



GOES-R and GeoXO

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A note from Pam Sullivan, GOES-R /GeoXO system program director:



It was, as ever, a busy quarter for us. The GOES-R ground system server replacement effort concluded and we awarded the follow-on

ground sustainment contract. We continued environmental testing of the GOES-U satellite and the mission integration efforts with the Falcon Heavy launch vehicle. On the GeoXO front, work on the imager development contract began and we finished the remaining Phase A Studies. The departures of 30+ year GOES alumni John Fiorello and our longtime DPM Ed Grigsby, and the sadly too-soon passing of our Review Manager Jonathan Gal-Edd are reminders to value and enjoy the colleagues and friends we make along the way. Thank you for your efforts in making our program a welcoming team. I hope you all can take some time off to enjoy the summer.

GOES-R PROGRAM HIGHLIGHTS

GOES-U completed a successful test deployment of its solar array to ensure it will function correctly in space. [This critical test verified that the satellite's large, five-panel solar array — which is folded up when the satellite is launched — will properly deploy when GOES-U reaches geostationary orbit.](#) GOES-U's solar array will convert energy from the sun into electricity to power the entire satellite, including the instruments, computers, data processors, sensors, and telecommunications equipment.



The GOES-U solar array fully deployed. Photo credit: Lockheed Martin

DID YOU KNOW:

Wildfires started by lightning account for more than half of the acreage burned in the U.S. The GOES-R Geostationary Lightning Mapper (GLM) gathers lightning strike data that can be used to inform emergency personnel about potential wildfires.

GOES-R PROGRAM HIGHLIGHTS (CONTINUED)

The GOES-R ground system server replacement effort, begun in 2016, is now complete. The replacement of IBM servers with Dell servers resolved a significant IT security vulnerability. As part of the effort, the team implemented virtual servers, which reduced the overall number of servers from ~1200 to ~700.



An L3Harris team member tests new server equipment at the Consolidated Backup. Photo credit: L3Harris

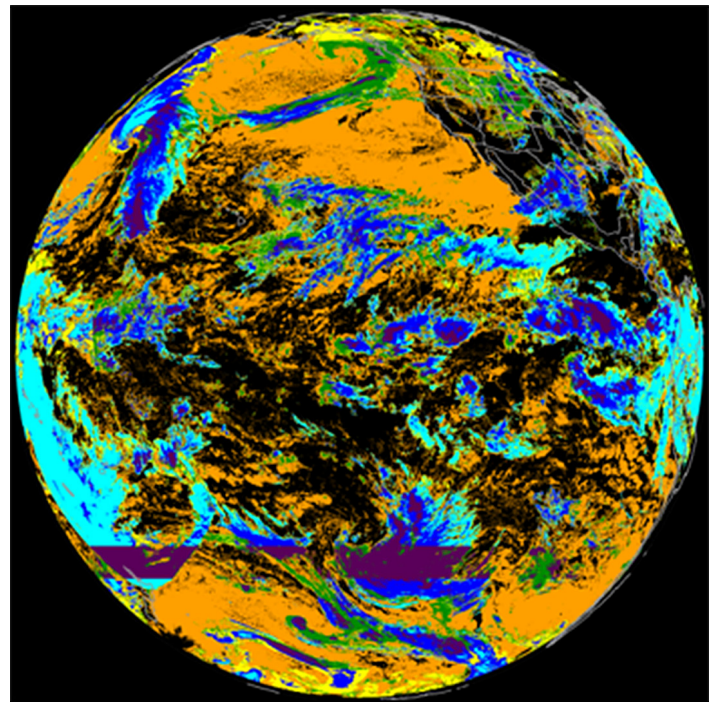
A new study shows the immense value of GOES-R Series data. The Aerospace Corporation recently completed a "GOES-R Socioeconomic Benefits Study" in two phases (May 2021 and December 2022, respectively). The goal of the study was to demonstrate a dollar value of selected GOES-R Series data from 2018 to 2040. In phase 1, the team assessed the aggregated present [value of GOES-R Advanced Baseline Imager \(ABI\) data to selected hurricane forecasting attributes](#) to be \$8.36B (2020 dollars) in benefits from improved hurricane forecasting to the U.S. hurricane-endangered public. In phase 2, the team made a more approximated, heuristic assessment of a wide range of products and service areas including wildfires, winter storms, flash flooding, severe thunderstorms and tornadoes, drought, general public forecasts and warnings, air quality, aviation weather, search and rescue, GOES-R Data Collection System, and climate policy. They assessed a value range of \$20B to \$50B over the GOES-R lifetime, which is well over the life cycle cost of the ~\$11B system. This pioneering study opens the way for more in-depth analyses. The phase 2 report is physically available to the public at the NASA Headquarters library in Washington, D.C., and will be electronically available later this summer.

On May 11, 2023, NOAA awarded the Geostationary Ground Sustainment Services (GGSS) contract to L3Harris Technologies Inc. of Palm Bay, Florida. [The five-year contract will provide sustainment services to extend the functions of the ground system that supports NOAA's GOES-R Series.](#)



GGSS team celebrates the award of the sustainment contract. Photo credit: GOES-R Program

The GOES-16 and GOES-18 ABI cloud cover layers data products achieved provisional validation on May 16, 2023. Provisionally-validated data are ready for operational use but are not fully validated. These data products are now available to the broader user community.



GOES-18 cloud cover layers data product. Image credit: NOAA

GOES-R PROGRAM HIGHLIGHTS (CONTINUED)

GOES-U end-to-end (ETE) test 3b was conducted on May 25-26, 2023. The operations team, located at the NOAA Satellite and Operations Facility (NSOF) in Suitland, Maryland, transmitted operational command sequences to the GOES-U spacecraft and instruments, located at the Lockheed Martin facility in Littleton, Colorado, and validated the responses. ETE tests validate the compatibility between the flight and ground systems in a mission operations context. ETE 3b focused on encryption, storage mode, and completing the testing of Compact Coronagraph commands.

The ground system team conducted a successful first GOES-U Ground Readiness Exercise (GRE) on June 5-9, 2023. GRE-1 demonstrated four-satellite ground system operations with the focus primarily on GOES-U. The exercise

confirmed the ground system, work processes, and staff are capable of performing four-satellite operations.

On June 14, 2023, the GOES-U team conducted the first of several Countdown Readiness Tests (CRTs), using the spacecraft simulator at Lockheed Martin in Colorado.

CRT-1 represents the initial trial run of new procedures developed for GOES-U, incorporating adjustments to account for SpaceX Falcon Heavy launch processing.

The SpaceX GOES-U Mission Specific Critical Design Review (MSCDR) was held on June 15, 2023. The MSCDR confirmed the SpaceX Falcon Heavy launch vehicle design meets final performance and interface specifications, safety requirements, and mission objectives and can now proceed into the systems acceptance phase.

GeoXO PROGRAM HIGHLIGHTS

GeoXO spacecraft, Lightning Mapper (LMX), Atmospheric Composition (ACX) and Ocean Color (OCX) Phase A Studies are complete. These definition-phase studies will help design the GeoXO spacecraft and instrument concepts, mature necessary technologies, and help define potential performance, risks, costs, and development schedule. The results of the studies will be used to set performance requirements for the development contracts.

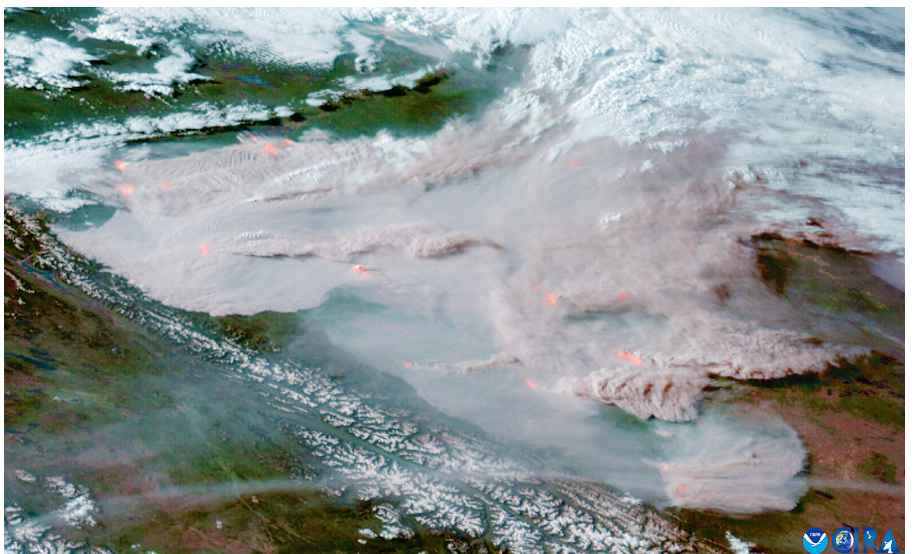
The National Telecommunications and Information Administration (NTIA) Spectrum Planning Subcommittee approved the GeoXO Stage 1 spectrum

filing in April 2023. In Stage 1, the initial planning effort is complete, including proposed frequency bands and other available characteristics. NTIA manages the federal government's use of spectrum, ensuring that America's domestic and international spectrum needs are met while making efficient use of this limited resource.

The GeoXO Program Management Plan was approved in April 2023. The plan defines the goals and objectives of the program, the environment within which the program operates, and the management agreement commitments of the program, including identifying the high-level requirements of both the program and each constituent project.

IMAGERY AND SCIENCE APPLICATIONS

Unusually hot and dry weather triggered an early and intense start to the wildfire season in Canada. In early May 2023, fires ignited across western Canada. [GOES-18 \(GOES West\) monitored the spread of the fires and smoke and observed the formation of pyrocumulonimbus clouds from intense fires in Alberta.](#) In early June, [thick smoke from fires in Ontario and Quebec moved into the eastern U.S.,](#) triggering air quality alerts across the region. Historically high fine particulate concentrations were detected across the Northeast and Mid-Atlantic. GOES-16 (GOES East) tracked the billowing smoke and [monitored air quality](#) in near real-time. Canada is on track to have the worst wildfire season on record and smoke from the fires continues to affect regions of the U.S.



GOES-18 observed hot spots and thick smoke from wildfires burning in Alberta, Canada, on May 15, 2023. Image credit: NOAA/CIRA

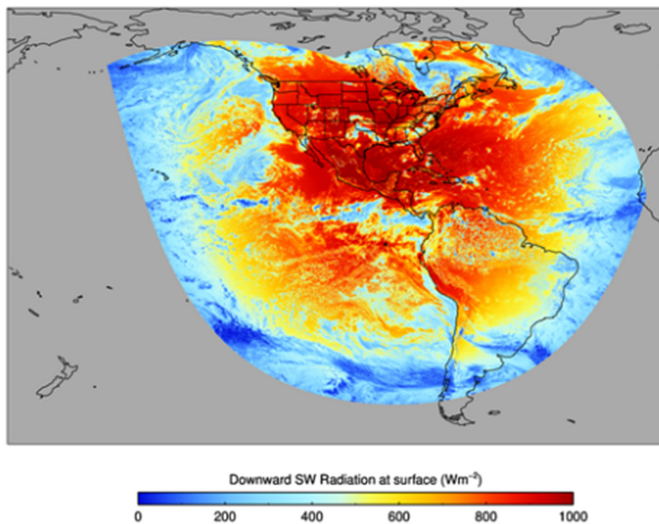
IMAGERY AND SCIENCE APPLICATIONS (CONTINUED)

The GOES-R and Joint Polar Satellite System (JPSS) Hazardous Weather Testbed 2023 Spring Experiment was conducted from May 22 through June 16, 2023.

During the experiment, GOES-R and JPSS products and capabilities were demonstrated within a simulated warning operations environment, with National Weather Service (NWS) forecasters as the primary evaluators. The exposure to GOES-R and JPSS data products and capabilities during the height of the spring severe weather season provided forecasters and scientists an opportunity to evaluate the utility of a number of new data products.

GOES-R and GeoXO are featured prominently in the 2022 NOAA Satellite and Information Service (NESDIS) Science Report, published on May 30, 2023. The [report](#) showcases the GOES-T launch and the first data and imagery from GOES-18 as well as many uses of GOES-R data, including improved estimates of wildfire smoke and air quality predictions, enhanced flood inundation mapping and forecasting, support for coral health forecasts, drought monitoring, and the use of machine learning to improve observational capabilities. The report also looks forward to the new technology and scientific advancements GeoXO will provide for weather forecasting, and monitoring environmental hazards, air quality, and ocean health.

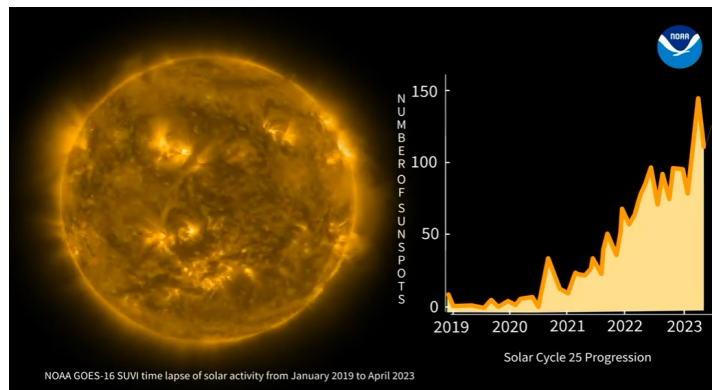
2022.07.21 G16/G17 ABI DSR at 18:00 UTC



Instantaneous downward shortwave radiation at the surface as estimated from the GOES-16 and GOES-17 satellites on July 21, 2022 and highlighted in the 2022 NESDIS Science Report. This data is used to support coral health forecasts and drought monitoring. Image credit: NOAA

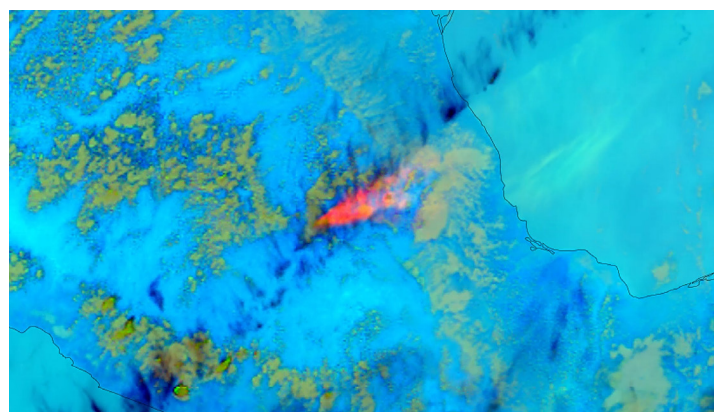
Solar Cycle 25 has ramped up much faster than scientists predicted, producing more sunspots and eruptions than experts had forecast. Tracking and predicting the sun's solar cycles gives a rough idea of the frequency of space weather storms of all types – from radio blackouts to geomagnetic storms and solar radiation storms – and it's used by many industries to gauge the potential impact of space weather on Earth. [A new time lapse](#)

[animation shows GOES-16 Solar Ultraviolet Imager \(SUVI\) imagery during Solar Cycle 25 from December 2019 through April 2023 alongside the progression of the number of sunspots.](#) SUVI images the solar corona in six different extreme ultraviolet wavelengths. NOAA's space weather forecasters use SUVI imagery to issue alerts and watches for space weather storms.



GOES-16 SUVI imagery alongside the progression of the number of sunspots from December 2019 through April 2023. Image credit: NOAA

In May 2023, GOES-16 monitored the eruption of Mexico's Popocatepetl Volcano. Popocatepetl, Aztec for smoking mountain, is located 45 miles southeast of Mexico City. With about 25 million people living within 60 miles of Popocatepetl, it is considered one of the most dangerous volcanoes in the world. Geostationary satellites like GOES-16 and GOES-18 are the primary tool for monitoring volcanic clouds. [GOES-16 observed Popocatepetl's ash plumes in near real-time and monitored hazardous sulfur dioxide from the eruption.](#)



GOES-16 ash RGB (red-green-blue) imagery of the Popocatepetl eruption. The ash plume is pink in this type of imagery. Image credit: NOAA

Can Lightning Research Improve Hurricane Intensity Forecasts? [NESDIS published a Q&A with Dr. Stephanie Stevenson on June 2, 2023.](#) Stevenson is a meteorologist at the NOAA/NWS National Hurricane Center (NHC) in Miami. Through her ground-breaking research and efforts, new applications using GOES-R GLM data are being used as guidance for NHC forecasts as well as in media and decision-support briefings.

IMAGERY AND SCIENCE APPLICATIONS (CONTINUED)

A new feature from NOAA explains how the study of lightning went from earthbound to a bird's eye view. Tools and techniques for lightning detection have come a long way since Benjamin Franklin tested his lightning rod, [shifting our view of this powerful severe weather phenomenon from the ground to the sky](#). Satellites have allowed us to detect and map lightning storms like never before – from space. The GOES-R GLM is the first optical lightning detector on a satellite in geostationary orbit. NOAA began using the GLM in March 2017. In July 2018, the NWS started including its data in operational weather forecasts.

On June 21, 2023, the NASA Marshall Star highlighted the center's work in building cutting-edge instruments to study the science of lightning and improve safety. [The article features the work GOES-R/GeoXO senior science advisor Steve Goodman and others have done to place a](#)

[lightning mapper in geostationary orbit](#). The NASA Marshall team contributed to the GLM aboard the GOES-R Series. GLM is based on the design heritage of pathfinder Marshall instruments. The lightning mapper design concepts are also being used by European and other space agencies for their operational geostationary lightning mappers. The article also highlights the work the NASA Short-term Prediction Research and Transition Center (SPoRT) is doing to develop applications to predict when lightning will strike, using GLM data and machine learning. Recently, due to the tight relationships between lightning and other key phenomena such as severe storms, fires, aerosols, and precipitation, the World Meteorological Organization and the Global Climate Observing System declared lightning as an essential climate variable, deeming lightning measurements more valuable than ever before.

EDUCATION AND OUTREACH

The GOES-R Program, in partnership with JPSS, NESDIS, NASA Goddard Space Flight Center, and the Cooperative Institute for Research in the Atmosphere (CIRA) produced nine "Earth from Orbit" videos during this quarter. [Earth from Orbit](#) is a series of short videos that showcase a compelling weather event, environmental hazard, or interesting meteorological phenomenon, as seen by NOAA satellites. A web article with additional information accompanies each video.

The Cooperative Institute of Meteorological Satellite Studies (CIMSS) at the University of Wisconsin-Madison announced the winning projects for the 2023 GOES Virtual Science Fair on May 26, 2023. During the [virtual science fair](#), middle and high school students (grades 6-12) worked with GOES satellite data to investigate weather and natural hazards and conveyed their projects with scientific posters. High school submissions also required a short video where students explain their project, similar to a poster session at a professional conference. By offering authentic STEM (science, technology, engineering and math) engagement to a pre-college audience, this activity serves as a pipeline to society's scientists of tomorrow and NOAA's future workforce.



Earth from Orbit: Happy Earth Day 2023. Image credit: NOAA

NOAA SciJinks, in partnership with the GOES-R Program, published two new educational posters. ["What Causes a Tornado?"](#) explains what atmospheric conditions are necessary for a tornado to form, how these storms develop, how they are measured, and how GOES-R satellites help forecasters issue tornado warnings. ["What is the Jet Stream?"](#) explains jet streams and how they impact weather, air travel, and many other things that take place in our atmosphere. The posters are companion pieces to videos and web articles on the same topics.

Verifying Flash Flood Advisory Boundary Locations using GOES-16 ABI Imagery: A Case Study of Tropical Storm Beta (2020)

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ABSTRACT

With an increasing amount of severe flash floods worldwide, meteorologists are seeking more efficient and accurate ways to issue warnings to populations. Despite the increasing coverage of Doppler radar networks, large parts of the world still lack these valuable instruments to track storms and measure precipitation rates. Although satellite products to calculate precipitation rates in these areas including the GOES Rainfall Rate/Quantitative Precipitation Estimation product do somewhat assist meteorologists in determining flash flood advisory boundaries, this study focuses on an extrapolation-based method to determine relative rainfall amounts. This is fueled by the growing presence of weather stations on the ASOS network worldwide. Based on satellite data at an ASOS station with a known amount of rainfall, we can determine whether flash flood conditions are occurring at a nearby location. In this study, we explored the correlations of GOES ABI data with rainfall totals over a one-hour period. This can compound and serve as verification for traditional radar-based estimates. Using imagery from GOES-16 ABI bands, I examined a situation in the Houston metropolitan area with two nearby ASOS stations with a significant difference in one hour rainfall.

RESEARCH QUESTION

How can GOES ABI data be used to detect flash flood conditions and determine boundaries for flash flood advisories?

METHODS and DATA

- Tropical Storm Beta made landfall near the Mississippi Peninsula on the SE Texas Coast on September 21, 2020, prompting the issuance of several flash flood warnings in the Houston metropolitan area.
- The resultant rainfall patterns caused some locations to experience significantly more flash flooding than others.
- In this study, a 1-hour period from 15:00 to 16:00 UTC was examined, in which Hobby Airport (PHOU) received 1.1 in of rain, while nearby Sugarland Airport (KSGF) received only 0.20 in.
- Band 13 (10.3 μm) shows a significant correlation between the one-hour average value of satellite radiance and rainfall that fell in an area.
- The band was selected for I can provide an estimation of relative intensity of convection and effectively differentiated between the rainfall in the two airports.
- Band 10 (12.2 μm) verifies the scale provided by band 13, showing a clear boundary between areas of heavier and lighter rainfall.
- Although band 10 can indicate colder clouds and more intense storms than what is presented, this is irrelevant due to the small scale of the study (the viewing angle of the satellite is uniform throughout the area).
- Band 2 (6.4 μm) also displays higher intensity rainfall occurring at PHOU with an area of rainfall at KSGF.
- However, the reflective nature of band 2 makes this a secondary band to use for verification due to the general cloud cover in tropical storm conditions (resulting in more uniform reflectance compared with the rapidly transitioning clouds within the Houston wet season).

RESULTS and CONCLUSIONS

- GOES imagery can provide effective verification for radar-based flash flood warnings.
- ABI bands, such as Band 13 (10.3 μm) provide intensity information and allow for identification of clear boundaries.
- When radiance data is averaged over one hour, there is a inverse correlation between rainfall totals and radiance.

- GOES had higher radiance values for the entire period observed, verifying the lower rainfall total that was recorded by the KSGF ASOS station.
- Similar trends were visible in bands 2, 10, and 11.
- In addition to using this data to verify flash flood advisory data, imagery can improve warning accuracy in areas that lack radar infrastructure.
- The accuracy of flash flooding is increasing globally, and it is simply not possible to let us weather radar in some locations.
- GOES imagery is a useful tool for detecting flash flood conditions and verifying flash flood advisory boundary locations.

References

NOAA Weather and Climate Watch
GOES-16 ABI Data
NOAA Science and Technology Center for Severe and High Impact Weather Research and Forecasting
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2023 top GOES high school project: Verifying Flash Flood Advisory Boundary Locations using GOES-16 ABI Imagery: A Case Study of Tropical Storm Beta (2020). Image credit: CIMSS

EDUCATION AND OUTREACH (CONTINUED)

A new immersive augmented reality (AR) app from GOES-R and JPSS is now available. Learn about the NOAA satellites that monitor extreme weather by completing a series of missions. Play at home or play the app's six challenges at the NASA Goddard Visitor Center! [WeatherSats AR](#) is available for download to mobile devices from the Apple and Google app stores.



WeatherSats AR app promotional image: Image credit: NOAA/JPSS

On June 21, 2023, NASA held a ribbon-cutting ceremony for its new Earth Information Center at NASA Headquarters in Washington, D.C. [The center is part physical space and part virtual experience](#), which shows how NASA data can improve lives in the face of disasters,

environmental challenges, and our changing world. NOAA is one of NASA's partners in the [Earth Information Center](#), along with FEMA, EPA, USAID, USDA and USGS. The Earth Information Center draws data from research conducted by NASA's centers and government and industry partners. GOES GeoColor imagery is featured in the "Earth Now" section of the exhibit.

In June 2023, the American Meteorological Society Committee on Satellite Meteorology, Oceanography, and Climatology conducted a virtual short course titled "NOAA Environmental Satellite Enterprise: Applications and Opportunities." The [short course](#), primarily designed for undergraduate and graduate college students, was conducted in the form of three training sessions on June 22, 27, and 29. Two of the training sessions, *Monitoring global lakes and reservoirs using multi-satellite observations*, and *Monitoring and predicting the opening of the Northwest Passage* provided hands-on experience for applying environmental satellite data products to a range of environmental conditions encountered in both operations and research. The final session provided an opportunity for participants to hear personal experiences about the career pathways of several professionals employed in different parts of the environmental satellite enterprise.

CONFERENCES AND EVENTS

The TEMPO (Tropospheric Emissions: Monitoring of Pollution), GeoXO ACX (Atmospheric Composition Instrument), and TOLNet (Tropospheric Ozone Lidar Network) programs held a joint science meeting on May 1-5, 2023, at the University of Alabama in Huntsville. The theme of the meeting was "Building the Pathway from TEMPO to GeoXO." The [joint meeting](#) brought together the science teams to facilitate the coordination and long-term planning of air quality observations over North America from geostationary Earth orbit. Hourly trace gas and aerosol data from the TEMPO and GeoXO ACX missions are set to significantly advance our capabilities to understand, monitor, and predict air quality, weather, and climate over the next few decades.



ACX science team members at the TEMPO/TOLNet/ACX joint science team meeting. Photo credit: NOAA

GeoXO team members attended the 2023 NOAA CoastWatch annual science meeting in Honolulu, Hawaii, on May 22-25, 2023. GeoXO System Program Director Pam Sullivan presented an overview of the next-generation GeoXO mission and OCX instrument and members of the program met with future users of OCX to better understand the applications and user needs and discuss user readiness activities. This year's CoastWatch meeting emphasized concerns that are unique to the Pacific Islands region and highlighted the potential for collaborative efforts.



NOAA CoastWatch annual science team meeting attendees. Photo credit: NOAA

CONFERENCES AND EVENTS (CONTINUED)

Members of the GeoXO Program attended the 3rd International Operational Satellite Oceanography Symposium, held June 12-16, 2023, in Busan, South Korea. The symposium focused on engaging users on requirements and priorities, demonstrating the use of satellite data in coupled numerical models and emphasizing socio-economic benefits from Earth observation. It provided an opportunity for GeoXO to meet users and gather information to inform GeoXO ocean color capabilities and applications.

Arizona State University (ASU), in coordination with NOAA/NESDIS, conducted a two-day air quality tabletop

exercise on June 14-15, 2023, in Phoenix, Arizona. The event brought together decision-makers from the city, county, state, and federal levels as well as experts specializing in air quality and remote sensing. The exercise examined how stakeholders currently use—and can use in the future—NOAA data, products, and services to identify threats and hazards, determine risk, develop decision-making thresholds, and implement timely air quality actions and warnings to inform the public and reduce negative health impacts. This tabletop allowed the GeoXO Program to engage with air quality users and decision-makers to help inform data products that will be available from the GeoXO ACX instrument.

AWARDS

GEO ground system assistant project manager Lili Alvarado received a 2023 Women of Color Technology All-Star Outstanding Achievement Award in June 2023. Technology All-Stars are accomplished women of color from mid-level to advanced stages of their careers that have demonstrated excellence in the workplace and in their communities. Lili will be honored at the Technology Recognition Event during the [2023 Women of Color STEM Conference](#) in Detroit, Michigan, on Oct. 13, 2023.

On July 6, 2023, NASA recognized the following team members with Robert H. Goddard Honor Awards for their achievements:

Leadership

■ Candace Carlisle

Professional Administrative

■ Heather Matthews

Robert H. Goddard Award of Merit

■ Stephen Schaeffer

■ Joanna Joiner

MEET THE TEAM



In this issue, meet Daniel Gillies, the new GOES-R and GeoXO deputy program systems engineer (PSE).

His job involves the integration of requirements across all elements of the program – from flight and ground to IT and operations. PSE is there to ensure we meet our program commitments.

Daniel joined the team in February 2023 from NASA Headquarters, where he was working on the Small Spacecraft Technology and Flight Opportunities Programs. He was also previously director of mission management and integration at Rocket Lab and was instrumental in New Zealand's first successful orbital rocket launch, a major milestone in that country's history.

Daniel is excited about his new role at GOES-R and GeoXO,

working for an operational program that benefits people's lives and well-being. "I'm incredibly proud to assist in supporting the development, launch and operations of spacecraft that support life-saving weather forecasts and alerts, provide near real-time monitoring of critical infrastructure and resources, and which will soon, via GeoXO and the OCX instrument, provide important data for managing our fisheries," said Gillies. "I'm ecstatic about the opportunity to apply my experience to a more Earth-facing role with NOAA as part of a team that has a direct impact on the quality of life on Earth," he added.

Daniel is both an aerospace engineer and fisheries and wildlife scientist. Outside of work, he loves working in his garden, wildlife photography, and birding. He also once attempted to launch beer hops into space, and although they only reached the stratosphere, they did make their way into a fairly successful craft brew!

UPCOMING EVENTS

GeoXO Imager System Requirements Review/System Definition Review

Aug. 29-31, 2023

National Weather Association 48th Annual Meeting

Sept. 9-13, 2023

2023 EUMETSAT Meteorological Satellite Conference

Sept. 11-15, 2023

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