



National Aeronautics and  
Space Administration



# THE SCIENCE DIRECTORATE

AT NASA'S LANGLEY RESEARCH CENTER



**ANNUAL 20**  
**REPORT 17**



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# LETTER FROM THE DIRECTOR



David F. Young  
Director, Science Directorate  
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It is my pleasure to present NASA Langley Research Center's Science Directorate 2017 Annual Report. This report includes research highlights from Calendar Year 2017 and organizational metrics from Fiscal Year 2017.

Our research stretches across four main areas: Air Quality, Radiation and Climate, Atmospheric Composition and Active Remote Sensing. In these areas, we are involved in a number of scientific initiatives, including advanced instrument development, field and space-borne experiments and data retrieval, analysis and archival. We also take significant pride in our robust Applied Science programs, and our ability to receive and share scientific data through the Atmospheric Science Data Center (ASDC). We further extend our research to the public through our efforts in Communication, Education and Public Engagement.

Researchers in the Science Directorate work to produce key climate data records from several satellite atmospheric monitoring instruments developed at Langley. In 2017, two Langley-led instruments, SAGE III/ISS and CERES Flight Model-6 were successfully launched and are taking measurements that are extending important long-term data records necessary to better understanding Earth's atmosphere. Also in 2017, SABER reached 15 years of operation in space and continues to find new purpose as it assists with identifying Earth-like planets in habitable zones. CALIPSO continues to gather vertical profiles of clouds and atmospheric aerosols 11 years into service. The Langley legacy of Earth Science data continues with the development of CLARREO Pathfinder, TEMPO, and MESCAL.

We look forward to merging the expertise of the Science Directorate and Flight Projects in 2018, and leveraging the full potential of both organizations for continued, pre- and post-launch successes in 2018 and beyond.

I would like to say a special thanks to Rosemary Baize, Deputy Director for the Science Directorate, and to the rest of the Science Directorate front office for stepping up and providing exceptional leadership during my detail to Flight Projects in 2017. As she begins her retirement, I would also like to recognize Angela Davis for 38 years of unmatched service and administrative support to NASA.

Approximately 300 civil servant and contractor scientists and support personnel serve as the backbone of the Science Directorate, and are the reason we consistently advance research that leads to a safer planet and better tomorrow.

As NASA celebrated its Centennial year in 2017, we were given the opportunity to reflect on the evolution and success of NASA Langley's Earth Science research, and those who played a part. For the next 100 years, we will continuously search for better ways to measure and understand the Earth's atmosphere. I hope that you find this report informative.

A handwritten signature in black ink that reads "David F. Young". The signature is written in a cursive, flowing style.

# QUARTER 1

SAGE III/ISS Launched from KSC Aboard Space X Falcon 9/Dragon Spacecraft

**FEBRUARY 23**



ACT-America Completes Winter Campaign

**MARCH 9**



Wind Space (Wind SP) Pathfinder Development

**MARCH 16**

SAGE III/ISS First Light

**MARCH 23**

Standoff Ultra- Compact Raman Sensor Developed

**APRIL 20**

CALIPSO REVEX held at CNES to Review Status and Present Key Findings

**MAY 18**

ASDC Presents Successful Operational Readiness Review

**MAY 18**

Energy Briefing to Dominion Energy and Virginia Secretary of Technology

**MAY 25**

SAGE III/ISS Post-Launch Acceptance Review

**MAY 25**

# QUARTER 2

LMOS Science Flights Conclude

**JUNE 22**



DAWN Completes 100 Hours of Flight Time

**JUNE 27**



# QUARTER 3

KORUS-AQ Results Briefed to Korean Ministry of Environment

**JULY 19**

CLARREO Pathfinder Undergoes Successful SRR/MDR

**JULY 25**

ERBE/CERES Data Extended

**AUGUST 2**

CERES/Terra Perform Deep Space Maneuver and Scan

**AUGUST 5**

OWLETS Field Campaign Completed

**AUGUST 16**

Total Solar Eclipse/  
GLOBE Observations

**AUGUST 21**

RBI CDR

**SEPTEMBER 26-28**

BATAL Campaign Completed in India

**SEPTEMBER 8**

NAAMES Completes Fall Campaign

**SEPTEMBER 21**

ARCSTONE Completes Mid-Term Review by ESTO IIP

**SEPTEMBER 25**

SAGE IV IIP Team Completes Six-Month ESTO Review

**SEPTEMBER 26**

NASA and CNES Sign Letter of Agreement for MESCAL

**NOVEMBER 30**

Coordination of NASA Disasters Program Monitoring of Mt. Agung Eruption

**NOVEMBER 30**

Tropospheric Ozone Retrievals Enhanced with use of Langley Cloud Products

**OCTOBER 3**

SAGE III Data Released for Public Use

**OCTOBER 27**

ACT- America Completes Fall Campaign

**OCTOBER 30**

TEMPO Spectrometer/  
Telescope Integration

**NOVEMBER 17**

CERES FM6 Launches Aboard NOAA's JPSS-1

**NOVEMBER 18**

Convective Weather and Aircraft Icing Presentation to NWS Aviation Meteorologists

**NOVEMBER 7**

New SABER Data Products Developed

**NOVEMBER 7**

Severe Thunderstorm Prediction Dataset Delivered to FAA and NOAA ESRL

**NOVEMBER 22**

# QUARTER 4

2017 QUARTERLY TIMELINE

# Did You Know? ...



At an average aircraft speed of about **150** meters/second, ACT-America has flown almost exactly the distance between the Earth and the moon during **3** campaigns



**CERES FM6** **1997**  
became the **7th**  
CERES instrument to  
become activated since

## ACT - America

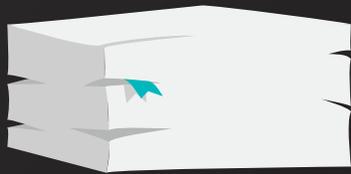


has flown across **34** frontal systems  
**\$ 33** fair weather events  
during **73** research flights

In 2017, **342 DEVELOP** participants conducted **70** projects impacting **49** US states and **13** countries.



**SABER** data are used in more than 1,300 peer-reviewed journal articles with more than **640** different authors and co-authors.

**1,300**  
  
**articles**



## CLARREO

studies with economists show that the economic value of higher accuracy climate observations is

**\$20** Trillion  
U.S. Dollars

The Science Directorate Education Team distributed more than **8,000** sky color books for Earth Science Week.

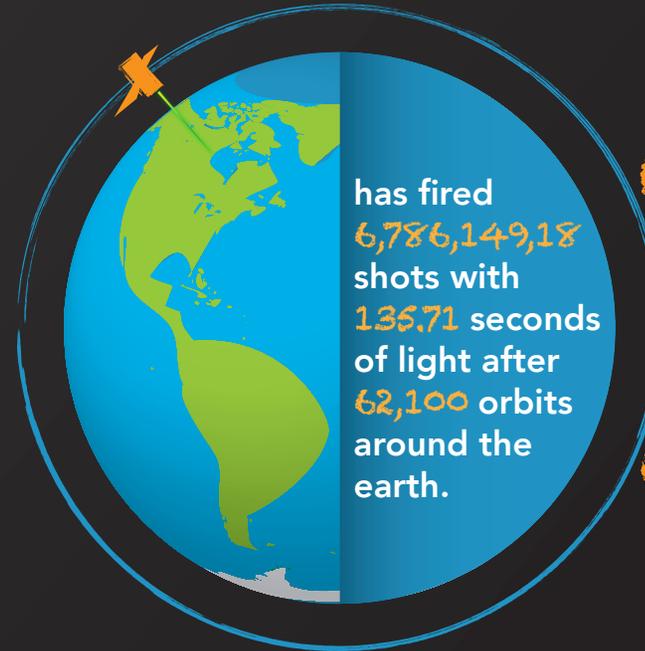
After launching to the International Space Station in February 2017, the **SAGE III** instrument has acquired over **4,500** sunrise, sunset, moonrise, and moonset occultation events this year.



Data produced and publically available at NASA Langley's Atmospheric Science Data Center is **~282TB**



**CERES** instruments utilized the same materials and detectors that were developed just before **1890** by Samuel Pierpont Langley for a bolometer that measured how much radiance came from the sun.

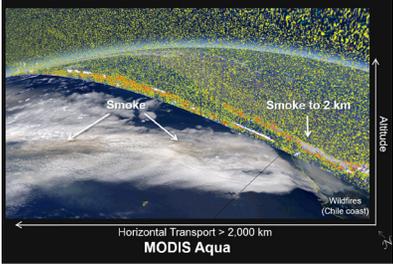


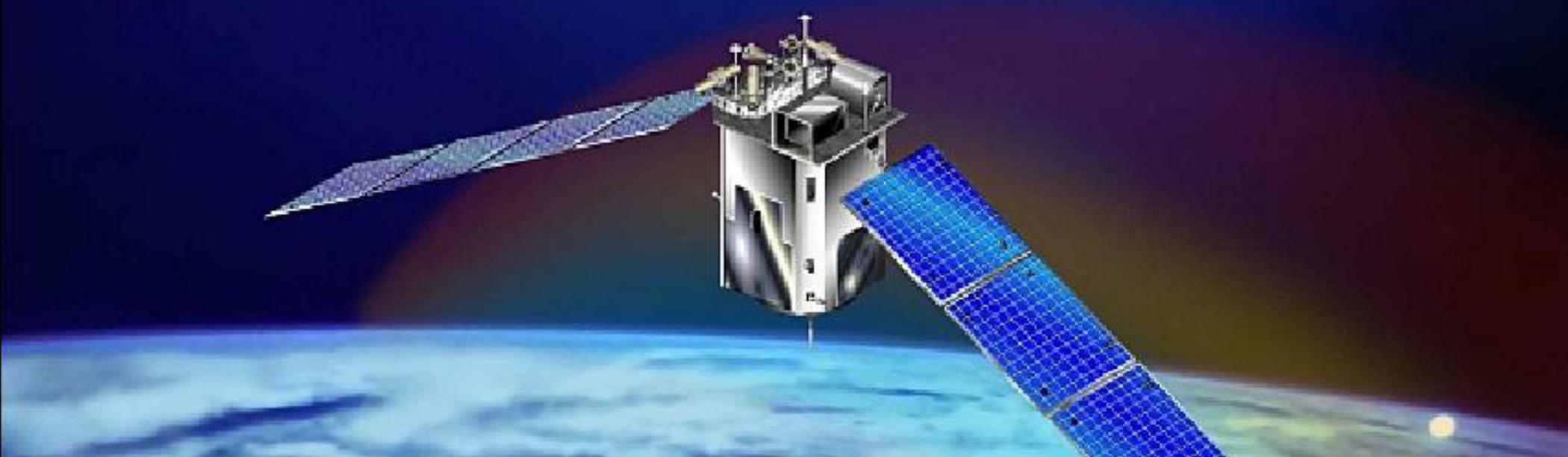
The detectors on **ERBE** and **CERES** are the hottest spots of the entire satellite. They typically operate at **36 degrees Celsius**. More classical imaging instruments such as **MODIS**, have fairly low liquid nitrogen-like temperatures.



# FEATURES

## FROM 2017





## After 15 Years, SABER on TIMED Still Breaks Ground from Space

About 21 years ago, team members started building and testing the Sounding of the Atmosphere using Broadband Emission Radiometry, or SABER instrument. Back then, they dreamed of how great two years of data from an unexplored region of the upper atmosphere would be.

Now, 15 years later, SABER aboard the Thermosphere, Ionosphere, Mesosphere, Energetics and Dynamics, or TIMED, spacecraft has more than delivered on that dream as it continues to provide a wealth of fundamental knowledge about the radiation budget, chemistry and dynamics of the upper atmosphere.

“SABER, which marked 15 years of on-orbit operation on Jan. 22, 2017, has provided a never-before-seen view of the atmosphere and paved the way for new avenues of scientific study,” said NASA Langley’s Deputy Director Clayton Turner. “Fifteen years of SABER data has deepened our knowledge of the planet’s radiation budget — the balance between Earth’s incoming and outgoing energy. That’s an important achievement.”

Earth’s heat engine does more than simply move heat from one part of the surface to another; it also moves heat from Earth’s surface and lower atmosphere back to space. This flow of incoming and outgoing energy is Earth’s energy budget.

As Dave Grant, TIMED Project Manager from Johns Hopkins University – Applied Physics Laboratory, explained, TIMED was given a two-year baseline plan. “No one was thinking 15 years,” he said. “But here we are with more than 15,000 contacts with the spacecraft and 98 percent of all SABER data recovered.”

SABER continues to exceed expectations and find new purpose. The SABER data are now also being considered as a guide in the search for life on exoplanets. As Marty Mlynczak, SABER associate principal investigator and senior research scientist at NASA Langley explained, SABER detects elements through radiative signals from Earth’s atmosphere. Similar signals can be sought from Earth-like planets residing in habitable zones around sun-like stars. This knowledge can be utilized by NASA’s James

Webb Telescope in the search for new planets that may harbor life.

“In the ‘90s when we were building SABER, it had a specific focus,” said NASA Langley Deputy Director Clayton Turner. “But today, it has an even greater focus to understand Earth and other planets by leveraging the knowledge and expertise of the SABER instrument and team.”

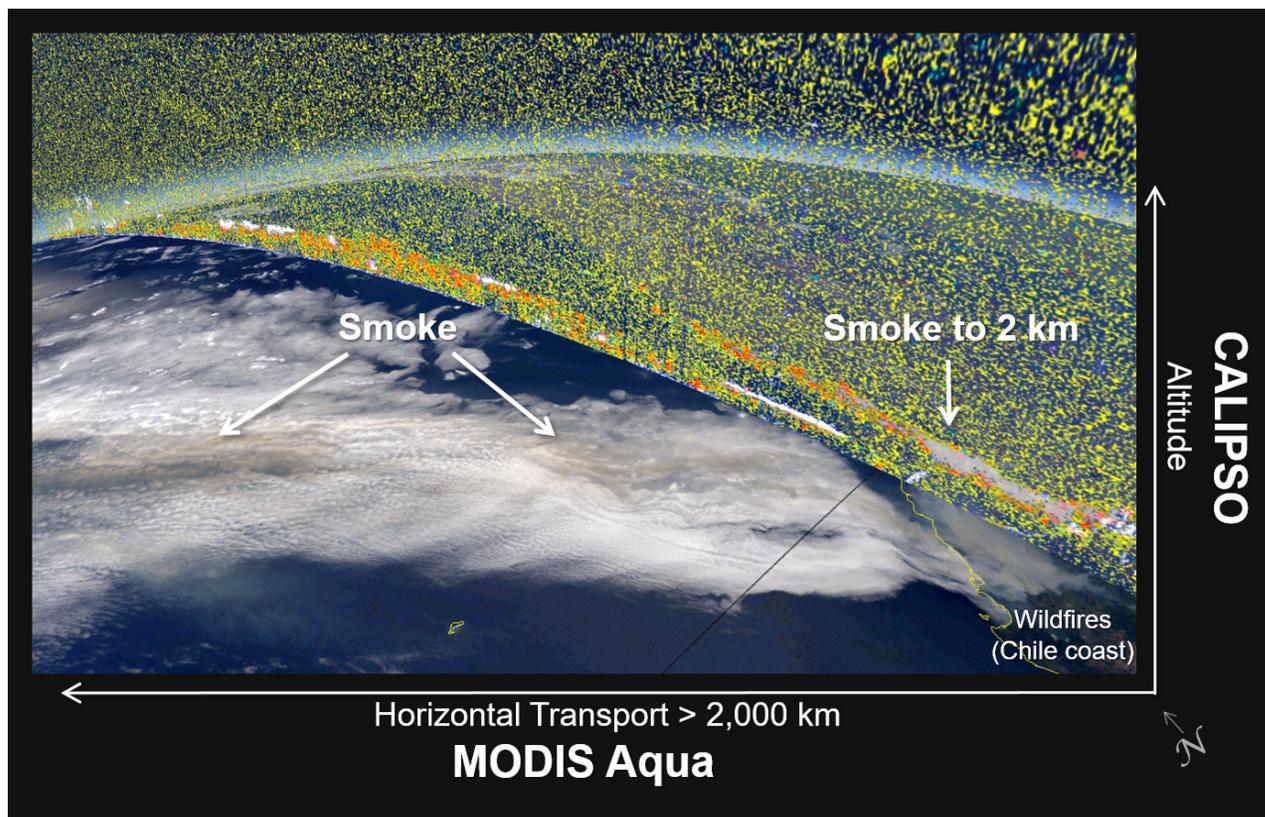
**This knowledge can be utilized by NASA’s James Webb Telescope in the search for new planets that may harbor life.**

# Satellites Capture Different Views of Devastating Fires in Chile

Wildfires ravaged Chile's countryside in January 2017. The blazes thwarted firefighters' efforts to control them, with new hot spots emerging daily. President Michelle Bachelet described the fires as the "greatest forest disaster" in Chilean history. Satellite data and scientific analysis verify this assertion. Between 2003 and 2016, MODIS detected an average of 330 daytime fire hot spots throughout Chile during the month of January. In 2017, the number jumped tenfold.

The NASA Disasters program responded to the Chilean fires following an International Charter Space and Major Disaster Activation. Amber Soja, an Associate Research Scientist with the National Institute of Aerospace, resident at NASA's Langley Research Center, led the NASA response to this disaster. "The people and fire community were devastated," said Soja, who has used satellite data to investigate fires for decades. "Multiple NASA centers rapidly responded with satellite data and products in an effort to provide the tools necessary to enhance decision-making in local and regional communities."

The Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Aqua satellite captured natural-color images of the smoke on January 27 as it rose over central Chile and the Pacific Ocean. Smoke has a brown tint compared to white clouds. Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) data, overlaid on the MODIS image, show a vertical slice of the atmosphere. The CALIPSO profile shows the altitude of clouds and smoke plumes. Close to the active fires, smoke was injected to 2 to 3 kilometers (1 to 2 miles), above



low-altitude clouds. Downwind smoke, over the open ocean, was measured at altitudes as high as 8 kilometers (5 miles).

Most of these fires were human-initiated, however record high temperatures and drought promoted this conflagration. As of late January, the fires had consumed roughly 5,059 km<sup>2</sup> (1,880 mi<sup>2</sup>), an area about the size of Delaware. The blazes burned several villages to the ground, destroying 1500 homes, livestock and vineyards, and the fires caused the deaths of at least 11 people, according to news reports. More than 20,000 people battled the blazes and international assistance was provided by 23 countries.

Even when compared at a global scale, these were considered particularly devastating fires, similar to the fires that burned in California in 2017. The NASA

Disasters program also provided support for the California fires. In 2017, the NASA Disasters program evaluated 92 disasters, and NASA LaRC often took the lead role in responding to fires and volcanoes.

Multiple NASA centers rapidly responded with satellite data and products ...

# 2015-2016 El Niño Provided ‘Natural Experiment’ on the Effects of Warming Seas

A marked increase in central Pacific Ocean sea surface temperatures during the strong 2015-2016 El Niño lofted abnormal amounts of cloud ice and water vapor unusually high up into the atmosphere, creating conditions similar to what could happen on a larger scale in a warming world.

The findings were part of a recent study led by Melody Avery, a researcher at NASA Langley. Researchers at NOAA’s Earth Science Research Laboratory, the University of Colorado at Boulder and Texas A&M University also contributed.

“In a warming world, we expect sea surface temperatures to rise. And what we were able to see from a natural climate cycle with our sophisticated sensors is the impact of rising sea surface temperatures on really high-altitude convection,” said Avery. “It just makes the storms really tall, and it puts a lot of ice way up high in the atmosphere. And we also observed an unusual amount of water vapor in the stratosphere.”

During El Niño events, surface waters in the central and eastern Pacific Ocean become warmer than usual. This warm condition affects everything from the local aquatic environment to weather in other parts of the world. The 2015-2016 El Niño was one of the three strongest on record since 1950.

Avery’s study focused on conditions in the atmosphere directly above the unusually warm 2015-2016 El Niño currents. She used measurements from NASA’s Aura satellite and the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation, or CALIPSO, a joint effort between NASA and France’s National Centre for Space Studies. Aura and CALIPSO are both part of the A-train, a constellation of six Earth-observation satellites that closely follow one after another along the same orbital track.



Instruments on those satellites allowed Avery and her colleagues to see the high-altitude cloud ice and water vapor with unprecedented clarity and develop model results that accounted for those variables. Avery believes the observations she and her fellow researchers made could prove useful if factored into future climate models.

“In order for models to be correct they have to be based on processes that are accurately represented,” she said. “And here was a chance to see this kind of process — nature provided the opportunity to see it.”

**In order for models to be correct they have to be based on processes that are accurately represented.**

# Smoke from Wildfires Can Have Lasting Impact

The 2017 wildfire season scorched thousands of acres in Georgia and Florida alone, according to the National Park Service. New research using data collected during NASA airborne science campaigns shows how smoke from this type of wildfire worldwide could impact the atmosphere and climate much more than previously thought.

The study found brown carbon particles released into the air from burning trees and other organic matter are much more likely than previously thought to travel to the upper levels of the atmosphere, where they can interfere with rays from the sun – sometimes cooling the air and at other times warming it.

The research used air samples collected during two airborne science missions supported by researchers from NASA's Langley Research Center in Hampton, Virginia — the 2012 Deep Convective Clouds and Chemistry (DC3) mission and 2013 Studies of Emissions and Atmospheric Composition, Clouds and Climate Coupling by Regional Surveys (SEAC4RS) mission. DC3 made observations in the central U.S. and SEAC4RS covered parts of the southeast and western U.S.

Researchers found surprising levels of brown carbon in the samples taken from the upper troposphere — about seven miles above the Earth's surface — but much less black carbon.

“That’s all the more reason to conduct additional studies”, according to Bruce Anderson, an atmospheric scientist at NASA Langley. “We need better information on how those aerosols are formed, what their radiative impacts are, how they’re removed from the atmosphere and whether there’s anything we can do to control that.”



According to other research conducted by NASA in recent years, the increase in brown-and-black-carbon-producing wildfires that rage across the U.S. every year could itself be a symptom of a warming world. A 2015 analysis of 35 years of meteorological data confirmed that fire seasons have become longer. In addition, climate models predict fire seasons will continue to increase in length and strength across the U.S. in the next 30 to 50 years.

The flight campaigns were sponsored by NASA's Tropospheric Composition, Radiation Sciences, and Upper Atmospheric Research programs.

That’s [surprising levels of brown carbon in the upper troposphere] all the more reason to conduct additional studies.

# NASA Aids Study of Lake Michigan High-Ozone Events

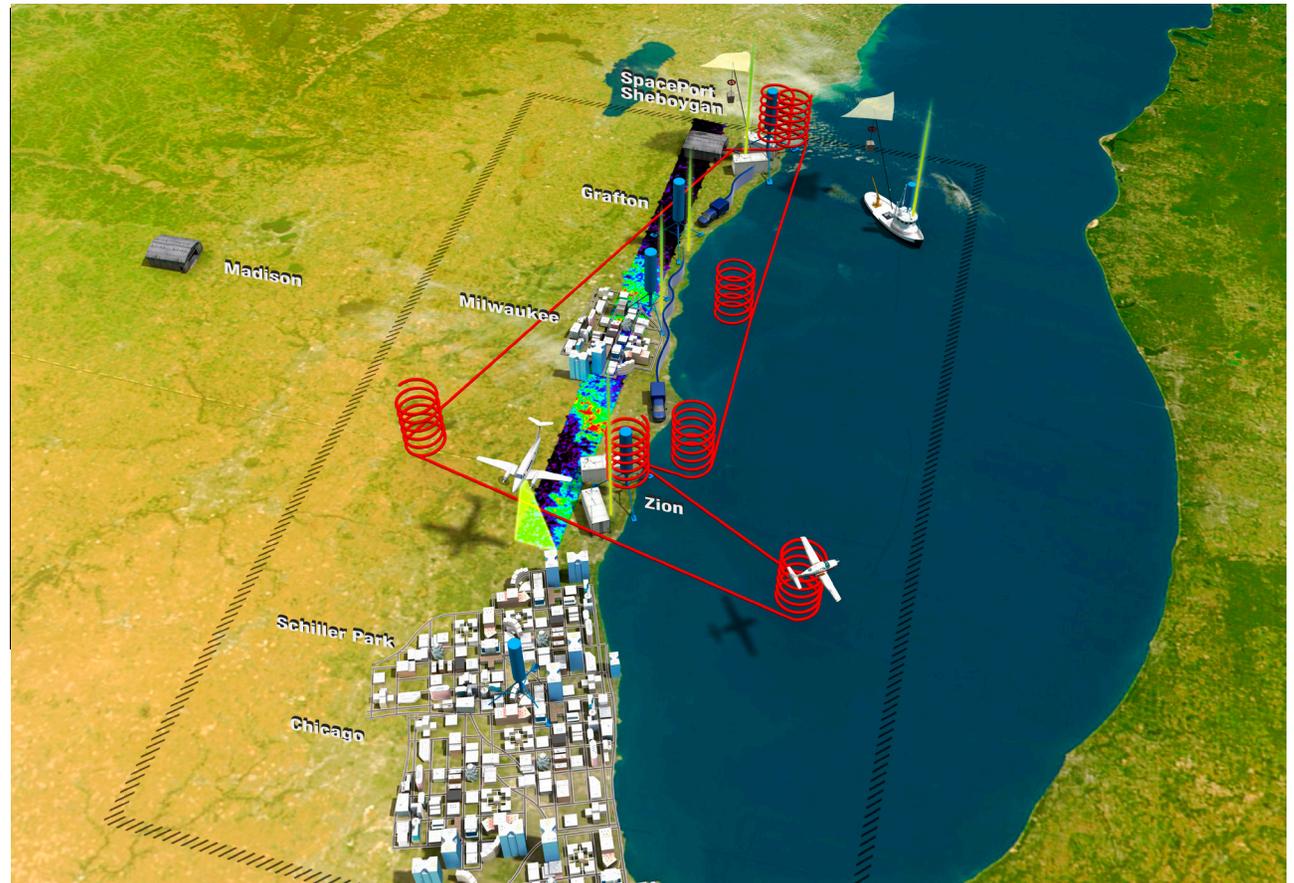
NASA researchers conducted science flights along the Wisconsin-Illinois Lake Michigan shoreline to help better understand the formation and transport of ozone, a potent air pollutant in the region.

The flights were a part of the Lake Michigan Ozone Study (LMOS), a collaborative, multi-agency field experiment using aircraft, ground, and ship-based measurements to look at high-ozone events in cities and towns along the Wisconsin-Illinois lakeshore. Ozone can cause shortness of breath, coughing, inflammation of the airways and make the lungs more susceptible to infection. It can also aggravate lung diseases such as asthma, emphysema and chronic bronchitis.

The study is specifically zeroing in on why ozone concentrations are highest along the lakeshore and drop off sharply inland.

“It’s not a well understood phenomenon,” said Jay Al-Saadi, an atmospheric scientist at NASA’s Langley Research Center in Hampton, Virginia. “We’re trying to gather the fundamental measurements that will let this team of people figure out what’s happening.” The NASA researchers and flight crew come from Langley, Goddard Space Flight Center in Greenbelt, Maryland, and Glenn Research Center in Cleveland, Ohio.

Flights of Langley’s UC-12 aircraft began May 22 from Madison, Wisconsin. The aircraft is outfitted with Geostationary Trace gas and Aerosol Sensor Optimization (GeoTASO), a remote-sensing instrument that observes reflected sunlight to measure atmospheric trace gases and aerosols over a wide area.



“This airborne mission is providing measurements that are similar to what the TEMPO, or Tropospheric Emissions: Monitoring of Pollution, satellite is going to measure,” said Al-Saadi. “What we’re trying to do is get these datasets into the hands of end users — air quality monitoring organizations and science organizations — to get them familiar with this type of remote-sensing observations and how to use them.”

Other government agencies and research institutions contributing to the study are the National Oceanic and Atmospheric Administration, the U.S. Environmental Protection Agency, several universities supported by the National Science Foundation, and the Electric Power Research Institute. Several states in the Lake Michigan region are involved as well. Field activities are expected to continue through June 22.

“We’re trying to gather the fundamental measurements (of high-ozone events) that will let this team of people figure out what’s happening.”

FEATURE HIGHLIGHTS - LMOS

## Early Airborne Results Address South Korean Air Quality

For six weeks in the summer of 2016 scientists from the United States and the Republic of Korea intensively studied air pollution over the Korean peninsula. Their mission: to diagnose the complex causes of the country's poor air quality and in so doing lay the groundwork for next-generation pollution monitoring from space that both nations plan to launch in the next few years.

Initial scientific results from the joint NASA-Korean field campaign released in July identified several strategies to reduce ozone and particulate matter levels in the Seoul metropolitan area and rural sections of the country. Seoul is one of the world's five most-populated urban areas.

Scientists from NASA and South Korea's National Institute of Environmental Research (NIER) presented findings from the Korea-United States Air Quality study (KORUS-AQ) to representatives of the Ministry of Environment at a scientific briefing in Seoul. The analysis will inform South Korean policymakers developing air quality strategies and in identifying specific emission sources.

Reducing ozone pollution and harmful fine particles in the air could be achieved by cutting emissions of nitrogen oxides and volatile organic compounds, the study found. Overall, more than three-quarters of the particulate matter measured during the study was formed by secondary chemical reactions rather than being directly emitted from smokestacks or tailpipes.

"It's an encouraging result to see there is a clear overlap in the sources that need to be targeted to improve both fine particle and ozone pollution," said James Crawford, lead U.S. KORUS-AQ scientist from NASA's Langley Research Center in Hampton, Virginia.



NASA and South Korea are both preparing air quality satellite missions for launch to geostationary orbits within the next five years. First will be the NIER Geostationary Environment Monitoring Spectrometer (GEMS), followed by NASA's Tropospheric Emissions: Monitoring of Pollution (TEMPO) instrument. TEMPO will make accurate hourly daytime measurements of tropospheric pollutants – ozone, nitrogen dioxide, sulfur dioxide, formaldehyde, and aerosols – over the United States, Canada and Mexico. GEMS will provide similar data over East Asia.

**It's an encouraging result to see there is a clear overlap in the sources that need to be targeted to improve both fine particle and ozone pollution.**

# NASA Invites You to Become a Citizen Scientist During US Total Solar Eclipse

NASA invited eclipse viewers around the country to participate in a nationwide science experiment by collecting cloud and air temperature data and reporting it via their phones.

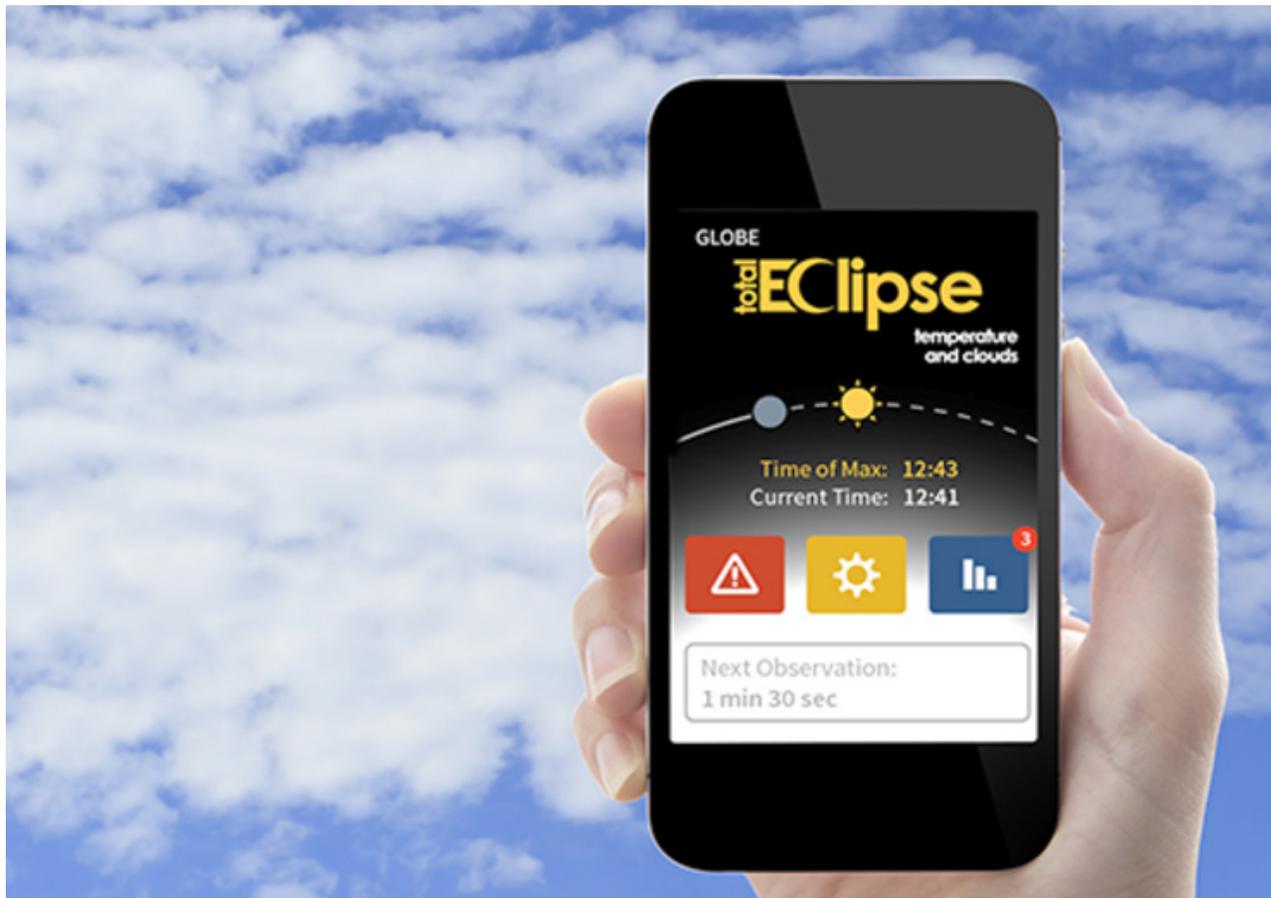
The Global Learning and Observations to Benefit the Environment, or GLOBE, Program is a NASA-supported research and education program that encourages students and citizen scientists to collect and analyze environmental observations. GLOBE Observer is a free, easy-to-use app that guides citizen scientists through data collection.

On Aug. 21, a total solar eclipse occurred across the entire continental United States. Crossing the country from Oregon to South Carolina over the course of an hour and a half, 14 states experienced night-like darkness for approximately two minutes in the middle of the day. The eclipse entered the U.S. at 10:15 a.m. PDT off the coast of Oregon and leaves U.S. shores at approximately 2:50 p.m. EDT in South Carolina.

NASA Langley's Science Education team contributed to the development of the GLOBE Observer Eclipse app and supported over 10 events Solar Eclipse events sharing how to use the app. Additionally, NASA Langley processed satellite matches for nearly 20,000 cloud observations submitted during the eclipse. The team also distributed over 28,000 solar viewing glasses.

"No matter where you were in North America, whether it's cloudy, clear or rainy, NASA wants as many people as possible to help with this citizen science project," said Kristen Weaver, deputy coordinator for the project. "We want to inspire a million eclipse viewers to become eclipse scientists."

Citizen scientists were able to participate by downloading the GLOBE Observer app and registering.



Observations were recorded on an interactive map.

To participate in future NASA activities, download the GLOBE Observer app <https://observer.globe.gov/about/get-the-app>.



We want to inspire a million eclipse viewers to become eclipse scientists.

# NAAMES Returns to Air and Sea to Study Plankton's Annual Cycle

In August, NASA Langley's North Atlantic Aerosols and Marine Ecosystems Study (NAAMES) returned to air and sea to research the declining, or deaccelerating, phase of the annual cycle of plankton in the North Atlantic. Since plankton form the base of the marine food web and impact the productivity of fisheries, understanding this declining phase is important to forecasting the future of potential impacts.

Plankton are strongly interconnected with climate and life on Earth. NAAMES scientists already have discovered shifts in plankton population rates that give rise to an early winter bloom with a climax in late spring.

NASA's C-130 aircraft made several instrumented flights above the North Atlantic, to rendezvous with the Woods Hole Oceanographic Institute's research vessel Atlantis, which served as a floating laboratory. By combining ship, airborne, computer modeling, sustained satellite and autonomous sensor data, NAAMES scientists from NASA Langley, Oregon State University and other universities and organizations, hope to improve predictions of Earth system processes and inform ocean management and assessment of ecosystem change.

"It's hard to imagine that organisms you can't see make a difference, and we all kind of struggle with that," said Mike Behrenfeld, NAAMES principal investigator from Oregon State University. "You look out in the ocean and you see water, but that water is just teeming with millions and millions of tiny organisms, and when you sum them up, they have a huge impact."

Each year, the annual cycle of the plankton follows four primary phases, including the declining and climax phases, and two transition periods.



After two successful NAAMES studies in summer and winter, and more than a decade of NASA satellite observations, the fall study is helping the team to build a clearer picture of this repeated cycle and what controls it.

"Fall is the deaccelerating cycle just after the bloom climax that occurred in summer," Behrenfeld said.

NAAMES will continue to study how the ocean and the atmosphere are connected. Plankton are an important carbon sink for atmospheric greenhouse gases, and the growth of plankton depends on carbon. Moreover, a warmer ocean holds less carbon.

The ocean is teeming with millions and millions of tiny organisms, and when you sum them up, they have a huge impact.

# NASA Chesapeake Bay Study To Help Improve Air-Quality Forecasts

Over the course of a few hours, measurements would pour in from several different sensors at several locations in the lower Chesapeake Bay — sometimes simultaneously, sometimes one right after another.

Sensors were installed on a C-23 Sherpa aircraft, an Unmanned Aerial Vehicle (UAV), a balloon, ground-based lidar stations, a maritime research vessel and automobile-based sensors. And that's just to name a few.

The sensors sampled the atmosphere at different altitudes and locations. They sometimes sampled the exact same locations at the exact same time to validate one another's data.

They were all on the hunt for one thing: ozone.

That trace gas is the star of the Ozone Water-Land Environmental Transition Study (OWLETS), a NASA study looking at ozone concentrations around the lower Chesapeake Bay.

There haven't been many studies of ozone around the Chesapeake Bay, but what few studies there have been have suggested that maybe — just maybe — ozone concentrations are higher over the water than the surrounding land.

"It wasn't a complete story," said Tim Berkoff, principal investigator for OWLETS at NASA's Langley Research Center in Hampton, Virginia, which is located in Hampton Roads. "And so that was something of interest, because if you have high ozone over water it can potentially impact air quality over land through bay breeze recirculation effects. The air goes out in the morning and comes back in the afternoon, and if you're photochemically cooking all this ozone over water it can potentially then be brought back over high population areas."



Other cities in the Hampton Roads area include Virginia Beach, Norfolk and Newport News. According to the Weldon Cooper Center for Public Service at the University of Virginia, the population of the area in 2016 was approximately 1.7 million

Gathering good, comprehensive ozone readings in a region that covers more than 500 square miles takes a lot of tools -- requiring many sensors to be deployed as part of the study.



“If you have high ozone over water it can potentially impact air quality over land ...”

# ACT-America Aims to Tell Four-Season Greenhouse Gas Story

NASA scientists are once again on the hunt for greenhouse gases in the sky.

Researchers from NASA Langley, Penn State and other partnering universities and organizations returned to the field to measure how weather systems transport carbon dioxide and methane through the atmosphere over the eastern part of the United States for the Atmospheric Carbon and Transport-America, or ACT-America study.

By measuring those greenhouse gases, they hope to improve our understanding of where they originate. And in the case of carbon dioxide, they hope to learn more about where it's being absorbed. Ultimately, by giving scientists a clearer understanding of what the sources and sinks are, the study could help refine climate models, which could in turn inform future policy decisions around the production of greenhouse gases.

Previous ACT-America flight campaigns took place in summer and winter. The focus this time is fall.

"We want to know the net balance of greenhouse gas sources and sinks over an annual cycle," said ACT-America Principal Investigator Ken Davis of Pennsylvania State University, University Park. "This will be the fall installment of putting that four-season story together."

The flights don't extend over the entire season — only about a six-week period. But the comparison of aircraft data and numerical models allows scientists to extend their understanding across space and time. For example, the flight data will provide useful comparisons to current ecosystem carbon models.



"We should be able to say, Hey, for these weeks, are the ecosystem models in these places doing the right thing or not?" Davis said. "We should be able to prune down toward the more realistic ecosystem carbon models."

Flights for the fall campaign wrapped up in early November. The next ACT-America flight campaign is scheduled for spring of 2018.

ACT-America, managed by NASA Langley, is one of six airborne studies funded by the most recent round of NASA's Earth System Science Pathfinder Program.

**This will be the fall installment of putting that four-season story together.**

# First SAGE III Atmospheric Data Released for Public Use

The first wave of atmospheric data from the Stratospheric Aerosol and Gas Experiment III (SAGE III), a NASA instrument that launched to the International Space Station earlier this year, is now available for public use.

The data, available through NASA Langley's Atmospheric Science Data Center, was collected June through August and includes measurements of ozone, aerosols and nitrogen dioxide. SAGE III scientists are releasing this initial dataset in order to solicit feedback from the international atmospheric science community.

To take measurements, SAGE III uses a technique known as occultation, which involves looking at the light from the Sun or Moon as it passes through Earth's atmosphere at the edge, or limb, of the planet. The space station provides a unique vantage point from which to take those measurements. This initial data release is of solar occultation measurements.

SAGE III is the latest in a legacy of Langley instruments that go back to the Stratospheric Aerosol Measurement (SAM), which flew on the 1975 Apollo-Soyuz mission. SAGE II, which was operational from 1984 to 2005, measured global declines in stratospheric ozone that were later shown to be caused by human-induced increases in atmospheric chlorine. Data from it and other sources led to the development of the Montreal Protocol on Substances that Deplete the Ozone Layer.

"It's exciting to see these data reach the research community," said SAGE III Program Scientist Richard Eckman. "Earlier SAGE observations have been used extensively in the World Meteorological Organization's periodic assessments of ozone depletion, which were begun in 1981. SAGE measurements have also contributed to the UN's Intergovernmental Panel on Climate Change assessment process. These ISS-based observations will reinitiate SAGE's contribution



toward the long-term monitoring of ozone vertical profiles that inform these ongoing international assessment activities."

Later in the year, the SAGE science team released lunar occultation data. Following this initial release, SAGE III data will be released on a monthly basis.



These ISS-based observations will reinitiate SAGE's contribution toward the long-term monitoring of ozone vertical profiles that inform these ongoing international assessment activities

# CERES Radiation Budget Instrument Launches Aboard JPSS-1

A bright flash. A streak of light against a dark sky. The roar of the United Launch Alliance Delta II rocket.

The National Oceanic and Atmospheric Administration's Joint Polar Satellite System-1 (JPSS-1) blasted off the launchpad at Vandenberg Air Force Base on the central California coast 1:47 a.m. PST (4:47 a.m. EST) Saturday, Nov. 18. On the NOAA satellite were five science instruments, including Clouds and the Earth's Radiant Energy System Flight Model 6 (CERES FM6), a NASA Langley instrument that measures the solar energy reflected by Earth, the heat the planet emits, and the role of clouds in that process.

"It's exciting to know the final CERES instrument has made the journey through Earth's atmosphere," said Norman Loeb, principal investigator for NASA's Radiation Budget Science Project at NASA's Langley Research Center in Hampton, Virginia. "CERES FM6 will add valuable data to the existing record and improve our understanding of Earth's radiation budget. The data are critical to improving seasonal and longer-term forecasts."

Built by Northrop Grumman and managed by Langley, CERES FM6 is the last in a series of instruments that provide a critical top-of-atmosphere dataset for Earth's radiation budget. At its new home in space, FM6 joins five other CERES instruments orbiting the planet on three other satellites. The CERES science team at Langley will achieve first light data from the new instrument in January 2018, extending a 32-year data record that began with the Earth Radiation Budget Experiment in 1984.

FM6 will contribute to an already extensive CERES dataset that helps scientists validate models that calculate the effect of clouds on planetary heating and cooling. The same data can also be helpful for



improving near-term, seasonal forecasts influenced by weather events such as El Niño and La Niña. El Niño and La Niña are weather patterns that develop when ocean temperatures fluctuate between warm and cool phases in the Equatorial Pacific Ocean.

CERES provides the only global top of atmosphere energy budget dataset. Data from CERES FM6 will help scientists further develop a quantitative understanding of the links between the Earth's energy budget and the properties of atmosphere and surface that define it.

**CERES FM6 will add valuable data to the existing record and improve our understanding of Earth's radiation budget.**

# NASA's CPEX Tackles a Weather Fundamental

A NASA-funded field campaign getting underway in Florida on May 25 has a real shot at improving meteorologists' ability to answer some of the most fundamental questions about weather: Where will it rain? When? How much?

Called the Convective Processes Experiment (CPEX), the campaign is using NASA's DC-8 airborne laboratory outfitted with five complementary research instruments designed and developed at NASA. The plane also will carry small sensors called dropsondes that are dropped from the plane and make measurements as they fall. Working together, the instruments will collect detailed data on wind, temperature and humidity in the air below the plane during the birth, growth and decay of convective clouds -- clouds formed by warm, moist air rising off the subtropical waters around Florida.

Convection, a column or bubble of warm air rising is the common way for precipitation to form. Convective clouds can join together to form a major rainstorm or can even become a hurricane.

DAWN, the Doppler Aerosol WiNd lidar, is one of five instruments used for CPEX. It is a relatively new addition to NASA's Earth science toolkit. It measures the horizontal wind profile below the plane, and was developed and is operated by NASA's Langley Research. In contrast with dropsondes, which collect data only from the spots where they're dropped, DAWN collects a swath of continuous data along the flight path.

"It's one of the most important measurements for understanding tropical convection, and it was not available till DAWN and similar sensors came on the scene," said Bjorn Lambrigtsen of NASA's Jet Propulsion Laboratory in Pasadena, California, a member of the CPEX science team.



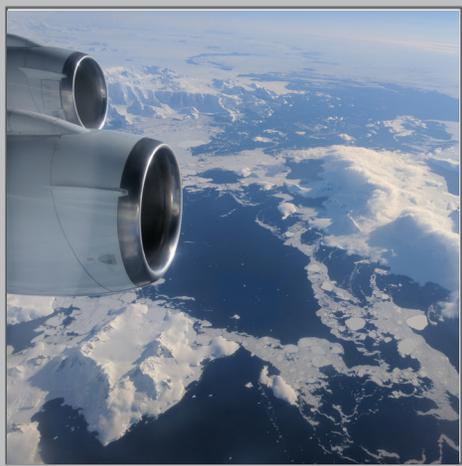
DAWN has its roots in lidar technology developed over decades. The ultimate goal is to position a DAWN-like instrument in space, perhaps on the International Space Station, said Michael Kavaya, DAWN PI from NASA Langley, "with the purpose of improving weather prediction."

Space-borne measurement of 3-D winds is a very important input for improving weather and severe-weather prediction models. 3-D Winds is the tentative name for such a satellite.

The ultimate goal is to position a DAWN-like instrument in space ... with the purpose of improving weather prediction.

### ATom Update

The Atmospheric Tomography Earth Venture Suborbital (ATom EVS-2) mission flew on the DC-8 to investigate the atmosphere over the Southern Ocean and the Antarctic continent during the spring breakup of the polar vortex and ozone hole.



### Centennial Symposium

Mike Freilich delivered a speech during the Centennial Symposium at the Hampton Roads Convention Center in Hampton, VA.

### ORACLES 2017 field deployment concluded

The NASA Langley airborne TAMMS and HSRL-2 instruments were deployed aboard the NASA P3 during the ObseRvations of Aerosols above CLouds and their intEractionS (ORACLES) 2017 mission.



### Meeting with NOAA Aviation Meteorologists

Kristopher Bedka and William Smith Jr. introduced LaRC satellite-derived aviation weather products to two Meteorologists in Charge at NOAA Central Weather Service Units (CWSU).

### Support of ASCENDS flight campaign

NASA Langley Research Center supported research flights for the Active Sensing of CO2 over Nights, Days, and Seasons (ASCENDS) field campaign based in Fairbanks, Ak.



### DEVELOP visits Shenandoah National Park

The DEVELOP Summer 2017 Shenandoah Health & Air Quality team visited their National Park Service partner at Shenandoah National Park in Luray, Va., on June 20.

### ICARE 2017

Gao Chen and Bruce Anderson, along with colleagues from NCAR attended the 2nd International Conference on Airborne Research for the Environment (ICARE 2017) held at DLR, the German Aerospace Research Center, in Oberpfaffenhofen near Munich, Germany July 10-13.



### 2017 VAST

The 2017 Virginia Association of Science Teachers (VAST) Professional Development Institute was held at the Hotel Roanoke on November 16-18.



### Hispanic Heritage Month

Marilé Colón Robles was featured as a panelist during Hispanic Heritage Month at NASA's Headquarters on October 12.



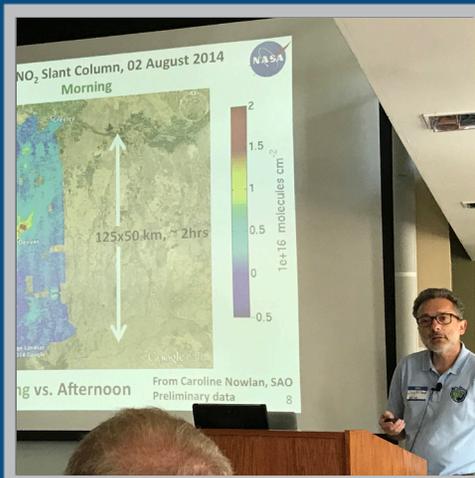
### CARAFE Field Campaign Support

NASA's Langley Research Center Science Directorate contributed to CARAFE by providing measurements of water vapor, vertical winds, and meteorological parameters.



### TEMPO Science Team Meeting

Jay Al-Saadi led a discussion of airborne validation strategies for TEMPO at the 5th Annual Tropospheric Emissions: Monitoring of Pollution (TEMPO) Science Team Meeting held at the Harvard-Smithsonian Center for Astrophysics, May 31 - June 1.



### BATAL has come to an end

NASA Langley scientists, Jean-Paul Vernier and Duncan Fairlie returned from a one month deployment in India where they launched 15 balloon flights.



### Earth Day at Union Station

Dianne Cheek and Rosemary Baize supported NASA's Earth Day event at Union Station on April 20.

### AGU 2017

Dave Young, David Green, Dave Bowles, David McGowan and Dave MacDonnell attended the 97th Annual Meeting of the American Geophysical Union.



### Thomas Zurbuchen visits NASA Langley

NASA Associate Administrator, Thomas Zurbuchen visited NASA's Langley Research Center in Hampton, Va. on March 23, 2017. Afterwards, Zurbuchen met with DEVELOP students.

### Meeting with Elected Officials and Congressional Staffers

Rosemary Baize and Brooke Thornton met with elected officials and congressional staffers outside of NASA Langley's Flight Mission Support Center.





### **SARP 2017**

Bruce Doddridge participated in the NASA Earth Science Division sponsored Student Airborne Research Program (SARP) 2017.



### **Jean-Yves Le Gail visits NASA's Centennial Symposium**

Jean-Yves Le Gail, President of the Centre National d'Etudes Spatiales (CNES), the French space agency, meets with NASA Langley Center Leadership during his visit for NASA's Centennial Symposium in Hampton, Va.

### **Flight Projects Development Program Workshop**

Patrick Taylor attended a two-day Flight Projects Development Program Workshop in Arlington, Va.



### **CLARREO Science Definition Team Meeting**

The twelfth biannual meeting of the Climate Absolute Radiance and Refractivity Observatory (CLARREO) Science Definition Team (SDT) was held at the National Institute of Aerospace in Hampton, Va., on November 14-15.



### Local Energy Alliance Program Event

Patrick Taylor participated in an event hosted by the Local Energy Alliance Program in Charlottesville, Va., on May 25.



### CNU's Life Long Learning Event

On March 30th, Mike Obland presented, "The History and Future of Science at Langley," to about 120 members of CNU's Lifelong Learning Program. His presentation and Q&A were a part of NASA Langley's Centennial Speaker Series.



### KORUS-AQ Science Team Meeting

The KORUS-AQ Science Team conducted its first data workshop at the National Institute of Meteorological Sciences (NIMS) in Jeju, Korea from February 27 - March 3.



### Science in 60 Seconds

DEVELOP participants at NASA Langley met NASA Associate Administrator Dr. Thomas Zurbuchen during his visit on March 23, 2017.





# METRICS

## FY 2017

NASA Langley's Science Directorate tracks a variety of metrics that are used to monitor our performance, effectiveness and impact in the scientific community. Our internal reporting system for our organization captures employee input, which is placed into a specific metrics category.

These FY16 metrics show that Science Directorate employees are actively engaged in the community through external recognition, assignments, citations, peer-reviewed publications, requested reviews, conference presentations, proposals, mission-directed dollars, scientific data usage, customer satisfaction and public engagement.

## Distinguished Awards



### Fellows

<b>Chambers, Lin</b>	American Association for the Advancement of Science (AAAS) Fellow
<b>Loeb, Norman</b>	American Meteorological Society (AMS) Fellow
<b>Minnis, Patrick</b>	American Meteorological Society Fellow
<b>Minnis, Patrick</b>	American Geophysical Union Fellow
<b>Taylor, Patrick</b>	Kavli Fellow, National Academy of Sciences
<b>Wielicki, Bruce</b>	American Meteorological Society Fellow

### NASA Honor Awards

<b>Wenbo Sun</b>	Exceptional Public Achievement Medal
<b>Jason Tackett</b>	Exceptional Public Achievement Medal
<b>Kevin Leavor</b>	Early Career Public Achievement Medal
<b>Michael Shook</b>	Early Career Public Achievement Medal
<b>Kenton Ross</b>	Silver Achievement Medal
<b>Sharon Rodier</b>	Silver Achievement Medal
<b>CERES Time-Interpolated and Space Averaging Team</b>	Group Achievement Award
<b>GLOBE Observer (GO) Team</b>	Group Achievement Award
<b>SAGE III on ISS Team</b>	Group Achievement Award



**SMD Funding  
Guideline at Langley  
\$213,275,000**

**Agency functions  
resident at Langley  
\$135,898,673**

**Published Work Citations FY17**

**64,027**

**Peer-reviewed publications in FY17**

**94**

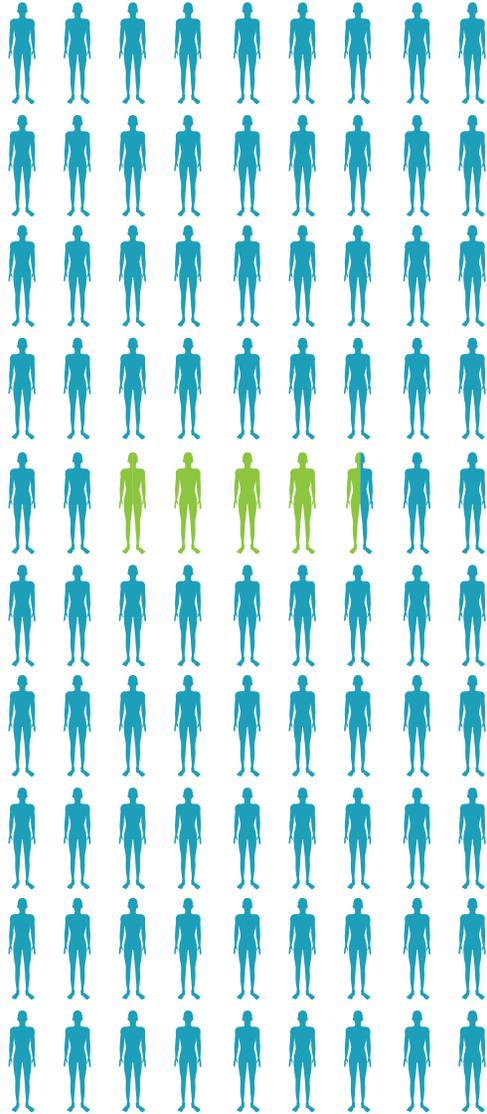
**Requested Reviews in FY17**

**167**

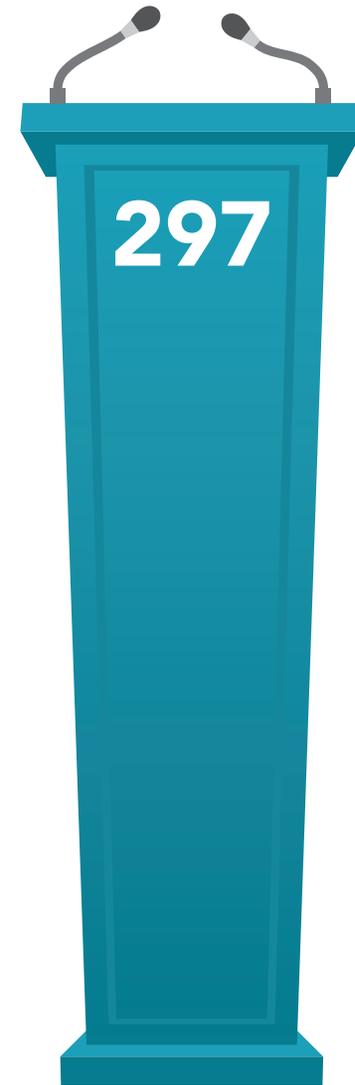
Papers	<b>157</b>
Proposals	<b>6</b>
Project / Program Plans	<b>4</b>

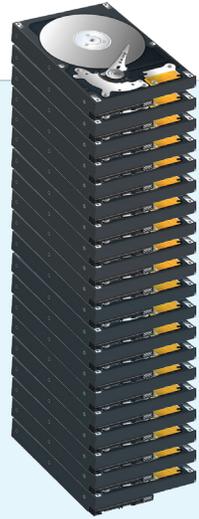


**5% of our Civil Service employees were detailed to perform critical functions at NASA HQ or within the center**

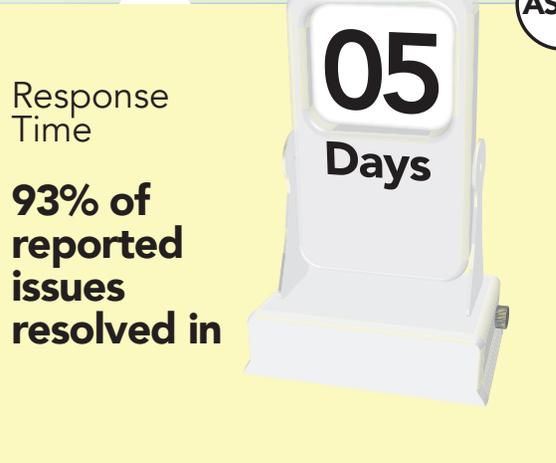


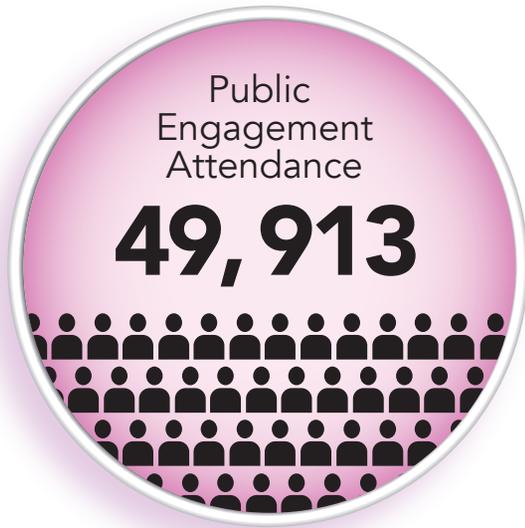
## Conference Presentations



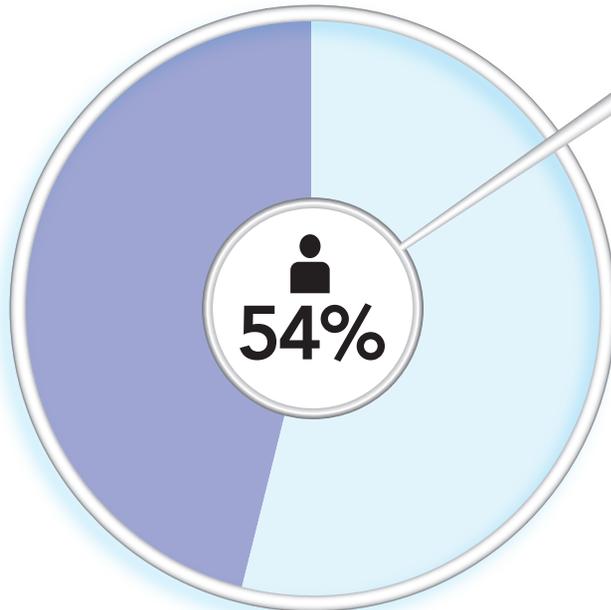
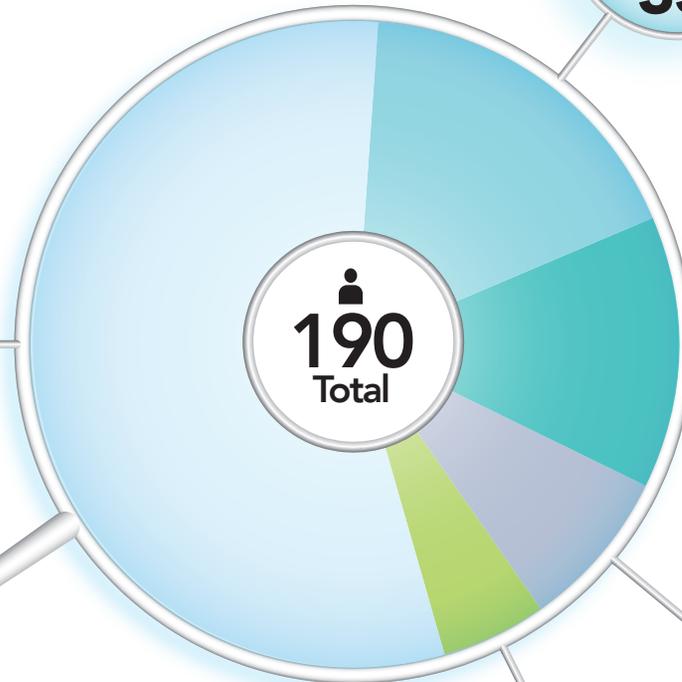


Amount of data stored  
**5.06**  
**Petabytes**





SD employees reached **49,913** people through 349 public engagement events in FY 2017



54% of SD employees participated in public engagement events







National Aeronautics and Space Administration

**Langley Research Center**

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Hampton, VA 23681

[www.nasa.gov/centers/langley](http://www.nasa.gov/centers/langley)

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