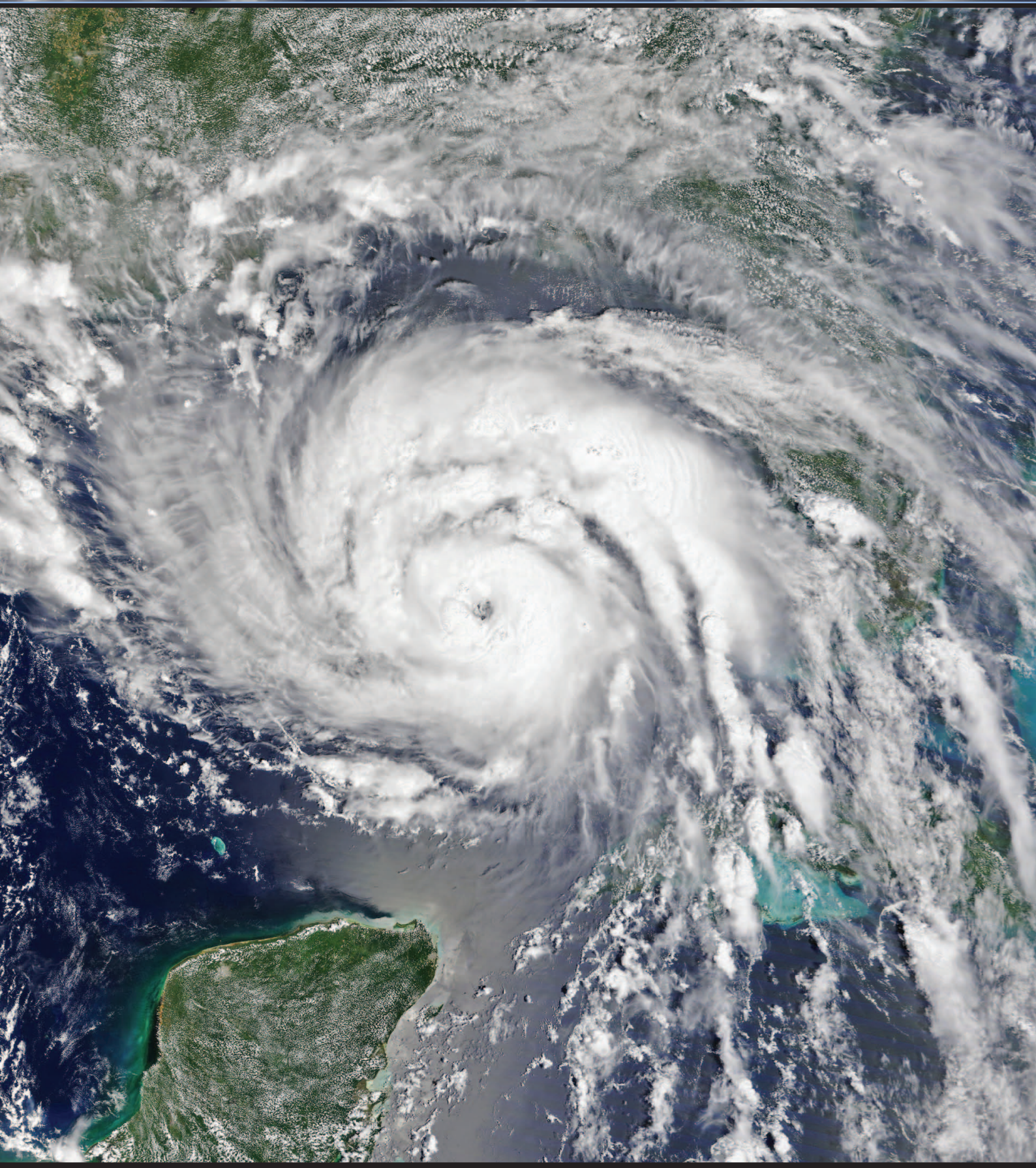
GEO Newsletter

Group for Earth Observation

Group for Earth Observation

No 71 - September 2021



Hurricane Ida, imaged by NASA's Terra satellite at 21.21 UT on August 28, 2021 as it drenched the island of Cuba
Image: NASA Worldview Snapshots (https://wvs.earthdata.nasa.gov/)

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Useful User Groups

Weather Satellite Reports

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

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

SatSignal

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

https://groups.io/g/SatSignal

MSG-1

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

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

GEO-Subscribers

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

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

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From the Editor

Les Hamilton

The recent IPCC (United Nations Intergovernmental Panel on Climate Change) ***Code Red for Humanity*** warning has provided a serious wake-up call for us all: that the warming of the planet is indeed the result of human activity and is in danger of getting out of control.

If ever the reality of Climate Change were doubted, you just have to look at this summer's events around the world to change your mind! In Europe alone the month of July was the hottest ever recorded, and temperatures climbing into the upper 40s Celsius helped to spawn a rash of severe wildfires around the Mediterranean Sea: in Turkey, Greece, Italy, Spain and Algeria. In California, over a dozen major fires have destroyed vast areas of forest: the long lived Dixie fire, which commenced on July 13 and was still burning a month later, devastated over 2600 square kilometres and destroyed overt 1,000 structures, including hundreds of homes in Greenville, California, and threatened to become the state's worst ever. And across the world, the huge northeastern Russian republic of Yakutia has been declared a disaster area with—at one point—over 150 wildfires burning simultaneously. There have also been over 250 major fires in the Amazon Basin this year. Some of the articles in this issue relate directly to the above.

At the time of writing, there is still no word of a definite launch date for Russia's long awaited Meteor M 2-3 satellite. The possible August launch date has now well and truly lapsed. Perhaps there will be news of a launch before the end of this year. Fingers crossed!

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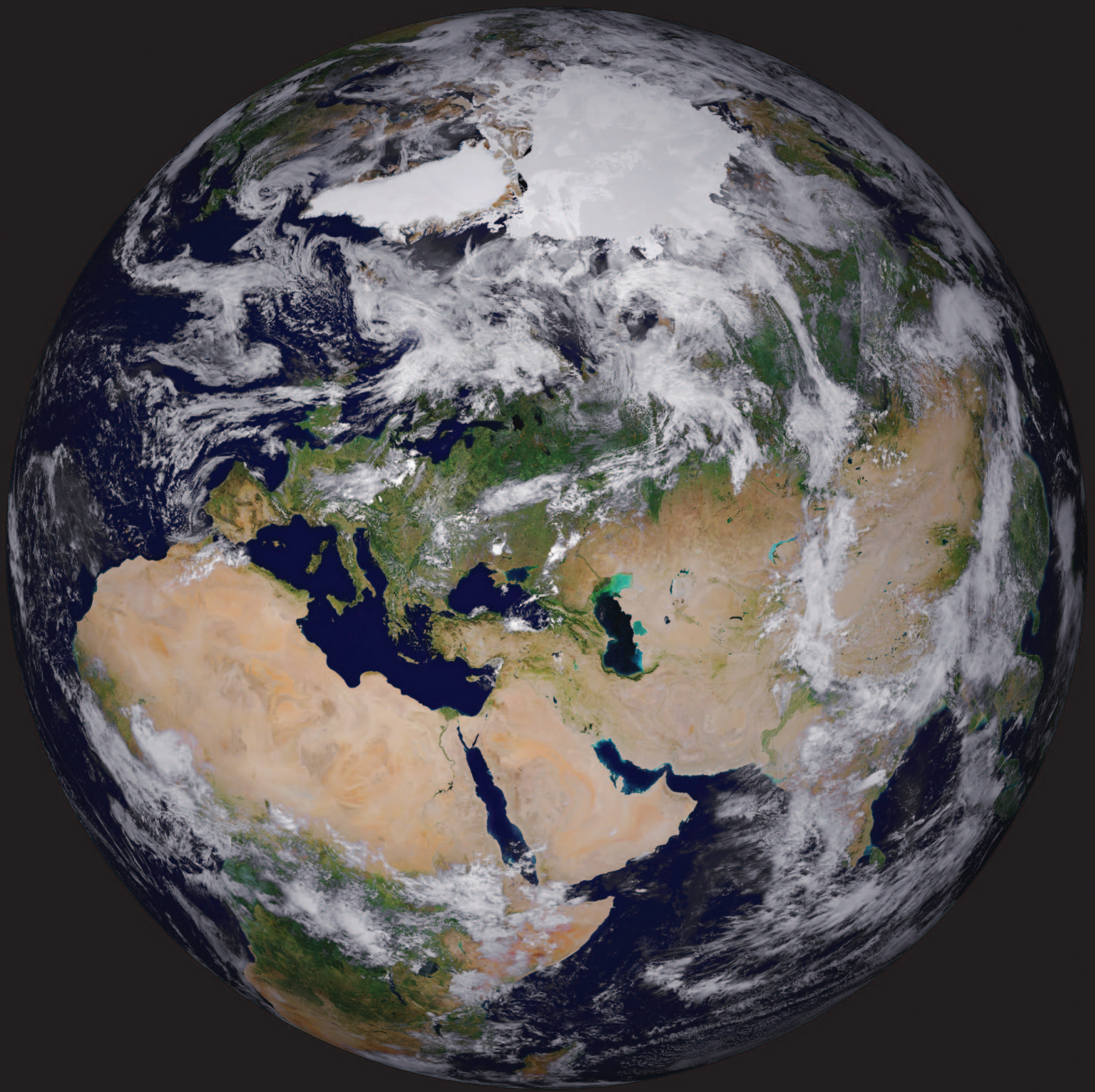
New Aspect of Earth

European Space Agency



Credit: Contains modified Copernicus Sentinel data (2019–20), processed by ESA and cloud layer from NASA

This image of Earth was compiled using tens of thousands of images from the Copernicus Sentinel-2 mission. Thanks to the satellite era, we are better placed to understand the complexities of our planet, particularly with respect to global change. Today's satellites are used to answer important to understand how Earth works as a system and how natural processes are changing under the pressure of human activity. Satellites also provide essential information for everyday applications such as to improve agricultural practices, for maritime safety and to help when natural disasters strike.

Hurricane Ida Devastates Louisiana

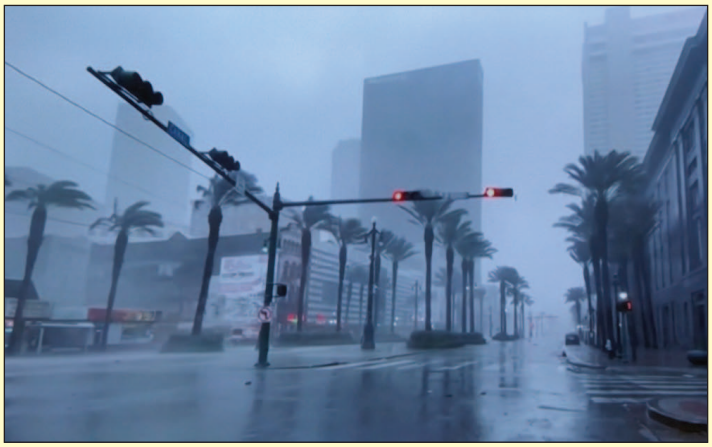
Les Hamilton

Sixteen years to the very day—August 29—that Hurricane Katrina hit Louisiana and Mississippi as a category-3 hurricane, Hurricane Ida made landfall at Port Fourchon Louisiana with sustained winds of 240 kilometres per hour (kph) and a central pressure of 930 millibars. Whereas Katrina—which at one point was a Category-5 hurricane—had weakened to Category-3 when it struck, Category-4 Ida arrived ashore at full power and weakened only slowly at first, remaining a dangerous major hurricane for several hours thereafter.

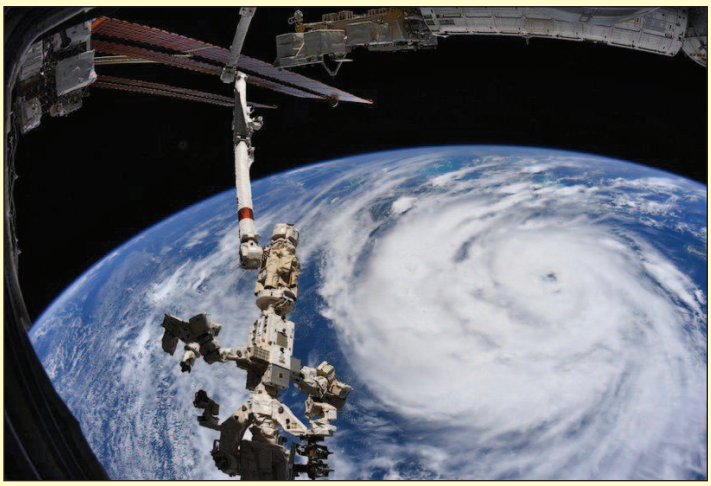
In its day, Katrina was the fourth most powerful hurricane to make landfall on the American mainland: time will tell whether Ida has now usurped this unwanted accolade.

The destructive power of a hurricane is generally measured in the cost of the damage caused, and Katrina, primarily on account to the damage resulting when the flood protection levees failed to protect New Orleans, flooding 80% of the city for several weeks, tops the list. Happily, the re-enginered levees around New Orleans kept the city safe from inundation by Ida, although the fierce winds and rain could not be prevented from severely damaging property and wiping out power to over one million consumers throughout the state of Louisiana.

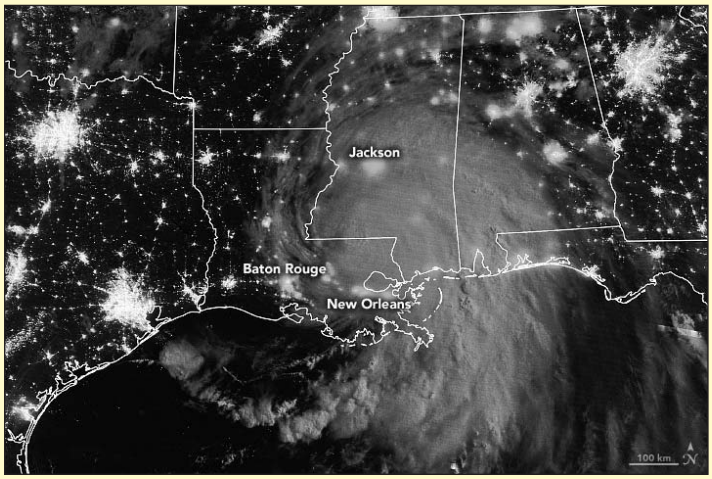
In the final 24 hours prior to landfall, Ida underwent what the *National Hurricane Center* termed a 'rapid intensification'. During this period, Ida's central pressure fell dramatically from 985 millibars (mB) to 929 mB, with accompanying winds strengthening from a mean of 150 kph to 270 kph. One factor fuelling this rapid intensification was the unusually warm water in the Gulf of Mexico, between 30-31°C, thus well above the 27°C threshold for hurricane generation.



This TV screenshot shows a deserted street in storm ravaged New Orleans where, thankfully, the levees held firm and widescale inundation by floodwater was averted.



European Space Agency's French astronaut Thomas Pesquet photographed Hurricane Ida on August 29 during his mission aboard the International Space Station.
Photo: ESA / NASA



At 2.50 am Central Daylight Time on August 30, the Visible Infrared Imaging Radiometer Suite (VIIRS) on the Suomi NPP satellite acquired this night time view of Hurricane Ida.
Image: NASA

Ida first developed on the afternoon of August 26 as a tropical depression southwest of Jamaica, and by the time it made landfall on Cuba late the following day, had intensified to Category-1 hurricane status, increasing to category-3 by the morning of August 29. In the west of Cuba, winds of up to 114 kph toppled palm trees and many houses were also destroyed by strong gusts. Electricity supplies were cut in a number of locations.

After passing Cuba, Ida gained strength to became a Category-4 hurricane, and when the storm first came ashore at Port Fourchon in Louisiana, an anemometer recorded a wind gust of 277 kph. By the time Ida had dissipated two days later, the entire state of Louisiana and parts of neighbouring Mississippi were without power. In all, some 1.3 million consumers were affected. And as the situation was assessed, it became clear that this major power outage was going to last for many weeks:

In this TV image, a roof has collapsed in New Orleans

there would be no rapid return to normality, posing major problems relating to air-conditioning and refrigerated storage, particularly as daytime temperatures at this time of the year frequently rise to 35°C and beyond. By the Tuesday, hundreds of thousands of Louisianans were sweltering in the aftermath of Hurricane Ida, with neither electricity or running water. People were clearing out food rotting in refrigerators. Those with swimming pools shared out buckets of water for bathing and to flush toilets.

The heavy rains that accompanied Hurricane Ida caused widespread flooding, and in outer New Orleans, some people were forced to climb on to the roofs of their houses to escape floodwaters caused by the downpour. In Mississippi, the rains caused a section of Highway 26 to collapse, seven vehicles tumbling into a deep hole, as a result of which two people lost their lives and ten others suffered injuries.

Particularly hard hit were the coastal communities of Louisiana, where roofs were ripped from homes, trees were uprooted, cars overturned and power lines brought down. Further damage was caused to many structures by wind borne debris,

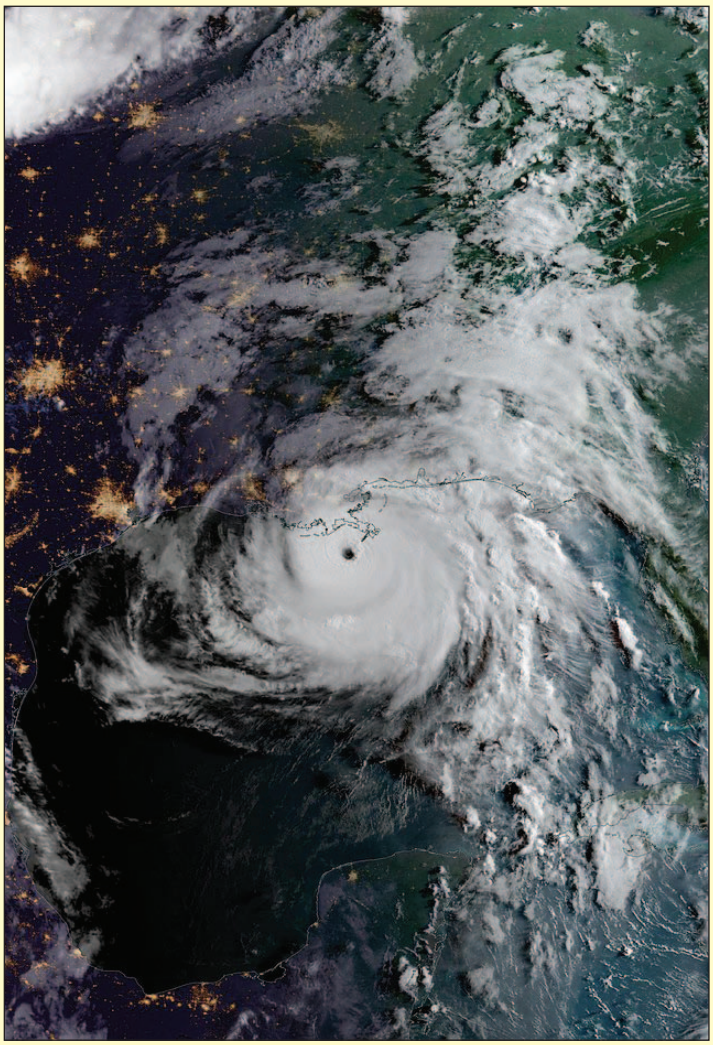
Farther afield, Hurricane Ida curtailed almost the entire Gulf Coast oil production, amounting to around 15% of U.S. output. And as a precaution, Louisiana's mainland refineries were also shut down. This combination of factors caused oil and gasoline prices to rise across the entire United States.

With many transport links severed by downed power lines and fallen trees, supplies of petrol were at a premium and long queues formed at the few gas stations that had fuel left and generator power to pump it.

With many water treatment plants becoming overwhelmed by floodwaters or crippled by power outages, some areas suffered shortages of drinking water. Some four hundred thousand inhabitants had no drinking water at all.

So serious was the situation in New Orleans, without electricity, tap water and gasoline, that an evening curfew was put in place to deter looters, while the thousands who had evacuated the region prior to the storm were advised not to return—there or anywhere else in south-east Louisiana—until they were advised it was safe to do so.

Map plotting the track and the intensity of Ida, showing the location of the storm at 6-hour intervals.
Image: Wikimedia



This satellite image shows Hurricane Ida, southeast of the Lousiana coast, on August 29 as a major Category-4 hurricane.
Image: NASA

In the immediate aftermath of Hurricane Ida's assault on Louisiana, it was estimated that the cost of repairing all the damage to power lines, homes and infrastructure could be fifteen billion dollars, though this may well prove to be an underestimate. What is certain is that it will probably be years rather than weeks or months before all the damage can be made good and people's lives return to normal.

Sweet and Salty Sonora

NASA Earth Observatory

Story by Andrea Wenzel

This photo of the Sonoran Desert in Southern California was taken with a camera mounted on the outside of the International Space Station. Blocky patches of farmland are concentrated on both ends of the Salton Sea, and a short section of U.S Interstate 10—which stretches over 3,800 kilometres from California to Florida—passes through the flat areas between the mountains. An array of solar panels stands north of the interstate.

The nearby Orocopia and Chocolate Mountains are comprised of a mix of sedimentary, igneous, and metamorphic rocks along the San Andreas Fault, allowing a variety of geologic features to be studied within a short distance. The mountains were among the locations that Apollo crews visited to train for their trips to the Moon. These 'outdoor classrooms' allowed the astronauts to learn the skills necessary to make scientific observations in barren and challenging landscapes. Such field work is still a part of astronaut training.

The Salton Sea, California's largest lake, started growing in 1905 after an irrigation canal broke and allowed the Colorado River to fill the basin. This lake has no natural outlet, so water must evaporate to leave the system; this makes it saltier than the ocean. Water continues to flow into the Salton Sea from agricultural runoff, but that runoff has decreased over time and does not balance out the water lost to evaporation. Because of this, the lake is expected to become saltier with time.

This ISS External High-Definition Camera photograph ISS064-E-8944 was acquired on December 1, 2020, with a Nikon D4 digital camera using a focal length of 85 millimeters. It is provided by the ISS Crew Earth Observations Facility and the Earth Science and Remote Sensing Unit, Johnson Space Center.

Colour in the Northern Caspian Sea

MODIS Web Image of the Day
https://modis.gsfc.nasa.gov/gallery/showall.php

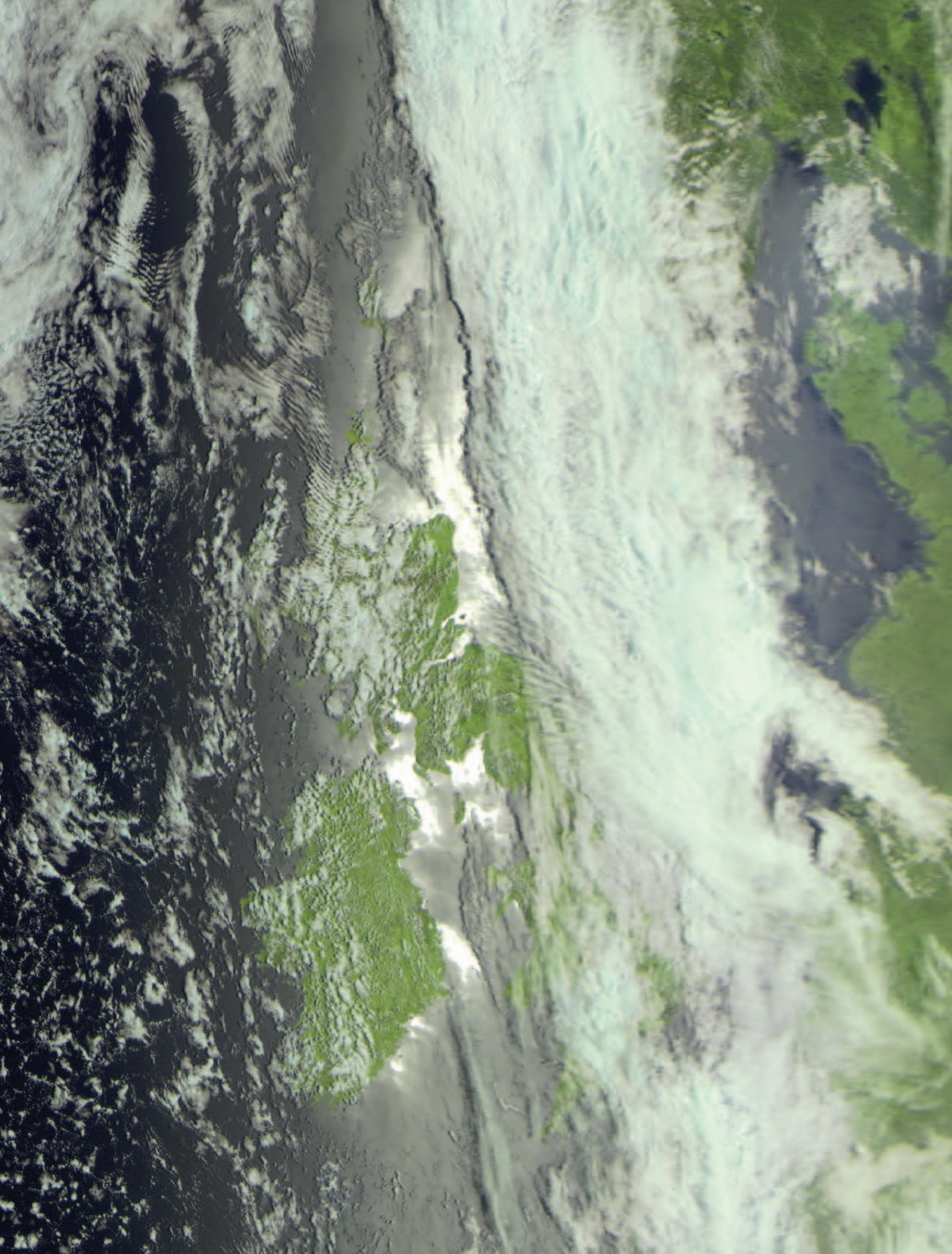
Swirls of green and tan stained the northeastern Caspian Sea on June 17, 2021, when the Moderate Resolution Imaging Spectroradiometer (MODIS) on board NASA's **Terra** satellite acquired this true-colour image of the region.

The Caspian Sea is the world's largest landlocked body of water. Stretching 1,200 kilometres from north to south, it intersects five countries in Asia and Europe, with Kazakhstan wrapped around the northeastern corner of this large landlocked lake. While the water is deep in the southern and central portions of the Caspian Sea, the northern section overlies a shelf, making it very shallow. The north receives heavy freshwater inflow from the large Volga River and from the Ural River. The Ural can be seen at the top of this image, but the Volga sits to the west (left). Both rivers carry sediment into the Sea, and their inflow creates currents that can lift sediment from the muddy bottom and carry it in swirls along with the current. Heavy wind may also stir the shallow waters and lift sediment.

Sediment appears tan or mud-coloured where it floats close to the surface, as can be seen along the coastline. As sediment sinks, its reflectivity changes, and this causes it to appear green in true-colour MODIS images.

While most of the colour in the northeastern Caspian Sea is probably sediment, it's not possible to rule out the presence of phytoplankton with true-colour imagery. These microscopic plant-like organisms sometimes reproduce so explosively that they can tint the water in shades of green or blue.

Image Credit: MODIS Land Rapid Response Team, NASA GSFC



On June 17, 2021, Meteor M2 captured this image showing strong sunglint on the waters around Scotland and Ireland.

NASA's AIRS Tracks Record-Breaking Heat Wave in Pacific Northwest

JPL News

The AIRS instrument aboard NASA's Aqua satellite collected temperature readings in the atmosphere and at the surface during an unprecedented heat wave in the Pacific Northwest and western Canada that started around June 26. The science instrument mapped the dome of high pressure that settled over the northwestern U.S. and western Canada in late June, sending temperatures into the forties Celsius.

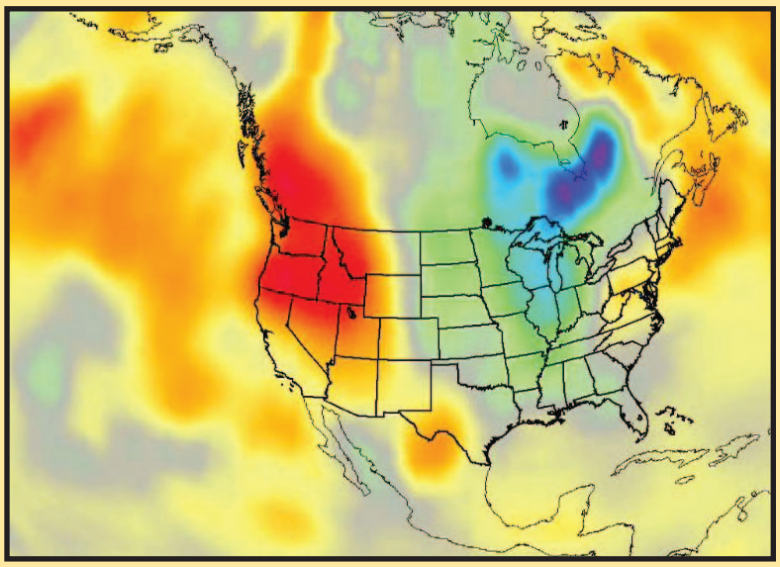
The unprecedented heat wave that started around June 26 smashed numerous all-time temperature records in the Pacific Northwest and western Canada. NASA's Atmospheric Infrared Sounder (AIRS), aboard the Aqua satellite, captured the progression of this slow-moving heat dome across the region from June 21 to 30. These images from the AIRS data show surface air temperature anomalies—values above (red/purple) or below (blue) long-term averages. Surface air temperature is what people feel directly when they are outside.

In many cases, the highs exceeded previous temperature records by several degrees or more. On June 28, Quillayute, Washington, set an all-time high temperature record of 43°C, shattering the old record of 37°C. Numerous weather stations broke records on consecutive days, showing the unprecedented nature of this extreme heat, which was also blamed for a number of fatalities. In British Columbia, the village of Lytton set a new all-time record for Canada at 48°C on June 29, only to break it the next day with a reading of 49°C.

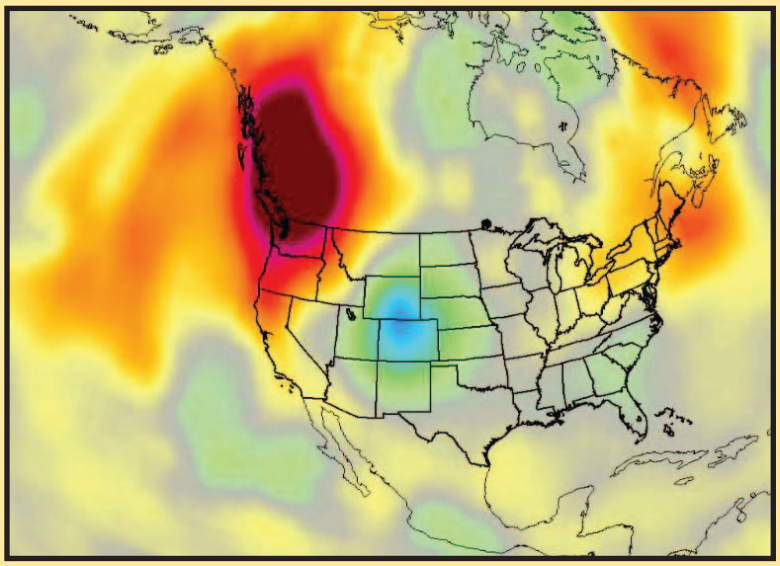
AIRS, in conjunction with the Advanced Microwave Sounding Unit (AMSU), senses emitted infrared and microwave radiation from Earth to provide a three-dimensional look at the planet's weather and climate. Working in tandem, the two instruments make simultaneous observations down to Earth's surface.

With more than 2,000 channels sensing different regions of the atmosphere, the system creates a global, three-dimensional map of atmospheric temperature and humidity, cloud amounts and heights, greenhouse gas concentrations and many other atmospheric phenomena.

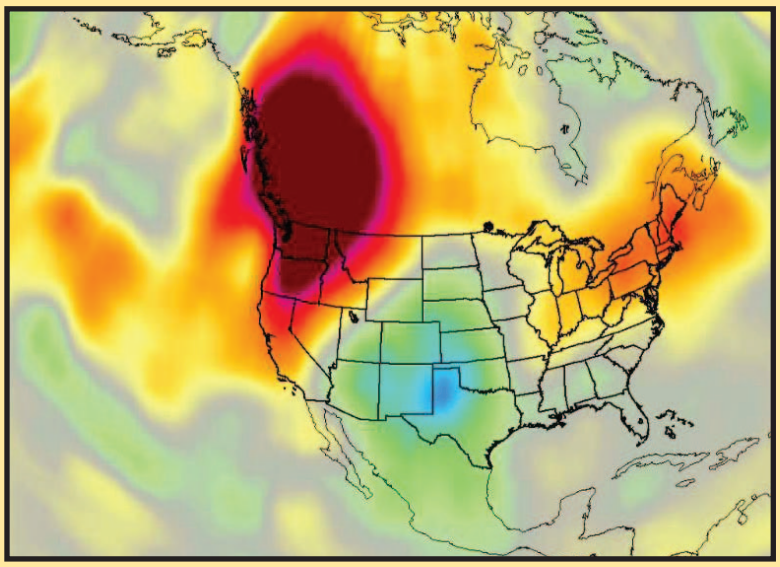
More information about AIRS can be found at: https://airs.jpl.nasa.gov/NASA Earth Observatory images by



AIRS image - June 21, 2021



AIRS image - June 26, 2021



AIRS image - June 30, 2021

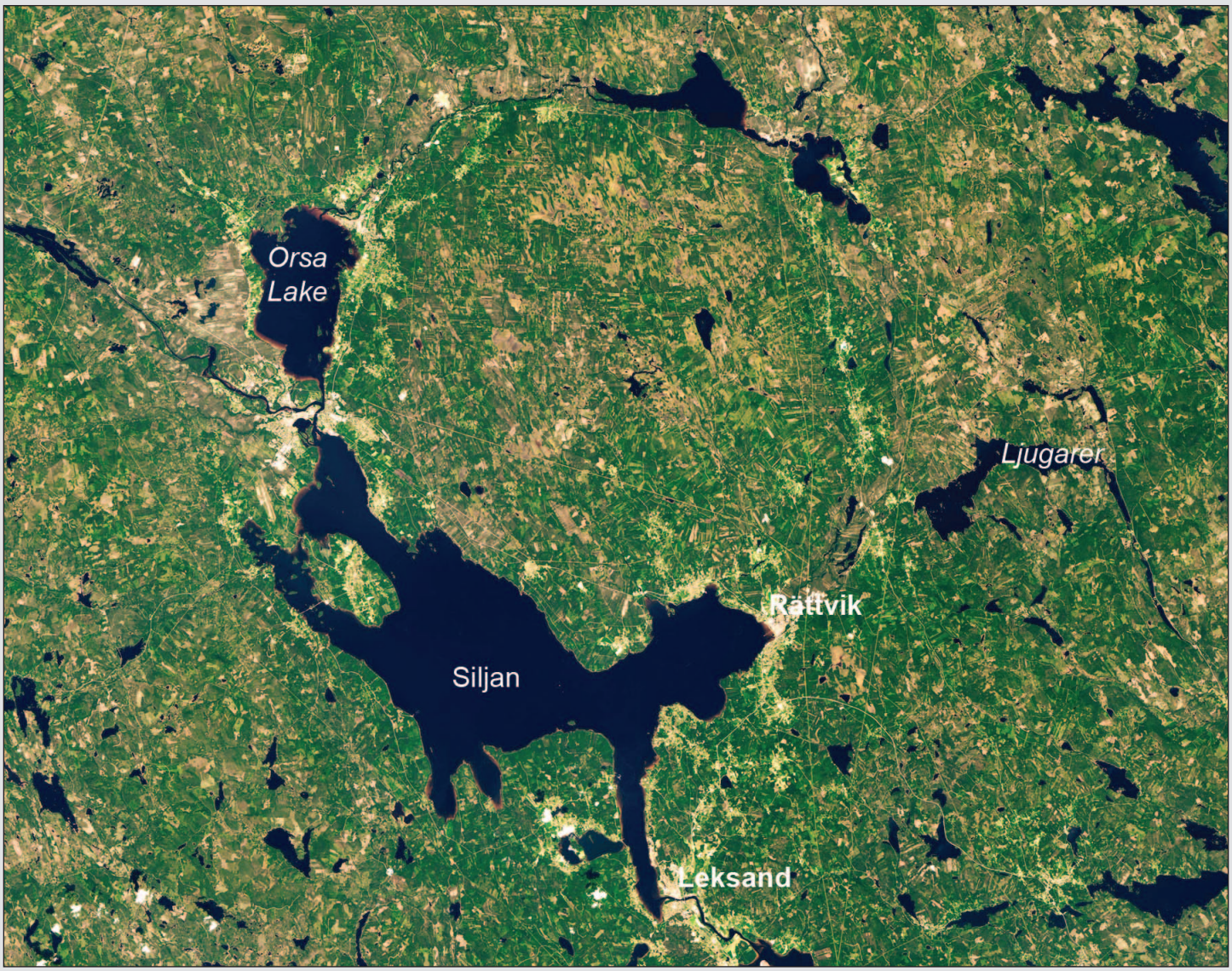
Images credit: NASA/JPL-Caltech

https://www.jpl.nasa.gov/images/heat-wave-surface-temperature

Sweden's Siljan Ring

NASA Earth Observatory

Story by Kathryn Hansen



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

Covered with lakes, forests, and mountains, Dalarna County has been called "Sweden in miniature." But the same region that today draws people to its idyllic lakeside villages and midsummer celebrations was also the site of an ancient, catastrophic impact.

Around 380 million years ago, in the Late Devonian period, an asteroid slammed into the land that is now south-central Sweden. The impact left quite a mark. Even after hundreds of millions of years of erosion, the scar is still recognizable. It is especially apparent when viewed from above.

The Siljan impact structure, or 'Siljan Ring', is visible in this image, acquired on June 24, 2020, with the Operational Land Imager (OLI) on Landsat 8. Measuring more than 50 kilometres across, Siljan is the largest-known impact structure in Europe and among the 20 largest on Earth.

Surveys of the structure have shown that the ground is slightly raised up across parts of the crater's centre. It is surrounded by a ring-like graben, or depression, which today is partially filled with water. Lake Siljan, on the crater's southwest side, is the largest lake; it connects to Lake Orsa via a small river.

People have lived near the crater for millennia without knowing its cosmic origin. In the late 1960s, scientists used drill cores to uncover the complex and ancient geology deep below the ground.

Research at Siljan is ongoing today. In a 2019 study, scientists described how they used drill cores to find that the deep, fractured rocks in the crater were suitable for ancient life. A subsequent paper in 2021 described the fossilized remains of fungi discovered at a depth of more than 500 metres.

Heatwave conditions over much of England were observed by the NOAA 20 satellite in this image acquired on July 17, 2021.
Many areas experienced temperatures in the 30s Celsius, eliciting warnings from the Met Office.

Frigid Weather in South Africa

MODIS Web Image of the Day

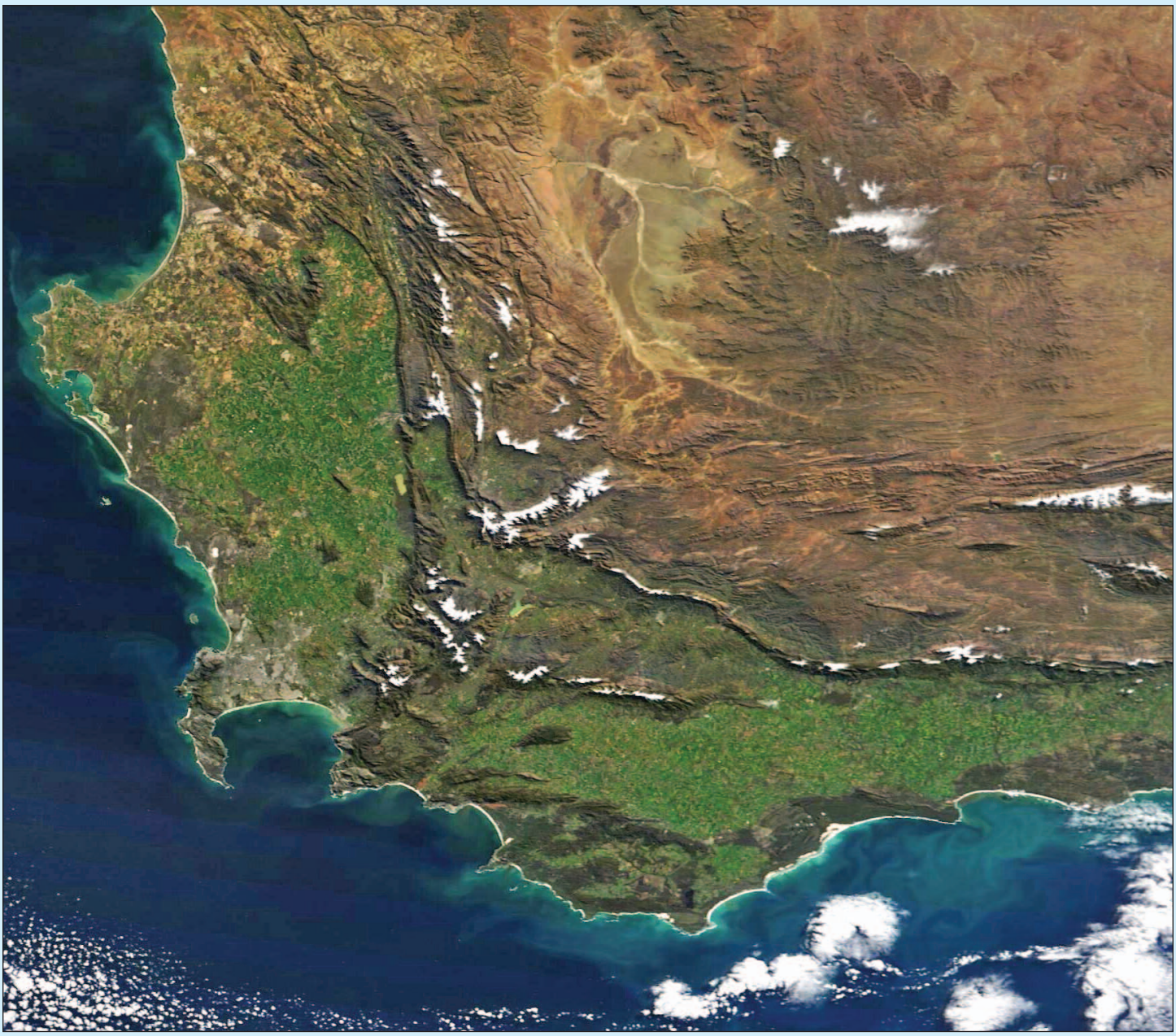


Image Credit: MODIS Land Rapid Response Team, NASA GSFC

South Africa shivered under frigid winter weather as snow—and minimum temperature records—fell across the country in late July 2021. According to the South African Weather Service (SAWS), a series of cold fronts sweeping across the country were responsible for the falling temperatures, gusting winds, and snow. The first cold front brought strong north-westerly winds and rain to the southwestern parts of South Africa on July 19, with precipitation in the form of snow along with bitterly cold temperatures inland.

A second, more intense cold front escorted even colder temperatures across much of the country beginning on July 21. On July 23, local media reported that nineteen records were smashed over the previous 24 hours, with several parts of South Africa recording their lowest minimum or maximum temperature in recorded history. On that day, temperatures in Kimberly (Northern Cape province) dropped to -9.9°C and Johannesburg (Gauteng province) saw -7°C. In the Eastern Cape, the town of Grahamstown reported a maximum temperature of only 6.8°C.

The Moderate Resolution Imaging Spectroradiometer (MODIS) aboard NASA's Terra satellite acquired this true-colour image of a sunny but frigid day in South Africa on July 23. Snow sits atop the higher elevations of most of the mountain ranges in the country and a broad swath of snow paints the Karoo region white, south of Sutherland, Northern Cape province.

A Summer of Fire-Breathing Smoke Storms

NASA Earth Observatory

Story by Adam Voiland

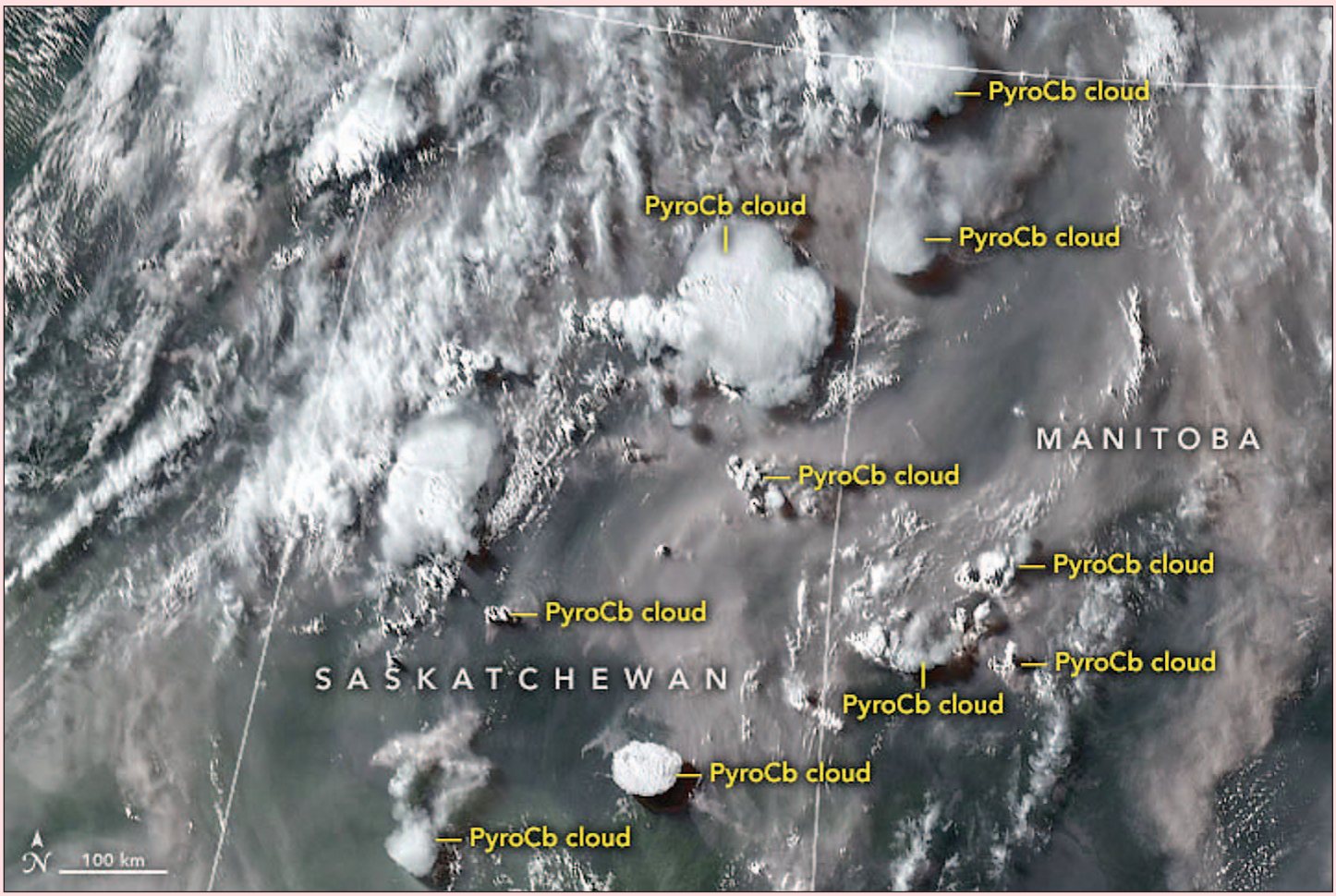


Figure 1 - This swarm of pyrocumulonimbus clouds along the Saskatchewan-Manitoba border on July 16, 2021. *Image: NASA*

In 2000, atmospheric scientists from the U.S. *Naval Research Laboratory* (NRL) first reported that smoke plumes from intense wildfires could spawn towering thunderstorms that channelled smoke as high or higher than the cruising altitude of jet aeroplanes. These pyrocumulonimbus (pyroCb), events wowed scientists at the time. Prior to that discovery, only explosive volcanic eruptions and extreme thunderstorms were thought to be capable of lofting material so high.

Though the workings of these smoke-infused storm clouds have come into clearer focus, their increasingly extreme behaviour in recent years has surprised and worried scientists who track them. The latest encounters with these fire-breathing smoke clouds came in North America in June and July 2021 during an unusually warm fire season that arrived early in Canadian and U.S. forests.

Michael Fromm and David Peterson of NRL and a team of colleagues from NASA and several other institutions have used the Advanced Baseline Imager (ABI) on the NOAA-NASA GOES weather satellites, as well as sensors on other satellites, to identify 61 pyroCbs in North America this year as of July 29, 2021, about the halfway point of the fire season.

Their observations included a remarkable outbreak of 10 pyroCbs along the Saskatchewan-Manitoba border on July 16. It was more of the wildfire smoke storms than scientists have ever observed in North America on a single day since they started tracking all of them with satellites in 2013. In the ABI image shown in figure 1, all of the marked clouds ended up generating PyroCbs, though some were still in the pyrocumulus (pyroCu) stage when the image was taken. Figure 2, overleaf, shows an example of a small pyroCb rising above the McKay Creek fire on June 30, 2021.

The July outbreak came two weeks after another unusual event—what Fromm called a 'monster pyroCb' that exploded on June 30 above the Sparks Lake fire in western Canada. A storm cell grew over a forest fire in British Columbia and spread across more than 160,000 square kilometres, an area slightly larger than the state of Georgia.

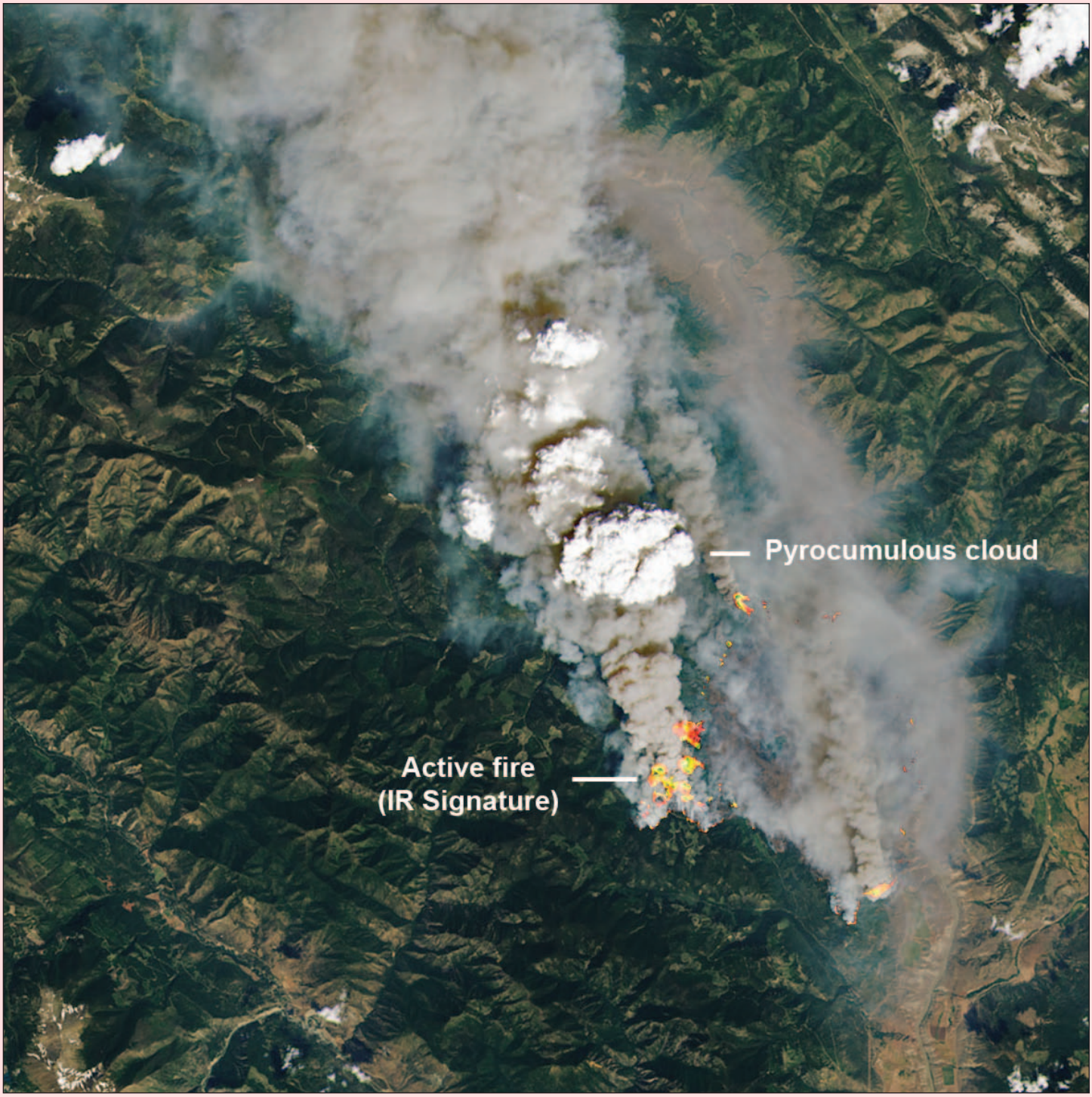


Figure 2 - A small pyroCb rising above the McKay Creek fire on June 30, 2021.
Image: NASA

As it spread out, it sent a chimney of smoke up to 16 kilometres, according to data collected by the Multi-angle Imaging SpectroRadiometer (MISR) on NASA's Terra satellite. Meanwhile, a GOES satellite observed the storm unleashing extraordinary bursts of lightning. After watching satellite clips of the storm blowing up and smoke spreading widely as updrafts hit the stratosphere, one meteorologist characterized the cloud's behaviour as 'absolutely mind blowing.'

Scientists say it was the largest single pyroCb cloud they have ever observed in North America. The *North American Lightning Detection Network* recorded nearly 113,000 cloud-to-ground lightning strokes during the event, a large amount for a storm in Canada. One meteorologist calculated that this single pyroCb event produced about five percent of Canada's total annual lightning all at once. Because smoke particles in pyroCbs limit the size of water droplets, the thunderstorms produce minimal rain. So the burst of lightning may have sparked new fires, accelerated their spread, and re-energised the meteorological engine that created it in the first place.

All of this played out during an unusually severe and odds-defying heatwave that pushed temperatures in British Columbia to record levels (figure 3). Those extreme temperatures would have been 'virtually impossible' without global warming, according to scientists from the *World Weather Attribution initiative*.

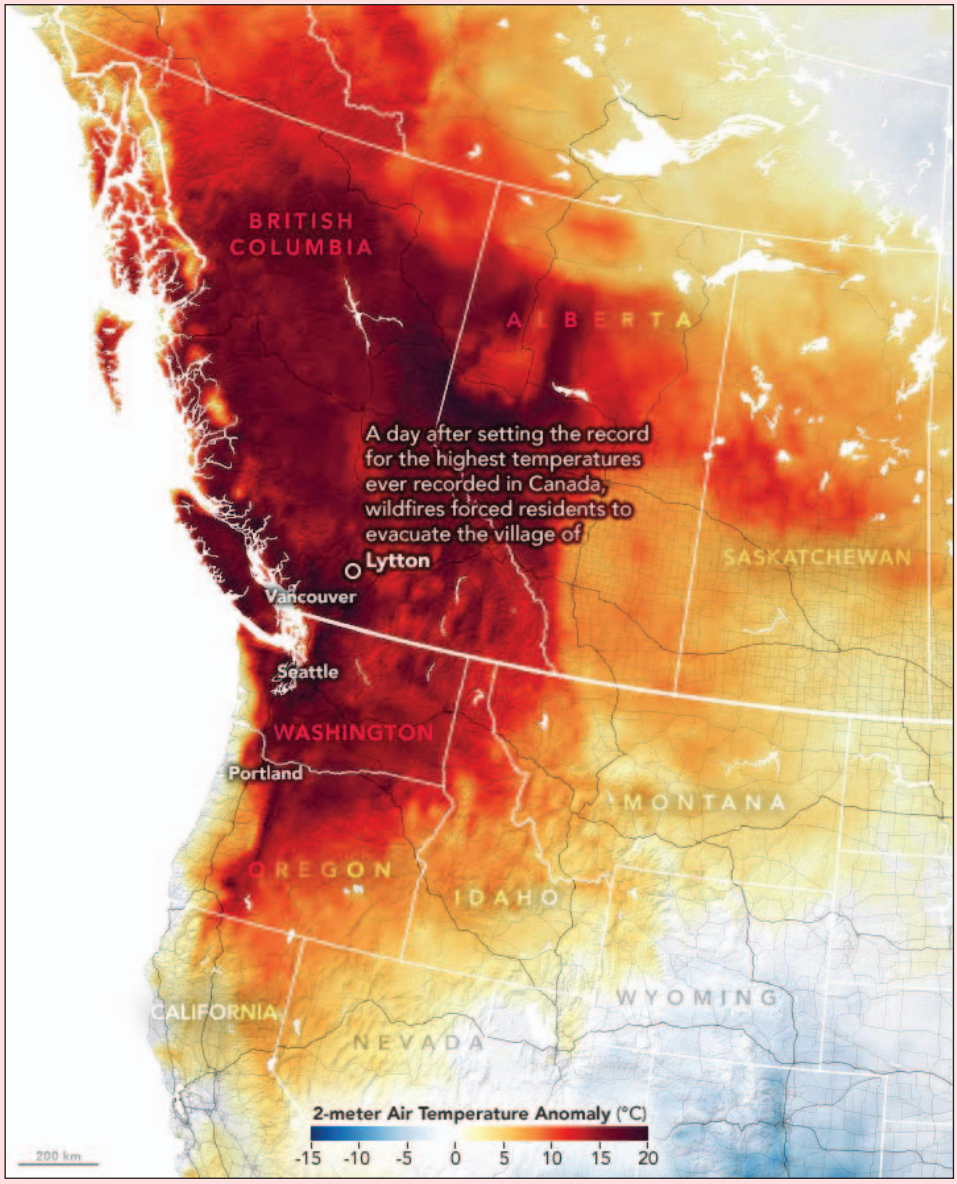


Figure 3 - The air temperature anomaly (heatwave) over British Columbia
Image: NASA

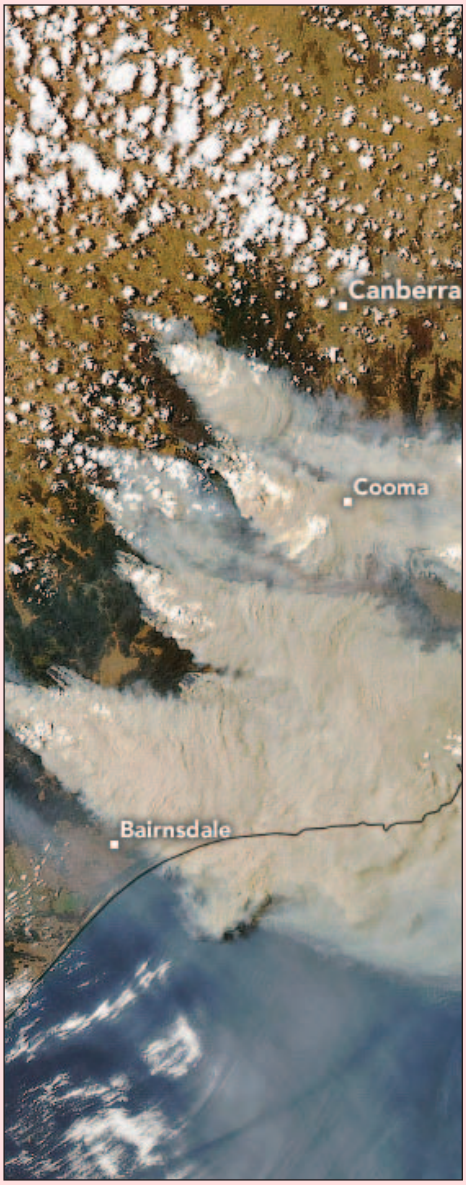


Figure 4 - Several pyroCbs are seen rising from smoke plumes above SE Australia in this MODIS image from January 4, 2020.
Image: NASA

"We're seeing pyroCbs occur almost nightly now, and we're only halfway through the fire season," said Peterson. "This could get much worse before it gets better."

With extreme fires and pyroCbs becoming more common, Fromm and Peterson find themselves asking what it all means. "We are running projects to make it easier to forecast where pyroCbs are going to pop up. The hope is that we can improve the systems that keep firefighters, pilots, and people as safe as possible," said Peterson. "But we're also watching how much smoke reaches the stratosphere and developing methods to quantify what it means for Earth's radiative balance and climate."

Based on past events—including a "super outbreak" in December 2019 and January 2020 when pyroCbs were even more numerous (figure 4)—scientists know that the smoke these events inject into the stratosphere can spread out and behave like a massive shade, leading to temporary regional cooling. The Moderate Resolution Imaging Spectroradiometer (MODIS) image above shows several pyroCbs rising from smoke plumes that were part of that outbreak.

With enough smoke in the stratosphere, the cooling effect could be sizable, perhaps even enough to cause global temperatures to decline, much like the eruption of ash from Mount Pinatubo famously did in the 1990s due to the volcanic particles that lingered in the atmosphere. The Australian fires delivered about 1/10th the mass of cooling aerosols into the stratosphere than Pinatubo did. "If pyrocbs become more frequent, the climate impacts could really start to add up," said Fromm. "It's something we will be watching closely."

NASA Earth Observatory images by Joshua Stevens and Lauren Dauphin, using MODIS and GOES data from NASA EOSDIS LANCE and GIBS/Worldview, Landsat data from the U.S. Geological Survey, and GEOS-5 data from the Global Modelling and Assimilation Office at NASA GSFC.

Malé, the Maldives

European Space Agency

Sentinel 2 image contains modified Copernicus Sentinel data (2019), processed by ESA, CC BY-SA 3.0 IGO

The Republic of Maldives consist of a chain of around 1200 small coral islands that are grouped into clusters of atolls scattered across 90 000 square kilometres of ocean. A number of these little islands can be seen in the image, with the turquoise colours depicting clear, shallow waters dotted by coral reefs which contrasts with the dark colours of the Indian Ocean.

Malé, located at the southern edge of the North Malé Atoll, can be easily spotted in the right of the image. The island is small enough to walk around in approximately one hour, with most sights concentrated on its northern shore. Malé is both a trade and tourist centre, connected with Sri Lanka and India by steamship lines, with several vessels visible in the image.

With a population of more than 200 000 and an area of around eight square kilometre, Malé is one of the most densely populated cities in the world, with the city covering almost the entire island.

Aerial view of the Malé viewed from the west
Image: Shahee Ilyas / Wikimedia Commons

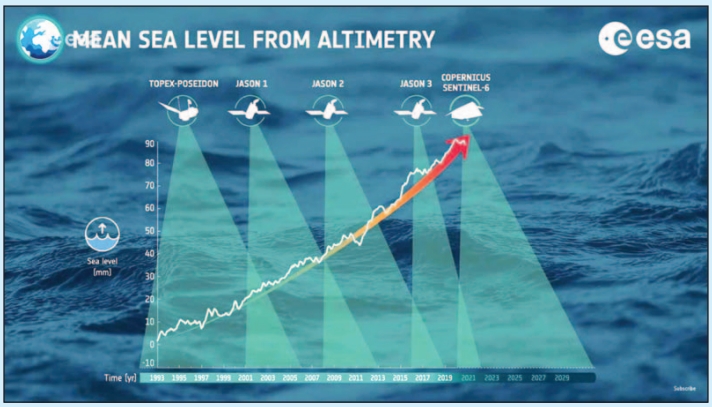
With more than 80% of the Maldives' land standing less than one metre above average sea level, the Maldives has the lowest terrain of any country in the world. This makes the archipelago particularly vulnerable to sea-level rise.

In response to this rising threat, the Maldives is working on enhancing the resilience of the country's islands, which includes constructing the artificial island of Hulhumalé—visible northeast of the airport island of Hulhulé.

Hulhulé lies immediately northeast of Malé and is connected to the latter by the 2.1 kilometre long Sinamalé Bridge. This bridge, which carries two car lanes and separate lanes for motorcycles and pedestrians, opened on August 20, 2018.

The island has been constructed by pumping sand from the sea floor onto a submerged coral platform, that rises around two metres above sea level. The reclaimed land provides some much-needed space, and will also help meet the industrial and commercial development of the Malé region.

Satellite data have shown that the global ocean has risen, on average, three millimetres a year over the last 25 years. Warming ocean waters, melting glaciers and diminishing ice sheets are making rising sea levels a real threat for low-lying islands such as the Maldives.



This graph illustrates the three millimetre annual increase in sea level rise at the Maldive Islands between 1993 and 2021.
Image: ESA

Following liftoff in November 2020, the Copernicus *Sentinel-6 Michael Freilich* satellite, the most advanced mission dedicated to measuring sea-level rise, is now fully operational, meaning that its data are available to climate researchers, ocean-weather forecasts and other data users. Learn more about the Sentinel-6 mission, click the URL at the foot of this page.

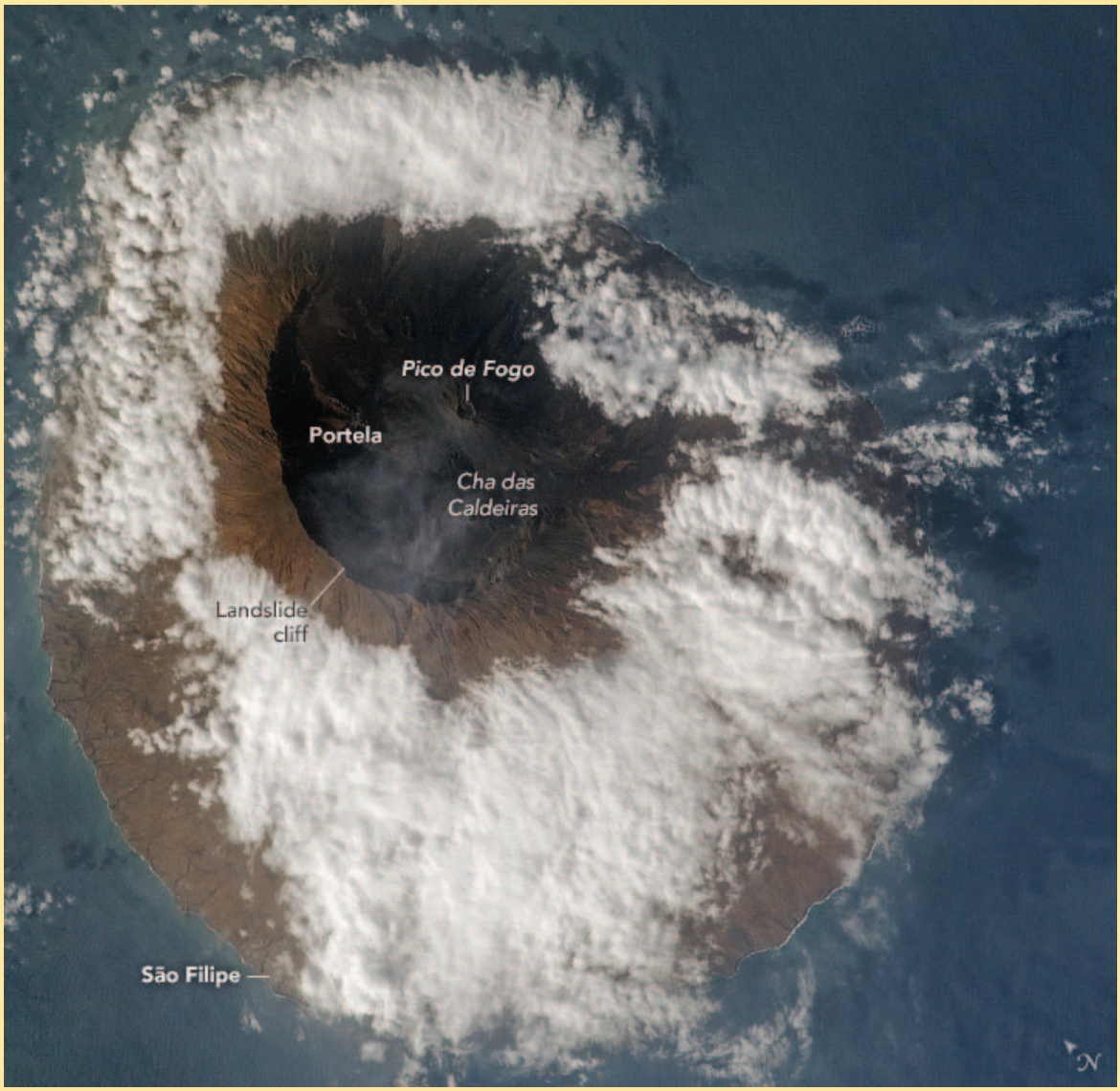
This image was captured by the Copernicus Sentinel-2 mission – a two-satellite mission to supply the coverage and data delivery needed for Europe's Copernicus programme.

https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Sentinel-6/New_sea-level_monitoring_satellite_goes_live

Fire Island, Cabo Verde

NASA Earth Observatory

Amber Turner, Jacobs, and Justin Wilkinson, Texas State University, JETS Contract at NASA-JSC



The Cabo Verde island of Fogo

Astronaut photograph ISS063-E-54142 was acquired on July 23, 2020, with a Nikon D5 digital camera using a focal length of 400 millimetres. It is provided by the ISS Crew Earth Observations Facility and the Earth Science and Remote Sensing Unit, Johnson Space Center.

This photo captures an astronaut's view of Fogo, an island 600 kilometres off the coast of West Africa. The name Fogo translates from Portuguese to English as 'fire'. The name epitomises the volatile nature of the Cabo Verde (Cape Verde) volcanic islands.

Pico de Fogo is the highest peak in Cabo Verde, towering 2829 metres above sea level. It is also the highest peak in West Africa. Pico de Fogo is the active cone at the summit of the Fogo stratovolcano that forms the island. As seen from the International Space Station, the semicircle of surrounding cliffs marks the edge of the Cha das Caldeiras summit caldera. Research by geologists shows that the entire east side of Fogo volcano slid into the sea in a process known as lateral collapse. That event, now known as the Monte Amarelo landslide, formed the caldera approximately 80,000 years ago.

Scientists using subsea backscatter sonar techniques have been able to identify the landslide rubble on the sea floor offshore of the east side of the island. So much material slid off the volcano flank that the debris field covers an area larger than the area of Fogo Island itself. Landslides are common on active volcanic islands—such as Fogo and the Hawaiian islands—as the repeated burial of unconsolidated rock debris by subsequent eruptions can create fault zones. Acidic solutions can also form from volcanic gases, and these can alter rock-forming minerals into clay minerals, leading to weaker rock masses.

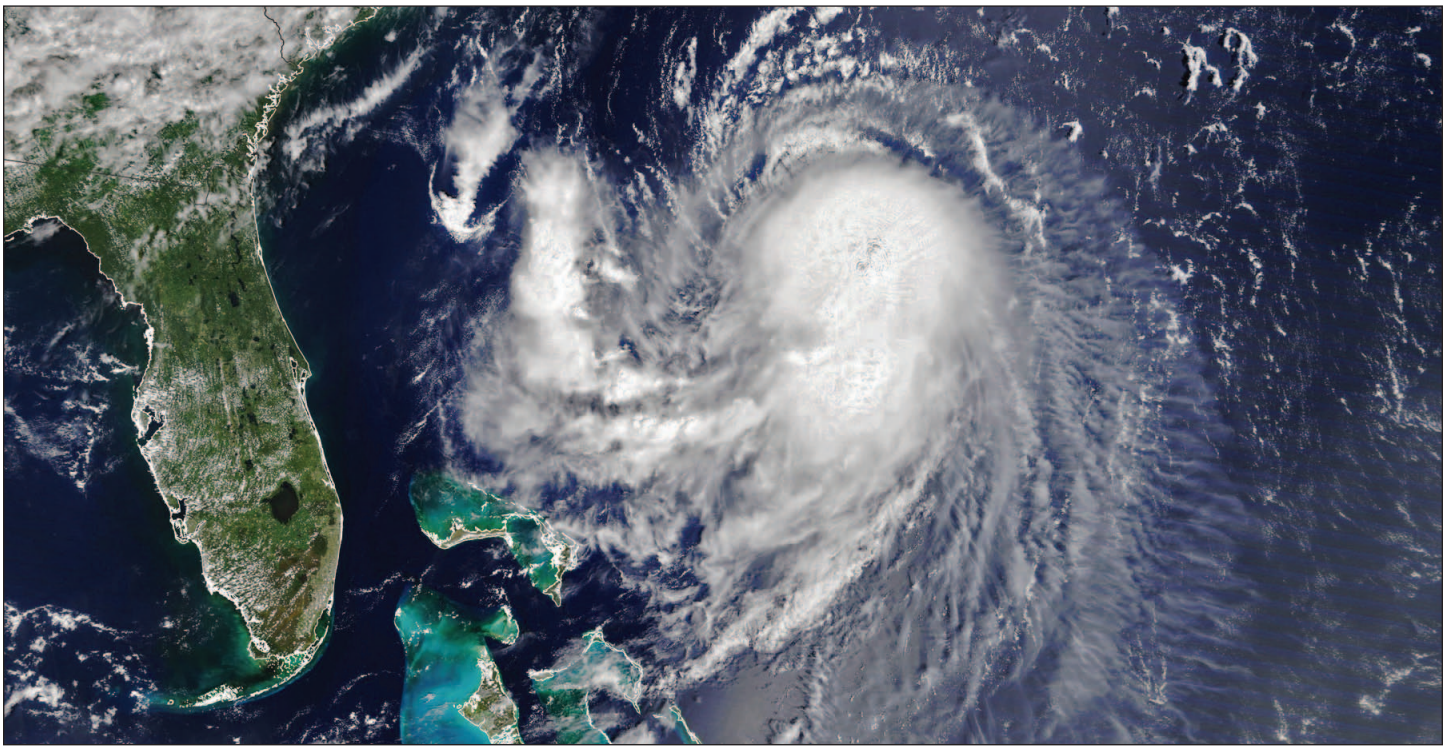
Sentinel 2C

Les Hamilton

Sentinel-2A, the first member of ESA's Copernicus Earth observation satellite constellation (along with Sentinel 2B) pased its sixth anniversery in orbit on June 23, 2021. With a design lifetime of just seven years, ESA engineers are already preparing its successor, Sentinel-2C. With a likely launch early in 2024, this one tonne satellite recently commenced a five month testing programme to determine its fitness for the rigours of space. When the time comes to take Sentinel-2A out of service, Sentinel-2C will replace it, as will Sentinel-2D eventually take over from Sentinel-2B.

Like its forebears, Sentinel-2C will carry a high-resolution multispectral imager supporting 13 bands in the visible, near infrared, and short wave infrared regions of the spectrum. With a 290 kilometre swath width and frequent revisit times, Sentinel-2C will provide unprecedented imagery of Earth to provide information, mainly for agricultural practices and for tackling the global issue of food security. In addition, the satellite's imagery will also be important in monitoring ice sheets and glaciers, coastal erosion and deforestation.

Right: Sentinel-2C being readied for testing
Image: ESA



Heavy winds, rain, and storm surge threatened the U.S. Northeast as Tropical Storm Henri approached. This natural colour image acquired by the MODIS instrument aboard NASA's Terra satellite at 15.45 UT on August 20, 2021 shows Henri about 640 kilometres southeast of Charleston, South Carolina. Sustained winds at the time measured 100 kilometres per hour, just 15 kph below the threshold for a Category-1 hurricane.

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

Henri Soaks the Northeast

NASA Earth Observatory

Story by Michael Carlowicz

Henri did not reach the northeast U.S. coast at hurricane force, but the slow-moving storm still left a soggy mark on the region as it became a rare tropical cyclone to make landfall in New England (see image on previous page). Months of rain fell in a few hours across New Jersey, New York, and several other states between August 21-23, 2021, landing on soils that were already soaked by an excessively wet summer.

Tropical Storm Henri made landfall near Westerly, Rhode Island, on August 22, with sustained winds of 95 kilometres per hour and gusts to 10 kph. In anticipation of the storm, the cities of Providence, Rhode Island, and New Bedford, Massachusetts, raised storm surge barriers in their ports for the first time since Hurricane Sandy in 2012 [1] . But the storm surge never became as severe as feared.

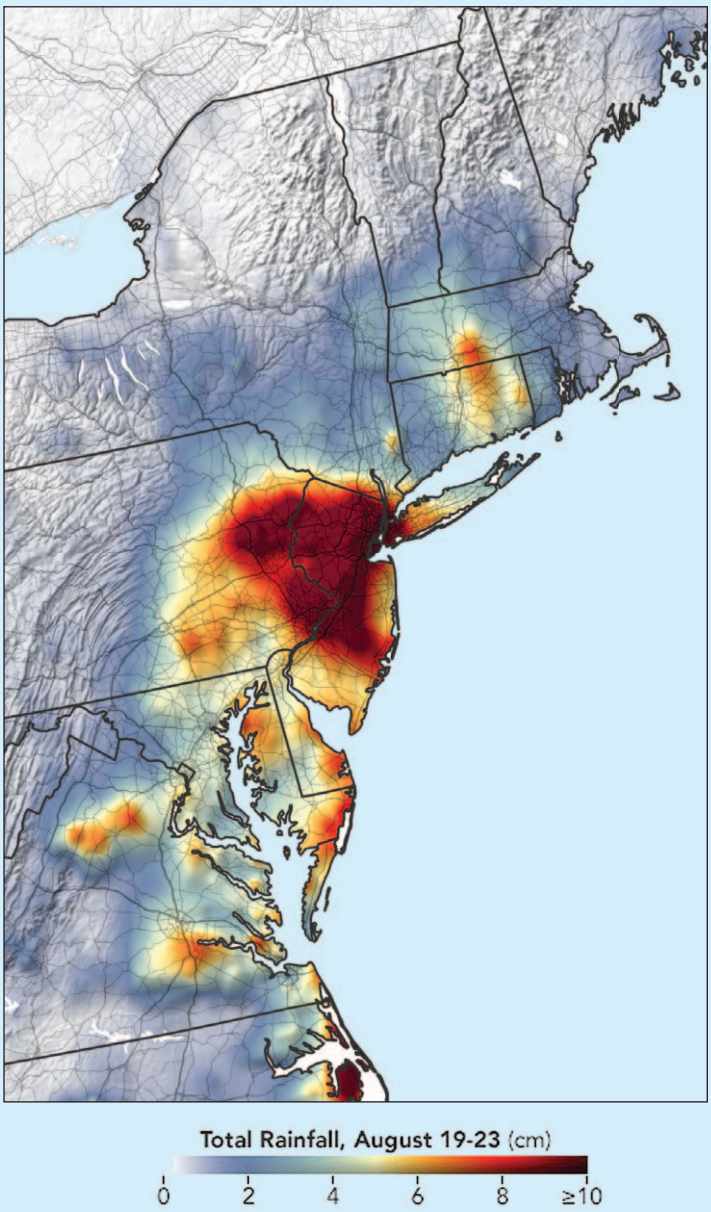
Rainfall was a different story. Widespread accumulations of 10 to 23 centimeters were recorded in New York, New Jersey, Pennsylvania, and Connecticut. Much of that rainfall fell to the western side of the storm, whereas the eastern and northern sides saw more moderate rainfall.

A broad satellite estimate of rain distribution is captured in the map, which shows data from August 19–23. The data are remotely-sensed estimates that come from the Integrated Multi-Satellite Retrievals for GPM (IMERG), a product of the *Global Precipitation Measurement* (GPM) satellite mission. Local rainfall amounts can be significantly higher when measured from the ground.

Henri meandered across the Atlantic toward New England for several days and thereafter moved slowly after landfall. Some meteorologists pointed to a blocking ridge of high pressure over the North Atlantic that kept the storm from moving east and northeast as it usually would. While still well offshore, Henri became connected to other weather systems along the East Coast that pulled in moisture from the outer edges of the storm to provoke downpours.

The soaking started half a day before Henri made landfall. Gauges in New York City's Central Park recorded 4.92 cm of rainfall between 10 and 11 p.m. on August 21, and a total of 20.8 cm by the time the storm had passed on August 23. Another 25.3 cm fell in Brooklyn. In New Jersey, the town of Cranbury was soaked with 22.6 cm, while Oakland caught 23.4 cm. Ardmore, Pennsylvania, recorded 10.8 cm, while New London, Connecticut—just west of the landfall—received 9.4 cm.

"Henri's slow westward-then-eastward loop across southern New England over a period of more than 24 hours while still classified as a tropical cyclone was extremely unusual if not unprecedented," wrote meteorologist Bob Henson in a blog post. "Nearly all tropical depressions, tropical storms, or hurricanes in the region move more rapidly north or northeast, hauled toward the Atlantic by strong upper-level winds more typical at that latitude than the exceptionally weak steering currents present on Monday."



Total Rainfall - August 19 - 23, 2021

NASA Earth Observatory image by Joshua Stevens, using IMERG data from the Global Precipitation Mission (GPM) at NASA/GSFC.

The soaking rain from Henri fell on a region that was already enduring one of its top three wettest summers on record. According to the National Weather Service, more than 58 cm of rain had fallen on New York City since June 1. Typically, the entire perior of June through August brings just 30 cm of rainfall.

Reference

Super Storm Sandy Savages States
GEO Quarterly No 36, page 42 (2012)

Smoke billows from fires in Turkey

European Space Agency

Captured by the Copernicus Sentinel-3 mission on July 30, 2021, this image shows smoke billowing from several fires which had been burning for several days along the southern coast of Turkey.

Over the weekend, tourists and local residents had to be evacuated from Bodrum and Marmaris, with some fleeing by boat as the flames crept closer to the shoreline. At the time, southeast Europe was experiencing extremely high temperatures. Greece was reported to be expecting an all-time European record of 47°C. The heatwave, the result of a heat dome, has seen temperatures reach above 40°C in many areas, and meteorologists expect the weather to continue for some time, making it the most severe heatwave since the 1980s.

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

California's Dixie Fire Keeps on Growing

NASA Earth Observatory

Story by Kathryn Hansen.

The Dixie fire in Northern California has surpassed the Bootleg fire in Oregon to become the largest fire so far this year in the United States. As of August 6, 2021, the Dixie fire had charred more than 1,750 square kilometres).

On August 4, 2021, an astronaut on the International Space Station shot a photo of the Dixie fire's thick smoke plume (figure 1). Figure 2, also acquired on August 4, shows the fire as observed by the Enhanced Thematic Mapper Plus (ETM+) on Landsat 7. It combines natural-colour with shortwave-infrared light to cut through some of the smoke and highlight the active fire fronts. In this view, the hottest and most active parts of the fire are orange-yellow.

Figure 1 - Photograph of the Dixie Smoke Plume from the ISS.
Astronaut photograph ISS065-E-220417 was acquired on August 4, 2021 and is provided by the ISS Crew Earth Observations Facility and the Earth Science and Remote Sensing Unit, Johnson Space Center.

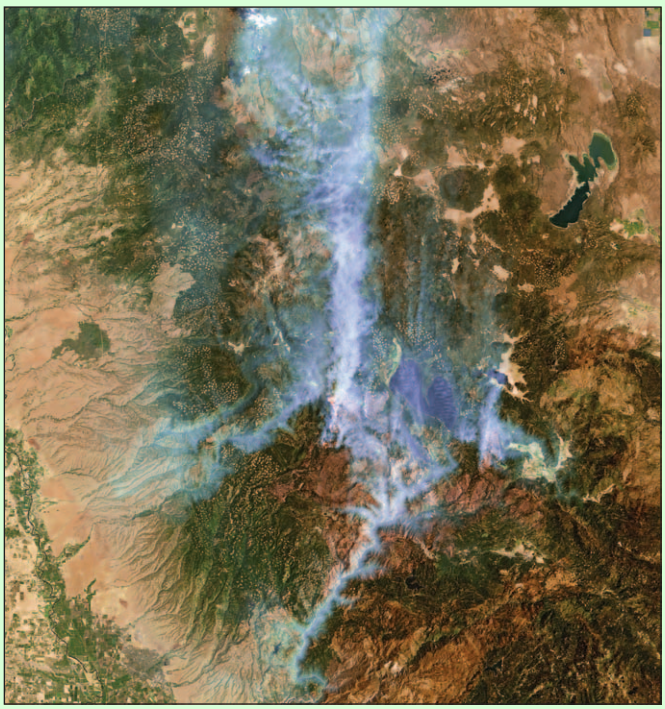


Figure 2 - The Dixie Fire viewed from Landsat 7
NASA Earth Observatory image by Joshua Stevens, using Landsat data from the U.S. Geological Survey.

With wind gusts as high as 65 kilometres per hour that day, the fire quickly advanced across the dry mountain vegetation. It burned through the historic Gold Rush era town of Greenville.

Notice that while most of the smoke is being carried toward the north, some smoke hangs in the valleys and canyons south of the active fire areas. Smoke, which can sink toward the ground during a temperature inversion, is especially apparent in the Feather River Canyon. Wind blowing down the canyon carried some of the smoke toward the Sacramento Valley.

The enormous blanket of smoke from the Dixie fire and dozens of others burning across the western U.S. is visible in figure 3, acquired on August 6, 2021, by the GOES-17 satellite. GOES-17 is operated by the National Oceanic and Atmospheric Administration (NOAA); NASA helps develop and launch the GOES series of satellites.

Overnight (August 5 to August 6) the Dixie fire grew by about 280 square kilometres to become the third-largest fire on record in California. It is still less than half the size of the August Complex, which burned more than 1 million acres in 2020.

NASA Earth Observatory images by Joshua Stevens, using Landsat data from the U.S. Geological Survey and GOES 17 imagery courtesy of NOAA and the National Environmental Satellite, Data, and Information Service.

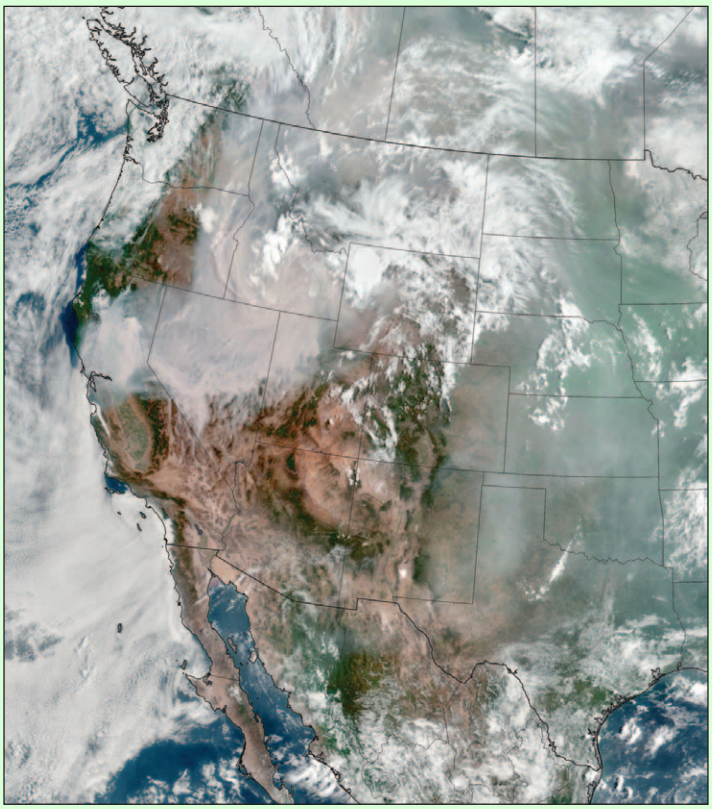


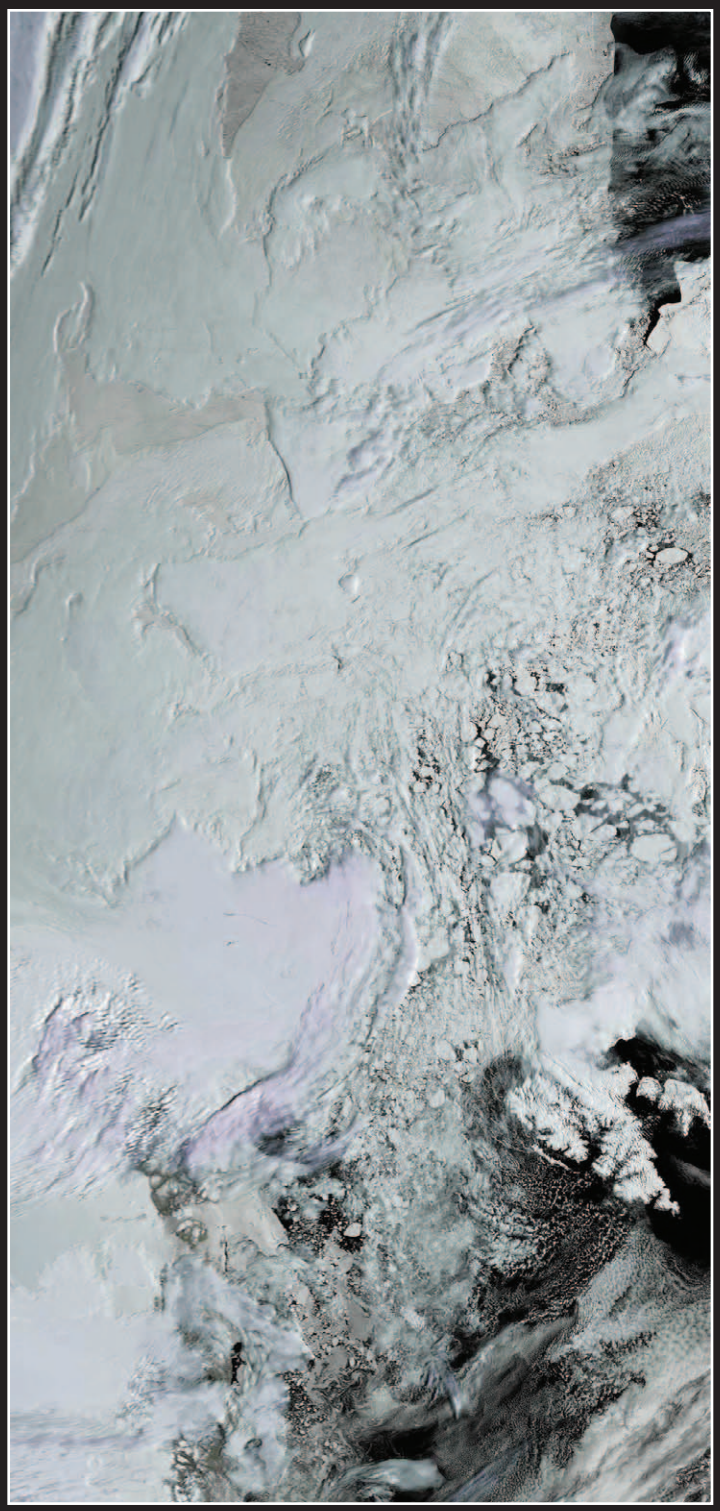
Figure 3 - The Dixie Fire viewed from GOES-17
NASA Earth Observatory image by Joshua Stevens, using GOES 17 imagery courtesy of NOAA and the National Environmental Satellite, Data, and Information Service (NESDIS).

Annular Solar Eclipse, June 20, 2021

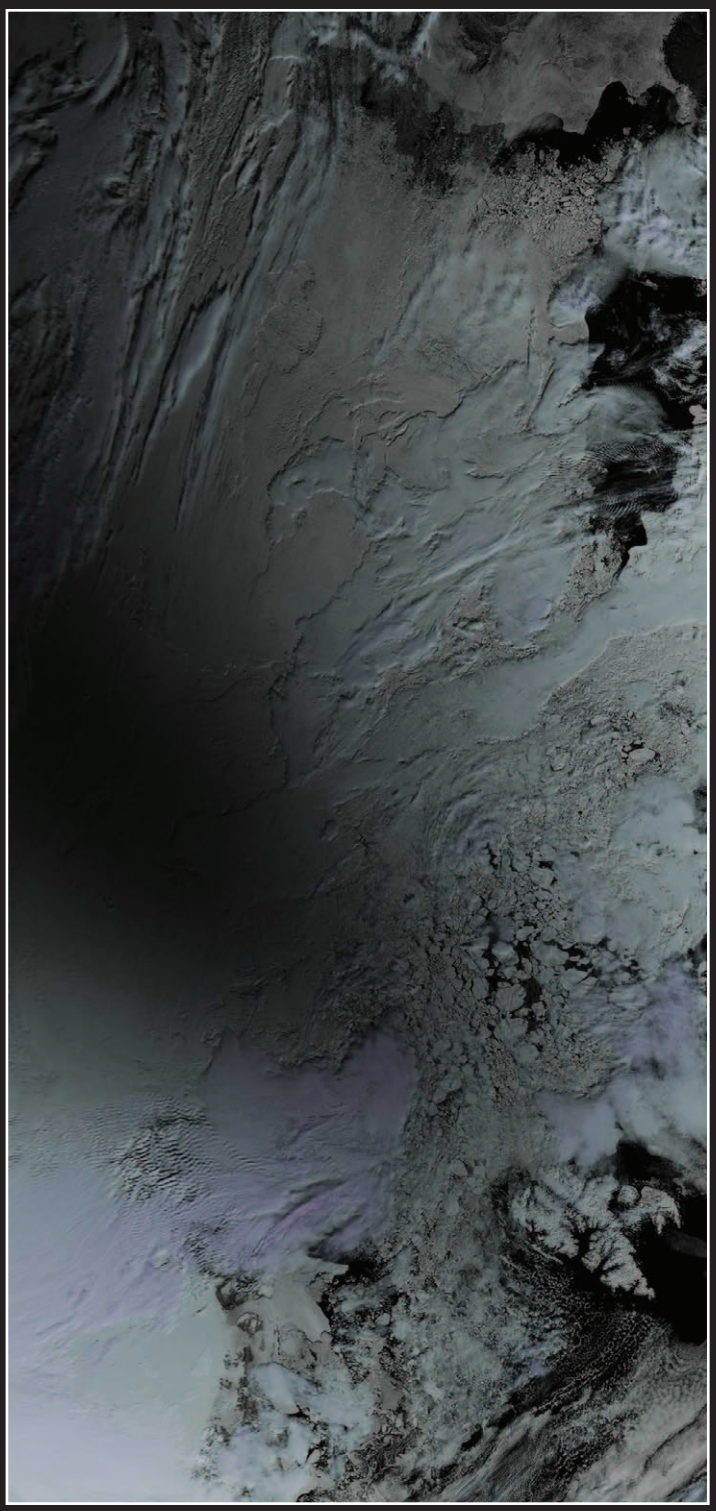
John Tellick

On June 20 this year, an annular eclipse of the sun took place over western Russia, Greenland, and northern Canada. Those of us at lower latutudes in Asia, Europe and the United States saw a partial solar eclipse—as seen in the above photo from SW London.

Although this eclipse was nowhere total, the contrast between solar illumination over the Arctic before (left) and during the eclipse (right) is clear from the two satellite images below.



This NOAA 19 image was acquired at 08:10 UT on June 10, 2021, and shows the Arctic ocean northwest of Svalbard under full solar illumination.



This Metop-C image was acquired at 10:52 UT on June 10, 2021, and shows much reduced illumination over the Arctic ocean northwest of Svalbard.

Add High Resolution Country Outlines to MeteorGIS images

Les Hamilton

One of the most popular features of the MeteorGIS software system is the ability to add country outline overlays to Meteor satellite images, particularly to clarify the scene when cloud prevails. The *Shape File* provided with the MeteorGIS installation package creates outlines at 50-metre resolution, which is generally satisfactory when viewing entire images.

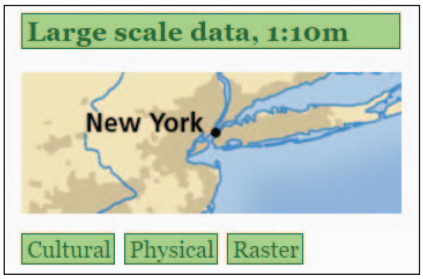
But when you zoom into a region with an intricately detailed coastline—like the sea lochs and islands of Scotland's west coast—the 50-metre *Shape File* gives a very poor representation of reality. To obtain fine detail you must use *Shape Files* offering 10-metre resolution.

Download 10-metre Shape Files

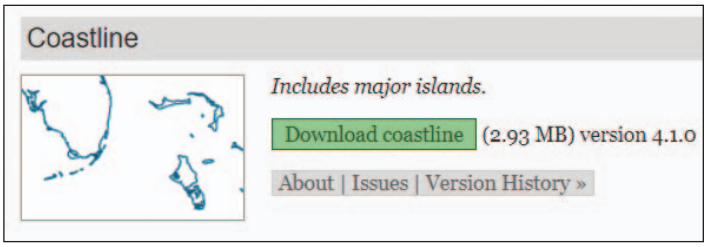
To obtain these *Shape Files*, visit

https://www.naturalearthdata.com/downloads/

then locate the panel headed '**Large scale data, 1:10m**' and click the green button labelled '**Physical**'.



This opens another screen where you will find the panel shown below with a green 'Download coastlines' button.



This downloads the file **ne_10m_coastline.zip**. Unpacking this file produces a set of six Shape Files. You only require three of these, namely:

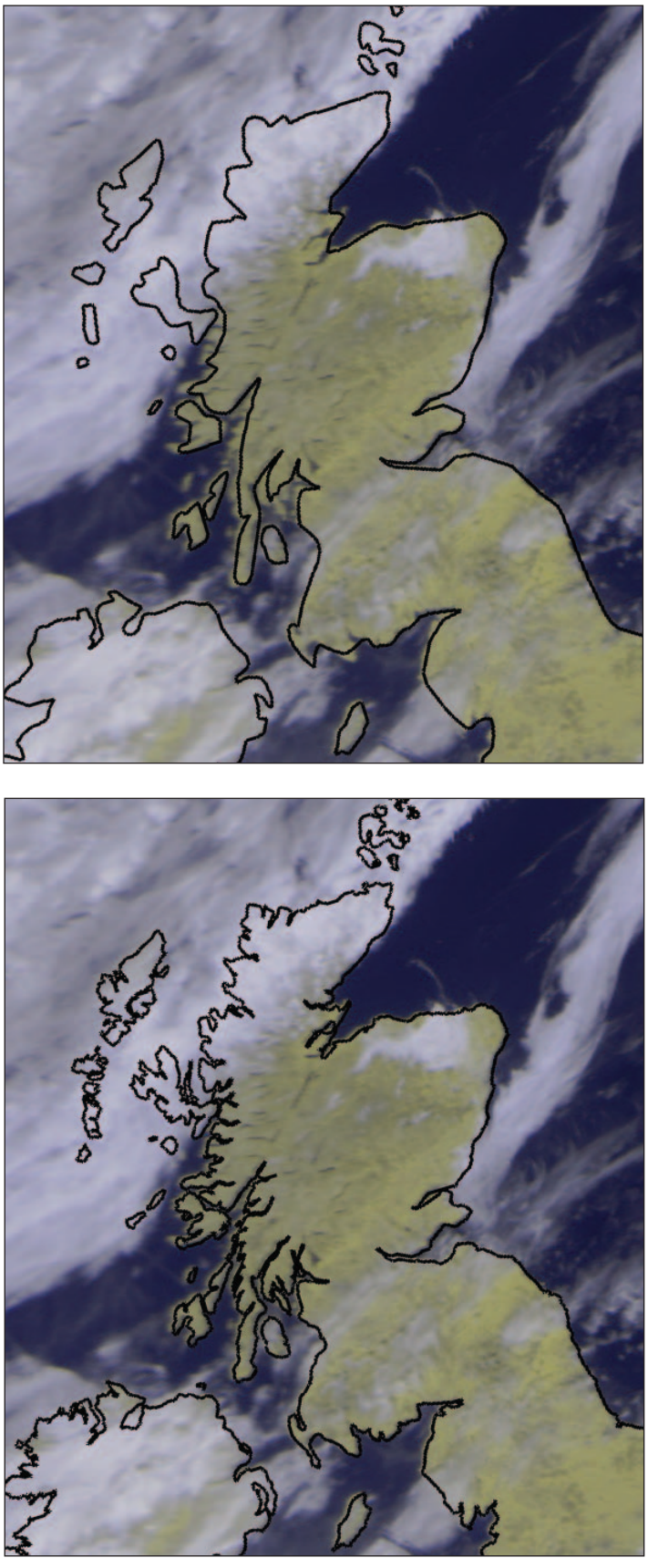
ne_10m_coastline.dbf
ne_10m_coastline.shp
ne_10m_coastline.shx

Copy these three files into your MeteorGIS folder and discard the other three.

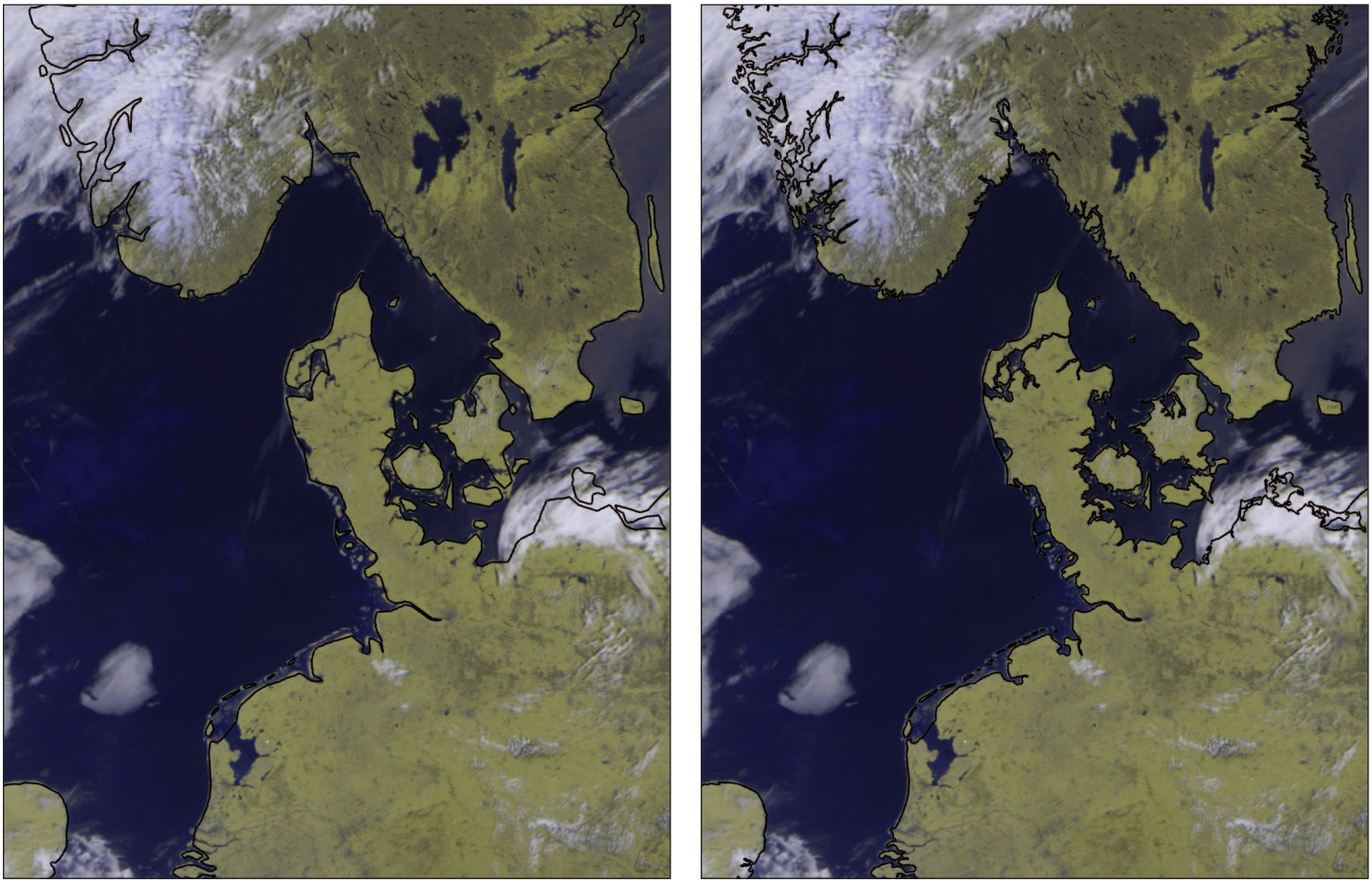
Modify the default.ini in the MeteorGIS folder

To bring these 10-metre country outlines into use you must edit the **default.ini** file in the MeteorGIS folder. This option is not available using the *MeteorGIS_Configurator utility*: it

continued on page 26



Country outlines applied to a Meteor M2 image acquired on June 12, 2015: 50 metre (above) and 10 metre (below).



Country outlines comparison over the Norwegian fjords in a Meteor M2 image acquired on June 12, 2015.
The image at left has the 50-metre overlay applied, that on the right uses the more detailed 10 metre overlay.

has to be done with a text processor such as *Wordpad* or *Notepad*.

Load **default.ini** into *Notepad* and scroll well down to the section headed '[Shapes] ' as illustrated below:

```
[Shapes]
shapesNumber=1
[Shape0]
filename=ne_50m_coastline.shp
color=000000
thickness=3
```

All that is required is to edit the '50' to '10', as shown below, then save the edited version of the ini file.

```
[Shapes]
shapesNumber=1
[Shape0]
filename=ne_10m_coastline.shp
color=000000
thickness=3
```

Job done! Next time you run MeteorGIS, provided you have 'Shapes' active (by setting *ShapesNumber* in *MeteorGIS_Configurator's* Shapes tab to a value greater than zero), you will see the 10-metre country outline overlay on your image. Note, there is no need to delete the 50-metre files. You can always use them again by reversing the edit above.

Controlling the overlay using a New ini File

It is, of course a matter of user preference whether country outlines are added to Meteor images or not. My personal preference is not to add outlines when the satellite detail is clear to view. However, where my region of interest is totally obscured by cloud, I like to be able to quickly add country outlines in order to judge the local weather situation.

> To save the bother of editing my default ini file time and time again, I made a copy of it, with the 10-metre overlay option active, **renamed it coastlines.ini,** and saved it in the MeteorGIS folder.

Once a Meteor M2 transmission has been processed by MeteorGIS, a batch file containing the code in the grey box at the foot of this page can reprocess the raw images saved in the Meteor_M2 subfolder, and add the overlay.

Using *Notepad*, create a text file containing this line of code, and name it **coastlines.bat** (be sure to include the space before each '/' character) and save it in the MeteorGIS folder. To reprocess your Meteor data, double click this **coastlines.bat** file and MeteorGIS.exe will spring into action and reprocess its data..

Important Note

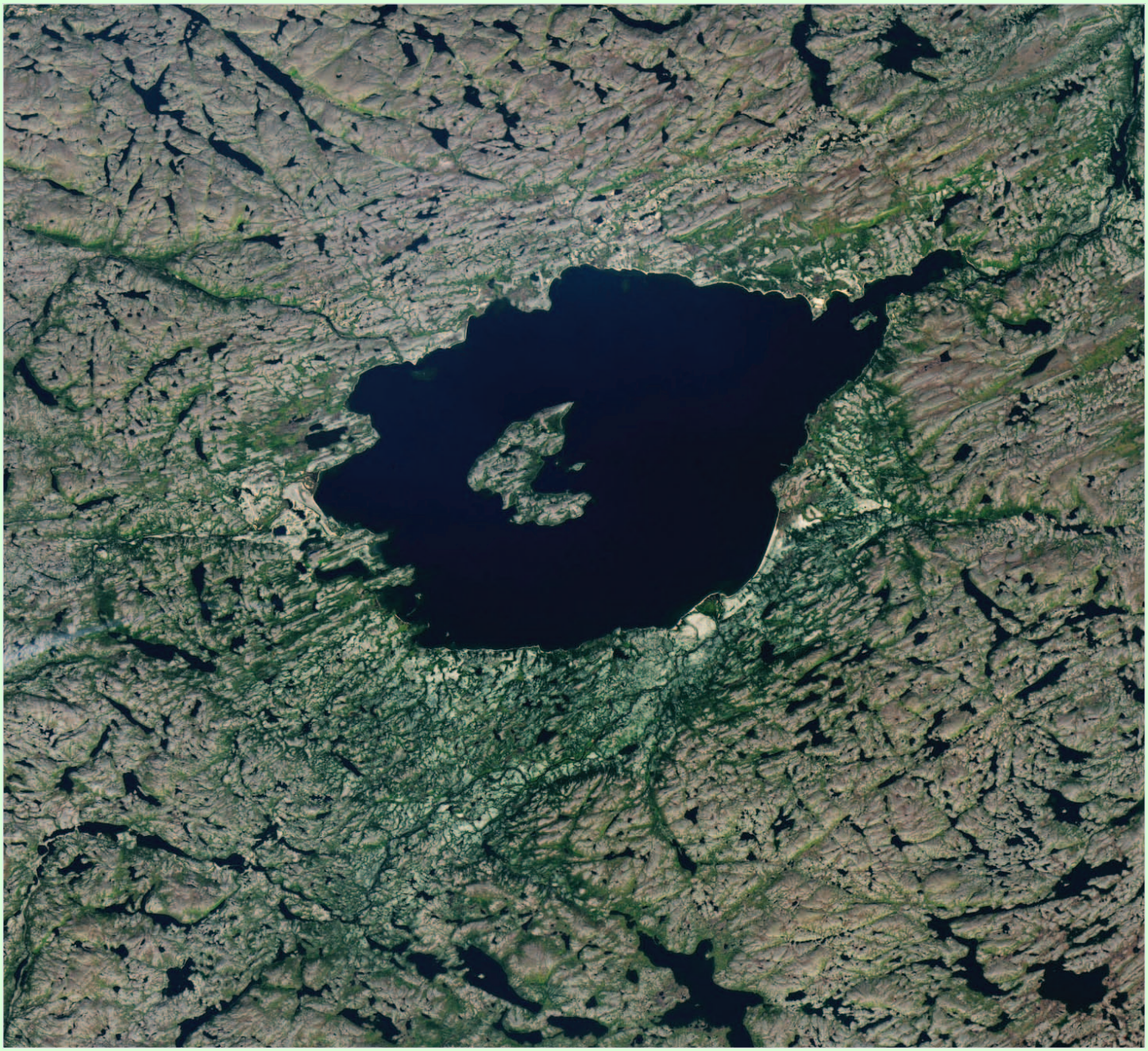
Because MeteorGIS **never** overwrites its files, make sure that t**he FinalImages folder is emptied** before running the batch file. Otherwise no new files will be saved.

```
MeteorGIS.exe /nolive /composeauto /sat:M2 /config:coastlines.ini
```

Violent Formation for Mistastin Lake

NASA Earth Observatory

Story by Adam Voiland



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

Skies were clear and the waters of Mistastin Lake were placid when the Operational Land Imager (OLI) on Landsat 8 captured this natural-colour image of Labrador, Canada, on an autumn day in 2017.

The scene would have looked quite different about 36 million years ago when an asteroid smashed into Earth and left an impact crater where the lake (called Kamestastin by the Innu people) now sits. While erosion has changed and obscured some of the features, a 50-metre wall still rings much of the crater. Geologists estimate the crater originally had a diameter of about 28 kilometres—about twice its current size.

Parts of the central peak are also visible in the lake as Horseshoe Island. These mound-like features are often found in the centre of large craters as a product of the melting and rebound of subsurface rocks. Meanwhile, the elongated, elliptical appearance of the crater is a result of periods when glaciers slid across this area during several ice ages.

Based on the presence of an unusual diamond-like mineral called cubic zirconia, the asteroid impact must have heated rocks at the site to at least 2370°C. That would be the hottest-known temperature recorded by a surface rock on Earth, according to one team of researchers.

Summer Colour in Northern Seas

NASA Earth Observatory

Story by Kathryn Hansen

In mid-June 2021, hints of a phytoplankton bloom brewed off the coast of Newfoundland, Canada. In the following weeks, the faint patch transformed into a brilliant blue expanse as the number of microscopic plant-like creatures exploded.

The bloom was in full swing on August 5, 2021, when the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's *Aqua* satellite acquired figure 1. Clouds are common over the Labrador Sea, and this day was no exception. But areas east and southeast of Newfoundland were clear enough for satellites to detect the stunning blue display. Faint traces of the bloom were still visible amid the clouds on August 23.

The colour of the ocean here is a good indication that the bloom is composed of coccolithophores, probably *Emiliania huxleyi*. The phytoplankton are covered in chalky calcite plates that are highly reflective, which make the ocean surface appear milky blue. Each cell is just a few nanometers across, but when enough of them congregate over a large area they become visible from space.

The region's currents and circulation patterns help enrich the water with nutrients, which can enhance the productivity of phytoplankton when combined with sunlight. The organisms become food for zooplankton, shellfish, and other marine creatures, which has helped make this region one of the richest fishing grounds in the world.

It remains to be seen if coccolithophores will persist into September as they did in 2019 and again in 2020. In previous years, *E. huxleyi* has been most abundant around mid-summer but less common in autumn.

Figure 1 - North Atlantic on August 5, 2021.

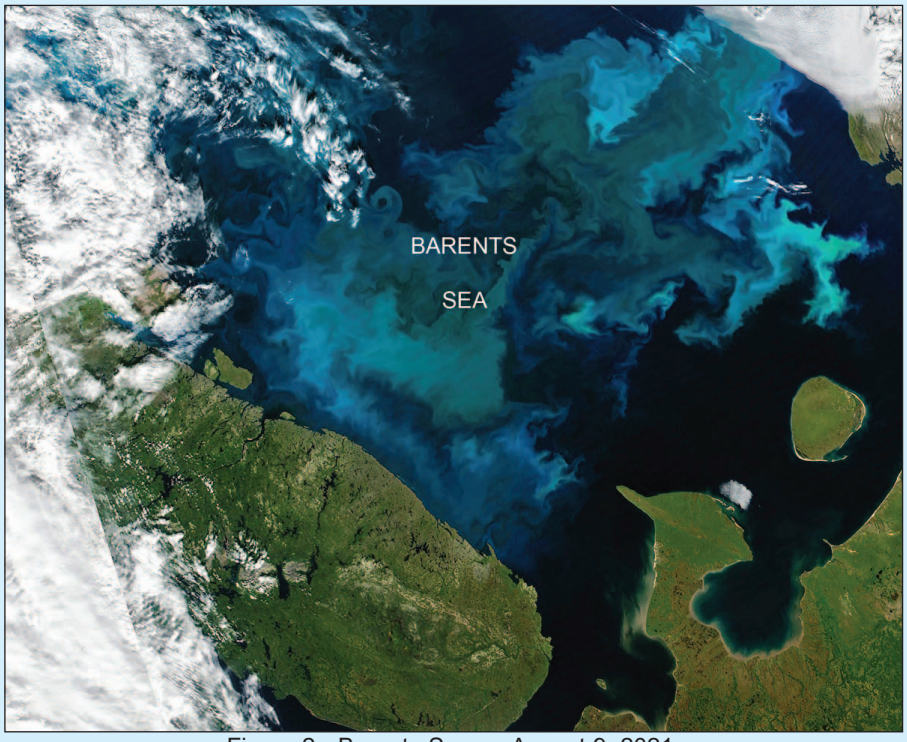


Figure 2 - Barents Sea on August 9, 2021.

Meanwhile, about 5,000 kilometres away, in the Barents Sea, a bloom that dazzled in mid-July continued to put on a display. Figure 2 was acquired on August 9, 2021, with the Visible Infrared Imaging Radiometer Suite (VIIRS) on the NASA-NOAA *Suomi NPP* satellite. Traces of the bloom were still visible over a week later on August 18.

This bloom is also most likely dominated by coccolithophores. *E. huxleyi* is common here from around late July into autumn, replacing blooms of diatoms that thrive in spring and early summer.

NASA Earth Observatory images by Joshua Stevens, using MODIS and VIIRS data from NASA EOSDIS LANCE and GIBS/Worldview and the Suomi National Polar-orbiting Partnership

Currently Active Satellites and Frequencies

Polar APT/LRPT Satellites			
Satellite	Frequency	Status	Image Quality
NOAA 15	137.6200 MHz	On	Good
NOAA 18	137.9125 MHz	On	Good
NOAA 19	137.1000 MHz	On	Good [1]
Meteor M N1	137.0968 MHz	Off	Dead [8]
Meteor M N2	137.1000 MHz	On	Good
Meteor M N2-2	137.9000 MHz	Off	Failed [12]

Polar HRPT/AHRPT Satellites				
Satellite	Frequency	Mode	Format	Image Quality
NOAA 15	1702.5 MHz	Omni	HRPT	Weak
NOAA 18	1707.0 MHz	RHCP	HRPT	Good
NOAA 19	1698.0 MHz	RHCP	HRPT	Good
Feng Yun 1D	1700.4 MHz	RHCP	CHRPT	None: Device failure
Feng Yun 3A	1704.5 MHz	RHCP	AHRPT	Inactive [2,10]
Feng Yun 3B	1704.5 MHz	RHCP	AHRPT	Active [2]
Feng Yun 3C	1701.4 MHz	RHCP	AHRPT	Active [2]
Metop A	1701.3 MHz	RHCP	AHRPT	Good
Metop B	1701.3 MHz	RHCP	AHRPT	Good
Metop C	1701.3 MHz	RHCP	AHRPT	Commissioning
Meteor M N1	1700.00 MHz	RHCP	AHRPT	Dead [8]
Meteor M N2	1700.0 MHz	RHCP	AHRPT	Good
Meteor M N2-2	1700.0 MHz	RHCP	AHRPT	System failure [12]

Geostationary Satellites				
Satellite	Transmission Mode(s)		Position	Status
Meteosat 8	HRIT (digital)	LRIT (digital)	41.5°E	IODC
Meteosat 9	HRIT (digital)	LRIT (digital)	3.5°E	On [5]
Meteosat 10	HRIT (digital)	LRIT (digital)	9.5°E	Off [4]
Meteosat 11	HRIT (digital)	LRIT (digital)	0°W	On [3]
GOES-13	GVAR 1685.7 MHz	LRIT 1691.0 MHz	60°W	Off
GOES-14	GVAR 1685.7 MHz	LRIT 1691.0 MHz	105°W	Standby
GOES-15 (W)	GVAR 1685.7 MHz	LRIT 1691.0 MHz	128°W	On [6]
GOES-16 (E)	GRB 1686.6 MHz	HRIT 1694.1 MHz	75.2°W	On[6,9]
GOES-17	GRB 1686.6 MHz	HRIT 1694.1 MHz	137.2°W	[11]
MTSAT-1R	HRIT 1687.1 MHz	LRIT 1691.0 MHz	140°E	Standby
MTSAT-2	HRIT 1687.1 MHz	LRIT 1691.0 MHz	145°E	On
Feng Yun 2D	SVISSR	LRIT	123.5°E	Backup/Off [7]
Feng Yun 2E	SVISSR	LRIT	86.5°E	On
Feng Yun 2F	SVISSR	LRIT	112.5°E	Standby
Feng Yun 2G	SVISSR	LRIT	99.5°E	On
Feng Yun 2H	SVISSR	LRIT	86.5²E	
Feng Yun 4A	HRIT (digital)	LRIT (digital)	99.5°E	On

Notes

1 LRPT Signals from Meteor M N2 may cause interference to NOAA 19 transmissions when the two footprints overlap.
2 These satellites employ a non-standard AHRPT format and cannot be received with conventional receiving equipment.
3. Meteosat prime Full Earth Scan (FES) satellite
4 Meteosat backup Full Earth Scan (FES) satellite
5 Meteosat prime Rapid Scanning Service (RSS) satellite.
6 GOES 15 also transmits EMWIN on 1692.700 MHz
GOES 16 also transmits EMWIN on 1694.100 MHz
GOES 17 also transmits EMWIN
7 There has been no imagery from Feng Yun 2D since June 30, 2015. Since Feng Yun 2G is operating from the same position (86.5°E), it is likely that FY-2D is now in standby as a backup satellite.
8 On March 20, 2016, Meteor M1 suffered a catastrophic attitude loss, frequently pointing its sensors towards the sun. The following day all signals ceased and it seems highly probable that this satellite is now incapable of imaging the Earth.
9 GOES Rebroadcast (GRB) provides the primary relay of full resolution, calibrated, near-real-time direct broadcast space relay of Level 1b data from each instrument and Level 2 data from the Geostationary Lightning Mapper (GLM). GRB replaces the GOES VARiable (GVAR) service.
10 Although Feng Yun 3A's status is recorded on the wmo-sat website as 'inactive (end of operation)', it continues (as of June 2018) to transmit imagery.
11 GOES 17 is expected to start operations during January 2019.
12 Following a collision with a micrometeorite, the power system aboard Meteor M2-2 has all but failed and is no longer capable of powering the AHRPT/LRPT instrument.