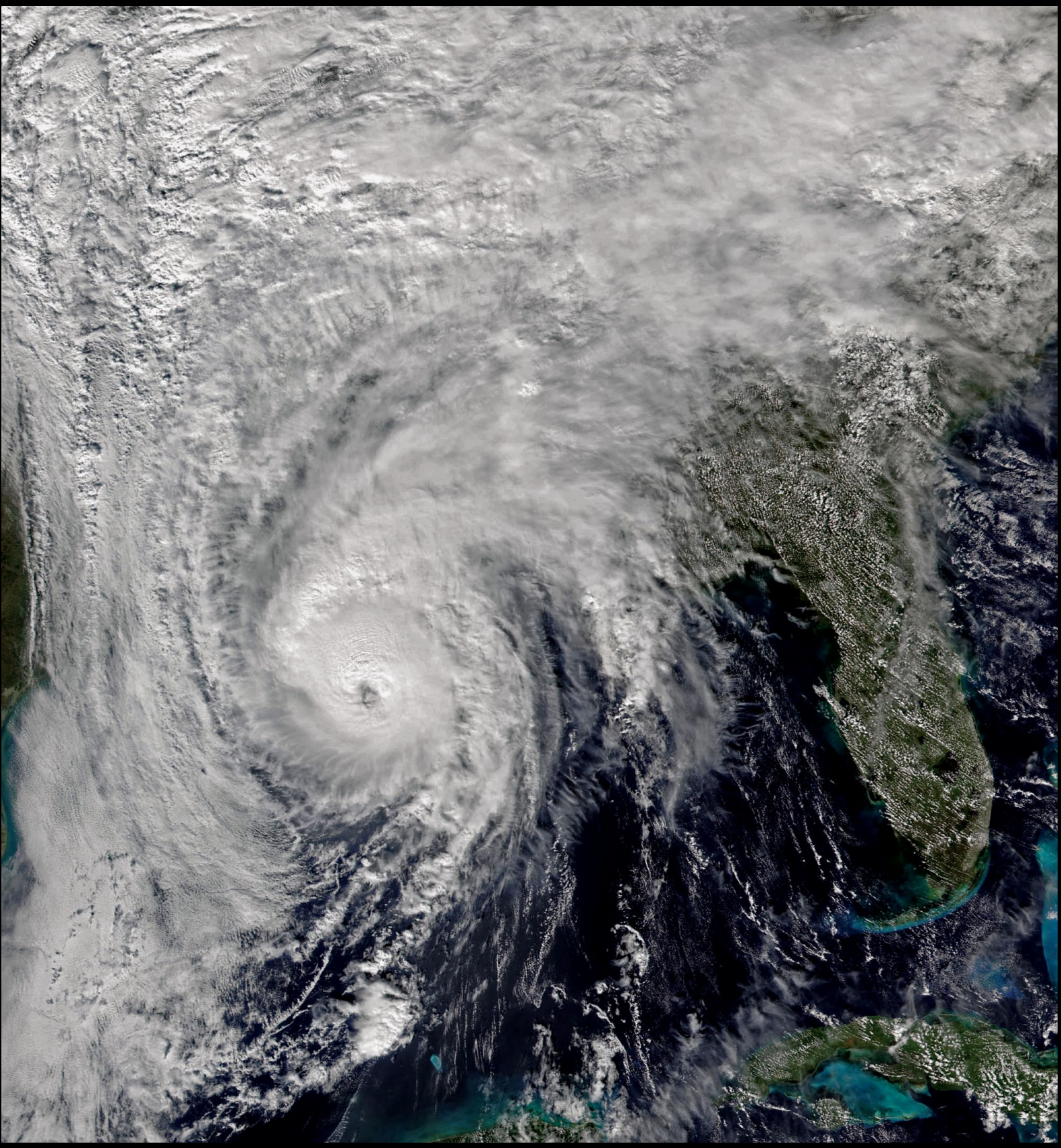
GEO Newsletter

Group for Earth Observation

Group for Earth Observation

No 68 - December 2020



Category-2 Hurricane Zeta, imaged as it approached the Louisiana coast by NOAA 20 on October 28, 2020, was the record-breaking eleventh named storm to make landfall on the continental United States this year.

Image © NASA Worldview

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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

As a year like none other draws to a close, perhaps we can all look forward to a brighter future as vaccines against COVID are proving successful. Another light on the horizon is the probable launch of Russia's Meteor M2-3 satellite near the end of the year.

Meanwhile, as lack of daylight degrades satellite imagery, it is worth investigating Meteor M2's infrared channel. An example image, showing superior land detail at this time of the year, is reproduced on page 22.

For those among the readership who find themselves having to spend more time than they would like in their homes this winter, there is an opportunity for a construction project, courtesy Ed Murashie. Ed retired earlier this year, and has busied himself building up an HRPT Ground Station from scratch. You can read all about this on page 10, and Ed will be happy to help anyone else keen on following in his footsteps via the '*Messages*' section of the GEO-Subscribers group.

Finally, everyone on the Management Team sends readers our very best wishes for Christmas and New Year. With news of COVID vaccination commencing before Christmas, there is at last reason to hope for a return to normalcy before next summer.

Contents

Quarterly Question

Francis Bell

Quarterly Question 67
My usual thanks to members who responded to the last Quarterly Question which related to identifying a satellite image of cloud free Iceland.

When reading some background information about Iceland I learned that it is one of a few countries which does not have its own army. The country of Costa Rica being another example of a country without its own army. An explanation for the lack of armies in these two example countries was provided in a member's answer to the Quarterly Question, and it certainly widened my perspective as to how such small countries try to maintain their independence.

Below is the informative answer I received to the second part of the question, from Richard Hoover , one of our readers in the USA.

> "Neither Costa Rica nor Iceland maintains a military. Rather they rely on the United States and other select members of NATO for provision of military assistance in the event of a threat. I have abstracted the relevant sections of the NATO / US Collective Defense Arrangements pertinent to Iceland and Costa Rica below:
>
> **"U.S. Collective Defense Arrangements**
>
> **"The North Atlantic Treaty**
> This is a treaty, signed on April 4, 1949, by which the Parties agree that an armed attack against one or more of them, in Europe or North America, shall be considered an attack against them all; and each of them will assist the attacked party by taking forthwith, individually and in concert with the other Parties, such action as it deems necessary, including the use of armed force.
>
> "**PARTIES**: United States, Albania, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, France, Germany, Greece, Hungary, ICELAND , Italy, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Turkey, United Kingdom
>
> **"The Rio Treaty**
> This treaty, signed on September 2, 1947, provides that an armed attack against any American State shall be considered as an attack against all the American States; and each one undertakes to assist in meeting the attack.
>
> "**PARTIES**: United States, Argentina, Bahamas, Bolivia, Brazil, Chile, Colombia, COSTA RICA Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Nicaragua, Panama, Paraguay, Peru, Trinidad & Tobago, Uruguay, Venezuela
>
> "As always a great magazine!"

Quarterly Question 68
This question, much harder than last time, asks you to identify the lake illustrated opposite, which is most certainly not one whose name will come readily to mind. Here are some details to help you.

This lake is the seventh deepest lake in the world and the tenth largest by volume (though not in surface area); it is also the second largest saline lake after the Caspian Sea. Although it is surrounded by snow-capped peaks, it never freezes. It measures 182 by 60 kilometres and has a surface area of 6,236 square kilometres.

Please send your answer to Francis Bell at the email address

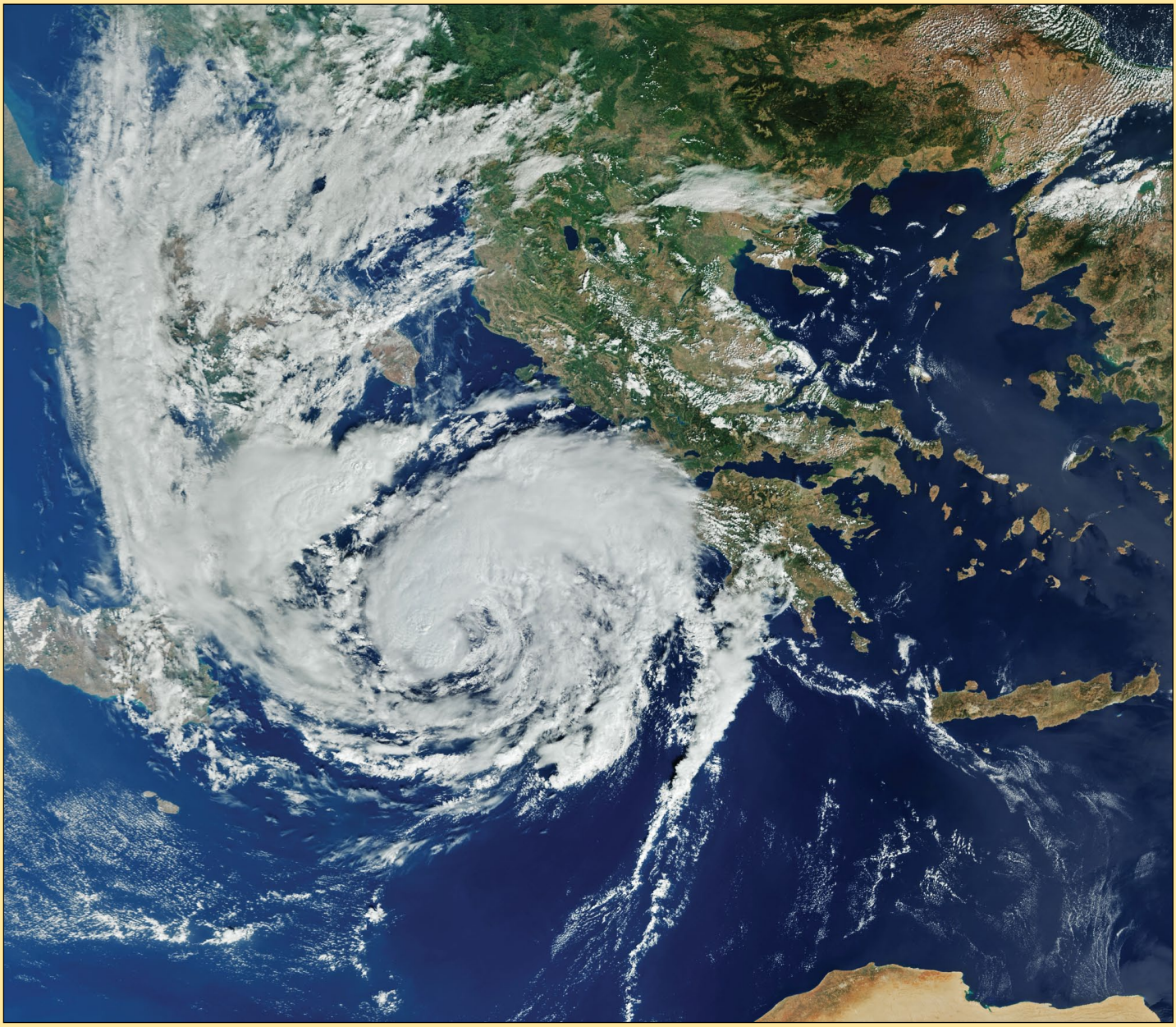
francis@francisbell.com

by February 26, 2021.

Can you identify this lake?
Image: NASA Worldview Snapshots

Medicane Ianos

European Space Agency



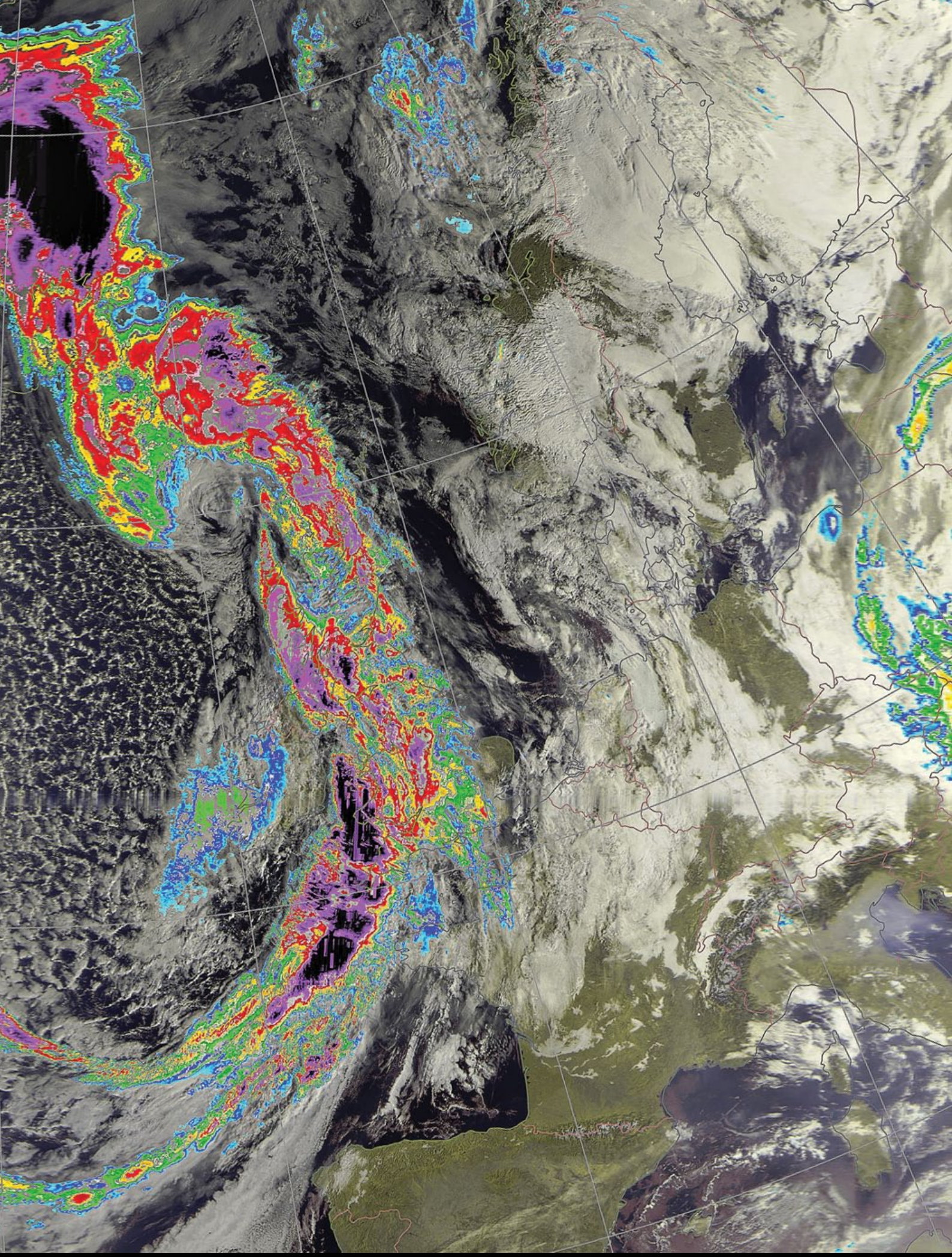
Medicane 'Ianos' pictures approaching Greece by Sentinel-3 on September 17, 2020.
Image contains modified Copernicus Sentinel data (2020), processed by ESA, CC BY-SA 3.0 IGO

The Copernicus Sentinel-3 mission captured this image of a Mediterranean hurricane, or '*Medicane*,' crossing the Ionian Sea and approaching Greece on September 17, 2020 at 10:48 CEST. Medicane Ianos, is imaged shortly before making landfall over Greece where it brought hurricane-force winds and heavy rain.

Medicanes are similar in form to hurricanes and typhoons, but can form over cooler waters. While hurricanes move from east to west, medicanes move from west to east and are generally less powerful.

Three people were reported to have died after the storm swept across Greece, flooding streets and homes and cutting power. Hundreds of people became trapped as Cyclone Ianos,hit areas north of Athens before heading south.

Train services linking the north and south of the country were cut off and as Ianos progressed eastwards in the early hours, the city of Karditsa in Thessaly was lashed by winds that peaked at 120 kilometres per hour, downing power lines and triggering landslides. Some 5,000 homes in the city were reportedly affected by flooding, while roads were also damaged.



The Meteor M2 satellite reactivated its LRPT infrared channel on September 30, 2020, and Rob Bale was quick to take advantage by creating this rainfall image via *Meteor GIS*, showing a band of heavy showers crossing the UK.

Iran's Rainbow Island

NASA Earth Observatory

Story by Adam Voiland

With its colourful soils, salt caves and mountains, and ochre-stained streams and beaches, Iran's Hormuz island is rich with memorable geology.

The island is a salt dome—a teardrop-shaped mound of rock salt, gypsum, anhydrite, and other evaporites that has risen upward through overlying layers of rock. Rock salt, halite, is weak and buoyant, so it loses its brittleness and flows more like a liquid when under high pressure.

The rising mass is not purely made of salt. Embedded within it are layers of clay, carbonates, shale, and iron-rich volcanic rocks, some of which have taken on vivid shades of red, yellow, and orange as they moved upward and interacted with water and minerals from other rock layers.

The concentric ring structure of the uplifted salt dome is visible in this natural-colour image acquired by the Operational Land Imager (OLI) on Landsat 8. Uplifted halite is widespread near the central and southern two-thirds of the island, which appear reddish amid outcrops of weathered volcanic rocks that appear grey. The tan northern third of the island is covered by a layer of sand and other sediment that was deposited by other processes.

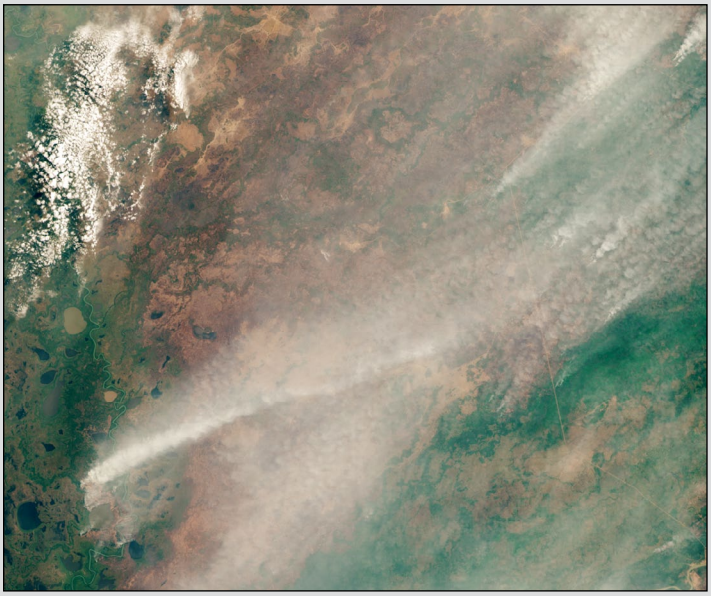
The ochre soils on the island have proven appealing to cooks, artists, and miners alike. Locals reportedly use the red soil to season a certain type of bread. Groups of artists have used it to create expansive sand carpets. Sand from a mine in the northern part of the island has also been used in paints, cosmetics, ceramic tiles, and for the exteriors of buildings.

One non-geological feature of the island stands out in the image: At its northern end, a small inlet hosts a concentrated patch of mangroves that appear green. Known locally as a hara forest, the area serves as habitat for numerous types of fish, molluscs, crustaceans, and migratory birds.

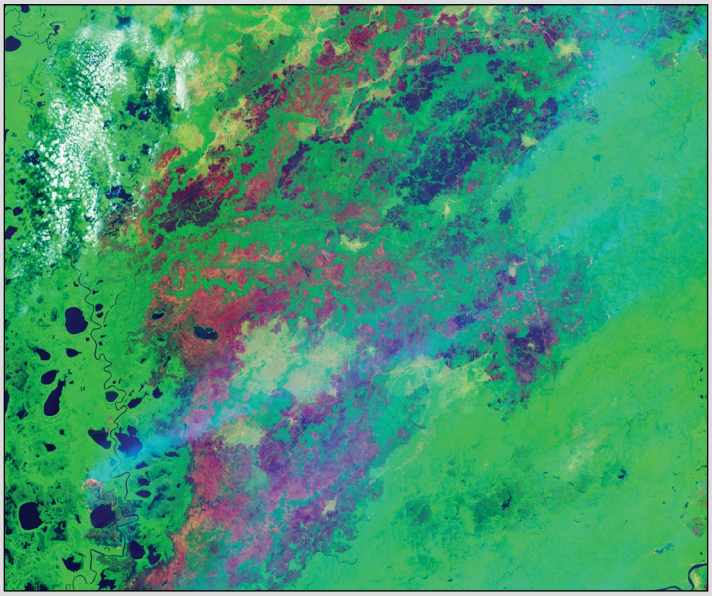
NASA Earth Observatory image by Lauren Dauphin, using Landsat data from the U.S. Geological Survey.

Fires Char the Pantanal

NASA Earth Observatory
Story by Adam Voiland



This natural colour image of the Pantanal shows smoke plumes from wildfires.



This false colour image of the Pantanal highlights active fires and charred terrain.

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

The Pantanal, a vast floodplain in South America, is among the largest wetlands in the world. The mosaic of grasslands, shrub lands, forests, marshes and lakes covers an area as large as West Virginia. It is home to thousands of species, including many that are rare and endangered, such as jaguars, giant river otters, hyacinth macaws, and giant armadillos.

Though the number of ranches and cattle pastures has increased on the plateaus that surround the Pantanal in Brazil, Paraguay, and Bolivia, the floodplain itself has remained mostly free of development in recent decades. But in the past few years, the Pantanal has faced a new challenge: uncontrollable fire.

The 2019 fire season (July through October) was unusually active, and a shortage of rainfall during the 2020 wet season (December through April) meant Pantanal wetlands never had a chance to recharge. That made it easier for fires to continue burning throughout the first half of the calendar year, when fire activity is typically minimal in this region.

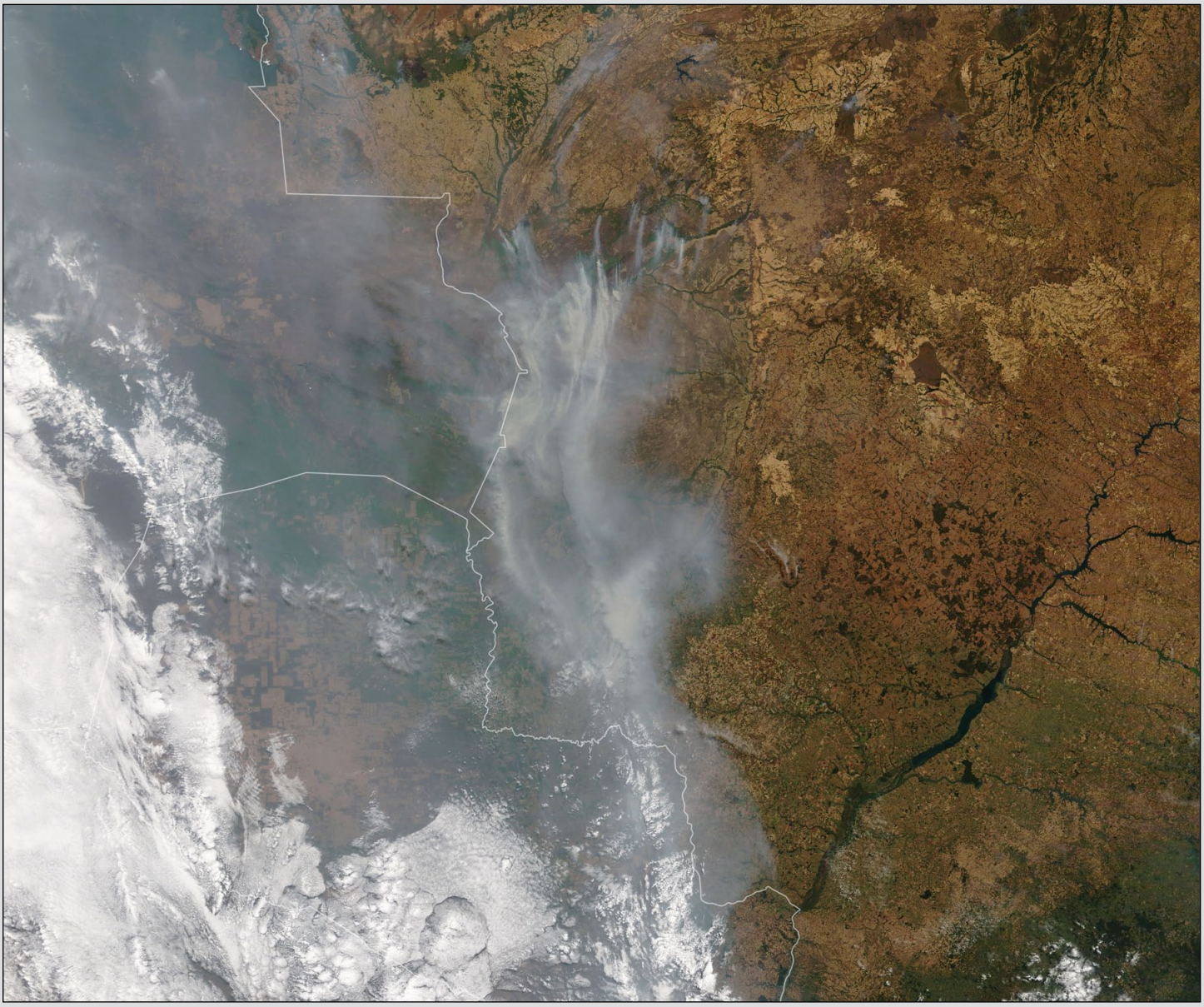
The unusually dry conditions have meant that many fires that were lit intentionally—often to maintain pastures—have been escaping and burning without control through Pantanal ecosystems. And once such fires have started to spread rapidly and widely, they can outpace the available infrastructure for firefighters to contain or stop them.

The result is vast burn scars like those in the false-colour images above. Both images were acquired on August 27, 2020, by the Operational Land Imager (OLI) on *Landsat 8*. The left hand image shows the scene in natural colour: the second image combines shortwave infrared, near-infrared, and green light (bands 7-5-2) to highlight active fires (bright red), land that has been charred (darker red), and intact vegetation (green). Although this may appear to be one continuous burn scar, the image actually shows burn scars from multiples fires. The oldest fire burned a portion of the scene in April 2020: two of the others were started in July.

Smoke has, at times, spread far from the source of these fires. On September 6, 2020, the higher-resolution Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's *Terra* satellite captured the image reproduced on page 9, showing a river of smoke streaming south from the Pantanal.

Though fires have been burning sporadically in the Pantanal since the beginning of 2020, it was in July and August—the beginning of the dry season—when fire activity surged. One analysis of NASA and NOAA satellite observations by the nonprofit *Instituto Centro de Vida* reported 4,200 hotspots in the Brazilian state of Mato Grosso in August 2020. That compares to 71 in August 2018 and 184 in August 2019.

As of September 9, 2020, fires had charred an estimated 24,000 square kilometres of the Pantanal region in 2020, according to Douglas Morton, chief of the biospheric sciences branch at *NASA Goddard Space Flight Center*. The previous record was set



This river of smoke streaming south from the Pantanal was imaged by NASA's Terra satellite on September 6, 2020.
NASA Earth Observatory images by Lauren Dauphin, using MODIS data from NASA EOSDIS/LANCE and GIBS/Worldview and Landsat data from the U.S. Geological Survey.

in 2005, when satellites detected the burning of 4,600 square kilometres in the biome.

> *"That is an extraordinary amount—more than 10 percent of the Pantanal—and we still have several weeks to go until the start of the wet season," said Morton. "The Pantanal has had fires before, but what is happening this year is extreme and unprecedented in the satellite era."*

The large number of thermal anomalies, or hotspots, detected by satellites does not mean that each is a separate fire. Most of the hot spots detected in the Pantanal since mid-July were associated with large fires that spread from just nine initial starting points, according to an *Instituto Centro de Vida* (ICV) report. As seen in the Landsat images on the previous page, several of the fires began in the municipality of Poconé, between the Transpantaneira Highway and the Paraguay River, explained Paula Bernasconi of ICV.

Though it is impossible to determine from satellite data the precise cause of every fire, experts who study South America say that many of the large dry season events this year were most likely triggered by human activities.

Fires are routinely used by farmers in the region to clear vegetation from new and existing pastures, explained Renata Libonati of the Federal University of Rio de Janeiro. Burning trash is also common, and fisherman regularly light campfires. Normally such activities would create small, short-lived fires that are barely visible to satellite sensors like MODIS. But in dry conditions, such fires can easily escape and spread.

While some of the savanna-like grasslands and shrub land areas of the Pantanal are well adapted to fire, other parts are home to plants and animals that could experience lasting damage. There is particular concern about fires that have entered Encontro das Águas park, which is home to many jaguars.

Experimenting with HRPT

Ed Murashie

What I love about our weather satellite hobby is that there are aspects for everyone. They can be working on hardware, software, learning about its history, studying satellite meteorology, or simply looking at beautiful images.

For me it is the hardware aspect. When it came time to setup a polar satellite high resolution picture transmission (HRPT [1]) station for a recent conference, I chose not to go with my old station but with a new design. This is the story of that adventure.

Antennas

It all started with the antenna. As I was going through my options, I kept thinking about how simple my GOES high resolution image transmission (HRIT) station was. Most hobbyists, including myself, use a WiFi grid dish that is 39” wide by 24” tall because it is readily available and relatively cheap.

Previously, I had bought a pack of five for $125 on a popular auction site. In the spirit of experimenting, after the HRIT station was up and running, I wondered if I could reduce the Viterbi HRIT error rate by adding ¼” hardware cloth to make it a full dish. Indeed it did—by cutting the error rate in half. The resulting fixed dish is shown in at lower right in figure 1.

Figure 1`
The author’s antenna array. The small one at right is the fixed GOES dish for HRIT, and the left one is the tracking polar satellites dish for (A)HRPT.

Having four more WiFi dishes left, I decided to cut one into thirds, take the two outside petals, and attach them to another dish to make a fuller dish. The pieces are held together using galvanized wire and epoxy.

An interesting fact about grid dishes is that the grid acts as a filter. For a linear signal like HRIT, the dish is rotated so the dipole is aligned with the signal polarity and the grids are parallel with the dipole. The linear signal reflects off the grids and is received by the dipole. If the grids are rotated 90 degrees with the dipole in the same position, a large portion of the signal passes through the grid and is lost.

I decided to not take a chance on the grid alone and see what the circular polarized HRPT signal losses might be, so the grid was lined with hardware cloth. A simple 2½ turn helix feed [2] made out of 8-gauge copper wire with a 5” round aluminum reflector was used. The helix coil finished dimensions are 64 mm outside diameter and 51 mm inter-winding spacing. The low noise preamp directly connected to the helix is my design based on a *Qorvo TQP3M9037* [3] ultra low noise amplifier with a noise figure of 0.4 dB and a gain of 20 dB. Another option would have been to use a GOES *SAWBird* [4] amplifier. My amplifier is housed in a Bud box located in a twist storage container [5] with integral seal. The feed is held in place with a single center mount consisting of two telescoping pieces of PVC pipe, a hose clamp to lock the pipes together at the right focal distance, PVC fittings and a pipe flange at the dish surface.

Tracking Mount

Next came the tracking mount. I have always had good luck with *Pelco* pan tilts, normally used for security cameras, so I decided to stick with that solution. A *PT680-24P/PP* rated at 50 pounds with built-in azimuth and elevation feedback potentiometers works great in this application. The

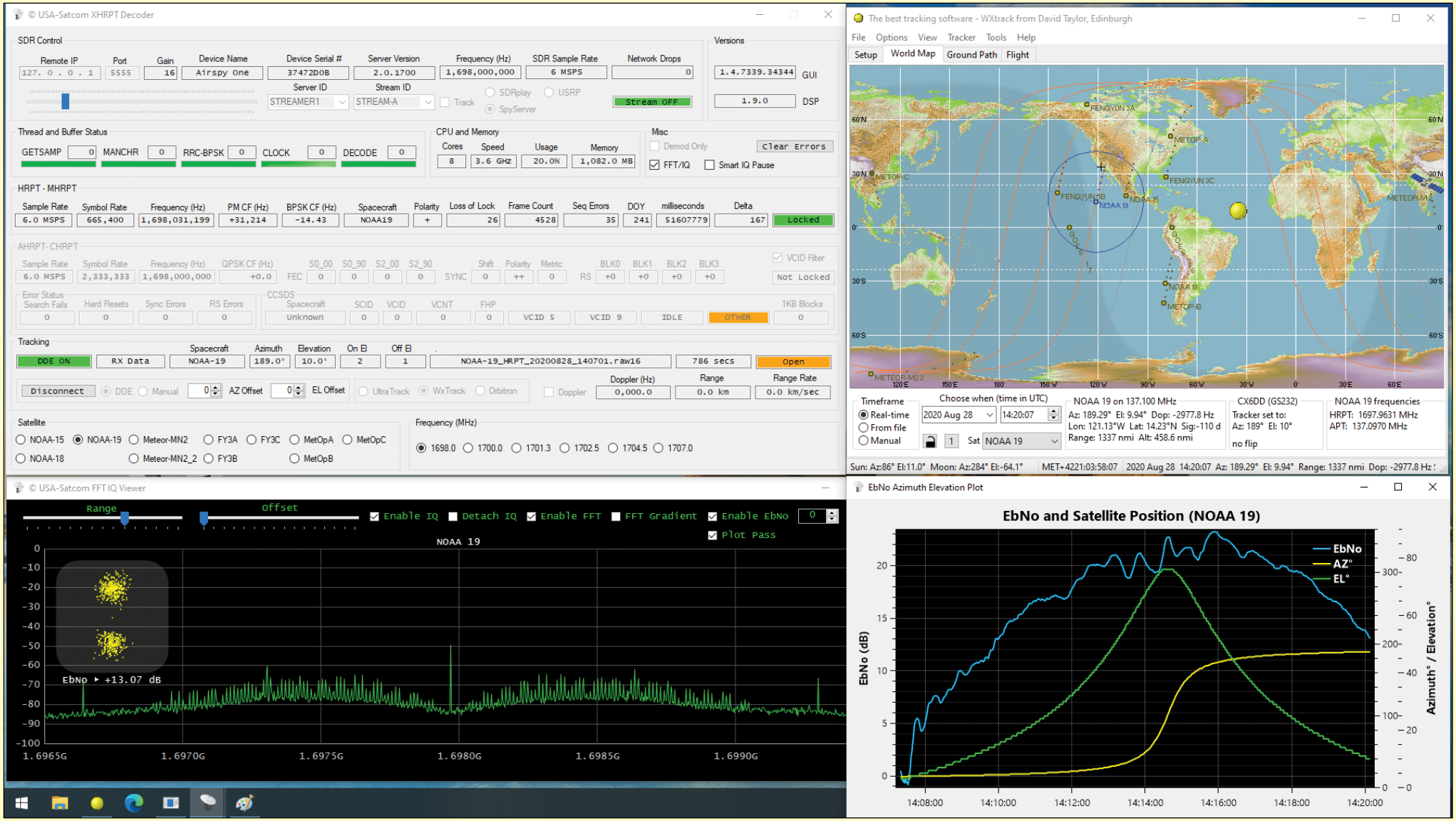


Figure 2
The Author's screen display with four programs active simultaneously

dish mounts cleanly on the top plate and considering the light weight I chose not to use counterbalances. Originally I used a *Yaseu G5400B* AZ/EL *controller* to drive the 24 V AC pan/tilt but later experimented by modifying a *Pelco MPT24DT* joystick controller to interface to a PC computer. The modification consists of four *CPC1976Y* solid state relays placed across the joystick switches and an op-amp circuit connected to the pan/tilt potentiometers to remove any offset and scaling issues.

A +6V and a +12V regulator are added inside the controller to power the AZ/EL potentiometers and external tracking interface board respectively. The tracking interface board used is a *Fox Delta ST3* board left over from my previous system, and connects to the PC through a USB port and to the *MPT24DT* through a 9-pin D-connector.

A tracking program such as David's Taylor's *WXTrack* [6] sends the desired antenna coordinates to the ST3 board. The ST3 measures the pan/tilt potentiometer voltages and calculates the antenna's current coordinates while driving the motor relays to match the desired coordinates. The ST3's nice two-line LCD displays the desired and current azimuth and elevation coordinates. The pan/tilt is mounted on two *Pelco* extensions so that when the dish is pointed at the horizon, the bottom edge does not bottom-out on the roof.

To mount the antenna to the roof, a wood structure was built, painted and attached to the roof with two long roof screws and caulking to prevent leaks. The wood structure consisted of two triangle shaped pieces made from 2" x 6" lumber with an angle that matches the roof pitch, and a wood deck the antenna mount bolts to. The deck edge closest to the roof is pulled slightly back so that water flows down the roof and under the wood structure. The antenna has been on the roof nearly a year and has stood up to 50 mph Santa Ana winds.

Software

I was impressed with how well the software defined radio (SDR) dongle handled the HRIT signal and wondered if there was Windows HRPT software out there. I was in luck: Raydel Abreu Espinet had written a free program *hrpt_rtl_noaa.grc*, based on the GNU Radio package. By running WXTrack and Raydel's decoder with either an RTL-SDR or AirSpy Mini SDR, I was able to receive the first images on the new station.

Once again the experimenter in me wanted more, and so the search was on for another program. I was intrigued when I came across xHRPT [7] written by Joe at usa-satcom.com. It claimed to decode NOAA-15, 18, 19, MetOp-A, B, C, FengYun-3A, 3B, 3C and Meteor-MN2 all for $150. The software installation was easy and it was compatible with *WXTrack* and the *AirSpy Mini* SDR. *Spyserver*—to serve the SDR data to *xHRPT*—was installed next along with *MetFy3x.exe* which performs additional post receive decoding of the MetOp, Meteor and FenYun data.

To display the images my choice is David Taylor's *ReadHRPT* program. Figure 2 (page 10) shows the computer screen during a NOAA-19 pass after the satellite passed overhead near 80 degrees and was within 10 degree of the horizon. Not bad for a cheap, lightweight, 40" dish! Starting in the top left screenshot (figure 2) and going clockwise, you see **xHRPT Decoder**, **WXTrack,** the **xHRPT receive signal strength plot** and the **XHRPT constellation/frequency plot** programs all running simultaneously.

Software operation is simple. You start *WXTrack*, choose the satellite you want to receive and then run *Spyserver*. Finally start x*HRPT Decoder*, click on the 'Connect' button in the Tracking section, set the Gain and then click on the 'Stream On' button in the SDR section. When the satellite comes up over the horizon, *xHRPT* selects the satellite from the tracking program data, opens a time stamped file, receives and saves the data. When finished, if the data is from MetOp, Meteor or FengYun, run *MetFy3x* to further decode the data. Finally open up *HRPTReader* and enjoy scrolling through the channels.

To see the station in operation head over to my website [8] and play the video, and while there check out an interesting comparison of HRPT visible Channel 2 and infrared Channel 3 during the recent California wildfires [9]. It was created using the free *Twenty20 Image Before-After WordPress* plugin and this simple one line command:

[twenty20 img1="601" img2="600" width="150%" offset="0.1" before="NOAA-19 VISIBLE" after="NOAA-19 CHANNEL 3" align="left" direction="vertical"].

I hope this has inspired you and given you some ideas on building your own HRPT station. If you have questions or want to share your experiments, you can do so on the GEO-Subscribers email group at *https://groups.io/g/GEO-Subscribers/topics*

References

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3 QORVO TQP3M9037 LNA
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5 Container Store SKU#10078214 4-1/2" diameter x 3-1/2" high 22 oz container

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7 USA-Satcom xHRPT decoder setup
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9 USA West Coast Fires Imagery
http://proengineered.com/calfires

Successful launch for the Sentinel-6 Michael Freilich Mission

NASA

The **Sentinel-6 Michael Freilich** satellite was successfully launched from Vandenberg Air Force Base, aboard a SpaceX Falcon 9 rocket, on November 21, 2020. This joint venture by the USA and Europe has been designed to monitor global sea levels and acquire critical ocean measurements over the coming five years. About the size of a small pickup truck, Sentinel-6 Michael Freilich will extend a nearly 30-year continuous dataset on sea level collected by an ongoing collaboration of US and European satellites while enhancing weather forecasts and providing detailed information on large-scale ocean currents to support ship navigation near coastlines.

An artist's impression of the Sentinel-6/ Michael Freilich satellite in orbit.
Image: NASA/JPL

Sentinel-6 Michael Freilich is named after former director of NASA's Earth Science Division, Michael Freilich. He was a pioneer in oceanography from space, and dedicated his life to a better understanding of the Earth, with the goal of improving the lives of those who call it home.

Sentinel-6 Michael Freilich will measure sea level at centimetre accuracy for more than 90% of the world's oceans to add to the long-term dataset that began with the joint US-French **TOPEX/Poseidon** satellite in 1992. The sea level monitoring effort has since continued through the **Jason-1**, **OSTM/Jason-2** and **Jason-3** missions, the last launched in 2016 and currently still operational.

A secondary objective of the mission is to measure temperature and humidity in the troposphere, the atmospheric layer in which we live. The satellites will also look at the stratosphere, the layer immediately above the troposphere. An instrument on board the satellites uses the Global Navigation Satellite System Radio-Occultation sounding technique, which analyses changes in signals from international global navigation system satellites to determine atmospheric temperature and humidity.

Sentinel-6 Michael Freilich and Sentinel-6B (due for launch in 2025) compose the Sentinel-6/Jason-CS (Continuity of Service) mission developed in partnership with ESA.

Sentinel-6 Michael Freilich launches from Vandenburg Air Force Base on November 21, 2020
Photo: NASA /JPL

Video Conferencing to the Rescue

Ed Murashie

One word that comes to mind this year is 'adapt'. People have had to adapt in the way they work, go to school and visit their friends. One of the tools used to adapt is video conferencing, which took getting used to for some. We have all seen virtual backgrounds swallow up the person talking, or the kids running around in the background, or choppy videos because of slow Internet connections. But once people became familiar with video conferencing it really started having its advantages. No more getting on a plane to fly off to attend a conference and having to pay the conference, hotel, and food expenses. Instead you have the convenience of being home and can pop in and out of a teleconference, if your kids let you!

I remotely attended two weather satellite related conferences this year, the Satellite Educator's Association Conference in July and the Community Meeting on NOAA Satellites in September. Here are some of the highlights that I think you will be interested in and where you can see the recordings.

Satellite Educator's Association Conference

The Satellite Educator's Association Conference at Cal State Los Angeles brings together teachers, student teachers, and industry leaders to talk about satellite related topics. The teachers and students learn where to find satellite technology resources and how to use them to teach science, technology, engineering and math, also called STEM. This year, instead of a two-and-a-half-day conference, it was condensed into one and was held online via Zoom.

For those that can receive GOES, checkout Steve Miller's talk where he discusses the advantages of new GOES-R satellite series and explains how they make a color image without a green sensor. You might also be interested in John Moore's augmented reality Merge Cube talk. Using a cube with different figures on each side and the *HoloGLOBE* software running on your phone, you see the cube replaced with an animation of the Earth. As you move the cube, you move the view of the Earth. This year instead of only being able to take one of my weather satellite stations to the conference, I had the pleasure of showing all of them so be sure to check out my talk on APT, HRPT, HRIT and GRB. All the talks can be found on the association's website [1].

Community Meeting on NOAA Satellites

Without a doubt, NOAA has figured out video conferencing and raised the bar. Not only were they using *WebEx* video conferencing software but also *Slido* for taking polls and asking questions. It was also an interesting format. Not only were they trying to convey information but they were also soliciting input on a few subjects including what the follow-on GOES-R mission should look like. They would give a GEO-XO talk, then ask questions while taking polls and finally answer the *Slido* questions that had been asked during the talk. *Slido* was interesting in that you would ask a question and others who see your question could 'up vote' it. The speaker would then be sure to answer the questions with the most votes before time ran out. For the benefit of the folks overseas, condensed versions of the day conferences were repeated at night which was more time-friendly for them. I enjoyed the weeklong conference because I could shift my work hours to later in the day.

There were many talks on the GOES-R follow-on mission called GEO-XO, including "NOAA Satellites and the Future" which started by showing some of the phenomenal weather events this year and ended with a GOES-R and GEO-XO timeline. "GEO Overview & GEO-XO Introduction" discussed GEO-XO planning with the various orbit types, locations and use of commercial satellites being considered. "Future NOAA Ground System Evolution" and "Migration to the Cloud" struck fear into those of us who enjoy working on the hardware: the good news is they plan on keeping GOES-R operational as long as possible.

The "GEO-XO User Engagement Effort" talk included the phrase, "People don't want a quarter inch drill, they want a quarter inch hole" to describe why NOAA wants to understand what the scientists need and not just supply any satellite. Even though you may not receive GOES, you might be interested in the links to the Fire, Weather Foresting, Human Health, Agriculture, Space Weather and Oceans Workshops that were held and how scientist are using satellite data for those applications. One day was devoted to the science of satellite observations, with talks on the lightning mapper, space weather, soundings and other satellite sensors.

And if you thought the conference was just about NOAA, you will be happy to know there were talks from the Korean, Japanese, Chinese, European, Canadian, and Brazilian meteorological agencies who gave an overview of their current and future weather satellites.

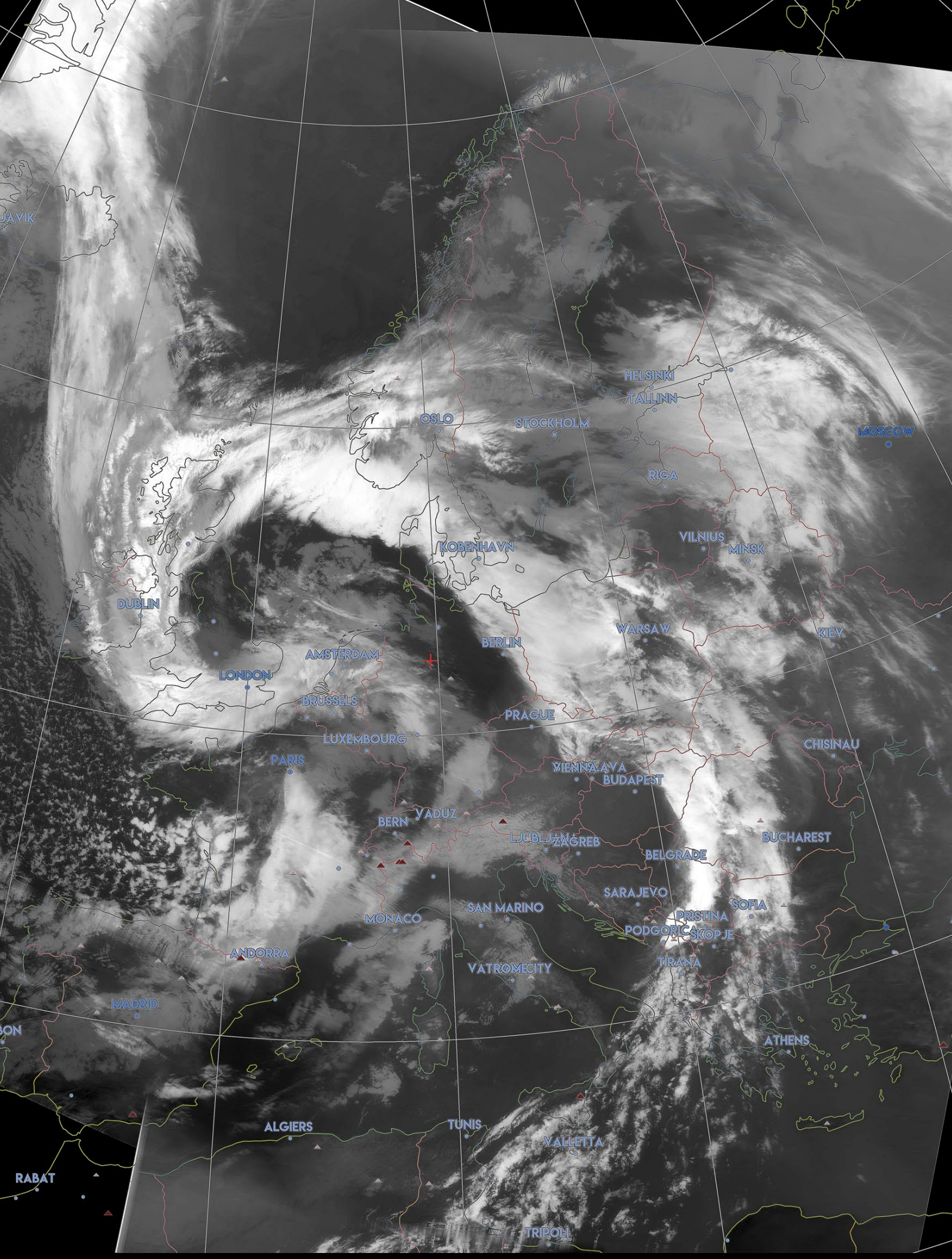
The slides from each presentation are available on the NOAA website [2]. I am sure you will find something interesting in one or more of the over forty talks.

Now we just need to have a go at a GEO video conference!

References

1 Satellite Educator's Association Conference
https://www.sated.org/conferences/conf33.htm

2 Community Meeting on NOAA Satellites
https://www.nesdis.noaa.gov/sat-community-2020

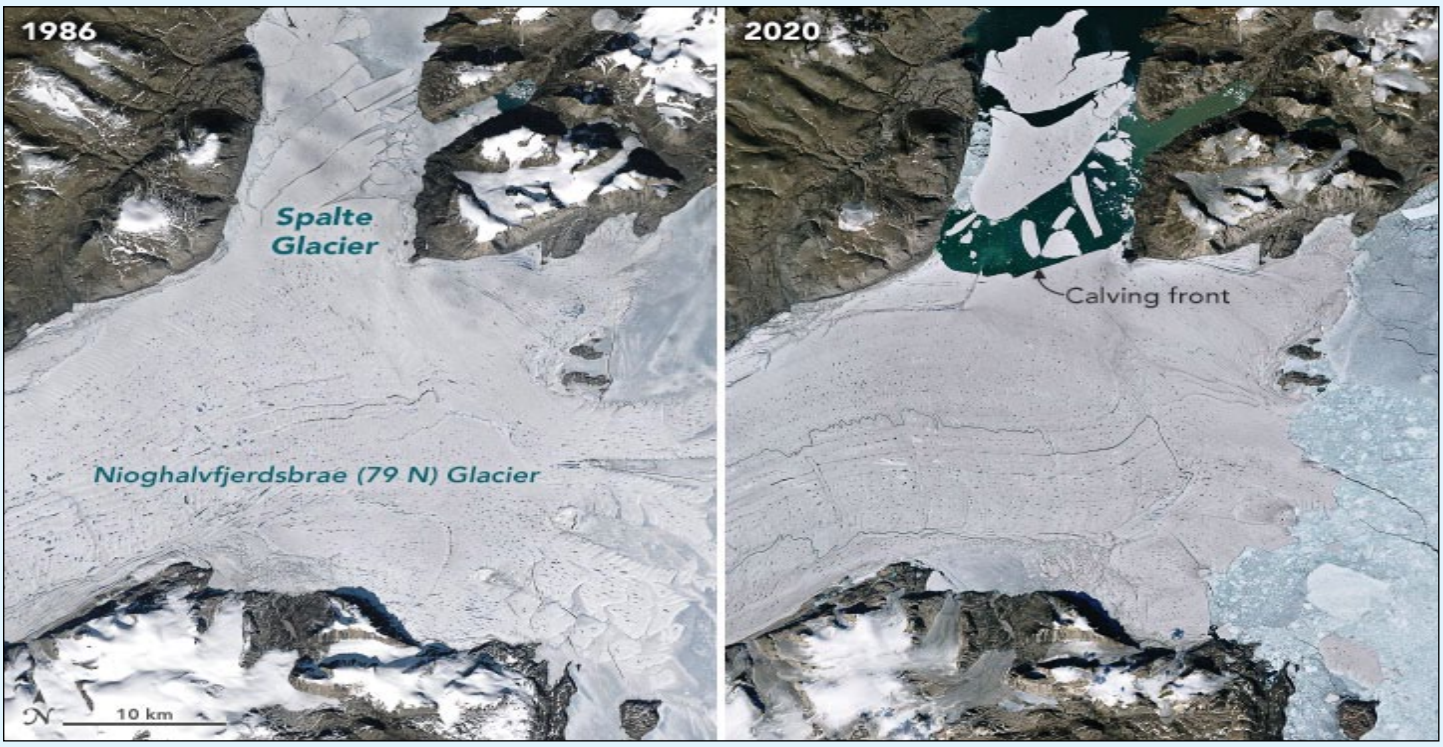


On October 4, 2020, Storm Alex wreaked havoc in southern France and inflicted a full month of rain on parts of the UK in just 24 hours. This composite infrared Meteor M2 image of the storm was created by Joachim Scharrer.

Spalte Splits

NASA Earth Observatory

Story by Kathryn Hansen.



1985 and 2020 images of the Spalte Glacier compared.

'*Spalte*' is a Danish verb meaning '*to split*'. The aptly named Spalte Glacier in northeast Greenland once branched from its parent glacier, Nioghalvfjerdsbrae (*79 North*), which is the Arctic's largest remaining ice shelf. In late June 2020, Spalte completely split off from its parent and crumbled away into numerous icebergs.

Scientists have been watching Spalte Glacier crack, shed ice, and retreat for decades. But the loss of 113 square kilometres of ice in summer 2020 means that the branch of floating ice on the northeast side of *79 North* is essentially gone for good. Scientists say the recent loss of Spalte, and the subtler changes to the adjacent *79 North*, are part of a 'progressive disintegration' that has happened amid unusually warm temperatures in recent years.

The pair of satellite images above show changes in the region across three decades. The right-hand image was acquired with the Operational Land Imager (OLI) on Landsat 8 on July 24, 2020, nearly one month after Spalte Glacier broke up. For comparison, the left-hand image from Landsat 5 shows the same scene on August 16, 1986.

The icebergs in the 2020 image had already started drifting north in Dijmphna Sound after breaking away on June 30. More rifts, already visible just southwest of the calving front, indicate that the *79 North* floating ice tongue is not in good shape," according to glaciologist Christopher Shuman.

Also visible in the 2020 image is a long, gray line with curves that resemble the line plot from a seismograph; this is actually a seasonal river of liquid water that runs along the top of the glacier. The location of the bends in the river, which move with the glacier, can be correlated to stationary rocky landmarks and used to track the overall flow of the ice. For now, the ice at the main front of *79 North* in Nioghalvfjerd Fjord is relatively steady, but recent research indicates further changes are likely to come.

About six small islands and submerged rocky 'pinning points' help to hold the floating front of *79 North* in place. Two of the larger islands are clearly visible in these images. According to Shuman, another small island in the northern fjord may once have been crucial for holding Spalte Glacier in place during the 1970s. 'This is the only ice shelf I know of that is fronted by so many distinct bedrock features,' he stated.

Even after the loss of Spalte Glacier, *79 North* remains the Arctic's largest ice shelf, measuring about 70 kilometres long and 20 kilometres wide. Together with neighbouring glaciers *Zachariæ Isstrøm* and *Storstrømmen*, the three glaciers are part of the Northeast Greenland Ice Stream and are the main outlets through which land-based ice can be drained from a 200,000-square-kilometre section of the Greenland Ice Sheet.

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

Large, Deep Antarctic Ozone Hole in 2020

NASA Earth Observatory

Story by Theo Stein, NOAA, and Ellen Gray, NASA Earth Science News Team, with EO Staff

Persistent cold temperatures and strong circumpolar winds supported the formation of a large and deep Antarctic ozone hole in 2020, and it is likely to persist into November, NOAA and NASA scientists reported.

On September 20, 2020, the annual ozone hole reached its peak area at 24.8 million square kilometres (Mkm^2), roughly three times the size of the continental United States. Scientists also detected the near-complete elimination of ozone for several weeks in a 6-kilometre high column of the stratosphere near the geographic South Pole.

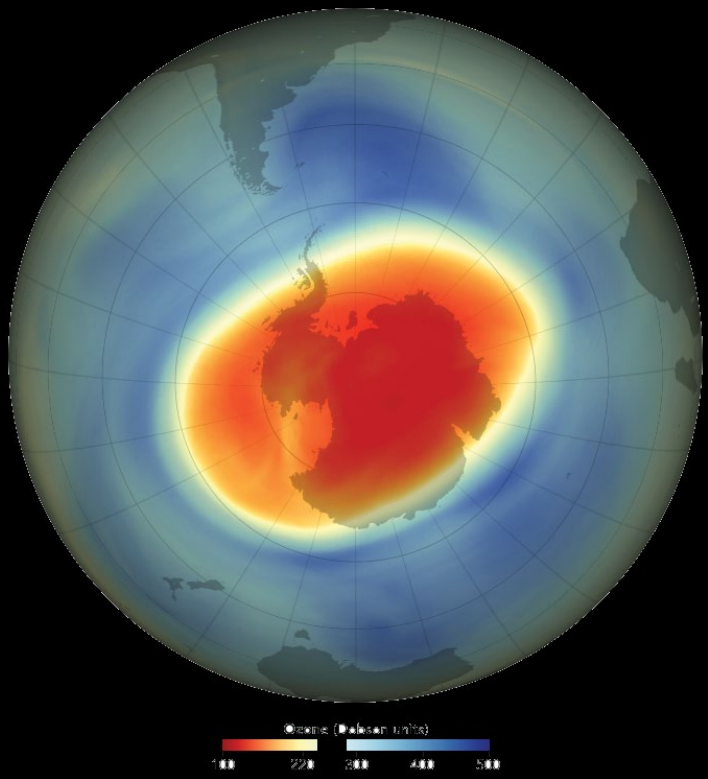
The map above shows the size and shape of the ozone hole over the South Pole on September 20, the day of its maximum as calculated by the *NASA Ozone Watch* team. NASA and NOAA monitor the ozone hole via complementary instrumental methods. NASA's Aura satellite, the NASA-NOAA Suomi NPP satellite, and NOAA's JPSS NOAA-20 satellite all measure ozone from space. Aura's Microwave Limb Sounder also estimates levels of ozone-destroying chlorine.

This year brought the 12th-largest ozone hole (by area) in 40 years of satellite records, with the 14th-lowest ozone readings in 33 years of balloon-borne instrumental measurements. However, scientists noted that ongoing declines in the atmospheric concentration of ozone-depleting chemicals (which are controlled by the Montreal Protocol) prevented the hole from being as large as it might have been under the same weather conditions twenty years ago.

> "*From the year 2000 peak, Antarctic stratosphere chlorine and bromine levels have fallen about 16 percent towards the natural level*," said Paul Newman, an ozone layer expert and the chief Earth scientist at NASA's Goddard Space Flight Center. "*We have a long way to go, but that improvement made a big difference this year. The hole would have been about a million square miles larger if there was still as much chlorine in the stratosphere as there was in 2000*."

This year represented a dramatic turnabout from 2019, when warm temperatures in the stratosphere and a weak polar vortex hampered the formation of polar stratospheric clouds (PSCs). The particles in PSCs activate forms of chlorine and bromine compounds that destroy ozone. Last year's ozone hole was the smallest since the early 1980s, growing to 16.4 Mkm^2 in early September.

> "*This clear contrast between last year and this year shows how meteorology affects the size of the ozone hole*," said Susan Strahan, a scientist with NASA Goddard and Universities Space Research Association. "*It also complicates detection of long-term trends*."



NASA Earth Observatory image by Joshua Stevens, using data courtesy of NASA Ozone Watch and GEOS-5 data from the Global Modeling and Assimilation Office at NASA GSFC.

Atmospheric levels of ozone-depleting substances increased up to the year 2000. Since then, they have slowly declined but remain high enough to produce significant seasonal ozone losses. During recent years with normal weather conditions, the ozone hole has typically grown to a maximum of 20 mkm^2 .

In addition to the area of the ozone hole, scientists also track the average amount of ozone depletion—how little is left inside the hole. On October 1, 2020, weather balloons launched from NOAA's South Pole atmospheric observatory recorded a low value of 104 Dobson units of atmospheric ozone. NASA's Ozone Watch reported a lowest daily value at 94 Dobson Units on October 6. Prior to the emergence of the Antarctic ozone hole in the 1970s, the average amount of ozone above the South Pole in September and October ranged from 250 to 350 Dobson units.

> "*The amount of ozone between 13 to 21 kilometres in altitude, as measured over the South Pole, has been close to record lows at several points this year. "It's about as close to zero as we can measure*," said Bryan Johnson, a scientist with NOAA's Global Monitoring Laboratory.

Still, the rate at which ozone declined in September was slower compared with 20 years ago, which is consistent with there being less chlorine in the atmosphere.

Giant Berg on Collision Course with South Georgia

European Space Agency

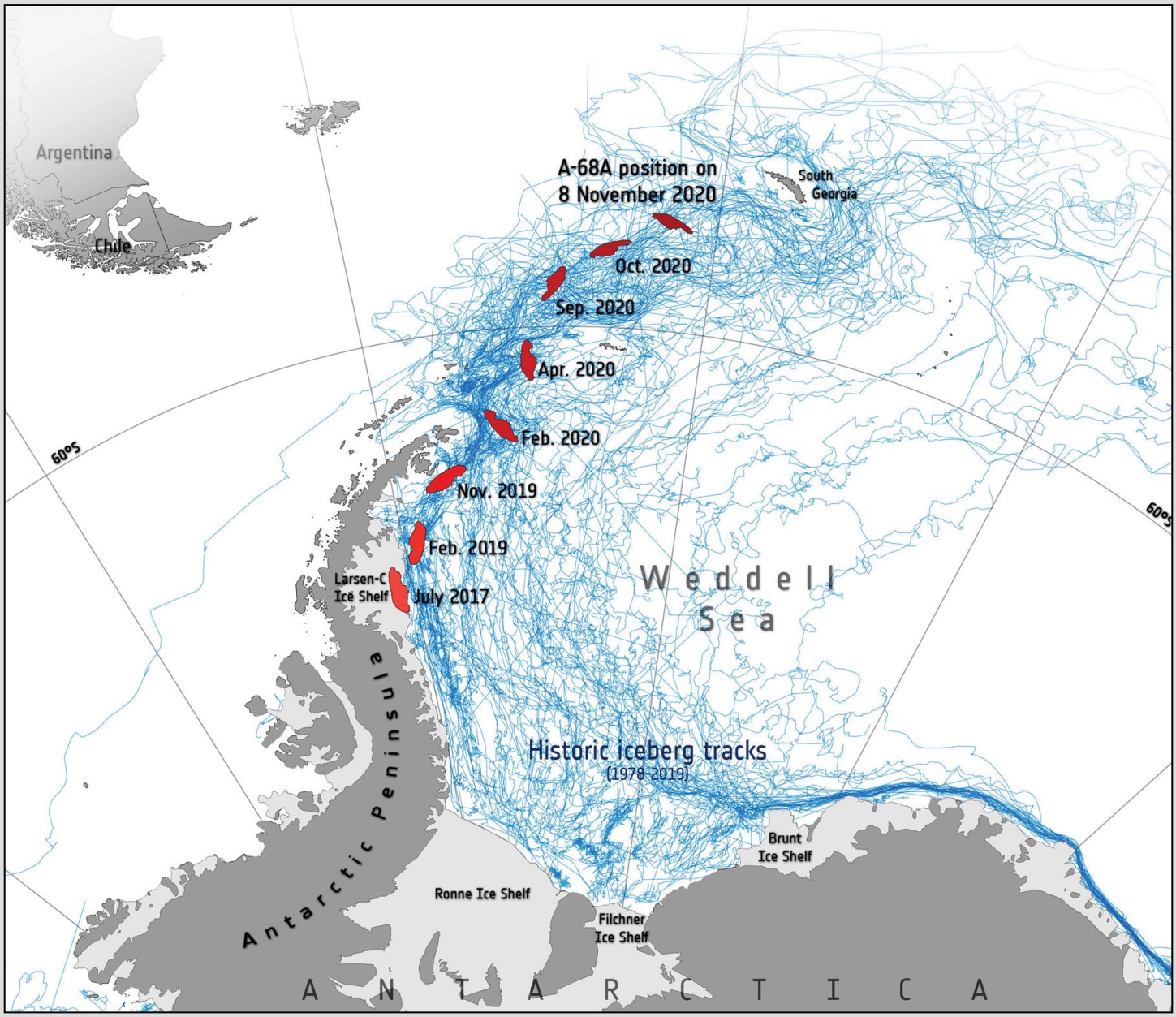


Image contains modified Copernicus Sentinel data (2017–20), processed by ESA; Antarctic Iceberg Tracking Database

The colossal iceberg that split from Antarctica's Larsen C ice shelf on July 12, 2017 is on a collision course with South Georgia.

Over the last three years, satellite missions such as Copernicus Sentinel-1 have been used to track the berg as it has drifted in the Southern Ocean. For the first two years it remained close to its parent ice sheet, impeded by sea ice. But now, as the map above illustrates, the main chunk of the A-68 berg, known as A-68A, is heading rapidly for South Georgia. It is now about 350 kilometres from the island.

About the same size as the South Atlantic island, it could ground in the shallow waters offshore and cause real problems for the island wildlife and sea-floor-dwelling life. Penguins and seals need access to the sea to feed, so the iceberg could easily block their foraging routes, and life on the sea floor could be crushed if the berg grounds. The fear is that if the berg does anchor against the South Georgia coast, it could remain there for up to 10 years. When iceberg A38 grounded here in 2004, many dead penguin chicks and seal pups were found along the shoreline.

The map includes historic iceberg tracks, based on data from a number of satellites including ESA's ERS-1 and ERS-2 as part of the *Antarctic Iceberg Tracking Database*, and shows that A-68A is following this well-trodden path. Hopefully, currents will take A-68A around South Georgia and off to the northwest, and eventually break it up.

Vatnajökull, Iceland

European Space Agency

ESA's Sentinel-2 mission captured this image of the Vatnajökull ice cap on July 6, 2019.
This image contains modified Copernicus Sentinel data (2019), processed by ESA

Covering an area of around 8400 square kilometres (km^2), which is three times the size of Luxembourg, Vatnajökull is not only classified as the biggest glacier in Iceland, but the biggest in Europe. With an average ice thickness of around 900 metres, the ice cap has about 30 outlet glaciers – many of which are retreating owing to warming temperatures. This summer time image of the ice cap was obtained on July 6, 2019.

The most prominent outlet glaciers of Vatnajökull include Dyngjujökull in the north, Breiðamerkurjökull and Skeiðarárjökull to the south. Vatnajökull conceals some of the most active volcanoes in the country, of which Bárðarbunga is the largest and Grímsvötn the most active. Periodic eruptions of these volcanoes melt the surrounding ice and create large pockets of water, which can often burst the weakened ice causing glacial floods, or 'jökulhlaup' in Icelandic.

During these jökulhlaups, the glacier's meltwater carries sediments and sands composed of ash to the coast. These outwash plains are called 'sandurs' and are commonly found in Iceland. Skeiðarársandur, the large area of black sand, visible south of the Skeiðarárjökull outlet glacier, covers an area of around 1300 km^2 and was formed as the glacial rivers in the area washed ash and ice towards the sea.

In the bottom-right of the image, on the southern side of Vatnajökull, the Jökulsárlón glacial lake, dotted with icebergs, is visible. Jökulsárlón began to form when the Breiðamerkurjökull glacier began retreating from the Atlantic Ocean owing to rising temperatures.

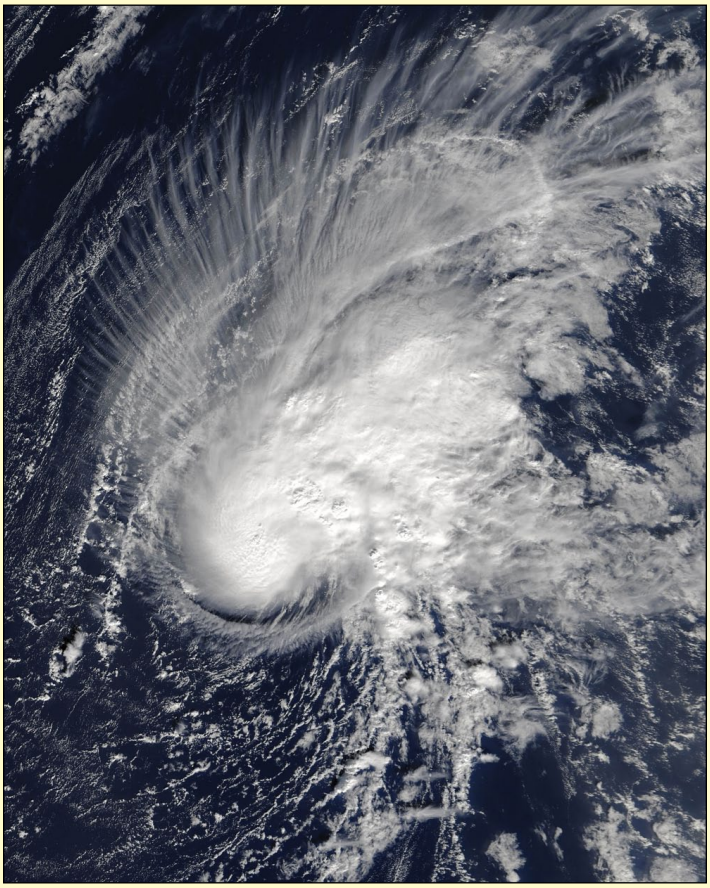
The lake has grown considerably over time because of the melting of the glacier. It now covers an area of around 18 km^2, and with a maximum depth of around 250 m it is considered Iceland's deepest lake. The lake connects with the ocean and is, therefore, composed of both seawater and freshwater—causing its unique colour.

Record Breaking Atlantic Hurricane Season

Les Hamilton

Hurricane Season 2005

For the first time, in 2005, the number of named storms in the Atlantic basin outstripped the official list, and letters of the Greek alphabet had to be pressed into service to extend the list of names. The 2005 hurricane season was also notable for stretching past the nominal end date to the very end of the year, when **Tropical Storm Zeta** was confirmed on December 30 of that year. Zeta was the record 28th named storm of 2005, a total that included no fewer than 15 hurricanes, also a record.

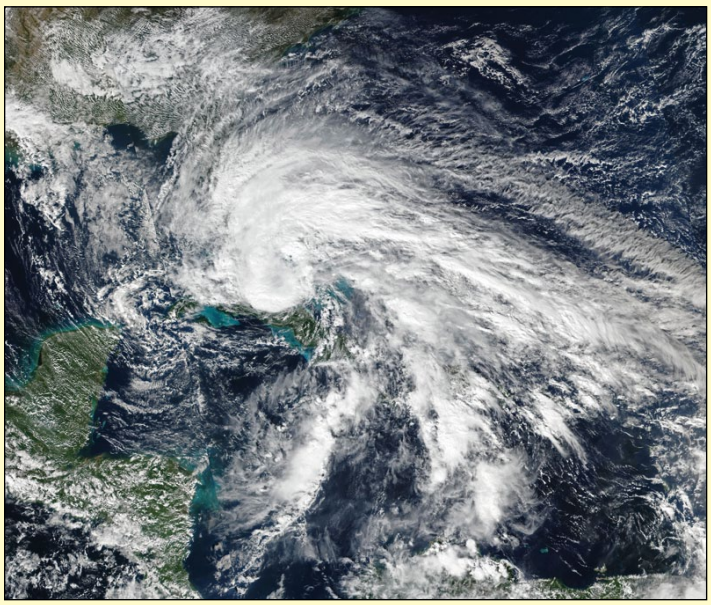


Tropical Storm Zeta at peak intensity in the open Atlantic on January 3, 2005
Image: Wikimedia / NASA

Hurricane Season 2020

The current hurricane season has broken all records. Whereas Tropical Storm Zeta was little more than an afterthought in 2005, forming as it did on December 30, this season's **Hurricane Zeta**, pictured on the front cover, formed a full two months earlier, in late October. It was already the 27th named storm of this season, and the 11th hurricane. Zeta hit Louisiana as a Category-2 hurricane with 170 kph winds which claimed six lives, disrupted power supplies to over two million consumers and produced heavy rain and a dangerous storm surge.

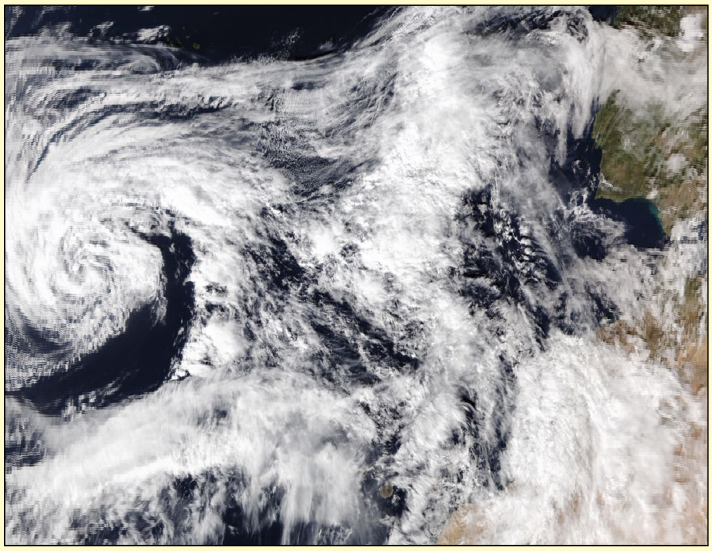
The 2005 record was soon equalled with the arrival of **Hurricane Eta**. This long-lived storm ravaged Nicaragua as a Category-4 hurricane on November 3 before



The Suomi-NPP satellite captured this image of Hurricane Eta making landfall on Florida on November 8, 2020
Image: NASA Worldview Snapshots

subsiding to tropical storm status over Cuba and then briefly strengthening to a Category-1 hurricane as it approached Florida on November 11. It was the first November storm to make landfall in Florida for 22 years, bringing torrential rain to the south of the state. Eta finally exhausted itself over the Atlantic Ocean on November 14. Hurricane Eta was, at the time, the second-most intense November Atlantic hurricane on record, behind only the Cuba hurricane in November 1932.

But records are made to be broken, and it was no surprise when, on November 10, **Tropical Storm Theta** developed southwest of the Azores in the eastern Atlantic, but well clear of land, to become the record-breaking 29th named storm of the year.

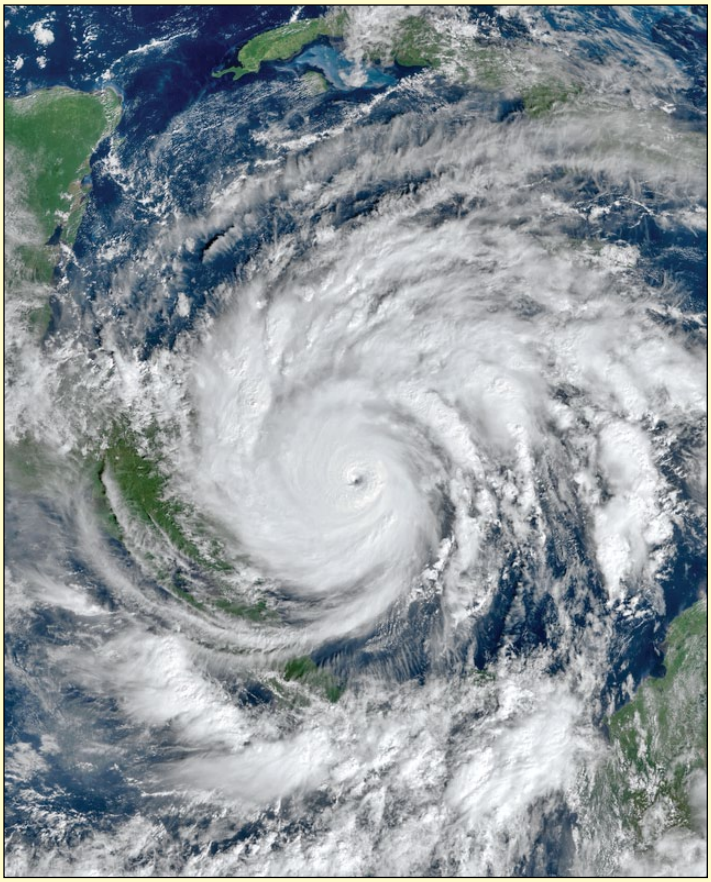


Tropical Storm Theta, imaged on November 11 by NOAA 20
Image: NASA Worldview Snapshots

And it didn't stop there! On November 16, **Hurricane Iota**, considered the most powerful storm ever to hit Central America, bore down on Nicaragua and Honduras as a Category 5 storm, with sustained winds of 260 kilometres per hour. Iota was the thirty-first tropical cyclone, thirtieth named storm, thirteenth hurricane, and sixth major hurricane of the record-breaking 2020 Atlantic hurricane season.

Iota was the only storm of the 2020 season to reach Cartegory-5, the highest status on the Saffir-Simpson Hurricane Wind Scale, and at one point strengthened from a Category-2 storm to a Category-4 major hurricane within the space of one hour, another record!

Hurricane Iota was the latest-season Atlantic hurricane ever known to attain Category-5 intensity, and only the second Category-5 hurricane ever recorded within the month of November—the other being the 1932 Cuba hurricane. Iota caused severe damage to areas of Central America already devastated by Hurricane Eta just two weeks previously. According to initial reports, more than 38 people died during floods and landslides caused by Iota, and nearly half million people in Guatemala and Honduras—189,000 of them children—were affected by this latest storm. The strong winds and heavy rainfall devastated crops, destroyed wooden buildings and ripped the roofs from structures, and tens of thousands of people were evacuated to government shelters for safety.



Hurricane Iota approaching Nicaragua on November 16, 2020
Image: NASA / Wikimedia

Naming Atlantic Storms and Hurricanes

Les Hamilton

Nowadays we are all familiar with the naming system for Atlantic Tropical Storms and Hurricanes: an alphabetic list of alternate girls' and boys' names that are applied in chronological order. But it wasn't always so! Early in the 20th century, only a few notable hurricanes were afforded informal names related to where they impacted, such as the 1928 *Okeechobee hurricane* and the 1938 *New England hurricane*.

It was not till 1953 that names originating from the *National Hurricane Center* came into force, initially based on phonetic alphabets, but the following year it was decided to employ a list of female names for tropical storms. Six such lists of names are currently maintained by the *Hurricane Committee* of the *World Meteorological Organization* and are used successively in a six-year rota.

Each alphabetic list consists of 21 names only, the letters Q, U X, Y and Z being deemed unable to support sufficient meaningful names, and since 1979, they have comprised alternate male and female names. Within the north Atlantic Ocean, names are assigned by the *National Hurricane Center* once a storm intensifies to tropical storm status (i.e., with sustained wind speeds of at least 39 miles per hour).

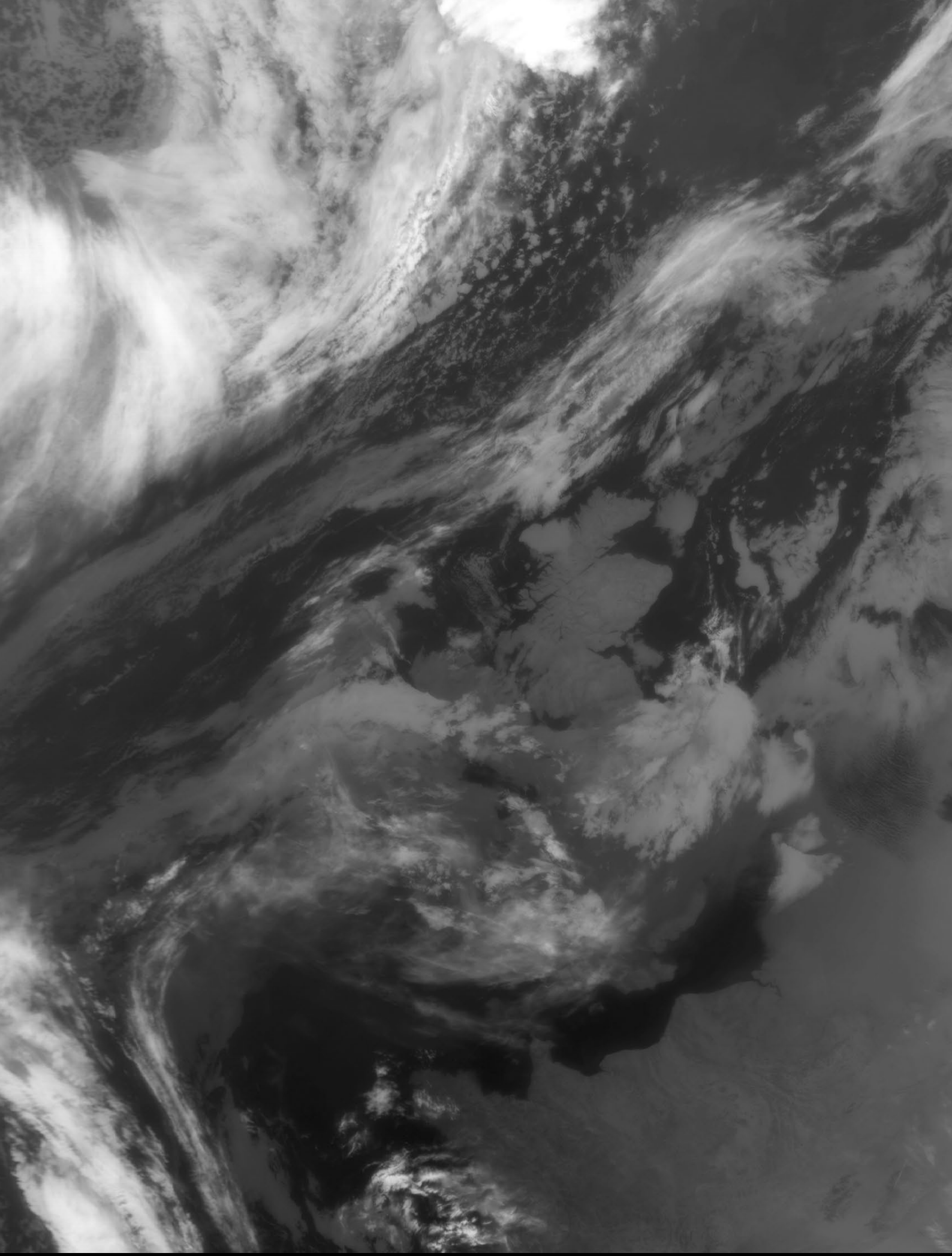
Until 2005 it had never been necessary to make use of all 21 names, but that year the list became exhausted as early as October 15 on the arrival of Hurricane Wilma a full month before the official end of Hurricane Season (June 1 - November 30). In the event, six further storms arose that year, invoking the contingency plan which uses the names of the letters of the Greek alphabet, culminating with Tropical Storm Zeta on December 30, to complete a then record total of 27 named storms for the calendar year.

Retired Names

Although the lists of storm names are intended to repeat in a six-year cycle, there are exceptions. Where a hurricane has proved particularly devastating, either because of the cost of damage incurred or the number of lives lost, its name is retired and replaced. The deadliest storm to have had its name retired was Hurricane Mitch, which struck Central America on October 29, 1998, dropping almost two metres of rainfall on Honduras, Guatemala, and Nicaragua, resulting in devastating flooding that claimed over ten thousand lives.

In August 2005, category-5 Hurricane Katrina had its name retired after causing over 1,800 deaths and $125 billion in damage in the city of New Orleans and its environs.

More recently, in August 2017, Hurricane Harvey, despite being only category-4, tied with Katrina when it hit Louisiana and Texas, also causing $125 billion of damage, primarily from catastrophic rainfall-triggered flooding in the Houston metropolitan area and southeast Texas.



With winter now starting to bite with widespread overnight frosts, infrared images from Meteor M2 become ever more interesting. This image was acquired from the 18.57 UT pass on November 30, 2020 and shows Scotland enduring its coldest night.

This Copernicus Sentinel-3 image acquired on September 10, 2020 shows the extent of the smoke plume over the western USA as close on a hundred wildfires burned in the states of Washington and Oregon.

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.