A Note from Pam Sullivan, GOES-R System Program Director:

2020 was an unforgettable year – for all the wrong reasons. Besides COVID-19 and social injustice, both of which affected the GOES-R/ GeoXO family, last year also brought a record-breaking Atlantic hurricane season and a record-smashing western wildfire season. As usual, our team rose to the challenge and delivered the mission. GOES-16 and GOES-17 continue to provide critical data to forecasters and GOES-T is in test preparing for a December launch. We're also planning for the future beyond GOES-R. We've renamed the mission Geostationary Extended Observations (GeoXO) to better reflect the advanced observations of atmosphere and ocean we plan for the GeoXO constellation. I look forward to the GeoXO Mission Concept Review in March and formalizing the program. I wish everyone a happy and healthy 2021. We have a lot to look forward to this year!

PROGRAM HIGHLIGHTS

GOES-16 (GOES-East) vigilantly monitored the record-breaking 2020 Atlantic hurricane season, providing critical information for tracking the storms and estimating intensity. In total, the 2020 season produced 30 named storms (top winds of 39 mph or greater), of which 13 became hurricanes (top winds of 74 mph or greater), including six major hurricanes (top winds of 111 mph or greater). This is the most storms on record, surpassing the 28 from 2005, and the second-highest number of hurricanes on record. 2020 is only the second year to use Greek letter storm names. The first was in 2005. Ten storms formed in September, the most in any single month on record. Twelve storms hit the U.S. coastline, five of which came ashore in Louisiana. View GOES-16 animation of the 2020 Atlantic Basin storms.
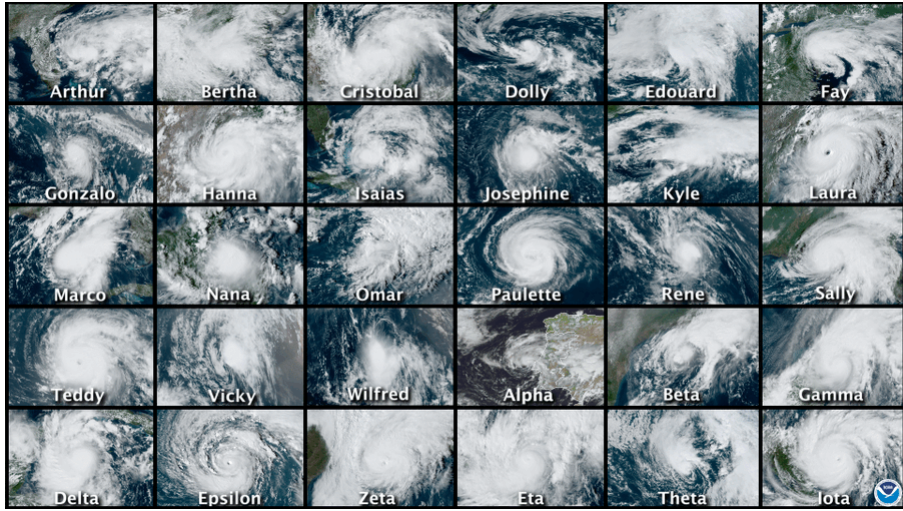
GOES-16 imagery of every named storm of the 2020 Atlantic hurricane season. Credit: NOAA

A new developmental GOES-16 atmospheric motion vector (AMV) product was demonstrated in real-time by the GOES-R AMV Algorithm Working Group during the 2020 Atlantic hurricane season. This product is derived using one-minute sequences of storm-targeted mesoscale-sector scans. The frequent multispectral image scanning from the Advanced Baseline

DID YOU KNOW? Two major hurricanes Eta and Iota, formed in November, marking the first time this has happened. Iota also attained Category 5 intensity on Nov. 16, making it the strongest storm to occur so late in the hurricane season.

Imager (ABI) meso-sector allows tailored algorithms to track rapidly-changing cloud features associated with hurricanes. The existing operational AMV algorithm was designed for tracking larger-scale atmospheric motions; the new mesoscale product telescopes down to the hurricane scales using novel techniques that provide dense wind observation coverage in the storm region. This data was used during the 2020 NOAA Hurricane Research Division hurricane field campaign. One mission into Hurricane Teddy observed the storm's rapidly expanding upper-level cloud field. GOES-16 mesoscale winds data were used to track this expansion in real-time to help direct the aircraft flights.
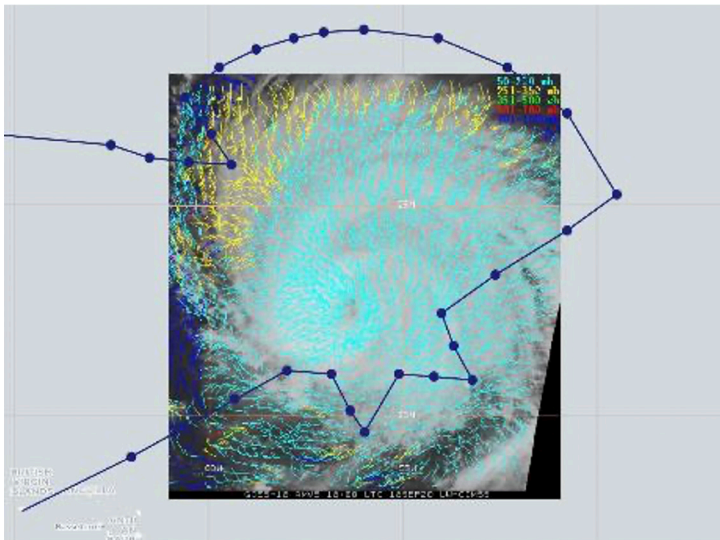
GOES-16 mesoscale winds data of Hurricane Teddy with NOAA G-IV flight track (blue line) and GPS dropsonde points (blue circles) overlaid. Credit: NOAA

GOES-T continues progress toward a December 2021 launch. End-to-end test #2 (ETE-2) was conducted in October and focused on thruster and instrument testing. During ETE-2, the operations team was located at the NOAA Satellite and Operations Facility (NSOF), while the spacecraft was in the thermal vacuum chamber at the Lockheed Martin facility in Littleton, Colorado. During the test, the operations team transmitted operational command sequences to the spacecraft and instruments and validated the telemetry responses. **GOES-T completed thermal vacuum testing in November**, which simulated the extreme temperatures of launch and the space environment. The spacecraft is now preparing for mechanical environments testing, which will take place in early 2021.

GOES-U development, testing and integration continue. The ABI radiator was delivered and integrated with the ABI instrument, and the Solar Ultraviolet Imager (SUVI) was delivered and integrated with the spacecraft. The Compact Coronagraph (CCOR)-1 instrument module is fully assembled and the first image was successfully taken. The Geostationary Lightning Mapper (GLM) completed electromagnetic interference testing, which ensures that it will not be damaged by electromagnetic radiation in space.

GOES-U SUVI telescope and electronics box installation. Credit: Lockheed Martin

The GOES-16 and GOES-17 Space Environment In-Situ Suite (SEISS) Magnetospheric Particle Sensors – Low Energy (MPS-LO) and GOES-16 SUVI data products reached full validation maturity, following a successful Peer Stakeholder-Product Validation Reviews. These products are now fully validated and operational.

GeoXO

Geostationary Extended Observations (GeoXO) has replaced Geostationary and Extended Orbits (GEO-XO) as the name of the future geostationary environmental satellites mission. The new name more accurately captures the expanded ocean and atmosphere observations recommended for the GeoXO constellation. A preliminary GeoXO webpage is now live with a mission overview and downloadable fact sheet.

The GeoXO User Requirements Working Group provided its recommendation for the GeoXO constellation. NOAA recommends real-time, high-resolution visible and infrared imagery as well as additional observations to address emerging environmental issues and evolving user needs. NOAA plans to incorporate day/night visible imagery, infrared sounding, atmospheric composition, and ocean color, as well as an improved lightning mapper in the GeoXO system, pending program approval. The recommended GeoXO observational

capabilities will support NOAA's Weather-Ready Nation, Healthy Oceans, Resilient Coasts, and Climate Science Mission Service Areas.

NOAA evaluated a range of space architecture options for delivering the recommended GeoXO observations effectively and efficiently. NOAA is currently planning, pending approval, a three-satellite GeoXO operational constellation. Spacecraft in the current GOES-East and GOES-West positions will carry the imager, lightning mapper, and ocean color instrument, and a centrally-located spacecraft will carry the sounder and atmospheric composition instrument. A day/night band is recommended as part of either the imager or the sounder. This constellation can also accommodate a partner payload on the spacecraft flying in the central location.

Recommended GeoXO Constellation
(Preliminary, pending program approval)

GEO-West
Visible/Infrared Imager
Lightning Mapper
Ocean Color

GEO-Central
Infrared Sounder
Atmospheric Composition
Partner Payload

GEO-East
Visible/Infrared Imager
Lightning Mapper
Ocean Color

The [Ocean Stakeholder Virtual Workshop](#) was held Nov. 17-20, 2020. More than 180 members of the ocean and ocean monitoring community who use NOAA's remote sensing data attended the workshop. Workshop session topics included ocean life, water quality, physical ocean properties, and planning and applications. Users discussed their needs in the areas of fisheries, aquaculture, habitat monitoring, coral reefs, oil spills/pollution monitoring, nutrient load and pathogen monitoring, microplastics and particulate loads, algal blooms, sea surface temperature, sea-level rise, ocean acidification, tides and currents, sea ice, resource management, marine weather and navigation, and storm surge and flooding.

An ocean color instrument in geostationary orbit will provide observations of ocean biology, chemistry, and ecology to assess ocean productivity, ecosystem change, coast/inland water quality, and hazards like harmful algal blooms. Credit: NASA

NASA released the [GeoXO Imager Phase A Study Request for Proposals](#) on Nov. 20, 2020. Industry was invited to submit a proposal for a definition-phase study of a geostationary imager instrument. Government evaluation of the proposals is now underway. The program expects to award study contracts in March 2021.
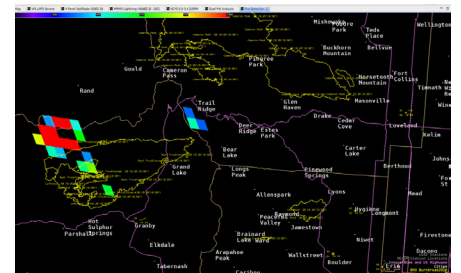
IMAGERY AND SCIENCE APPLICATIONS

A new resource, "[Beginner's Guide to GOES-R Series Data](#)," is now available to help new end-users acquire, analyze and visualize GOES-R data products. This toolkit includes an overview of GOES-R Series and data products, how to access data and imagery, how to display the data, and frequently asked questions.

VISUALIZE
with Python

GOES-16 full disk image of ABI L1b channel 3 radiances on May 29, 2020, visualized using Python. Credit: NOAA

On Oct. 22, 2020, National Weather Service (NWS) forecasters used GOES-16 imagery to alert emergency officials of the spread of the East Troublesome Fire in Colorado. [NWS forecasters in Boulder, Colorado were monitoring the fire hot spot in GOES-16 imagery and noted the apparent advancement of the fire east over the Continental Divide.](#) Forecasters alerted Rocky Mountain National Park (RMNP) dispatch, Laminar County officials, and NWS

GOES-16 fire power product with burn scar outlines (yellow) from NWS Boulder. Credit: NWS

IMAGERY AND SCIENCE APPLICATIONS (CONTINUED)

Central Region Headquarters. It was later confirmed that the fire had moved across the divide into western RMNP, showcasing how GOES imagery provides potentially life-saving decision support services.

A team from NOAA, the Cooperative Institute for Meteorological Satellite Studies (CIMSS), and academia published a case study that used the Kincade Fire to corroborate GOES-17 (GOES-West) ABI fire detection capabilities and their potential use in an operational context. The team analyzed ABI data from the 2019 Kincade Fire in California and compared it to observations

from the ALERTWildfire fire surveillance video system. They showed the fire's heat signature became evident in GOES-17 imagery 52 seconds after the ground-based cameras detected a heat source. This paper represents the first peer-reviewed examination of a very well-defined fire initiation time and GOES ABI detection of the fire.
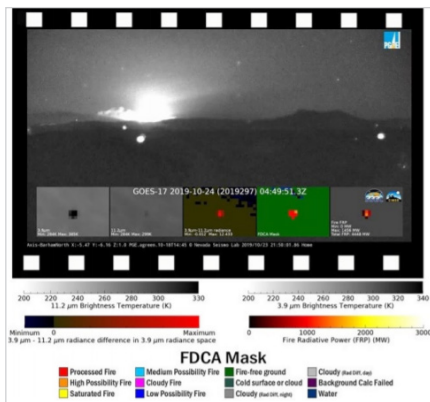
Image of the Kincade Fire ignition from the ALERTWildfire camera with corresponding GOES-17 3.9 µm, 11.2 µm, 3.9 µm-11.2 µm radiance, fire detection characteristics algorithm mask, and fire radiative power data. View animation of this imagery. Credit: SSEC

The World Food Program (WFP) is automated system to support their workers in the field who are affected by floods and other natural disasters using NOAA flood data products. During Hurricane Eta in Nicaragua, WFP produced a flood map using ABI and NOAA-20 Visible Infrared Imaging Radiometer Suite (VIIRS) data to support people on the ground responding to the humanitarian crisis.
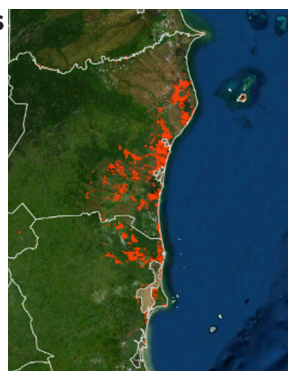
World Food Program flood map using NOAA Satellite data showing flooding from Hurricane Eta in Nicaragua. Credit: WFP

As severe weather events increase in frequency and intensity across the U.S. and around the world, scientists and forecasters are seeking more effective weather-mapping programs. Voice of America highlighted a virtual reality project underway at the University of Maryland on Nov. 10, 2020. Researchers are developing a weather-mapping program using 3-D virtual reality technology. This program, funded by NOAA, is hoping to make forecasting easier for meteorologists and lead to quicker and better decision making.

GOES-16 captured imagery of the largest iceberg in the world floating in the southern Atlantic Ocean over three weeks from Nov. 17 through Dec. 7, 2020. This imagery utilizes the day snow/cloud layers data product, which combines six different bands on the satellite's ABI to help distinguish clouds from snow and ice. Named A-68A, the iceberg was located about 130 miles off the island of South Georgia's coast. It originally broke off from the Larsen-C Ice Shelf in Antarctica on July 12, 2017. Later GOES-16 imagery showed that as the iceberg approached South Georgia Island, it rotated clockwise and followed the current parallel to the island. Its northern end then broke off on Dec. 18 (forming A-68D), followed by two more massive pieces that broke off (A-68E and A-68F) three days later.
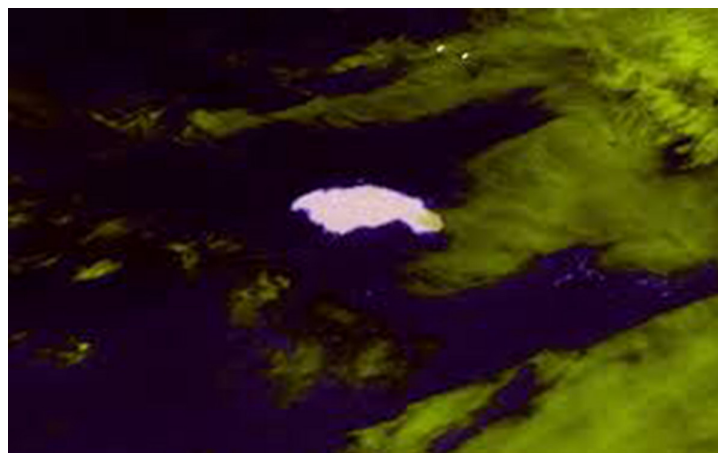
GOES-16 snow/cloud layers imagery of iceberg A-68A off the coast of the island of South Georgia. Credit: NOAA

EDUCATION AND OUTREACH

What are the different types of clouds?

Clouds are often one of the first things we notice when we look up into the sky. They're all made of water droplets or ice crystals, but they can take on many different appearances. Types of clouds include cumulus, altocumulus, cirrocumulus, altostratus, nimbostratus, and cumulonimbus clouds. A new video from NOAA SciJinks explains the different types of clouds and how they can help us predict the weather.

What are the different types of clouds? Credit: NOAA SciJinks

Some GOES history will be going on display at the Smithsonian's Air and Space Museum in Washington, D.C. Two instruments from the canceled GOES-Q satellite have been sitting in storage, collecting dust instead of weather data. GOES-Q was originally designed to be part of the GOES-N Series. However, because the existing satellites were performing well past their expected lifetimes, construction of the GOES-Q satellite was halted in 2002 after its flight imager and sounder were already manufactured. This year they were retired to the National Collection of the Smithsonian Institute.

Models of the GOES-N Series imager (left) and sounder (right) instruments that are located in the lobby of NOAA's Satellite Operations Facility (NSOF) in Suitland, Maryland. Credit: NOAA

NOAA SciJinks published two new resources for kids. The GOES-R activity book makes learning about weather and satellites fun with a variety of puzzles, coloring pages, and other activities.
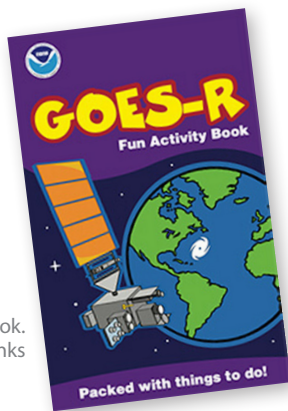
GOES-R fun activity book. Credit: NOAA SciJinks

An online scavenger hunt sends kids on a quest for weather knowledge. In this activity, students adventure between articles on the NOAA SciJinks website, learning all about Earth's many weather phenomena and gathering the missing words or phrases needed to assemble a secret word.

Throughout 2020, NOAA celebrated 50 years of science, service, and stewardship. As part of this milestone anniversary, NOAA's Satellite and Information Service looked back at 50 years of images from space. These images represent the whole spectrum of what Earth-observing satellites provide: life-saving weather information, essential atmospheric and environmental data, critical hurricane updates, near-real-time wildfire detection, and much more.
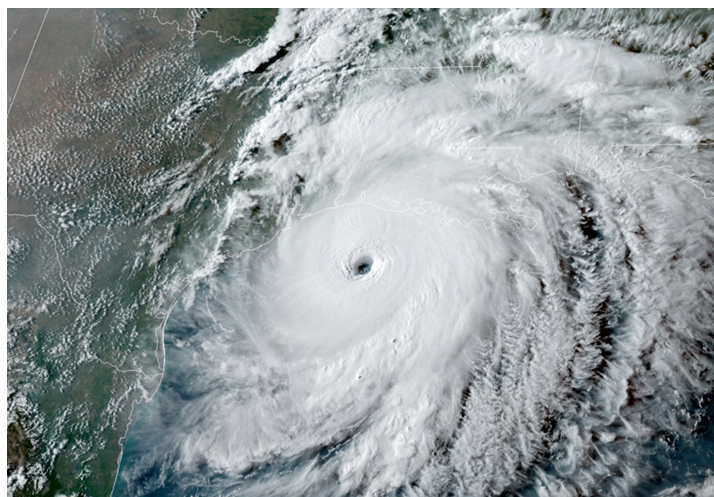
GOES-16 view of Hurricane Laura on Aug. 26, 2020. Credit: NOAA

AWARDS AND ACCOLADES

NOAA GOES-R civil servants were honored with the NOAA Administrator's Award for achieving a fully operational GOES-R constellation, culminating a decades-long effort to bring a new generation of NOAA satellites into service. Those honored include Gustave Comeyne, Kevin Fryar, Craig Keeler, Elizabeth Kline, Daniel Lindsey, Angela Michael, Stephen Schaeffer, Matthew Seybold, Pamela Sullivan, Monica Todirita, James Valenti, Christopher Wheeler, John Tsui, Victor Kalu, Charles Bryant, Gregory Johnson, Jaime Daniels, Scott Rudlosky, Fred Wu, Timothy Schmit, Robert Redmon, Gregory Mandt, Nicolaie Todirita,

Timothy Walsh, Ida Hakkarinen, Mike Stringer, and David Zehr. The NOAA Administrator's Awards recognize employees who have demonstrated exceptional leadership, skill, and ingenuity in their significant, unique, and original contributions that bring unusual credit to NOAA, the Department of Commerce, and the Federal Government.

Scott Rudlosky received the Department of Commerce Silver Award for scientific/engineering achievement. Scott was recognized for his leadership in the development, validation, and implementation of the first-ever GOES-R GLM data products. From pre-launch

algorithm development through post-launch validation to user training, Scott has been instrumental in realizing the benefits of GLM to improve forecasting.

Hugh Christian was named a 2020 American Geophysical Union (AGU) Fellow. Hugh was honored for pioneering space-based lightning mapping instruments (including the GOES-R GLM) and advancing knowledge of atmospheric and space electricity. His early space-based lightning studies produced the first global maps of lightning activity and its seasonal and regional variations. The AGU Fellows program recognizes members who have attained scientific eminence in the Earth and space sciences for achieving a breakthrough, discovery, or innovation in their field.

MEET THE TEAM

In this issue, meet Mike Grotenhuis, the GOES-R Magnetometer instrument systems engineer. With the switch to the Goddard Magnetometer (GMAG) for GOES-T and GOES-U, Mike has been focused on GMAG flight model 1 and 2 development, testing, and delivery, including measuring their pre-launch performance, ensuring they meet instrument specification and interface requirements, and participating in satellite-level integration and testing as well as anomaly resolution. Mike was recently honored as both the GOES-R outstanding team member for the fourth-quarter fiscal year 2020 and the 2020 GOES-R outstanding team member of the year for his contributions to GMAG development and testing.

Stressing the importance of space weather data, Mike explains, "Nearly all of our electrical infrastructure, including our electrical grid, cell phones, and GPS is susceptible to the high energy particles and radiation emitted by the sun. Just like meteorologists forecast our terrestrial weather and provide warnings when it becomes dangerous, the NOAA Space Weather Prediction Center uses the information from spaceborne instruments to predict and provide warnings for space weather. The magnetometer is particularly useful for detecting the onset of geomagnetic storms."

Mike's favorite part of his job is analyzing instrument data. "When my analysis is used to improve instrument performance or characterize and respond to anomalies, it is particularly fulfilling," said Mike. With the GOES-T launch coming up in December, Mike looks forward to the on-orbit calibration and performance of the new GMAG instrument.

Mike holds a Bachelor of Arts in physics from Cornell University and a Master of Science in physics from the University of Minnesota – Twin Cities. Mike and his wife like to spoil their two Jack Russel Terriers with many walks and hikes. Mike also enjoys playing cards, particularly poker.

UPCOMING EVENTS

GOES-T Mission Rehearsal 1
Feb. 8-12, 2021

GeoXO Mission Concept Review
March 23-25, 2021

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