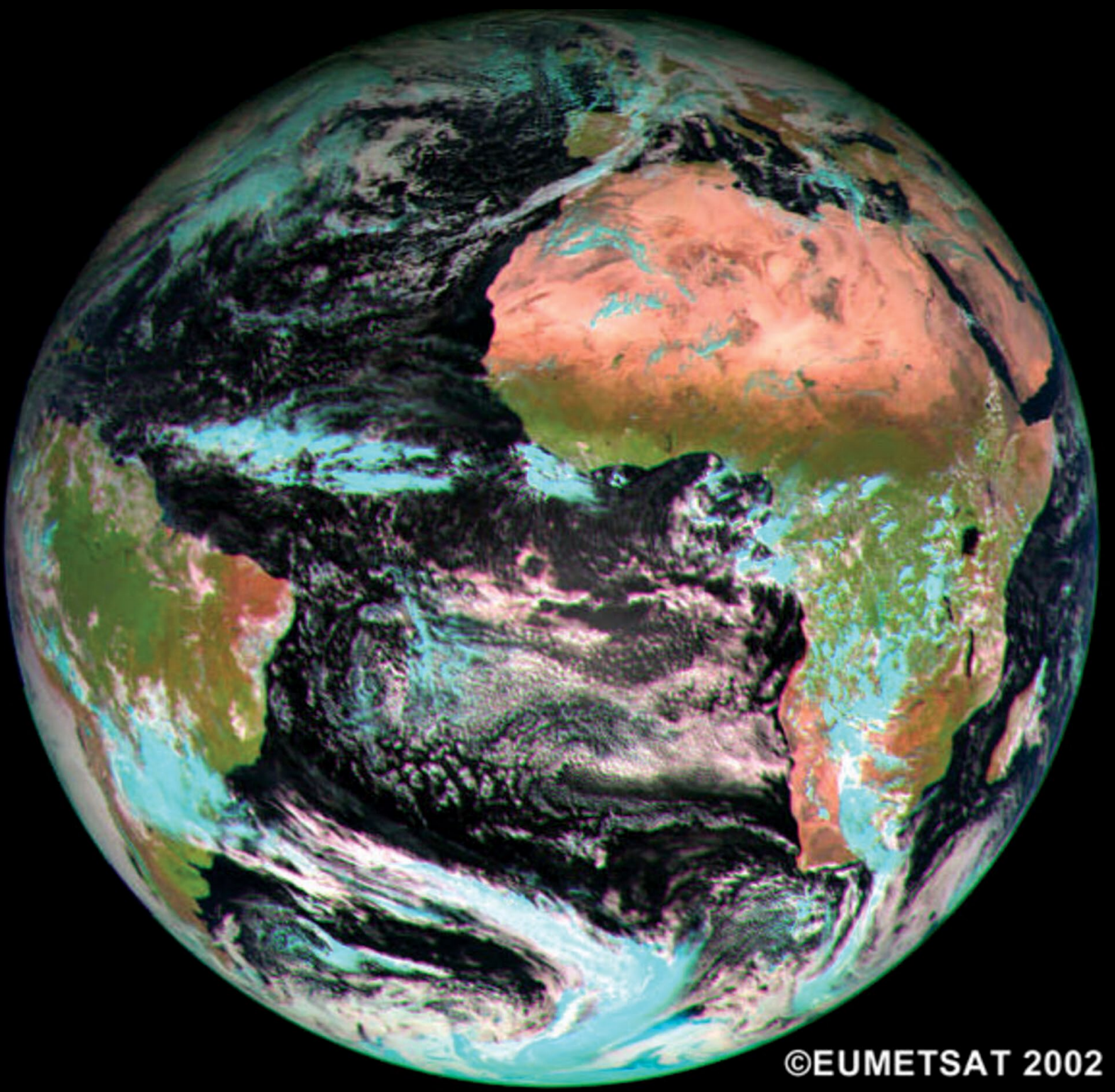
GEO Newsletter

Group for Earth Observation

Group for Earth Observation

No 77 - March 2023



This was the very first image transmitted from the now-retired Meteosat-8 geostationary weather satellite

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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/

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Group for Earth Observation

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http://www.facebook.com/groupforearthobservation

From the Editor

Les Hamilton

One of the most significant satellite launches for two decades occurred on December 13 last year when the first of the **Meteosat Third Generation** satellites, MTG-I1 (now Meteosat-12 in orbit), took place from Korou in French Guiana. The MTG system heralds a magnitude shift in data collection and dissemination. You can read an introduction to the new Meteosat constellation in our article on page 8.

Since the December issue, much has happened word-wide: severe flooding in both Australia and New Zealand at the hands of Pacific cyclones, with the north island of New Zealand in particular suffering major damage to infrastructure. In the northern hemisphere there was an almost unprecedented 'weather bomb' event that brought paralysing Arctic cold to Canada and the United States, during which some locations experienced temperatures as low as minus 50 degrees Celsius. Not even southern states like Florida and Texas escaped this crippling cold. And of course, most recently, there were the devastating earthquakes in Turkey and Syria that claimed tens of thousands of lives and caused incalculable damage to property.

Our thoughts go out to all who have been affected by these recent events, and hope that the year ahead will bring better times for all.

Contents

NASA Launches SWOT Mission to Survey Earth's Water

NASA

The Surface Water and Ocean Topography (SWOT) spacecraft was launched atop a SpaceX Falcon 9 rocket from Vandenberg Space Force Base in California on Friday, December 16, 2022.
Credits: NASA/Keegan Barber

A satellite built for NASA and the French space agency Centre National d'Études Spatiales (CNES) to observe nearly all the water on our planet's surface lifted off on its way to low-Earth orbit at 3:46 am PST on December 16, 2022. The Surface Water and Ocean Topography (SWOT) spacecraft also has contributions from the Canadian Space Agency (CSA) and the UK Space Agency.

The SWOT spacecraft launched atop a SpaceX rocket from Space Launch Complex 4E at Vandenberg Space Force Base in California with a prime mission of three years. The satellite will measure the height of water in freshwater bodies and the ocean on more than 90% of Earth's surface. This information will provide insights into how the ocean influences climate change; how a warming world affects lakes, rivers, and reservoirs; and how communities can better prepare for disasters, such as floods.

After SWOT separated from the second stage of the SpaceX Falcon 9 rocket, ground controllers successfully acquired the satellite's signal. Initial telemetry reports showed the spacecraft to be in good health. SWOT will now undergo a series of checks and calibrations before it starts collecting science data in about six months time.

> '*Warming seas, extreme weather, more severe wildfires – these are only some of the consequences humanity is facing due to climate change*,' said NASA Administrator Bill Nelson. '*The climate crisis requires an all-hands-on-deck approach, and SWOT is the realisation of a long-standing international partnership that will ultimately better equip communities so that they can face these challenge*s.'

SWOT will cover the entire Earth's surface between 78 degrees south and 78 degrees north latitude at least once every 21 days, sending back about one terabyte of unprocessed data per day. The scientific heart of the spacecraft is an innovative instrument called the Ka-band radar interferometer (KaRIn), which marks a major technological advance. KaRIn bounces radar pulses off the water's surface and receives the return signal using

two antennas, one on either side of the spacecraft. This arrangement—one signal, two antennas—will enable engineers to precisely determine the height of the water's surface across two swaths at a time, each of them 50 kilometres wide.

'*We're eager to see SWOT in action*,' said Karen St. Germain, NASA Earth Science Division director. '*This satellite embodies how we are improving life on Earth through science and technological innovations. The data that innovation will provide is essential to better understanding how Earth's air, water, and ecosystems interact—and how people can thrive on our changing planet*.'

Among the many benefits the SWOT mission will provide is a significantly clearer picture of Earth's freshwater bodies. SWOT will provide data on more than 95% of the world's lakes larger than 62,500 square metres and rivers wider than 100 metres. Currently, freshwater researchers have reliable measurements for only a few thousand lakes around the world. SWOT will push that number into the millions.

Along the coast, SWOT will provide information on sea level, filling in observational gaps in areas that don't have tide gauges or other instruments that measure sea surface height. Over time, that data can help researchers better track sea level rise, which will directly impact communities and coastal ecosystems.

Such an ambitious mission is possible because of NASA's long-standing commitment to working with agencies around the world to study Earth and its climate. NASA and CNES have built upon a decades-long relationship that started in the 1980s to monitor Earth's oceans. This collaboration pioneered the use of a space-based instrument called an altimeter to study sea level with the launch of the **TOPEX/Poseidon** satellite in 1992.

'This mission marks the continuity of 30 years *of collaboration between NASA and CNES in altimetry*,' said Caroline Laurent, CNES Orbital Systems and Applications director. '*It shows how international collaboration can be achieved through a breakthrough mission that will help us better understand climate change and its effects around the world*.'

SWOT measurements will also help researchers, policymakers, and resource managers to better assess and plan for things, including floods and droughts. By providing information on where the water is—where it's coming from and where it's going—researchers can improve flood projections for rivers and monitor drought effects on lakes and reservoirs.

'*SWOT will provide vital information, given the urgent challenges posed by climate change and sea level rise*,' said Laurie Leshin, NASA's Jet Propulsion Laboratory (JPL) director. JPL developed the KaRIn instrument and manages the U.S. portion of the mission. '*That SWOT will fill gaps in our knowledge and inform future action is the direct result of commitment, innovation, and collaboration going back many years. We're excited to get SWOT science underway*.'

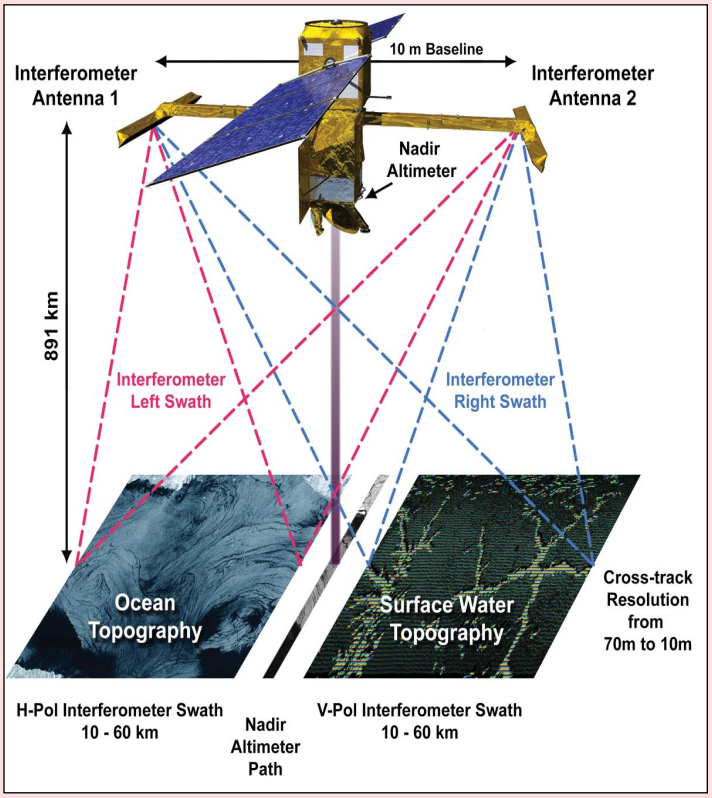
More Mission Information

JPL, which is managed for NASA by Caltech in Pasadena, California, leads the U.S. component of the project. For the flight system payload, NASA is providing the KaRIn instrument, a GPS science receiver, a laser retroreflector, a two-beam microwave radiometer, and NASA instrument operations. CNES is providing the Doppler Orbitography and Radioposition Integrated by Satellite (DORIS) system, the dual frequency Poseidon altimeter (developed by Thales Alenia Space), the KaRIn radio-frequency subsystem (together with Thales Alenia Space and with support from the UK Space Agency), the satellite platform, and ground control segment. CSA is providing the KaRIn high-power transmitter assembly. NASA is providing the launch vehicle and the agency's Launch Services Program, based at Kennedy Space Center, is managing the associated launch services.

References

- NASA SWOT website
  https://www.nasa.gov/swot
- SWOT Press Kit
  https://www.jpl.nasa.gov/press-kits/swot

SWOT Swath Data



Source: Yeosang Yoon with images from NASA

This diagram illustrates the swaths of data that SWOT will collect. The interferometer will produce two parallel tracks, with a Nadir track from a traditional altimeter in the gap between the swaths. The overall width of the swaths will be approximately 120 km.

Icy Lake Paiku

NASA Earth Observatory

Story by Kathryn Hansen

Thousands of lakes dot the Qinghai-Tibet Plateau, the planet's largest and highest alpine lake system. Sometimes called the 'world's largest water tower,' the plateau supplies freshwater for billions of people living downstream. Changes in lake levels can affect this important water resource, as well as influence precipitation and temperature patterns in the region.

On February 19, 2022, an astronaut onboard the International Space Station shot this photograph of Lake Paiku, a deep lake on the plateau's southern reaches at an altitude of 4591 metres. At the time of this image, ice had formed on the lake's shallower areas, primarily toward the south. The lake's depth gradually increases to about 60 metres in the southern half; in contrast, the northern half quickly reaches more than 70 metres deep.

The lake's significant depth affects the timing of seasonal evaporation—one of the main factors that influences the water budget of lakes with no outlets, such as Paiku. Averaging 41 metres deep, Paiku can store more heat than shallower lakes for much of the year. During the monsoon season (July to September), little evaporation, combined with additions of water from rainfall and melting glaciers, causes the lake levels to rapidly rise. After the monsoon season (October to December), high evaporation and small additions of water cause lake levels to drop significantly.

When ice covers the lake in winter, there is no significant change in the water level, but there are other dynamics at play. Research has shown that during these cold months, the plateau's lake water acts like a lens, accumulating heat from the region's high amount of solar radiation. When the ice breaks up, the heat is quickly released back to the atmosphere where it can influence local temperatures and precipitation.

The plateau's lakes have seen decadal changes, too, amid warming temperatures, changing precipitation, shrinking glaciers, and melting permafrost. Many lakes on the plateau's interior have grown larger, while lakes toward the plateau's south have been shrinking.

Lake Paiku, located in a southern dry belt near the slope of the Himalayas, is one of the shrinking lakes. Scientists estimate lake levels have declined by about four metres since 1972, reducing its water storage by 8.5 percent.

Astronaut photograph ISS066-E-150477 was acquired on February 19, 2022 and is provided by the ISS Crew Earth Observations Facility and the Earth Science and Remote Sensing Unit, Johnson Space Center.

Flooding Along Australia's Fitzroy River

NASA Earth Observatory

Story by Kathryn Hansen

Figure 1 - Fitzroy flooding on January 9, 2023

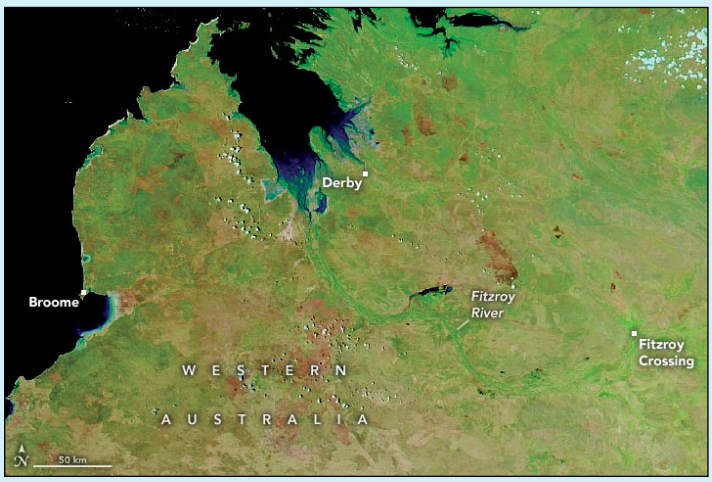


Figure 2 - The Fitzroy basin on December 30, 2022

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

Starting on December 30, 2022, remnants of Tropical Cyclone Ellie brought days of torrential rain and wind to northern Western Australia. The deluge caused the Fitzroy River to swell to record-high levels, inundating floodplains and isolating several riverside communities.

The flooding is visible in figure 1, a false-colour image acquired on January 9, 2023, with the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Aqua satellite. Water appears light to dark blue; vegetation is green and bare land is brown. Figure 2, acquired with Aqua MODIS on December 17, 2022, shows the same area prior to the storm.

Flooding is common along rivers of the Kimberly region in Western Australia. But the amount of water delivered by the ex-tropical cyclone was exceptional. From December 30, 2022, through the first week of January 2023, rainfall totals across the region ranged from 200 to 500 millimetres.

As a result, the Fitzroy River's flow rate reached about 60,000 cubic meters per second—well above the 23,000 cubic meters per second usually seen during floods on this river, and one of the highest flow rates ever observed in any Australian river. Australia's Bureau of Meteorology reported that the river's water levels near the town of Fitzroy Crossing peaked at a record-high of 15.81 metres on January 4. That's almost two metres higher than the previous record attained during flooding in 2002.

The floodwater left many roads and bridges impassable, isolating Fitzroy Crossing, Derby, Broome, and many of the region's remote indigenous communities. Floodwaters around Fitzroy Crossing

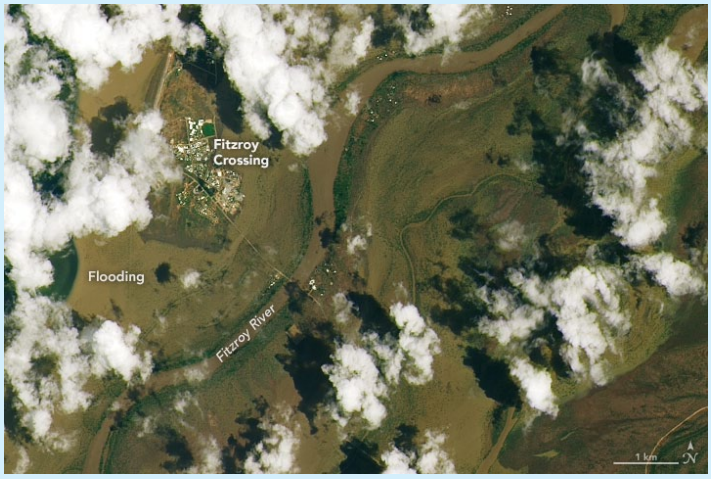


Figure 3 - Floodwaters around Fitzroy Crossing on January 7

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

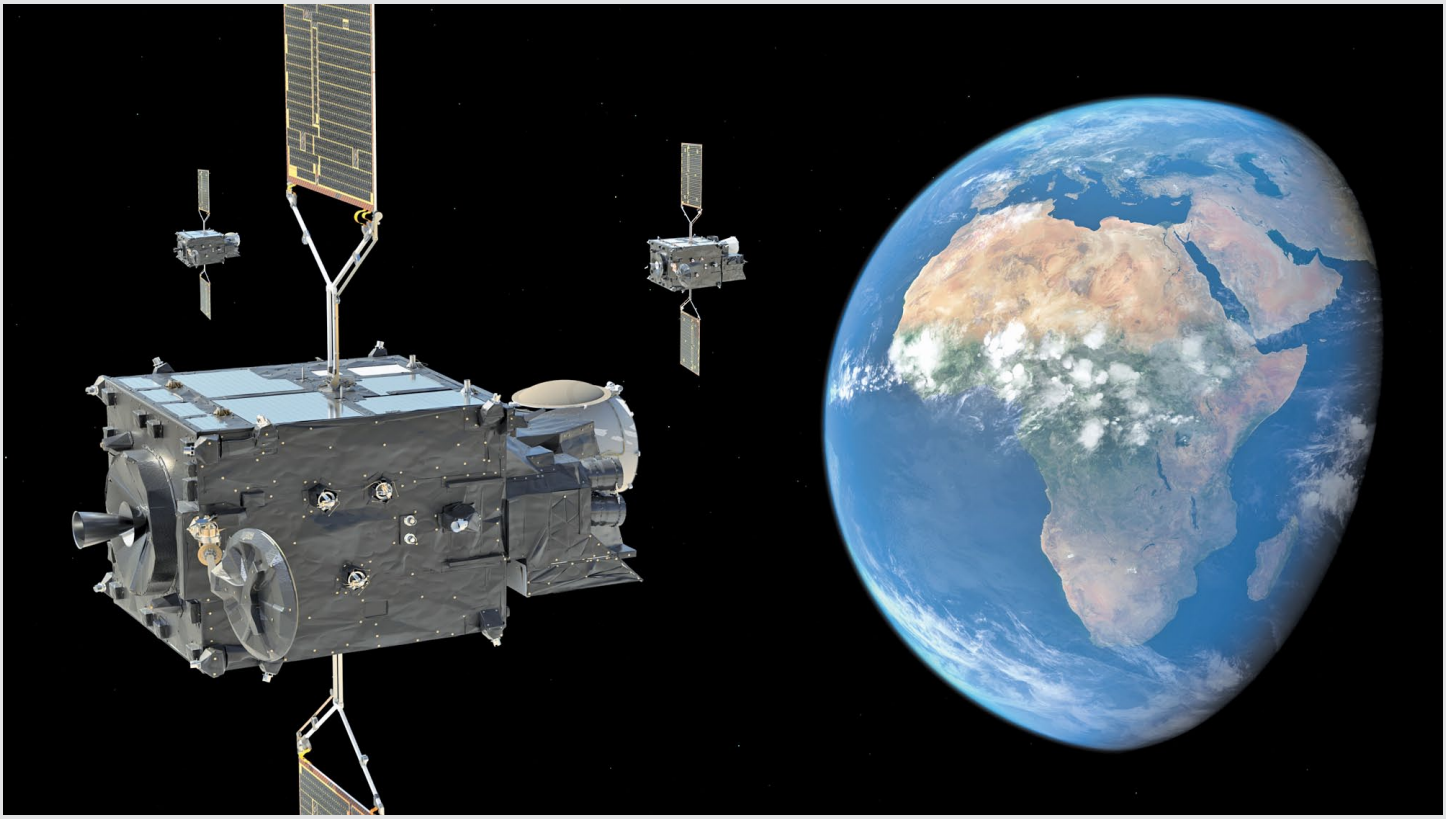
are visible in figure 3, a natural-colour image, acquired on January 7, 2023, with the Operational Land Imager (OLI) on Landsat 8.

Tropical Cyclone Ellie first hit Australia's Northern Territory as a category-1 storm on December 23, 2022. It then weakened into a tropical low before moving into Western Australia on December 30. By January 7, 2023, the former tropical cyclone had moved back into the Northern Territory and further weakened as it moved toward Queensland.

The recent flooding in Western Australia follows several severe flooding events that have occurred in eastern Australia during three consecutive years of La Niña conditions. La Niña usually brings wetter-than-average conditions to the country. 2022 was Australia's ninth-wettest year on record.

Introducing Meteosat Third Generation

Les Hamilton



This is an artistic depiction of the MTG 3-satellite constellation in geostationary orbit around the Earth
Credit: ESA/Mlabspace, CC BY-SA 3.0 IGO

The Mission

Building on the long-standing partnership between ESA and EUMETSAT, Meteosat Third Generation will guarantee the continuity of data for weather forecasting from geostationary orbit for the next two decades. MTG is a cooperative venture between ESA and EUMETSAT, in which ESA is responsible for the definition and implementation of the MTG satellites and the procurement of recurrent hardware, while EUMETSAT is in charge of operating the spacecraft throughout its lifetime. The MTG satellites will eventually replace the current Meteosat Second Generation operational system at 0° longitude.

To meet its projected 20-year operational life, the Meteosat Third Generation mission comprises six satellites: four Imaging satellites (MTG-I) and two Sounding satellites (MTG-S). When fully deployed, the system will include two MTG-I satellites operating in tandem—one scanning Europe and Africa every 10 minutes and the other only Europe but every 2½ minutes—along with a single MTG-S satellite which will provide fast local-area coverage over selected parts of Earth.

The image above shows an artistic impression of the three satellite constellation, with the two MTG-I satellites at foreground and left and the single MTG-S satellite on the right.

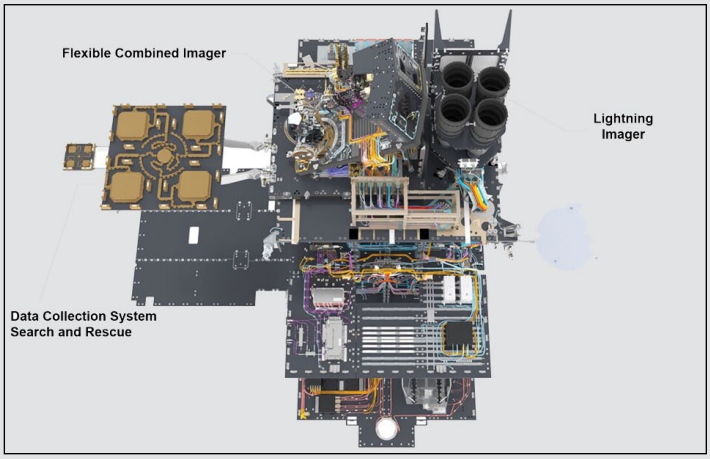
Following the successful launch of the first MTG-I satellite, the first MTG-S will launch during 2024 and the second MTG-I in 2025. The remaining three satellites will be launched around ten years later to replace the first constellation, which has a nominal life of 8.5 years but sufficient fuel to remain operational for more than 10.7 years.

The combination of MTG's innovative instruments, along with their increased resolution and sensitivity, is set to take weather forecasting to a new level, particularly regarding the challenging task of early detection and prediction of rapidly evolving and potentially dangerous weather events such as severe thunderstorms.

MTG-I1

The first MTG satellite, MTG-I1 (i.e. MTG-i-one), was launched aboard an Ariane-5 launcher from Kourou in French Guiana on December 13, 2022. This satellite carries two completely new instruments designed to deliver high-quality data for the improvement of weather forecasts.

The instrument package carried aboard each of the MTG-I satellites includes a Flexible Combined Imager (FCI) and a Lightning Imager (LI), plus systems for data collection and search and rescue relay.



Schematic diagram of an MTG-I satellite
Credit: ESA

The Flexible Combined Imager unit undergoing testing
Image: ESA

Satellites	Three-axis stabilised satellites, each weighing 3600 kg (including almost 2 tonnes of fuel)
Dimensions	2.3 x 2.8 x 5.2 metres (launch configuration)
Instruments	Flexible Combined Imager (FCI), Lightning Imager (LI), Data Collection and Retransmission Service, Geostationary Search and Rescue Relay (DCS/GEOSAR)
Power	2 kW
Life	Nominal design life 8.5 years (with fuel to last for >10.7 years)

MTG-I Specification

The Flexible Combined Imager (FCI)

FCI is an optical imager that will observe 16 channels in the visible and infrared spectrum, of which eight are placed in the solar spectral domain between 0.4 - 2.2 µm. FCI will operate at wavelengths between 0.3 - 13.3 µm, will have a spatial resolution of 1-2 kilometres, and will be able to scan the full Earth disc in 10 minutes. FCI will also operate in a 'high spatial resolution fast imagery mode' which can zoom in on smaller areas and deliver data images of selected regions every 2½ minutes, but for a tradeoff spatial resolution of 500 metres.

FCI offers significant enhancement in detection capabilities with respect to radiometric, spectral and spatial resolution over its predecessor, the Spinning Enhanced Visible and Infrared Imager (SEVIRI) carried by its predecessor Meteosats, resulting in improved forecasts and earlier prediction of severe weather events. The additional channels on FCI will improve the detection of thin cirrus clouds, aerosols, and localised fire events.

Flexible Combined Imager (FCI)		
Spectral Bands (µm)	Nadir Resolution (km)	Radiometric Accuracy
VIS 0.4	1.0	5%
VIS 0.5	1.0	5%
VIS 0.6	1.0; 0.5 *	5%
VIS 0.8	1.0	5%
VIS 0.9	1.0	5%
NIR 1.3	1.0	5%
NIR 1.6	1.0	5%
NIR 2.2	1.0; 0.5 *	5%
IR 3.8 (TIR)	2.0; 1.0 *	<0.1K as 300K
WV 6.3	2.0	<0.3K as 250K
WV 7.3	2.0	<0.3K as 250K
IR 8.7 (TIR)	2.0	<0.1K as 300K
IR 9.7 (O_3)	2.0	<0.3K as 250K
IR 10.5 (TIR)	2.0: 1.0 *	<0.1K as 300K
IR 12.3 (TIR)	2.0	<0.2K as 300K
IR 13.3 (CO_2)	2.0	<0.2K as 270K
* indicates RSS Mode		
Repeat Cycle		
Full Earth Disc every 10 minutes		
Rapid Scan Service (RSS) every 2½ minutes		

Frequencies available in the FCI

The Lightning Imager (LI)

LI provides real-time data on the location and intensity of lightning flashes to enable more precise forecasts of severe thunderstorms. The presence of lightning is a clear sign of atmospheric turbulence, which can be associated with extreme weather events. LI can detect all types of lightning: cloud to cloud, cloud to ground, and intra-cloud flashes, providing an advantage over ground based lightning detection networks.

LI will offer a completely new capability for European meteorological satellites by continuously monitoring more than 80% of Earth's disc. In so doing it will be able to detect severe storms in their early stages and will therefore be key for issuing timely warnings. Its detectors are so sensitive that they will be able to detect relatively weak lightning, even in full daylight.

LI consists of four identical optical telescopes. These will collectively and continuously measure at a wavelength of 777.4 nanometres with a very narrow bandwidth and a spatial resolution of 4.5 kilometres at nadir, which will be triggered by optical pulses above a threshold that are initiated by lightning.

MTG-S

The instrument package that will be carried on each of the MTG-S satellites includes an Infrared Sounder (IRS) and the Sentinel-4 ultraviolet visible and near-infrared sounder, the latter part of the EU's Copernicus programme.

Satellites	Three-axis stabilised satellites, each weighing 3800 kg (including fuel)
Instruments	Infrared Sounder (IRS), Copernicus Sentinel-4 ultraviolet visible & near-infrared mission (UVN)
Power	2 kW
Life	Nominal design life 8.5 years (with fuel to last for >10.7 years)

MTG-S Specification

Infrared Sounder (IRS)

IRS is a hyperspectral infrared sounder set to revolutionise weather forecasting by tracking the 3D structure of atmospheric water vapour and temperature for the first time on an operational basis. IRS includes the ozone band within the Long-Wave Infrared (LWIR) and the carbon monoxide band within Medium-Wave Infrared (MWIR). This will allow measurement within the free troposphere, leading to information on enhanced levels of pollution in the boundary layer below.

IRS will provide vertical profiles of temperature and moisture every 30 minutes over Europe: a world first. The satellite will also be capable of providing local-area coverage over selected parts of Earth, with an increased repeat cycle of just 15 minutes. IRS uses interferometric techniques in two spectral bands, LWIR at 8.26-14.70 µm and MWIR at 4.44-6.25 µm, with a spectral resolution of 0.625 cm^{-1} and a spatial resolution of 4 × 4 kilometres.

Copernicus Sentinel-4 Sounder (UVN)

The Copernicus Sentinel-4 Ultraviolet, Visible and Near-infrared Sounder is dedicated to providing hourly measurements over Europe of aerosols, ozone (0_3), nitrogen diozide ($N0_2$), sulphur dioxide (SO_2) and other trace gases such as formaldehyde (HCHO) and glyoxal (CHOCHO), mainly for air quality applications.

Nowcasting

Nowcasting in meteorology uses available weather data to forecast, by extrapolation, for a period just a few hours into the future. Satellite data is particularly important in nowcasting because it can pick out the size, shape, intensity, speed and direction of movement of weather features on a continuous basis. This can make it possible to forecast individual weather events with reasonable accuracy.

Infrared Sounder (IRS)		
IR wavenumber (cm)	Nadir Resolution (km)	Radiometric Accuracy
700	4	<0.5K at 280K
714	4	<0.5K at 280K
715	4	<0.4K at 280K
729	4	<0.4K at 280K
730	4	<0.3K at 280K
769	4	<0.3K at 280K
770	4	<0.2K at 280K
1040	4	<0.2K at 280K
1118	4	<0.224K at 280K
1210	4	<0.35K at 280K
1600	4	<0.224K at 280K
1630	4	<0.2K at 280K
1750	4	<0.2K at 280K
1871	4	<0.269K at 280K
1980	4	<0.4K at 280K
2134	4	<0.757K at 280K
2175	4	<0.906K at 280K

Frequencies available in the IRS

The combination of the frequent, high resolution and high quality imagery and sounding products from MTG will be a breakthrough for European forecasters in their most challenging task, nowcasting. This is about detecting, in real time, rapidly developing high-impact weather phenomena like thunderstorms, predicting their evolution a few hours ahead and issuing timely warnings and advice to public and private decision makers. Nowcasting is critical for the protection of life and property and vital sectors of the economy, in particular civil aviation.

Nowcasting relates to the monitoring and prediction, in quasi real time, of rapidly evolving and potentially damaging weather phenomena such as severe thunderstorms. Earlier detection of such phenomena will increase the available reaction time for issuing severe weather warnings and implementing the necessary measures to avoid potentially catastrophic impacts. Improving warnings by a few hours can in the more extreme cases be the difference between safe evacuation of the public and significant loss of life.

To achieve all its aims, the design of the MTG satellites is based on a significantly different approach compared with the first two generations of Meteosat. Rather than implementing the spinning satellite design adopted for the MSG-1 and MSG-2 missions, where the entire satellite rotated at one

hundred revolutions per minute, the MTG satellites accommodate their state of the art instruments on a three-axis stabilised satellite platform. This means that the orientation of the satellites remains fixed with respect to Earth such that their instruments continually point directly towards Earth's disc. By comparison, the instruments aboard the previous generations of Meteosats actually spent less than 5% of their time pointing towards the Earth.

Prime Contractor	Thales Alenia Space for overall programme and MTG-I satellite; OHB for MTG-S satellite
Project and commissioning	Satellite design and development and recurrent satellite builds managed at ESA's European Space Research and Technology Centre (ESTEC) in the Netherlands (on behalf Eumetsat)
Launchers	Ariane 5 from Kourou, French Guiana

Latest News

MTG-I1 successfully reached geostationary orbit, nearly 36,000 kilometres above the Equator on December 28, 2022. Following its release from its Ariane-5 launcher, MTG-I1 entered the critical launch and early operations phase (LEOP). This phase was performed on behalf of EUMETSAT by Telespazio from the Fucino Space Centre in Italy.

During the LEOP, which lasted nearly 15 days, a series of critical operations successfully deployed the satellite's solar arrays, manoeuvred it into geostationary orbit, and deployed its communications antennas from their stowed launch positions.

According to Seán Burns, EUMETSAT's Director of Operations and Services to Users:

'The LEOP confirmed the correct functioning of MTG-I1's core systems to generate its own power, change its orbit, and reliably communicate with the ground'.

Now, EUMETSAT has control of a healthy satellite and will begin an intense 12-month commissioning phase. During the commissioning phase, we activate and calibrate the satellite's payload instruments and validate the processing of the instrument data.

"After commissioning, MTG-I1 will move to its final position over Europe, currently served by an older satellite of the second generation Meteosat series, and be declared operational. Then we will begin disseminating MTG-I1's crucial data that will transform the forecasting of severe weather events in Europe and beyond."

MTG-I1 will become fully operational towards the end of 2023 and is the first of EUMETSAT's highly advanced and innovative third generation of Meteosat geostationary satellites that will serve European users into the 2040s.

In a statement from EUMETSAT Director of Programme Preparation and Development Cristian Bank, he stated:

'Meteosat Third Generation is EUMETSAT's most complex and innovative meteorological satellite system so far,'

'When fully deployed, the MTG constellation of two imagers and one sounder satellite will allow meteorologists, for the first time, to track from space the full life cycle of convective storms – from initial instability in the atmosphere to lightning strikes.'

References

For more information about all aspects of the Meteosat Third Generation programme, please consult the following URLs.

All the following are active links: just click to open in your internet browser

Meteosat Third Generation
https://www.eumetsat.int/meteosat-third-generation

MTG Ground Segment
https://www.eumetsat.int/mtg-ground-segment

Flexible Combined Imager
https://www.eumetsat.int/mtg-flexible-combined-imager-fci

Imaging Service
https://www.eumetsat.int/mtg-imaging-service

Lightning Imager
https://www.eumetsat.int/mtg-lightning-imager

Infrared Sounder
https://www.eumetsat.int/mtg-infrared-sounder

Sounding Service
https://www.eumetsat.int/mtg-sounding-service

Sentinel 4
https://www.eumetsat.int/sentinel-4

MTG Data and Products
https://www.eumetsat.int/mtg-data

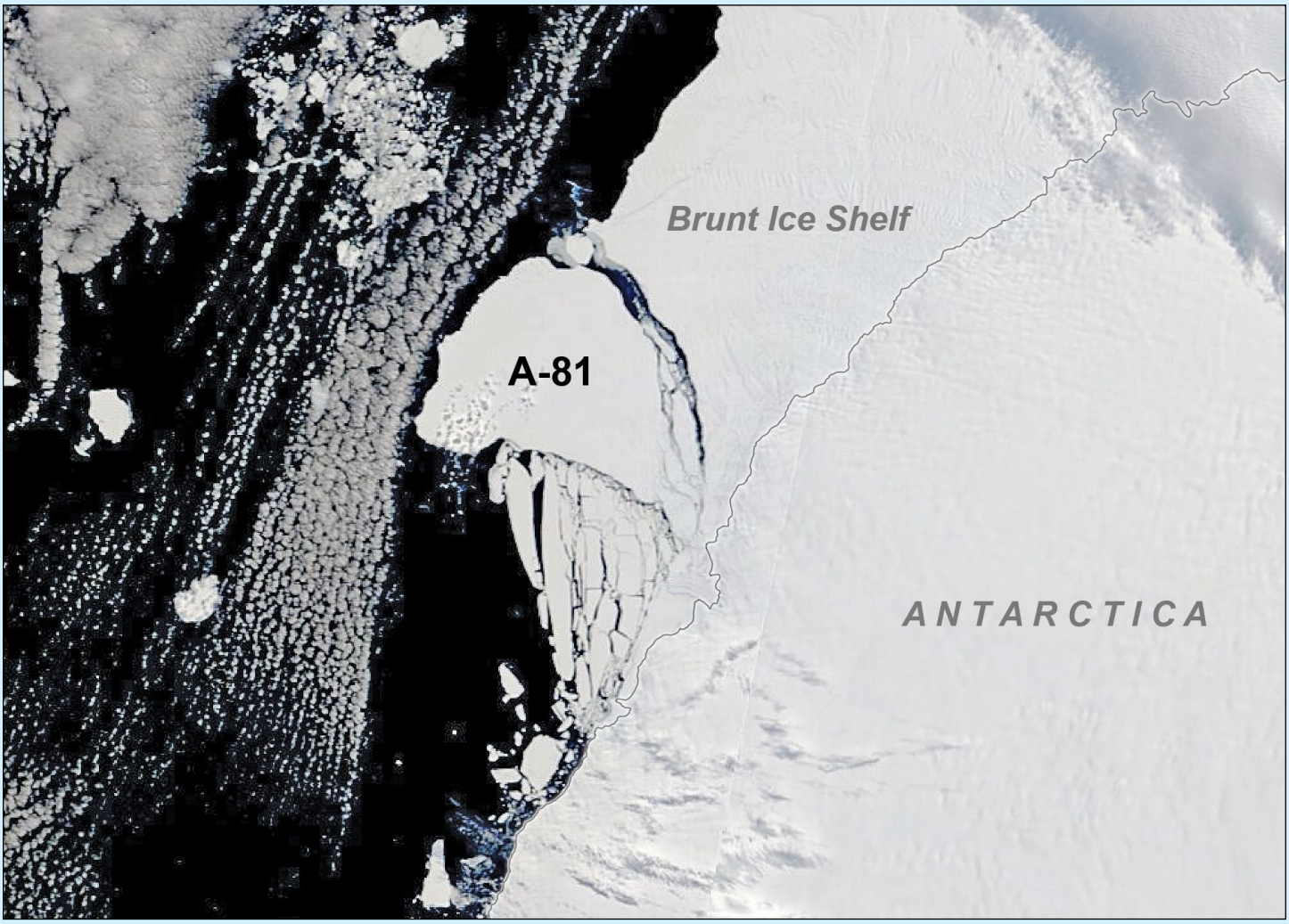
Introducing MTG
https://www.esa.int/Applications/Observing_the_Earth/Meteorological_missions/meteosat_third_generation/Introducing_MTG

EUMETSAT takes over control of its newest weather satellite
https://www.eumetsat.int/eumetsat-takes-over-control-its-newest-weather-satellite

Antarctica's Brunt Ice Shelf Finally Breaks

NASA Earth Observatory

Story by Kathryn Hansen



NASA Earth Observatory image by Lauren Dauphin, using MODIS data from NASA EOSDIS LANCE and GIBS/Worldview and Landsat data from the U.S. Geological Survey

In February 2019, a rift spanning most of the Brunt Ice Shelf in Antarctica appeared ready to spawn an iceberg about twice the size of New York City. The question among scientists was not if the growing rift would finish traversing the shelf and break, but when? Now, nearly four years later, it has done just that.

According to the British Antarctic Survey (BAS), the break occurred late on January 22, 2023, and produced a new iceberg with an area of 1550 square kilometers. The U.S. National Ice Center has named the Iceberg A-81. The berg is visible in the image above, acquired on January 24, 2023, with the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite.

The glacial ice in the shelf flows away from the interior of Antarctica and floats on the eastern Weddell Sea. The shelf has long been home to the British Antarctic Survey's Halley Research Station, where scientists study Earth, atmospheric, and space weather processes. BAS reported that the station, which was relocated farther inland in 2016 as the chasm widened, was unaffected by the recent break.

The break occurred along a rift known as Chasm 1. This chasm started growing in the 1970s, followed by a period of dormancy, and then resumed growth in 2012. It continued to lengthen for almost a decade, extending by as much as four kilometers per year in early 2019. But even this growth spurt slowed. That is until the 2022-2023 Antarctic summer, when the chasm speeded up and ultimately broke past the McDonald Ice Rumples—a submerged knob of bedrock that served as a pinning point for this part of the shelf. Several factors may have contributed to the completion of the break, including a lack of sea ice to help resist, or 'push back', against the stresses on the shelf ice in 2023.

A second image, shown on page 13, was acquired with the Operational Land Imager (OLI) on Landsat 8, and shows the extent of Chasm 1 on January 12, 2021, about one year prior to the break. Notice several other cracks across the northeast part of the shelf.

The 'new crack' in that image ultimately separated in February 2021 and formed Iceberg A-74.

"*The rapid formation of subsequent rifts—to long-standing Chasm 1—and recent calving to the northeast makes it clear that these shelf areas are dynamic with poorly understood stresses*,' said Christopher Shuman, a University of Maryland, Baltimore County, glaciologist based at NASA's Goddard Space Flight Center.

The breaking (calving) of icebergs from ice shelves is part of a natural, cyclical process of growth and decay at the limits of Earth's ice sheets.

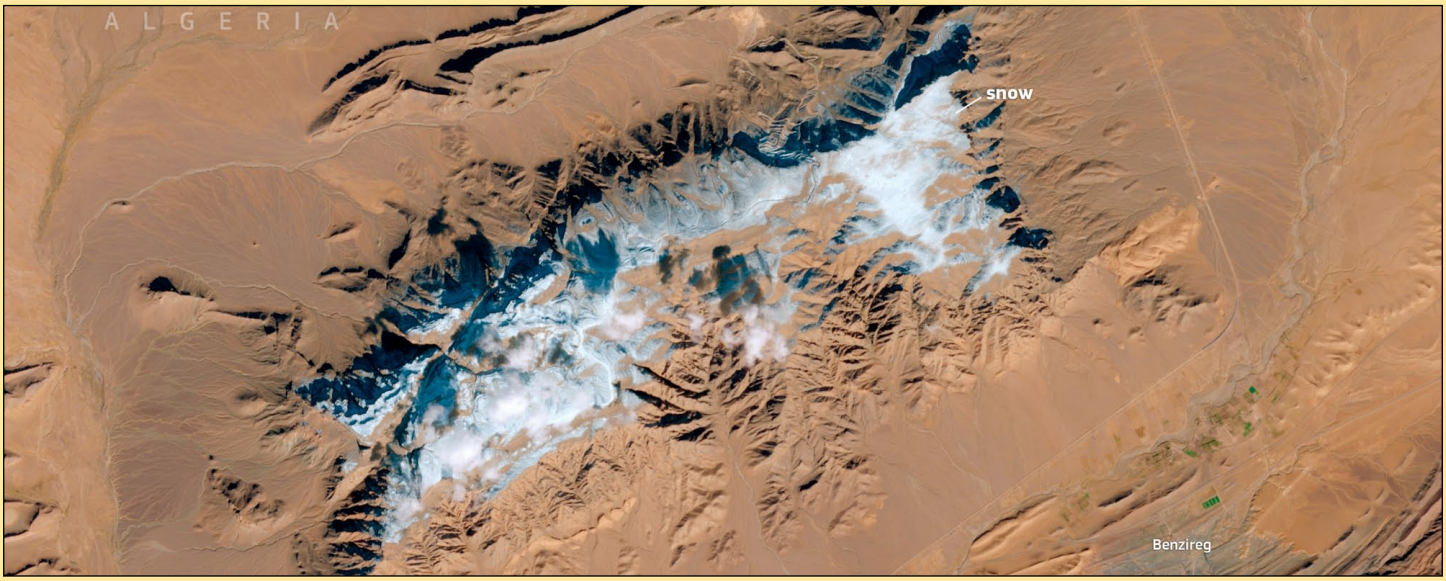
As glacial ice flows from land and spreads out over the sea, shelf areas farthest from shore grow thinner. These areas are stressed by storms and tides, and thin as they are melted from both above or below, ultimately making them more prone to forming rifts and breaking away.

As for the 'new' Brunt, it remains to be seen how the complex floating glacial ice responds to the most recent calving event. According to Shuman: "*We have no solid idea what 'normal' really is for this unusual ice shelf*."

NASA Earth Observatory image by Lauren Dauphin, using MODIS data from NASA EOSDIS LANCE and GIBS/Worldview and Landsat data from the U.S. Geological Survey

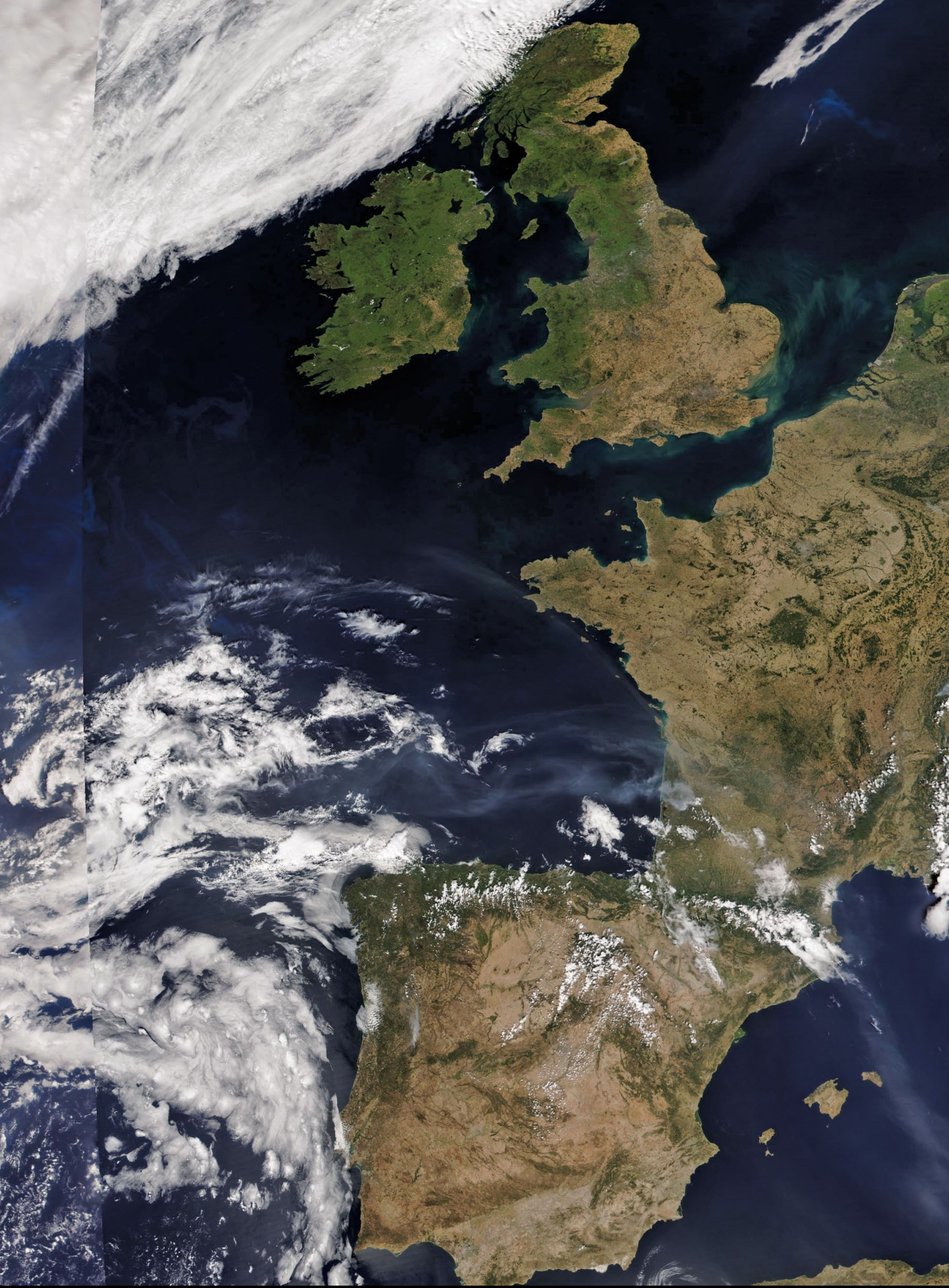
Snow in the Sahara Desert in Algeria

Copernicus Image of the Day



Credit: European Union, Copernicus Sentinel-2 imagery

On January 24, 2023, heavy snowfall fell in northwest Algeria, on the peaks of the Bèchar Province, on the edge of the Sahara Desert. This image, acquired the following day by one of the Copernicus Sentinel-2 satellites, shows the snow-capped peaks and the town of Benzireg. Snowfalls are very rare in the Sahara because of the high temperatures and dry air. Usually, the snow in the lower Saharan Atlas Mountain Range melts rapidly, but Sentinel-2 happened to be at the right place to record the rare event.



This superb image of cloud-free British Isles, France and Spain was captured by NOAA 20 on August 11, 2022

World's Longest Conveyer Belt System

NASA Earth Observatory

Story by Emily Cassidy

On the western edge of the Sahara Desert, a white line 61 miles long cuts across the sand. This conspicuous line is the world's longest conveyer belt system, which traverses Western Sahara's desert from the Bou Craa phosphate mine to the coastal town of El Marsa near Laayoune. The conveyor belt helps transport a critical mineral from remote parts of northern Africa to farmlands across the world, including to the United States.

Phosphorous is a fundamental element to all living things and forms the backbone of our DNA. It is also one of three key nutrients used in commercial fertilisers. Most of the phosphorous in these fertilisers comes from phosphate rock, which is mined predominately is China, Western Sahara and Morocco, and the United States.

According to the U.S. Geological Survey, Morocco and Western Sahara produce about 38 million metric tons of phosphate rock a year, which was 17% of global production in 2021. USGS also estimates that this region contains 70% of all known phosphate rock reserves on the planet.

White dust from chalky phosphate rock can be seen blowing from the belt structure in figure 1, acquired on December 14, 2022 by the MODIS instrument) on NASA's Terra satellite. The white dust helps the belt stand out from the beige and brown desert landscape.

The open pit mine and its conveyor belt, which carries 2,000 tonnes of phosphate rock an hour, is so conspicuous in the Sahara Desert that it has attracted the attention of astronauts on the International Space Station. The photograph of the mine in figure 2 was taken by an astronaut in 2018.

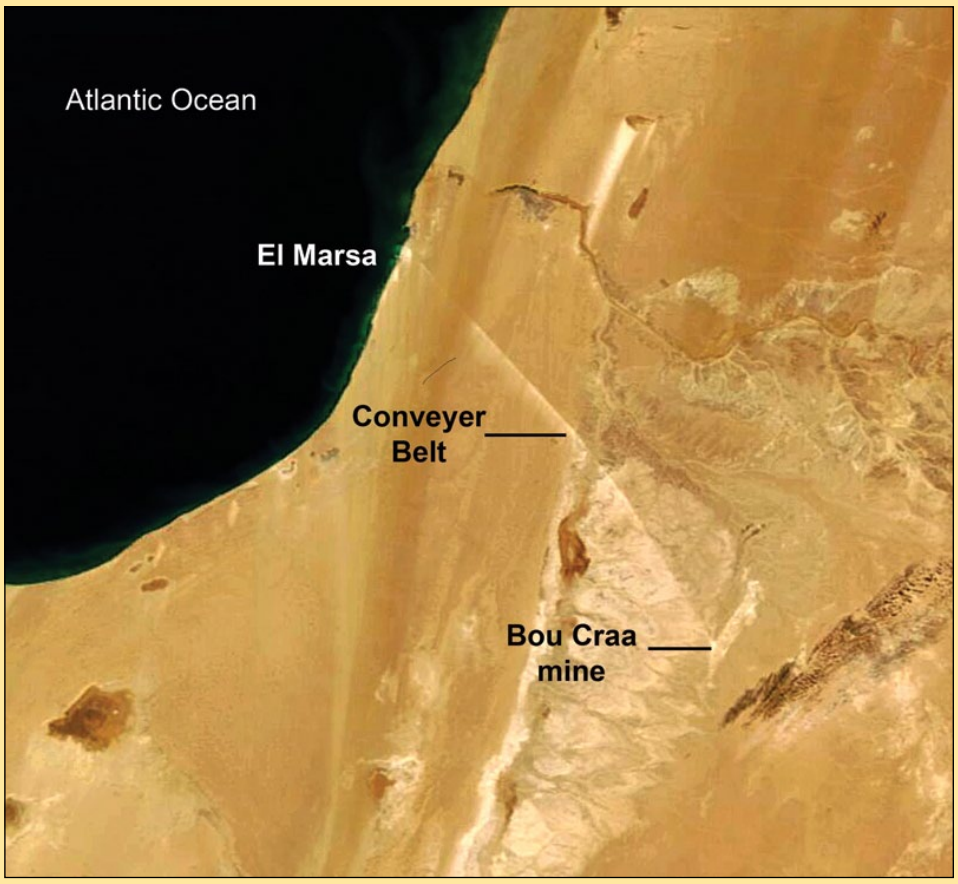


Figure 1 - MODIS image from NASA's Terra satellite showing the conveyer belt
Image by Lauren Dauphin, using MODIS data from NASA EOSDIS LANCE and GIBS/Worldview

Figure 2 - The open mine as viewed from the International Space Station
Astronaut photograph ISS056-E-32453 is provided by the ISS Crew Earth Observations Facility and the Earth Science and Remote Sensing Unit, Johnson Space Center

Severe Winter Floods in Latvia

Copernicus Image of the Day

https://www.copernicus.eu/en/media/image-day

Latvia is at risk of being affected by the worst flooding episode since 1981 due to an ice jam in the Daugava River. The ice jam is affecting the normal flow of the river, causing the water level to rise and threatening to flood large areas in central Latvia. This image is a data visualisation of the CEMS product released on 18 January and highlights in blue the 8 square kilometre area near the city of Jekabpils, throughout which the river is frozen.

The Copernicus Emergency Management Service (CEMS) has been activated (EMSR644) to map the extent of the ice that is obstructing the flow of the river.

Credit: European Union, Copernicus Sentinel-2 imagery and Copernicus Emergency Management Service data

Lake Turkana

MODIS Web Image of the Day

Sitting in the arid landscape of Africa's Eastern Rift Valley, Lake Turkana is both the largest permanent desert lake and the largest alkaline lake on Earth. This long, narrow lake, which stretches 250 km from north to south and 43 km across, is located almost entirely in Kenya. At the northernmost tip, a delta is formed by the influx of the Omo River. This area, as well as the Omo River itself, belongs to Ethiopia.

The lake's salty, alkaline water creates a unique ecosystem, where species have adapted to harsh conditions. Turkana contains about 50 different species of fish, with 11 species found only in this lake. It is home to the largest remaining population of the Nile crocodile and supports more than 350 native and migratory bird species.

Three rivers, the Turkwel, Kerio, and Omo, provide water to Lake Turkana, but Turkwel and Kerio are seasonal. The Omo River provides 90% of the inflow (about 19 cubic kilometres) of water each year. No rivers exit the lake, so the only outflow is by evaporation, which readily occurs in the hot, dry climate. The Omo River not only provides water to Lake Turkana but its waters are also used for hydroelectric power generation, and some are diverted for agriculture.

Currently, a new hydroelectric dam is under development in Ethiopia as part of an expanding system of power plants that should double the electricity output as well as increase industrial farming. The Gilgel Gibe III dam will likely have major impacts on Lake Turkana, the species that rely on the lake for life, and the people relying on the lake for their livelihoods.

The Moderate Resolution Imaging Spectroradiometer (MODIS) on board NASA's Terra satellite acquired this true-colour image of Lake Turkana on December 21, 2022. The Omo Delta is visible as a large dark area at the northern tip of the long, shallow lake.

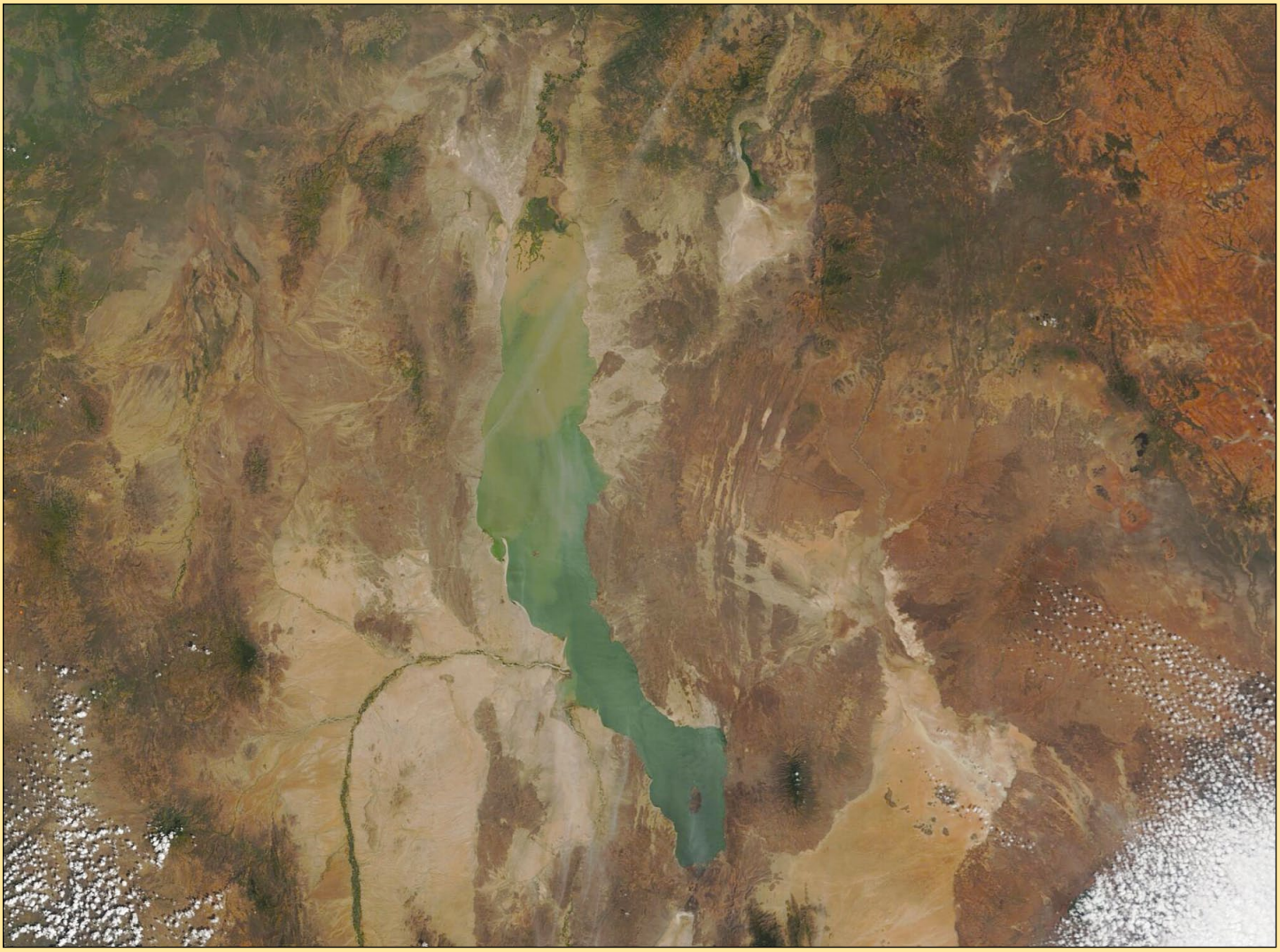


Image Credit: MODIS Land Rapid Response Team, NASA GSFC

End of the Road for Meteosat-8

Les Hamilton

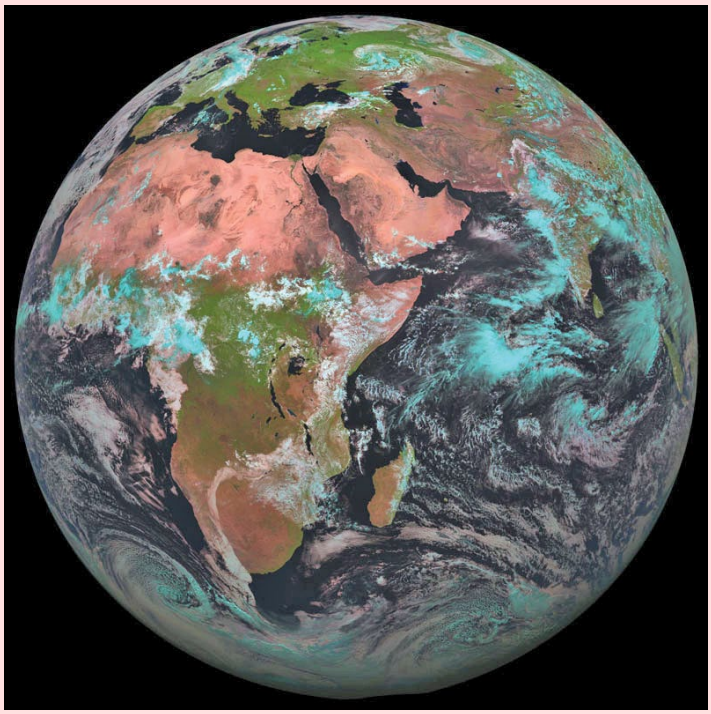
MSG-1, launched on August 28, 2002 and renamed Meteosat-8 once in orbit—the world's longest-serving geostationary meteorological satellite—officially retired at the end of 2022 after 20 years of service despite originally having a design lifetime of only seven years. Its very first full Earth image is reproduced on the front cover of this issue of *GEO Quarterly Newsletter*.

During its operational lifetime, Meteosat-8 produced about a million images over Europe, the whole of Europe and Africa as well as the Indian Ocean, its islands and surrounding countries. It monitored countless storms and severe weather events, helping national weather services to provide timely warnings to their communities and civil authorities. Meteosat-8 completed 7,366 orbits of the Earth, the equivalent of 5,000 trips to the moon.

After providing the full Earth imagery service over Europe and Africa from longitude 0° for almost five years, Meteosat-8 was designated as the standby satellite in May 2007 once the full commissioning of its successor, Meteosat-9, was complete. Another year forward, in May 2008, and Meteosat-8 started to provide the rapid scan service (RSS).

With the commissioning of more MSG satellites, Meteosat-8 eventually became totally redundant at 0° longitude and was repositioned to 41.5°E on September 21, 2016 to provide the Indian Ocean Data Service (IODC).

Using all its remaining propellant, Meteosat-8 will now be elevated to a 'graveyard orbit' around 250 kilometres above the geostationary ring. Once there, the satellite's spin rate will be reduced from 100 to 20 revolutions per minute and all its electrical systems will be switched off. These procedures will minimise the risk that the satellite could break up, generating debris that would pose a threat to other operational satellites.



This is the final image from Meteosat-8 disseminated by EUMETSAT to meteorologists , captured on July 1, 2022
Image: EUMETSAT

To maintain the Indian Ocean Data Coverage service, Meteosat-9, took over as the prime IODC satellite, at a target longitude of 45.5° E, on 1 June 2022.

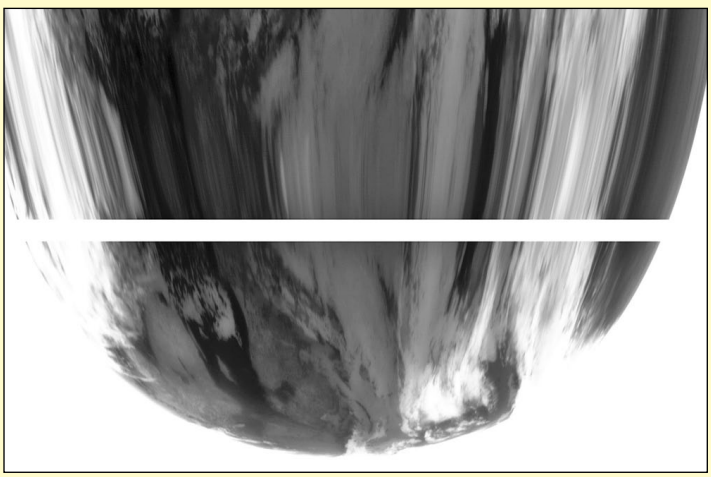
Probable Demise of Meteor M-N2

Les Hamilton

Not for the first time, Meteor M-N2 suffered a major orientation problem on December 24, 2022, and has not produced any transmissions since.

The final image, transmitted over central Europe, part of which is shown here, clearly indicated that the satellite was pointing towards the Earth's southern limb.

In the past, such problems have generally been corrected within a couple of weeks or so, but the length of radio silence experienced from Meteor on this occasion does rather suggest that its failure could be permanent.



Phytoplankton Bloom around the Falkland Islands

MODIS Web Image of the Day

Brilliant jewel-toned swirls coloured the dark waters surrounding the sedate landscape of the Falklands Islands in mid-December 2022. The Moderate Resolution Imaging Spectroradiometer (MODIS) on board NASA's Terra satellite acquired a true-colour image of the spectacular scene on December 19.

The Falkland Islands, also known as Islas Malvinas, is a group of more than 700 islands situated in the South Atlantic Ocean, about 500 kilometres east of southern Argentina. Just two of the islands—East Falkland and West Falkland—comprise the bulk of the Connecticut-sized landmass.

The bright colours lighting up the Southern Ocean are caused by massive populations of microscopic plant-like organisms called phytoplankton. These tiny organisms contain chlorophyll and other pigments and thrive in nutrient-rich waters, such as can be found in the Malvinas Current, which sweeps cold water from near the Antarctic northward and around the Falkland Islands. As sunlight begins to lengthen in the springtime, the combination of abundant light and dense nutrients proves a heady concoction for phytoplankton, spurring them to reproduce explosively. This often results in huge floating blooms which can easily be seen from space.

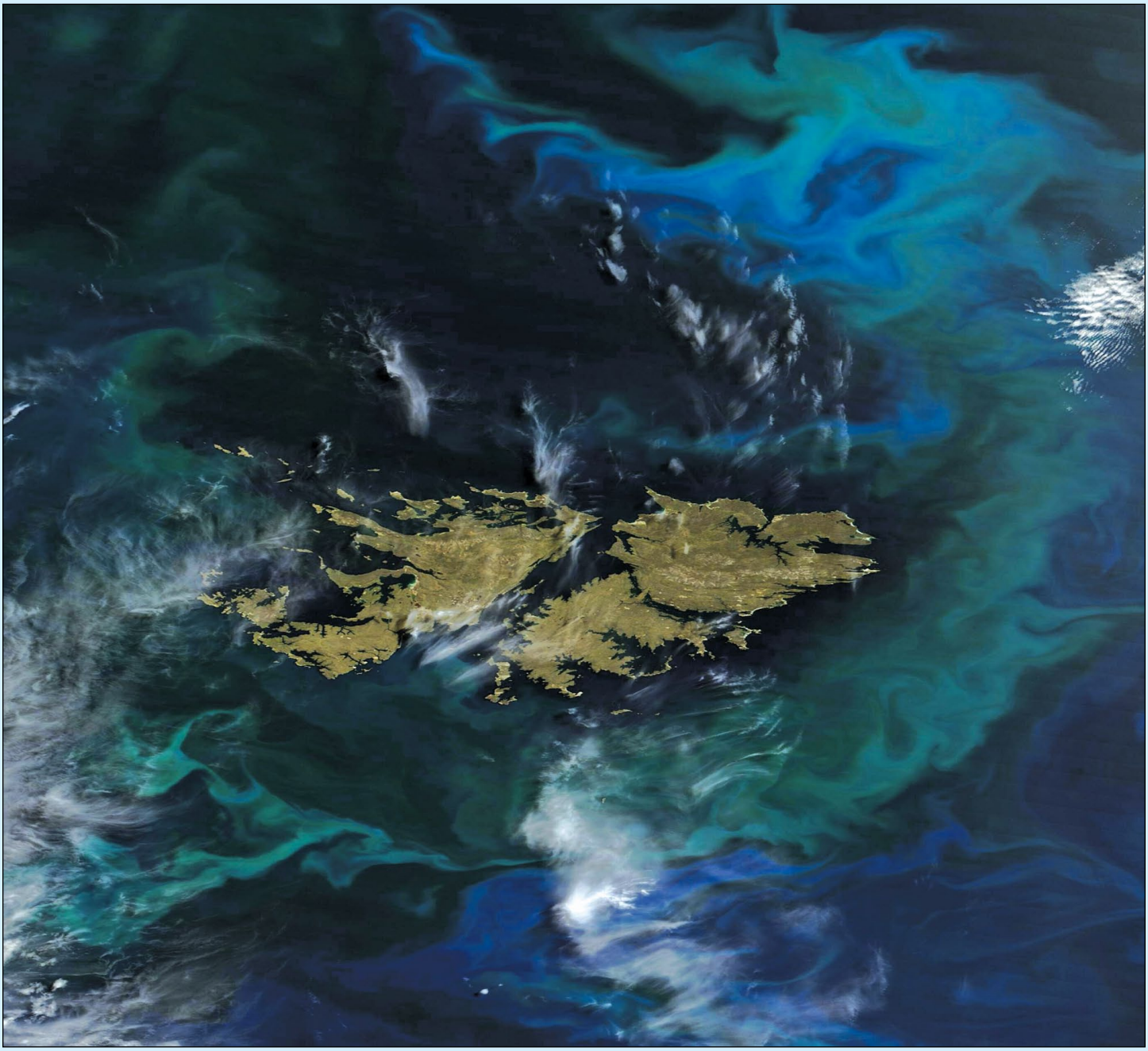


Image Credit: MODIS Land Rapid Response Team, NASA GSFC

Racing to Mine Lithium

NASA Earth Observatory

Story by Adam Voiland

Exploding white dwarf stars are thought to be the ultimate source of much of our solar system's lithium. But on Earth, there are certain environments where this soft, lightweight, silvery-white metal is most concentrated and easily mined: notably in briny groundwater aquifers found beneath desert salt flats.

An ideal climate for mining lithium is generally arid, punctuated by seasonal rains or melting. This allows water to pool in shallow, salty lakes and then evaporate during the summer—a cycle that helps to concentrate the lithium. Thermal hot springs, volcanic activity, and a subsiding landscape also typically accompany major lithium reserves.

These conditions abound in the Atacama Desert in South America, where some of the world's largest lithium deposits and mining operations are located. But they can also be found in Nevada's Clayton Valley—the site of the only active lithium mine in the United States. The town of Silver Peak was established in the 1860s around gold and silver mines, but since the 1960s the town has focused on harvesting lithium, which is concentrated under the Clayton Valley in an area where an extinct volcano left lithium-rich deposits.

The Operational Land Imager-2 (OLI) on Landsat 9 acquired this natural-colour image of the lithium mining operation in Silver Peak on December 8, 2022. The mine pumps brine to the surface and shunts it into a series of shallow evaporation ponds. Colour variations in the ponds are due to varying concentrations of lithium in the water: lighter blue ponds have higher concentrations of lithium. The valley's frequently dry, sunny, and windy weather evaporates water and leaves an increasingly concentrated lithium brine—a process that can take 18 months or more. The brine is then pumped to a nearby facility where it is processed, dried into a powder, and packaged.

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

Global demand for lithium has ballooned in recent years and is forecast to continue surging in the coming decade because the metal is used in the rechargeable batteries used to power electric vehicles. Makers of laptops, cell phones, and other products with rechargeable batteries also rely heavily on lithium. Lithium is also used in ceramics, certain types of glass, industrial grease, and some types of medication.

Like many lithium mines around the world, the mine at Silver Peak is adding new pumps and evaporation ponds to try to keep up with the demand. The mine, which has been the only U.S. source of lithium for decades, plans to double its production by 2025. Demand for U.S. produced lithium is particularly strong due to tax incentives that reward consumers for buying electric vehicles with domestically produced and assembled parts.

The Silver Peak mine generates about one percent of the world's annual production of lithium. Brine operations, mostly in Chile and Argentina, generate about 75 percent of worldwide production. The mining of lithium-containing ore, which is especially common in Australia, accounts for the rest.

Fog in the California's Central Valley

MODIS Web Image of the Day

Thick fog frequently fills California's Central Valley in late fall and winter, often creating a risk for drivers as visibility plummets. The Moderate Resolution Imaging Spectroradiometer (MODIS) on board NASA's Terra satellite acquired a false-colour image of a huge bank of fog on December 15, 2022.

In this type of false-colour image, infrared and visible light (MODIS Bands 7,2,1) are combined to help separate snow, which appears electric blue, from cloud and fog. Fog and most clouds look bright white, although high, cold clouds which contain ice crystals, may be tinted with electric blue. Vegetation appears green, open land looks tan, while water shows up as inky-black.

The formation of fog requires three ingredients: wet ground, still air, and cold temperatures. Conditions are ripe after the ground has become damp from recent rainfall. During the day, the warmth of the Sun causes the moisture to evaporate into the air. After sunset, air temperature slowly drops. Because cool air can hold less moisture than warm air the many tiny moisture droplets suspended in the air during the day combine into large droplets, creating 'low cloud', or fog.

The Central Valley winter fog, also called Tule (too-le) tends to form—often rapidly—after sunset, becomes thickest just before dawn, then slowly thins as the air warms in the morning. Tule fog season typically begins in December and ends in February.

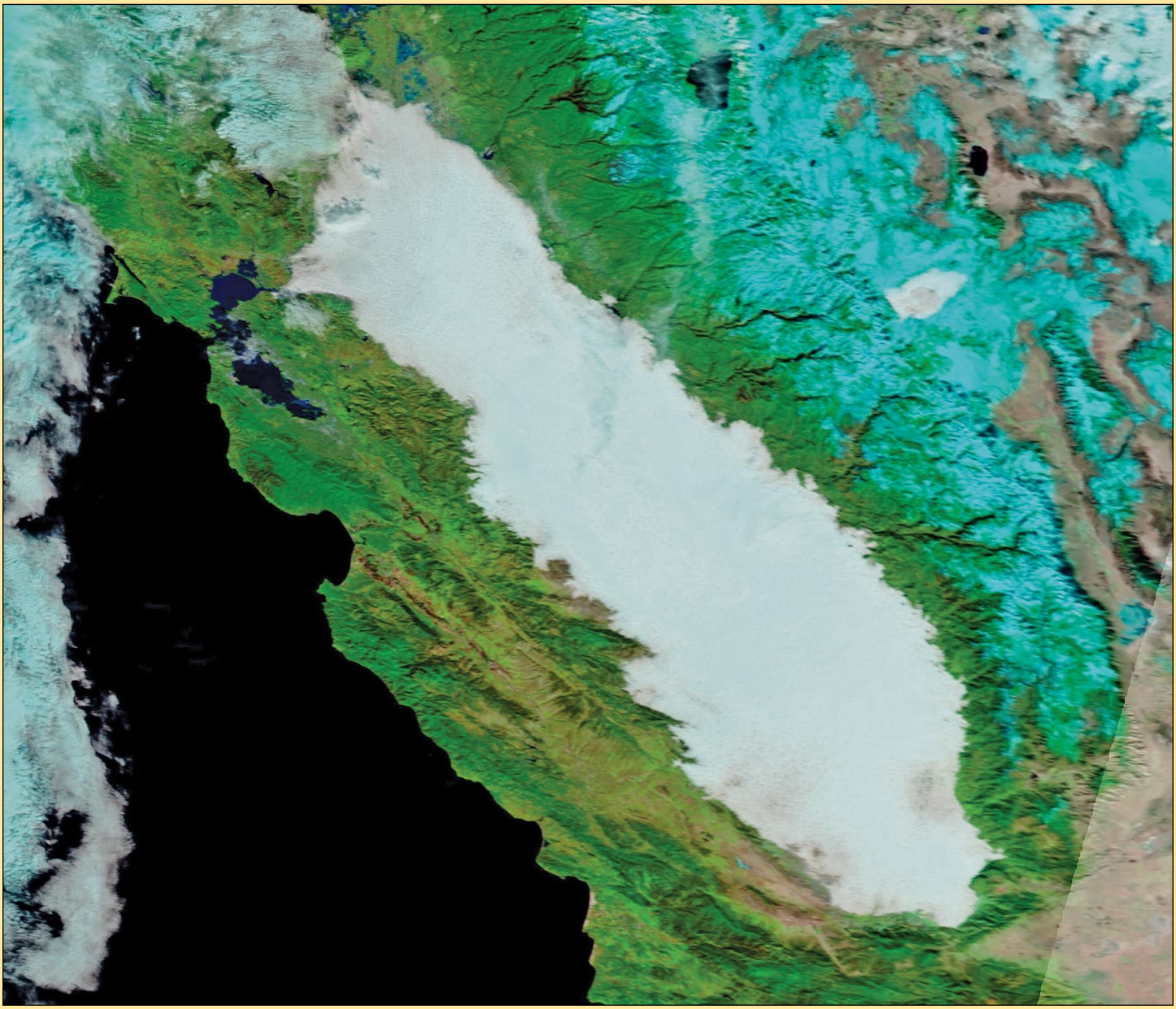


Image Credit: MODIS Land Rapid Response Team, NASA GSFC

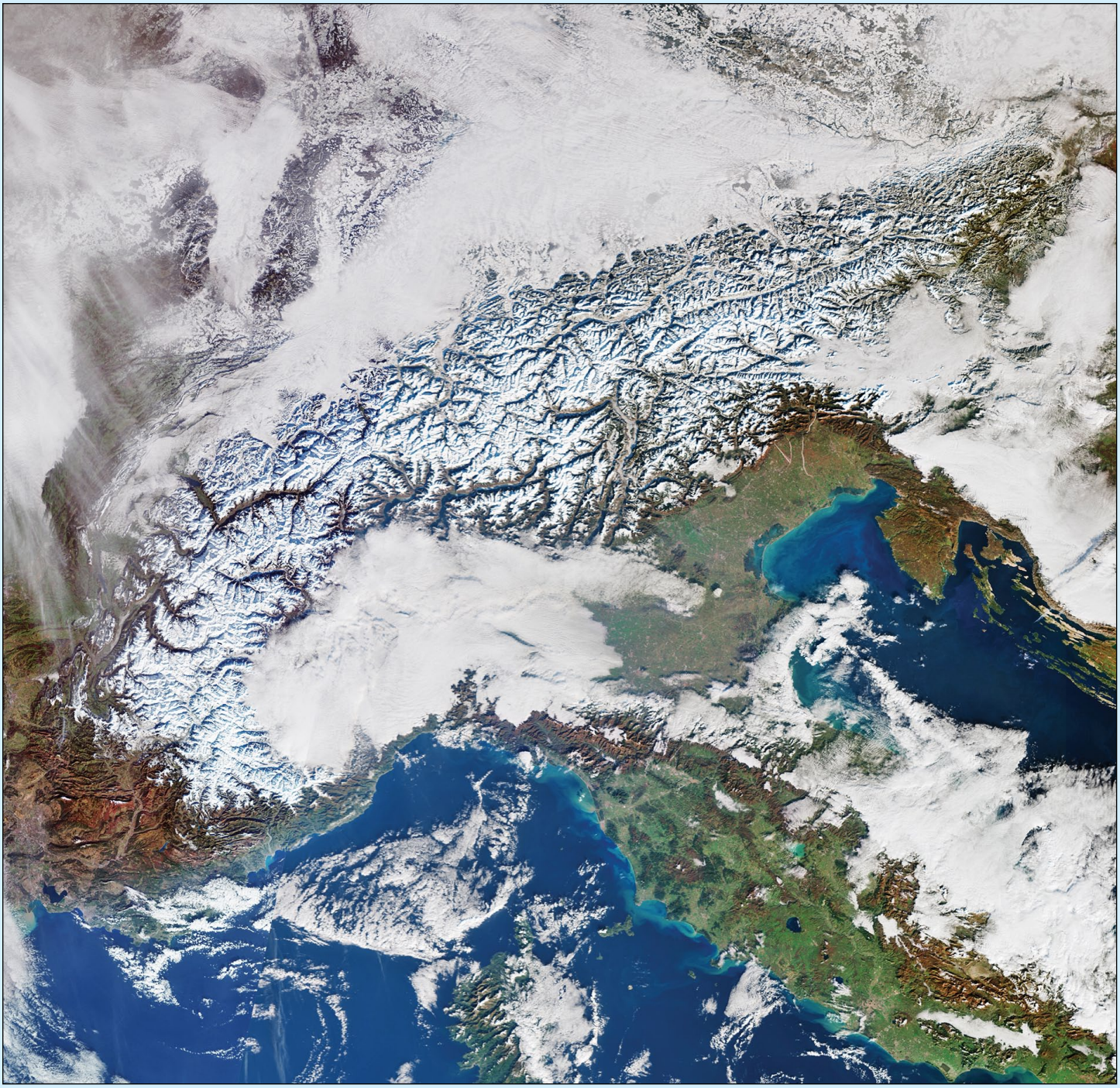
Snowy Alps

European Space Agency

Snow cover is a vital source of water for industry, agriculture and human consumption. Records show that winter snow cover in the Alps during 2022 was the lowest it has been since 2001. This Copernicus Sentinel-3 image captured on December 18, 2022 shows the wide-coverage of snowfall which hopefully bodes well for the coming year.

Carrying a suite of cutting-edge instruments, the Copernicus Sentinel-3 mission measures Earth's oceans, land, ice and atmosphere to monitor and understand large-scale global dynamics.

Sentinel-3 measures the temperature, colour and height of the sea surface as well as the thickness of sea ice, while over land it provides indices of vegetation state, maps land and measures the height of rivers and lakes.



Saba Island

NASA Earth Observatory

Story by Emily Cassidy

Saba is a 13-square-kilometer island in the Dutch Caribbean rich in biodiversity. Located about 140 kilometres east of the US Virgin Islands, the active stratovolcano rises 1,500 metres above the sea floor. Above the water, rainforests cover the steep slopes of the volcano, home to many birds, orchids and reptiles, including an endemic spotted lizard, the Saban anole (Anolus sabensis). Below the water, corals and other species thrive.

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

The Operational Land Imager (OLI) on Landsat 8 captured this natural-colour image of Saba on August 16, 2022. The largest city and capital of the island, called *The Bottom*, lies between the port and the higher elevations of the volcano. The island has no natural sandy beaches which makes it less of a tourist destination than other Caribbean islands, but Saba's coastal waters have been ideal for divers looking to spot healthy populations of corals and sea urchins.

Saba Wearing a Cap
Photo: Richie Diesterheft / Creative Commons Attribution-Share Alike 2.0

That is until recently. In early 2022, sea urchins in the Caribbean started mysteriously dying off. Sea urchins graze on algae, the main competitors for corals for space and light, and they remove algae from coral surfaces, allowing baby corals to attach and grow. In this way, the survival of coral reefs depends on healthy populations of sea urchins.

In early February 2022, dive shops in the Caribbean began reporting on mysterious sea urchin die-offs, specifically the long-spined sea urchin (*Diadema antillarum*). Saba's reef was once home to more than 5,000 *D. antillarum*. But in April 2022, in a section of Saba's reef called 'Diadema City', half of the long-spined sea urchins died off in just one week, and only 100 remained in June, according to reporting in ScienceNews.

The massive loss of sea urchins is reminiscent of a die-off that started in 1983, in which virtually all of the *D. antillarum* population in the Caribbean was eliminated within a year. Although the exact cause of the 1983 and 2022 die-offs is still a mystery, many researchers agree that the speed and scope of the event in the 1980s indicates the spread of an unknown disease.

Populations of *D. antillarum* never fully recovered from the die-off nearly 30 years ago, which incentivised Dutch researchers to cultivate and breed them in the lab. The researchers hope to repopulate the sea urchins in Saba's surrounding waters, to help the reef bounce back.

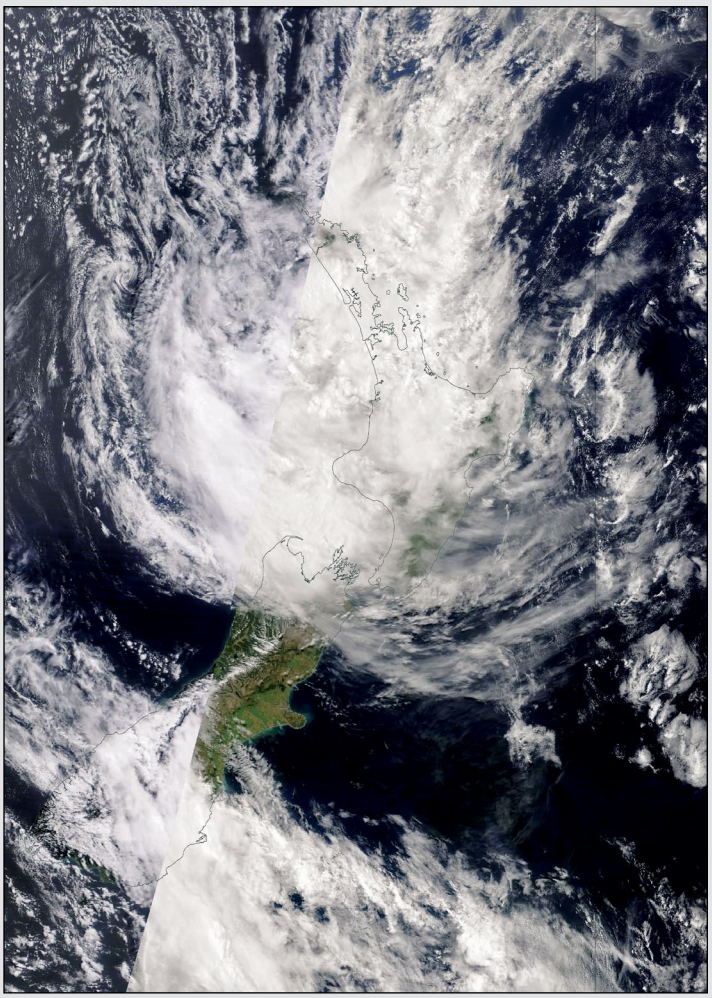
Unprecedented Deluge Swamps Auckland

Les Hamilton

Described as 'the biggest non-earthquake event' in New Zealand's history by the nation's finance minister Grant Roberston, the city of Auckland was deluged by torrential rainfall on Friday, January 27, 2023, the result of an influx of warm moist air from the tropics which tracked south across the Tasman Sea over North Island.

The *National Institute of Water and Atmospheric Research* claimed that the rainstorm created the city's wettest 24 hours ever after more than 150 mm of rain fell in just three hours, rising to a record 249 mm over 24 hours. This figure represented more than eight times the city's average January rainfall and 40% of its annual average rainfall. The previous 24 hour rainfall record was a 'mere' 161 mm. The storm also broke previous monthly rainfall records: 206 mm for January 1986 and 304 mm in July 1998, the area's wettest month ever. In just three days this January, 320 mm had already fallen with forecasts of more heavy rain for the days ahead. Average rainfall for the Auckland area is 386 mm per year!

The unprecedented precipitation led to sudden and widespread flooding, prompting the imposition of a state of emergency across the entire Auckland metro area which has a population of 1.6 million people. The city's international airport was closed after its terminal was overrun with water and some 2000 stranded passengers had to be evacuated from its terminal: in all, some 9000 passengers had their flights cancelled because of the situation. That Friday evening, Elton John was due to perform at a concert, which a full house of 40,000 people were expected to attend in the Mount Smart Stadium. The event was cancelled just minutes before it was due to start, with concert-goers already in their seats.



This MODIS image from NASA's Terra satellite shows the warm air mass descending on New Zealand's North Island of January 27, 2023
Image: NASA

And a second Elton John concert planned for the following evening also had to be cancelled at short notice while fans were already driving to the venue, as it was deemed too dangerous to continue. Many of the concert-goers who did turn up later found themselves stranded because their cars had become swamped by floodwaters and could not be started.

Between that fateful Friday evening and the following Saturday morning, *Fire and Emergency New Zealand* crews responded to 719 incidents across the region, received more than 2,242 emergency calls and rescued 126 people who had been trapped in houses or cars by the floodwaters, or had been involved in vehicle crashes. Sadly, four people lost their lives as a result of the flash floods and landslides that took place.

The widespread flooding led to many properties teetering precariously at the edges of virtual cliff-faces following dramatic landslides. Other properties simply floated off their foundations. Thousands of homes and business premises were inundated by floodwaters, losing both power and water supply and many of the city's roads were closed by flooding. Many residents had to be evacuated from their homes, some aided by rescuers in kayaks.

Over 5000 affected homes required to be assessed for storm damage, and ultimately 277 homes or buildings were red stickered and 1615 yellow stickered. A red sticker indicated that a building was uninhabitable and unsafe to enter, while a yellow sticker allowed people restricted access to certain parts of a building in order to claim possessions.

Following what has been dubbed a once in 250 year event, insurance companies face many thousands of claims ranging from rebuilding entire properties to replacement of possessions suffering water damage. The cost of the clean up is expected to top the NZ$97 million bill for the 2021 West Coast flooding but will be much less than the estimated NZ$31 billion insurance costs of the Christchurch earthquakes in 2010-2011.

Cyclone Gabrielle Lashes New Zealand

NASA Earth Observatory

Story by Kathryn Hansen

Cyclone Gabrielle lashed New Zealand with strong winds and heavy rain in mid-February 2023, adding to what has already been an unusually wet start to the year. The latest round of extreme weather brought destructive flooding, storm surge, and landslides to the region.

The Visible Infrared Imaging Radiometer Suite (VIIRS) on the NASA-NOAA Suomi NPP satellite acquired this image at about 3 pm local time on February 14, 2023. It shows Cyclone Gabrielle as it slowly moved toward the southeast. At the time, the storm was centred near the North Island, but its cloud bands spanned much of the country.

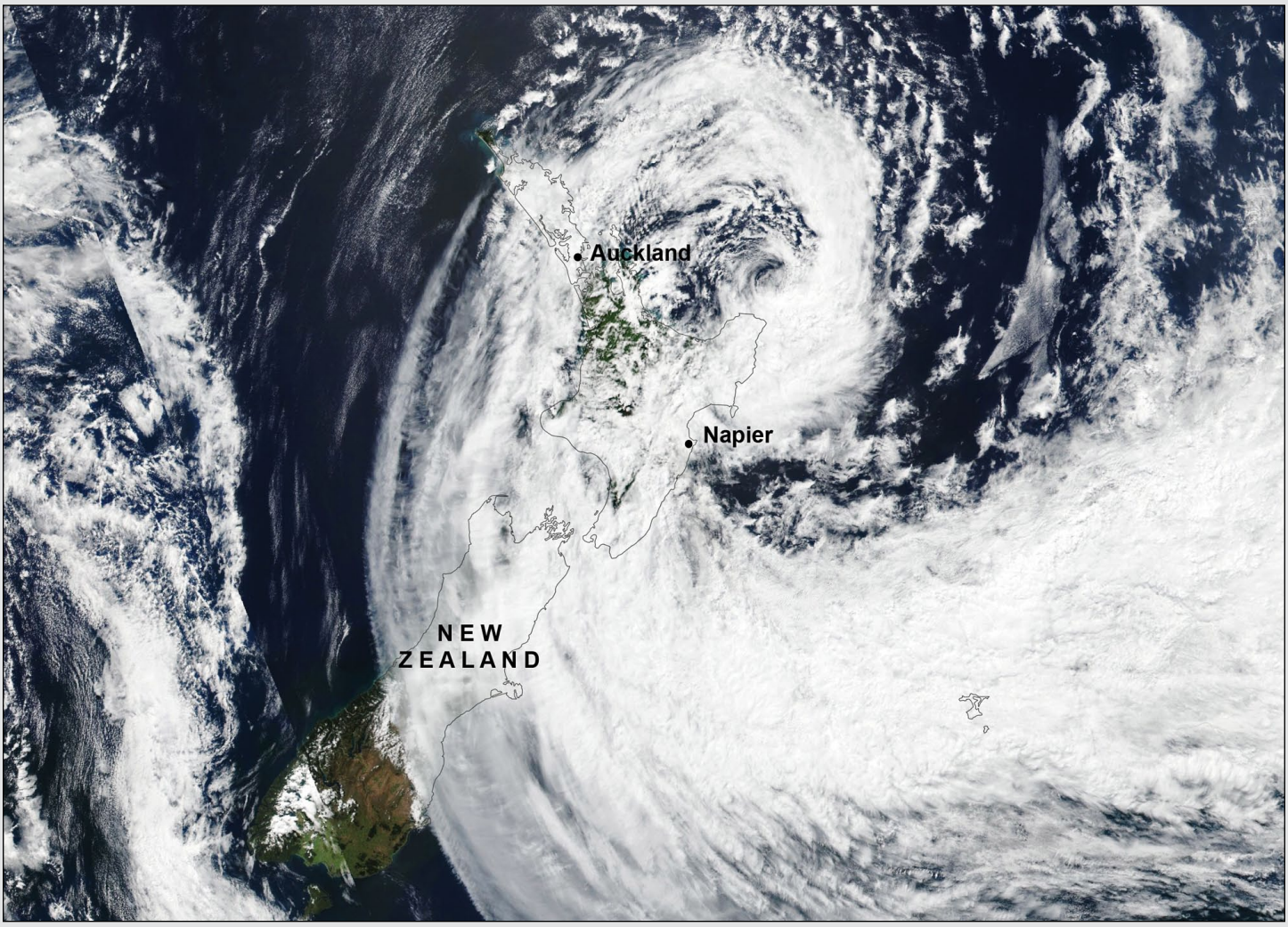
Cyclone Gabrielle encountered New Zealand as a powerful subtropical storm after transitioning from a tropical cyclone. Rainfall from the still-powerful storm began falling on the island nation on February 11 and continued for the next several days. Accumulations at Napier Airport (Hawke's Bay Airport) reached 175.8 millimetres over a 24-hour period from February 13-14, more than three times the average typically seen during the entire month of February.

By around 7 am local time on February 15, the cyclone was continuing to move slowly toward the southeast and away from New Zealand. Still, warnings for heavy rain and swell remained in effect along some central parts of the country.

According to news reports, officials declared a national state of emergency—only the third such declaration in the country's history. The storm left hundreds of thousands without power, led to the cancellation of flights, and damaged roads, homes, and infrastructure.

The drenching rains in February follow the storm that hit the country on January 27. During that storm, parts of Auckland saw all-time daily rainfall records, which contributed to the city's wettest January on record.

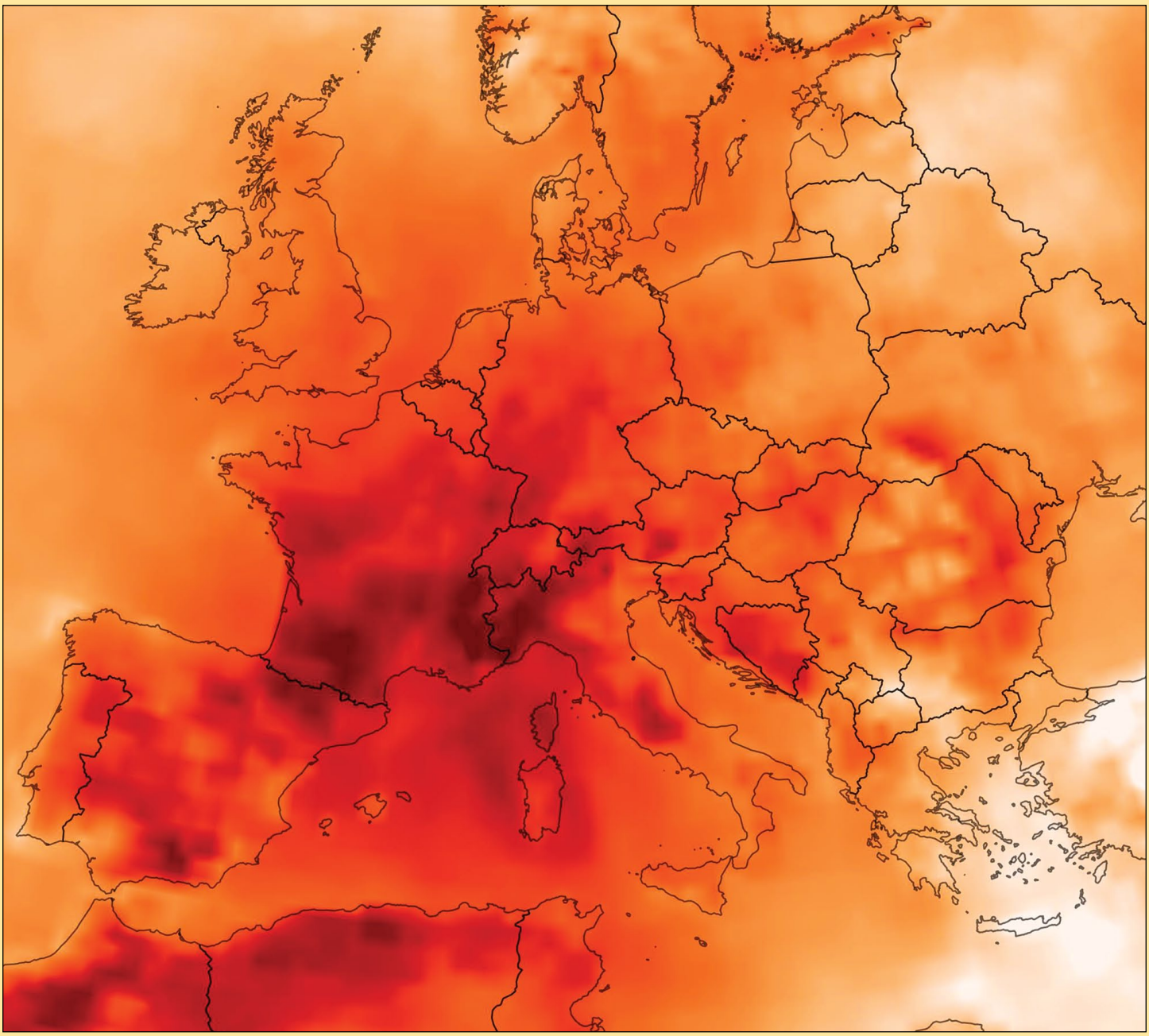
According to the New Zealand meteorological service, an average of ten tropical cyclones form in the South Pacific each year between November and April. Of those, only one will normally affect New Zealand as an ex-tropical cyclone, most often in February or March.



NASA Earth Observatory image by Lauren Dauphin, using VIIRS data from NASA EOSDIS LANCE, GIBS/Worldview, and the Suomi National Polar-orbiting Partnership

Record 2022 Temperatures in Europe

Copernicus Image of the Day



Credit: European Union, Copernicus Climate Change Service data

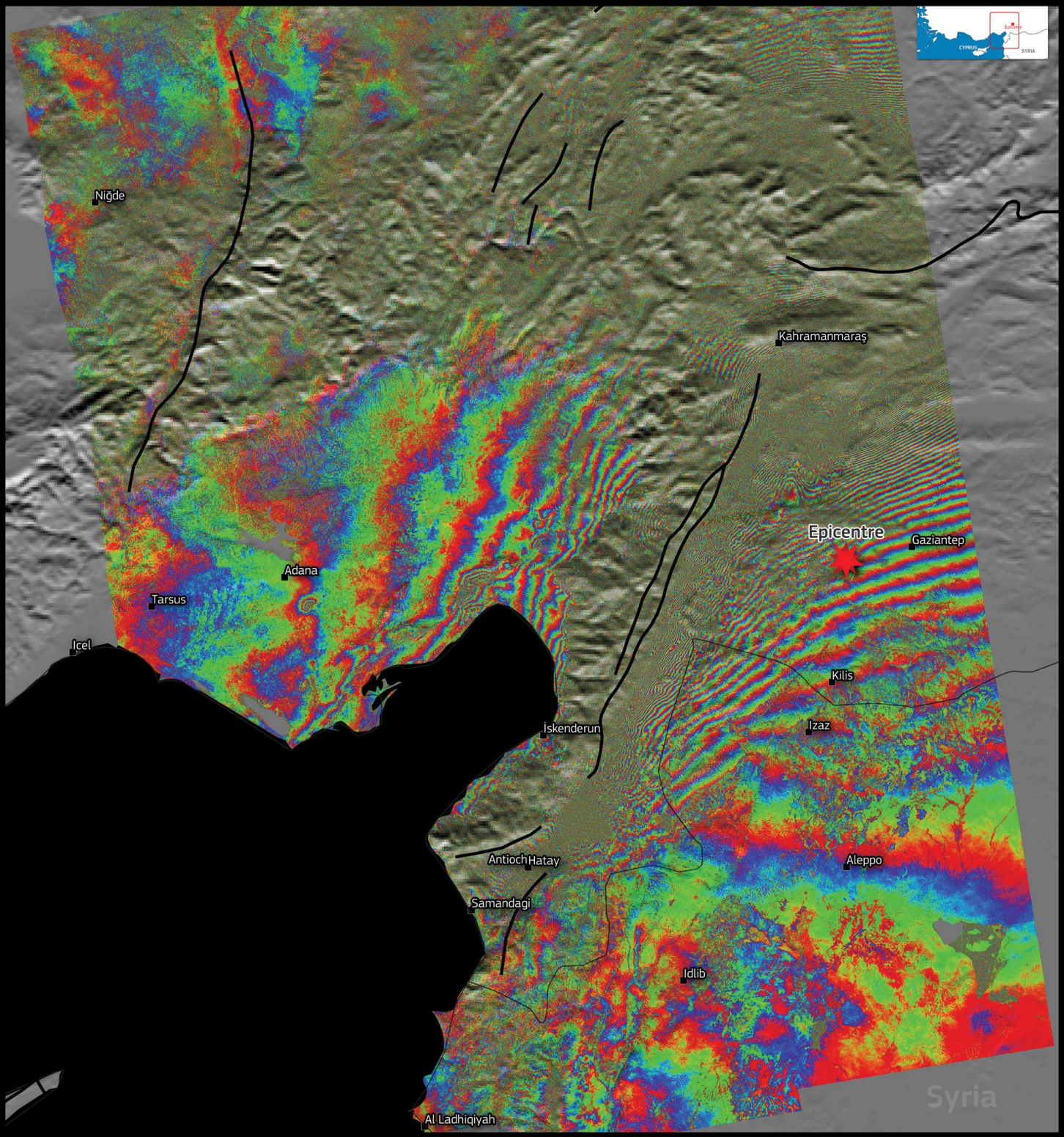
In 2022, Europe experienced extremely high temperatures and a continuous rise in the concentration of greenhouse gases in the atmosphere. According to the Global Climate Highlights for 2022, recently published by the Copernicus Climate Change Service (C3S) which is implemented by ECMWF, (European Centre for Medium-Range Weather Forecasts) many temperature records were broken.

The summer season in 2022 was extremely warm, and it was in fact the hottest on record for the European continent, with many countries in Western and Northern Europe affected by intense and prolonged heatwaves. Temperatures in the Autumn were also significantly above average, and the season was registered as the third warmest on record. Overall, 2022 was the second-hottest year on record for the continent: apart from Iceland, all of Europe recorded annual temperatures higher than the 1991-2020 average. The unusually warm and dry weather caused significant drought conditions to affect large parts of Europe, especially in countries in the south-west, such as France and Spain.

This image, created using data retrieved from the C3S Climate Data Store, shows the Surface Air Temperature Anomaly for the average temperatures in 2022 in Europe.

Interferogram of the Anatolian Earthquake

Copernicus Image of the day
https://www.copernicus.eu/en/media/image-day



Credit: European Union, Copernicus Sentinel-1 data
Processed by European Commission Directorate-General for Defence Industry & Space (DG DEFIS)

A devastating 7.8 magnitude earthquake has hit Türkiye and Syria. The damage is considerable, with many tens of thousands of fatalities. The earthquake was so strong that it caused massive ground deformations. This interferogram was created using radar data acquired by the Copernicus Sentinel-1 satellite in ascending orbit on January 28 and February 9, 2023. The areas with the greatest displacement are those close to the Anatolian fault, where analysis of the radar data indicates a displacement along the satellite's line of sight of about four metres.

Italian Apennine Mountain Range Covered with Snow

Copernicus Image of the Day

Credit: European Union, Copernicus Sentinel-3 imagery

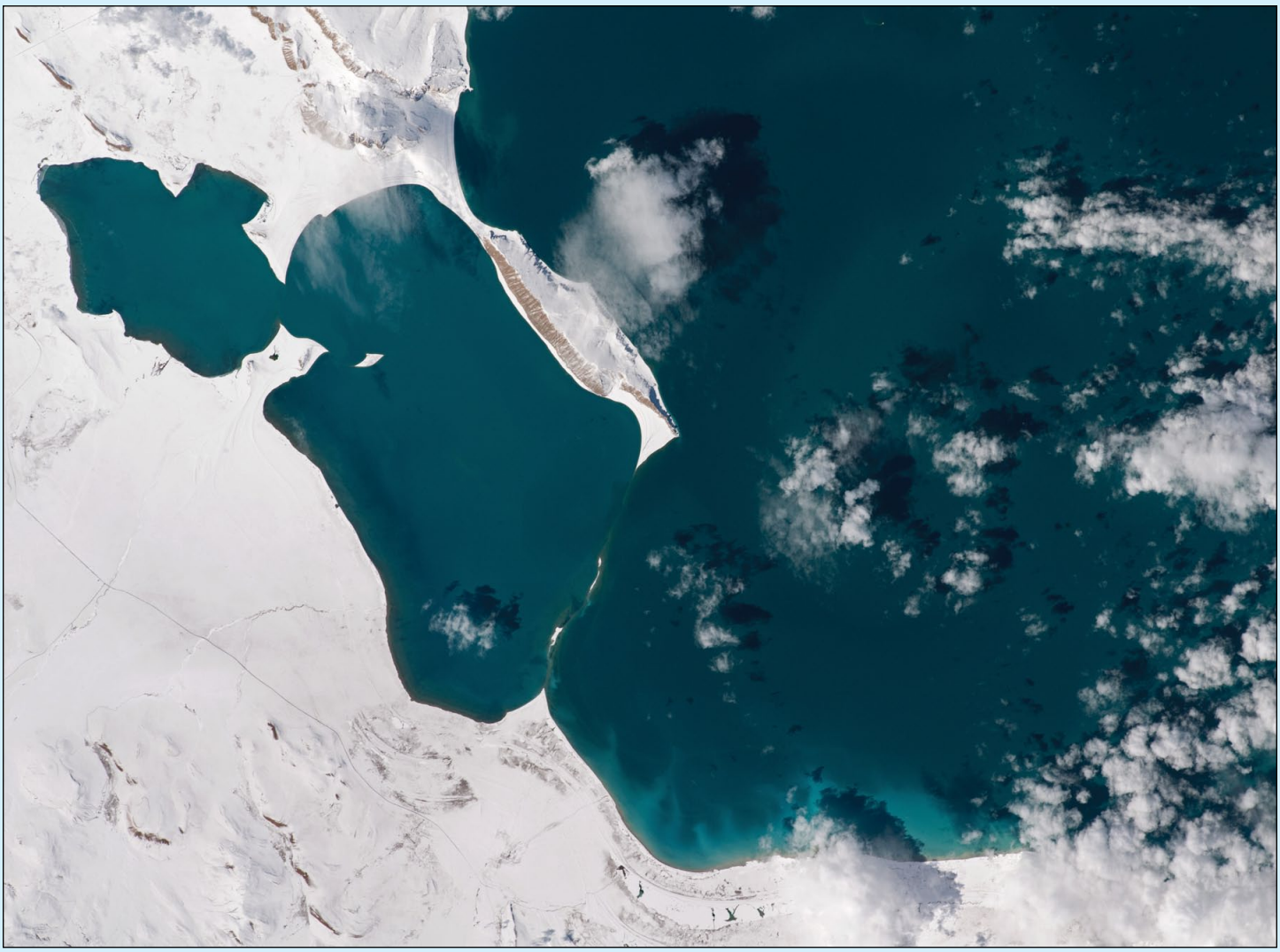
After an unusually warm start of the winter season characterised by the lack of significant snowfall, a massive late January snowstorm covered the peaks of central and southern Italy with snow. Several municipalities in inland Italy were heavily affected, and local schools were closed for several days in order to prevent children, parents and teachers from commuting in unsafe road and weather conditions. The fresh snow cover on the Central and Southern parts of the Apennine range is visible in this image, acquired by one of the Copernicus Sentinel-3 satellites on January 24, 2023.

The Copernicus Land Monitoring Service product portfolio includes Snow & Ice (HR-S&I) Monitoring products, which provide high resolution (20 × 20 metres) information derived from Copernicus Sentinel-2 satellite data on snow and ice conditions in the 38 Member States and Cooperating Countries of the European Environment Agency.

Siling Lake - Tibet

NASA Earth Observatory

Caption by Cadan Cummings, Jacobs, JETS Contract at NASA-JSC



Astronaut photograph ISS066-E-86268 is provided by the ISS Crew Earth Observations Facility and the Earth Science and Remote Sensing Unit, Johnson Space Center.

While orbiting over the northern Tibetan Plateau, an astronaut aboard the International Space Station captured this photograph of Siling Lake. The lake, also called Selincuo, is one of the largest water bodies on the Tibetan Plateau. In this image, fresh snowfall from the previous day blankets the landscape.

Located at an elevation of approximately 4,500 metres, Siling Lake is a high-altitude endorheic lake, which means that it does not drain through any outlets. The lake is fed by precipitation—approximately 38 centimetres per year—as well as runoff from rain, snow, and glacial meltwater from the surrounding landscape. Siling Lake is a saline water body due to the lack of outflow, which concentrates salts as the lake water evaporates.

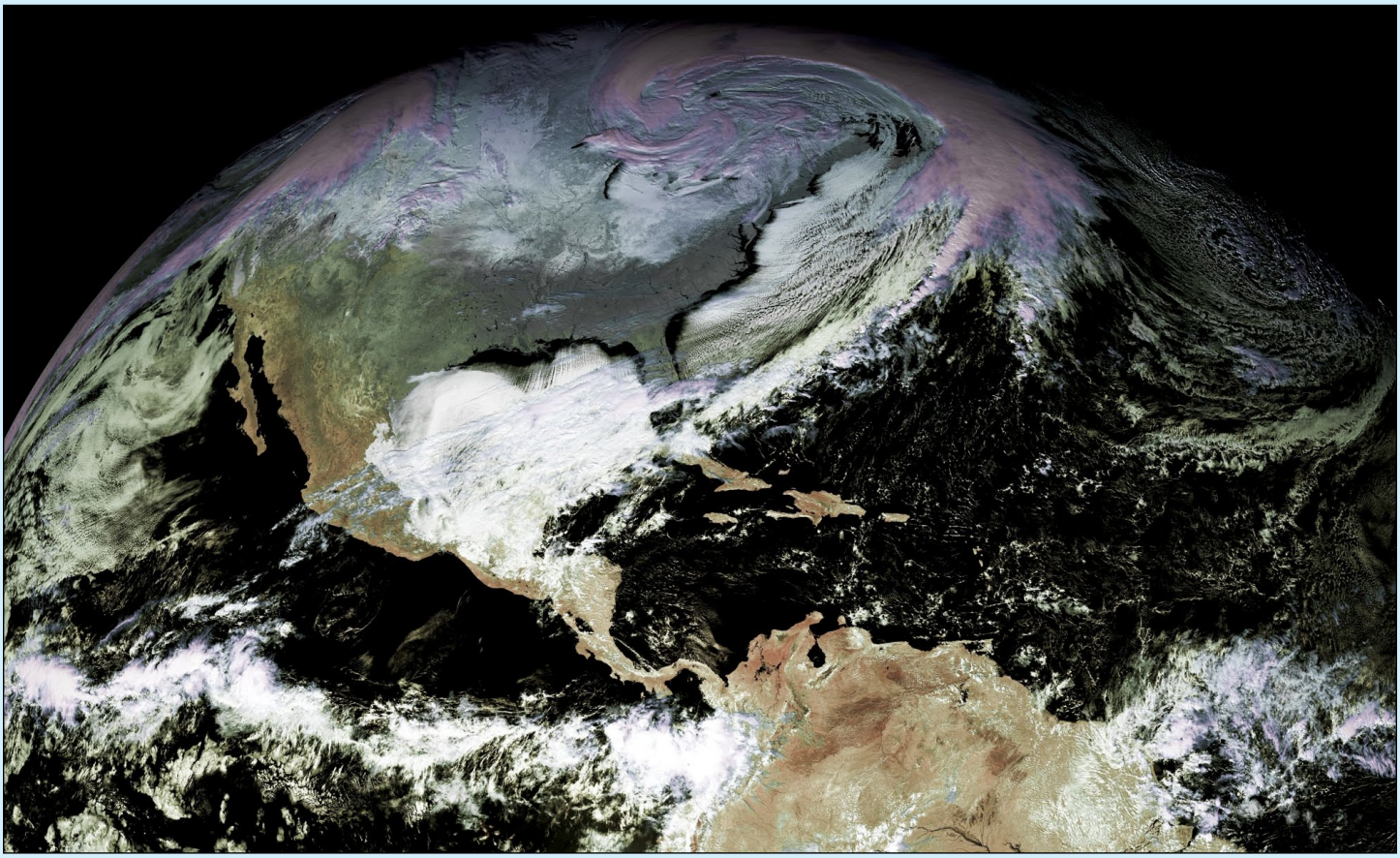
The climate of Siling Lake is typically below freezing from December until mid-April, causing the lake to freeze over. The lake was not yet frozen when this photograph was taken on December 4, 2021, further amplifying the contrast between the white snow and the blue hues of the water.

Changes in global climate have led to fluctuations in lake size, with waterbodies on the southern Tibetan Plateau shrinking and lakes on the northern portion growing. Siling Lake has been growing since the 1970s, and scientists have used several modeling approaches to try and explain this trend. However, conclusions have varied between two potential causes: an increase in glacial melt runoff, or a decrease in annual wind speed between the 1980s and early 2000s.

The Tibet Selincuo Wetlands around Siling Lake were designated as a Ramsar wetlands area in 2018. The wetlands provide important habitat for two vulnerable species of eagles, the Pallas's fish-eagle (*Haliaeetus leucoryphus*) and the eastern imperial eagle (*Aquila heliacal*). Gymnocypris selincuoensis fish are also part of the wetlands ecology and are endemic to Siling Lake.

Weather Bomb brings Extreme Cold to North America

Les Hamilton



This image from NOAA's GOES-E geostationary satellite illustrates the weather over North America on December 24, 2022
Image provided by John Tellick - © EUMETSAT 2022

In December 2022, during the week leading up to Christmas, a polar vortex caused a spell of exceptionally cold weather to descend from the Canadian Arctic to cover large swathes of the United States. So severe was the cold that sub zero temperatures were widespread as far south as Texas. On one occasion, Elliott in Montana experienced a low of -51 degrees Celsius.

Stretching from the Great Lakes near Canada to the Rio Grande along the Mexican border, a bomb cyclone resulted in the deaths of at least 60 people because of the freezing conditions in the US states of Colorado, Illinois, Kansas, Kentucky, Michigan, Missouri, Nebraska, New York, Ohio, Oklahoma, Tennessee, and Wisconsin.

Half of these fatalities were recorded in western parts of New York State, which was so severely hit by the conditions that one observer likened it to a war zone. Particularly badly affected was the city of Buffalo and its environs, which were hit by a massive dump of lake-effect snow. At its height the blizzard was depositing almost ten centimetres of snow per hour, and at Buffalo airport, snow accumulations reached a depth of more than one metre.

Some of the fatalities in Buffalo, a city near the border between Canada and New York state, were found frozen to death in their cars after being stranded due to the whiteout blizzard conditions. Others simply died from the cold trapped in piles of snow on the streets.

In New England, more than 200,000 consumers awoke on Christmas morning to find themselves without power, while many more had to cancel their travel plans for visiting family and friends over the Festive Season because roads had become impassable and snowbound airports were forced to cancel some 13,000 flights across the nation. Because of the warnings of impending extreme cold, schools in Boston and Worcester, Massachusetts, New England's two largest cities, were closed on December 23 over concerns about the risk of hypothermia and frostbite. People were warned to stay indoors and minimise travel.

At its worst, as many as 1.8 million properties were without power throughout the US, with thousands of flights from airports cancelled and delayed.

In Canada, at least 140,000 homes lost power, principally in the provinces of Ontario and Quebec. In Yellowknife in the Northwest Territories the temperature fell to -28°C overnight bringing the risk of frostbite in just minutes. In Whitehorse, in Canada's Yukon territory, the temperature fell to -30°C with wind chill factored in.

Orion Views Earth From Afar

NASA Earth Observatory

Story by Kathryn Hansen

On December 7, 1972, the crew of the Apollo 17 mission were on their way to the Moon when they snapped an iconic photograph of Earth that became known as the **Blue Marble**. Now, 50 years later, humans are preparing to return to the Moon via the Artemis missions. In the process, cameras have again captured stunning views of our home planet from afar.

The new photographs were taken in November 2022 during the uncrewed Artemis I mission. The purpose of Artemis I is to demonstrate the performance of systems on the Orion spacecraft during spaceflight, and to ensure its safe reentry, descent and splashdown on Earth. The subsequent mission, Artemis II, will include a human crew.

The upper photo was acquired on November 16, on the first day of the 26-day mission. Unlike the camera carried on the Apollo spacecraft, the camera that shot this image was mounted externally on the Orion spacecraft. Attached to the tip of a solar array wing, the camera—and three others just like it—can be used by engineers to remotely inspect Orion's exterior. It can also capture spacecraft selfies. In the background of this selfie was Earth, located about 92,000 kilometres in the distance.

By the mission's 13th day, Earth was 432,210 kilometres away when a camera on the spacecraft's solar array acquired the lower image on November 28. This was the farthest distance from Earth reached by Orion during the Artemis I mission, and the farthest distance reached by any vehicle designed to carry people to space and back. Earth and our Moon hang like dots in the distance.

Orion returned to Earth on December 11, 2022, when the spacecraft splashed down in the Pacific Ocean off the coast of San Diego around 12:40 p.m. Eastern Time. But you don't have to wait for the next mission, Artemis II, for more photographs of Earth from space. Astronauts on the International Space Station snap outstanding pictures of Earth from above almost every day.

Earth shows in the background of this Artimis image from November 16, 2022

Both Earth and Moon appear in this this Artimis image from December 11, 2022

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	Off - probably terminal failure
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 [1]
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	128°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	137.2°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	Off
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 lb 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.