2024 Annual REPORT

Science at NASA's Langley Research Center

National Aeronautics and Space Administration

INDEX

National Aeronautics and Space Administration

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Content

Joe Gasbarre

Director of NASA Langley's Science Directorate (Acting)

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MESSAGE from the DIRECTOR

It is my pleasure to present the 2024 Annual Report for Science at NASA's Langley's Research Center in Hampton, Va. The past year has included many significant accomplishments across a diverse portfolio of science capabilities that help us better understand and prepare for changing environments on Earth and beyond.

The collaborative nature of our work enhances our ability to **pioneer**, **discover** and **inspire** through essential partnerships and collaborations that stretch across Langley organizations, NASA centers, industry and academia. Our international partners and science communities expand our capabilities, expertise, and impacts worldwide.

Our technological innovations lead to high value scientific discovery at lower costs. We build complex, intricate spaceflight and atmospheric flight hardware to explore the unknown. We continually lead and support advanced instrument development for the field whether that be from the ground, air, or space. We have the unique and long-standing expertise needed to develop and deliver cutting-edge measurement technologies.

At the root of it all, we connect and engage communities through transparent, open data as we furnish solutions, provide societal value and increase public understanding. Our experts embrace NASA's science goals and help translate science to action.

In the year ahead, planning commences for launch of Langley's Athena and ARCSTONE missions, while progress continues on CLARREO Pathfinder toward a 2026 launch. We will work to advance our technology demonstrated through integrated, small satellite solutions like DEMETER, and increase collaboration with the Italian Space Agency (ASI) on the Luce Lidar mission.

It is my honor to share this incredible work with all of you.

Joe Gasbarre
Director of NASA Langley's Science Directorate (Acting)

OUR VISION

We PIONEER technologies and techniques to DISCOVER transformative science that INSPIRES communities and society.

Pioneer

We PIONEER science technologies and techniques to improve how we measure and observe complex systems that drive change to Earth and planetary atmospheres and environments.

We achieved the first long-term record of the vertical structure of the atmosphere and the first-ever global ocean retrievals. These advancements were enabled by the world's most accurate airborne ocean-profiling lidars (using the High Spectral Resolution Lidar technique) to serve the next-generation spaceborne observing system.

Learn more on p. 5

Discover

We DISCOVER meaningful scientific knowledge in the areas of radiation and climate, atmospheric composition and air quality, atmospheric weather processes and ocean ecosystems that leads to a greater understanding of our home planet and beyond.

Initial findings of NASA's ARCSIX airborne mission over the Arctic Ocean north of Greenland unveiled surprises of small, newly formed ice crystals within 'warm' Arctic clouds, and unexpected structures in the sea ice thickness distribution. ARCSIX also had a front row seat for an anomalous sea ice decline event that occurred over a span of 2.5 weeks during the campaign.

Learn more on p. 19

Inspire

Our interdisciplinary and highly collaborative work supports NASA's science goals and helps translate science to action that INSPIRES communities and society.

NASA's Tropospheric Emissions: Monitoring of Pollution (TEMPO) measures North American pollution within a four-square-mile area and reveals how pollution varies by neighborhood within a city. TEMPO's openly accessible air quality data is used for studies of rush hour pollution, improved air quality alerts, and the transport of pollution from forest fires and volcanoes.

Learn more on p. 13

For more than 50 years, NASA's Langley Research Center has worked alongside international partners and collaborators to understand the complex systems driving changes to Earth and planetary atmospheres and environments.

OUR VISIONARIES

Our organization includes about 350 of the most brilliant and equipped experts who are passionate about solving the world's toughest scientific challenges as we seek to better understand our home planet and beyond.

Chris Hostetler
NASA's Senior Technologist for Lidar Science

"Lidar is such a technique that, when flown in formation with a capable ocean color sensor, can revolutionize satellite ocean remote sensing."

Norm Loeb
NASA's Senior Technologist for Radiation Sciences

"Year-to-year changes are important to understand, measure and model. Those timescales are important for seasonal predictions."

Jim Crawford
NASA's Senior Technologist for Atmospheric Composition

"For today, people need reliable forecasts of air quality, and for tomorrow, they need effective policies to improve air quality."

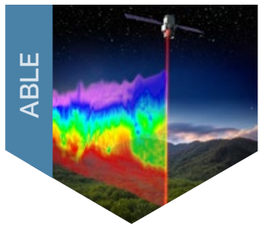
SPOTLIGHT ON THE FUTURE OF LANGLEY SCIENCE

Look out for the '**Spotlight on the Future of Science**' icon throughout this report, signaling some examples of visionary team members and future leaders who are forging the path for science at NASA Langley. These spotlights include some of our early- to mid-career scientists, researchers, project managers, and contributors of innovative ideas that push boundaries of research or applications that tackle global challenges.

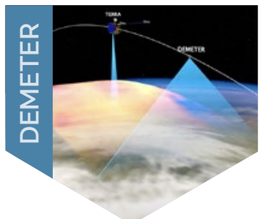
Learn more about our people *https://science.larc.nasa.gov/people*

PIONEER TECHNOLOGY DEVELOPMENT

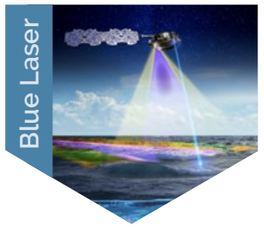
We advance and employ novel measurement techniques to enable scientific discovery. From initial concept design all the way to in-space validation, NASA researchers consistently build and test new ideas and new technology.



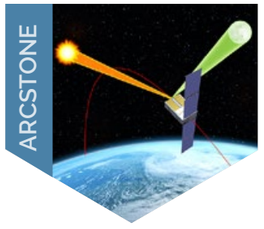
The Atmospheric Boundary Layer Lidar PathfindEr (ABLE), a cross-cutting Differential Absorption Lidar (DIAL), is a pathfinder mission concept to enable the first demonstration of humidity profiles from DIAL in space. Water vapor is the most dominant of the short-lived greenhouse gases and plays a critical role in Earth's weather and climate systems.



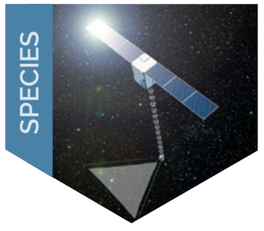
The DEMonstrating the Emerging Technology for Measuring the Earth's Radiation (DEMETER) sensorcraft measures the Earth's Radiation Budget (ERB) from the top of the Earth's atmosphere. DEMETER preserves the existing ERB data continuity while increasing capability with a solution that reduces cost, size, mass and overall risks associated with data gaps.



Advancing ocean profiling lidar technology includes an innovative interferometric receiver technique to measure the vertical profile of temperature and salinity and the development blue-wavelength lasers to profile to up to two times greater depths than the current state-of-the-art to quantify global plankton stocks, plankton community composition, diel vertical migration of zooplankton and fish, and mixing layer depths.

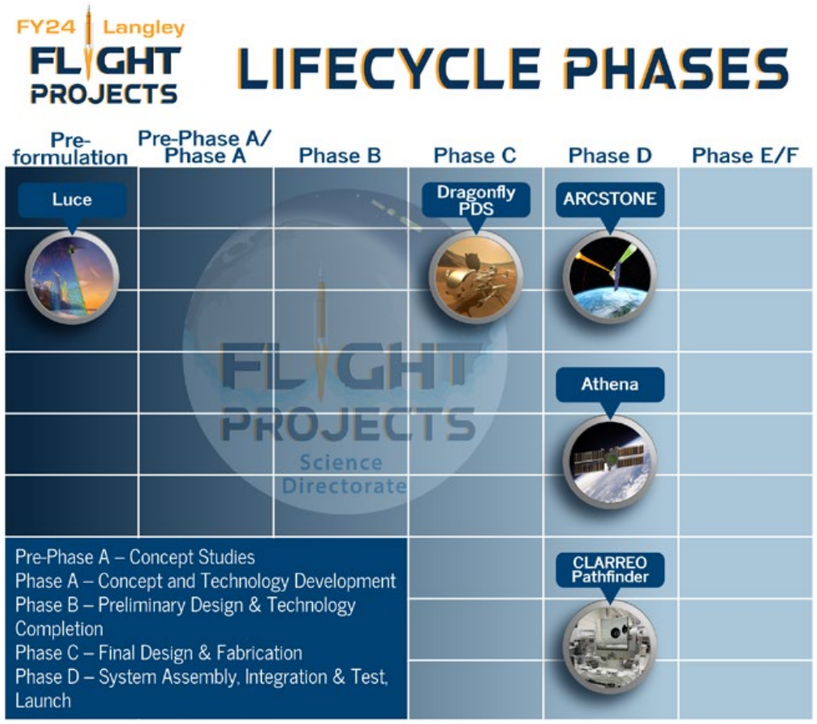


ARCSTONE is a mission concept that provides a solution to one of the most challenging tasks in remote sensing from space — achieving required instrument calibration accuracy on-orbit. The orbiting spectrometer will provide lunar spectral reflectance with accuracy sufficient to establish lunar calibration standards for past, current, and future Earth weather and climate sensors, and future constellation observing systems.

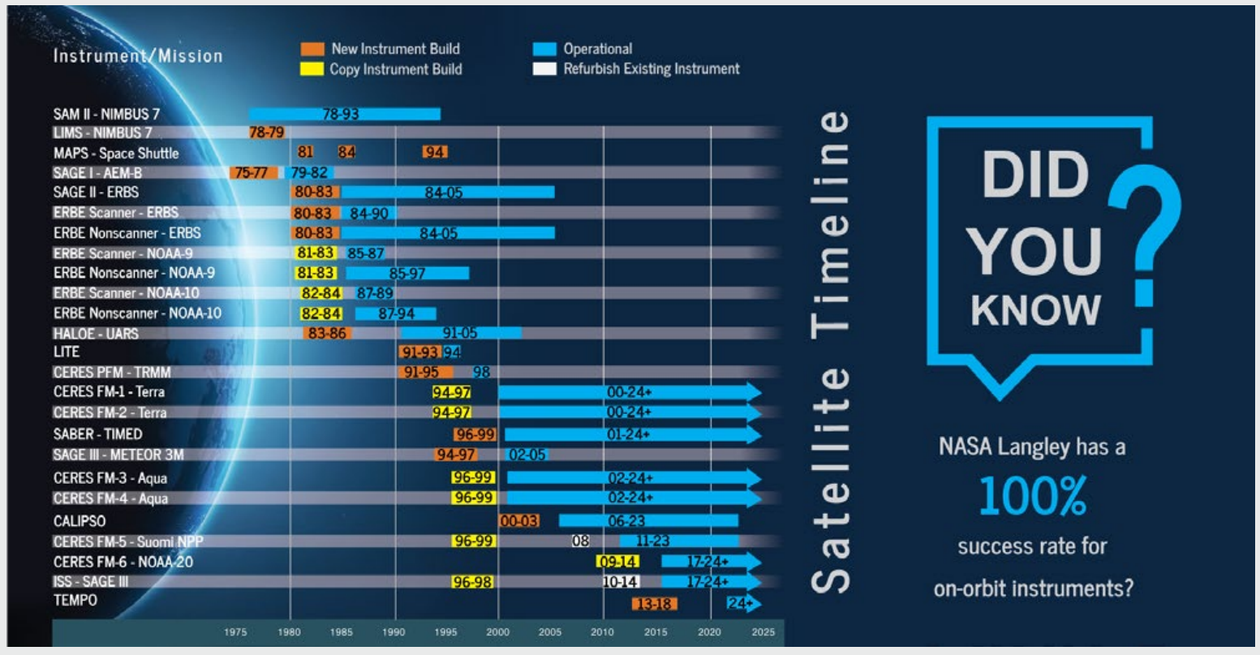


The Smart Polyimide Expandable Collector to enable Investigations for Earth Science (SPECIES) is a low-cost, deployable optic to enable lidar and passive remote sensing instruments to significantly reduce their size, weight, and power (SWAP) required to enable new CubeSat/SmallSat architectures.

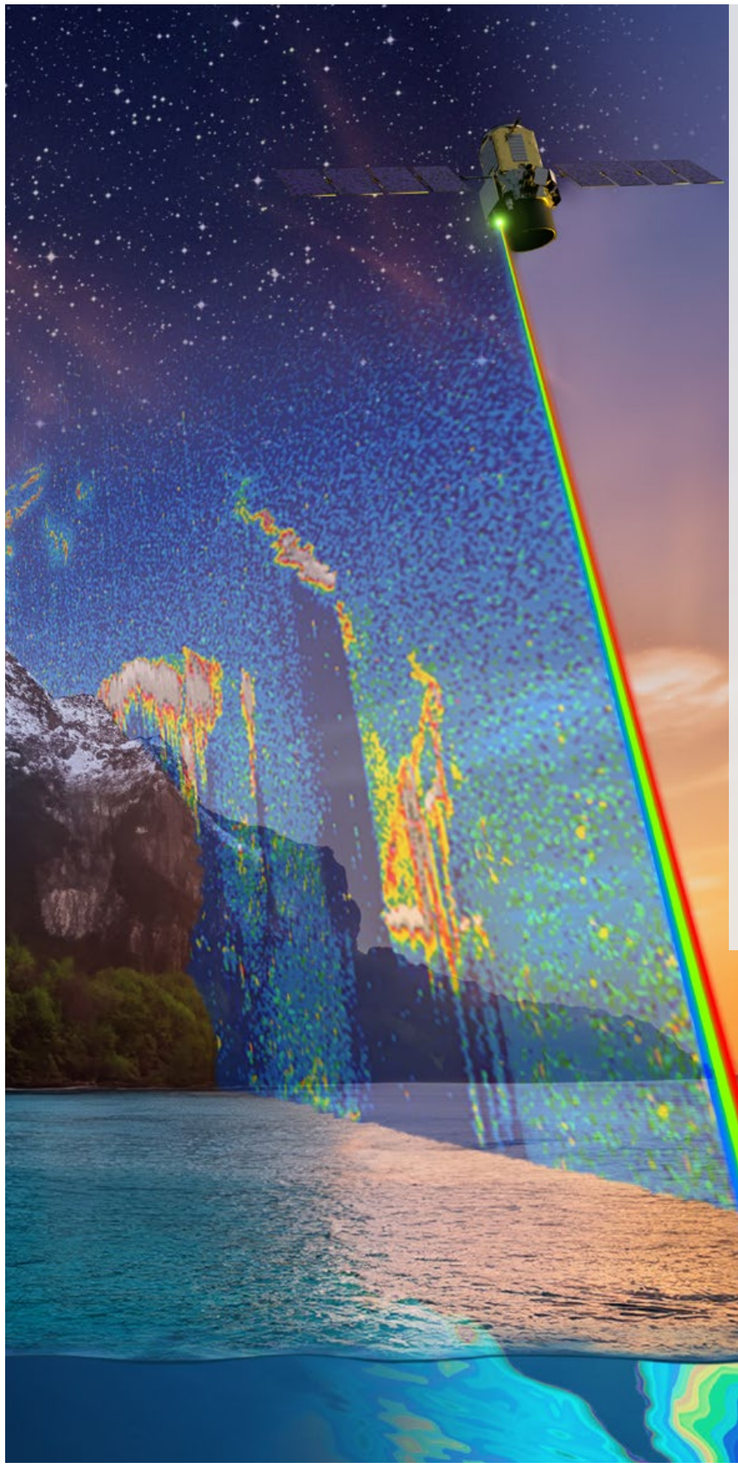
FLIGHT PROJECTS



We build complex, intricate spaceflight and atmospheric flight hardware to explore the unknown. Langley's Flight Projects Branch uses an integrated approach to science, engineering, safety, mission assurance, and management, which enables us to take on and accomplish the most challenging of missions. The Science Directorate partners with other Langley directorates to accomplish the goals of NASA science. Flight Projects are thoughtfully progressed through 'Lifecycle Phases' with clearly established objectives.



PIONEER ▶ 2024 HIGHLIGHTS



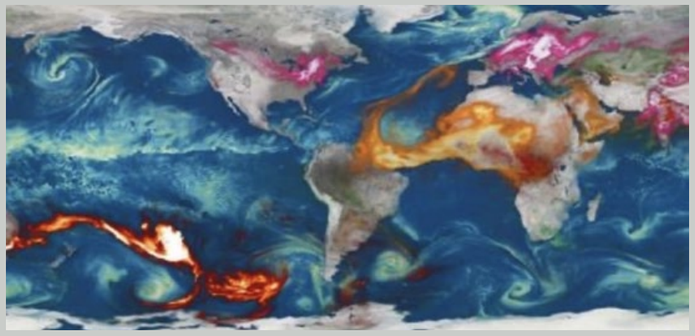
Luce Lidar ▶ Technology to Observe the Earth's Atmosphere, Surface and Oceans

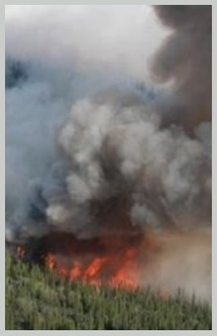
Luce ("lew-chay"), meaning 'light' in Italian, is a spaceborne lidar mission led by the Italian Space Agency (ASI), with an expected launch in 2032. The Luce mission will address the Decadal Survey's Aerosol, Clouds, Convection, and Precipitation (ACCP) science measurements originally identified for the Atmosphere Observing System (AOS) lidar instrument and will also enable multidisciplinary science.

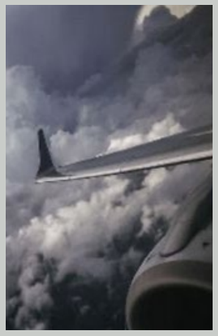
The Luce Lidar will improve understanding of the processes that influence climate, weather, and air quality by vertically profiling the microphysical and optical properties of clouds and aerosols. The mission also aims to study phytoplankton biomass and zooplankton dynamics and to provide observations of surface vegetation, ice and snow. The Luce lidar will further help improve weather and air quality forecasts with unique observations of dust, volcanic ash, and wildfire smoke as well as measurements that enhance cloud information from weather satellites.

NASA Langley's demonstrated expertise in the design, development, operation, and science analysis of Earth observation lidar systems are a key element for the success of the Luce mission.

The Luce Lidar consists of a three-wavelength laser, with up to 8 detector channels, providing high signal-to-noise ratio (SNR) backscatter lidar observations and first-ever measurements of laser-induced Raman scattering and fluorescence from space. NASA's expected contributions to the mission include the lidar detector system, data uplink/downlink services, and direct support to the lidar science and data processing. In 2024, Langley led NASA's engagement with ASI, completed a pre-formulation study including a successful Mission Concept Review (MCR), and was approved by NASA headquarters to formally move into the Formulation Phase.







Luce Lidar Applications for Societal Benefit:

Weather Forecasting *by observing cloud distributions & properties to improve retrievals and model assimilation*

Water Resource Management *by providing satellite-based snow depth/water equivalent estimates in high terrain*

Climate Modeling *by providing measurements of aerosol, cloud and biological processes improving climate prediction*

Air Quality *through more precise measurements of aerosols to better forecast impacts on human health*

Disaster Monitoring *by rapidly conveying observations and predictions of volcanic plumes and wildfire smoke*

PIONEER ▶ 2024 HIGHLIGHTS

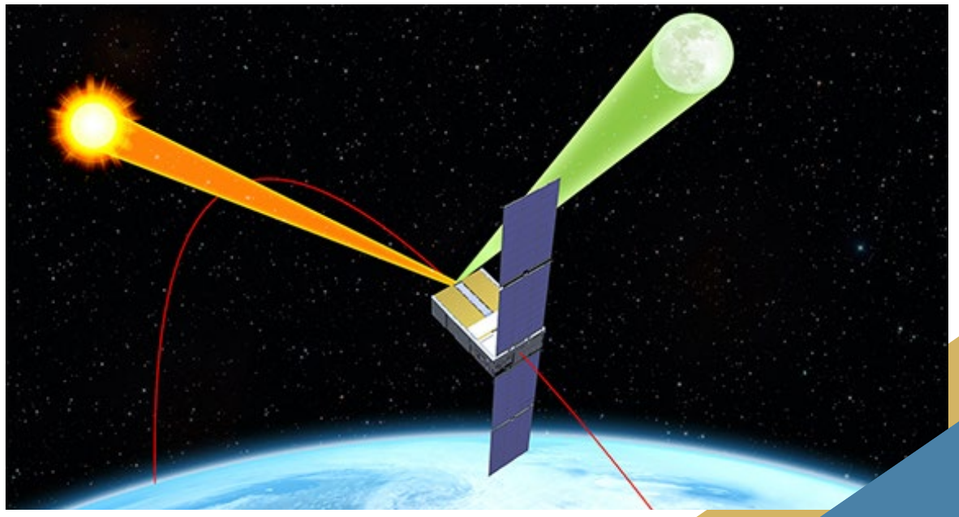
ARCSTONE ▶ Paving the Way for Future Space Sensor Accuracy

ARCSTONE is set to demonstrate the Moon's potential as a high-accuracy, cost-efficient calibration reference for Earth observation sensors, supporting enhanced climate and weather monitoring from space. The sensors of a space-based climate observing system must be re-calibrated regularly in flight to evaluate drift effects with high precision, and successions of instruments must be cross-calibrated with high accuracy and consistency across multiple instruments and platforms that make long-term observations.

> *Measurement accuracy is critical to the entire Earth Observing System (EOS). ARCSTONE sets a standard of excellence for lunar calibrations.*
> *- **Costy Lukashin,** ARCSTONE Principal Investigator*

In 2024, the ARCSTONE project hit several key milestones in its mission to revolutionize space sensor calibration using lunar reflectance. The team successfully completed the opto-mechanical assembly and flight payload testing, marking the first major step in preparing the 6U CubeSat for its mission. In August, the team advanced to ConOps Simulation Testing, followed by the integration of the payload into the CubeSat bus at Blue Canyon Technologies (BCT). By September, they achieved full system integration and completed initial functional tests, including radiometric characterization. November brought further progress with successful vibration testing and post-vibration verification of the spacecraft, ensuring it meets launch requirements specified by SpaceX for a Falcon 9 launch.

Selected as a part of NASA's CubeSat Launch Initiative, ARCSTONE is one of eight small research satellites from seven states to fly as either auxiliary payloads or deployments from the International Space Station (ISS). ARCSTONE will be placed into a Sun-synchronous orbit after its planned launch for June 15, 2025, on the SpaceX Transporter-14 mission.



Athena ▶ As Agencies Align, Athena Brings Wisdom and Strategy

NASA, the U.S. Space Force and NOAA have strategically aligned efforts to gain wisdom from Athena — a SmallSat that will demonstrate the ability of NovaWurks SensorCraft architecture to support future missions. Athena serves as a pilot opportunity for transformational activities by demonstrating energy budget measurements at the top-of-atmosphere (TOA) from space on a new type of satellite host.

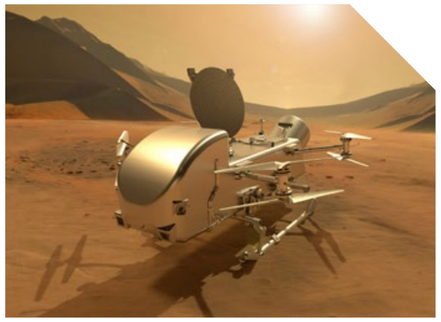
> *Athena will demonstrate the critical science measurement, but also an architecture that is adaptable and more cost-effective for the taxpayer and the government. - **Kory Priestley**, Athena Principal Investigator*

In 2024, launch planning commenced as the spacecraft successfully completed environmental testing and sensorcraft integration. The flexible building block architecture provided by the NovaWurks platform has enabled the Athena team to adjust rapidly to demands in changing launch vehicles while maintaining optimal positioning to meet and demonstrate scientific objectives.

Athena is a one-year mission that is scheduled for launch on the SpaceX Transporter-13 mission tentatively in the spring of 2025 onboard a SpaceX Tracer from Vandenberg Space Force Base, Calif. Once in polar orbit, NASA's Athena will collocate measurements with CERES instruments on other NASA spacecraft to demonstrate the capability of sustaining critical Earth Radiation Budget observation measurements well into the future.

PIONEER ▶ 2024 HIGHLIGHTS

Dragonfly ▶ Steady Progress on Innovative EDL Technologies for Titan-bound Rotorcraft



Dragonfly, NASA's only mission to the surface of another ocean world, is designed to investigate the complex chemistry that is the precursor to life. To ensure a safe and successful Entry, Descent, and Landing (EDL) of Dragonfly, NASA Langley designed, managed and coordinated a number of tests, analyses and experimental assessments in 2024. Langley manages Dragonfly's Parachute Deceleration Subsystem (PDS), including planetary EDL parachute and deployment mortar system design, development, test and evaluation (DDT&E).

In December 2024, the team successfully passed an EDL Phase Critical Design Review (CDR) -- a multidisciplinary technical review that ensures a product's design is ready for fabrication, testing, and demonstration. The team is preparing for a CDR for the Parachute Deployment System in 2025.

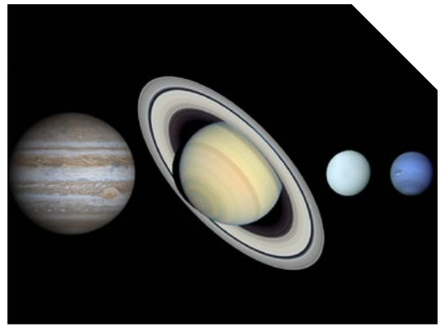
SCALPSS ▶ Designed to Adapt to Various Lunar Landers for Imaging of Plume Surface Interactions

Developed at NASA Langley, Stereo Cameras for Lunar Plume-Surface Studies (SCALPSS) is an array of cameras placed around the base of a lunar lander to collect imagery during and after descent to produce a 3D view of the lunar surface. Additionally, SCALPSS was designed to collect validation data for plume-surface interaction analysis, which is critical for future Lunar and Mars Lander vehicle designs. SCALPSS has been developed to simplify integration to various landers from multiple providers such as Commercial Lunar Payload Services (CLPS) and Human Landing Systems (HLS) by focusing on common interface and environmental testing requirements that allow each application the ability to modify as needed.

In 2024, Langley supported flight operations of the first SCALPSS instrument (SCALPSS 1.0), which flew on the CLPS Intuitive Machines (IM-1) flight. Although the payload was unable to collect Plume Surface Interaction (PSI) data due to some lander contingencies, SCALPSS was able to demonstrate that the hardware successfully survived launch, lunar transit, and lunar landing. Data was collected throughout the flight, including after several days on the lunar surface, and all hardware operated as expected. This provided increased confidence in the second SCALPSS payload (SCALPSS 1.1) which was successfully integrated to the CLPS Firefly Aerospace Blue Ghost Lander for launch in early 2025. After integration, the payload has been run through multiple tests, including before, during and after lander environmental testing. Also in 2024, Langley has supported the integration of a third payload (SCALPSS 1.x) to be delivered to Blue Origin for integration to its Mk1 lander for its first test flight currently planned for mid-2025. Langley is also supporting development of a next-generation SCALPSS instrument (SCALPSS 2.0), which will include upgraded avionics and improved imaging. This payload is being targeted for both CLPS and HLS/Artemis opportunities beginning as early as 2026.

In 2024, Langley also began a new project, PSI Instrumentation, with a focus on development of an expanded avionics system to support a PSI instrumentation suite payload for future missions. The hope is that other PSI sensors being developed throughout NASA, industry, and academia will eventually be centrally coordinated by the PSII project for the development of these instrument suites. This project also developed a SCALPSS-like measurement system that will be used in the Human Landing System (HLS) PSI Ground test in Langley's 60-ft vacuum sphere in 2025.

GRAM Suite ▶ Enabling Accurate Simulations of Planetary Environments



NASA Langley and NASA Marshall provide an integrated approach to understanding robust aerospace systems that can perform in all atmospheric bodies in the Solar System, from Venus and Earth to Uranus and Neptune. Working in coordination with other Langley and Marshall organizations, we leverage our collective knowledge of the Earth System to develop innovative techniques and methods to better understand and simulate other planetary atmospheres.

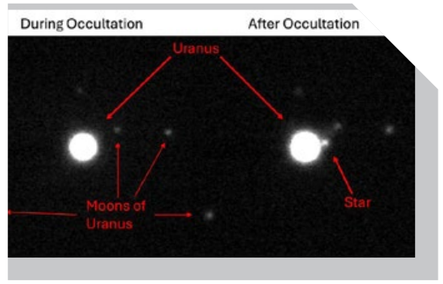
Atmospheric models enable accurate simulations for a multitude of planetary environment scenarios. In 2024, we updated and enhanced the Global Reference Atmospheric Models (GRAM) Suite, which provides engineering level reference models of planetary atmospheres (density, pressure, temperature, and winds) that are used by flight mechanics for simulations and other tools. To support the feasibility of a Uranus aerocapture mission, we delivered a new model code for Uranus, and we presented details of the UranusGRAM model and noted important new results and views of Uranus from NASA's James Webb Space Telescope.

CLARREO Pathfinder ▶ Advancing Climate Science Through Unprecedented Accuracy

CLARREO Pathfinder's (CPF) data will help us better understand Earth's changing climate. CPF's data will do this by taking highly accurate measurements of sunlight reflected by Earth and the Moon. These measurements, which will be anchored to international calibration standards, will be five to ten times more accurate than those from existing sensors.

The CPF project reached several key milestones in 2023 and 2024, advancing its mission to measure Earth's climate from space with unprecedented accuracy. In December 2023, the team conducted a successful Pre-Environmental Review (PER) despite encountering electrical issues, which were resolved by March 2024, allowing a Delta PER to be completed. Successful environmental testing confirmed the payload's readiness to operate in space conditions. After environmental testing, the payload was integrated with the ExPRESS Payload Adapter (ExPA), which is the interface mechanism used to attach CPF to the International Space Station (ISS). By October 2024, the fully-integrated payload passed all post-environmental and pre-storage functional and performance testing and was placed in storage at the Laboratory for Atmospheric and Space Physics (LASP), awaiting its future launch to the ISS.

Stellar Occultation ▶ Improved Technique More Accurately Models Planetary Atmospheric Layers



Stellar occultations occur when a planet, such as Uranus, passes in front of a distant star, from our point of view on Earth. By measuring the received starlight, scientists can determine the temperature, density and pressure of the planetary atmosphere at many altitude layers. In 2024, Langley scientists revised the procedure for processing stellar occultation observations into temperature, density, and pressure measurements and applied it to 26 Uranus stellar occultations observed between 1977 and 1996, producing temperatures that are moderately warmer than the original results, but far colder than the temperatures measured by Voyager 2. An international team of researchers from the U.S., Thailand, and Japan conducted additional analysis that revealed some flaws in Voyager 2 data. They presented a new, one-dimensional atmospheric model for Uranus, based on the new stellar occultation results and reliable Voyager 2 measurements.

SPOTLIGHTS ON THE FUTURE OF LANGLEY SCIENCE

Xiaomei Lu, *Research Scientist*

"New lidar remote sensing algorithms are enabling scientists to transform raw lidar data into valuable, actionable products, such as the vertical distribution of phytoplankton beneath the ocean's surface, snow accumulation atop sea ice and land surfaces, and detailed 3D structures of vegetation in forests. These advanced spaceborne lidar products are revolutionizing how we monitor and manage the environment. By providing a more detailed, 3D view of Earth's ecosystems, lidar technologies enhance our ability to make more accurate predictions and assessments. These breakthroughs not only deepen our understanding of Earth's systems but also inform critical decisions in policy, urban planning, and resource management, ultimately supporting sustainability and resilience in the face of a rapidly changing climate."

Snorre Stamnes, *Research Scientist*

"Polarimeter instruments will revolutionize remote sensing of the Earth and planets because the amount of information they can collect is an order of magnitude greater than that of multispectral and hyperspectral remote sensors. The latest generation of polarimeter instruments measure the intensity and degree of polarization of light at multiple channels and multiple angles. They also fit in a cubesat form factor, use little energy, have no moving parts, and are increasingly accurate and affordable. Potential applications of polarimetry include improving machine vision for self-driving cars and autonomous drones, improving weather forecasting, and studying the transport of dust particles on Earth and Mars. The synergistic combination of lidar and hyperspectral, hyperangular polarimeter measurements using Artificial Intelligence/ Machine Learning represents a powerful and exciting frontier in remote sensing technology."

Amin Nehrir, *Research Scientist*

"The technologies advanced through the High Altitude Lidar Observatory (HALO) program have enabled substantial reduction in lidar system size, weight and power over its predecessors and helped to bridge critical observational gaps enabling new airborne sampling strategies alongside other active and passive remote sensors from a wide range of airborne platforms in support of the weather and dynamics, carbon cycle, radiation sciences, and tropospheric chemistry Research & Analysis (R&A) programs. These airborne R&A programs serve not only as an opportunity to address scientific knowledge gaps and demonstrate new technologies, but also as a means to build community consensus and advocacy for new remote sensing techniques for future satellite missions."

Yongxiang Hu, *Research Scientist*

"Although laser light traveling underneath snow and ocean surface were not primarily targeted by space lidar measurements, these signals were surprisingly useful for Earth observations as they provided first-ever direct, regress measurements of snow depths at high spatial resolution, and physical properties of phytoplankton."

John Smith, *Research Scientist*

"Our vast and dynamic oceans play a central role in climate and weather, yet scant measurements of their physical properties exist. Remote sensors today are blind to what occurs below the surface, and what's seen at the surface may not reflect what's going on below. A deployable airborne lidar capable of peering deep into the ocean to rapidly acquire profiles of temperature and salinity across a wide geographic area would provide oceanographers and modelers a picture of the ocean they've never had before. Such measurements could one day be used to improve cyclone forecasts, saving lives, and avoiding unnecessary evacuations that disrupt the lives of those living in coastal areas."

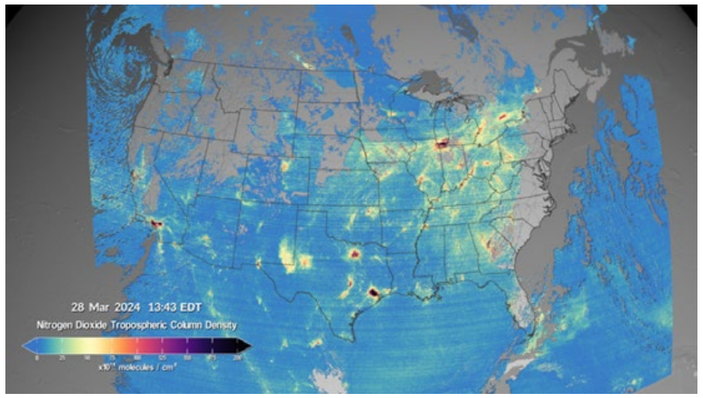
Vianni Ricano Cadenas, *Engineering Project Management*

"One of the most exciting aspects of serving in a Project Management role is helping lead a skilled team to overcome complex technical challenges to ensure mission success. In my current role, it has been incredibly rewarding to see my project achieve key milestones as we move closer to launch, knowing the meaningful impact it will have on the science community."

DISCOVER ▶ SPACE-BASED

TEMPO ▶ Hourly Air Quality Measurements Across North America

The TEMPO (Tropospheric Emissions: Monitoring of Pollution) instrument is on the Earth-facing side of IntelSat's 40e satellite, which is in a geostationary orbit 22,000 miles above Earth's equator. TEMPO gathers high quality, near-real time, air quality data at neighborhood scales from hourly daytime scans of the atmosphere over North America from the Atlantic Ocean to the Pacific Coast and from roughly Mexico City to central Canada.



The TEMPO instrument measured elevated levels of nitrogen dioxide (NO2) from a number of different areas and emission sources throughout the daytime on March 28, 2024. Yellow, red, purple, and black clusters represent increased levels of pollutants from TEMPO's data and show drift over time.

Since October 2023, the TEMPO calibration and validation team has been working on evaluating and improving the various TEMPO data products. In 2024, NASA and the Center for Astrophysics | Harvard & Smithsonian announced the public release of TEMPO's air quality data made available from Langley's Atmospheric Science Data Center (ASDC). The TEMPO team also published an interactive, digital showcase of new science imagery, including ideas for exploration and scientific highlights that provide a quick and easy way for the public to visualize this important, large data set from TEMPO.

More than 600 early adopters (or application users), including federal, state, and local air quality agencies; public health workers; educators; non-profit organizations; and international partners were trained with proxy TEMPO data for societal benefit. Now, they have TEMPO data products to use in developing their applications.

SPOTLIGHT ON THE FUTURE OF LANGLEY SCIENCE

Laura Judd, *Research Scientist*

"Air quality ground monitors cannot measure everywhere, but satellites can offer information in-between monitors. At Langley, we use airborne measurements to connect satellite observations to the air quality we are breathing near the surface. These measurements are important for validating satellite products and improving models used to provide actionable information to improve the air we breathe."

Learn more about the Synergistic TEMPO Air Quality Science (STAQS) mission.

TEMPO BY THE NUMBERS ▶ April-Oct. 2024

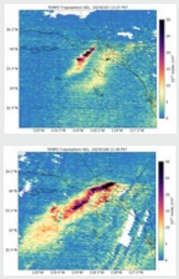
1 petabyte of V03 TEMPO data have been downloaded from *Earthdata Search*.

A petabyte could store over 76 years of high-definition video content.

"TEMPOs data will play an important role in the scientific analysis of pollution. For example, we will be able to conduct studies of rush hour pollution; linkages of diseases and health issues to acute exposure of air pollution; how air pollution inordinately impacts communities; the potential for improved air quality alerts; the effects of lightning on ozone; and the movement of pollution from forest fires and volcanoes.

- Xiong Liu, Center for Astrophysics | Harvard & Smithsonian (CfA), and Principal Investigator for TEMPO.

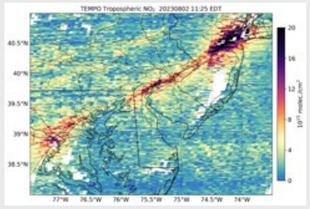
TEMPO PRELIMINARY DATA & USE CASES ▶



Los Angeles Wildfires

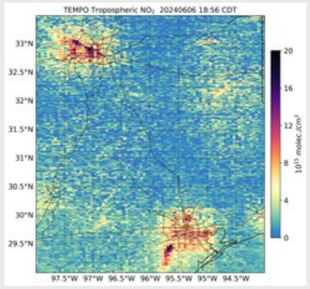
The Palisades wildfire in Los Angeles initiated during the morning of January 7, 2025, and rapidly spread throughout the afternoon. TEMPO observed the strongly evolving tropospheric nitrogen dioxide (NO2) vertical column densities (VCDs) associated with the smoke plume from the Palisades wildfire. The TEMPO NO2 map at 13:37 LT (local time) from that day shows high NO2 VCDs within the smoke plume extending over the Pacific Ocean in addition to an NO2 plume from Los Angeles urban center.

By January 8, the Eaton wildfire broke out just to the north of Los Angeles while the Palisades wildfire continued to burn to the west. TEMPO observed strongly varying NO2 VCDs associated with both smoke plumes and tracked the transport of the high NO2 from the Eaton fire over the Los Angeles urban center.



Traffic-Related Emissions

During "First Light" on August 2, 2023, TEMPO demonstrated its capability to monitor NO2 VCDs associated with traffic-related emissions. The map shows a distinct increase in NO2 VCDs along the Interstate 95 corridor extending from Washington, D.C. to New York City.



Coal-Fired Power Plants

The hourly observing capability of TEMPO enables robust monitoring of air pollutants from coal-fired power plants and cities. On June 6, 2024, TEMPO observed varying NO2 VCDs from a chain of power plants across southeast Texas with the highest NO2 amount originating from a large plant to the southwest of Houston. Elevated NO2 VCDs were also observed across the urban centers of Houston and Dallas.

DISCOVER ▶ SPACE-BASED

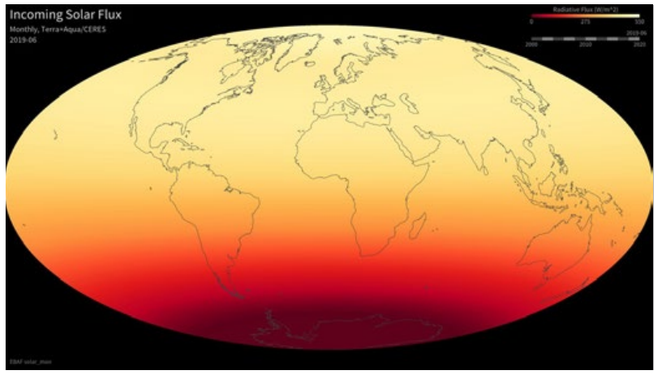
CERES ▶ A Long-term, Integrated Global Climate Data Record

Measurements of Earth's Radiation Budget (ERB) — energy entering, reflected, absorbed, and emitted by the Earth system — can only be obtained from space. Atmospheric radiation plays a key role in determining atmospheric and oceanic dynamics and regional and global precipitation. Since 2000, the Clouds and Earth's Radiant Energy System (CERES) project has globally tracked the Earth's Radiation Budget (ERB) and produced a comprehensive set of ERB data products for climate, weather and applied science research.

In 2024, Langley released the NOAA-20 data products (Edition 1C). To provide continuity in climate data, the CERES team is involved in the development of NASA's Libera instrument, a new sensor that will fly on the next JPSS satellite targeted for launch in 2027.

CERES involves a high level of data fusion. During the CERES period, the team has processed data from 7 CERES instruments, 2 MODIS, 2 VIIRS and 20 geostationary imagers, all integrated to obtain climate accuracy in radiative fluxes from the top to the bottom of the atmosphere. More than 90 percent of the CERES data product volume involves two or more instruments.

CERES instruments are currently flying on four satellites: Terra, Aqua, Suomi National Polar-Orbiting Partnership (S-NPP), and NOAA-20.



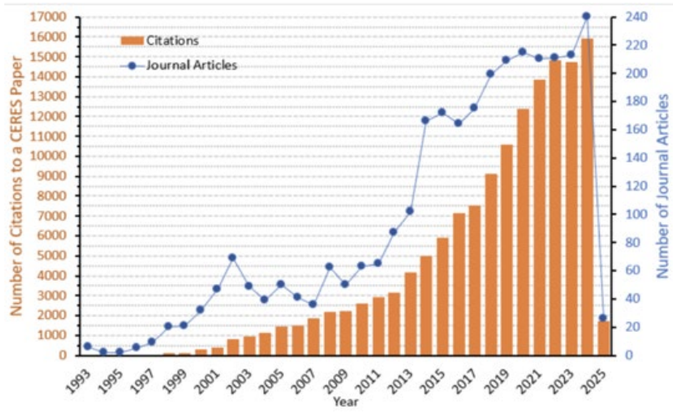
This map shows monthly top of atmosphere radiative fluxes from March 2000 to the present from the Energy Balanced and Filled (EBAF) data product. These data are produced by averaging observations collected by the Clouds and the Earth's Radiant Energy System (CERES) sensors on NASA's Aqua and Terra satellites, filling in gaps and constraining the fluxes to remove the inconsistency between average global net TOA flux and heat storage in the Earth-atmosphere system. Credit: NASA's Science Visualization Studio

ABOUT THE ERBS PROJECT ▶

The NASA's Earth Radiation Budget Satellite (ERBS) project produces climate data records of Earth's radiation budget and the associated cloud, aerosol, and surface properties. The project utilizes data from the multiple radiation budget instruments in orbit and ancillary measurements to produce integrated, self-consistent data products over the entire suite of radiation budget instruments. The data products utilize coincident imager measurements and Clouds and the Earth's Radiant Energy System (CERES) instrument broadband radiative fluxes from Terra, Aqua, Suomi National Polar-orbiting Partnership, NOAA-20, and operational geostationary satellite observations. In total, scientists have used 32 instruments on 26 spacecraft thus far to produce an accurate and temporally consistent description of the radiation budget, not only at the top of the atmosphere but also at the surface and within the atmosphere. The ERBS project is the only project worldwide whose prime objective is to produce global, climate-quality ERB data from dedicated ERB satellite instruments.

CERES BY THE NUMBERS ▶

CERES Journal Publication and Citation Counts
(1993 - February 2025)



Total number of peer-reviewed journal articles: **3,235**

Total number of citations to CERES papers: **144,545**

There were **2,308** unique users of CERES data products for climate research and **159,000** unique users for Applied Sciences (energy, buildings, and agriculture sectors).

CERES PUBLICATION HIGHLIGHTS ▶

Observational Assessment of Changes in Earth's Energy Imbalance Since 2000

Satellite observations reveal that global mean net flux (NET) at the top-of-atmosphere (or equivalently, Earth's energy imbalance) has doubled during the first twenty years of this century. The increase is associated with a marked increase in absorbed solar radiation (ASR) that is partially offset by an increase in outgoing longwave radiation (OLR).

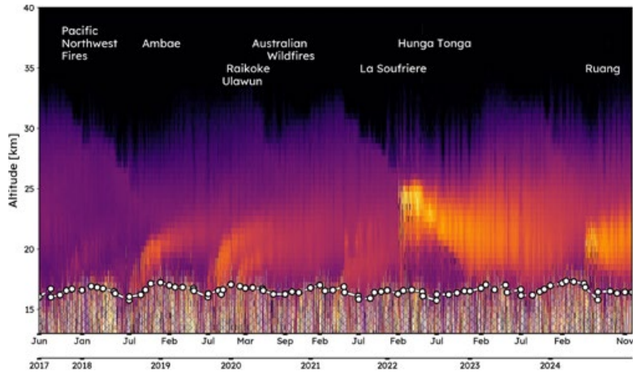
Continuity in Top-of-Atmosphere Earth Radiation Budget Observations

As the number of ERB instruments will decrease from four to one in just 10 years, there is a high probability that a data gap in the EBAF record will occur, making it challenging to maintain continuity.

DISCOVER ▶ SPACE-BASED

SAGE III on ISS ▶ Studying the Planet to Protect it, Make Predictions, and Inform Action

The Stratospheric Aerosol and Gas Experiment (SAGE) is a series of instruments designed by NASA to observe stratospheric ozone, aerosols, and water vapor from space. SAGE III, the newest and most advanced addition to the SAGE family, makes its measurements by locking onto the Sun or Moon and scanning the limb, or thin profile of the atmosphere, from the unique vantage point of the International Space Station.



The figure above displays the SAGE III aerosol extinction mission overview with multiple extreme fire and volcanic eruption events noted. Yellow and orange colors indicate increased amounts of aerosols in Earth's stratosphere.

Aerosols can impact climate by shading the Earth or heating the atmosphere, as well as facilitating chemical reactions leading to enhanced ozone depletion. In 2024, the mission released a Level 2 aerosol auxiliary data product with an added feature that filters out clouds in SAGE III observations, which sometimes can be mistaken for aerosols when examining SAGE'S measurements. This feature will refine the data set and provide data users with an even more accurate picture of the impact that stratospheric aerosols have on Earth's atmosphere. The SAGE III operations, ground systems, and data processing teams consistently released monthly science products to the public ahead of schedule.

In April, the stratosphere was still under the influence of the January 2022 Hunga Tonga–Hunga Ha'apai eruption. Over two years after the eruption, the aerosol loading was still 50% greater than it was prior to the eruption and 150% greater than it was when SAGE III science observations began in June 2017. The April 2024 eruption of Ruang in Indonesia sent plumes of ash and gas 20 km into the atmosphere refreshing the stratospheric aerosol load. Through the study of SAGE III observations, NASA scientists have found this consistent enhancement of the stratospheric aerosol layer over the past several years has produced a less than 1% shading of the Earth's surface. Though small, this shading is non-negligible when studying the impacts on Earth's climate system.

In July, SAGE III's Program Scientist Richard Eckman and Lead Algorithm Scientist Robert Damadeo were elected to the prestigious International Ozone Commission (IO3C). Membership in the IO3C is highly selective, limited to about 30 leading scientists globally. The IO3C plays a crucial role in organizing studies of ozone worldwide, including ground-based and satellite measurement programs to better understand atmospheric composition and ozone dynamics.

The third cohort of SAGE III Science Team selections were made from proposals submitted to the third ROSES solicitation targeting SAGE-like science. In October, the mission held its seventh annual Science Team Meeting at NASA Langley which was the first for this new cohort of ten Principal Investigator-led teams.

> *The stability of SAGE III's measurements enable ground-based ozone observations from across the globe to be compared against the highly-precise standard of SAGE data. The accuracy of SAGE III aerosol data makes it the benchmark for all other stratospheric aerosol datasets, helping facilitate algorithm improvements for current and future missions. The stratospheric water vapor data is gaining importance as older systems age-out, leaving SAGE III to bridge the record into the next decade.*
> ***- David Flittner,*** SAGE III/ISS Project Scientist

SAGE III on ISS BY THE NUMBERS ▶ July 1, 2017 to December 31, 2024

Total Occultation Acquired: 72,463

SAGE PUBLICATION HIGHLIGHTS ▶

An empirical characterization of the aerosol Ångström exponent interpolation bias using SAGE III/ISS data

This work uses multispectral measurements of vertically resolved aerosol extinction coefficients from SAGE III/ISS to demonstrate how the use of the Ångström exponent for interpolation of aerosol data between two different wavelengths creates a bias.

Characterization of stratospheric particle size distribution uncertainties using SAGE II and SAGE III/ISS extinction spectra

A new algorithm was developed to infer particle size distribution parameters from SAGE II and SAGE III/ISS extinction spectra using a lookup table approach.

ARCSIX ▶ Studying Melting Sea Ice North of the Arctic Circle

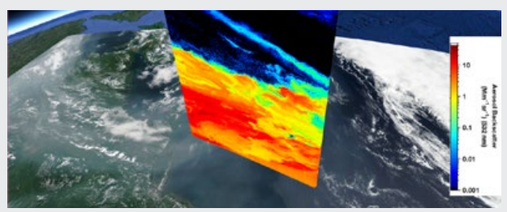
As the Arctic experiences its unprecedented warming and sea ice rapidly melts, NASA's ARCSIX mission is racing to understand the cascading impacts of amplified Arctic warming on our global climate. In 2024, NASA wrapped up a 7-week field campaign spread over 4 months that completed more than 344 science flight hours across a total of 44 science flights between the three aircraft: Wallops Flight Facility (WFF) P-3 (19 flights and 179.5 hours), Langley G-III (15 flights and 127 hours), and the SPEC Learjet (10 flights and 40 hours).

Initial findings show a surprising occurrence of small, newly formed ice crystals within "warm" Arctic clouds and an unexpected structure in the sea ice thickness distribution. ARCSIX also had a front row seat for an anomalous sea ice decline event that occurred over the northeast Greenland coast and spanned 2.5 weeks of the campaign. The observations and initial results from ARCSIX emphasize the urgent need for continued research to mitigate and adapt to a warming world.

SPOTLIGHT ON THE FUTURE OF LANGLEY SCIENCE

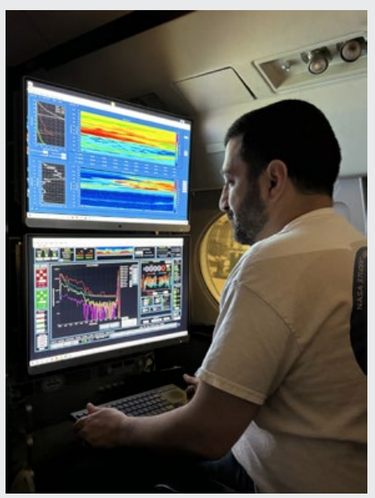
Patrick Taylor, *Research Scientist*

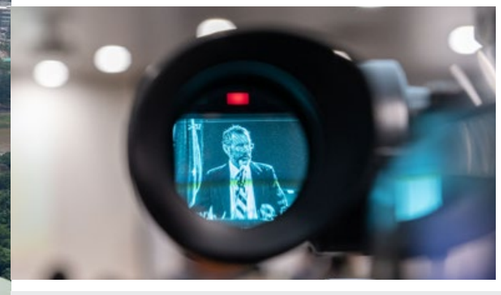
"While the Arctic feels distant from our everyday lives, we are all connected to it. For one, the U.S. is an Arctic Nation. More broadly, the conditions within the Arctic impact food supply, the global economy, and national security. Coastal Alaska is home to some of our most productive fisheries. The rapid changes in the Arctic are impacting us directly at home by influencing weather patterns and impacting sea level. The ARCSIX mission collected an unprecedented data set of Arctic sea ice, clouds, aerosols, and radiation that will be used for decades to understand drivers of the rapid Arctic climate change. Combining airborne data with satellites and atmospheric models, we are improving our predictions to strengthen our national security, inform strategic economic decisions, and enable the us to better live and operate in the Arctic."



Langley's HALO Instrument Captures Variability of Smoke with Latitude

During the return transit from NASA's ARCSIX campaign from Greenland to New Hampshire, the G-III aircraft flew under EarthCare through a plume of thick Canadian forest fire smoke.





ASIA-AQ ▶ ASIA-AQ Campaign Soars to Success: NASA Leads Global Air Quality Mission Across Asia

In Spring 2024, ASIA-AQ headed to Thailand to study thick layers of haze caused by waves of smoke and fire that blanket the landscape in Southeast Asia. Such hazes contain mixtures of small airborne particles that degrade air quality and have harmful health effects. During the last two weeks of March 2024, NASA's DC-8 aircraft flew several flights sampling pollution gradients between Bangkok and Chiang Mai, while the G-III focused on remote sensing of pollutant distributions over Bangkok. The team will use the data to refine models of how the region's haze forms, evolves chemically over time, and moves throughout the region.

In October 2024, the ASIA-AQ data was finalized and made available to the public. In collaboration with international partners, these data are supporting joint analyses and early findings to be delivered to each country in early 2025 in the form of Rapid Science Synthesis Reports.

Short-term, intensive airborne measurements provide a unique, multidimensional view of pollution that is comprehensive in chemical detail and vertically resolved to provide information on the distribution of pollutants throughout the lower atmosphere. This perspective is valuable for informing how satellite observations connect to surface measurements and for assessing air quality models used to forecast and diagnose the conditions leading to poor air quality.

In 2024, NASA's ASIA-AQ team completed airborne research flights across the Philippines, South Korea, Taiwan, and Thailand to improve our understanding of air quality across diverse urban settings. The campaign utilized NASA's DC-8 to collect in situ atmospheric data and G-III to remotely sense distributions of key pollutant across megacities in each country. The campaign was executed in collaboration with international partners like South Korea's National Institute of Environmental Research, Taiwan's Ministry of the Environment, Thailand's Geo-Informatics and Space Technology Development Agency, and the Philippines' Department of Environment and Natural Resources. The campaign's data will play a vital role in understanding local air quality drivers and supporting satellite monitoring efforts of South Korea's Geostationary Environment Monitoring Spectrometer (GEMS).

Clockwise from top left. Team photo with the G-III & DC-8 in the Philippines. Local scientists with the G-III in the Philippines. DC-8 last low approach of the campaign (Taiwan) team in Thailand.

[VIDEO]: Airborne and Satellite Investigation of Asian Air Quality

Boeing EcoDemonstrator ▶

NASA, Boeing, and Industry Partners Leading the Charge in Sustainable Aviation

Langley's Science Directorate continued its longstanding leadership of in-flight contrail and emissions testing with joint NASA Science Mission Directorate (SMD) and Aeronautics Research Mission Directorate (ARMD) collaboration with the Boeing Company. Flying high over the skies of Washington was the Boeing ecoDemonstrator Explorer – a pre-delivery United Airlines 737-10 aircraft equipped with low-emitting CFM LEAP-1B engines burning sustainable aviation fuel and a specially-formulated low-sulfur Jet A fuel. Trailing behind was NASA's DC-8 flying laboratory, which measured the particle and trace gas composition and contrail ice crystals formed behind the 737 MAX.

After wrapping the flight test portion of the project, the science team spent 2024 analyzing the comprehensive dataset from the DC-8 airborne instrumentation. The team gathered in May, and again in December, with key industry and government stakeholders at the Federal Aviation Administration headquarters in Washington D.C. to present research findings showing the dramatic soot particle reductions associated with the combination of the advanced engine technology and sustainable fuels. These results are important for demonstrating U.S. technologies for reducing climate-altering contrail cirrus clouds and improving surface air quality.

NASA's sustainable aviation research is part of the agency's work to advance U.S. industry's global economic competitiveness and ensure sustainable future growth of the aviation sector as the world works toward multinational net-zero climate emissions targets set for 2050.

AWARD-WINNING NEWS

Boeing and NASA are Hot on the Trail of Aircraft Emissions

An Aviation Week article by Guy Norris titled, 'Boeing and NASA are Hot on the Trail of Aircraft Emissions,' won the 2024 Aerospace Media Award for 'Best Sustainable Aviation Submission.'

BENEFITS

The Boeing ecoDemonstrator program tests aviation technologies to improve fuel economy, reduce noise, and improve the in-flight experience. The program's benefits include:

- reduce the environmental impact of flying
- improve the safety of Boeing airplanes
- improve the operational efficiency of aircraft
- improve the in-flight experience for passengers

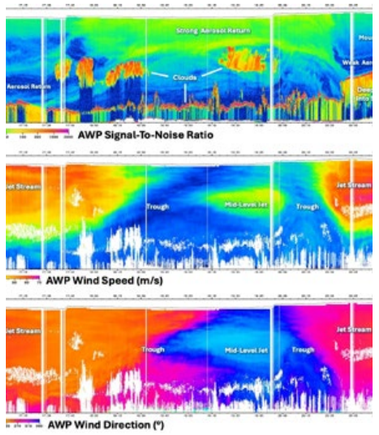
SPOTLIGHT ON THE FUTURE OF LANGLEY SCIENCE

Rich Moore, *Research Scientist*

"Reducing climate-warming contrail cirrus is necessary for ensuring the future of sustainable aviation and U.S. economic competitiveness across the global market. Fortunately, U.S. leadership in developing low-emitting aircraft engine technologies as well as the production of sustainable aviation fuels (SAFs) hold great promise for achieving these goals by reducing aircraft engine particle emissions and resulting contrails. The benefits of these reductions also extend to the ground, where airport workers and communities can enjoy improved air quality and health. Research conducted by NASA and our industry partners continues to quantify and demonstrate advanced sustainable technology and fuels, guide industry investment, and equip policymakers with the information and tools needed to make data-driven decisions."

3-D Doppler Wind Lidar ▶

NASA and NOAA's 3-D Wind Campaign Collects Unprecendented Atmospheric Data that Could Revolutionize Weather Forecasts



The successful completion of the NOAA-sponsored Aerosol Wind Profiler (AWP) 3-D Wind Demonstration Campaign marks a major leap forward in atmospheric measurement technology and research. Aboard NASA's Gulfstream-3, AWP combined with the Langley HALO lidar system to measure unprecedented, high-resolution 3-D wind, water vapor, and aerosol profiles over a range of weather conditions, from calm winds, to a hurricane and mid-latitude cyclones. With 47 flight hours and data spanning across North America and the Atlantic, this campaign demonstrates AWP's capability to measure complex wind patterns with extremely high accuracy relative to dropsonde measurements. Current research will demonstrate how this incredibly high detail and precision AWP data will enhance NOAA's weather analyses and forecast models, offering a glimpse into how these measurements could revolutionize weather prediction when our technology is flown in space.

SPOTLIGHT ON THE FUTURE OF LANGLEY SCIENCE
Kris Bedka, Research Scientist

"Prior to my research career, I never would have dreamed that a lidar system like AWP could measure atmospheric winds with such high accuracy. It is an incredibly exciting and rewarding experience to design and execute research flights to measure the atmosphere in unprecedented ways. It is also exciting to be at the forefront of designing technologies and space mission concepts that will enable a wind lidar to fly aboard a satellite to benefit everyone across the globe via better weather forecasts."

PACE-PAX ▶

Sampling Key Ocean and Atmospheric Variables in the West Coast Region

PACE-PAX researchers share first-hand accounts from the field:

The Plankton, Aerosol, Cloud, ocean Ecosystem Postlaunch Airborne eXperiment (PACE-PAX) was a one-month field campaign to gather data for validation of the recently launched PACE satellite. PACE-PAX involved coordinated flights between the high-flying NASA ER-2 equipped with satellite proxy instrumentation, and the low-flying Naval Postgraduate School's (NPS) Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) Twin Otter for in-situ ground truth. NASA Langley operated the High Spectral Resolution Lidar (HSRL) instrument aboard the ER-2, providing vital data to validate and refine the data products generated by the PACE mission.

LARGE had a suite of aerosol in-situ instruments aboard the Twin Otter aircraft, which was based out of Marina, Calif, measuring aerosol optical and microphysical properties. The Twin Otter completed 17 research flights totaling 60 flight hours during the month of September 2024, sampling local and transported wildfire emissions, agricultural dust, and marine aerosols in the West Coast region.

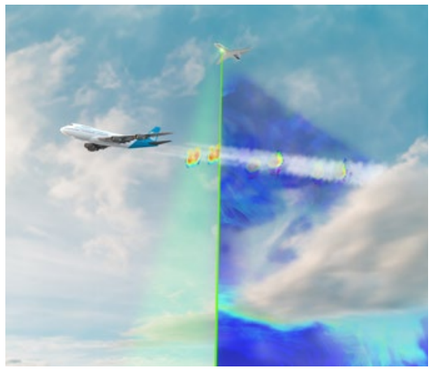
SARP ▶

Students Gain Hands-on Research Experience Alongside Langley's Airborne Scientists

More than fifty students gained hands-on research experience as part of NASA's 16th annual Student Airborne Research Project (SARP) program, collaborating with the LARGE and Differential Absorption of CO Measurement (DACOM)-Diode Laser Hygrometer (DLH) groups from NASA Langley on airborne research flights. Utilizing the WFF P-3B aircraft and leveraging the existing ARCSIX payload, the teams collected data on urban air quality, agricultural and wetland emissions, and remote sensing validation in both Washington, D.C. and Southern California. Langley scientists flew with the students during each flight, operating the instrumentation and sharing their airborne science expertise and the scientific context in how measurements are used.

CODEX Brings Hope for Sustainable Air Travel

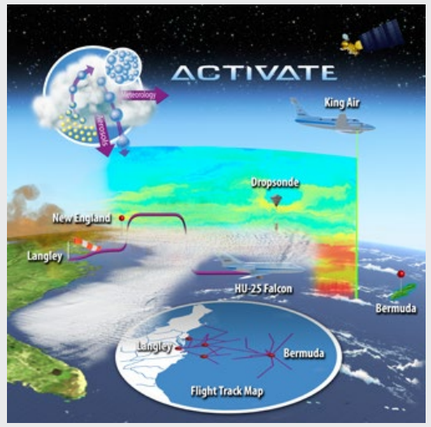
Contrails from airplanes are a hidden climate threat, contributing to global warming by trapping heat in the atmosphere. During the Contrail Optical Depth Experiment (CODEX) NASA's Langley G-III and GE Aerospace's 747 Flying Test Bed conducted crucial flight tests using the cutting-edge High Altitude Lidar Observatory (HALO). The tests remotely analyzed contrail optical properties, their evolution, and ice supersaturation in the atmosphere, providing valuable insights for managing contrail impacts and mitigating their climate effects.



APEX Campaign Serves as a Benchmark for Future Satellite Retrievals

The Active Passive PBL Profiling EXperiment (APEX) campaign has concluded a critical six-month series of airborne missions, advancing our understanding of the marine boundary layer and its role in climate dynamics. From October 28 to November 15, 2024, the team completed 11 science flights, coordinating with the Westcoast & Heartland Hyperspectral Microwave Sensor Intensive Experiment (WH2YMSIE) and the Moisture and Aerosol Gradients/Physics of Inversion Evolution (MAGPIE) to validate cutting-edge passive microwave technology. These flights, conducted aboard the LaRC G-III, ER-2, and Twin Otter, focused on measuring temperature, moisture, and turbulent atmospheric processes across diverse conditions. The data collected will serve as a benchmark for future satellite retrievals and support ongoing climate research under the Decadal Survey Planetary Boundary Layer Incubation program.

ACTIVATE Airborne Field Campaign Concludes with a Free, Virtual Open Data Workshop



The Earth Venture Suborbital-3 (EVS-3) mission ACTIVATE (Aerosol Cloud meTeorology Interactions oVer the western ATlantic Experiment) recently held its final and sixth Science Team Meeting on 20 November 2024. This meeting also served as an open data workshop and was advertised widely to the public. The meeting was four hours in duration and held virtually on TEAMS. Attendance totaled 69 participants, 21 of which were from outside the science team.

The open meeting consisted of science presentations focused on using data and linking the measurements to various modeling scales. Nine of the 12 speakers were early career researchers. Multiple talks linked the remote sensing data to the detailed in situ measurements to better the performance and capabilities of the HSRL-2 lidar and Research Scanning Polarimeter. More specifically these talks examined new and improved ways to estimate planetary boundary layer height, aerosol fine mode fraction, and the phase of clouds (e.g., ice versus liquid). Moreover, two presentations included research groups outside the ACTIVATE science team with one being presented by an international collaborator evaluating a model with ACTIVATE airborne data. The ACTIVATE team is continuing analyses on the full dataset. To date, ACTIVATE has 77 peer reviewed publications with a list on the project website: https://science.larc.nasa.gov/activate

ACTIVATE Publication Highlights

Microphysical Evolution in Mixed-phase Mid-latitude Marine Cold-air Outbreaks

Cold-air outbreaks off the U.S. East Coast are visually spectacular in satellite imagery, with overcast, reflective clouds evolving into more broken cloud fields. This work applies ACTIVATE aircraft data to describe the microphysics of these clouds and factors driving the transition to open cloud fields.

Total Column Optical Depths Retrieved from CALIPSO Lidar Ocean Surface Backscatter

The Ocean Derived Column Optical Depth (ODCOD) algorithm enables improved estimates of full-column optical depths from the 532 nm measurements acquired by the The Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) aboard the CALIPSO spacecraft. This work was possible due to ACTIVATE's strategic flight paths under CALIOP overpasses.

Boundary Layer Structures Over the Northwest Atlantic Derived from Airborne HSRL and Dropsonde Measurements during the ACTIVATE Campaign

The Planetary Boundary Layer Height (PBLH) and Mixed Layer Height (MLH) are essential for studying the lower atmosphere and its interaction with the surface. This work demonstrates the utility of ACTIVATE airborne data in evaluating PBLH and MLH estimates from the HSRL-2 and further improves HSRL-2's estimation of PBLH.

DISCOVER

HIGH-ALTITUDE BALLOONS

BalNeO: A New Era in Tracking Stratospheric Aerosols

The Balloon Network for Stratospheric Aerosol Observations (BalNeO) is revolutionizing our understanding of stratospheric aerosols and their role in the climate system. From its first two stations in France and Brazil, BalNeO launched lightweight instruments on balloons to fill a critical gap in measuring aerosol size distributions and concentrations, especially in the tropics.

The network's inaugural flights have already yielded valuable insights, such as detecting aerosol layers linked to wildfires and volcanic activity. On June 4, 2024, balloon-borne instruments revealed a layer of enhanced aerosol concentration near the tropopause, likely originating from wildfires in British Columbia that occurred ten days prior. This observation expands our knowledge on the source, transport and impacts of stratospheric aerosols.

BalNeO aims to extend its activity in India and the U.S. in 2025 to ultimately become a reference network for stratospheric aerosol observations.

GROUND-BASED

CRAVE: Continuous World-Class Surface Radiation Measurements

The CERES (Clouds and the Earth's Radiant Energy System) Radiation Validation Experiment (CRAVE) provides continuous world-class surface radiation measurements and validation of CERES and other satellite products. CRAVE consists of two active sites at Granite Island in Lake Superior and at NASA's Langley Research Center. In 2024, the CRAVE team provided status updates of both sites and presented, "The Component Summation Technique for Measuring Upwelling Longwave Irradiance in the Presence of an Obstruction."

LARGE Tests New Instruments from Ground Sampling Site

The Langley Aerosol Research Group Experiment (LARGE) team operated a ground sampling site at the Marina, Calif., airport control tower during PACE-PAX. LARGE was able to use the site as a testbed for new instrument development. LARGE deployed two new experimental instruments that measure the Ultraviolet (UV)/visible hyperspectral extinction and absorption of aerosols. These instruments will allow more direct validation of hyperspectral satellite observations (e.g., by PACE), and facilitate retrieval of aerosol properties critical to climate modeling.

The setup of the ground site shared many instruments with the airborne payload, allowing for a detailed evaluation of the sampling efficiency and inlet cutoff diameter of the Twin Otter aircraft, as well as providing long-term context for the sampling region.

DISCOVER ▶ HELIOPHYSICS

Program Office Launches in Support of NASA's Space Weather Research

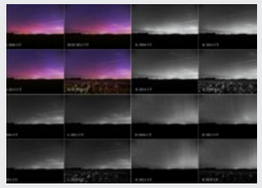
In late October 2024, NASA Langley's Science Directorate officially launched the NASA Space Weather Program Office (SWPO). The Langley-based SWPO is a part of NASA's Science Mission Directorate Heliophysics Division located at NASA Headquarters (HQ). Once fully staffed, the SWPO team will support NASA Headquarters' Space Weather Program by:

- Providing Support for Space Weather Research & Analysis Activities
- Managing Budgetary Actions, Reporting, and Communications
- Developing Timely and Compelling Communication Products
- Leading/Supporting other Space Weather activities as required by NASA HQ

NASA heliophysics works as the research arm of the nation's space weather effort, coordinating with other federal agencies, including the U.S. National Oceanic and Atmospheric Administration, the National Science Foundation, the U.S. Geological Survey, the U.S. Air Force Research Laboratory, and the U.S. Naval Research Laboratory, on the National Space Weather Strategy and Action Plan. In addition to research missions, NASA also supports improvements in space weather prediction models, such as those used by NOAA's Space Weather Prediction Center, the U.S. government's official source for space weather forecasts.

As staffing and processes mature in 2025, the SWPO team is focused on management of the Research to Operations to Research (R2O2R) program, which will bring more of an end user focus to NASA's space weather research activities.

LANGLEY HELIOPHYSICS PUBLICATION HIGHLIGHTS ▶



A Rare Observation of a Blue Aurora at Mid-Latitude

Blue aurorae, while present at high latitudes, have been very little documented at subauroral latitudes. During the night of the 24 to 25 September 2023, a series of aurorae were seen from 48.3 latitude geographic north, 1.2geographic E (49.88N, 84.55E in geomagnetic coordinates). These aurorae appeared on the North, North-East horizon.

Global Thermospheric Infrared Response to the Mother's Day Superstorm of 2024

Earth experienced the strongest geomagnetic storm in 20 years over 10-13 May 2024. These are the largest single day power values observed by THE Sounding of the Atmosphere using Broadband Emission Radiometry (SABER) mission in 22 years and the first time the daily power radiated by NO exceeded that of CO2.

Energy mapping of Jupiter's auroral electrons from Juno/ UVS Data Using a New H2 UV Emission Model

Juno, a NASA spacecraft that studies the Jovian system, continues to expand our knowledge of Jupiter's magnetosphere and its environment. Onboard instruments such as Jupiter Energetic Particle Detector Instrument (JEDI) and Jovian Auroral Distributions Experiment (JADE), in situ measurements have allowed us to derive a realistic representation of charged particle energy distributions precipitating in the auroral regions.

Characterization of Radiation Exposure at Aviation Flight Altitudes Using the Nowcast of Aerospace Ionizing Radiation System (NAIRAS)

The Nowcast of Aerospace Ionizing RAdiation System (NAIRAS) model and the Automated Radiation Measurements for Aerospace Safety (ARMAS) dosimeter were used to estimate radiation exposure for airline crews. Radiation dose rates were measured and calculated for 45 fairly representative flights between August 2022 and March 2023.

▶ PLANETARY

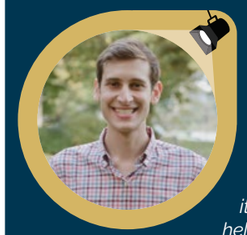
Stellar Occultation Observations Conducted to Study Planetary Atmospheres

On November 12, 2024, NASA Langley researchers coordinated a Uranus stellar occultation observation using two telescopes in Japan and one in Thailand. A stellar occultation occurs when a planet, such as Uranus, passes in front of a distant star, from our point of view on Earth. Scientists observe the starlight as it passes through the atmosphere of Uranus, detecting the refraction caused by the atmosphere and using it to determine the temperature, density, and pressure of Uranus' atmosphere at many different altitudes.

Telescope observations were conducted by scientists and students at the National Astronomical Research Institute of Thailand using the Thai National Telescope, Hokkaido University and Kyoto Sangyo University. As a result of these observations, the observers in Thailand and Japan learned how to perform stellar occultation observations and validated that their observatories and instruments are capable of these observations in the future. The team at Langley is looking forward to including them in upcoming observations in 2025 and beyond to better understand the temperatures in the middle atmosphere of Uranus. NASA Langley is conducting ongoing analysis of these observations.

The same Langley researchers are coordinating a large campaign to observe a Uranus stellar occultation on April 8, 2025. This will be the brightest star that Uranus has occulted in about 30 years, making it a premier opportunity to study Uranus' atmosphere in detail. At least seven large telescopes located in the U.S. Mountain West and Hawaii will attempt to observe the occultation.

SPOTLIGHT ON THE FUTURE OF LANGLEY SCIENCE
William Saunders, Planetary Scientist

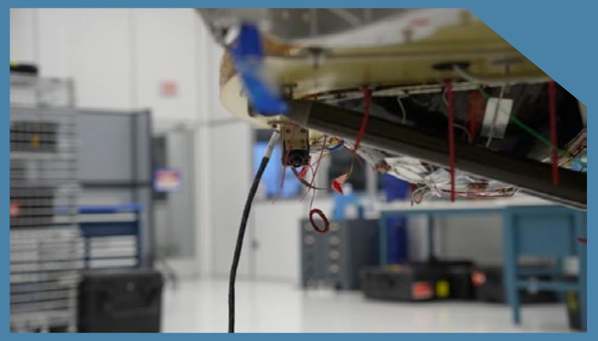


"The atmosphere of Uranus is an enigma—the upper altitudes are much hotter than we can explain. By observing stellar occultations (when Uranus briefly blocks light from a distant star), we can measure Uranus's temperatures from Earth, better understand how its atmosphere works, and even help a future mission to Uranus."

On the Path to Discovery

NASA's Dragonfly rotorcraft will explore a variety of locations on Saturn's moon Titan.

In December 2024, Langley's Dragonfly team successfully passed an Entry, Descent and Landing (EDL) Phase Critical Design Review (CDR) -- a multidisciplinary technical review that ensures a product's design is ready for fabrication, testing, and demonstration. The team is preparing for a CDR for the Parachute Deployment System in 2025.



Tiny NASA cameras will picture interaction between lander, Moon's surface.

In its first flight in 2024, SCALPSS 1.0 collected data throughout the SCALPSS 1.0 CLPS Intuitive Machines (IM-1) flight, and into several days on the lunar surface. All hardware operated as expected, providing increased confidence in the second SCALPSS payload (SCALPSS 1.1) which was successfully integrated to the CLPS Firefly Aerospace Blue Ghost Lander for launch in early 2025. Also in 2024, Langley has supported the integration of a third payload (SCALPSS 1.x) to be delivered to Blue Origin for integration to its Mk1 lander for its first test flight currently planned for mid-2025. Langley is also supporting development of a next-generation SCALPSS instrument (SCALPSS 2.0) which will include upgraded avionics and improved imaging.

Visit our PIONEER section highlights to learn more about these missions.

SPOTLIGHTS ON THE FUTURE OF LANGLEY SCIENCE

Katherine Travis, *Research Scientist*

"Multiple perspectives are key to fully challenge the ability of models to quantify changes in air quality in response to changes in human activities or natural events such as fires. The most rigorous model development is achieved with improved agreement both at the surface and aloft. Airborne observations in particular provide detailed information to test our understanding of a wide range of pollutant emissions and develop model processes that govern pollution build-up. No integrated assessment of air quality is complete without the airborne perspective."

Lauren Childs-Gleason, *DRCS Process Improvement & Capacity Building Lead*

"The vantage point of space gives an unparalleled perspective when responding to disasters. The DRCS harnesses NASA's ingenuity and expertise to provide creative solutions that efficiently apply satellite data to support informed decision making when disasters strike. Employing a user-centric, continuous-improvement model, the DRCS nurtures relationships within the disaster response community to facilitate NASA Earth observation data getting into the hands of responders when and where they need it to help save lives and livelihoods."

Yolanda Shea, *Research Scientist*

"CLARREO Pathfinder will take more accurate measurements of reflected sunlight than any other instrument. These unprecedented measurements will provide a guidepost for other instruments taking similar observations and serve as a cornerstone of the future climate observing system."

Falguni Patadia, *Research Physical Scientist*

"We provide our users with the trusted value-added surface radiation and meteorological data and research they need to make informed decisions related to energy, built environments and agriculture. By removing data accessibility barriers through innovative solutions like API access, web-based analytics, and geospatial services, POWER improves their potential to make decisions that enhance societal well-being."

Rob Damadeo, *Research Scientist*

"We used over 40 years of heritage and knowledge, alongside state-of-the-art technology, to modify and optimize the SAGE solar occultation technique. The SAGE IV concept enables a more robust and cost-effective way to ensure a stable record of the health of the ozone layer in the decades to come as well as a reference standard for upcoming missions studying the impact of volcanic eruptions and extreme wildfires on the stratosphere."

Charles Hill, *Research Scientist*

"The ultraviolet performance of the SAGE III optical train is susceptible to molecular contamination, particularly organosilicon compounds. To monitor the molecular contamination environment of the International Space Station, the SAGE III team built thermoelectric quartz crystal microbalance-based Contamination Monitoring Packages (CMPs) that continuously measure mass deposition on orbit and can be warmed to perform thermogravimetric analyses to identify contaminant materials. Reaching far beyond the original intent, we have used CMP data to fundamentally change NASA's understanding of how contaminants propagate, accrete, desorb, chemisorb, physisorb, and interact with atomic oxygen in low Earth orbit. The team is also working to extend their techniques to planetary mission applications."

INSPIRE ▶ ASDC

NASA Langley is home to the Atmospheric Science Data Center (ASDC), a leading provider of atmospheric science data products and services to the science community. Data products translate discoveries into meaningful knowledge that inspires action by scientists, educators, decision makers, and the public. The ASDC supports more than 60 projects and provides access to more than 1,000 archived collections. These data sets were created from satellite measurements, field experiments, and modeled data products.

At the root of NASA Langley's scientific discoveries, we connect and engage communities through transparent, open data as we flourish solutions, societal value and public understanding and exchange.

ASDC Provides Near Real-Time, Openly Accessible Air Quality Data

The ASDC played a crucial role in supporting the TEMPO (Tropospheric Emissions: Monitoring of Pollution) data archive, distribution, and user services. TEMPO provides valuable data for near real-time air quality monitoring, with ASDC ensuring easy access to these data for researchers and policymakers.

TEMPO measures North American pollution within a four-square-mile area and reveals how pollution varies by neighborhood within a city. TEMPO's openly accessible air quality data is used for studies of rush hour pollution, improved air quality alerts, the transport of pollution from forest fires and volcanoes.

In 2024, The ESDIS (Earth Science Data and Information System) team hosted a webinar titled, 'Finding Your TEMPO Data,' which had more than 800 registrants and 400 participants. ASDC presenters provided an overview of the TEMPO mission and its data products and demonstrate how to discover and access TEMPO data products using NASA's Earthdata Search.

2024 ASDC HIGHLIGHTS ▶

Empowering Scientists with Open Science: TOPS Team Launches Key Training Module

The Transform to Open Science (TOPS) project is equipping researchers with essential skills to embrace open science, promoting transparency, collaboration, and knowledge-sharing across the scientific community. Instructed by Gao Chen, Kathleen Dejwakh, and Daniel Kaufman, the "Open Science 101" module covered the ethos behind open science, including motivations, credit systems, and its community benefits. Feedback from the session will shape a more comprehensive course, set to be rolled out in 2025.

DSCOVR and EPIC 10th Anniversary Celebration Underscores ASDC's Role to Ensure Earth Observation Data

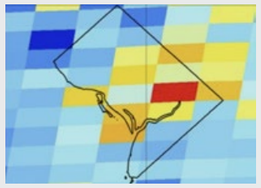
The 10th anniversary of the DSCOVR (Deep Space Climate Observatory) mission and its Earth Polychromatic Imaging Camera (EPIC) celebration underscored the role of the ASDC to ensure that DSCOVR's data continues to serve as a valuable resource for researchers, policymakers, and advocates striving for a more sustainable future. Langley presenters highlighted key initiatives such as data harmonization, increased user engagement through workshops and tools, and advancements in open science to enhance EPIC's Earth observation data.

Engagement to Transform Earth Science Data into Actionable Solutions for Global Challenges ▶

The ASDC hosted a one-day 'Bootcamp' for 17 students through the Virginia Space Grant Consortium. Participating students gained hands-on experience with NASA's air quality monitoring tools, such as TEMPO and AERONET (AErosol RObotic NETwork), learning how to apply satellite data to real-world environmental issues.

The ASDC led a workshop for NASA's DEVELOP National Program participants, focusing on how air quality data from instruments like TEMPO and Pandora can be analyzed and interpreted to assess pollution levels and inform urban mitigation strategies.

The ASDC in collaboration with ESDIS, organized an interactive public workshop at Old Dominion University's Pneuhaus Festival, where participants explored how Earth observations can be used to monitor air quality



At the 2024 Health and Air Quality Applied Science Team (HAQAST) Public Meeting, the ASDC co-hosted an early-career workshop with the Health Effects Institute. Multiple Langley presentations showcased the ASDC's pivotal role in bridging satellite and suborbital data with real-world applications for air quality and public health experts.

INSPIRE ▶ POWER

The Prediction of Worldwide Energy Resources (POWER) project provides solar and meteorological datasets and value-added parameters from NASA research through web services that support renewable energy, building systems, and agriculture decisions.

POWER's Accessible Solar Data Drives Everyday Applications

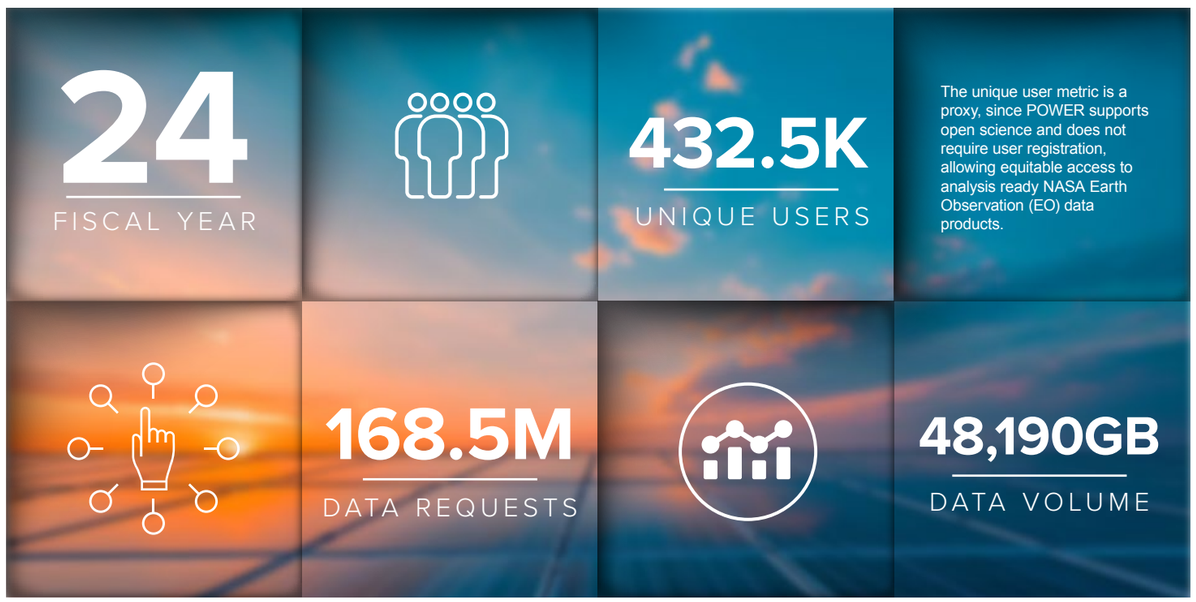
Urban Solar, a North American private company that manufactures solar energy systems, uses POWER data and services to acquire solar irradiance data to optimize and design solar-powered lighting solutions for bus stops, bus shelters, and bus signage. They have installed over 25,000 solar lighting solutions across North America. King County Metro, a customer of Urban Solar, in Seattle, Washington has installed 1,300 solar-powered lights since 2013. By removing access barriers and providing trusted data, POWER enabled Urban Solar to make sustainable, informed decisions.

POWER Modernizes Cloud Infrastructure, Providing Reliability to Users

Two-Years, Zero Downtime. Based on POWER team assessments finding rapidly increasing usage metrics in 2021 and the corresponding increase system usage, the POWER team prioritized migration to the cloud. Since the migration, POWER has provided 142.26 TB of data via the cloud via 290,196,752 requests to 617,731 new users with 100% uptime — meaning no interruption and continuous reliability for POWER data users.

"The coverage and quality of the POWER database provides a consistent, trustworthy data source for our studies, no matter where the project is."

- Ryan Danks. Global Practice Leader, Building Performance at RWDI



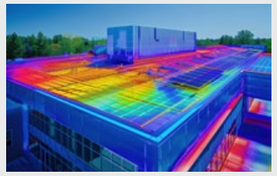
Annual POWER Global Community Summit: Fostering Meaningful Connections, Exchanging Valuable Insights, and Exploring New Opportunities for Supporting User Communities

The 2024 POWER Global Community (GloCo) Summit was hosted virtually on November 6 and 7 and offered an array of presentations and sessions to spark conversation and connection, inform users of the latest enhancements to data product offerings, share user stories, and capture emerging user needs. The summit had over 305 registrants from over 50 counties and was attended by 137 unique participants over the two days. To begin the summit, Shanna Combley, NASA Energy Resources program manager, gave opening remarks, followed by keynote presentations representing the renewable energy, sustainable infrastructure, and agroclimatology communities. Twelve unique lightning talks from POWER users showcased the use of POWER data to enable missions across the globe. On day two, four individuals were presented with the NASA Recognition of Excellence Awards for RETScreen® expert users. The awards recognized exceptional achievements in utilizing solar and meteorological datasets provided by the NASA POWER project in conjunction with the RETScreen® Clean Energy Management Software.

POWER DATA USE CASES ▶

Enabling Global Deployment of Renewable Energy Technology

Alpha 311 is a company that develops vertical axis wind turbines that can be placed on buildings, light poles, and other structures. Alpha 311 uses POWER's wind speed and wind direction parameters to help retrofit turbines to new and existing infrastructure. To date, POWER data has been applied in project proposals in 68 countries and is key in helping organizations from schools and hospitals to commercial manufacturing plants and sports stadiums deploy renewable energy technology around the globe.



POWER Serves as Tool to Ensure Decision Making Confidence

Rowan Williams Davies & Irwin Inc. is a climate and performance engineering firm that utilizes POWER data to support their decision making on sustainable infrastructure. They use POWER in tandem with their in-suite tools to confirm their analysis that feed their recommendations to clients. By leveraging POWER's data tools and services, RWDI helped decreased the carbon footprint of buildings and cities and increased efficiency while providing the most cost-effective solutions.

POWER Helps Bring Clean Water to West African Communities

Davis & Shirtliff, based out of Kenya, specializes in designing solar-powered water pumps for West African communities. Integrating POWER's API with the SolarCalc Solar Sizing Solution they developed, Davis & Shirtliff leverages solar data to aid in their sizing and power forecasting of certain sites. With the help of NASA POWER, they've successfully brought clean water to 530,000 people by reducing design time from five hours to three to five minutes, decentralizing knowledge, and creating more informed proposals.

POWER's Platform as a Classroom Tool to Drive Tangible Results

Arunai Engineering College in India uses POWER's Data Access Viewer to access solar data used to calculate energy output from the campus' 10 kWp solar photovoltaic microgrid. The system, along with POWER data, is used as a teaching tool for future engineers and scientists focused on sustainable energy solutions. Each month, the data provided by the POWER project used to inform energy prediction calculations, supports the campus energy savings of around $100, or 5% of their energy costs. As of October 2024, the microgrid system has produced a total of 32,985 kWh of electrical energy since its installation in November 2021.

Sizing Solar Panels for Regenerative Sludge Drying

POWER solar data is used by HUBER SE, a German company with expertise in the treatment of water, wastewater, sludge, and waste, to calculate the size of solar panels used in their regenerative sludge drying process. The data helps inform decisions that maximize efficiency and decrease costs. HUBER SE manages 23 plants around the world, including one in North Carolina, and currently treats more than 650,000 tons of sludge each year.

INSPIRE

CEOS SEO

"Our goals of saving lives and building a sustainable economy mean we are delivering actionable science and scientific understanding to improve response to disasters, to improve agricultural yields with fewer inputs, to protect our biodiversity, and better manage our water resources. On this 40th anniversary, NASA salutes CEOS for its impact and accomplishments across all Earth science domains." ***- Karen St. Germaine,*** NASA's Earth Science Division Director

SEO Celebrates and Supports CEOS in its 40th Anniversary Year

2024 marked the 40th Anniversary of the Committee on Earth Observation Satellites (CEOS) -- the primary forum for international coordination of civil space-based Earth observations. The Systems Engineering Office (SEO) was conceived by NASA in 2007, as a contribution to CEOS, and is currently led by NASA Langley. SEO supports CEOS to increase awareness and applications of accessible Earth Observation data, along with the tools and services needed to effectively use Earth Observation data for the greatest societal benefit. In recognition of 40 years, CEOS SEO coordinated more than 40 national civil space agency leaders who expressed the value and impact of CEOS.

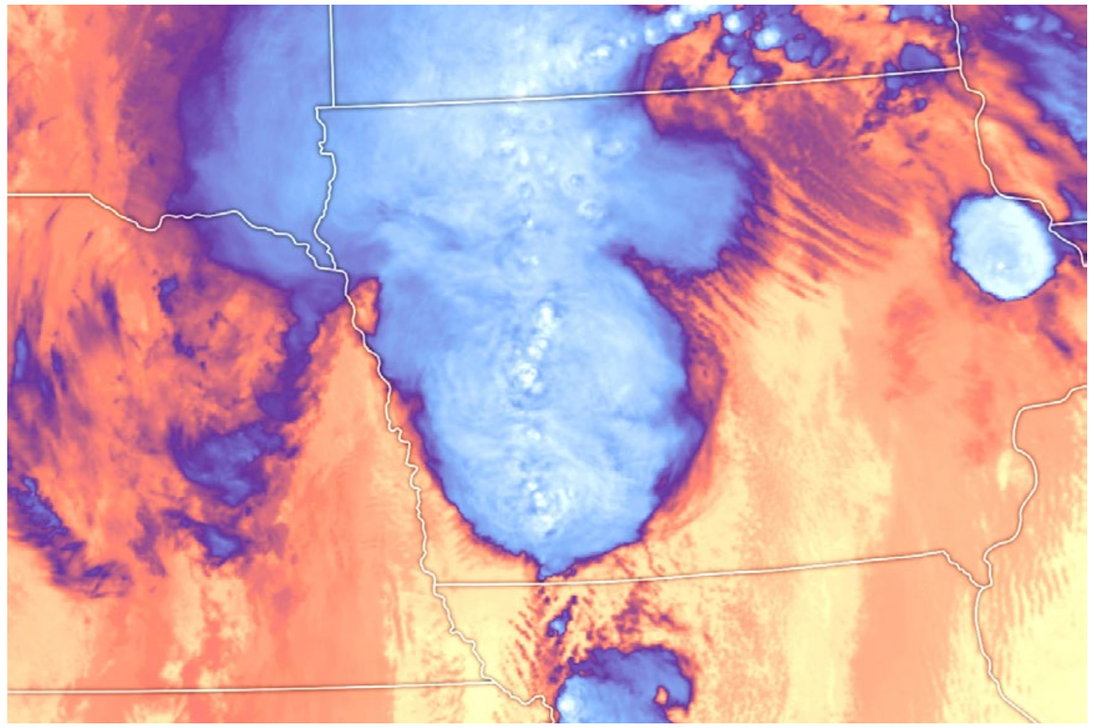
During the 38th Plenary meeting of the Committee on Earth Observation Satellites (CEOS), held in Montreal, Canada in October 2024, CEOS renewed a commitment to:

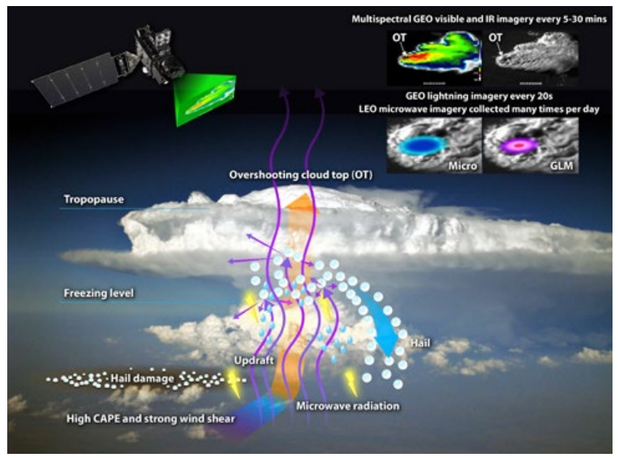
- Monitor the environment from space through the coordinated planning, production, improvement, interoperability and availability of space-based climate data records on a global scale for maximum impact.
- Support disaster risk management and enhance the contribution of space-based Earth observations in support of disaster risk reduction, mitigation and post-event recovery.
- Continue to enhance the provision of quality assured space-based Earth observations across the Group on Earth Observations (GEO) to ensure interoperability and accessibility of data, ultimately maximizing observation benefits through integration with other data types, such as in situ.
- Support the UN Sustainable Development Goals (SDGs) where appropriate and practicable.

Global Geospatial Solutions: CEOS SEO Impact across the Earth Observation Sector

The CEOS Systems Engineering Office (SEO) plays a pivotal role in advancing Earth observation technologies and supporting sustainable development through innovative tools and partnerships. SEO hosted a Cloud Native Geospatial Workshop at SatSummit and FOSS4G events in 2024, offering hands-on training to attendees on leveraging cloud-based Earth observation data, empowering non-experts to engage with large datasets. SEO also actively contributes to the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM), serving on the U.S. Delegation. Through initiatives like the CEOS Analytics Lab, CEOS Visualization Environment, and the Open Data Cube, SEO fosters the global adoption of open-source solutions and cloud frameworks, supporting collaboration across civil and commercial geospatial communities worldwide.

SEVERE STORM RESEARCH





Severe Storm Research Techniques Empower Developing Countries Without Weather Radar Coverage

While severe storms over the U.S. are quite well observed by the NOAA ground-based weather radar network, developing countries often to not have such networks, leaving people and their property at risk. In coordination with NASA scientists, Langley has developed automatic and innovative techniques for quickly identifying severe storm indicators like overshooting tops from satellite imagery. Fortunately satellites collect frequent and detailed imagery of severe storms throughout the globe. These Langley techniques can be used to detect storms and provide advanced warning to local communities where there are radar gaps. They can be used by forecasters in near-real-time to issue warnings, as well as to quantify severe storm frequency, climate trends, and risk from long-term geostationary satellite records. This has made it possible to provide the reinsurance industry and the severe storm research community with new and highly detailed insights into severe storm activity that cannot be compiled from other data sources.

INSPIRE ▶ DRCS

NASA's Disasters Response Coordination System: Bringing Clarity to Crises

When disasters threaten, the perspective from space offers more than a dramatic view – it holds the key to enhanced response, resilience and recovery. Imagine a hurricane bearing down on a vulnerable coastline; its winds bringing down power lines it's water sweeping away homes, businesses and roads. Emergency responders and community leaders need to quickly make life-saving decisions with limited information. Now, picture having accurate, timely and actionable information from a constellation of Earth-observing satellites vigilantly capturing critical data. Imagine having information at your fingertips to discern where and how much floodwaters are rising, see where power outages are spreading, and better understand widespread impacts of the storm. This is the aim of NASA's Disasters Response Coordination System (DRCS), an initiative of NASA's Earth Science Division's Disasters Program that turns science into action and data into decisions.

Launched in June 2024, the DRCS is already demonstrating its value, strengthening disaster response efforts worldwide.

A "Whole-of-NASA" Approach to Disaster Response

The system's structure includes a central project office at NASA's Langley Research Center and Center Response Coordinators across six NASA centers, ensuring robust representation and use of NASA's collective capabilities. This whole-of-NASA approach supports streamlined data-driven decision-making and operational efficacy during crises to aid agencies and organizations tasked with operational disaster preparedness and response.

> *Emergency response is a team sport. The DRCS isn't about NASA swooping in with answers – it's about working side by side with responders to give them the tools they need to save lives.* ***- Katie Picchione,*** NASA DRCS Coordination Lead

DRCS By the Numbers: June 13 – Dec. 31, 2024

12 activations

5 hazard types responded to by DRCS *(hurricane, flood, landslides, severe convective weather, earthquakes)*

14 Earth observation missions/instruments utilized in response products

24 unique organizations engaged

14 conference/meeting presentations given and/or sessions chaired by DRCS network

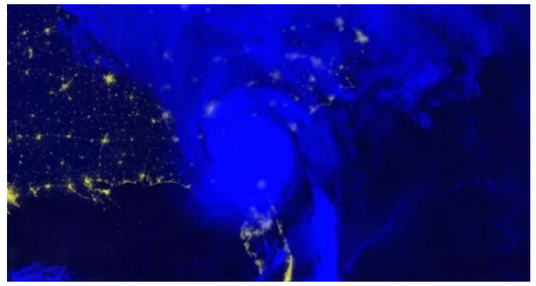
69 products posted on the Disasters portal

12 US states responded to by DRCS *(AL, AR, FL, GA, IA, LA, MS, NC, SC, TN, TX, VA)*

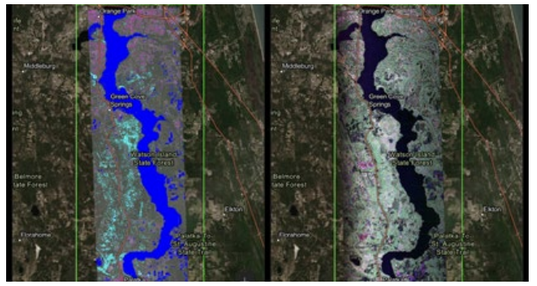
4 countries responded to by DRCS *(Bangladesh, Nepal, Costa Rica, USA)*

Turning Data Into Decisions ▶

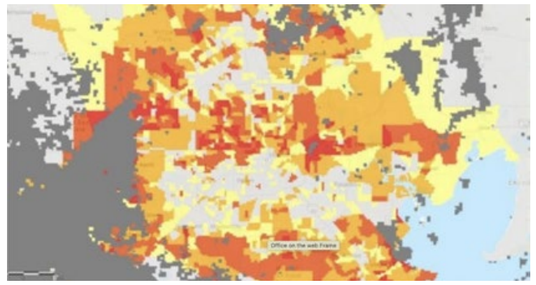
By analyzing data from Earth observation satellites and other platforms, the DRCS team provides detailed, and often near-real-time products to enhance the understanding of disaster impacts.



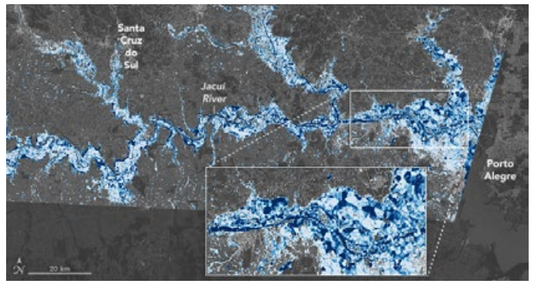
Federal and state agencies requested the DRCS' support in September 2024, when Hurricane Helene, battered Florida's Big Bend region. Using NASA's Black Marble technology, the DRCS analyzed nighttime lights imagery to pinpoint extensive power outages and potential infrastructure damage. These insights enabled the Federal Emergency Management Agency (FEMA) and local responders to prioritize resources and respond quickly in the hardest-hit and most vulnerable communities.



A few weeks later, Hurricane Milton intensified rapidly, threatening Florida's Gulf Coast with devastating winds and flooding. The DRCS collaborated with NASA's Airborne Science Program to deploy the Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR). This technology provided wide-area radar data, even through thick storm clouds, allowing emergency managers to assess flood extent and damage in near real time to help them guide relief efforts and safeguard lives.



When an oppressive heat wave followed a derecho that swept through Houston last spring, the DRCS used Black marble technology to assess power outages that affected over a million residents. At FEMA's request, NASA identified neighborhoods with both prolonged outages and high vulnerability enabling targeted relief efforts that helped to make sure power was restored quickly to those most at risk.



In April and May 2024, several days of heavy rainfall caused devastating widespread flooding in the city of Porto Alegre and other cities in the southern Brazilian state of Rio Grande do Sul. The DRCS team mapped landslides in the region using high-resolution Commercial Satellite Data Acquisition (CSDA) data, shared Black Marble imagery to aid in identifying regions without power and astronauts aboard the ISS took photographs of the region in support of the International Disasters Charter.

Track DRCS Activations in 2025 ▶

Since Jan. 7, several major wildfires have swept through in Los Angeles County in California, as strong Santa Ana wind gusts stoke the blazes. The DRCS is sharing maps and data to aid partners in identifying burned structures and critical infrastructure, fire extent, air quality, and other impacts the fires are having on the community. The DRCS are sharing products directly with partners and are also sharing them on the NASA Disasters Mapping Portal as they become available.

INSPIRE ▶ DEVELOP

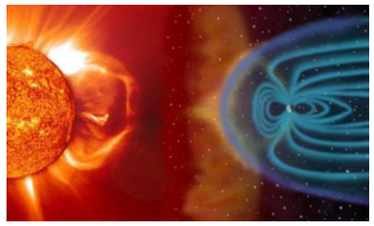
DEVELOP provides 10-week research opportunities for participants to address environmental and policy concerns through the practical application of NASA Earth science information and geospatial data. Working in interdisciplinary teams and with the support of science advisors and mentors, DEVELOP participants build research and science communication skills that help them succeed in the workforce.

Record Setting – Over 1,000 Applications Received for Summer 2024

DEVELOP received a record number of 1,011 participant applications for the summer 2024 term. Interest in the program has continued to increase, as the number of submitted applications for the summer term has doubled since 2018.

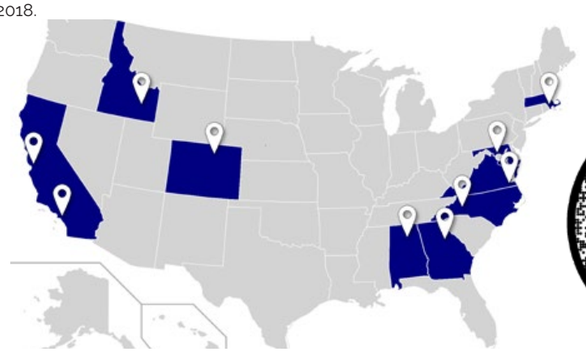
DEVELOP Day

DEVELOPers traveled to NASA Headquarters on August 6th, where where 25 summer project representatives participated in poster sessions, flash talks, and highlight presentations. The day also included highlights from DEVELOP alumni, current partners, and NASA leadership.



Space Weather Pilot Projects

DEVELOP partnered with NASA's Heliophysics Division to pilot two space weather applications projects. The projects partnered with the National Park Service to enhance aurora borealis watch planning in high latitude national parks and John Deere, along with public and private organizations in Brazil, to quantify Global Navigation Satellite System (GNSS) errors from equatorial plasma bubbles that disrupt agricultural operations.

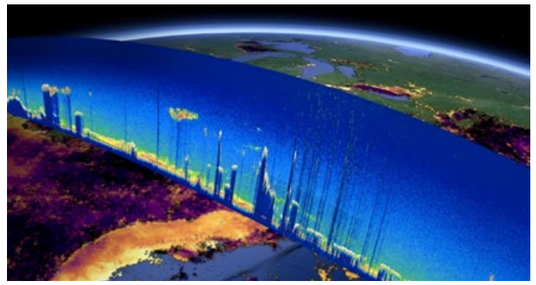


DEVELOP has permanent locations across the U.S.

Learn more and apply:

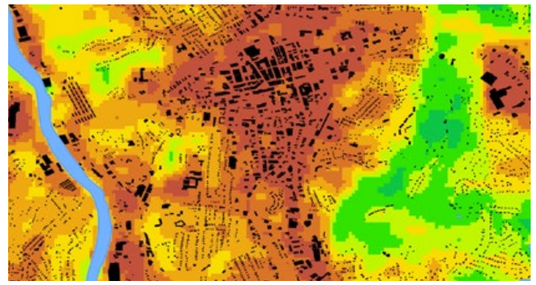
SCIENCE AT NASA'S LANGLEY RESEARCH CENTER

DEVELOP Project Highlights ▶



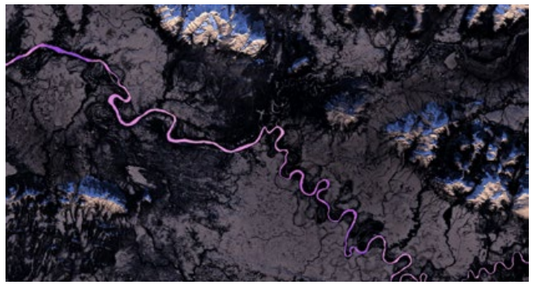
Hampton Roads Health & Air Quality

Virginia's Hampton Roads region is a historic hub for coal storage and transportation, which has raised concerns about air quality and the associated human health risks. Partnering with the Virginia Department of Environmental Quality, the DEVELOP teams mapped particulate matter distribution with MODIS and CALIPSO in comparison with ground sensors and the spatial patterns of gaseous pollutants using TEMPO and TROPOMI to monitor air quality trends.



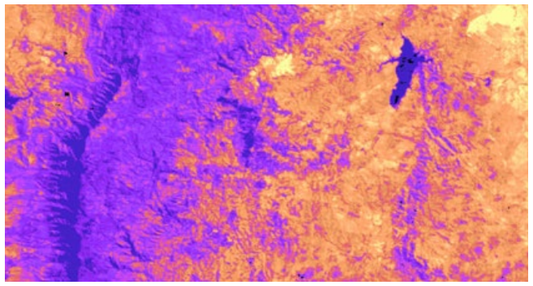
Asheville Urban Development

Features of urban landscapes, such as dark pavement and sparse vegetation, lead to low albedo and reduced evapotranspiration, increasing the urban heat island effect. In partnership with the City of Asheville, North Carolina and Asheville GreenWorks, this project identified urban heat island hot spots by examining satellite-derived land surface temperature, albedo, and evapotranspiration with social vulnerability data to identify locations in Asheville most in need of heat mitigation measures.



Alaska Ecological Conservation

Caribou are known for their long-distance migrations from wintering grounds to specified calving zones. Warming temperatures and resulting shifts in river ice phenology have the potential to restrict the caribou's ability to cross large rivers along their migration routes. DEVELOP partnered with the National Park Service to identify these changes using ice detection indices that incorporate optical and radar remotely sensed data to mitigate caribou population decline in Alaska.



Cordoba Wildland Fires

Córdoba, Argentina has experienced intensified wildfire activity, where fires burned over 300,000 hectares across the province in 2020. This project partnered with the Instituto Nacional de Tecnología Agropecuaria to address gaps in understanding of parameters influencing fire behavior and growth. The DEVELOP team used NASA's remote sensing capabilities to analyze biophysical parameters, including vegetation and precipitation, that contribute to wildfire risk.

CY24 DEVELOP By the Numbers:

Awarded **231** Participant Opportunities
Conducted **58** Projects
Received **2,133** Applications
Impacted **29** States and **8** Countries

INSPIRE

MY NASA DATA

My NASA Data is a NASA Langley project that supports the use of authentic NASA Earth data for educators and learners in grades 3-12. The NASA Earth data is curated, aligned to Next Generation Science Standards, organized by Earth system sphere, and packaged in a variety of learning resources (Mini Lessons, Interactives, and Lesson Plans) and a user-friendly data visualization tool.

My NASA Data Usage Record Eclipsed by the Eclipse

My NASA Data's usage record was eclipsed by the Eclipse - seeing a year's worth of activity, 1 million visitors, in just one month from states within the path of totality. Visitors most frequently viewed lesson plans and mini-lessons. There were more than 32,000 views of story maps and interactives. Educators were invited and encouraged to continue using My NASA Data and a webinar was scheduled for new users.

NC Space Education Ambassadors: A Pilot of the 'My NASA Data Teacher Leader Program'

NASA Langley's Science Activation team partnered with NASA's Office of STEM Engagement (OSTEM) to provide training to 22 Space Education Ambassadors from North Carolina. This effort served as a pilot for the first phase of the developing 'My NASA Data Teacher Leader Program.' Educators learned how to integrate data to provide data-rich science instruction.

MY NASA Data Digital Engagements: FY24

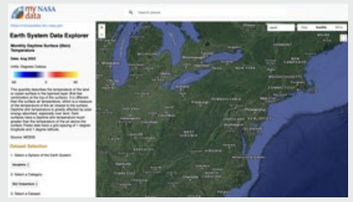
Pageviews: **1,864,550**

Story Maps & Interactives: **175,437**

Earth System Data Explorer Maps Loaded and Activity: **355,422**

Total Digital Engagements: **2,395,409**

My NASA Data experienced remarkable growth in FY24 due in part to the overwhelming interest in solar eclipse content related to the annular eclipse in October 2023 and the total eclipse in April 2024.



New Data Visualization Tool Brings NASA Satellite Data Down to Classrooms

In 2024, the My NASA Data team wrote and released a new data visualization tool that is based on Google Earth Engine. The updated Earth System Data Explorer visualization tool allows users to access and download NASA Earth data. Educators can explore the data then create custom data tables, graphs, and plots to help students visualize the data. Students can create and investigate comparisons between land surface temperatures, cloud cover, extreme heat, and a wide range of other variables for a specific location or region around the globe.

GLOBE

NASA Langley has been a GLOBE Partner since 2003. GLOBE at Langley creates pathways for all to engage in The GLOBE Program, envisioning a worldwide community working together to better understand, sustain, and improve Earth's environment at local, regional, and global scales. If you're not already observing clouds for NASA, start by downloading GLOBE Observer, the app of The GLOBE Program.

GLOBE Clouds Reached 1 Million Geostationary Satellite Comparisons

In May 2024, the GLOBE Clouds team reached the 1 millionth geostationary satellite comparison to GLOBE citizen science data. Since 2017, the Global Learning and Observations to Benefit the Environment (GLOBE) Clouds team has been working with Langley's Satellite ClOud and Radiation Property retrieval System (SatCORPS) team to provide geostationary satellite imagery and data to GLOBE citizen scientists. You can access the combined satellite and citizen science data sets on the GLOBE Observer Get Data webpage.

GLOBE Cloud Observations: Fy24

Total Cloud Observations: **178,009**

Total satellite collocations: **191,311**

Geostationary satellites: **146,049**

Terra: ***17,399****, NOAA-20:* ***27,717****, Aqua:* ***146***

Total sky photographs received: **496,990**

Eclipse Teacher Workshop with NIA for Hampton Roads Teachers

Langley's Science Activation team joined forces with the National Institute of Aerospace (NIA) to provide a teacher workshop for Hampton, Newport News, York, Portsmouth, and Chesapeake teachers through a CoVA STEM grant. The teachers learned and practiced GLOBE data collection protocols for recording and reporting cloud observations, air temperature and surface temperature. Through collecting data using the GLOBE protocols, the teachers will engage students in science and engineering practices embedded in the science curriculum throughout the year in a real-world and relevant way. The students will join other learners from across the country and 127 other countries in becoming citizen scientists contributing the data collected to GLOBE and NASA.

GLOBE Educators and Students Across the U.S. Conduct Research During Eclipse

In April 2024, 39 GLOBE educators and their students collected air temperature and cloud cover data using the GLOBE Observer app's Eclipse tool. During a 5-week virtual GLOBE Eclipse workshop series, 10 of these educators extended their Eclipse research with training in the GLOBE Clouds, Air Temperature, and Surface Temperature protocols. The workshop is a collaboration across Science Activation projects including GLOBE Mission Earth, the NASA Earth Science Education Collaborative (NESEC), and the GLOBE Program U.S. Country Coordinator Office. Read more in the Bulletin of the American Astronomical Society.

GLOBE Eclipse Data Presented at the Civil Air Patrol National Conference

In August 2024, Langley's GLOBE team gave a first look at GLOBE Eclipse data at the Civil Air Patrol (CAP) National Conference in San Antonio, Texas. For the first time in CAP history, all 52 wings, comprised of all 50 US states, Puerto Rico, and Washington, DC, participated together. This event engaged over 3,000 cadets, 1,000 senior members, as well as 40,000 students and 600 educators through the CAP's Aerospace Education program. This has led to the NASA/CAP 2025 Contrail Mission, where cadets and senior members will gather contrail data and airplane information for the team.

INSPIRE

LEADERSHIP IN THE SCIENCE COMMUNITY

BY THE NUMBERS: INSPIRING SCIENTIFIC EXCHANGE

Our shared science knowledge through peer-reviewed publications, presentations, technical documents, ensures accuracy and credibility by subjecting it to critical evaluation by other experts in the field, thus upholding the integrity of scientific knowledge and advancing the field through robust research findings.

24
FISCAL YEAR

Langley science authors and co-authors reported contributions to **79** peer-reviewed journal publications.

Langley scientists gave **389** presentations at meetings, conferences and other events.

Langley science authors reported **63** conference papers and **181** conference posters.

LEADERSHIP IN ACTION: SHAPING THE FUTURE OF SCIENCE

H.J.E. Reid Award

The H.J.E. Reid Award Selection Committee awarded first place to the paper, "Airborne HSRL-2 measurements of elevated aerosol depolarization associated with non-spherical sea salt." The selected paper was a collaboration among researchers from NASA Langley, the National Institute of Aerospace, the University of Arizona, and the University of Miami. Authors included Richard Ferrare, Johnathan Hair, Chris Hostetler, Taylor Shingler, Sharon P. Burton, Marta Fenn, Marian Clayton, Amy Jo Scarino, David Harper, Shane Seaman, Anthony Cook, Ewan Crosbie, Edward Winstead, Luke Ziemba, Lee Thornhill, Claire Robinson, Richard Moore, Mark Vaughan, Armin Sorooshian, Joseph S. Schlosser, Hongyu Liu, Bo Zhang, Glenn Diskin, Josh DiGangi, John Nowak, Yonghoon Choi, Paquita Zuidema and Seethala Chellappan.

Blue Marble Awards

The NASA Environment and Energy Award Program recognizes NASA civil service employees and contractors who demonstrate environmental leadership while carrying out NASA's mission. In 2024, two Langley teams received a NASA Blue Marble Award for 'Excellence in Resilience or Climate Change Adaptation.'

- The NASA Climate Adaptation Science Investigators Workgroup Initiative (CASI) was awarded for their science-based data and tools. The workgroup includes NASA Langley's Paul Stackhouse, Bradley Hegyi, Patrick Taylor, Elizabeth Wiggins, and John Murray.
- The Disasters Response Coordination System (DRCS) team was awarded for their science-based disaster response and resiliency planning. The team includes Josh Barnes, Patrick Rhea, Rachel Soobitsky, Lauren Childs-Gleason, Carrie Roller and Robert Emberson.

National Academies Panel on Developing a Contrails Research Agenda

Richard Moore was appointed to a National Academy of Sciences Engineering and Medicine ad-hoc committee tasked with creating a national research agenda to address the global climate impact of aviation-induced cloudiness (AIC) and persistent contrails (PC). The committee's goal is to better understand, quantify and develop solutions to reduce the climate effects of these phenomena from commercial aviation.

NOAA Science Advisory Board Climate Working Group Membership

Ali Omar completed a three-year term (Aug 2020-Dec 2023) on the NOAA Science Advisory Board Climate Working Group, which provides scientific advice on NOAA's climate programs. During his tenure, he played a key role in drafting the white paper "Air Quality in a Changing Climate: NOAA's Role (2023)," offering recommendations for predicting the impacts of climate change on air quality.

Lawrence Award

The winning paper, "Isolating the Surface Type Influence on Arctic Low-Clouds" by Patrick C. Taylor and Emily Monroe, was selected for the 2024 SD Lawrence Award and will be nominated for the 2025 Center-wide Reid Award. The award called for papers published between 2022 and 2024, to recognize the best research conducted on-site at NASA Langley.

Community Outreach: Highlighting the Canadian 2023 Extreme Fire Season

Amber Soja and Nancy French co-led the development of the keynote panel "Canadian 2023 Extreme Fire Season" at the IAWF Fire Behavior and Fuels conference, featuring a diverse group of Canadian experts across various fields. The panel focused not only on scientific data but also on the personal and administrative challenges faced during the extreme fire season, including evacuation experiences, community interactions, and managing escalating fire conditions with limited resources.

Meeting of the SITSat Task Team

Yolanda Shea co-led a hybrid meeting of the SI-Traceable Satellite Sensor (SITSat) Task Team during the CEOS WGCV meeting in Sioux Falls, SD, where global space agency representatives discussed upcoming activities. The team focused on refining communication strategies and updating the website content as part of their joint effort with the Global Space-Based Intercalibration System (GSICS).

U.S. CLIVAR Workshop on Polar Amplification

Patrick Taylor co-chaired the U.S. Climate and Ocean - Variability, Predictability, and Change (CLIVAR) workshop on Polar Amplification, which brought together researchers from both the Arctic and Antarctic climate change fields to foster collaboration and identify key knowledge gaps. The workshop aimed to prioritize research areas, define strategies to address gaps, and enhance community collaboration, with a particular focus on seasonally resolved processes and the asymmetries between Arctic and Antarctic amplification.

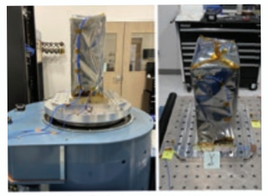
Langley Researchers Elected to International Ozone Commission

Robert Damadeo and Richard Eckman were elected to the International Ozone Commission (IO3C) at the 2024 Quadrennial Ozone Symposium in Boulder, Colorado. The IO3C, established in 1948, includes about 30 leading scientists worldwide and organizes global efforts to study ozone, including measurements and analysis of atmospheric processes affecting it.

#1

Girls in Aviation Day

#2



ARCSTONE Vibration Test

#3

Back to School Career Day

#4

2024 State of the Federal Labs

#5

ARCSIX Spring Campaign

#6

CLARREO Pathfinder PSTOR

#7

Tackling Aviation's Contrail Crisis

#8

Solar Eclipse Interviews

#9

NASA Langley Inspires Educators

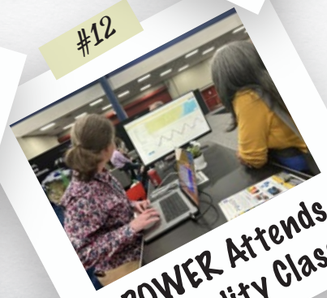
#10

Fire Behavior & Fuels Conference

#11

DC-8 Retires with a Water Salute

#12



POWER Attends Commodity Classic

1

While in Marina, Calif. For PACE-PAX, the LARGE team supported Women in Aviation's Girls in Aviation Day. Members of the public were able to tour the Twin Otter and see the instruments, chat with NASA scientists, and learn about the PACE and PACE-PAX missions and airborne science.

2

The ARCSTONE team, in collaboration with Blue Canyon Technologies (BCT), successfully completed vibration testing of the fully integrated spacecraft and Mercury-6T dispenser. The tests met SpaceX's rigorous launch environment requirements, ensuring the payload's readiness for space. Following the test, functional checks confirmed nominal performance.

3

On September 26, 2024, Dr. Yolanda Shea joined NASA's Back-to-School Career Day, sharing her journey as a lead scientist for an Earth Science mission. She was a panelist on the "Earth: Your Home, Our Mission" discussion, inspiring K-12 and college students across the nation to explore careers in STEM and space exploration!

4

Key players from the Department of Energy's Jefferson Lab and NASA Langley Research Center unite at the State of the Labs event in Newport News. Networking and collaboration with local businesses and stakeholders are paving the way for groundbreaking advancements in science and technology.

5

A research scientist monitors data measurements in-flight during the spring campaign of the ARCSIX mission. Aircraft deployments in May and June of 2024 were timed to document the start of the ice melt season.

6

The CLARREO Pathfinder (CPF) team marked a major project milestone with a successful Pre-Storage Review at LASP in Boulder, CO (Nov 19-21, 2024). The review assessed payload performance, testing, compliance, and launch prep. The payload is now in storage at LASP, awaiting quarterly tests before its eventual journey to the ISS.

7

NASA's Rich Moore joined Aviation Week's Check 6 editors to discuss the science behind contrails and their climate impact. They explored how innovations in aircraft engines and sustainable fuels could reduce aviation's carbon footprint, offering a path forward to a greener, more sustainable air travel future.

8

On April 8, 2024, Marty Mlynczak participated in three live TV interviews with WTKR, WSLS, and WBTV, discussing the upcoming total solar eclipse. Broadcasting from NASA Langley's Pearl Young Theater, he shared insights on the event with viewers before sunrise. Mlynczak also spoke to Hampton University's student newspaper to boost NASA's outreach efforts.

9

At the 2024 Space Exploration Educators Conference, NASA Langley's Science Activation Team led engaging hybrid sessions on Earth from Space and GLOBE citizen science during the eclipse. Educators learned how to make observations using the GLOBE Observer app, with NASA astronaut Megan McArthur making her first GLOBE observation live!

10

Amber Soja from NASA Langley leads the charge at the IAWF International Fire Behavior & Fuels Conference, uniting global experts to share breakthroughs in wildfire research. From lightning talks to strategic outreach, the event highlighted NASA's role in advancing wildfire science and the new Wildland Fire Initiative.

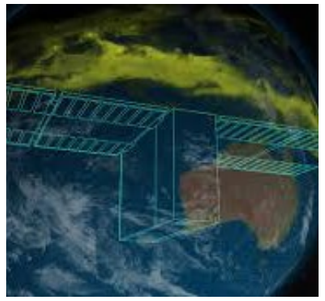
11

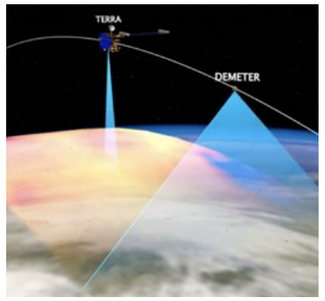
The DC-8 aircraft returned to NASA's Armstrong Flight Research Center Building 703 in Palmdale, California, on April 1, 2024, after completing its final mission supporting Airborne and Satellite Investigation of Asian Air Quality (ASIA-AQ). The aircraft and crew were welcomed back with a celebratory water salute by the U.S. Air Force Plant 42 Fire Department.

12

At the farmer-led, farmer-focused 2024 Commodity Classic, Langley's POWER team was able to provide farmers and educators from across the US and Canada with individual demonstrations of the POWER application that can impact daily decision making. The appeal of free access was particularly notable for owners of smaller farms, who expressed keen interest in leveraging POWER's meteorological data and emerging service of tracking climate change trends.

OUR FUTURE





Building Bridges from Innovative Technologies to Cost-Efficient Measurements to Societal Benefits

The Science Directorate is devoted to finding out how the Earth and its atmosphere are interacting and changing, and what that means for the health of the planet and quality of life. In 2025, we will continue our world-class Earth Science research with an integrated observation approach enabled by our innovative measurement technologies.

As NASA Langley takes lidar to new heights to better understand our Earth, we will continue to develop innovative and cost-efficient ways to maintain long-term data records with SmallSats like SAGE IV. The planned 2025 launch of NASA's Athena in partnership with the U.S. Space Force will help to enable reconfigurable sensorcrafts such as DEMETER.

After launch in 2025, the ARCSTONE SmallSat will set a new standard for lunar calibrations that will improve measurement accuracy of the entire Earth Observing System (EOS). With the 2024 release of TEMPO's preliminary air quality data, we'll continue to learn more about issues affecting environmental and public health as we engage organizations to expand our collective knowledge and abilities in using TEMPO data for applied research with societal benefits.

Langley's Lidar Technology Dives Deeper for Ocean Studies and Fosters International Collaborations

As we continue to foster international collaborations, NASA will progress the Luce Lidar in partnership with Agenzia Spaziale Italiana (ASI). The CALIPSO partnership between NASA and Centre national d'études spatiales (CNES) paved the way by achieving first-ever global ocean retrievals from space-based lidar. In addition to observations of surface vegetation, ice and snow, Luce will study phytoplankton biomass and zooplankton dynamics.

We will continue to advance Langley technologies including the High Spectral Resolution Lidar (HSRL)-1, which helped scientists study the North Atlantic phytoplankton bloom, and HSRL-2, which measures ocean surface wind speed. Our blue laser technology is developing towards measurements of the vertical structure of marine biomass to quantify global plankton stocks, plankton community composition, diel vertical migration of zooplankton and fish, and mixing layer depths.

As our Earth Science data and coordinated efforts continue to benefit society through enhanced economic security and environmental stewardship, we'll continue to explore the unknown from ocean depths to planetary atmospheres.

Exploring the Unknown Beyond Earth

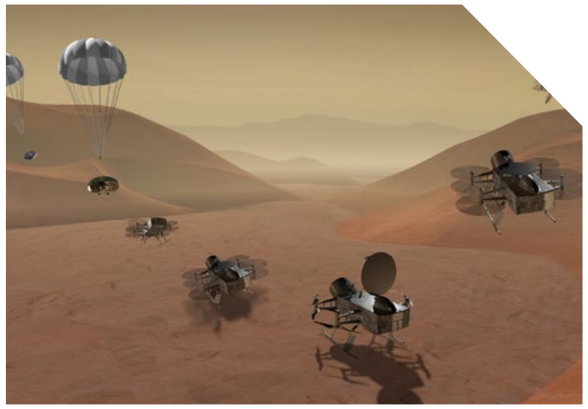
To ensure a safe and successful Entry Descent and Landing (EDL) of NASA's Dragonfly rotorcraft to the surface of Saturn's largest moon, Titan, NASA Langley will continue to manage Dragonfly's Parachute Deceleration Subsystem (PDS), including the planetary EDL parachute and deployment mortar system design, development, test and evaluation (DDT&E).

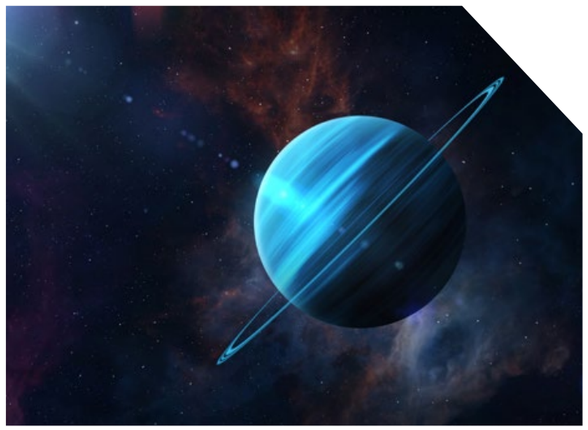
As we seek to explore the unknown, Langley is coordinating an international observation effort to learn more about Uranus' atmosphere from a stellar occultation occurring in April 2025.

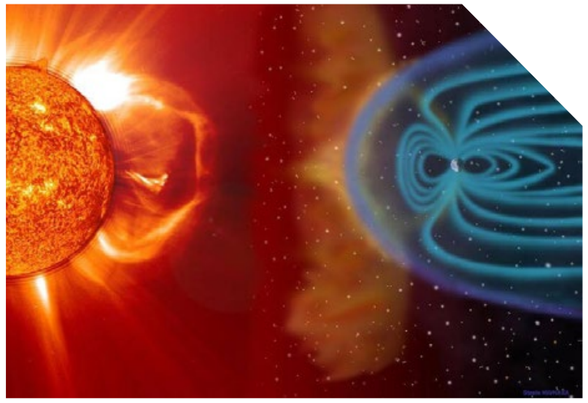
Since 2024, NASA Langley is proud to join NASA's Space Weather Center of Excellence, an integrated multi-agency initiative to advance the science and technology of space weather. The center's team also includes researchers from the National Center for Atmospheric Research (NCAR) High Altitude Observatory (HAO), the University of Michigan, the University of Alaska, the University of Iowa.

NASA's continued heliophysics research will improve space weather forecasts and nowcasts in Earth's orbital environment, including cislunar space that is becoming a focus of NASA activity as we return astronauts to the Moon. This will help predict geomagnetic storm impacts on airline and orbital space operations.

Our scientists collaborate and cross disciplines to advance research that leads to a safer planet and a better tomorrow. This year and beyond, our scientific research and innovations lead to new discoveries, new questions and new applications.







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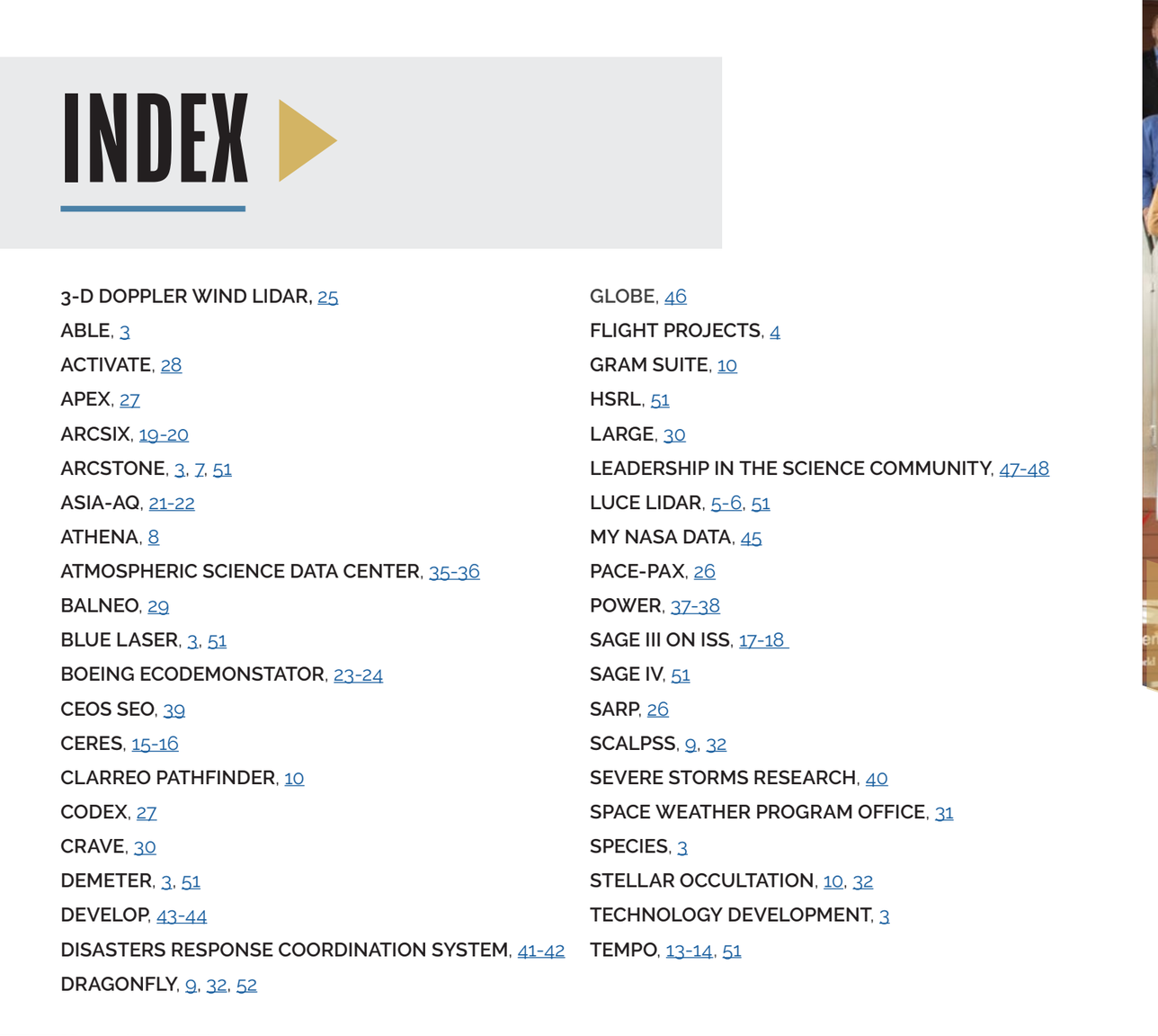

The Science Directorate is home to NASA Langley's Proposal Development Office (PDO). PDO works with NASA Langley teams to prepare for, develop, and submit winning proposals. PDO works across all disciplines and Langley Directorates with the goal of making the proposal process as straightforward and efficient as possible.

PDO BY THE NUMBERS: FY24

Proposal opportunities tracked: **130**
Proposal opportunities posted on Inside Langley: **84**
Total number of proposals (LaRC led & Partnerships) submitted for the Center: **99**
Total number of proposals (LaRC led & Partnerships) submitted for SD: **70**
Total number of LaRC led proposals submitted for the Center: **55**
Total number of LaRC led proposals submitted for SD: **44**
Total number of Partnership proposals submitted for the Center: **44**
Total number of Partnership proposals submitted for SD: **26**
LaRC-led Proposals Submitted, **55**
LaRC-led Proposal Pending: **25**
LaRC-led Proposals Selected: **17**
LaRC-led Proposals Declined: **13**

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