National Aeronautics and Space Administration

NASA's Earth Science Division Research & Analysis Program

Explaining Earth Observations

NASA's Earth Science Research and Analysis (R&A) Program collects and analyzes data from Earth-observing satellites, airborne campaigns and surface-based instruments. It then uses these data to advance our scientific understanding of Earth as a system and to improve our ability to predict its response to natural and human-induced changes. The program sponsors research pertaining to six key focus areas, which are listed here along with some examples of how R&A is advancing Earth science.

Atmospheric Composition improves our understanding of the composition of Earth's lower atmosphere (troposphere and stratosphere), as it relates to climate, ozone, aerosol particles, solar radiation, air quality, atmospheric chemical processes, and surface emissions of gases and particles.

Carbon Cycle & Ecosystems conducts research that helps detect and predict changes in the Earth's terrestrial and aquatic ecosystems, including biogeochemical cycles, land cover, biological diversity, and regional and global carbon cycles.

Climate Variability & Change supports research and analysis to characterize the roles played by the oceans, ice, land and atmosphere within Earth's climate system and to understand more completely their future evolution in response to human-induced and naturally occurring changes.

Earth Surface & Interior supports research and analysis of solid-Earth processes and properties from crust to core. These activities help provide the scientific underpinnings for studies of natural hazards like earthquakes and volcanic eruptions, as well as the space geodetic observations and products foundational to many space missions.

Water & Energy studies the distribution, transport, and transformation of water and energy, including the impacts of extreme weather events such as droughts and floods. The focus area employs and improves remote sensing techniques to collect and interpret measurements on global precipitation, snowpack, soil moisture, water quality, evaporation, surface water and groundwater.

Weather researches the dynamics and thermodynamics of the atmosphere and its interaction with the oceans and land, ranging from local processes to global-scale phenomena and lasting from minutes to a season.

For more information, please visit

science.nasa.gov/earth-science/programs/research-analysis

Image Captions:

Front and Back Cover: The Alaska range south of Fairbanks taken during NASA's ABoVE airborne campaign (photo by Ross Nelson/NASA)

Inside Gate: Von Kármán vortices over the North Atlantic Ocean from the MODIS instrument on the Aqua satellite (image from Jeff Schmaltz/LANCE/EOSDIS MODIS Rapid Response)

Inside Spread from Top Left to Bottom Right: Nitrogen dioxide pollution over the United States in 2005 from NASA's Ozone Monitoring Instrument (OMI) (image by T. Schindler/NASA Goddard's Scientific Visualization Studio); The calving of the A-68 iceberg from the Larsen C ice shelf in natural color (left) and in false color thermal image (right) on September 16, 2017, from the Operational Land Imager and Thermal Infrared Sensor, respectively, on the NASA/USGS Landsat 8 satellite (image from J. Stevens/NASA Earth Observatory); Trembling aspen (*Populus tremuloides*) forest, near Ester Dome, Alaska (photo by Peter Griffith/NASA); Infrared image of Hurricane Edouard as it rapidly intensified during the HS3 airborne campaign in 2014 (image from MSFC MARC Earth Science Branch/NASA); Trends in total water storage in California, Nevada and bordering states from NASA's GRACE satellite mission, September 2011 to September 2014 (image from NASA JPL/Caltech); Result of GPS Imaging of vertical velocities plotted over topography in California—red values are positive [upward] and blue values are negative [downward] (image from Hammond, W. C., G. Blewitt, and C. Kreemer (2016), "GPS Imaging of vertical land motion in California and Nevada: Implications for Sierra Nevada uplift," *J. Geophys. Res. Solid Earth*, 121, 7681–7703, doi:10.1002/2016JB013458).

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ADVANCING EARTH SCIENCE

The R&A Program supports and works with NASA scientists, domestic and international partners, academic institutions, nonprofits and other government agencies to conduct high-level research through large-scale satellite missions, targeted field campaigns, data analysis and advanced scientific computing. These data complement, calibrate and validate satellite observations and provide real-world inputs for quantitative models that detect and predict conditions on Earth and test scientific hypotheses.

The R&A Program achieves these goals through key programmatic elements, including:

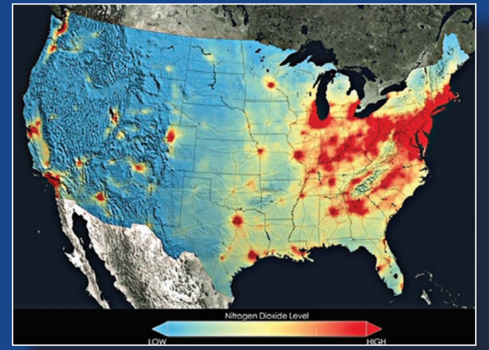
Satellite data records: Provide detailed scientific observations on global and regional scales to advance our understanding of Earth as an integrated system.

Airborne science: Enables scientists to test new measurement approaches, collect detailed *in situ* and remote-sensing observations to investigate processes, and provide complementary observations and calibration/validation information for satellites.

Surface-based measurements: Provide unique observational capability that complements satellite measurements and provides calibration, validation and algorithm testing capability.

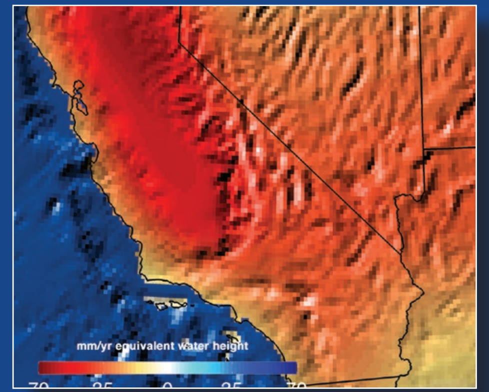
Modeling: Offers a best estimate of the current state of components within the Earth system and the mechanisms that couple them, including short-term forecasts that support field missions and longer-term forecasts that assess Earth's response to various drivers of change.

High-end scientific computing: Converts satellite observations into scientific data products and allows scientists to execute large-scale modeling, data assimilation and re-analyses efforts.



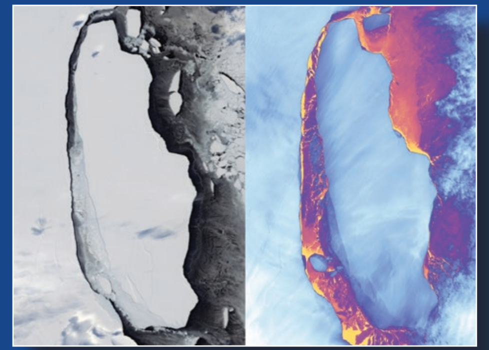
OBSERVING ATMOSPHERIC IMPACTS OF THE CLEAN AIR ACT

The National Ambient Air Quality Standards within the Clean Air Act place restrictions on pollutants, including NO_2 from cars and power plants, that can be emitted into the atmosphere. Using data from the Ozone Monitoring Instrument (OMI) aboard the Aura satellite, scientists funded by NASA's Atmospheric Composition focus area found that NO_2 levels over the United States decreased by 20–60% from 2005 to 2014, shedding more light on the relationship between pollution and our atmosphere.



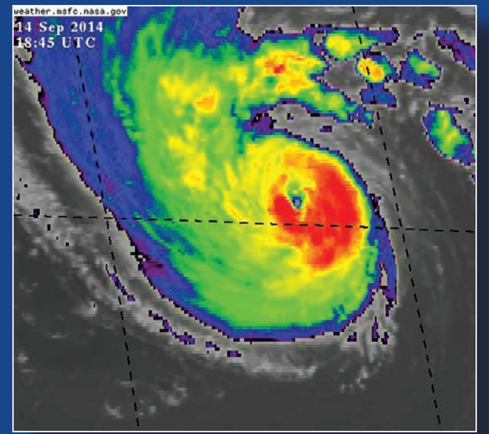
TRACKING WATER DURING DROUGHT

From 2014–2016, up to 60% of California suffered from "exceptional drought." During that time, research funded by NASA's Water & Energy Cycle focus area helped scientists and communities better understand the distribution of freshwater throughout the state. Observations and model output from NASA's Airborne Snow Observatory and GRACE satellite mission revealed where freshwater was previously stored, estimates of drought severity, and how groundwater levels were subsequently affected. These data help scientists gain a more holistic understanding of the water cycle during times of drought.



REDRAWING THE MAP

In July 2017, approximately 2,240 square miles of ice—nearly the size of Delaware—broke off the Larsen C ice shelf in Antarctica and drifted into the Southern Ocean. NASA's airborne Operation IceBridge, associated with the Climate Variability & Change focus area, had observed the rift firsthand in November 2016, and imagery from MODIS on NASA's Aqua satellite confirmed the final rupture.

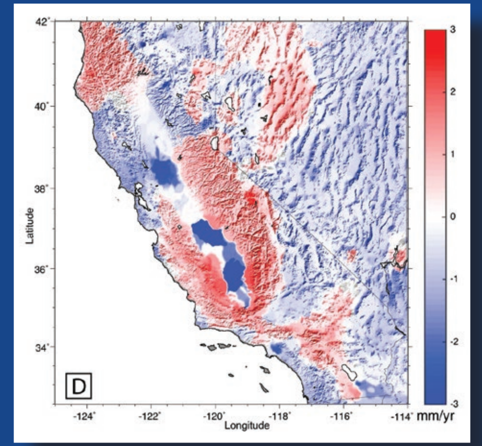


SOLVING THE MYSTERY OF HURRICANE INTENSIFICATION

Although scientists have significantly improved the ability to predict when and where hurricanes will strike, it is still difficult to predict their intensity. Research associated with NASA's Weather focus area seeks to understand what makes hurricanes strengthen and weaken. Observations collected during the Hurricane and Severe Storm Sentinel (HS3) airborne campaign combined with model simulations showed that, counter to expectations, Saharan dust surrounding a storm system does not automatically weaken it. This new information may be incorporated into forecast models and aid in our ability to predict storm strength in the future.

MAPPING FOREST EVOLUTION

Researchers funded by NASA's Carbon Cycle & Ecosystems focus area developed a way to tell a tree's age from space. Using a lidar-based mapper during the Arctic-Boreal Vulnerability Experiment (ABoVE), scientists found that tree height, which can be accurately measured with lidar, correlates with tree age in northern tree line areas. These data can be used to create large-scale maps showing changes in the structure and spatial distribution of forests as northern climates continue to warm. These changes affect wildlife habitat, climate feedbacks and hydrological and biogeochemical cycles.



MEASURING MOUNTAIN MOVEMENTS

Although plate tectonics is largely responsible for causing mountain uplift, a new method for analyzing GPS data confirms that humans may also have an effect. Researchers funded by NASA's Earth Surface and Interior focus area used GPS imaging, a new method for mapping the vertical velocities of solid Earth, to show that human-controlled groundwater pumping during periods of extreme drought caused the Sierra Nevada Mountains to rise faster than natural drivers alone would suggest. This new technique will help scientists identify interesting geophysical phenomena and improve our understanding of how the solid Earth moves.