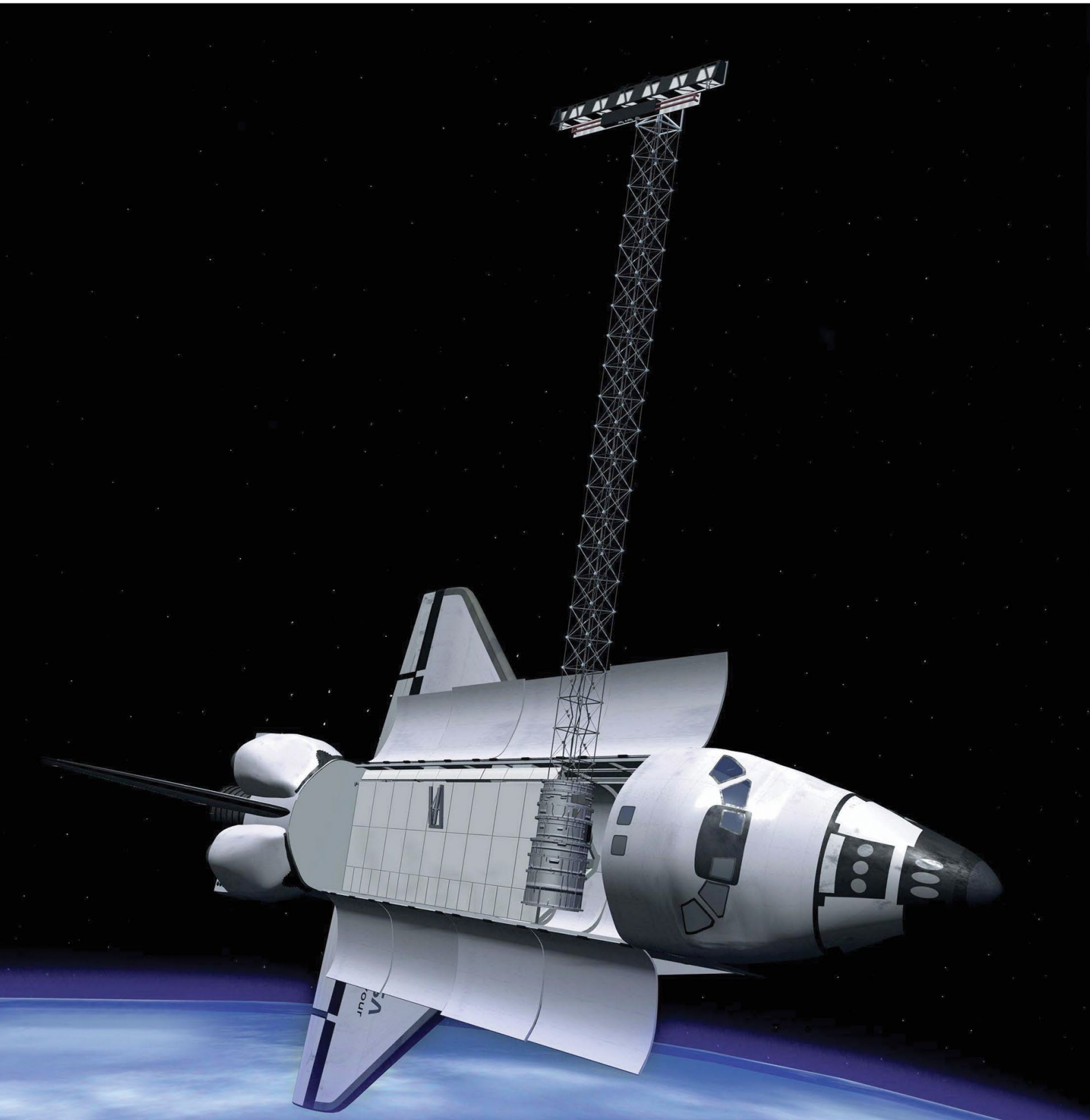
GEO Newsletter

Group for Earth Observation

Group for Earth Observation

No 83 - September 2024



This artistic rendition illustrates Space Shuttle Endeavour during the STS99 SRTM Mission
Image: NASA

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Useful User Groups

Weather Satellite Reports

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

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

SatSignal

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

https://groups.io/g/SatSignal

MSG-1

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

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

GEO-Subscribers

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

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

Copy for the Newsletter

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

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

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

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

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

lesw.hamilton@gmail.com

GEO Quarterly Back-issue Archive

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

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

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

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

From the Editor

Les Hamilton

Important Information Concerning GEO

As of July 25, 2024, GEO's web pages disappeared from the internet. Additionally, the email addresses of its Management Team are no longer valid.

As many readers will know, GEO was set up by the late Francis Bell, who oversaw the Group's activities, including maintaining its on-line presence. It appears that, with the winding up of his estate, GEO's on-line presence has lapsed.

Notwithstanding, the **GEO Quarterly Newsletter page**, which has for some time now been hosted on my own web space, is unaffected at:

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

Any reader needing to contact me with material for the newsletter should now use the email address listed below (because the old "geo-web" email address is now defunct).

lesw.hamilton@gmail.com

The cover image this issue is an artistic representation of Space Shuttle Endeavour during the STS99 Shuttle Radar Topography Mission undertaken in early 2000. This eleven-day mission was responsible for acquiring the digital elevation model of Earth which is responsible for all the high definition topographic mapping available today. Read about this on page 12.

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Geological Wonderland in Alaska

NASA Earth Observatory

Story by Adam Voiland

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

From a geological perspective, Adam's Inlet in Alaska has undergone major changes in the blink of an eye. Just 130 years ago, the inlet was covered by ice hundreds of meters thick. Today, it is ice-free. The inlet, which drains into the East Arm of Glacier Bay, lies within Glacier Bay National Park.

'*Since the end of the Little Ice Age about 150 years ago, Glacier Bay has seen deglaciation on a scale almost unseen anywhere else on Earth*,' said Dan Shugar, a University of Calgary geomorphologist. '*In Adam's Inlet, the retreat of the ice has exposed a remarkable landscape. Steep slopes, glacial rivers, ocean tides and sediment are smashing together to create a geological wonderland*.'

The OLI-2 (Operational Land Imager-2) on Landsat 9 captured this image of the area on August 28, 2023. Several streams flow into the inlet, including a large one that drains meltwater from the Casement Glacier. It is one of several glaciers in the eastern part of the park that has retreated by several kilometres in recent decades, partly because of warming air and water temperatures.

'*These rivers transport incredible quantities of fine-grained sediment*,' stated Shugar. '*They are braided, meaning they have lots of strands that interweave, and can change dramatically from day to day over the melt season.*'

They also dump large quantities of sediment into the ocean, resulting in striking offshore plumes and sometimes giving the water a turquoise color. This effect, seen in the eastern part of the inlet, is caused by rock flour (fine-grained silt and clay particles) suspended in the water, that absorb certain wavelengths of light. Also notable is the alluvial fan near the centre of the image. These features form where sediment-laden rivers drain from narrow, steep valleys into broader plains.

'*When the gradient decreases, the water moves less quickly and is less able to carry sediment*,' Shugar explained. '*The sediment drops out and creates these beautiful landforms*.'

Southeast of the alluvial fan, debris from a landslide has tumbled into a braided stream that enters the inlet from the south. The landslide occurred in 2020, delivering enough material to temporarily block the stream. It has since carved a channel through the debris.

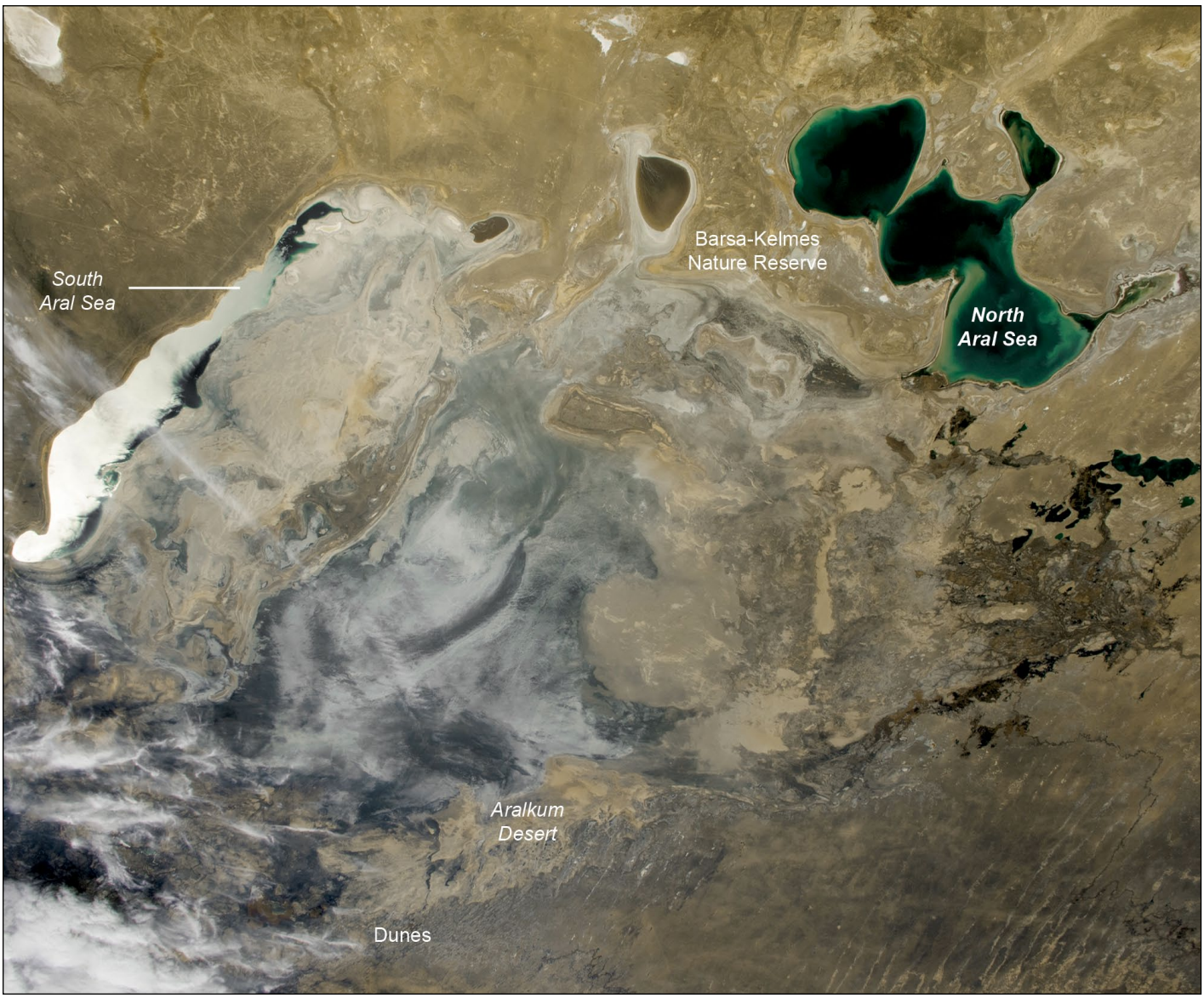
While that event caused minimal damage, landslides crashing into inlets in this region have had serious consequences. In nearby Lituya Bay, an earthquake in 1958 triggered a landslide that sent 90 million tons of rock plunging into the inlet and generated tsunami waves that inundated land up to an elevation of 524 metres)—higher than New York's Empire State Building.

That event, one of the largest known examples of a landslide, generated waves that flattened so much surrounding forest that the damage is still visible in Landsat imagery today.

Dunes and Desert Replace the Aral Sea

NASA Earth Observatory

Story by Cadan Cummings, Jacobs, JETS II Contract at NASA-JSC.



Astronaut photograph ISS070-E-4509 was acquired on October 17, 2023 - © NASA / JSC

An astronaut aboard the International Space Station took this photograph of the Aral Sea while in orbit over Kazakhstan. This 'sea' is actually an endorheic lake, located along the Kazakhstan and Uzbekistan border and fed by the Amu Darya and Syr Darya rivers. For the past 60 years, the lake has experienced a rapid decline in surface area due to the diversion of its two inflowing rivers to irrigate crops. At its greatest extent, the Aral Sea would have spanned almost the entirety of this photo.

The Aral Sea was previously the world's fourth-largest lake by surface area. But since the 1960s, it has decreased to approximately 10 percent of its original area. Desertification is visible toward the southeast where the dried lake bed has transformed into the Aralkum Desert. This region is one of the newest deserts in the world and spans 62,000 square kilometres. Sand dunes, built by winds blowing across the dry landscape, are visible in the bottom-centre of the image. In addition to dunes, the rapid aridification of the Aral Sea has triggered sand and dust storms that impact local air quality.

In the local Turkic language, 'aral' translates to 'island', an allusion to the Aral Sea's past as an expansive lake with over 1,100 islands. The Barsa-Kelmes Nature Reserve is situated on one of these former islands, between the remains of the North Aral Sea and South Aral Sea. The reserve provides habitat for hundreds of plant and animal species. As part of a U.S. Agency for International Development project to restore the local ecosystem and slow aridification, black saxaul shrubs (*Haloxylon aphyllum*) are being planted to help reestablish populations of native plant and animal species. These also mitigate the effects of dust storms by helping hold the soil in place.

Botswana's Salt Pans

MODIS Web Image of the Day

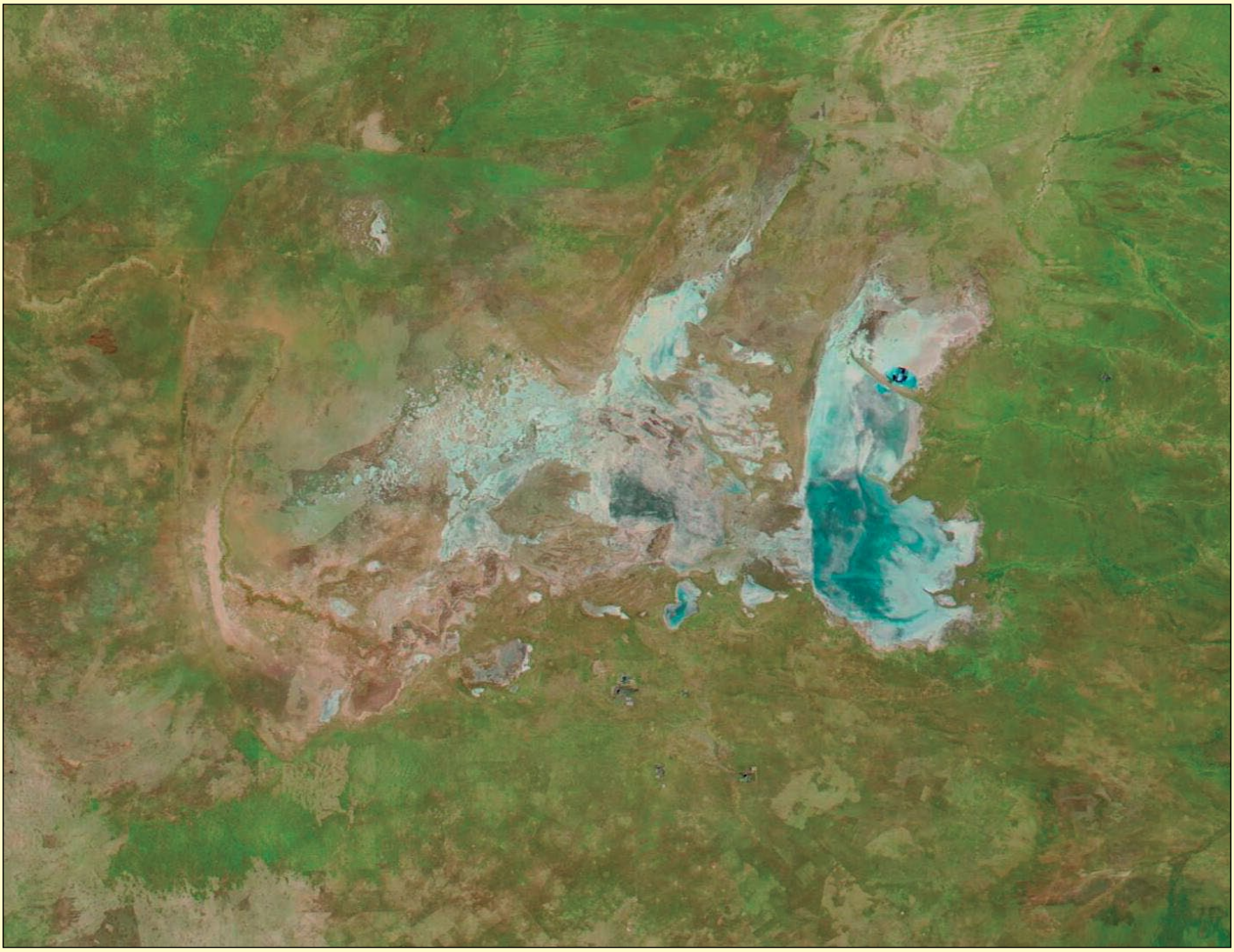


Image Credit: MODIS Land Rapid Response Team, NASA GSFC

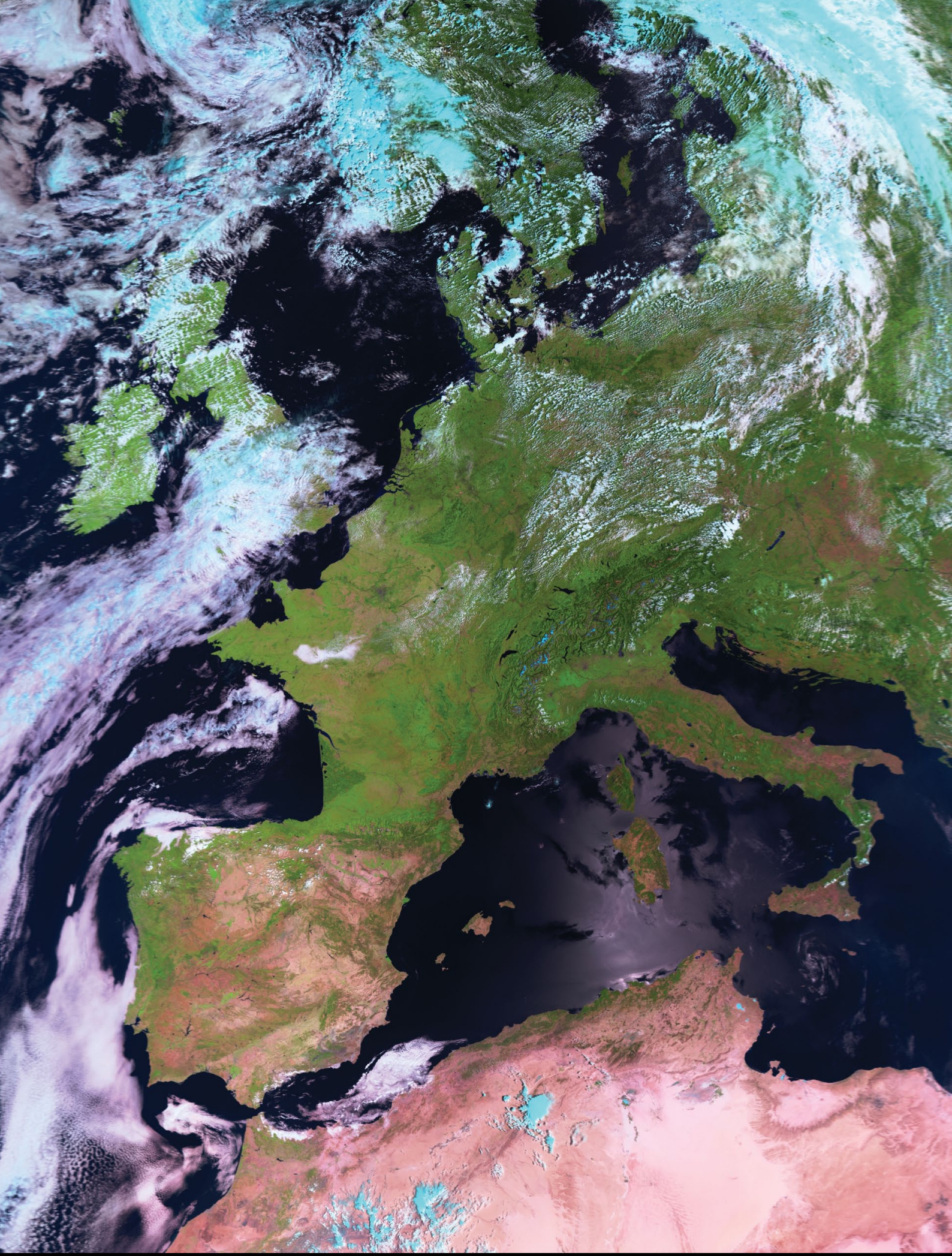
This striking false-colour image of Botswana's Makgadikgadi Salt Pans was acquired on May 31, 2024, by the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite. The image was acquired at the end of the wet season, when rainwater had moistened the mineral crusts and accumulated to create areas of open water in this normally remorselessly arid region.

This type of false-colour image highlights water, which is coloured in electric blue tones, with deeper water looking darker blue and shallow water much lighter. Dry mineral crust, which is highly reflective, looks white while the same type of crust, moistened by underlying water, is tinted blue. Vegetation appears bright green and open land is tan.

This collection of salt flats covers roughly 30,000 square kilometres across northern Botswana, northeast of Africa's Kalahari Desert.

The Salar de Uyuni, found in Bolivia, is the largest continuous salt pan on Earth and the Makgadikgadi Salt Flats come in second as far as contiguous mineral crusting. However, when the desert and savanna that are interspersed between the individual salt flats that make up the Makgadikgadi are taken into account, Botswana's salt flats cumulatively span a larger area.

The pans are the salty remains of ancient Lake Makgadikgadi. Scientists estimate that this inland sea once spanned anywhere from 80,000 to 275,000 square kilometres. The Okavango, Zambezi, and Cuando rivers probably emptied into this lake until tectonic shifts changed the elevation of the landscape and a changing climate dried up the rains. After millions of years of evaporation and shifting landscape this expanse of mineral-crusted flats is all that remains of that massive prehistoric lake.



Enrico Gobbetti acquired this Metop B image on August 10, 2024 using the Satdump software

Svalbard Melts

NASA Earth Observatory

Story by Emily Cassidy

The Svalbard archipelago's ice caps suffered extreme episodes of melting in summer 2024, brought on by exceptionally high air temperatures.

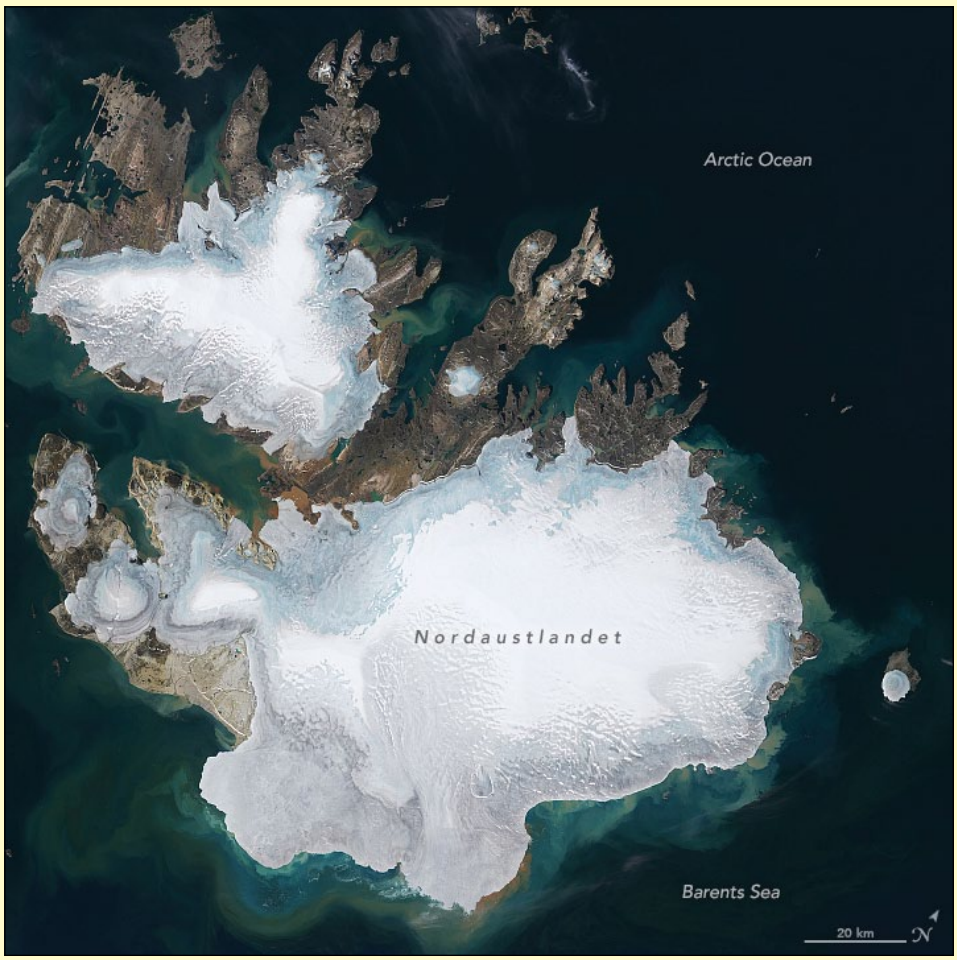
Situated between mainland Norway and the North Pole, Svalbard is one of the fastest-warming places on the planet. Over half of its land area is covered with ice, composing about six percent of the planet's glaciated area outside Greenland and Antarctica.

In late July and early August 2024, temperatures hovered around 4°C above average for this part of the Arctic Circle. The warming took its toll on Svalbard, home to some of Earth's northernmost glaciers, causing snow and ice to rapidly melt.

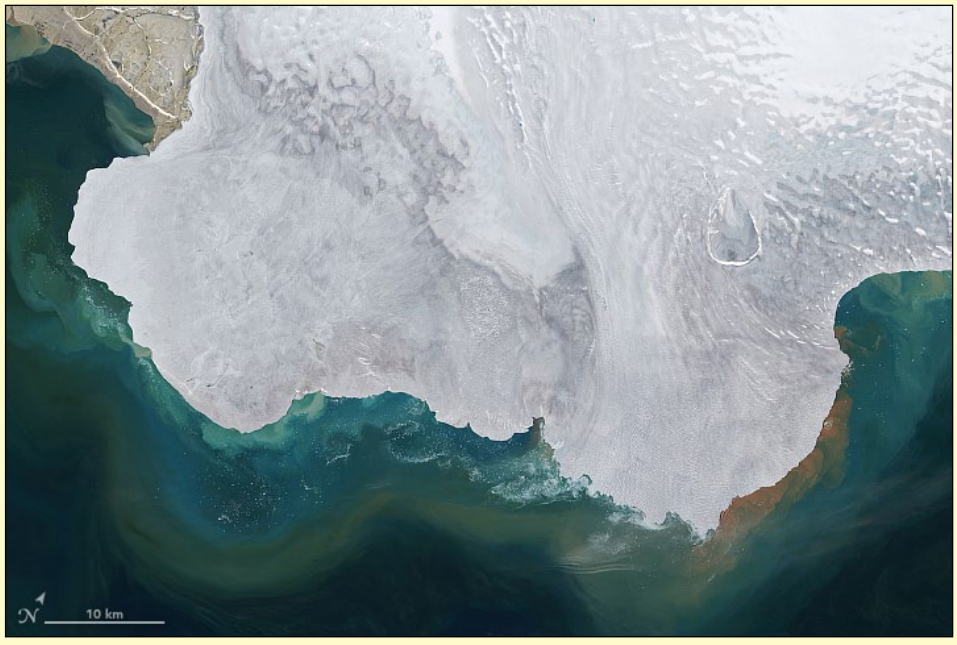
The OLI (Operational Land Imager) on Landsat 8 captured these images of Nordaustlandet—the second largest island in the archipelago—on August 9, as water and sediment drained off the coast and into the Arctic Ocean. Sediment is most likely causing the striking swirls of colour in the water surrounding the island. The melting of seasonal snow, and an older, compressed layer of snow called 'firn', left some areas of glacial ice (light blue) bare and exposed in the images.

According to Xavier Fettweis, a climatologist at the University of Liège, Svalbard's ice caps broke their all-time record for daily surface melt on July 23, 2024. Svalbard shed about 55 millimetres of water equivalent that day, a rate five times greater than normal.

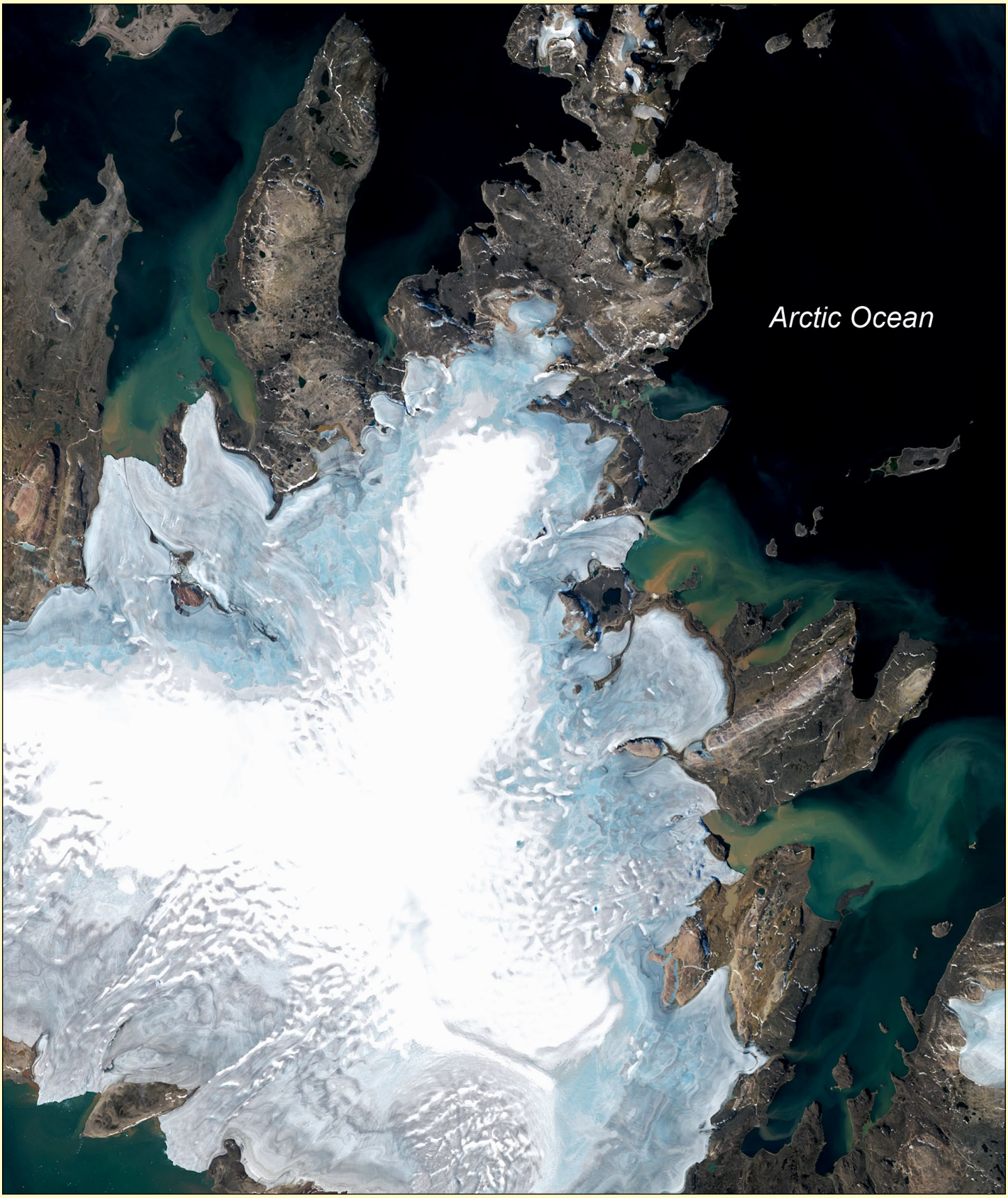
The exceptional melting continued into August, corresponding with a persistent heat dome that baked parts of Scandinavia's Arctic.



Nordaustlandet, the second largest island in the Svalbard archipelago as imaged by Landsat 8 on August 9, 2024
NASA Earth Observatory images by Lauren Dauphin, using Landsat data from the U.S. Geological Survey



This expanded view of the southern coastline of Nordaustlandet, emphasises the swirls of colour in the Arctic Ocean caused by meltwater runoff



Detail from the northern peninsulas of Nordaustlandet island
NASA Earth Observatory images by Lauren Dauphin, using Landsat data from the U.S. Geological Survey

In Longyearbyen, Svalbard's capital on the main island of Spitsbergen, temperatures reached 20.2°C on August 11, its highest August temperature on record and about 2.2°C above the previous monthly record, according to meteorologist Daan van den Broek.

Svalbard experienced its warmest summer on record in 2023, according to the *Copernicus State of the Climate* report. This report cited several contributing factors for the warmth, including below-average sea ice cover and above-average sea surface temperatures.

Early Summer Colour in Hudson Bay

MODIS Web Image of the Day

Image Credit: MODIS Land Rapid Response Team, NASA GSFC

As spring gave way to early summer in late June 2024, the waters of southern Hudson Bay resembled an artist's palette—awash with sepia, sienna, turquoise and jade shades, and topped by splashes of titanium white. The Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite acquired this true-colour image of the multihued scene on June 23.

The conglomeration of colours is a result of natural events surrounding spring thaw. Each winter, Hudson Bay and all rivers flowing into it freeze over. Snow lies heavily over the surrounding landscape of northeastern Canada. As temperatures warm and sunlight lengthens in late spring, snow and ice begin to melt. Meltwater carries sediment from the land into rivers as well as the Bay. In turn, the rivers dump their sediment load into Hudson Bay as well as creating currents that can stir sediment up from the Bay's bottom. Sediment appears muddy brown when near the surface but takes on green and blue tones as it sinks below the surface.

In this image, sediment is clearly apparent on the western shore, around Akimiski Island, and in the southern tip of the Bay. Along the shoreline, a mud-coloured halo strongly suggests that the primary source of this sediment is most likely run-off from the land. The very dark colour in the south probably comes predominantly from the sediment spilled by several large rivers. This colour swirls northward towards the centre of the Bay, following currents. Patches of bright white in the north are remnant patches of winter's sea ice.

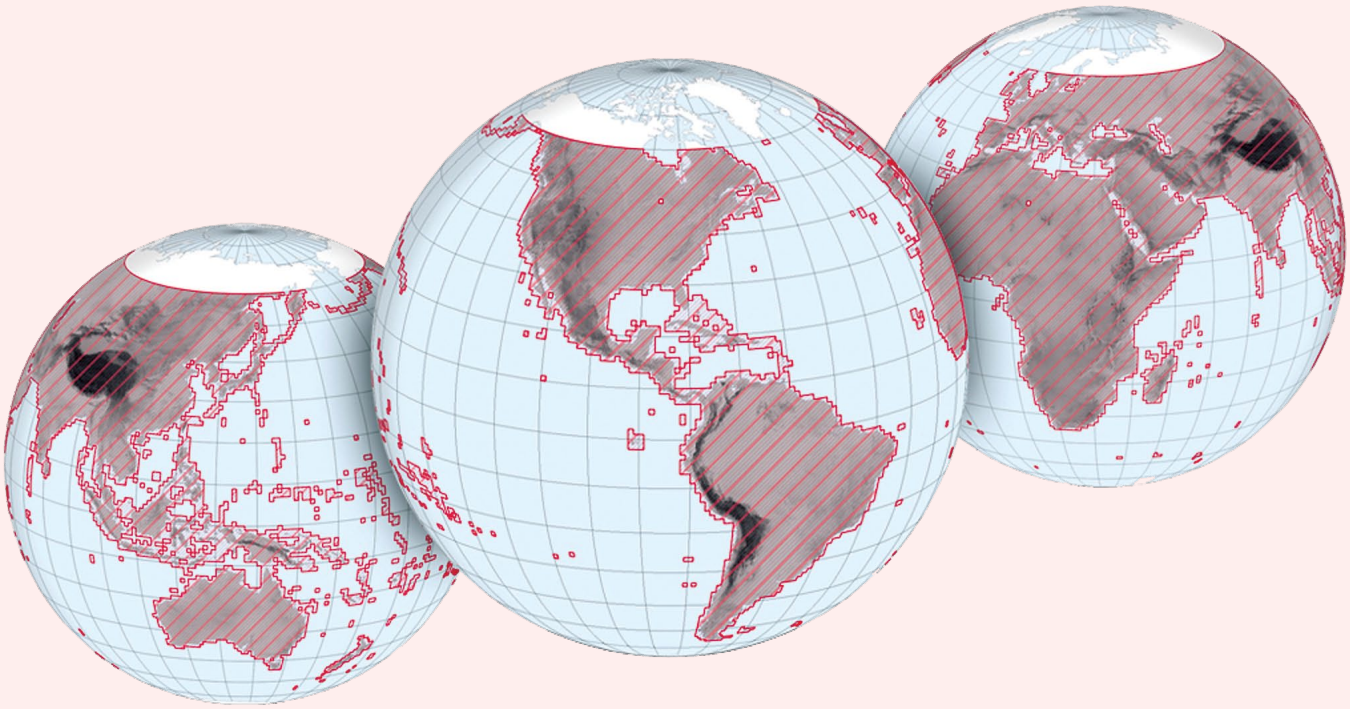
Hudson Bay's freeze-thaw cycle has remained fairly constant over recent decades, with sea ice typically melting between June and August and freeze-up beginning again in late October or November. More recently, the tendency has been for melting to begin early and freeze-up to begin later, extending ice-free days. This is bad news for polar bears, which depend on plentiful ice to successfully hunt for ringed seals and other prey. When ice melts, the bears retreat to shore where food is scarce. They must fast or feed on whatever meagre food can be found until ice returns. Since bears burn about one kilogram per day while on land, too much time on shore can lead to stress and starvation.

This image of spectacular convective clouds over the island of Sicily was captured by the NOAA 21 satellite on August 5, 2024
Image: NASA *Worldview Snapshots (https://wvs.earthdata.nasa.gov)*

The SRTM Mission to Map the Elevation of Earth

NASA Earth Observatory

Story by James Riordon/NASA's Earth Science News Team



NASA Earth Observatory image by Michala Garrison, using topographic data from the Shuttle Radar Topography Mission (SRTM) and SRTM coverage boundary data from the United States Geological Survey (USGS)

Kevin Kregel had his lucky fishing hat firmly in place, complete with an array of fishing tackle above the floppy brim and a chinstrap cinched up tight. It was time to try the fly-cast manoeuvre. Commander Kregel wasn't out for trout on a mountain stream. He was at the controls of the space shuttle Endeavour. Instead of wielding a fly-fishing rod, he and the crew of the 97th shuttle mission were preparing to whip a slender, 60-metre-long mast into place on day two of their 11-day quest to create an unprecedented map of Earth.

With one end of the mast mounted in the orbiter's payload bay and the other cantilevered out into space, the it was a central part of the Shuttle Radar Topography Mission (SRTM). It was also the longest instrument ever flown aboard a space shuttle. A detector at the end of the mast and another nestled inside the shuttle bay were ready to collect reflections from a radar beam aimed at the Earth below. First, there was the matter of swinging the fragile mast around to precisely orient the instrument in orbit. Doing it with a detector as heavy as a grand piano attached to its far end was going to be the tricky part.

Closing Mapping Gaps

Nearly a quarter century after the mission to map the world, the SRTM's data still yields results. Just this year, it aided in wildfire forecasting for Iran's Zagros Mountains, tracking soil erosion in South Africa, assessing flood risk on the coast of Brazil, and even determining how the locations of power-generating wind turbines affect real estate values. Tens of thousands of research papers are published every year that rely on SRTM maps for these and other environmental safety studies.

Back when Endeavour launched on February 11, 2000, much of Earth's surface was a mystery, topographically speaking. No-one knew the precise heights of many of the world's mountains or the depths of the valleys between them. Where height information did exist, topographical maps varied in quality and scale from country to country. The result was an incomplete patchwork of maps.

Prior to 2000, correcting these mapping deficiencies had proven elusive. Most imaging satellites had a hard time seeing through cloud cover, particularly over portions of South America and Africa. It was expensive to fly mapping instruments on planes crisscrossing remote regions, and in some cases countries denied access to airborne mapping efforts due to political conflicts. Scientists and engineers at NASA's *Jet Propulsion Laboratory* set out to solve the problems with an instrument that could see through clouds and map much of the planet over the course of a single space shuttle mission.

Their solution was the SRTM instrument that now hangs from the ceiling in the *Smithsonian National Air and Space Museum's Steven F Udvar-Hazy Center* in Fairfax County, Virginia. Only a fraction of its fragile mast extends from the golden canister where it was stored for the trip to orbit and back. Fully deployed, the trusswork of slender rods would

reach two-thirds the length of a football field. When packed away, the entire thing collapsed like an accordion to fit in the canister, which is a bit taller than the average adult.

The radar system at the heart of the SRTM instrument had flown twice on Endeavour for prior mapping efforts. During those missions, the instrument offered two-dimensional views of the ground from orbit. By combining data from different vantage points, NASA scientists produced stereoscopic images that revealed stunning 3D topographic views. But the need for multiple passes over the locations slowed the process, and while clouds are transparent to radar, changes in the atmosphere between orbits limited the quality and accuracy of the resulting maps. The missions primarily focused on areas of scientific interest in South America, Africa, Europe, Asia, and Oceania, covering about 10% of the planet's surface on each of the two flights.

With a radar antenna mounted at the end of the SRTM mast and another inside the shuttle bay, the new instrument could continuously view Earth in 3D, ensuring that atmospheric changes from one orbit to another were no longer a problem. Because it could capture images in a single pass over any given area, the SRTM would be able to scan large areas of the planet and reveal detailed topography nearly ten times faster than its predecessor. In total, the SRTM collected elevation data over 80% of Earth's landmass in a single flight, with coverage spanning the areas shown in the maps at the top of page 12.

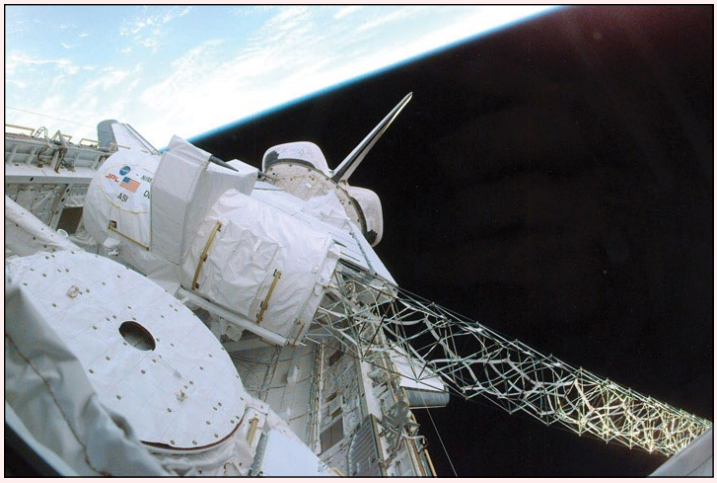
Fishing for Data

Were it not for the weightlessness in orbit, a thousand-pound radar antenna would have been far too heavy for the delicate mast to handle. But even in space, there's still the problem of inertia—the resistance that objects with mass exhibit to changes to their motion. That meant that the SRTM mast was going to flex whenever the spacecraft turned to place the instrument in position to map the planet below. Despite its rigid design, the long mast would act like a spring, with the antenna wobbling at the end after any shuttle manoeuvres.

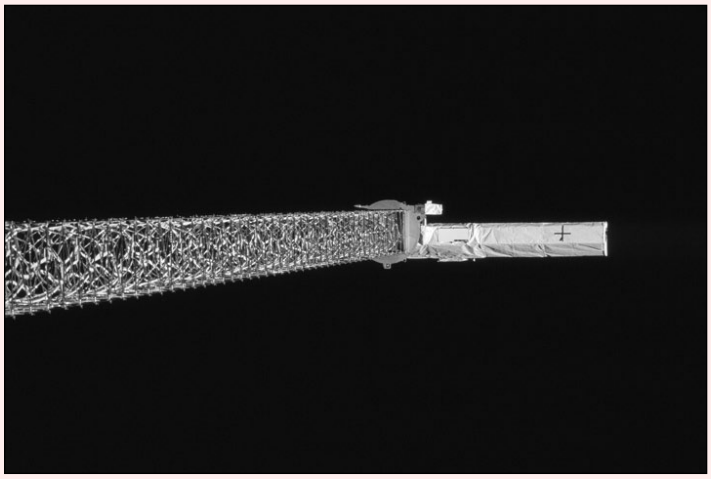
> "*It's a very small angle wobble, less than a degree*," said Scott Hensley, a senior research scientist at JPL who helped develop the SRTM instrument, "*but it translates into big error*." The motion would have amounted to inaccuracies on the order of as much as 300 meters in features on a topographical map.

The JPL design team had anticipated the flexing and installed a system of gas jets at the end of the mast to counteract the wobble. "*It was a really clever idea*," Hensley said. "*It worked for like a day and a half, and then I think it froze, so it no longer ejected the gas*." Fortunately, engineer Bill Layman had outlined a fly-casting contingency plan in the event of a problem with the jets. Which brings us to Kregel and his fishing hat.

Layman's fly-cast manoeuvre mimicked the motions that sport fishers use when casting with long, flexible fly-fishing rods. In order to rotate the SRTM mast into position,



Part of the boom trusswork supporting the SRTM instrument while in orbit on February 16, 2000
Photo from the NASA image and video library



The SRTM instrument pictured at the end of the boom while in orbit on February 12, 2000
Photo from the NASA image and video library

Kevin Kregel (left) and Endeavour pilot Dominic Gorie pictured during the SRTM mission
Photos from the NASA image and video library

Kregel and Endeavour pilot Dominic Gorie, pictured above, first applied a short burst with the shuttle's thrusters, comparable to the initial flick of a fly rod. This caused the mast to bend backward slightly as the shuttle turned, and then to rebound forward. When the mast straightened out, a second burst of the thrusters speeded up the shuttle's rotation, mimicking the forward portion of a cast.

The timing and strength of the thrusts were tuned to prevent further vibrations as the mast swung into place. Reversing the thruster procedure brought everything to a quiet, vibration-free halt, with the radar system in position to start mapping.

Unlike the frozen gas jets, the fly-cast manoeuvre relied on the shuttle's limited supply of thruster propellant. That meant the technique had the potential to cut the mission short. But Kregel and Gorie managed the fly-cast manoeuvre to reposition the SRTM on six occasions with enough efficiency to leave plenty of propellant to complete the full mapping schedule. The deft piloting allowed the shuttle team enough time to collect elevation data over most of Earth's landmass, between the southern tip of Greenland and the southern tip of South America.

In 2000, the space shuttle Endeavour flew its final scientific mission upside down and backwards. With the bay doors open toward Earth below, the instruments of the Shuttle Radar Topography Mission (SRTM) scanned the planet with cloud-penetrating radio signals. With one detector at the end of a telescoping 60-metre mast and another in the shuttle's bay, SRTM offered an unprecedented 3D view of Earth (image at right).

This was not the final time that Endeavour went to space: there would be 11 more flights over the following decade, primarily dedicated to supporting the International Space Station. A quarter century later, though, the SRTM flight stands out as one of Endeavour's most significant scientific missions in its 19 years of service.

The SRTM system recorded data on magnetic tapes that resembled large video tapes. Because the scanning ran 24 hours a day for the duration of the mission, the Endeavour crew split into two teams, working alternate shifts, to change tapes every half hour. In all, they gathered 12 terabytes of data on 320 tapes over nearly 10 days. After a few years of data processing, the U.S. Geological Survey (USGS) made the resulting topographical maps publicly available for free in 2003.

Initially, the USGS distributed high-resolution maps of the U.S. with each pixel representing an area 30 metres on a side, roughly twice the size of a basketball court. Maps of the rest of the planet initially featured lower-resolution pixels 90 metres across. In 2015, the USGS released full-resolution maps for the entire globe. Finally, in 2020, NASA produced a new topographical map, designated NASADEM (NASA Digital Elevation Model),

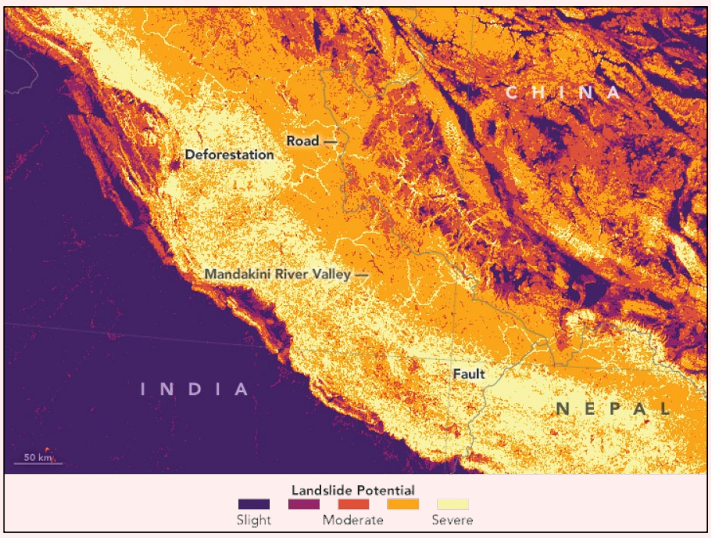
https://www.earthdata.nasa.gov/esds/competitive-programs/measures/nasadem

created with SRTM data that had been reprocessed to improve the height accuracy of features. It also included data from other mapping missions to fill in holes in the earlier maps.

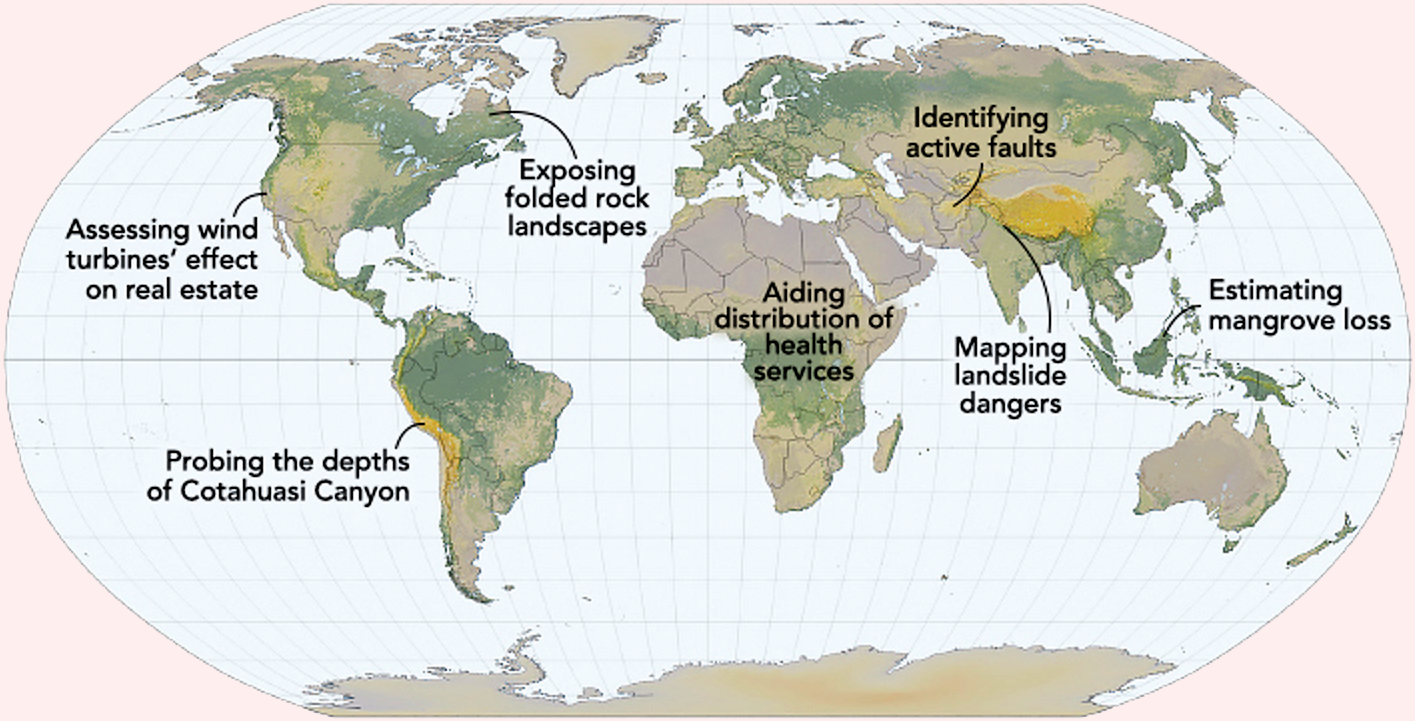
SRTM Benefits Science, Society, Economics, and the Environment

Elevation is crucial information for a spectrum of scientific studies, including many that directly address the safety and livelihoods of people around the planet. In areas susceptible to flooding and landslides, estimates suggest that thousands of lives could be saved each year by combining rainfall information with elevation maps to predict landslide dangers (pictured above). Among the data's social justice applications, SRTM-based maps are proving crucial to the placement of health services and clinics for people in areas of difficult terrain in Sub-Saharan Africa.

This artistic rendition shows Endeavour in orbit with the SRTM boom extended, while surveying Earth
Image from the NASA image and video library



Maps such as this combining rainfall information with elevation maps, can assist in predicting potential landslide dangers
Landslide susceptibility map by Jesse Allen, using data provided by Thomas Stanley and Dalia Kirschbaum (NASA/GSFC), and topographic data from SRTM.



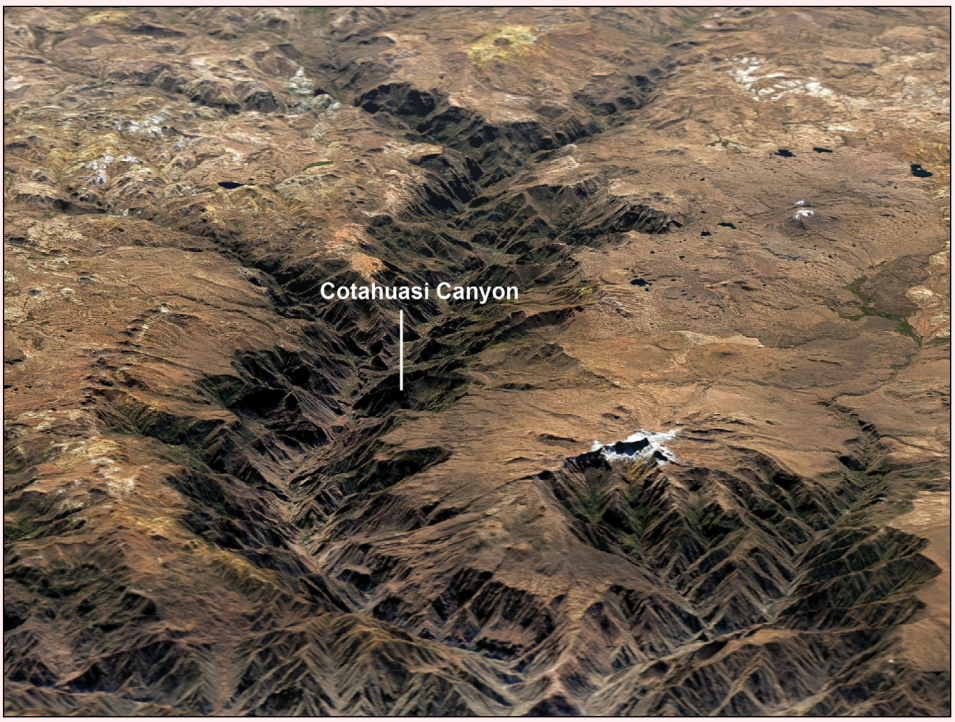
Sites of Discovery

Every year, tens of thousands of research papers and numerous applications rely on maps derived from Shuttle Radar Topography Mission (SRTM) data.

Landscape features in regions of the world that are difficult to access would likely remain hidden today if it weren't for SRTM and NASADEM. Recently, Landsat 8 images overlain over SRTM elevation maps have revealed the extraordinary depths of the remote Cotahuasi Canyon in Peru, as seen in the image at right.

In another example, shown at the top of the following page, the same technique exposed enormous folded rock landscapes in Canada, scoured clean by retreating glaciers following the last ice age.

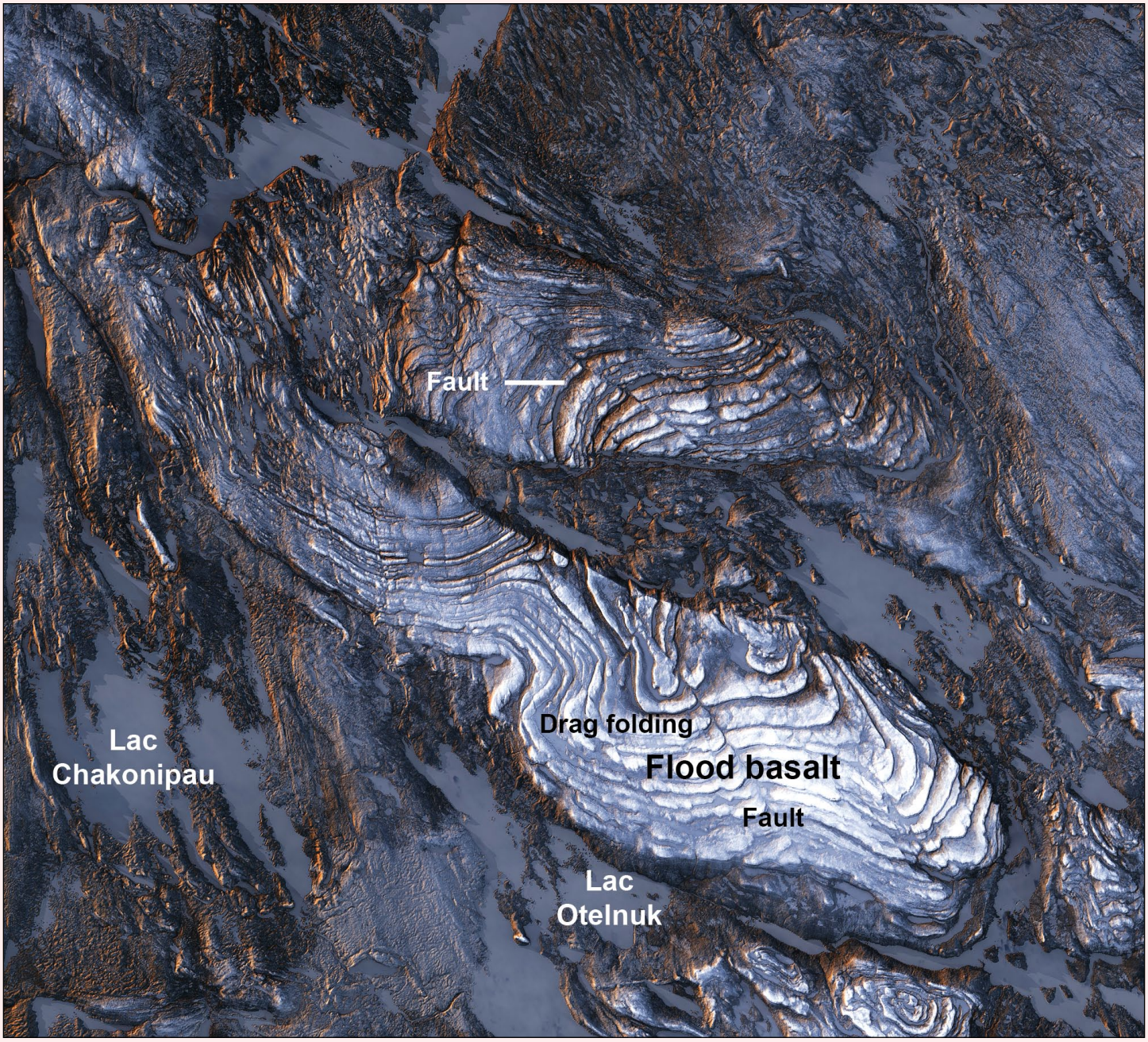
In the decades since the shuttle mapping mission, SRTM data have helped researchers identify active fault lines that could be the source of earthquakes in Afghanistan, estimate mangrove loss in Malaysia due to deforestation, and even determine how the locations of power-generating wind turbines affect real estate values. Tens of thousands of research papers are published every year that rely on SRTM maps for these and other environmental, economic, agricultural, and public safety studies.



Landsat 8 images overlaid over SRTM elevation maps have revealed the extraordinary depths of the remote Cotahuasi Canyon in Peru
Images by Joshua Stevens, using topographic data from SRTM and Landsat data from the U.S. Geological Survey.

Topographic Maps Continue to Achieve New Heights

Other space-based measurements have added to our knowledge of Earth's topography since SRTM. Satellite missions such as NASA's ICESat (Ice, Cloud, and land Elevation Satellite), its successor ICESat-2, and an instrument aboard the International Space Station called GEDI (Global Ecosystem Dynamics Investigation) have collected trillions of precise laser measurements that have improved the accuracy of the maps. The European Space Agency's Copernicus program used additional satellite and modelling



This scene, referenced on the previous page, shows how a Landsat 8 image has been overlain over an SRTM elevation map to reveal enormous folded rock landscapes in Canada
Images by Joshua Stevens, using topographic data from SRTM and Landsat data from the U.S. Geological Survey.

data to create even more datasets of Earth's surface heights. Improvements to space-based topographic maps will continue with the launch of the *NASA-ISRO Synthetic Aperture Radar*, which will provide new, more precise measurements of Earth's surface.

"*Although future mapping efforts may offer improved views of Earth, the value of the SRTM data shows no signs of diminishing*", stated Gerald Bawden, who oversees the SRTM program at NASA Headquarters.

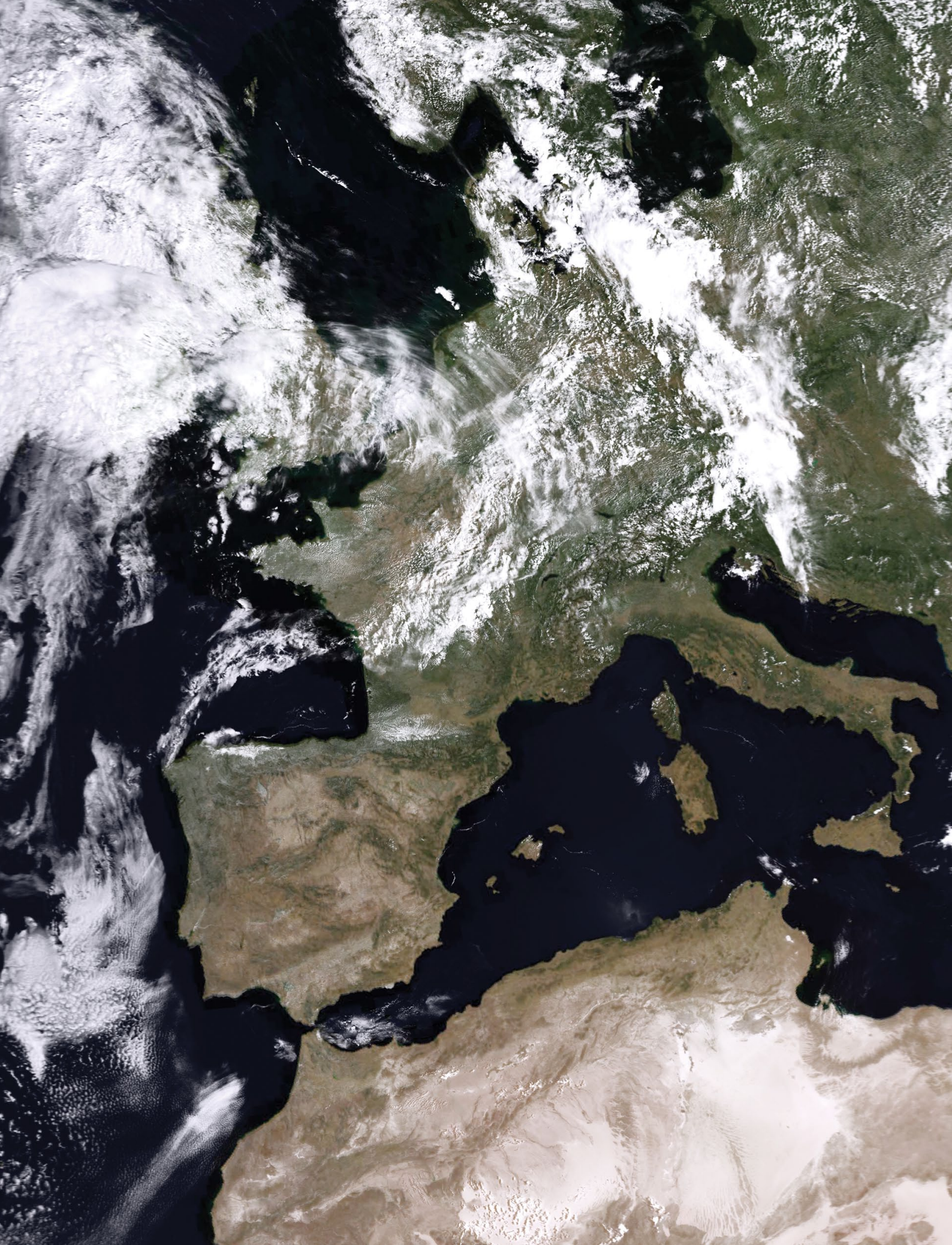
"*The magic of SRTM is that we clearly had a near-global snapshot*," he said.

"*It took less than two weeks to collect, but it now provides a baseline for everything from climate change and geologic hazards to urban planning and deforestation. This is a gold mine of information for coming generations*."

Bawden expects SRTM-derived maps to be an invaluable resource until the end of the century and beyond.

For Scott Hensley, the senior research scientist at NASA's Jet Propulsion Laboratory (JPL) who helped develop the instrument, the SRTM effort is both professionally and personally significant.

"*I've worked on a lot of cool missions, but SRTM is one of the highlights of my career at JPL*," Hensley said. "*It's one of the things that I'm really proud of because of its scientific and public benefits. I know that I've contributed to the betterment of humankind by working on this mission*."



This NOAA 19 image was acquired by Enrico Gobbetti on August 4, 2024 using the Satdump software. Satdump describes this version of the NOAA channel 2 stream as MSA. In reality, the software has extracted the cloud data from the image and superimposed it over a NASA BlueMarble backdrop.

Madeira

European Space Agency

The Copernicus Sentinel-2 mission captured a rare, cloud-free image over the Portuguese archipelago of Madeira in the North Atlantic Ocean.

Lying off the northwest coast of Africa, the archipelago is an autonomous region of Portugal and comprises two inhabited islands, Madeira, the largest, Porto Santo (top right), and two uninhabited groups, the Desertas (partially visible at the bottom) and the Selvagens (not pictured).

The islands of Madeira are volcanic in origin: they are the tops of mountains that rise from the ocean floor deep below. The Portuguese explorers named them Madeira, which is Portuguese for wood, inspired by the dense forests that covered the islands when they arrived.

The lush main island of Madeira is famous for its rugged, green landscape and is home to unique endemic flora and fauna.

The four islands of the Madeira archipelago
Image contains modified Copernicus Sentinel data (2024), processed by ESA

Madeira
Image contains modified Copernicus Sentinel data (2024), processed by ESA

To protect this natural environment, two thirds of the island are designated as national park. The Madeira Natural Park includes the Laurisilva of Madeira, a Unesco World Heritage site and the largest surviving area of primary laurel forest. This type of vegetation is now confined to the Macaronesian Islands: the islands of Madeira, the Azores, the Canary Islands and Cabo Verde.

Funchal, Madeira's capital, can be seen as a large, light-brown area on the island's southeast coast, on the lower slopes of mountains that rise to 1200 metres. The runway of Madeira's airport is visible on the east coast. Madeira's airport is one of the most challenging in the world to approach, due to its exposure to the strong winds blowing over the flat Atlantic surface and the mountainous terrain.

Porto Santo, shown below, features white, sandy beaches along its south coast. Here, the island's main town, Vila de Porto Santo, can also be spotted, with its airport visible just to the north. At each end of the island are hills. At 515 metres, Facho Peak, on the east, is the highest.

The narrow Desertas Islands at the bottom are also designated as a natural reserve. Uninhabited by humans due to scarce and poor-quality water, Desertas are home to numerous species of birds, as well as the protected Mediterranean monk seal. The islands are relatively barren with their reddish and brown ground, a reminder of their volcanic origin.

Funchal, the capital city of Madeira on the south coast

Madera Airport on the east coast

The island of Porto Santo

Daytime Land Surface Temperture (June 2024)

MODIS Web Image of the Day

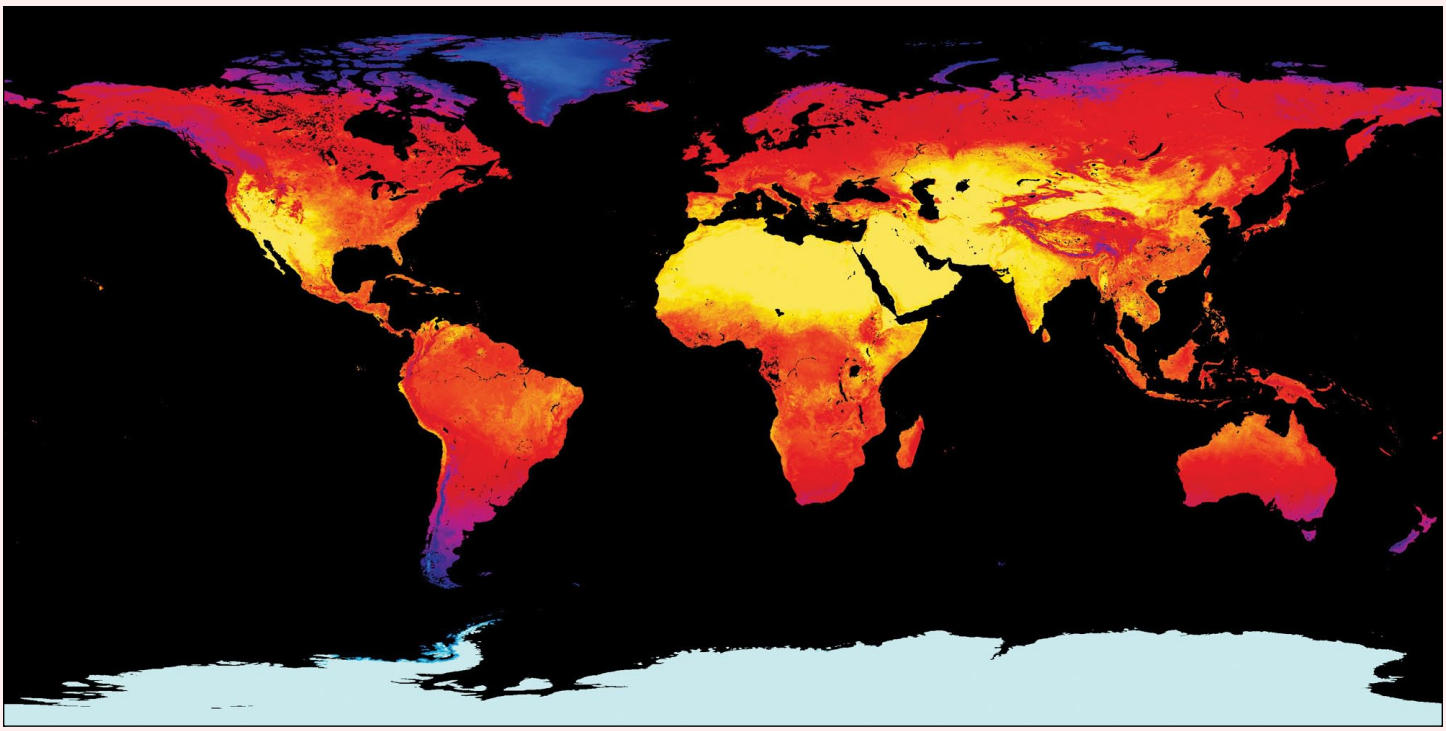


Image Credit: MODIS Land Rapid Response Team, NASA GSFC

During the month of June 2024, the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite acquired data that was used to create this Land Surface Temperature (daytime) image of the Earth. Land surface temperature is a measurement of how hot the top millimetre of the land is to the touch. It differs from air temperature (the temperature given in weather reports) because land heats and cools more rapidly than air.

This image depicts land surface temperature. The warmest temperatures are pale yellow, while the coldest temperatures are dark blue. Moderate temperatures are depicted in shades of pink and purple. Black means 'no data' was gathered and is typical of ocean surfaces in this dataset.

June is summer in the Northern Hemisphere and winter in the Southern Hemisphere. The most frigid temperatures, not surprisingly, are found in Antarctica, where it is deep winter. This is evident by the white area at the bottom of the image. The Arctic, found in the far north (top) is also showing cool land temperature.

A large swath of the centre of the Earth's land masses, however, is covered in yellows, depicting temperatures in the 32-45°C range. This includes the Western United States, portions of northern South America, the Sahara Desert and part of the Sahel in Africa as well as the Horn of Africa, the Arabian Peninsula, India, parts of China, Mongolia, and Russia, and even the top end of Australia. Western Madagascar is also showing high land surface temperatures despite its location far south of the equator.

Of particular note is that the boreal forest and northern tundra regions of North American, Russia, and Europe appear in red, suggesting substantially warm land surface temperatures. In some boreal regions, where the ground is typically in permafrost and stays frozen year-round, land surface temperature appears to approach 27°C—quite warm for boreal forests in June. One example which has been used to illustrate summer temperatures in boreal forests is Lahti, Finland.

The mean average temperature in June between 1970 and 2000 in Lahti was 15°C, according to an article published by NASA's Earth Observatory Earth Explorer site.

The article can be found at the following URL:

https://earthobservatory.nasa.gov/biome/bioconiferous.php.

NASA-Funded Studies Explain

How Climate Is Changing Earth's Rotation

NASA JPL

The Arctic is captured in this 2010 visualization using data from NASA's Aqua satellite. A new study quantifies how climate-related processes, including the melting of ice sheets and glaciers, are driving polar motion.

Researchers used more than 120 years of data to decipher how melting ice, dwindling groundwater, and rising seas are nudging the planet's spin axis and lengthening days.

Days on Earth are growing slightly longer, and that change is accelerating. The reason is connected to the same mechanisms that also have caused the planet's axis to meander by about 10 metres in the past 120 years. The findings come from two recent NASA-funded studies focused on how the climate-related redistribution of ice and water has affected Earth's rotation.

This redistribution occurs when ice sheets and glaciers melt more than they grow from snowfall, and when aquifers lose more groundwater than precipitation replenishes. These resulting shifts in mass cause the planet to wobble as it spins and its axis to shift location—a phenomenon called polar motion (figure 2). They also cause Earth's rotation to slow, measured by the lengthening of the day. Both have been recorded since 1900.

Analysing polar motion across 12 decades, scientists attributed nearly all of the periodic oscillations in the axis' position to changes in groundwater, ice sheets, glaciers, and sea levels. According to a paper published recently in *Nature Geoscience*, the mass variations during the 20th century mostly resulted from natural climate cycles.

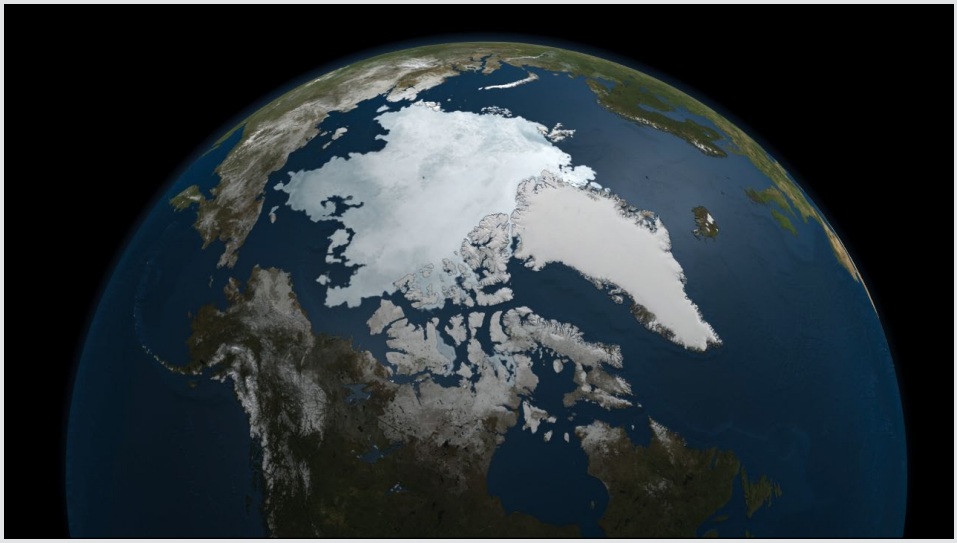


Figure 1
The Arctic is captured in this 2010 visualization using data from NASA's Aqua satellite. A new study quantifies how climate-related processes, including the melting of ice sheets and glaciers, are driving polar motion. Another study looks at how polar meltwater is speeding the lengthening of Earth's day.
Credit: NASA's Scientific Visualization Studio

Figure 2
This image is taken from an animation, exaggerated for clarity, illustrating how Earth's rotation wobbles as the location of its spin axis, shown in orange, moves away from its geographic axis, which is shown in blue and represents the imaginary line between the planet's geographic North and South poles.
The full animation can be accessed from the original NASA report at: https://www.jpl.nasa.gov/news/nasa-funded-studies-explain-how-climate-is-changing-earths-rotation
Credit: NASA's Scientific Visualization Studio

The same researchers teamed on a subsequent study that focused on day length. They found that, since 2000, days have been getting longer by about 1.33 milliseconds per 100 years, a faster pace than

at any point in the prior century. The cause: the accelerated melting of glaciers and the Antarctic and Greenland ice sheets due to human-caused greenhouse emissions. Their results were published in the July 15 *Proceedings of the National Academy of Sciences*.

'*The common thread between the two papers is that climate-related changes on Earth's surface, whether human-caused or not, are strong drivers of the changes we're seeing in the planet's rotation*,' said Surendra Adhikari, a co-author of both papers and a geophysicist at NASA's Jet Propulsion Laboratory in Southern California.

Decades of Polar Motion

In the earliest days, scientists tracked polar motion by measuring the apparent movement of stars. They later switched to very long baseline interferometry, which analyses radio signals from quasars, or satellite laser ranging, which points lasers at satellites.

Researchers have long surmised that polar motion results from a combination of processes in Earth's interior and at the surface. Less clear was how much each process shifts the axis and what kind of effect each exerts—whether cyclical movements that repeat in periods from weeks to decades, or sustained drift over the course of centuries or millennia.

Need Some Space?

For their paper, researchers used machine-learning algorithms to dissect the 120-year record. They found that 90% of recurring fluctuations between 1900 and 2018 could be explained by changes in groundwater, ice sheets, glaciers, and sea level. The remainder mostly resulted from Earth's interior dynamics, like the wobble from the tilt of the inner core with respect to the bulk of the planet.

The patterns of polar motion linked to surface mass shifts repeated a few times about every 25 years during the 20th century, suggesting to the researchers that they were largely due to natural climate variations. Past papers have drawn connections between more recent polar motion and human activities, including one authored by Adhikari that attributed a sudden eastward drift of the axis (starting around 2000) to faster melting of the Greenland and Antarctic ice sheets and groundwater depletion in Eurasia.

That research focused on the past two decades, during which groundwater and ice mass loss as well as sea level rise—all measured via satellites—have had strong connections to human-caused climate change.

'*It's true to a certain degree*' that human activities factor into polar motion, said Mostafa Kiani Shahvandi, lead author of both papers and a doctoral student at the Swiss university ETH Zurich. '*But there are natural modes in the climate system that have the main effect on polar motion oscillations.*'

Longer Days

For the second paper, the authors used satellite observations of mass change from the GRACE mission (short for Gravity Recovery and Climate Experiment) and its follow-on GRACE-FO, as well as previous mass-balance studies that analysed the contributions of changes in groundwater, ice sheets, and glaciers to sea level rise in the 20th century to reconstruct changes in the length of days due to those factors from 1900 to 2018.

Scientists have known through historical eclipse records that length of day has been increasing for millennia. While almost imperceptible to humans, the lag must be accounted for because many modern technologies, including GPS, rely on precise timekeeping.

In recent decades, the faster melting of ice sheets has shifted mass from the poles toward the equatorial ocean. This flattening causes Earth to decelerate and the day to lengthen, similar to when an ice skater lowers and spreads their arms to slow a spin.

The authors noticed an uptick just after 2000 in how fast the day was lengthening, a change closely correlated with independent observations of the flattening. For the period from 2000 to 2018, the rate of length-of-day increase due to movement of ice and groundwater was 1.33 milliseconds per century—faster than at any period in the prior 100 years, when it varied from 0.3 to 1.0 millisecond per century.

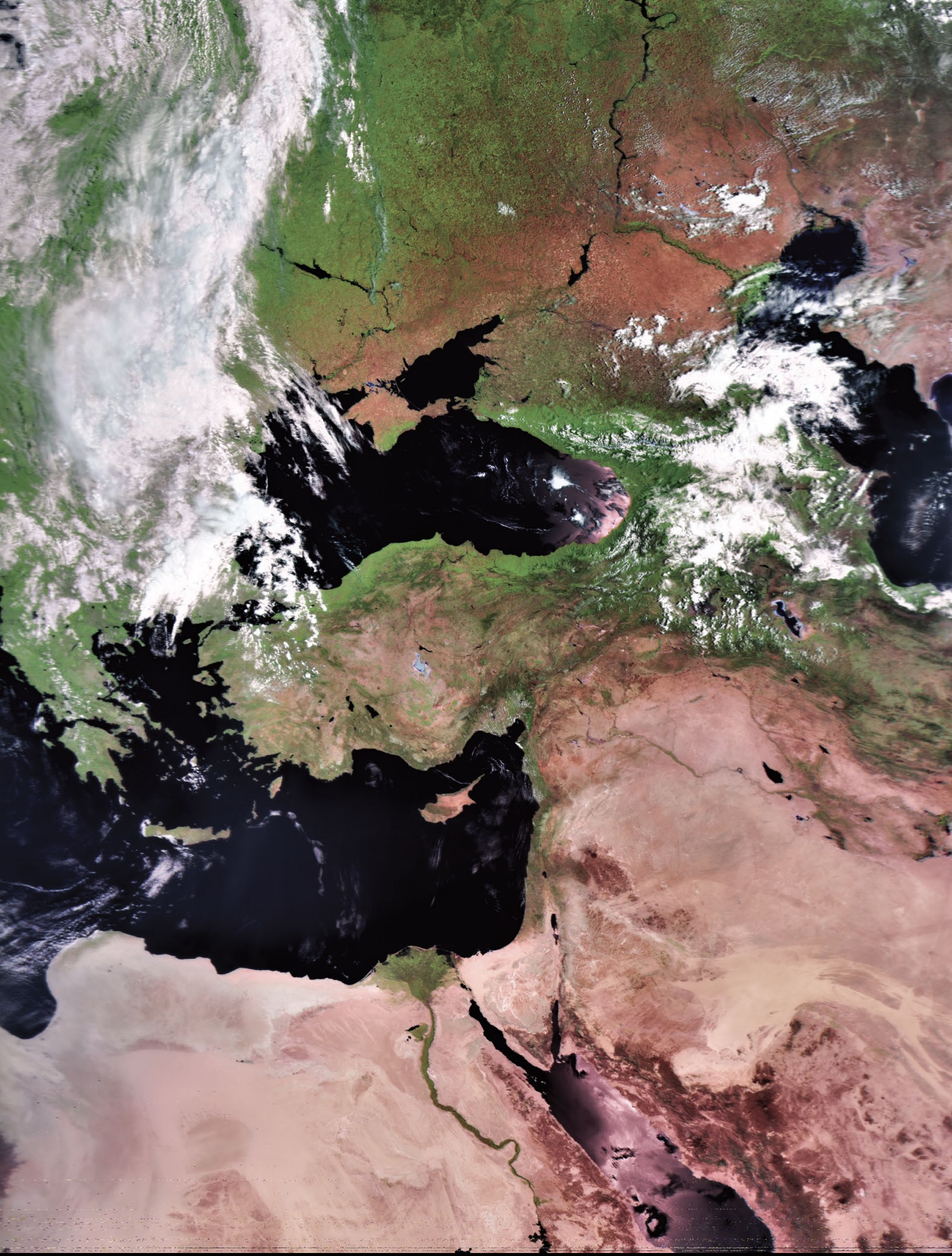
The lengthening due to ice and groundwater changes could decelerate by 2100 under a climate scenario of severely reduced emissions, the researchers note. (Even if emissions were to stop today, previously released gases—particularly carbon dioxide—would linger for decades longer.)

If emissions continue to rise, lengthening of day from climate change could reach as high as 2.62 milliseconds per century, overtaking the effect of the Moon's pull on tides, which has been increasing Earth's length of day by 2.4 milliseconds per century, on average. Called lunar tidal friction, this effect has been the primary cause of Earth's day-length increase for billions for years.

'*In barely 100 years, human beings have altered the climate system to such a degree that we're seeing the impact on the very way the planet spins*,' Adhikari said.

Reference URL for the Original Article

https://www.jpl.nasa.gov/news/nasa-funded-studies-explain-how-climate-is-changing-earths-rotation



This Meteor M2-3 RGB123 HRPT image was acquired by Enrico Gobbetti on July 2, 2024 using the Satdump software.

Clear Skies over Svalbard Archipelago

MODIS Web Image of the Day

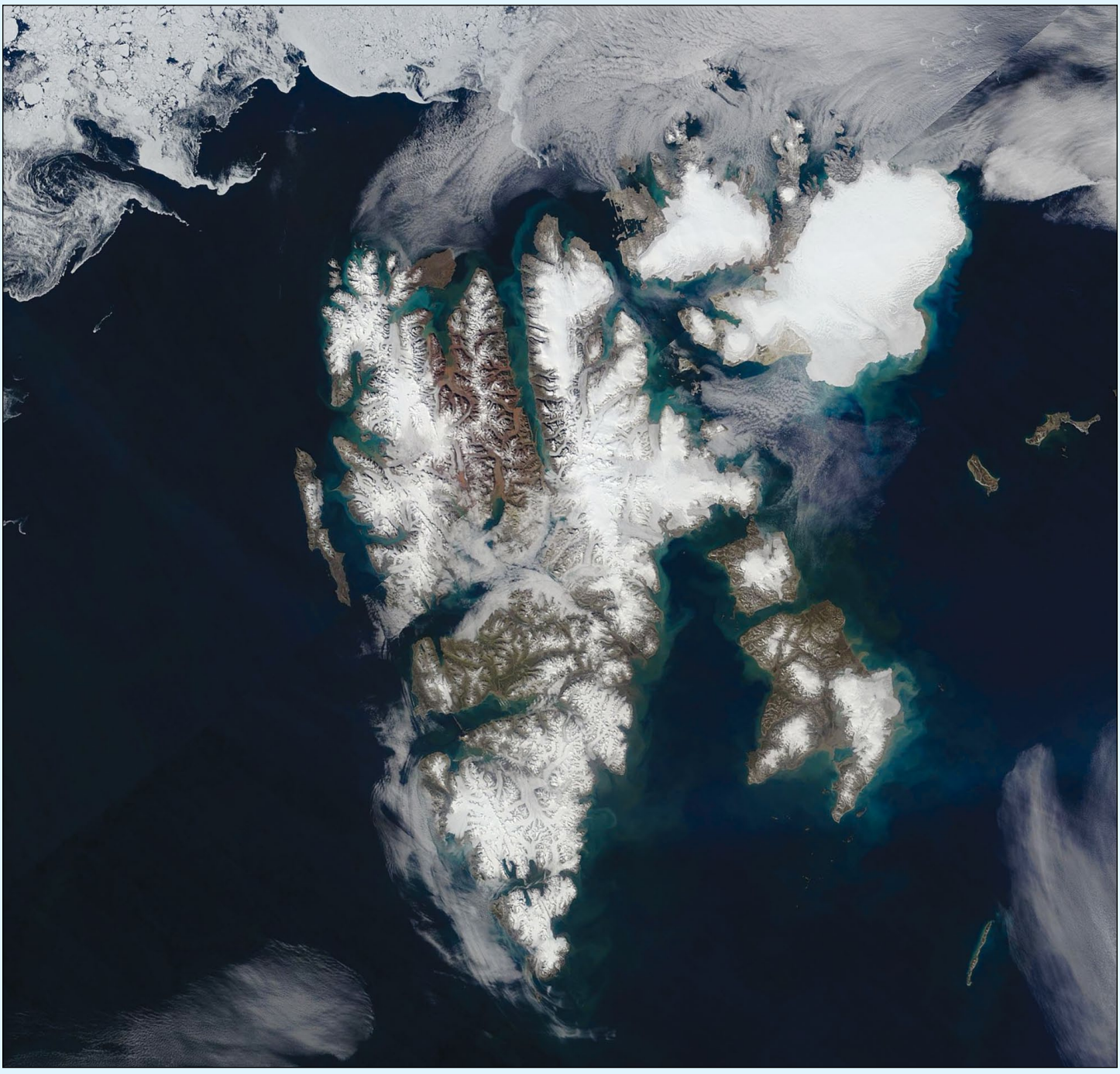


Image Credit: MODIS Land Rapid Response Team, NASA GSFC

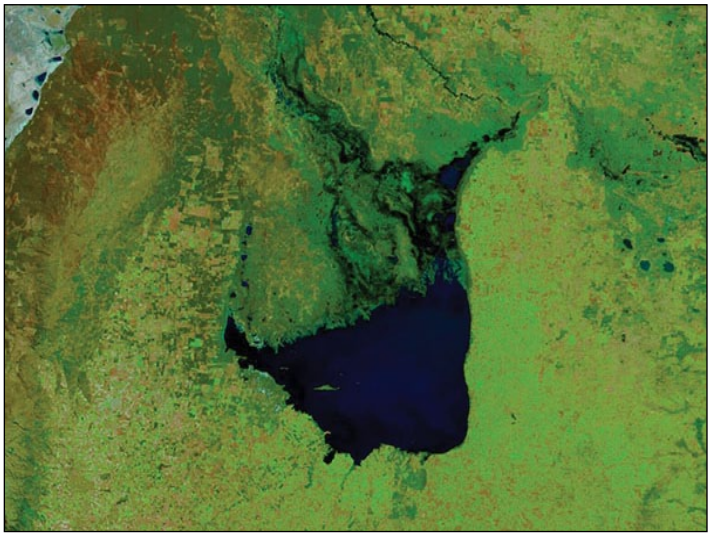
Beautifully clear skies allowed the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite to acquire a gorgeous true-colour image of the Svalbard Archipelago on July 17, 2024.

This group of ice-coated islands, which belongs to Norway, sits north of mainland Europe and halfway between Norway and the North Pole. It is surrounded by the Arctic Ocean (north), Barents Sea (southeast), Greenland Sea (southwest), and the Norwegian Sea. There are nine main islands, including Spitsenbergen, which is the largest, as well as North East Land, Edge Island, Barents Island, Prins Karls Foreland, Kvit Island, Kong Karls Land, Bjorn (Bear) Island and Hopen.

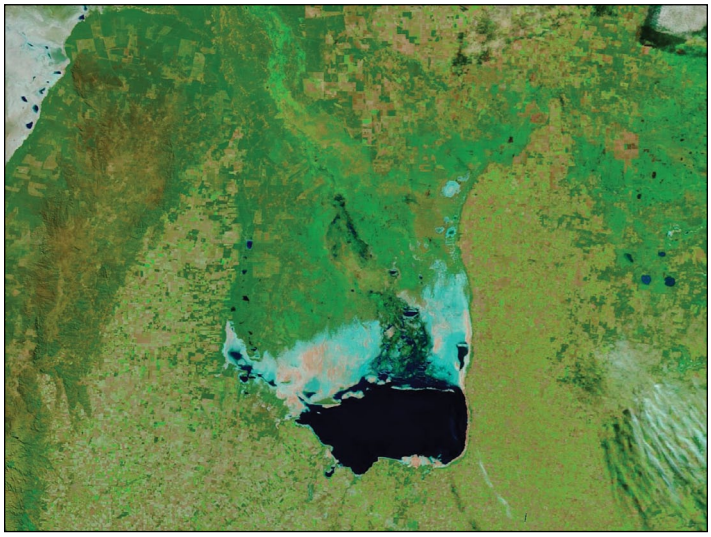
In this image, sea ice covers the Arctic Ocean and snow and ice sit atop most of the landmass. Some clouds are visible in the south, and it appears that some fog (low cloud) covers valleys in central Spitsbergen. Ice remains atop Svalbard's islands year-round, although sea ice cover was exceptionally low in the summer of 2023 due to unusually high air temperatures.

Shrinking Mar Chiquita

MODIS Web Image of the Day



Mar Chiquita imaged on July 16, 2000



Mar Chiquita imaged on July 13, 2024

Image Credit: MODIS Land Rapid Response Team, NASA GSFC

The beautiful yet saline Mar Chiquita sits in central Argentina, providing water to residents as well as critical habitat for several types of bird. Mar Chiquita has captured the title of Argentina's biggest lake, despite the fact the water level is variable. When the water level is high, the lake covers as much as 6,000 square kilometres. When low, it shrinks to 2,000 square kilometres, exposing expansive salt and mud flats along its northern shore.

The fluctuating water level can spur drastic changes in salinity, with salt content ranging from 25 grams per litre when the lake is brimming full, to 290 grams per litre when it shrinks. For comparison, sea water typically contains about 35 grams per litre of salt.

Much of Argentina has been in significant drought since at least 2022. This drove crop yields dramatically down in 2023, especially in the province of Cordoba, where Mar Chiquita is located. Lack of rainfall combined with high temperatures and increased water diversion for human use has resulted in dramatic shrinkage of the lake. And several equally dramatic impacts. With more mud flats exposed, the northern edge of the lake has become a source of dust storms. Increasing salinity and smaller area has raised concerns about the ability of the lake to support the breeding of Chilean Flamingos. In addition, half of the world's population of Wilson's Phalarope rests and feeds in Mar Chiquita each year. Biologists are concerned that shrinking saline lakes may tip some species into severe crisis.

The Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite acquired a pair of false-colour images that, when compared, show the startling shrinkage of this biologically important lake. The right-hand image was acquired on July 13, 2024, after light rains had slightly lightened at least three years of drought. The left-hand image was acquired more than two decades ago, on July 16, 2000, when Mar Chiquita was much more robust.

Water appears blue in this type of false-colour image, but deeper water looks deep blue while shallow water has a light blue tint. Minerals and salts are highly reflective and show up white: however, if they are damp the presence of water adds a light blue shade. Vegetation appears bright green while open or lightly vegetated land looks tan or brown.

Tahiti

In this crystal clear, true colour image taken by Copernicus Sentinel-2 on 25 July 2024, depicts Tahiti and its precious coral reefs. Earlier this summer, the village of Teahupo'o, known for its surf break and large waves, hosted the surfing competitions of the Olympic Games 2024.

Credit: European Union, Copernicus Sentinel-2

Exploring the Beauty of Lake Eyre

Copernicus Image of the Day

Credit: European Union, Copernicus Sentinel-2

Lake Eyre, officially known as Kati Thanda–Lake Eyre, is an endorheic lake in the east-central part of the Far North region of South Australia, around 700 kilometres north of Adelaide.

While the lake is mainly dry, with heavy rains and the right conditions, the lake comes to life and becomes home to thousands of waterbirds including pelicans, silver gulls, red-necked avocets and more.

On July 20, 2024, Copernicus Sentinel-2 captured the full size of the lake. This scene is a short-wave infrared composite. We can discern vegetation in green, water in deep blue and dry salt surfaces in turquoise.

Northwest Passage

MODIS Web Image of the Day

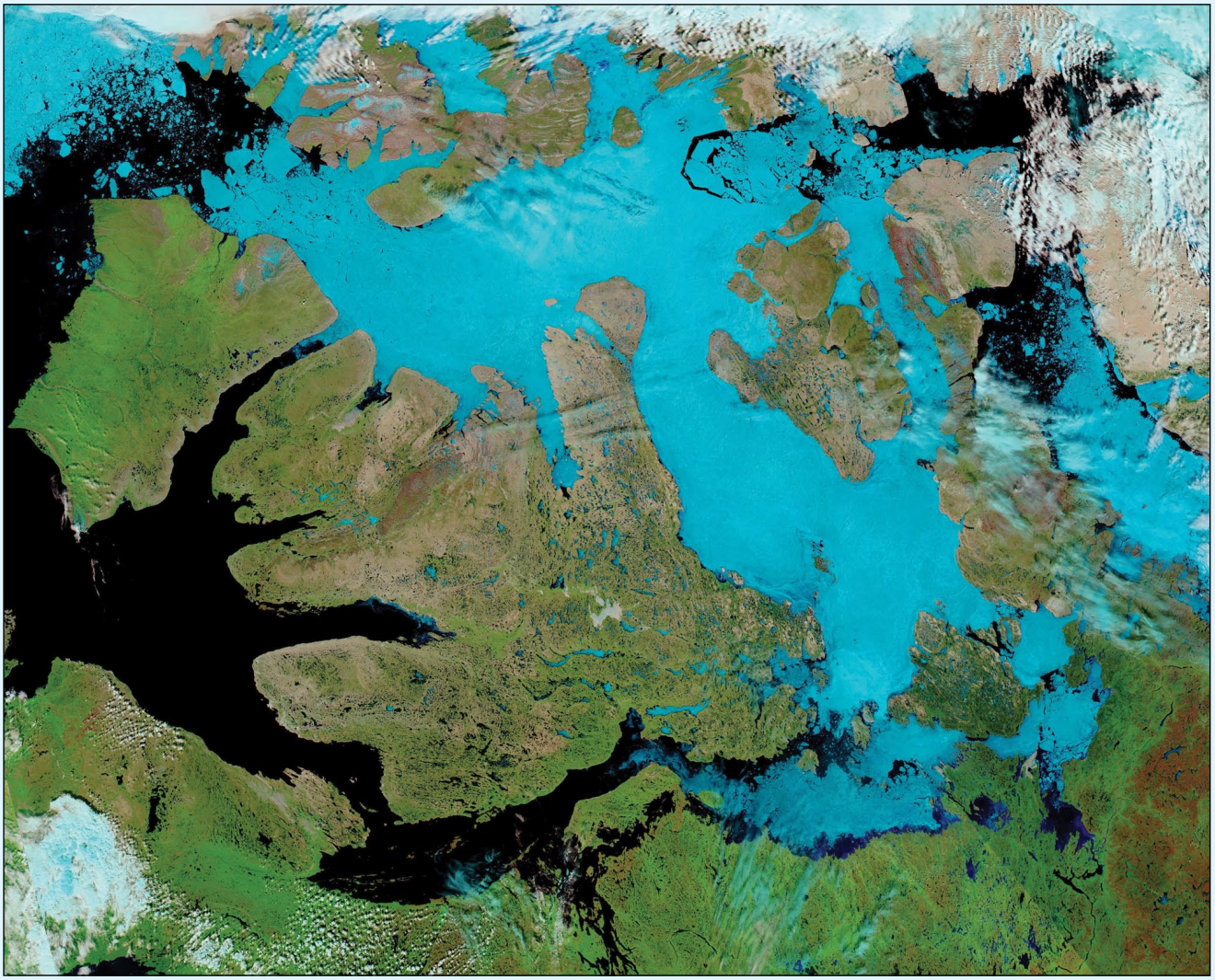


Image Credit: MODIS Land Rapid Response Team, NASA GSFC

The Northwest Passage traces a sea route from Europe to Asia that winds through islands along the northern edge of Canada—a route much shorter than a trip around the southern tip of Africa. While such a passage was a longed-for dream as far back as the second century CE, it wasn't until 1906 that the first recorded successful voyage through the Northwest Passage was completed. It took Roald Amundsen and his crew of six three years to sail his 21 × 6 metre sloop, a converted herring boat named Gjøa, through the icy passage.

As the climate warms, the passage across the top of Canada becomes more of a reality. Summer Arctic sea ice minimum extent reached a new low in 2007, creating conditions that fostered more frequent success for mariners attempting the crossing. The summer Arctic sea ice minimum reached a new record low in 2012. And, according to the *NASA Climate* website, summer Arctic sea ice extent is shrinking by 12.2% per decade due to warmer temperatures. Traffic through the Northwest Passage now occurs on a regular basis during the peak of summer.

There is a twist to the story, however. According to *YaleClimate 360*, melting sea ice appears to be making the Northwest Passage more difficult. As ice nearer the North Pole melts, it releases chunks of ice large enough to prove dangerous to ships. And these chunks are floating down to the waters around northern Canada. They cite an article published in the journal *Communications Earth and Environment*, which found that the navigable period in the Eastern Beaufort Sea, at the eastern edge of the passage, had shrunk from 27 weeks in 2007 to 13 weeks in 2021.

On July 13, 2024, the Northwest Passage appeared to remain firmly covered in ice, based on this false-colour image captured by the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Aqua satellite. The image centres on Victoria Island, the largest island visible. The route across the passage requires skirting Victoria Island either to its north or south.

This type of image uses a combination short-wave infrared, near infrared, and visible light (MODIS bands 7-2-1) to help highlight snow and ice, both of which appear bright electric blue. In contrast, open, ice-free, ocean water looks deep blue. Vegetation is green, open land is tan, and clouds are usually white although high, cold clouds which are filled with ice crystals may take on a tint of pale electric blue.

Australia's Snowy Mountains Coated in White

NASA Earth Observatory

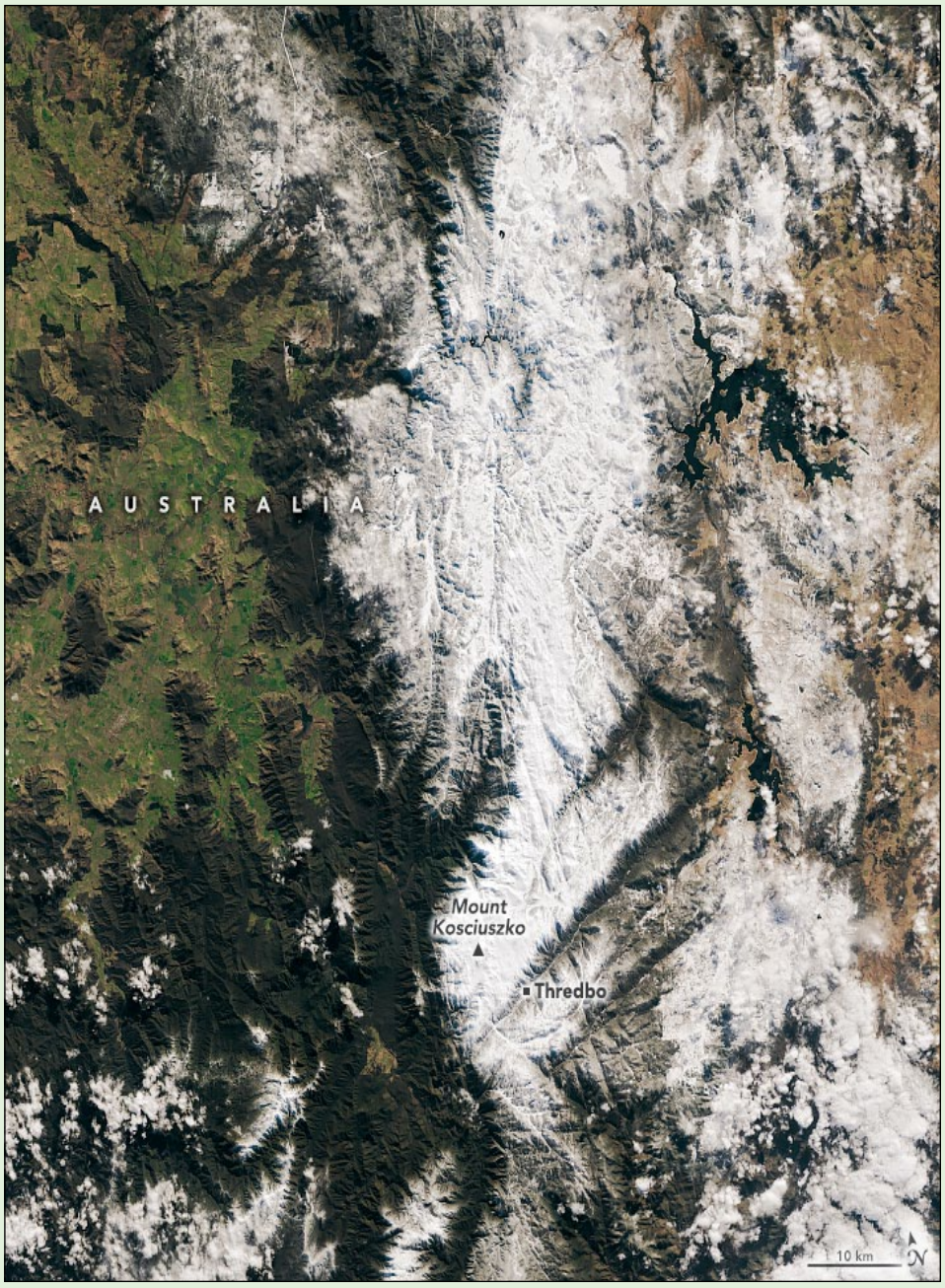
Story by Lindsey Doermann

Winter made a bold—if late—entrance to the mountains in southeastern Australia. Much to the delight of skiers Down Under, a period of seasonal weather in July 2024 brought significant accumulations to the Snowy Mountains in New South Wales.

The OLI (Operational Land Imager) on Landsat 8 captured this wintry image of Australia's Snowy Mountains on July 28. Part of the Australian Alps, the range is home to the country's tallest peaks, including Mount Kosciuszko at 2,228 metres, as well as several popular ski resorts. Peak snow season in this region usually lasts from June to August, although snow commonly falls at higher elevations in May and can linger through October.

Winter got off to a slow start in the Snowy Mountains in 2024, however. Slopes were mostly bare for the traditional opening of the ski season in early June, according to news reports. Meteorologists attributed the lack of snow to blocking highs, or strong high pressure systems, that persisted over the Great Australian Bight.

Weather patterns changed on July 19 as heavy snow reached the mountains. On July 21, the Thredbo ski resort reported that 59 centimeters of snow had fallen during the storm. Smaller accumulations arrived in subsequent days. Starting July 28, a strong cold front delivered 'unusually low' temperatures to parts of New South Wales and yet more snow fell on the mountains. According to news reports, some of Australia's extreme winter weather in 2024 was influenced by a rare sudden stratospheric warming event over the Antarctic.



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

Variable snow years are the norm in the Australian Alps, according to the Australian Bureau of Meteorology. Climate patterns such as *El Niño*, *La Niña*, and the *Indian Ocean Dipole* modulate each winter's snowpack. Despite the significant year-to-year variability, long-term observations point to a thinning alpine snowpack. Maximum snow depth has trended down since the late 1950s, the agency reported, adding that the declines are linked with warming trends. The annual average temperature has risen about 1.4 degrees Celsius in the region since 1950.

Etesian Winds over the Aegean Sea

MODIS Web Image of the Day

Image Credit: MODIS Land Rapid Response Team, NASA GSFC

Each summer, the Aegean Sea is combed by strong northerly winds. Known as 'Etesian winds', they usually originate from air masses over southern Russia or the Caspian Sea and sweep southward. They winds are dry and relatively cool, so they can help moderate the peak summer heat of Greece, Türkiye, and the associated islands in the Aegean.

Etesian winds may come on suddenly and often reach gale force. Blowing between 62-74 kilometres per hour, gale-force winds can cause difficulty with small craft navigation and may feed rapid spread of wildfires.

The name 'Etesian' is said to derived from the Greek word 'etesios', which means annual. They are also known as 'meltemia' in the region.

On July 28, 2024, the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite captured a true-colour image that revealed the presence of Etesian winds blowing across the Aegean Sea. For orientation, Greece is in the west (left) and Türkiye sits in the east (right). Crete, a large Greek island, stretches across the southern section of the image at the border between the Aegean Sea (north) and Mediterranean Sea (south).

While the wind itself is, of course, invisible, the optical phenomenon known as 'sunglint' marks its passage. Sunglint occurs when the reflection of light off water aims directly back at the satellite sensor. This creates a bright, mirror-like area in a true-colour image when the water surface is still and flat. In contrast, where the surface has been roughened by passing wind, light is scattered in many directions, causing those areas to appear darker. As flowing air strikes tall objects, such as the tall terrain of Crete, it is blown around the object. This creates turbulence near and on the edges, but the lee side is protected from the wind and looks bright. The direction of moving air can be estimated from the patches of bright sunglint behind the islands, including Crete.

Foxe Basin's Scenic Sea Ice

NASA Earth Observatory

Story by Kathryn Hansen

The seasonal melting of sea ice across the central Arctic Ocean and surrounding basins peaks in July, the region's warmest month. In Foxe Basin, currents, tidal motion, and winds can stir up the now-fragile pieces of ice, producing art-like patterns on the water's surface. One such moment of seasonal beauty was on full display on July 15, 2024, when the OLI-2 (Operational Land Imager-2) on Landsat 9 captured the image shown in figure 1.

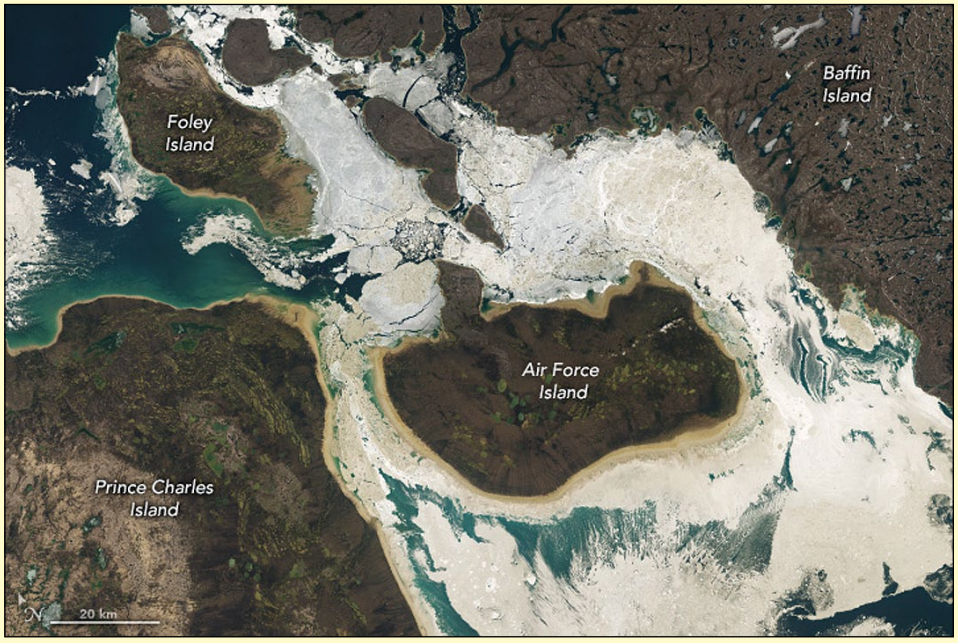


Figure 1 - Foxe Basin

NASA Earth Observatory images by Wanmei Liang using Landsat data from the USGS

Foxe Basin, off the west coast of Baffin Island in Nunavut, Canada, measures about 400 kilometers across at its widest point. Hudson Bay lies to the south, connected to the basin by Foxe Channel, and additional waterways within the Canadian Arctic Archipelago lie to the west. Figure 1 shows the northeastern part of Foxe Basin and several of its largest islands.

The basin's waters are often clogged with first-year sea ice—seasonal ice that is less than a year old. New ice begins to form each year around October, according to *Environment and Climate Change Canada*, and it continues to spread and thicken through the winter until melting begins in late May or early June. As of August 2024, the basin was nearly ice-free, except for areas west of Baffin Island and within Foxe Channel.

Figure 2

A zoomed view at the eastern coastline of Foxe Basin

Figures 2 and 3 show detailed views of patterns in the ice on July 15. The basin's ice is often in motion, producing the wispy tendrils of ice and paths of open water that trail some of the larger pieces.

All of this motion also helps stir up sediment, which is the main reason for the ice's muddy appearance. Pieces of eroded soil and debris—sloughed from the surrounding land and stirred up from the shallow seafloor—mix with the seawater and stain the ice brown. Algae, which can grow under the ice and wash on to its surface, might also be contributing to the discoloration.

Figure 3

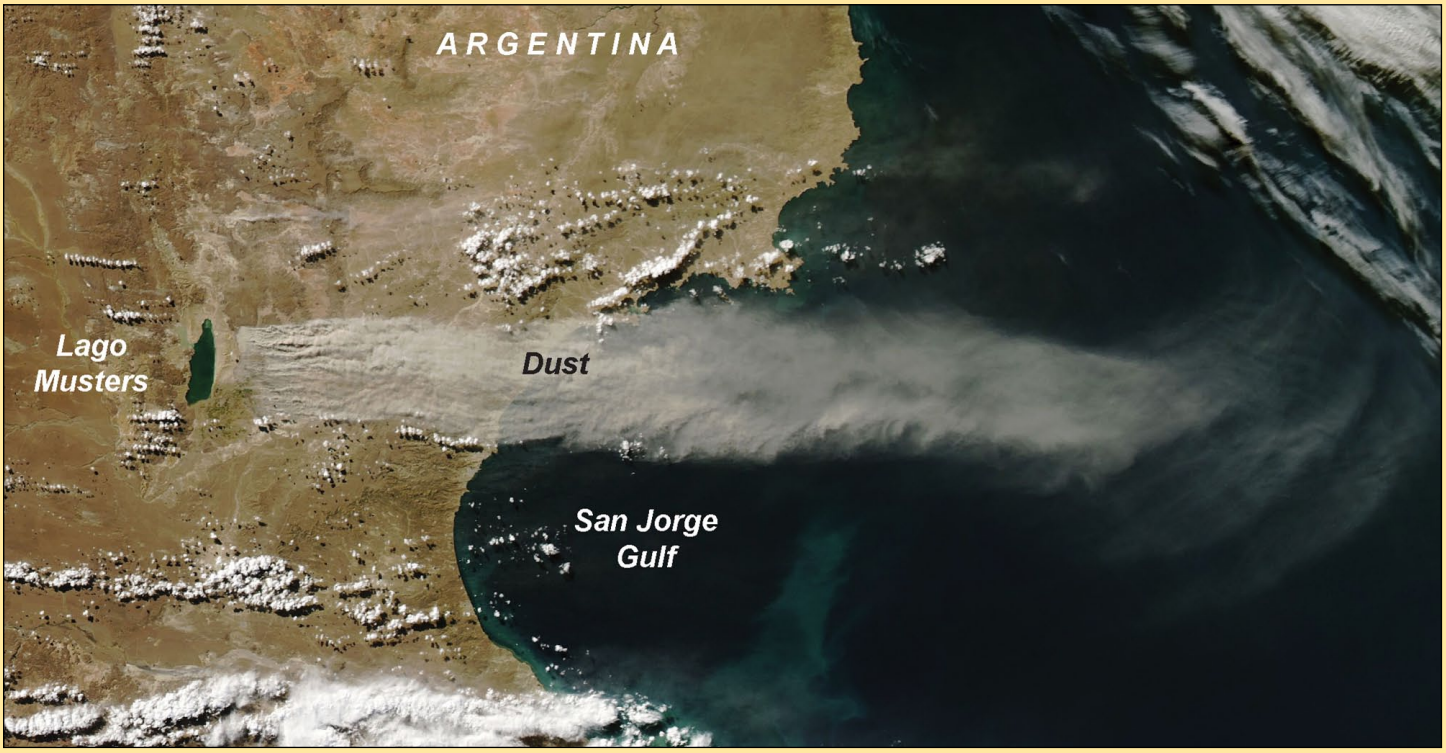
Patterns in the ice to the south of Foxe Basin

The basin is a haven for an array of wildlife. Several polynas—areas of open water within the sea ice—are an important gathering place for species such as bowhead whales and polar bears. Walrus, migrating birds, and other creatures also rely on the basin's resources.

Blowing in the Patagonian Wind

NASA Earth Observatory

Story by Adam Voiland



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

Strong northwesterly winds often race down the eastern side of the Andes Mountains and whip across the central Patagonian Desert. In the process, they sometimes lift dust from Argentina's drying Lago Colhué Huapi, fuelling intense dust storms.

The MODIS (Moderate Resolution Imaging Spectroradiometer) on NASA's Aqua satellite acquired this natural-colour image of dust streaming from the silty lake bed, east of Lago Musters, on March 29, 2024. Lago Colhué Huapi

https://earthobservatory.nasa.gov/images/148381/a-dusty-day-in-patagonia

is a particularly rich source of dust because the shallow lake regularly grows and shrinks with variations in the flow of the Senguer River and the pace of evaporation. When lake water levels are low, as they were when MODIS captured this image, fine-grained, lightweight particles are easily transported by the wind.

To better understand dust activity from Lago Colhué Huapi, NASA scientists have analysed satellite and surface weather data over five decades, assessing the year-to-year variability in dust storms and identifying periods of high activity.

Dust storms peak during the summer (December through March), though events in the wintertime (May through August) are also common. Most years have 15 to 30 moderate to large dust events.

Dust storms are frequent and persistent enough in this area that they have exposed an open-air archaeological site along the lake's edge. The *Puesto Roberts 1* site, located in an old floodplain on the southeast side of Lago Colhué Huapi, was first identified in 2019 when archaeologists noticed that winds had exposed a five-centimetre layer of sandy loam soil littered with stone tools and the bones of a wild species of llama called guanaco.

Archaeologists identified 427 artefacts at the site—including stone cutting blades, milling tools, scrapers, and egg-shaped bola stones used for hunting—spread across 15 square metres, according to a 2022 study led by Heidi Hammond, an archaeologist at the *National University of the Patagonia San Juan Bosco*. The artefacts, which are roughly 1,500 to 1,000 years old, are thought to be the remains of a temporary campsite where people cleaned and ate guanaco. Most of the stones were made of chert, a locally available fine-grained sedimentary rock, but researchers also found examples of quartzite, andesite, basalt, xilopal, rhyolite, black obsidian, tuff, silicified tuff and gneiss artefacts.

In assessing the size distribution of the artefacts, the smallest artefacts were notably scarce. '*Due to the strong erosive action of wind*,' the authors noted, '*these types of pieces were probably mobilised and therefore their representativeness in the assemblage is low*.'

Ship Tracks over the Pacific

MODIS Web Image of the Day

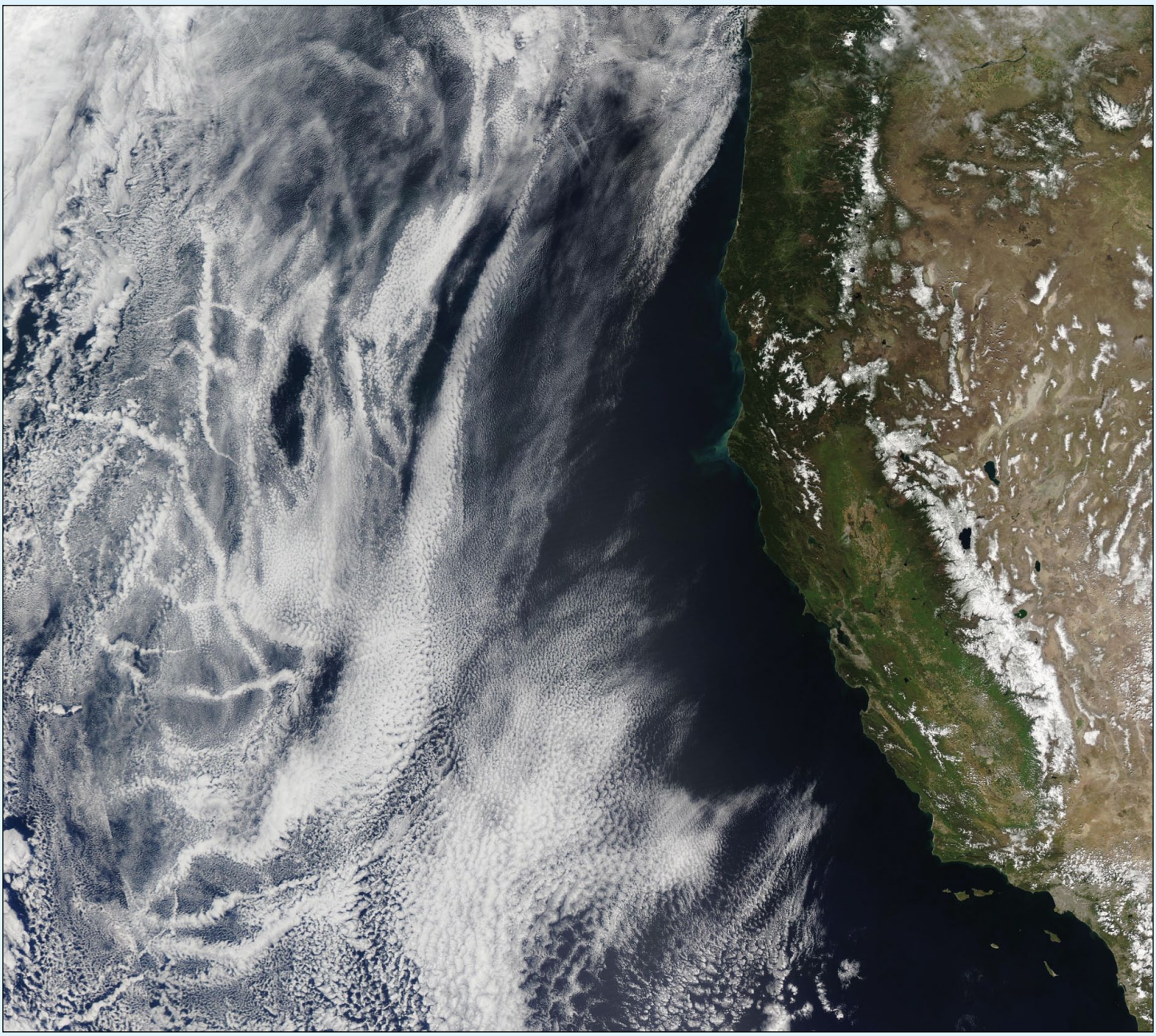


Image Credit: MODIS Land Rapid Response Team, NASA GSFC

Linear clouds crisscrossed the Pacific Ocean off the coast of California in early April 2024, each marking the passage of a ship. The Moderate Resolution Imaging Spectroradiometer (MODIS) acquired this true-colour image of the distinctive clouds known as 'ship tracks' on April 1.

Ship tracks are thin, narrow clouds that form when water vapour condenses around the tiny particles emitted by ships in their exhaust. They don't form over every passing ship, but tend to be found where thin, low-lying stratus and cumulus clouds are also present. Ship tracks often appear brighter than surrounding clouds, because clouds that form due to ship exhaust usually have more and smaller droplets than do normal, unpolluted clouds. The smaller droplets scatter light in many directions, and it is this increased reflectance that makes them appear white in satellite images.

This area of the North Pacific Ocean is a remarkably busy waterway, with heavy shipping traffic year-round.

The combination of a high number of ships releasing emissions and atmospheric conditions conducive to the formation of a variety of low-level clouds make the North Pacific a hot spot for viewing ship tracks.

Landslide Dams the Chilcotin River

NASA Earth Observatory

Story by Adam Voiland

Late on July 30, 2024, land along the south bank of the Chilcotin River in Farwell Canyon began to sink and flow into the valley below. When the landslide stopped moving, a large piece of earth had dropped more than 50 metres, leaving a mound of debris 1,000 metres long, 600 metres wide, and 30 metres deep that blocked the river and completely halted its flow.

When the OLI-2 (Operational Land Imager-2) on Landsat 9 captured the image shown in figure 1 on August 1, 2024, water had begun to pool behind the landslide deposit, creating a long, narrow lake. Figure 2 shows the same area on July 16, about two weeks before the landslide.

Soon after the event was discovered, local authorities issued flood warnings for areas upstream of the landslide and evacuation orders for areas immediately downstream.

'*The major threat in situations like this is that large amounts of water build up behind the landslide dam and eventually trigger destructive outburst floods*,' said Robert Emberson, a member of NASA's Landslides research team and one of the associate program managers for NASA's Disasters program.

On August 5, water began to overwhelm the natural dam, causing water levels downstream to increase rapidly and carry woody debris down the river. Preliminary modelling from British Columbia's *River Forecast Center* indicated that water levels would surge above typical spring flooding levels on the Chilcotin upstream of the point where it flows into the Fraser River.

On the Fraser, estimated flows are likely to be similar to or below peak flows that occur during typical spring flooding. However, '*the water will react differently, with greater momentum and force, than a gradual increase in water levels*,' officials from the *Ministry of Emergency Management and Climate Readiness* (EMCR) warned.

As a trickle and then a gushing torrent of water chiselled through the landslide debris, authorities urged people to stay away from the riverbanks due to the risk of fast-moving water and debris. A gauge downstream at Big Bar showed Fraser River water levels peaking on August 6 at 3,640 cubic metres per second: a sharp increase, though not a historical record for that date.

Figure 1 - The scene on August 1, 2024 following the landslide

Figure 2 - The image, acquired on July 16, 2024, shows the scene prior to the landslide
NASA Earth Observatory images by Wanmei Liang, using Landsat data from the U.S. Geological Survey

Figure 3 - This photograph shows debris-filled water pooling behind the landslide dam on August 1.
Photo provided by EMCR

'Fortunately, the Chilcotin River is sparsely populated, and evacuation warnings have already been issued,' Emberson said. 'But the impact of flooding on agriculture downstream is still a concern.'

Figure 3 shows debris-filled water pooling behind the landslide dam on August 1. Figure 4 shows the leading edge of the floodwater after it broke through the dam and flowed south along the Chilcotin River into the Fraser River on August 5.

The event occurred in a remote part of British Columbia, about 100 kilometres southwest of Williams Lake, in an area known as Nagwentled by the Tŝilhqot'in, an Athabaskan-speaking indigenous group in the area. Nagwentled roughly translates to 'landslides across the river.' Indeed, scars along the south side of the river, and tongue-shaped debris fields visible in multiple areas, indicate that landslides have occurred relatively frequently.

'The scalloped edges in the terrain immediately south of the point of failure appear to be ancient landslide scarps, some of which were likely considerably larger than the event in July,' said Daniel Shugar, a geomorphologist at the University of Calgary.

Figure 4 - The leading edge of the floodwater after it broke through the dam on August 5.
Photo provided by EMCR

The river is also an important waterway for several types of salmon. In a statement issued following the landslide, the Tŝilhqot'in National Government expressed particular concern that the event had blocked the movement of Taseko sockeye, an endangered population that had been on track to return to spawning grounds at record low levels prior to the landslide.

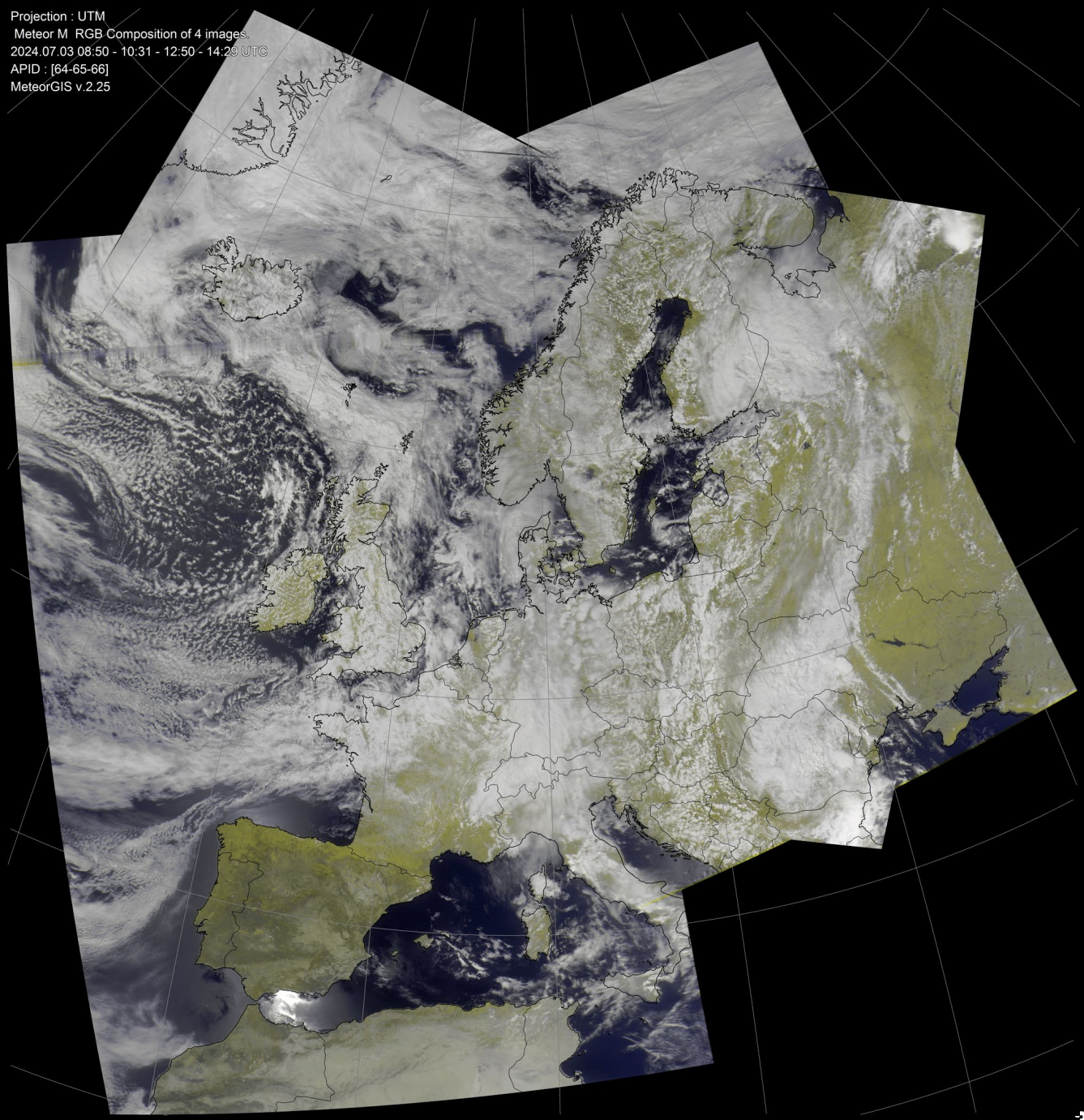
‘[We are] calling on all levels of government, downstream First Nations, the Pacific Salmon Commission, and other Nations and States, especially Alaskan fisheries, to take all precautionary measures possible to conserve Tšilhqot‘in territory-bound salmon,’ the group said.

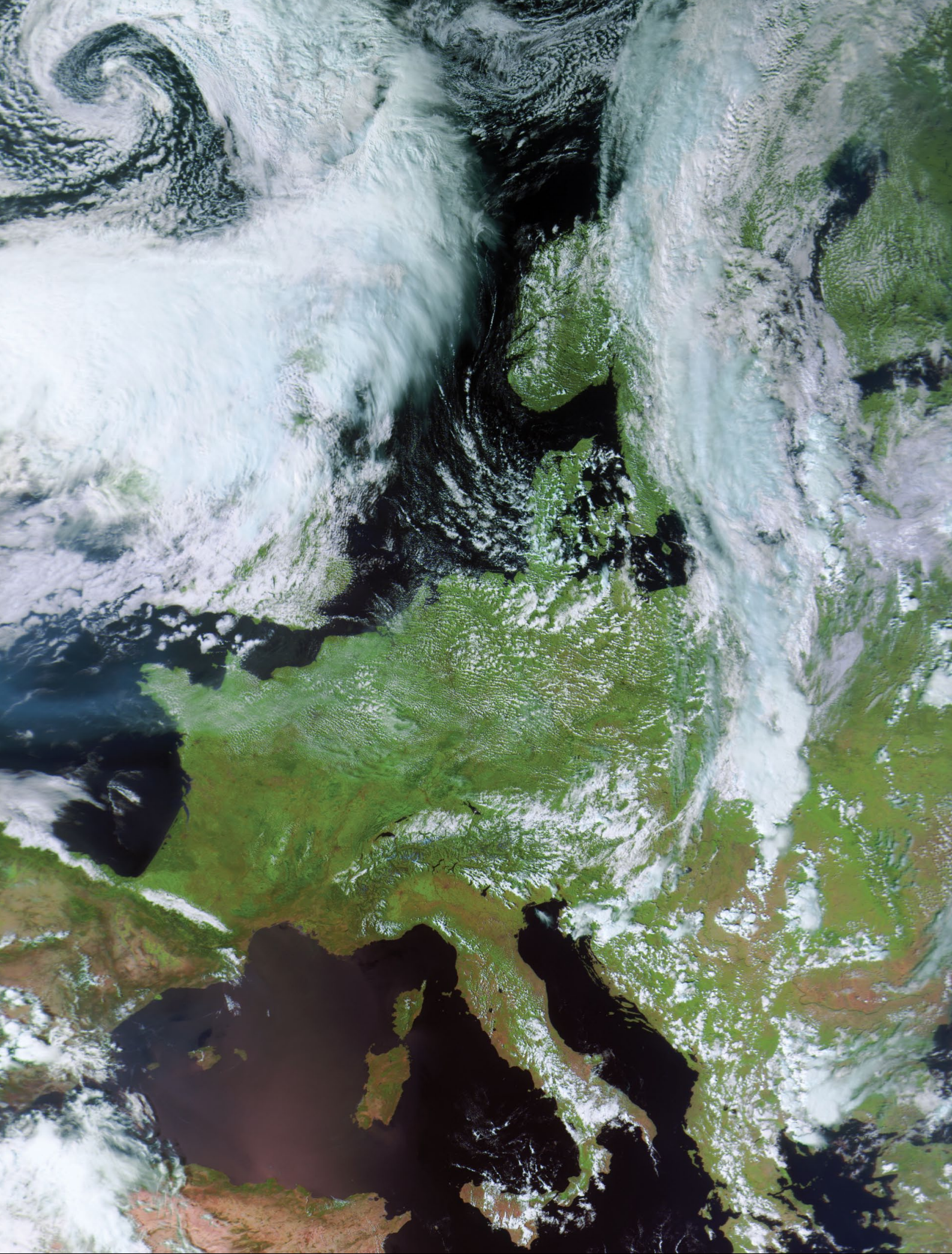
There are some ranches, farms, and mining operations along the river edges, and people regularly canoe and camp along the Chilcotin. A stretch of the canyon downstream with large sand dunes is a common destination for hikers, campers, and mountain bikers. According to the *Canadian Broadcast Company*, one person in the area was partially buried by the initial landslide and had to be rescued by a local resident.

Government officials and university scientists will be monitoring the situation in the coming days and weeks from the ground and from the air with helicopters and uncrewed vehicles using a variety of technologies. They will also be using satellites and other forms of remote sensing. “Satellites are indispensable for near-real-time monitoring of evolving disaster situations like this,” Shugar said. “Having eyes in the sky to see the entire slide and impounded lake is tremendously useful.”

Meteor Multi-image Composite

Joachim Scharrer sent in this Meteor M image composite he obtained from four passes of the satellite on July 3, 2024



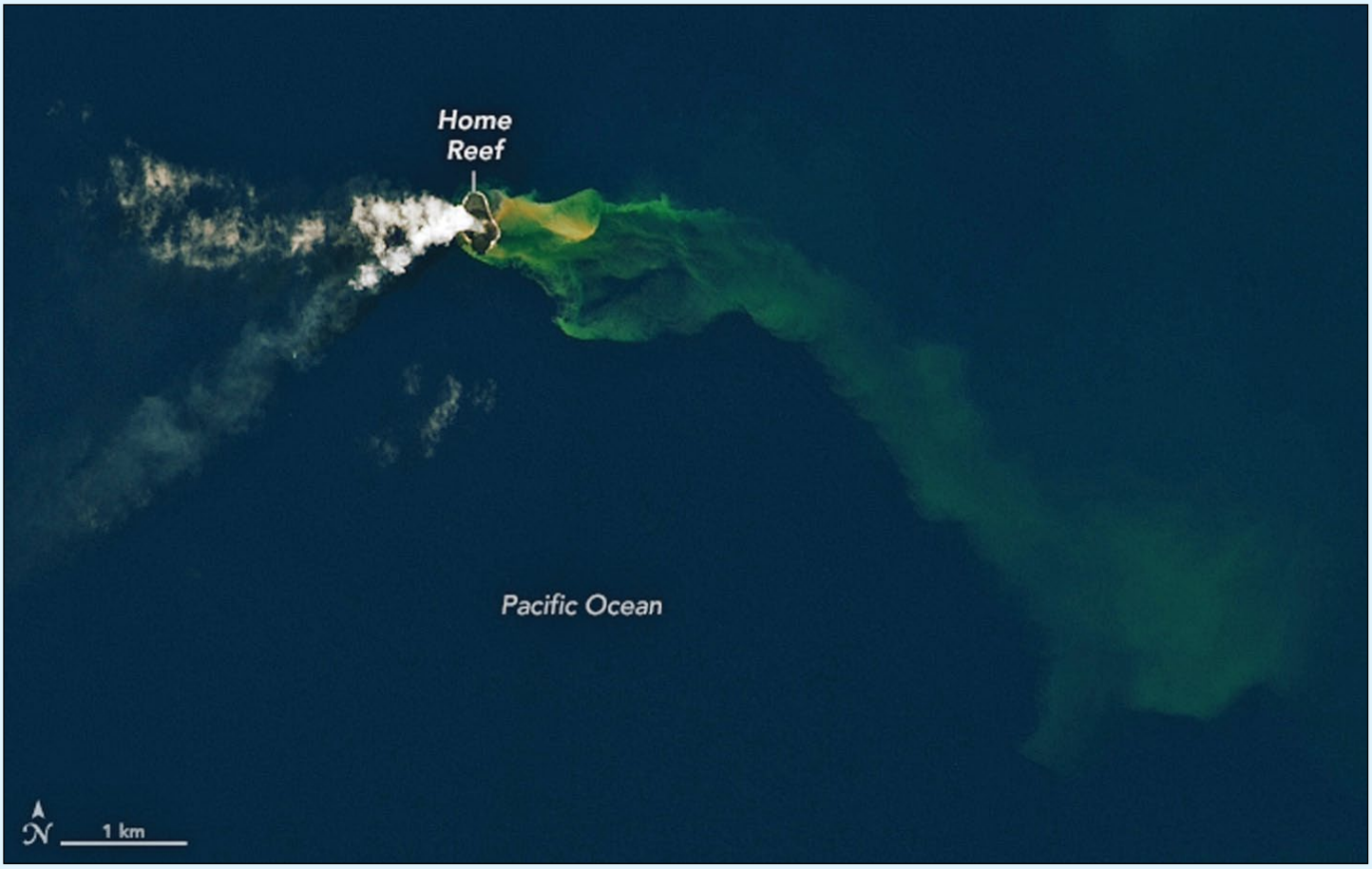


This Meteor M2-4 RGB123 HRPT image was acquired by Enrico Gobbetti on August 21, 2024 using the Satdump software.

Home Reef Volcano Grows

NASA Earth Observatory

Story by Lindsey Doermann



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

Dry land is ephemeral at Home Reef, a mid-ocean volcano in the central Tonga islands. Cycles of eruptions and erosion have periodically created and destroyed a small island there since at least the mid-19th century. In June 2024, an eruption tacked on new area to the speck of land, lofted a volcanic plume into the sky, and discoloured the surrounding seawater.

Volcanic activity at Home Reef is on display in this image, acquired by the OLI-2 (Operational Land Imager-2) on Landsat 9 on June 15, 2024. On that day, lava flowed from a vent on the island, according to Tonga Geological Services, expanding the land that emerged in a September 2022 eruption and causing the coastline to bulge out to the east.

As a cloud of volcanic emissions streamed west, a plume of discoloured water flowed east and south, its lighter colour contrasting with the blue seawater. Previous research has shown such plumes of superheated acidic water can contain particulate matter, volcanic rock fragments, and sulphur, as well as precipitates of silicon, iron, and aluminum oxides.

At other submarine volcanoes, scientists have detected a change in water colour via satellite imagery up to one month prior to an eruption, suggesting that ocean colour could presage a potentially destructive event.

Home Reef sits within the Tonga-Kermadec subduction zone, an area where three tectonic plates are colliding at the fastest converging boundary in the world. Here, the Pacific Plate is sinking beneath two other small plates, yielding one of Earth's deepest trenches and most active volcanic arcs.

The first recorded eruption at Home Reef dates to 1852, with another potential island-forming eruption occurring in 1857, according to the Smithsonian Institution Global Volcanism Program. The volcano reawakened in 1984 and 2006, both times creating small new islands and sending pumice 'rafts'—concentrated patches of porous, lightweight volcanic rock—drifting across the ocean surface.

No floating patch of stone was apparent around Home Reef in June 2024. Nonetheless, ships were advised to stay at least four kilometres away from the island. The volcanic activity posed low risk to communities on the nearby Vava'u and Ha'apai island groups, according to Tonga Geological Services. The agency was also reporting satellite-detected thermal anomalies at the volcano through at least June 27.

Tristan da Cunha

NASA Earth Observatory

Story by Adam Voiland

Tristan da Cunha, often said to be the most remote inhabited island in the world, is the sort of place where seabirds outnumber people. It is part of an island group in the South Atlantic Ocean situated approximately halfway between the southern tips of South America and Africa. Neighbouring volcanic peaks within the group include the smaller, uninhabited Inaccessible Island and the Nightingale Islands.

The OLI-2 (Operational Land Imager-2) on Landsat 9 captured this image of the island group on May 24, 2023. Tristan da Cunha's highest point, Queen Mary's Peak, reaches 2,060 metres above sea level and displays steep gullies that radiate downward on all sides.

The island's vegetation is divided into distinct zones related to elevation. Large tussock-forming grasses once covered the island's coastal fringes, but most of this has become pasture, according to the Royal Botanic Gardens, Kew. Woodlands of *Phylica arborea*, known as island cape myrtle, cover the volcano's lower slopes (dark green) and transition into ecosystems that include tree ferns, sphagnum moss, small grasses, bryophytes, and lichens on its upper reaches (light green).

Offshore, underwater forests of giant kelp surround the islands. The kelp, *Macrocystis pyrifera*, is one of the fastest-growing seaweeds on the planet. Though suspended sediment may be discolouring the water in some areas, signs of kelp forests (green) are visible in several areas immediately offshore. In preparation for an ecological survey of the island's marine ecosystems, a team of National Geographic researchers used dozens of Landsat 7 and 8 images to locate the likely locations of kelp forests and plan underwater surveys.

About 240 people live in **Edinburgh of the Seven Seas**, the small town on the northern edge of the island. The

Tristan da Cunha

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

The Tristan da Cunha group of islands

main occupations are fishing and farming. Many residents harvest crayfish—sold as Tristan rock lobster—and raise potatoes and livestock. Away from town, thousands of birds, including populations of northern rockhopper penguins, Atlantic yellow-nosed albatross, and broad-billed prion, nest on the small, circular island.

The number of birds might be higher if mice and rats had not found their way to the islands. Most likely introduced by sailors in the 1800s, rodent populations have boomed despite an annual rat hunting competition and holiday. The small mammals are thought to eat large numbers of bird eggs and young birds.

Ecologists have warned that an abundance of oversized mice may even be on the verge of pushing a critically endangered seabird, the Tristan albatross, to the brink of extinction on Gough Island (out of the scene to the southeast). Another notable species on Inaccessible Island is the Inaccessible Island rail, the smallest living flightless bird in the world.

All of the islands are the product of a volcanic hot spot, a type of volcanism that brings magma from deep within Earth's mantle. Tristan da Cunha, the youngest and largest of the group, formed about 200,000 years ago. It last erupted in October 1961, forcing people on the island to evacuate. Radiometric dating techniques indicate that Nightingale is the oldest of the three main islands, with volcanic rocks ranging from 360,000 to 18 million years old. Inaccessible Island has rocks that range from 1 million to 6 million years old.

Niagara Falls between Canada and the USA

Copernicus Image of the Day

Credit: European Union, Copernicus Sentinel-2

Niagara Falls are a system of waterfalls on the Niagara River between Lake Erie and Lake Ontario. From west to east, the individual waterfalls are named Horseshoe Falls, Bridal Veil Falls and American Falls. The river flows from southeast to northwest on this image scene. The water flow over Horseshoe falls reaches maximum volume on late spring or early summer days, so this True Colour Sentinel-2 image of May 30, 2024 probably captures such a situation. At night, a substantial part of the water is directed via a system of tunnels to reservoirs and the hydroelectric power stations located east and west of the river on the northern part of the image. Downstream of the falls, the Rainbow Bridge, the Whirlpool Rapids Bridge, the Niagara Gorge Rapids and the Niagara Whirlpool are visible. Two artificial reservoirs are located east and west of the river.

Snow Gathers on the Southern Alps

MODIS Web Image of the Day

Image Credit: MODIS Land Rapid Response Team, NASA GSFC

A high-pressure system over New Zealand kept the clouds away and the sun shining on the gorgeous winter colours of South Island in mid-July 2024. The Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite acquired a true-colour image of the bright morning on July 16.

Snow topped the Southern Alps, which are the rugged mountain chain that extends for about 650 kilometres along the western side of South Island. The snowpack is still thin, relative to deep winter averages, after a mild and mostly dry June. The first week of July brought fresh snow along with dropping temperatures, which made conditions perfect for ski resorts to top off the fresh fall with artificial snow.

According to Mountain Watch, "A significant low from the Southern Ocean got the season's ski-tips pointing straight down the mountain at the start of July though, with some 30-50 cm of fresh snow racking up for most of the resorts".

Along with snowy peaks, several large valleys of the Southern Alps are filled with low cloud (fog). Fog appears tinted slightly tan in this image and has a ground-glass appearance compared with the sharp, crisp white of the highly reflective snow. It's also interesting to compare the appearance of the fog with the clouds over the ocean. The minor colour differences are primarily due to reflectivity, with the sunlight reflecting off of the smooth surface of the snow making it appear much brighter than any of the uneven surfaces of the clouds.

A crystal clear view of Øresund Bridge

Copernicus Image of the Day

Credit: European Union, Copernicus Sentinel-2

The Øresund bridge is one of the longest bridges in the world, spanning the Øresund straight between Denmark and Sweden. The bridge connects to a tunnel which the road and railway enter on a small artificial island. The main span is supported by a system of cables on two large pylons: these are difficult to spot due to their small footprint, but are nicely highlighted by shadows on this Sentinel-2 image with the sun angle so low. The white spots on the sea are foam caps of large waves.

Forest fire in Madeira

Copernicus Image of the Day

This image, acquired on August 18, 2024 by one of the Copernicus Sentinel-3 satellites, shows a plume of smoke 130 kilometres long rising from the Portuguese island of Madeira as a result of a large forest fire which started on August 15.

The fire began in the Serra de Água area of Ribeira Brava and quickly spread to Câmara de Lobos, where it continued to pose a significant threat despite containment efforts. The flames came close to population centres, forcing the evacuation of at least 100 residents as more than 120 firefighters battled the blaze.

Credit: European Union, Copernicus Sentinel-3 imagery

Currently Active Satellites and Freqencies

Polar APT / LRPT Satellites				
Satellite	**Frequency**	**Status**	**Format**	**Image Quality**
NOAA 15	137.6200 MHz	On	APT	Intermittent sync problem
NOAA 18	137.9125 MHz	On	APT	Good
NOAA 19	137.1000 MHz	On	APT	Good
Meteor M N2	137.1000 MHz	Off	LRPT	Failed
Meteor M N2-3	137.9000 MHz	On	LRPT	Variable [1]
Meteor M N2-4	137.9000 MHz	On	LRPT	Good

Polar HRPT/AHRPT Satellites				
Satellite	**Frequency**	**Mode**	**Format**	**Image Quality**
NOAA 15	1702.5 MHz	Omni	HRPT	sync problem
NOAA 18	1707.0 MHz	RHCP	HRPT	Good
NOAA 19	1698.0 MHz	RHCP	HRPT	Good
Feng Yun 3C	1701.4 MHz	RHCP	AHRPT	Inactive [2]
Feng Yun 3D	7820.0 MHz	RHCP	AHRPT	Active {2}
Feng Yun 3E	7860.0 Mz	RHCP	AHRPT	Commissioning
Metop B	1701.3 MHz	RHCP	AHRPT	Good
Metop C	1701.3 MHz	RHCP	AHRPT	Good
Meteor M N2-2	1700.0 MHz	RHCP	AHRPT	Active [8]
Meteor M N2-3	1700.0 MHz	RHCP	AHRPT	Active
Meteor M N 2-4	1700.00 MHz	RHCP	AHRPT	Active

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

Notes

1 Currently, M2-3 and M2-4 transmit on 137.9 MHz but have on occasions switched to 137.1 MHz. Transmission is currently on a Symbol Rate of 72,000 baud, though 80,000 baud has been used in trials.
2 These satellites employ a non-standard AHRPT format and cannot be received with conventional receiving equipment.
3 Meteosat prime Full Earth Scan (FES) satellite
4 Meteosat prime Rapid Scanning Service (RSS) satellite.
5 Repurposed for use by the US Space Force
6 GOES 15 also transmits EMWIN on 1692.700 MHz GOES 16 also transmits EMWIN on 1694.100 MHz GOES 17 also transmits EMWIN
7 GOES Rebroadcast (GRB) provides the primary relay of full resolution, calibrated, near-real-time direct broadcast space relay of Level Ib data from each instrument and Level 2 data from the Geostationary Lightning Mapper (GLM). GRB replaces the GOES VARiable (GVAR) service.
8 Following a collision with a micrometeorite, the power system aboard Meteor M2-2 has been compromised. AHRPT is still being transmitted when the solar panels are sunlit, but there is insufficient battery power to enable the LRPT stream.
9 Japanese satellites MTSAT-1R (Himawari-6) and MTSAT-2 (Himawari-7) are no longer active and are probably retired. Current Japanese operational geostationary satellites are Himawari-8 and Himawari-9.