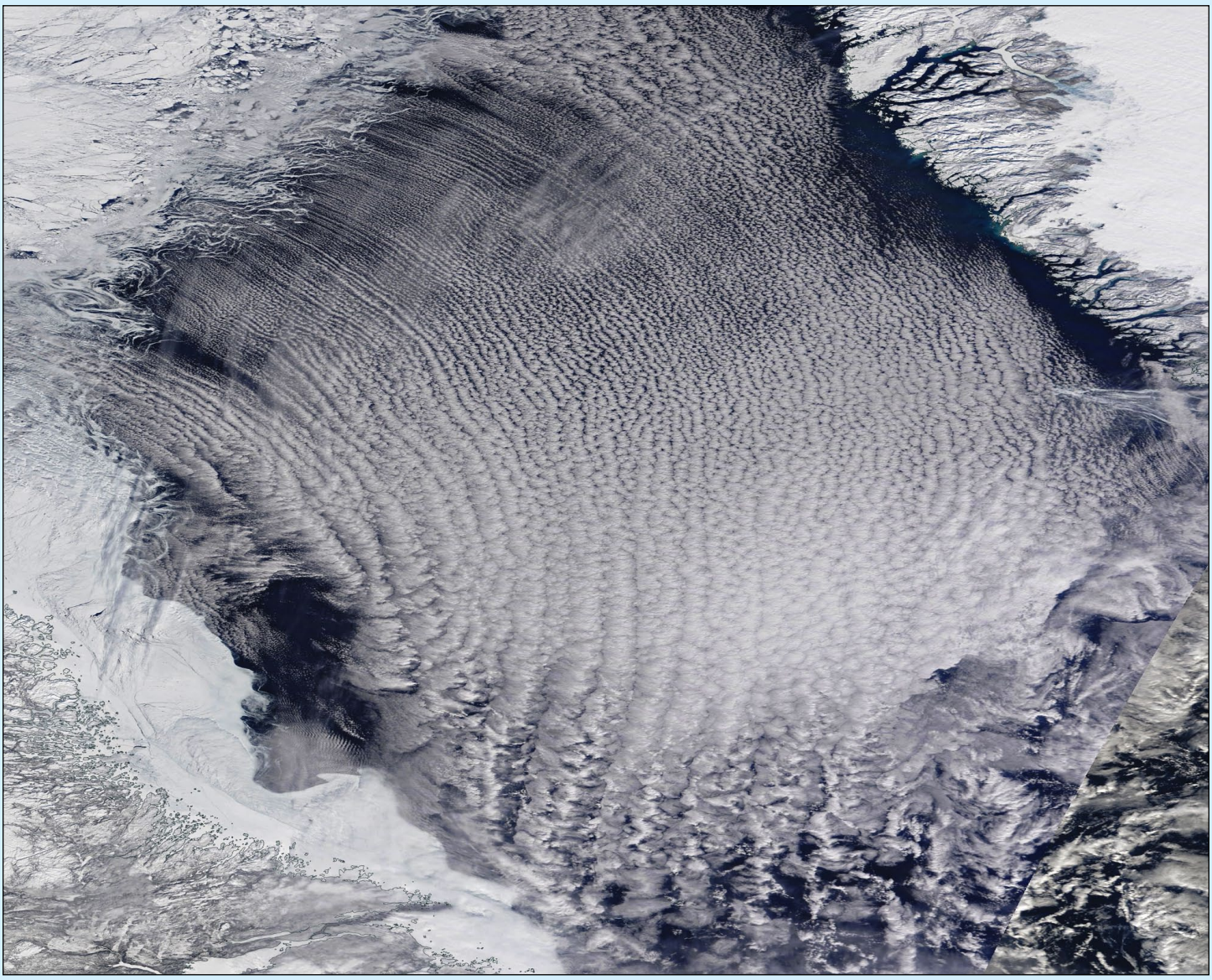


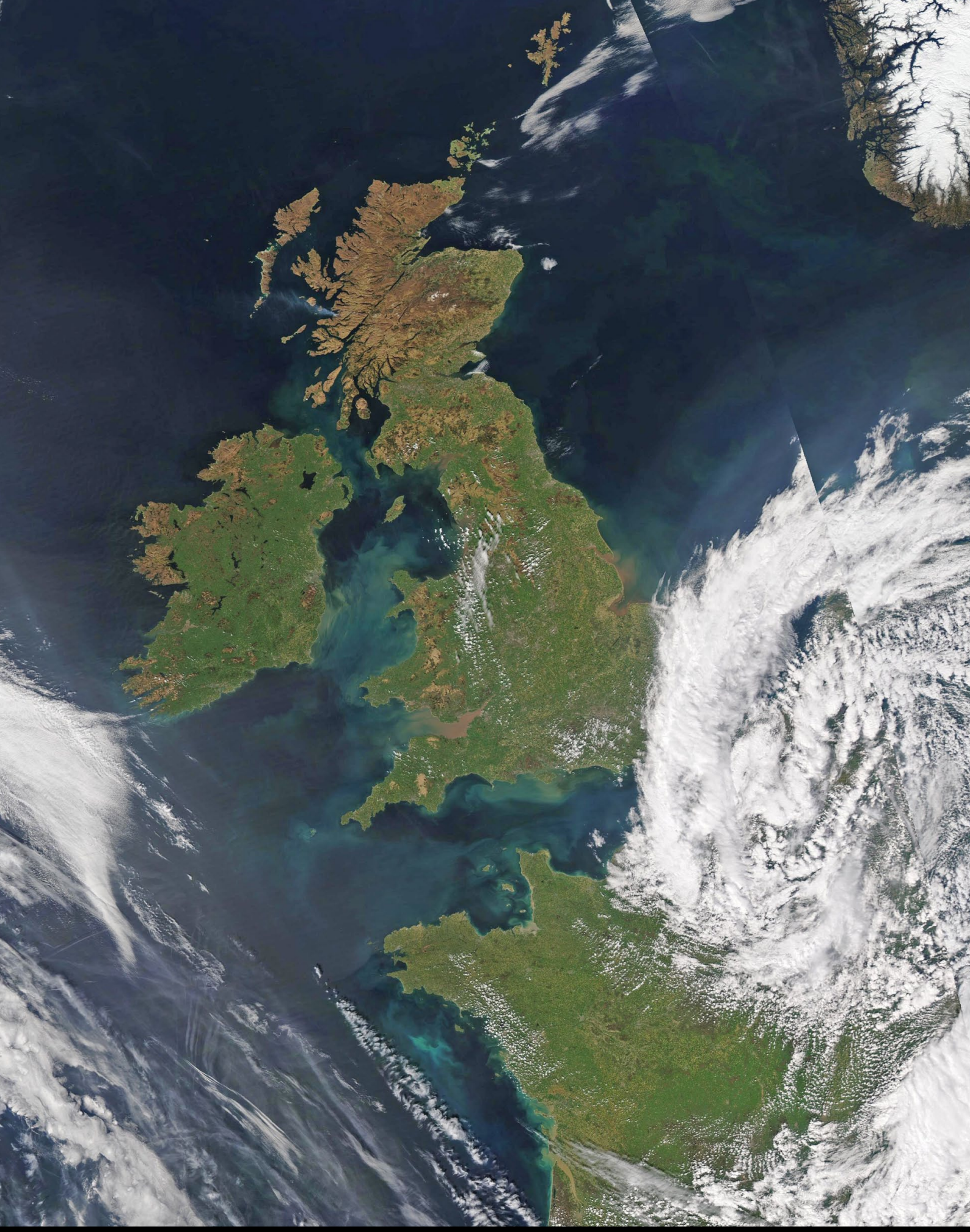
Image Credit: MODIS Land Rapid Response Team, NASA GSFC

On March 23, 2023, the Moderate Resolution Imaging Spectroradiometer (MODIS) on board NASA's Terra satellite captured this true-colour image of a spectacular cloud formation above the Labrador Sea.

The Labrador Sea is flanked by Canada's Labrador Peninsula in the southwest and Greenland in the northeast. It is part of the North Atlantic Ocean and connects to the Arctic Ocean via various straits and bays to the north. Springtime brings big changes to the region, as fast ice—ice which clings to shore—and floating sea ice begin to melt as daylight lengthens. Despite warming air temperature, strong winds often blow from the north, carrying bitterly frigid air. Both the melting ice and frigid air can create beautiful patterns when viewed from space.

In this image, the sheets of fast ice clinging to the Labrador Peninsula are edged with delicate filigrees. These delicate patterns are created by the interaction of thin ice floating over moving currents and waves.

The predominant pattern, however, consists of the long, parallel bands of white that stretch across the Labrador Sea. Called 'cloud streets', this type of cumulus cloud is common during the spring, when cold, dry air blows over comparatively warmer water. The clouds form at the top of parallel cylinders of rotating air, created by rising warm, moist air. On the upward-rotating side of the cylinders (rising air), water vapour condenses and forms clouds. Along the downward-rotating side (descending air), skies remain clear. The streets form along the direction of the prevailing wind.



Following a chilling winter and early spring, the British Isles enjoyed a summer-like respite for five days in mid April when High Pressure settled over the North Sea bringing day-long sunshine and warm temperatures. NASA's Aqua satellite imaged the final day of this spell as rain clouds approached England from the east.
Image: NASA Worldview Snapshots (https://wvs.earthdata.nasa.gov)

A Salty Desert Retreat

NASA Earth Observatory

Story by Lindsey Doermann

The salty Siwa Oasis is one of five large oases scattered across Egypt's Western Desert, a vast sandy expanse that is part of the Sahara. Situated about 50 kilometres east of the Libyan border and nearly 600 kilometres west of Cairo, the region averages only about 10 millimetres of rainfall annually. However, owing to its unique geology, there is currently enough water to support agriculture, tourism, and salt harvesting operations.

The oasis has sustained settlements dating as far back as ancient Egypt's 26th dynasty in the 6th century BCE. Travellers to the area today can visit, among other ruins, the temple where Alexander the Great was said to be pronounced the son of the deity Amun. They may also delight in bobbing in the dense waters of its many salt ponds.

Figure 1 shows several lakes and nearby springs amid the arid environment. It was captured on January 23, 2023, by the **Operational Land Imager-2 (OLI-2) on Landsat 9**. The array of lakes exists here because of a tectonically formed depression that reaches depths of 20 metres below sea level. Surface water in the depression is supplied by springs that are fed by shallow groundwater, which in turn is supplied with water from the **Nubian Sandstone Aquifer System** (NSAS)—one of the largest aquifers in the world.

Cultivated land, primarily used to grow olives and date palms, is visible in figure 2 as the dark areas abutting the lakes. The extraction of water through wells for irrigation has caused the surface area of the Siwa lakes to fluctuate significantly.

Researchers monitoring the Siwa region via remote sensing over the past several decades have found that the surface area of the lakes and the extent of waterlogged land generally increase in tandem with agricultural activity. Drainage in the Siwa area is poor, so agricultural runoff and excess irrigation water pumped from wells tend to pool. Changes to well design and water management have helped to mitigate these issues.

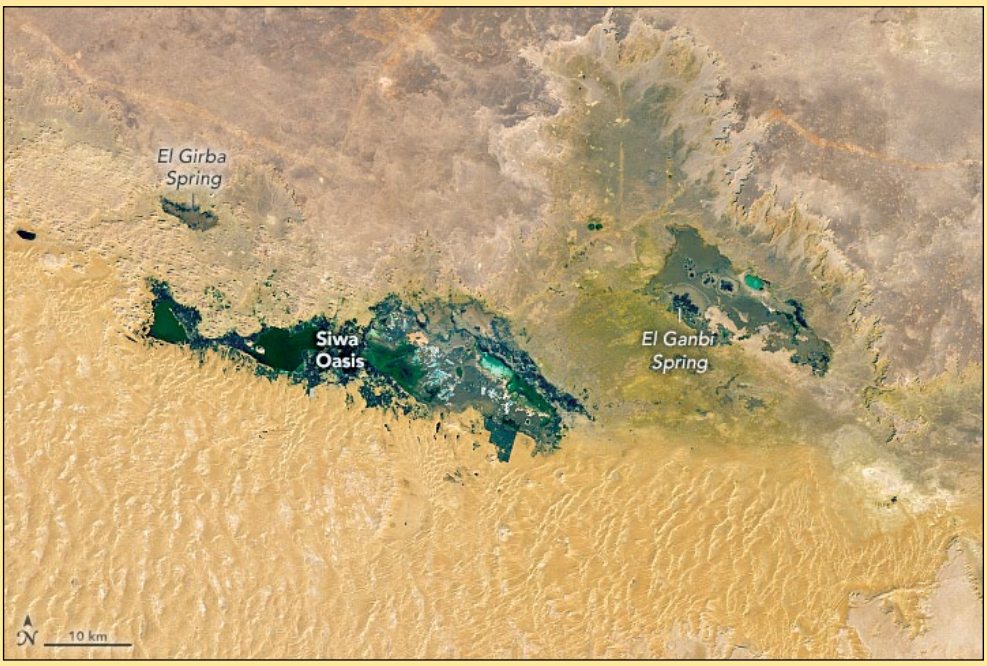


Figure 1 - The Siwa oasis, imaged by the Operational Land Imager-2 (OLI-2) aboard Landsat 9 on January 23, 2023
NASA Earth Observatory images by Lauren Dauphin, using Landsat data from the U.S. Geological Survey.

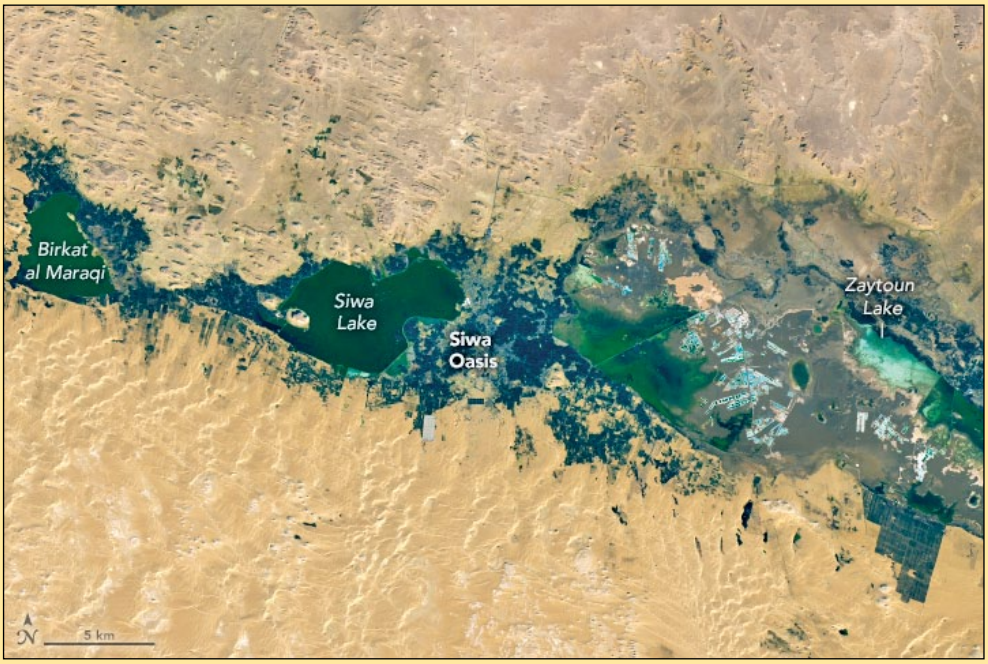


Figure 2 - The Siwa oasis, imaged by the Operational Land Imager-2 (OLI-2) aboard Landsat 9 on January 23, 2023
NASA Earth Observatory images by Lauren Dauphin, using Landsat data from the U.S. Geological Survey.

But water is only part of Siwa's story. The area is rich in salt deposits, which is evident in this detailed view of evaporation ponds used for salt harvesting (figure 3, on next page).

Near-surface groundwater has high salt content and contributes to salt accumulation in the topsoil. Water from the deep aquifer, while suitable for irrigation, still contains some salt and contributes to soil salinity when it's applied to cropland.

The accumulation of salts in the soil and groundwater has had a profound impact on crop yield. For example, one study reported that olive and date palm yields decreased about 46% and 55%, respectively, from 2000 to 2011. Researchers have proposed establishing a surface drainage network to sustain more agriculture.

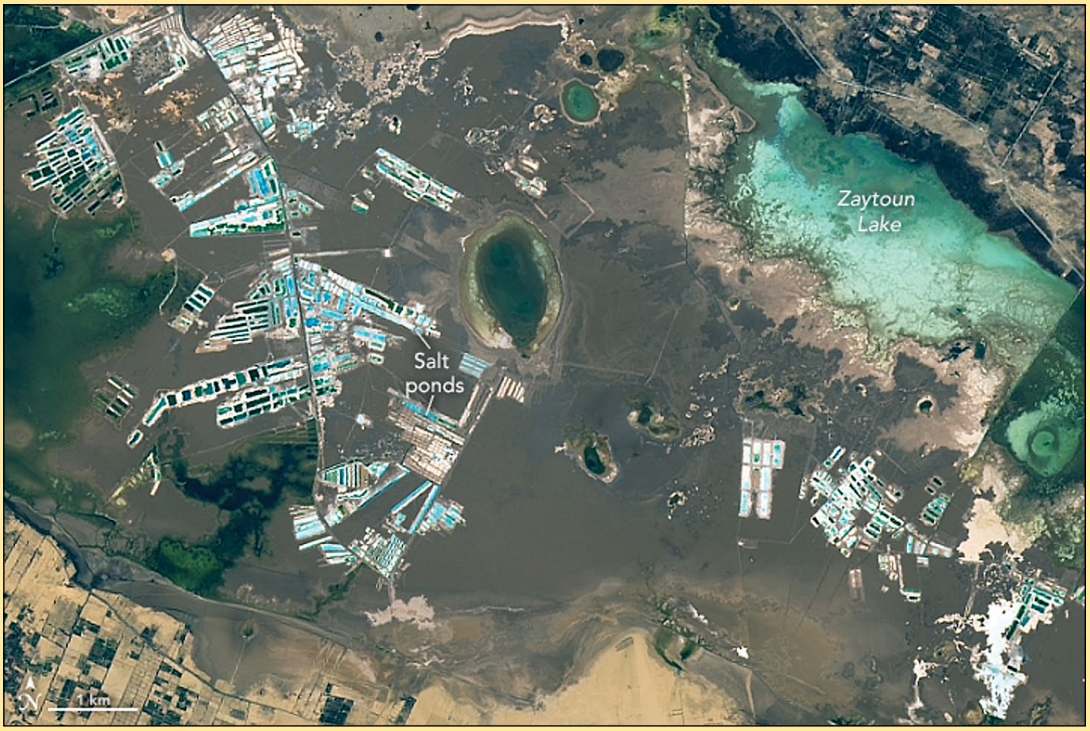
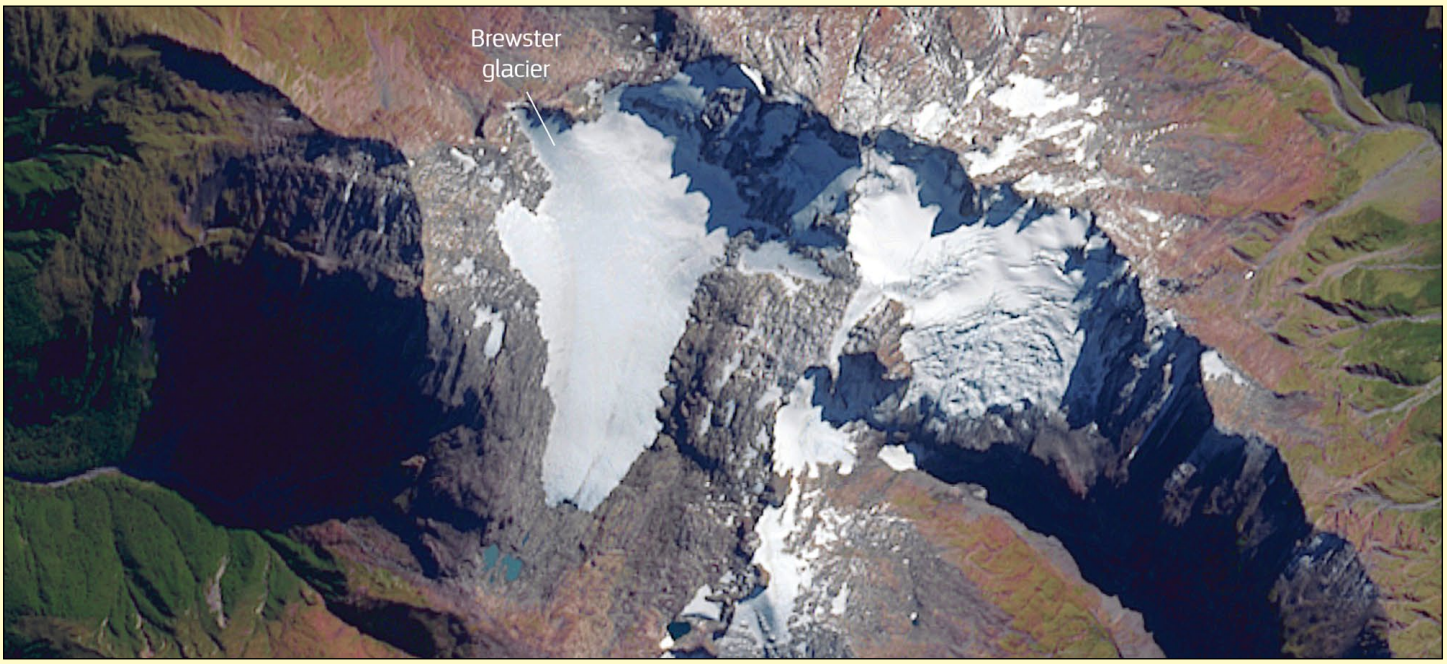


Figure 3 - Evaporation ponds in the Siwa oasis, imaged by the Operational Land Imager-2 (OLI-2) aboard Landsat 9 on January 23, 2023
NASA Earth Observatory images by Lauren Dauphin, using Landsat data from the U.S. Geological Survey.

Glaciers in New Zealand threatened by Climate Change

Copernicus Image of the Day



Credit: European Union, Copernicus Sentinel-2 imagery

The glaciers in New Zealand are rapidly retreating due to the effects of climate change, and it is predicted that many of them will vanish within the next decade. Among those at risk is the Brewster Glacier, which can be seen in this image acquired by one of the Copernicus Sentinel-2 satellites on 22 March, 2023. According to the scientists at the *National Institute of Water and Atmospheric Research* (NIWA) who monitor the glacier, it has lost its distinctive 'happy, living' features. The annual snow line survey conducted by NIWA highlights the alarming rate of melting and the fact that it poses a serious threat to the environment, water resources, as well as local communities and wildlife that depend on the glaciers.

The Copernicus Sentinel satellites are essential tools for monitoring the changing conditions of the world's glaciers.

Contrails Crisscross the Iberian Peninsula

MODIS Web Image of the Day

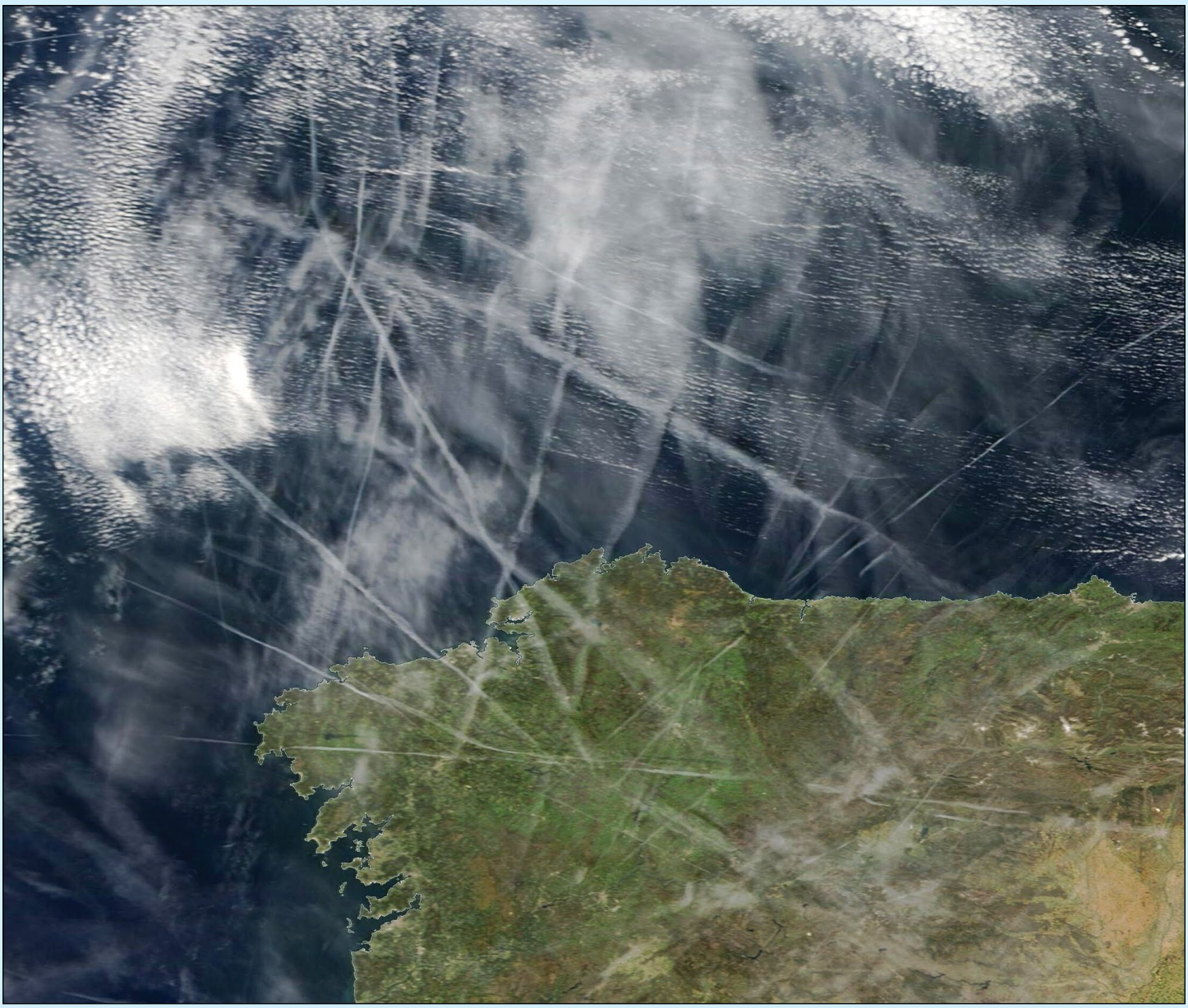


Image Credit: MODIS Land Rapid Response Team, NASA GSFC

Long streaks of cloud crisscrossed the skies over the Iberian Peninsula on April 7, 2023. The Moderate Resolution Imaging Spectroradiometer (MODIS) on board NASA's Terra satellite acquired this true-colour image of the complex pattern.

The streaks are a type of cirrus cloud known as a 'contrail'. Cirrus clouds typically form in the sky when humidity is high, but contrails form in the wake of passing aircraft due to particles and water vapour contained in their exhausts. The temperature and humidity of the air affects how long contrails last. When air is dry, contrails last just seconds or minutes; but when the air is humid, contrails can be long-lived. Young, freshly formed contrails appear like neat lines, with sharp and distinct sides. As contrails age, they spread outward until they become difficult to distinguish from naturally occurring cirrus clouds.

The complex set of contrails captured in this image is a mix of both young and older contrails that have formed in the wake of many different aircraft. Near the right side of the image, a few thin lines stretch from the northeast to the southwest, marking the youngest contrails. The majority, however, are older and appear as thick gray lines over the North Atlantic and passing over the coast of Spain. A group of fuzzy cloud-like areas located inland are most likely older contrails, while broad swaths of white over the North Atlantic are banks of clouds.

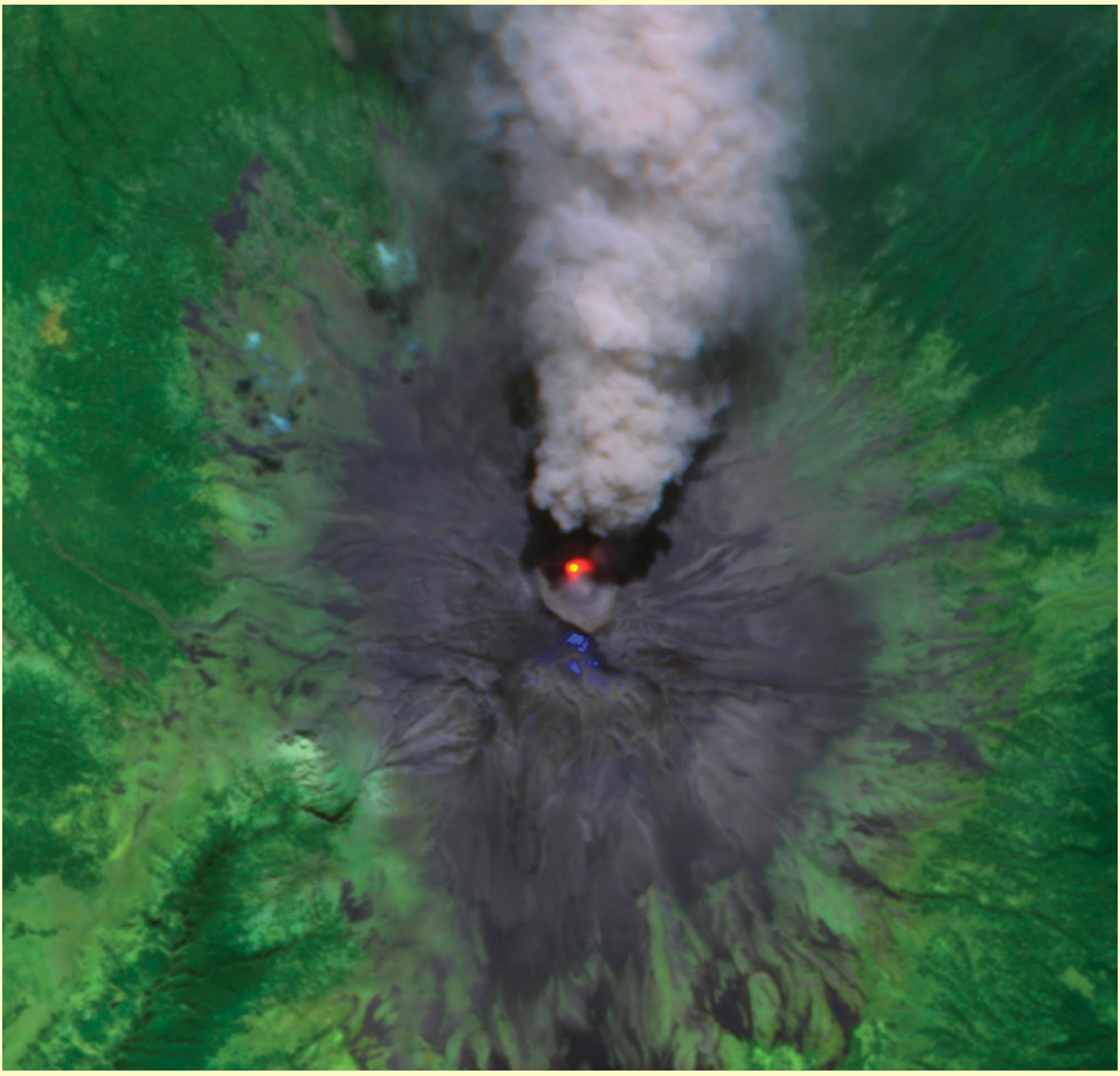
Volcanic Activity at Mexico's Popocatépetl Volcano

Copernicus Image of the Day

Popocatépetl is one of the most active volcanoes of Mexico. At the end of April 2023, its volcanic activity increased, with frequent explosions and emissions of ash and toxic gases. The National Centre for Disaster Prevention (CENAPRED) and the National Autonomous University of Mexico (UNAM) issued a yellow alert and advised people to stay away from the volcano.

This image, acquired by one of the Copernicus Sentinel-2 satellites on April 26, 2023 at 17:18 UTC, shows the volcano's emission plume and hot spots in the crater.

The Copernicus Sentinel-2 satellites play an important role in volcanic activity monitoring thanks to the Short-Wave InfraRed channels of their Multispectral Instrument. The high spatial resolution and an average revisit time of five days allow them to monitor different volcanic processes and improve hot-spot detection techniques.



Credit: European Union, Copernicus Sentinel-2 imagery

Tulips abloom in the Netherlands

Copernicus Image of the Day

Credit: European Union, Copernicus Sentinel-2 imagery

As spring arrives, the mesmerising tulip fields of the Netherlands burst into full bloom, adorning the European landscape with an impressive array of vibrant colours. This image, acquired by a Copernicus Sentinel-2 satellite on April 30, 2023, shows the breathtaking beauty of the blooming fields near Julianadorp, a picturesque village located in the province of North Holland known for its flowering fields.

The image catches just the tulips' hues of red, yellow and pink, which create a kaleidoscope of colours visible from space.

Copernicus plays a crucial role in agriculture by providing valuable crop monitoring and management data, such as identification of optimal planting times and tracking plant health, ultimately enhancing productivity and sustainability.

NASA Uses 30-Year Satellite Record to Track and Project Rising Seas

NASA Earth Data

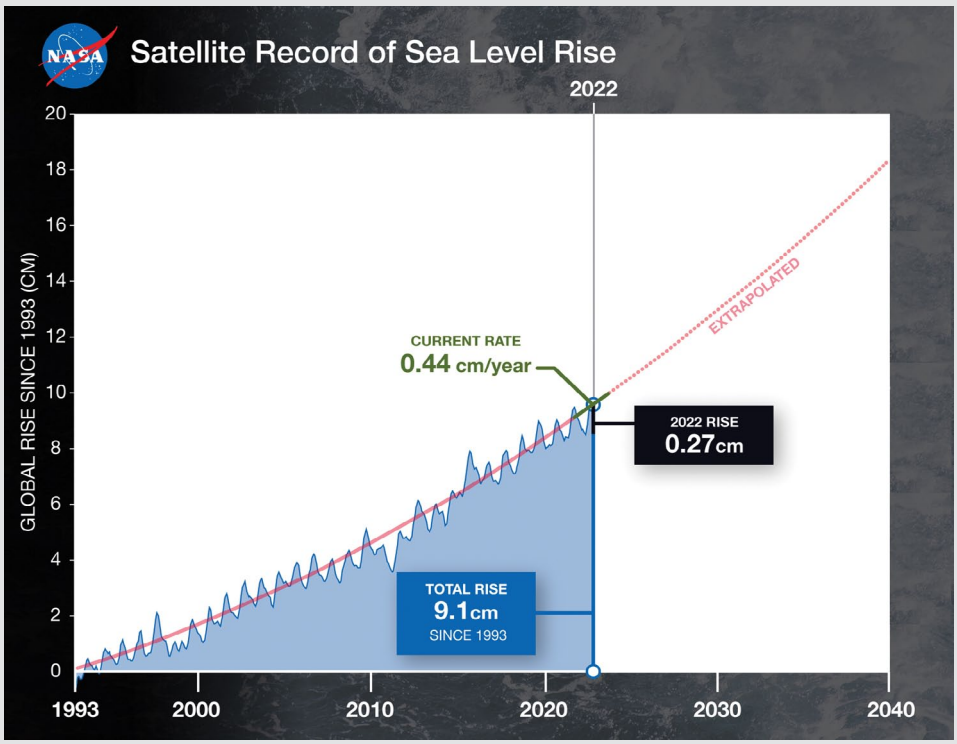
Observations from space show that the rate of sea level rise is increasing. Knowing where and how much rise is happening can help coastal planners prepare for future hazards.

The average global sea level rose by 0.27 centimetres from 2021 to 2022, according to a NASA analysis of satellite data. That's the equivalent of adding water from a million Olympic-size swimming pools to the ocean every day for a year, and is part of a multi-decade trend of rising seas.

Since satellites began observing sea surface height in 1993 with the U.S.-French *TOPEX/Poseidon* mission, the average global sea level has increased by 9.1 centimetres, according to NASA's *Sea Level Change* science team. The annual rate of rise—or how quickly sea level rise is happening—that researchers expect to see has also increased from 0.20 cm per year in 1993 to 0.44 cm per year in 2022. Based on the long-term satellite measurements, the projected rate of sea level rise will hit 0.66 cm per year by 2050.

The graphic above shows rising sea levels (in blue), obtained from data recorded by a series of five satellites starting in 1993.

"We have this clear view of recent sea level rise—and can better project how much and how quickly the oceans will continue to rise—because NASA and Centre National d'Études Spatiales (CNES) have gathered decades of ocean observations. By combining that data with measurements from the rest of the NASA fleet, we can also understand why the ocean is rising," said Karen St. Germain, director of NASA's Earth Science Division in Washington. *"These fundamental climate observations help shape the operational services of many other federal and international agencies who are working with coastal communities to mitigate and respond to rising waters."*



This graphic shows rising sea levels (in blue) from data recorded by a series of five satellites starting in 1993. The solid red line shows the trajectory of rise from 1993 to 2022, illustrating that the rate of rise has more than doubled.
By 2040, sea levels could be 3.66 inches (9.3 cm) higher than today.
Credits: NASA/JPL-Caltech

The 2022 increase was less than the expected annual rate because of a mild *La Niña*. During years with an especially strong *La Niña* climate pattern, average global sea level can even temporarily drop because weather patterns shift in a way that leads to more rainfall over land instead of the ocean.

"With an increasing demand for accurate and timely climate information, NASA is committed to providing annual sea level observations and future projections in order to help vulnerable communities around the world better understand the risks they face in a new climate," said Nadya Vinogradova Shiffer, a NASA program scientist for ocean science. *"Timely updates are key to showing which climate trajectory we are on."*

Despite natural influences like *La Niña*, sea levels continue to rise because of human-caused climate change driven by the excess amounts of greenhouse gases like carbon dioxide that society pumps into the atmosphere. Climate change is melting Earth's ice sheets and glaciers, adding more fresh water to the ocean, while warming causes the expansion of seawater. Both of these effects contribute to rising seas, overriding many natural effects on sea surface height.

"Tracking the greenhouse gases that we add to the atmosphere tells us how hard we're pushing the climate, but sea levels show us how much it's responding," said Josh Willis, an oceanographer at NASA's Jet Propulsion Laboratory in Southern California. *"These measurements are a critical yardstick for how much humans are reshaping the climate."*

A Long-Term Record

The measurements of sea surface height that began 30 years ago with *TOPEX/Poseidon* have continued

through four subsequent missions led by *NASA* and partners, including the French space agency *CNES*, ESA (European Space Agency), and the U.S. *National Oceanic and Atmospheric Administration*. The most recent mission in the series, *Sentinel-6/Jason-CS* (Continuity of Service), consists of two satellites that will extend these measurements through 2030. The first of these two satellites, *Sentinel-6 Michael Freilich*, launched in 2020, with the second slated to head to orbit in 2025.

"The 30-year satellite record allows us to see through the shorter-term shifts that happen naturally in the ocean and helps us identify the trends that tell us where sea level is headed," said JPL's Ben Hamlington, a sea level researcher who leads NASA's Sea Level Change science team.

Scientific and technical innovations by NASA and other space agencies have given researchers a better understanding of the current state of the ocean on a global scale. Specifically, radar altimeters have helped produce ever-more precise measurements of sea level around the world. To calculate sea level height, they bounce microwave signals off the ocean's surface and record the time the signal takes to travel from a satellite to Earth and back, as well as the strength of the return signal.

When altimetry data from all ocean basins is combined with more than a century of observations from coastal surface-based sources, together they dramatically expand and improve our understanding of how sea surface height is changing on a global scale. And when those measurements of sea level are combined with other NASA data sets on ice mass, land motion, and other Earth changes, scientists can decipher why and how seas are rising.

Learn more about sea level and climate change at:

https://sealevel.nasa.gov/

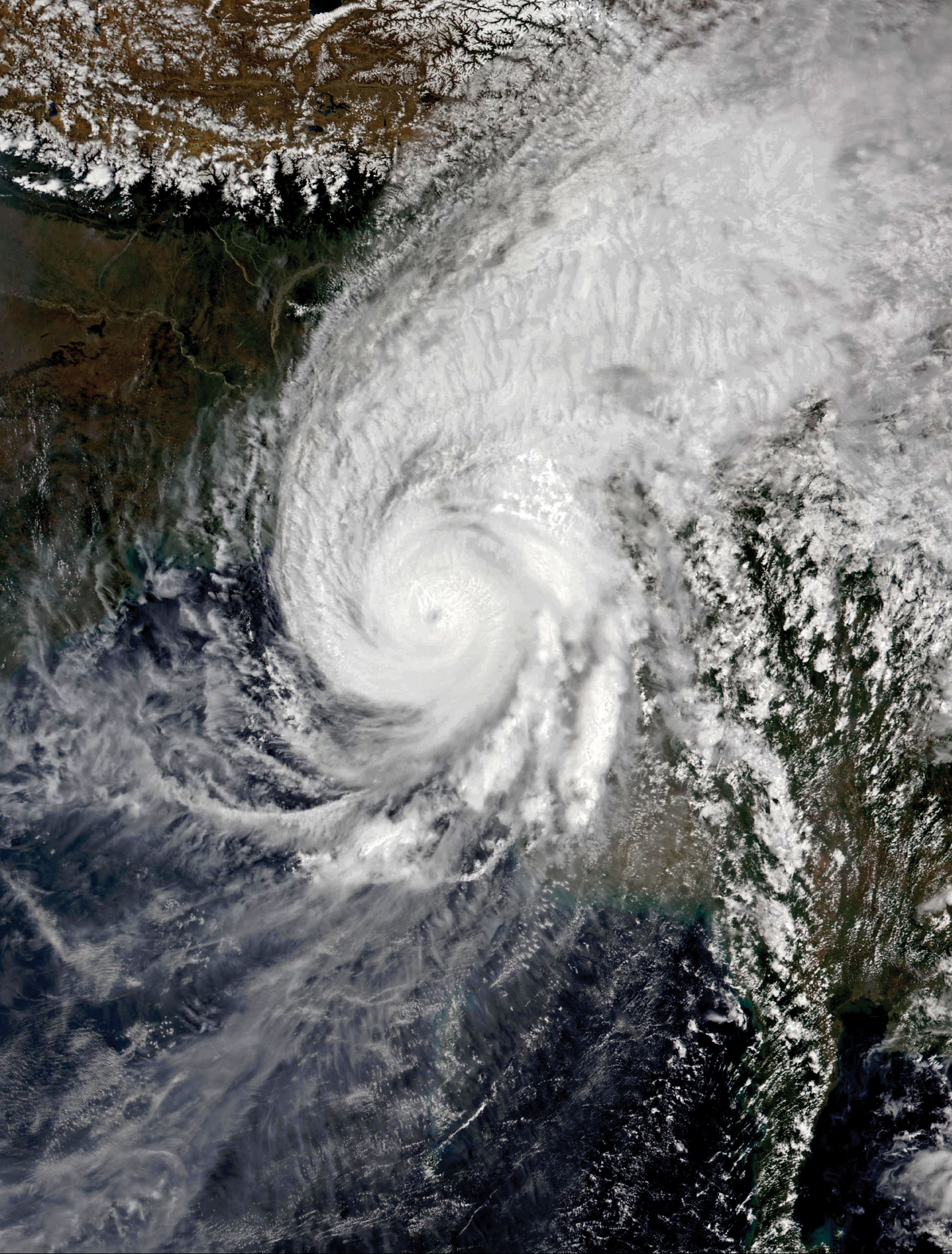
Saharan Dust Plume in the Mediterranean Basin

Copernicus Image of the Day

In early April 2023, multiple plumes of Saharan dust were observed originating from Africa, and on April, Copernicus Sentinel-3 captured an image of a large plume stretching hundreds of kilometres from the coast of Libya to Türkiye. These dust plumes can have severe impacts on the environment, air quality, and human health. Therefore, monitoring them is crucial for protecting human health and the environment.

The Copernicus Atmosphere Monitoring Service provides essential information on the movement and behaviour of these Saharan dust plumes, enabling authorities to take preventive measures to minimise their impact.

Credit: European Union, Copernicus Sentinel-3 imagery



The NOAA 20 satellite captured this splendid image of Cyclone Mocha over Bangladesh and the Bay of Bengal on May 14, 2023
Image: NOAA

Sicily

MODIS Web Image of the Day

The triangular-shaped island of Sicily sits at the heart of the Mediterranean Sea, positioned roughly 160 kilometres north of Tunisia, in north Africa, and just three kilometres from the southern tip of mainland Italy. This strategic location has placed the Mediterranean's largest island at the crossroads of history for many thousands of years and through a variety of civilizations. The island has been inhabited for at least 10,000 years.

On February 22, 2023, the Moderate Resolution Imaging Spectroradiometer (MODIS) on board NASA's Terra satellite acquired a true-colour image of Sicily surrounded by the blue waters of the Mediterranean Sea, coloured in green, and the highest peaks topped with winter snow.

In the east, a light gray plume can be seen rising from Sicily's most iconic feature, Mount Etna, and blowing towards the southeast over the Mediterranean. Standing at 3,329 metres tall, the volcano is in almost continuous eruption. In late November 2022 a new fissure vent opened on Etna's southeast crater, permitting lava to flow and beginning a new effusive eruption. On February 8, 2023, the volcano observatory in Catania released a bulletin for aviation services mentioning that the effusive eruption at the summit craters had ended. Low level activity above background levels have continued, with very little ash emission. The light gray plume captured in this image is most likely consists primarily of volcanic gases with little ash.

Image Credit: MODIS Land Rapid Response Team, NASA GSFC

Frozen Lakes in Manitoba

MODIS Web Image of the Day

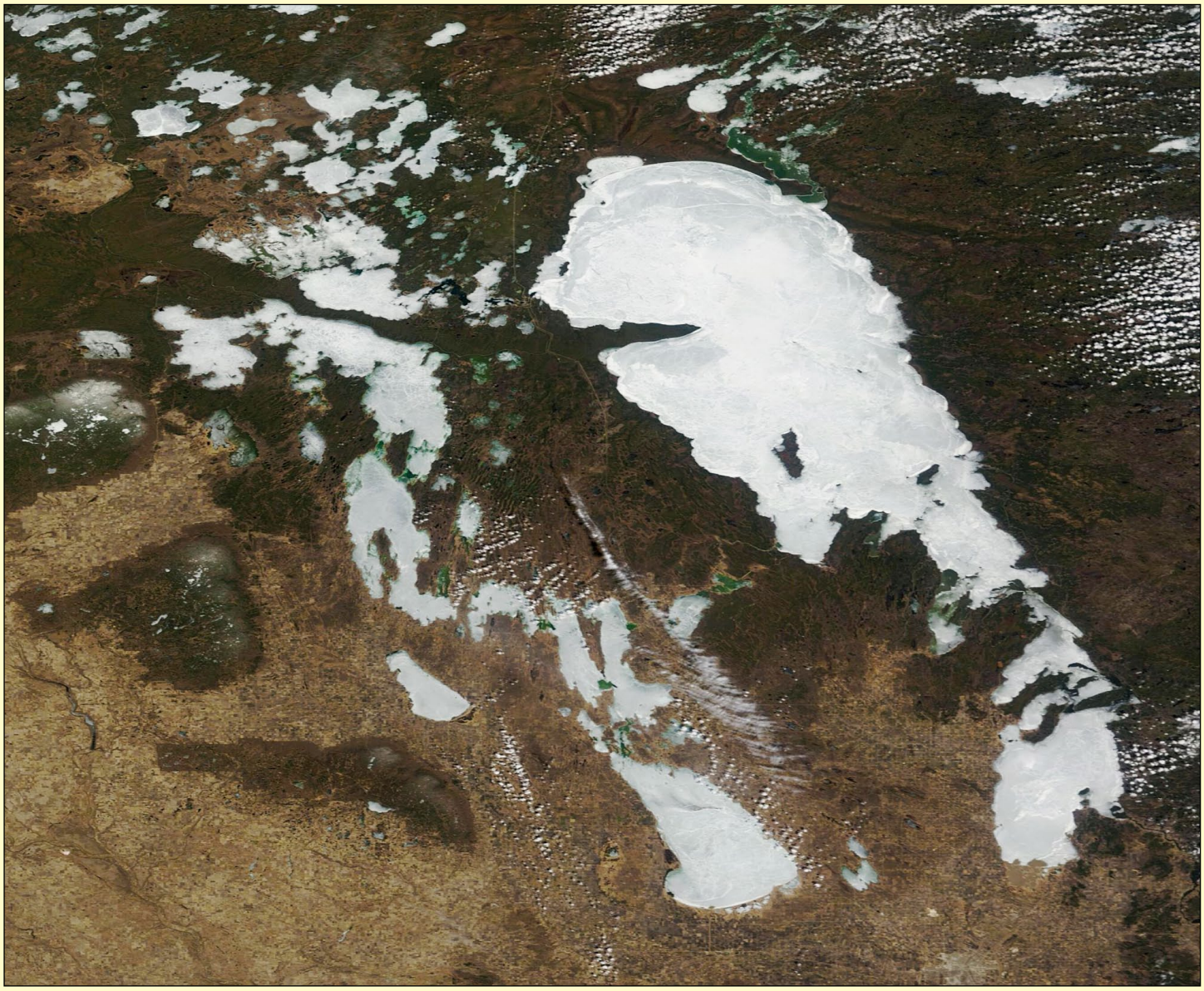


Image Credit: MODIS Land Rapid Response Team, NASA GSFC

The province of Manitoba, Canada has been called 'the land of 100,000 lakes' and, on May 4, 2023, most of the many lakes and ponds remained covered in ice.

On that same day, the Moderate Resolution Imaging Spectroradiometer (MODIS) on board NASA's Terra satellite acquired a true-colour image of **Lake Winnipeg**, said to be the 12th largest freshwater lake on Earth, and several surrounding lakes. To the west of northern Lake Winnipeg, sits Lake Winnipegosis, and Lake Manitoba stretches south of Winnipegosis. Together, Lakes Winnipeg, Winnipegosis, and Manitoba are often referred to as Manitoba's Great Lakes. The lakes are surrounded by wetlands and forest (dark green) and prairie or grasslands (light tan) and are covered with bright white ice.

The origins of the lakes and surrounding wetlands can be traced to the last ice age. The wetlands were created in the low-lying topography ground down by the advancing and retreating ice sheets. The three Manitoba Great Lakes, however, are actual remnants of glacial Lake Agassiz. This was an ice-dammed lake that formed south of the Laurentide Ice Sheet about 14,500 years ago. At its largest, Lake Agassiz was 1,125 kilometres long and 400 kilometres wide. As the ice dams melted and receded at the end of the ice age, about 8,000 years ago, outlets to the sea opened and the lake drained, leaving behind the deeper lakes.

Tropical Cyclone Ilsa

MODIS Web Image of the Day

Around midnight local time on April 13, 2023, Tropical Cyclone Ilsa made landfall in Western Australia. Bearing winds that gusted to 298 kph (kilometres per hour), it was one of the most potent storms to hit the area in recent years.

Earlier that day, the Moderate Resolution Imaging Spectroradiometer (MODIS) on board NASA's **Terra** satellite acquired a true-colour image of the fierce cyclone approaching the Western Australian coast. Near the time this image was captured, Ilsa was approaching with sustained winds of 240 kph. That equates to a Category 5 storm on Australia's intensity scale, which is equivalent to a Category 4 storm on the Saffir-Simpson hurricane wind scale. Although the storm's centre had not yet reached the coast, its outer cloud bands were already interacting with the land.

According to Western Australia's Bureau of Meteorology, winds were especially fierce at Bedout Island (obscured in this image by clouds). Ground-based instruments measured sustained wind speeds of 218 kph there—topping the previous record of 194 kph measured at the island during Cyclone George in 2007.

The storm crossed the coast about 120 kilometres east-northeast of Port Hedland, maintaining Category 5 status on the Australian scale. By late April 14, Ilsa's windspeeds had decreased to near 80.5 kph, bringing it to Category 1 on the Australian scale. The storm brought damaging winds and torrential rain across a large swath of Western Australia. Fortunately, major cities, such as Port Hedland, were spared a direct hit and damage appeared to be relatively mild.

The strongest winds appeared to have crossed over more remote territory. Photos of severe damage to buildings and a tractor-trailer overturned have circulated on social media, as well as photos of near-total destruction of the Pardoo Roadhouse, a remote restaurant and gas station near Port Hedland. The cyclone passed directly over Pardoo Station, a cattle ranching operation, leaving only two buildings intact at the main location.

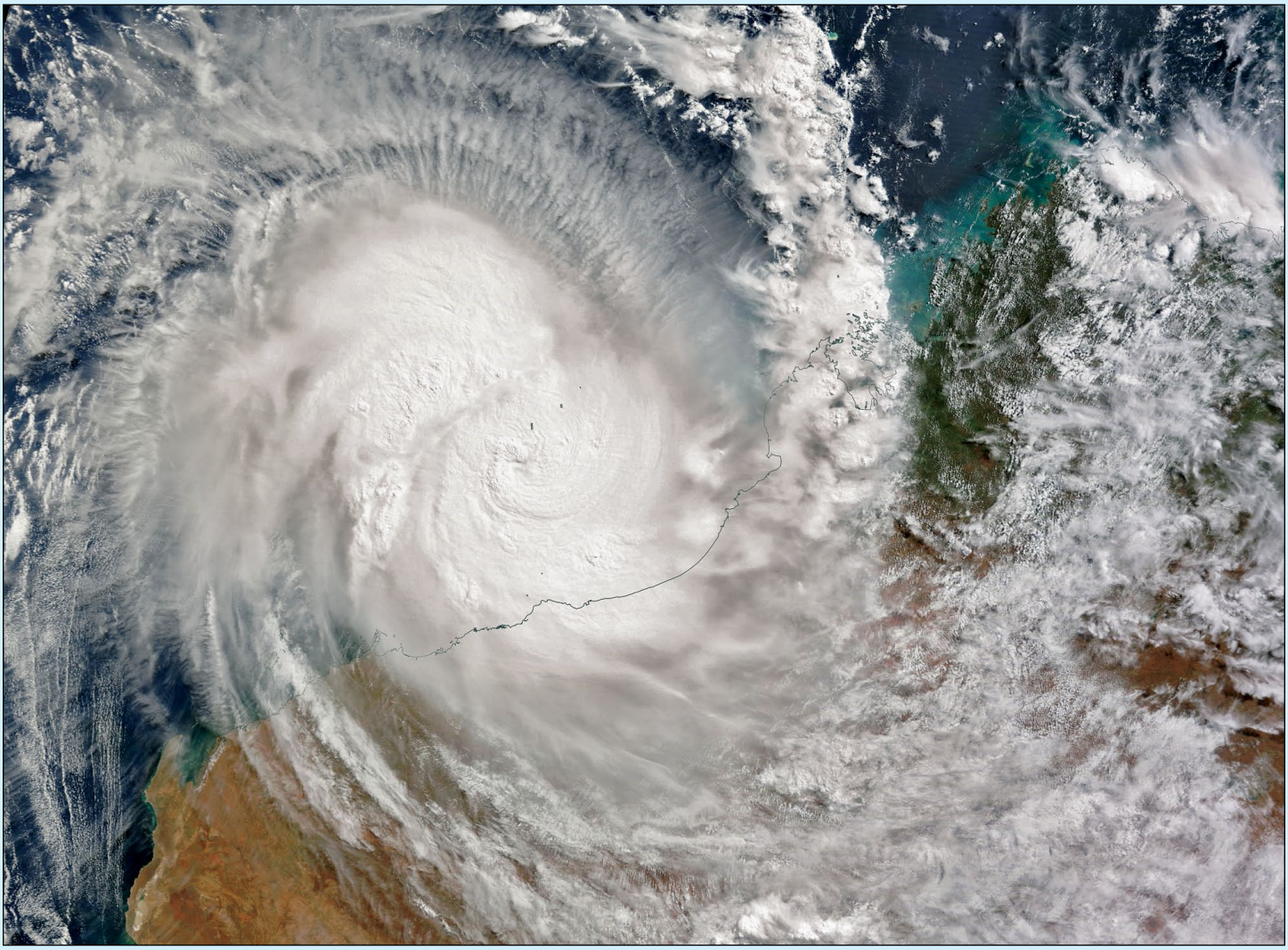


Image Credit: MODIS Land Rapid Response Team, NASA GSFC

A Dazzling Aurora Borealis

NASA Earth Observatory

Story by Adam Voiland

As we move closer to the peak of solar cycle 25, activity on the Sun is ratcheting up. One sign of this appeared in Earth's atmosphere in the form of the dazzling display of the aurora borealis that reached beyond the Arctic Circle deep into midlatitudes in late February 2023.

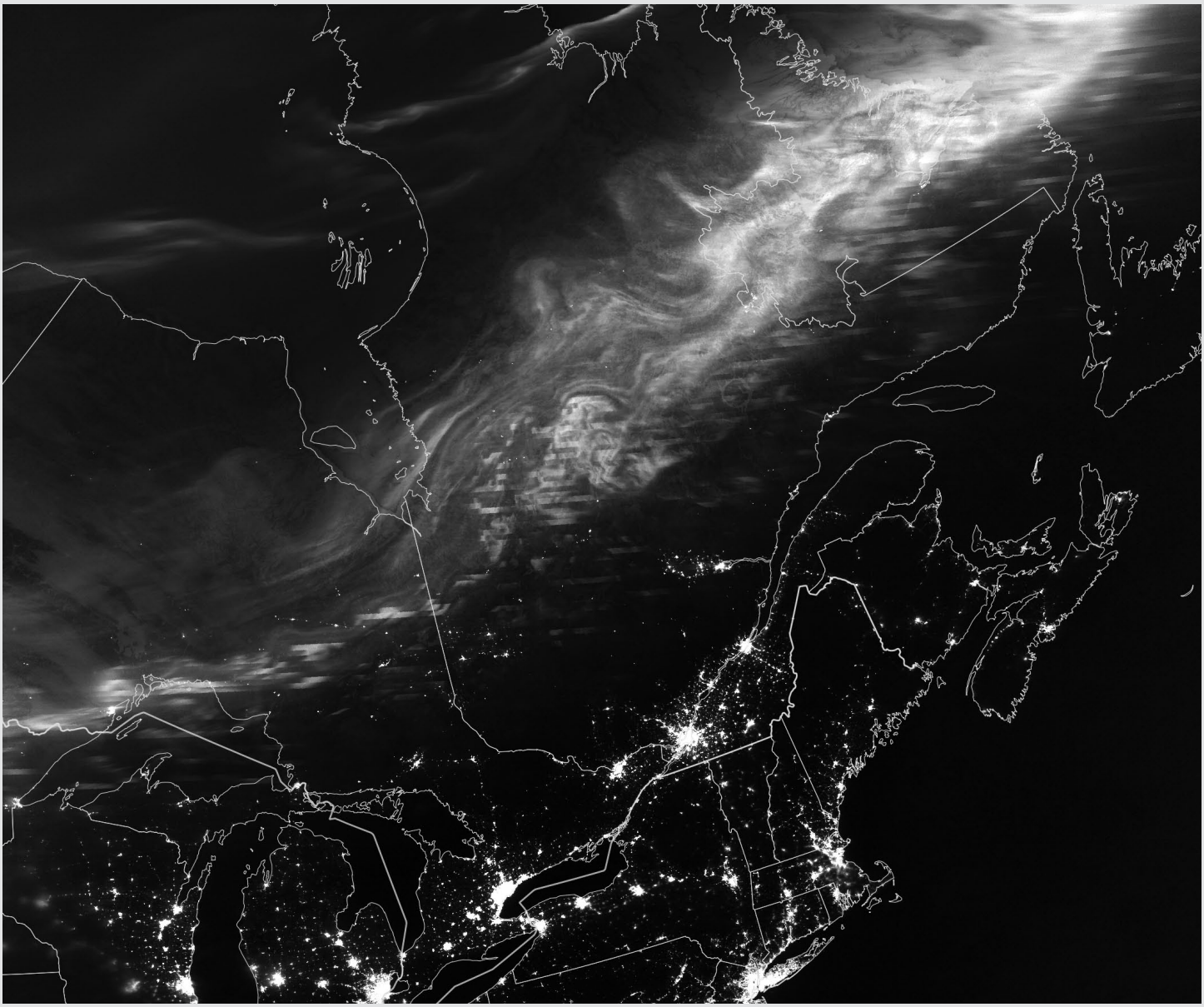


Figure 1 - This image of an aurora above North America as acquired by the Suomi-NPP satellite on February 28, 2023
NASA Earth Observatory image by Lauren Dauphin
using VIIRS day-night band data from the Suomi National Polar-orbiting Partnership

In the early morning hours of February 27, the Visible Infrared Imaging Radiometer Suite (VIIRS) on the NOAA-NASA **Suomi NPP satellite** acquired figure 1, an image of a ribbon of light in the skies over Quebec and Ontario. The nighttime satellite image was acquired with the VIIRS 'day-night band,' which detects light in a range of wavelengths from green to near-infrared and uses filtering techniques to observe signals such as airglow, auroras, city lights, and reflected moonlight.

A day later, NASA astronaut Josh Cassada took a photograph of the aurora (figure 2) from the International Space Station. The photo was taken while ISS was passing over southeastern Manitoba. His comment on Twitter: "Absolutely unreal."

People on the ground reported spotting the pulsating reds, greens, and purples of this aurora in Alaska, Washington, Michigan, New York and as far south as Ohio, according to a report in *The Washington Post*.

A solar cycle is traditionally measured by the rise and fall in the number of sunspots, but it also coincides with increases in solar flares, coronal

This is a photograph of the aurora taken from the International Space STATION
This astronaut photograph (ISS068-E-59877) was acquired on February 28, 2023, with a Nikon D5 digital camera using an 24 millimetre lens and is provided by the ISS Crew Earth Observations Facility and the Earth Science and Remote Sensing Unit, Johnson Space Center.

mass ejections (CMEs), radio emissions, and other forms of space weather. These bursts of magnetised plasma and energetic waves from the Sun's atmosphere can energise the gases and particles in Earth's magnetosphere. These particles crash into Earth's upper atmosphere at altitudes of 100 to 400 kilometres, where they excite oxygen and nitrogen molecules and release photons. The results are rays, sheets, and curtains of dancing light in the sky.

According to the *NOAA Space Weather Prediction Center*, the Sun erupted with two CMEs on February 25 and 26, including one associated with an M6.2 solar flare. The biggest flares are known as 'X-class', based on a classification system that divides solar flares according to their strength.

The smallest flares are A-class (near background levels), followed by B, C, M and X. Similar to the Richter scale for earthquakes, each letter represents a 10-fold increase in energy output. In this case, geomagnetic storm activity reached G3 on a scale from G1 to G5.

If you like watching auroral displays such as this one, you can participate in aurora *Citizen Science*

https://science.nasa.gov/citizenscience

through a project called *Aurorasaurus*.

https://www.aurorasaurus.org/

The project tracks auroras around the world via reports to its website and on *Twitter*, then generates a real-time global map of those reports.

Citizen scientists verify the tweets and reports, and each verified sighting serves as a valuable datapoint for scientists to analyse and incorporate into space weather models. The project is a public-private partnership with the New Mexico Consortium and is supported by the National Science Foundation and NASA.

Forecasts from space weather experts indicate the next peak of solar activity (solar maximum) will likely be reached in mid-2025.

Currently Active Satellites and Freqencies

Polar APT Satellites				
Satellite	**Frequency**	**Status**	**Format**	**Image Quality**
NOAA 15	137.6200 MHz	On	APT	Intermittant sync problem
NOAA 18	137.9125 MHz	On	APT	Good
NOAA 19	137.1000 MHz	On	APT	Good [1]
Meteor M N2	137.1000 MHz	On	LRPT	Good [1]
Meteor M N2-2	137.9000 MHz	Off	LRPT	System failure [8]

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	1700.0 MHz	RHCP	AHRPT	Off - probably terminal failure
Meteor M N2-2	1700.0 MHz	RHCP	AHRPT	Active [8]

Geostationary Satellites				
Satellite	**Transmission Mode(s)**		**Position**	**Status**
Meteosat 9	HRIT (digital)		45.5°E	IODC - On
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	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	On [6]
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	On [7]
GOES 18	GRB 1686.6 MHz	HRIT 1694.1 MHz	137.0°W	On [7]
MTSAT-1R	LRIT 1691.0 MHz	HRIT 1687.1 MHz	140°E	Standby
MTSAT-2	LRIT 1691.0 MHz	HRIT 1687.1 MHz	145°E	On
Feng Yun 2E	SVISSR (digital)	LRIT (digital)	86.5°E	On
Feng Yun 2F	SVISSR (digital)	LRIT (digital)	112.5°E	Standby
Feng Yun 2G	SVISSR (digital)	LRIT (digital)	99.5°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)	Just	Launched

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 prime Rapid Scanning Service (RSS) satellite.
5 Repurposed by 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.