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the earth observer

Editor's Corner

Steve Platnick
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At the beginning of each year, many of us reflect on accomplishments, fortunes, and failures over the past year before setting new goals, expectations, and yes, resolutions for the upcoming one. From the accomplishment side, this is a good time to consider the outstanding legacy of Landsat 5. The mission far exceeded expectations, operating 24 years beyond its three-year design life. However, after 27 years of continuous operation, the X-band transmitter began degrading rapidly this past fall (specifically the remaining power amplifier). In response, the mission operator, the U.S. Geological Survey, elected to suspend operations in November. While an additional attempt to restart the transmitter will be made in Spring 2012, the satellite is likely near the end of its operational life. The productivity of this mission has been remarkable. Since its launch in 1984, Landsat-5 has acquired and delivered more than a million images to the U.S. Geological Survey Earth Resources Observation Systems data center, and a similar number to international ground stations around the world. In so doing, Landsat-5 has become a backbone of land remote sensing, and has allowed the monitoring of changes to land cover, land use, and ecosystems. Further, the mission's longevity prevented an extended Landsat data gap follow-

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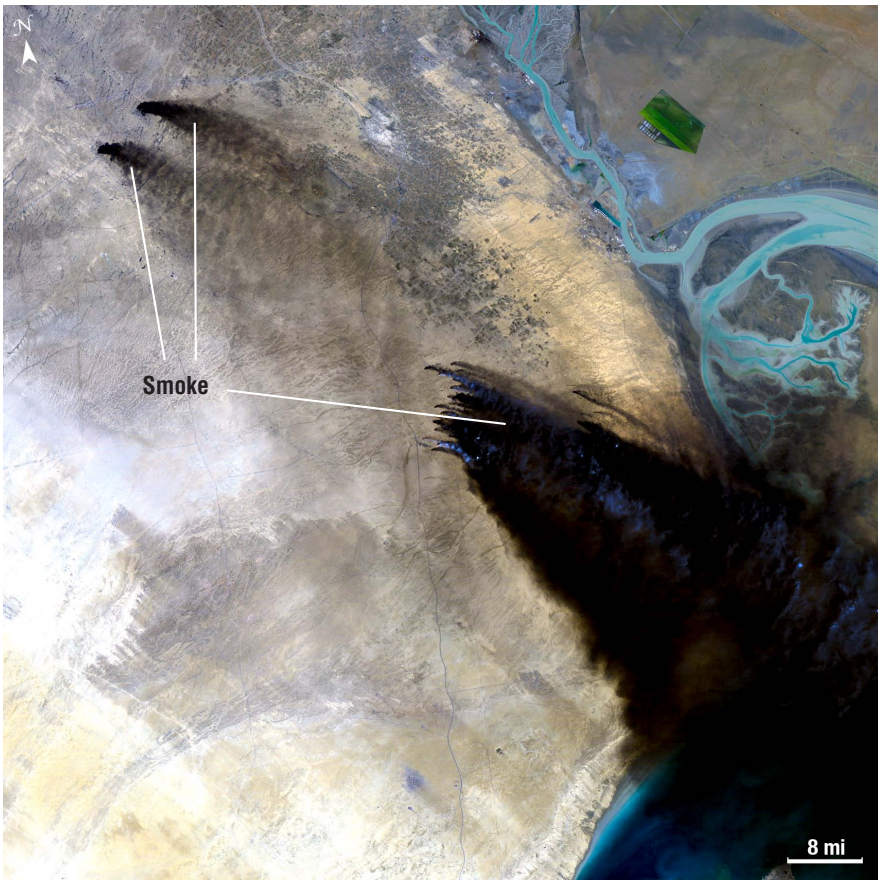

Among the more than one million images acquired by Landsat 5 during its remarkable 27-year mission, are some that chronicled events of historic significance. On February 26, 1991 Iraqi leader Saddam Hussein announced the withdrawal of Iraqi troops from Kuwait during the Persian Gulf War. As the soldiers withdrew, they set fire to the Kuwaiti oil fields. Several days before Hussein's announcement, on February 22, 1991, Landsat 5's Thematic Mapper captured this image over Kuwait clearly showing the thick black smoke spewing from the fires. This is just one of many examples of how Landsat's unique land-imaging capabilities have been used to monitor history as it unfolds. **Image credit:** NASA

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editor's corner

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In This Issue

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ing the 1993 launch failure of Landsat 6 and delays in the launch of a successor mission. Special commendation should be given to the USGS Landsat 5 operations team, which surmounted numerous technical obstacles to keep the mission running for many years. Currently, Landsat 7 is still in operation, and the Landsat Data Continuity Mission (LDCM) is due for launch in January 2013.

Said Landsat Project Scientist Jeff Masek: "When you consider the enormous changes that have taken place on Earth since 1984—changes in population, human land use, climate—we should feel fortunate that Landsat 5 provided such a consistent and reliable record of land transformation. As Darrel Williams [previous Project Scientist] used to say, Landsat provides a 'family photo album' for the Earth that shows us explicitly how rapidly the land environment is being altered."

NASA announced on January 25 at the American Meteorological Society annual meeting that the NPP mission has been renamed the *Suomi National Polar-orbiting Partnership*, or *Suomi NPP*, in honor of the late Verner Suomi, a pioneer of satellite meteorology. Further information on the naming, along with a link to an Earth Observatory feature article on the career and legacy of Verner Suomi, is at *www.nasa.gov/npp*.

Commissioning of NPP instruments continues after a delay caused by an ongoing degradation in the sensitivity of four near-infrared and visible channels on the Visible Infrared Imager Radiometer Suite (VIIRS). A subsequent investigation identified the source of the signal decrease as tungsten oxides on the surface of the mirror, likely due to a non-standard process that occurred during the mirror coating. While likely irreversible, the darkening of the VIIRS mirror caused by the contamination is expected to reach a plateau and remain at that level for the life of the mission. Although testing continues, the plateau for those channels is expected to provide signal-to-noise margins that still exceed the VIIRS design requirements.

The remaining commissioning activities for NPP instruments resumed on January 18 and are expected to take approximately six weeks. The Advanced Technology Microwave Sounder (ATMS) instrument was activated first and has been providing data since November 8.

As reported in the last issue, CloudSat successfully returned to daytime operations in October after overcoming its battery anomaly and associated power management issues. The satellite is currently flying just below the A-Train constellation orbit. After considering several options, the CloudSat Team presented a proposal to re-enter the A-Train to the Constellation Project Scientists on December 6, to NASA Headquarters

on January 4, and to the A-Train Mission Operations Working Group (MOWG) Re-Entry Ascent Review Board on January 18. The Board unanimously recommended re-entry of CloudSat into the A-Train pending the completion of the two Requests for Action (RFAs). Completion of the RFAs is expected before February 2. Re-entry will then commence with two maneuvers in early February and, if all goes well, CloudSat should be back to science operations by mid-March.

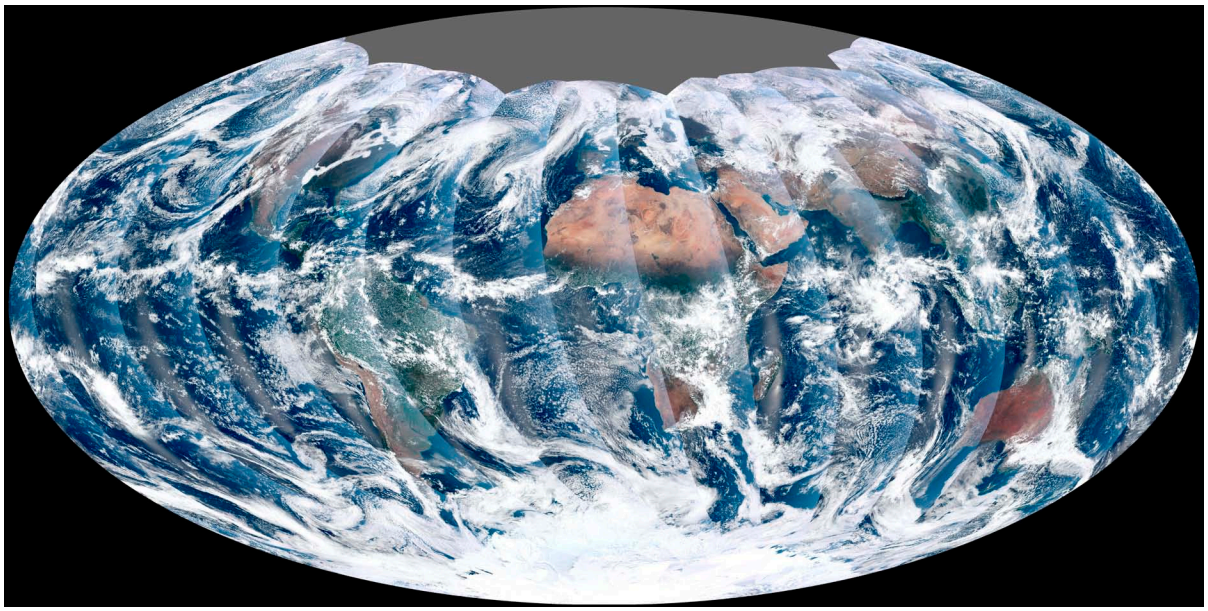
CloudSat will occupy a control box behind CALIPSO (30 seconds behind where Glory had planned to fly) where the unique and important science that CloudSat has provided can continue. The new location was chosen to enable continuation of near-concurrent observations with CALIPSO and the other A-Train members, and at the same time, ensure safe operations. Congratulations to the flight team for getting CloudSat back on track to rejoin the A-Train!

Also mentioned in our last issue, the Advanced Microwave Scanning Radiometer-EOS (AMSR-E) antenna stopped spinning on October 4, most likely due to aging lubricant. The instrument is now in safe mode. Fortunately, the other Aqua instruments are not impacted. The Japanese Aerospace Exploration Agency (JAXA), in collaboration with NASA's Goddard Space Flight Center Mission Operations, will make an effort to restart AMSR-E after the Global Change Observation Mission - Water (GCOM-W1) satellite launches later in the year. The hope is to allow for a period of overlap for radiometric intercomparison with the AMSR-2 instrument on GCOM-W1. JAXA will try to restart the instrument (no rotation) in the next 2–4 weeks and, after an evaluation, proceed to 4 rpm if feasible. Studies suggest that viable science data can be collected using either option.

For other Aqua news, we refer you to the *Aqua@10* sidebar on page 5 for an update about Aqua's tenth anniversary celebration at the Fall Meeting of the American Geophysical Union (AGU).

It seems a Holiday tradition for many at NASA to travel to end-of-the-year conferences. Two very important meetings took place to close out 2011—the 17th Conference of the Parties (COP 17) climate change conference in Durban, South Africa, and the Fall AGU meeting in San Francisco, CA. On behalf of the Earth Observing System Project Science Office, I'd like to thank those who participated in both those meetings, and particularly those who helped out or gave a presentation at NASA's exhibits. Praise about our presenters and the stunning visualizations displayed on NASA's Hyperwall continue to pour in. On page 4 of this issue, we share some of the experiences the Hyperwall had at both COP-17 and AGU, and provide a glimpse of where it is headed in 2012.

As we look forward to reporting on the next year of Earth Science at NASA, it's nice to have you onboard for another installment of *The Earth Observer*. ■



From its vantage 512 mi (824 km) above Earth, the VIIRS instrument on the Suomi NPP satellite compiles a picture of our planet every day. This image from November 24, 2011, is the first global image from VIIRS. **Image credit:** NASA's NPP Land Product Evaluation and Testing Element

feature articles

NASA's Hyperwall Has Become Quite the Globetrotter

Heather Hyre, NASA's Goddard Space Flight Center, Wyle Information Systems, heather.r.hyre@nasa.gov

What did Durban, South Africa and San Francisco, CA have in common? *The week of December 5-9, 2011, these two locations half a world apart were the sites of two very important scientific conferences, and NASA's Hyperwall appeared at both.*

Introduction

In December, the Earth Observing System Project Science Office (EOSPSO) staff coordinated NASA's outreach activities at both the 17th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP 17) conference in Durban, South Africa, and the American Geophysical Union (AGU) fall meeting in San Francisco, California. Combined, nearly 30 Mac minis were shipped to Durban and San Francisco to run the software needed to display large sets of NASA data on two different size *Hyperwalls*—or video walls—to raise public awareness about topics in Earth science. In Durban, fifteeen 42-inch flat screen monitors were arranged in a 5x3 array; in San Francisco, images and visualizations were displayed on a 3x3 array of flat screen monitors. To say the least, NASA's Hyperwall was a *big* hit at both conferences.

An International Effort to Protect Our Planet

The COP 17 conference was held November 28–December 8, 2011, at the Inkosi Albert Luthuli International Convention Centre, in Durban, South Africa. Once a year, the parties meet to assess global progress in facing climate change. This year, approximately 15,000 people attended.

Jake Kaye discussed different sources of atmospheric aerosols and how they affect Earth's climate while explaining the value of observing aerosols from space. **Image credit:** NASA

U.S. Center at COP 17

The U.S. Center—held on the sidelines of COP 17—provided an opportunity for agencies, academic institutions, nongovernmental organizations, and private sector companies from the U.S. to inform attendees about key climate initiatives and scientific research taking place in the U.S. NASA had the opportunity to inform delegates from nearly 200 countries about how satellites measure the health of our planet from space. **Jack Kaye** [NASA Headquarters (HQ)—*Associ-*

Erika Podest explained the importance of cloud formation and distribution during a Hyperwall presentation on the global water cycle. **Image credit:** NASA

ate Director for NASA's Earth Science Division], **Piers Sellers** [NASA's Goddard Space Flight Center (GSFC)—*Deputy Director of the Sciences and Exploration Directorate*], **Erika Podest** [NASA/Jet Propulsion Laboratory (JPL)], **Dan Irwin** [NASA's Marshall Space Flight Center (MSFC)], and **Eric Sokolowsky** [GSFC] traveled to Durban to support the two-week event and gave three, 90-minute Hyperwall presentations, joined by colleagues from other agencies, universities, and private companies. The presentations—*Fires in Africa*, *SERVIR: Bringing Climate Data to East Africa*, and *Viewing the Earth's Climate from Space*—were well attended and focused on ongoing collaborative research efforts related to key climate variables.

Presenters received communal praise for the stunning and powerful visualizations that were displayed on the arrangement of screens measuring 16 feet (~5 meters) across. Kaye's presentation—*Viewing the Earth's Climate from Space*—was deemed one of the so-called "Super-8" talks.

Additional Hyperwall content, developed to portray particular "themes" in climate, was displayed during 30-minute intervals in between events, showcasing data from NASA's Earth-observing satellite fleet and climate models four times a day. The themes covered topics related to land-cover and land-use change, the water cycle, severe storms, aerosols, human impacts on Earth, glacial melt, global precipitation patterns, and Earth's energy balance. Both Kaye and Podest served as docents during the 30-minute time slots, providing context for using NASA data in studying Earth's climate with discussions ranging from how to reduce greenhouse gas emissions, to talking about climate adaptation and mitigation.

Over 22,000 Earth and space scientists, educators, students, and policy makers visited San Francisco, CA, the week of December 5-9, 2011, to attend the largest geophysical conference in the world—the American Geophysical Union (AGU) fall meeting.

Enrico Piazza [NASA/Jet Propulsion Laboratory (JPL)] helped hand out nearly 6000 copies of the 2012 NASA Science calendar at the NASA exhibit. **Image credit:** NASA

Embrace, Connect, Inspire, Discover, and Learn: AGU

Over 22,000 Earth and space scientists, educators, students, and policy makers visited San Francisco, CA, the week of December 5-9, 2011, to attend the largest geophysical conference in the world—the American Geophysical Union (AGU) fall meeting.

The NASA exhibit offered over 35 Earth science presentations, including nine Hyperwall presentations (see Table on following page), along with several cutting-edge, interactive science, technology, and data demonstrations, and an assortment of edu-

Aqua Celebrates the Upcoming Tenth Anniversary of its Launch

On May 4, 2002, Aqua successfully launched on a Boeing Delta-*7920-10L* from Vandenberg Air Force Base in California carrying six Earth-observing instruments to observe Earth's oceans, atmosphere, land, vegetation, and ice and snow cover. Nearly ten years later, Aqua has provided an unprecedented amount of data that is being used to study Earth's water cycle. A poster session and oral Union session were held on Thursday, December 8, 2011, to highlight advances made in Earth science following nearly ten years of Aqua data. *The Earth Observer* plans to discuss these advancements in an article later this year.

A cake, recognizing Aqua's ten years of success was consumed at a NASA dinner party during AGU. **Image credit:** NASA

*Existing Hyperwall content and accompanying files are available online at **eospso.gsfc.nasa.gov/hyperwall**. New content will continue being developed to promote scientific literacy across a diverse group of audience members.*

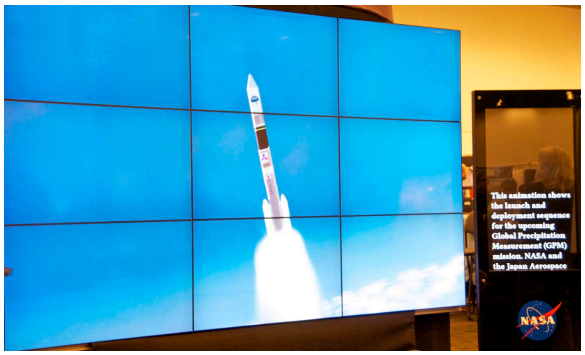
cational materials—including the 2012 NASA Science calendar, mission brochures, and posters.

A New Frontier

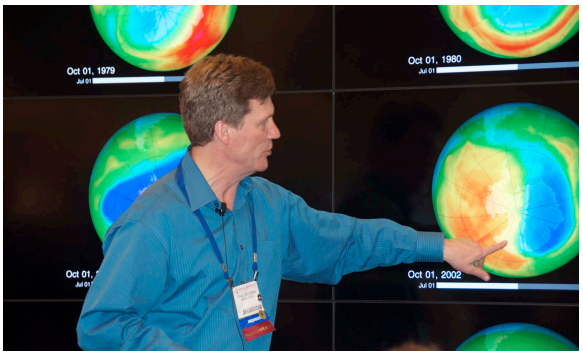
The compelling nature of understanding Earth, where we've been, and where we're headed inspires so many of us to study and attend conferences dedicated to improving our understanding of Earth. Advancements in technology, like the Hyperwall, are critical for making new discoveries, reaching new audiences, and raising global awareness of our planet. Next, NASA's Hyperwall will travel to New Orleans, LA, to support the American Meteorological Society 92nd Annual Meeting from January 22–26, 2012. With a full schedule of events lined up for 2012, the Hyperwall is expected to deliver new content and raise awareness about Earth science across the globe—one more reason why it's become quite the *globetrotter*. ■

Earth Science Hyperwall Presentations at the NASA Exhibit at AGU

Presenter	Topic
Eric Brown de Colstoun [NASA's Goddard Space Flight Center (GSFC)]	Tracking Fingerprints of Change
Phil Webster [NASA's Center for Climate Simulation]	NASA Center for Climate Simulation: Data Supporting Science
Eric Lindstrom [NASA Headquarters (HQ)]	The Dynamic Hydrosphere: A Quick Tour of the Dynamic Ocean and Cryosphere of Earth
Steve Platnick [GSFC]	Viewing Earth's Climate from Space
Laura Iraci [NASA's Ames Research Center]	NASA Science in the Middle of Nowhere: Measuring Greenhouse Gases in Railroad Valley, NV
Paul Newman [GSFC]	Overview of the Current State of the Antarctic Ozone Hole
Compton Tucker [GSFC]	Tropical Deforestation: A New Look
Ralph Kahn [GSFC]	Wildfire Smoke, Desert Dust, Volcanic Ash: Mapping Airborne Particles from Space
Gail Skofronick–Jackson [GSFC] and Dalia Kirschbaum [GSFC]	Precipitation Observations from Space: From TRMM to GPM



Gail Skofronick–Jackson [GSFC] showed an animation of the launch and deployment sequence for the upcoming Global Precipitation Measurement (GPM) mission during a Hyperwall presentation. **Image credit:** NASA



Paul Newman [GSFC] provided an overview of the current state of the Antarctic ozone hole, pointing out the importance of the Montreal Protocol. **Image credit:** NASA

Conference attendees gathered at the NASA exhibit to listen to scientists give 30-minute presentations on NASA's Hyperwall. **Image credit:** NASA

Eric Brown de Colstoun [GSFC] showed a global image of the Earth at night during his Hyperwall presentation titled "Tracking the Fingerprints of Change." **Image credit:** NASA

Congratulations!!!

Four scientists from NASA's Earth Sciences Division—**Christa Peters–Lidard**, **Paul Newman**, **Anthony Del Genio**, and **Gavin Schmidt**—were recently honored with prestigious awards by some of our community's leading professional science organizations.

Christa Peters–Lidard, Chief of the Hydrological Sciences Laboratory, and Paul Newman, Chief Scientist for Atmospheres—both at NASA's Goddard Space Flight Center—have been named 2012 Fellows of the American Meteorological Society. Election to grade of Fellow serves as a recognition of their outstanding contributions to the atmospheric or related oceanic or hydrologic sciences, or their applications, over a substantial period of years. A maximum of only two-tenths of one percent of the AMS membership is approved through the Fellow nomination process each year.

Anthony Del Genio, from the NASA Goddard Institute for Space Studies (GISS) has been named 2012 Fellow of the American Geophysical Union (AGU). To be elected a Fellow of AGU is a special tribute for those who have made exceptional scientific contributions. This designation is conferred upon not more than 0.1% of all AGU members in any given year.

Gavin Schmidt, a climate scientist based at GISS was awarded the inaugural Climate Communications Prize from the American Geophysical Union (AGU). The Climate Communications Prize, established by the AGU earlier this year, recognizes excellence in climate communication and was awarded to Schmidt for his efforts in scientific blogging through *Realclimate.org* and other outreach efforts. Schmidt also received the 2011 EarthSky Science Communicator of the Year award.

Please join us in congratulating Christa, Paul, Anthony, and Gavin on these awards.

feature articles

NASA's Applied Sciences Program—Earth Science Serving Society

Andrea Martin, NASA's Applied Sciences Program, andrea.s.martin@nasa.gov

The Applied Sciences Program serves as a bridge between the data and knowledge generated by NASA's ESD and the information and decision-making needs of public and private organizations.

NASA's Applied Sciences Program, within NASA's Earth Science Division (ESD), promotes and funds activities that identify and demonstrate innovative uses of and practical benefits from NASA's Earth-observing data, tools, and knowledge. The Applied Sciences Program serves as a bridge between the data and knowledge generated by NASA's ESD and the information and decision-making needs of public and private organizations. To this end, the program increases the benefits to society of the nation's important investments in NASA's Earth Science activities. The Applied Sciences Program achieves these ends by working towards the program's three primary goals of enhancing application research, increasing collaborations among new and existing partners, and accelerating applications of Earth Science data and information.

Application Areas

Through competitively selected, peer-reviewed responses to solicitations, the Applied Sciences Program funds projects that show creative use of NASA's Earth-observing data across the program's four national-priority application areas: Disasters, Ecological Forecasting, Health & Air Quality, and Water[1]. The successful applications developed through the program's projects have been used to improve early warning systems, address natural hazard response, facilitate water management, implement disease tracking, and adapt to climate change, among other topics.

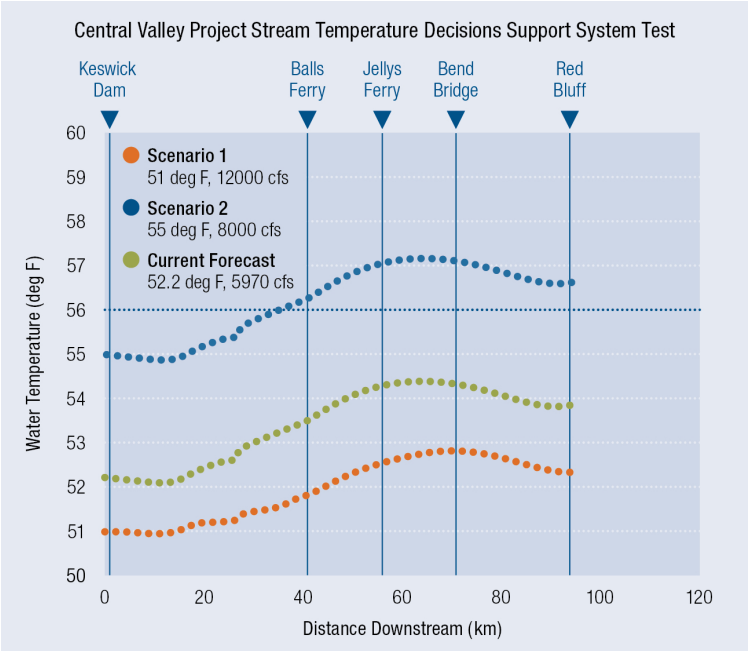


Figure 1. River temperature forecasts are available via NOAA's Pacific Coast Ocean Observing System (PaCOOS) web-based data interface and decision support system. These data show temperatures at various locations downstream of dams. **Image credit:** NASA/NOAA

Due to the interconnected nature of the Earth's systems, many Applied Sciences' projects managed within one application area can benefit other areas. The interconnected systems focus ensures that NASA investments in Earth-observing applications have a wide reach with maximum benefits. Also, by partnering with agencies such as the National Oceanic and Atmospheric Administration (NOAA), NASA's Applied Sciences Program encourages infusion of applications that fit closely with the needs of state, local, and federal agencies.

For example, a project in California, funded by the Applied Sciences Program in cooperation with NOAA, is using river temperature data to predict water temperature fluctuations for water-use decision making—see **Figure 1**. Not only is water use important for the citizens of California's Central Valley for drinking, irrigation, and industry, but also for the extremely temperature-sensitive *salmonid* species that depends on the river environment and is a major economic resource for the state. Proper water-resource management aids ecological forecasting that, in turn, adds stability to local economies.

[1] In addition to the current application areas mentioned here, the Applied Sciences Program plans to add five more—Agriculture, Climate, Energy, Oceans, and Weather—based on the nine societal benefit areas identified by the interagency U.S. Group on Earth Observations, of which NASA is a member.

Capacity Building

In addition to the application areas, the Applied Sciences Program supports four cross-cutting, capacity-building activities—DEVELOP, SERVIR[2], the Gulf of Mexico Initiative, and Earth Observation Training. These programs sponsor specific activities that improve the skill sets and capabilities of decision makers, community leaders, and resource managers in the U.S. and abroad—particularly in developing countries—on how to access and apply Earth-observing satellite data and other NASA assets for beneficial purposes.

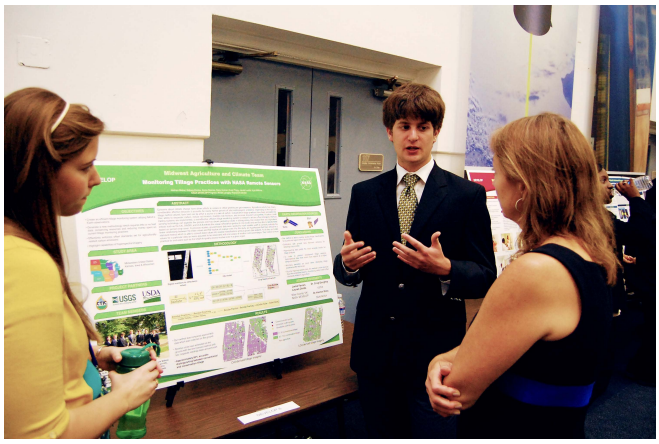


Figure 2. DEVELOP interns **Kelsey Rooks** and **Jacob Lourie** presented their project—Midwest Agriculture—at NASA's Langley Research Center DEVELOP Summer Highlight Presentation in August 2011. **Image credit:** NASA

DEVELOP[3] is a training program for students and young professionals that provides hands-on experience in using and integrating satellite remote sensing data into real-world application projects. Each year, approximately 250 DEVELOP students work with NASA scientists across the U.S. Working in teams, students incorporate Earth observations into examination of issues of local concern, such as tracking marine debris in the Gulf of Mexico, assessing air quality in Los Angeles, developing enhanced techniques for monitoring agriculture practices in the U.S. Midwest (see **Figures 2** and **3**), forecasting invasive species risk along the central Atlantic Coast, and examining wildfire damage and risk in Texas.

The Earth Observation Training program offers professional-level training to individuals and institutions, focused on developing skills and familiarity in accessing and using NASA's Earth observation data. The program hosts free in-person and online workshops and sessions throughout the year. Those who participate in these training sessions learn how to access, interpret, and apply NASA remote sensing data at regional and worldwide scales, using interactive case studies to build familiarity with the data and associated tools.

Currently, the Earth Observation Training program focuses on two of the Applied Sciences Program's application areas—Health & Air Quality, and Water. All training modules used during the in-person and online sessions are freely available to individuals and institutions that wish to learn more about remote sensing data and applications. To access online training modules that address either Health & Air Quality or Water, visit: *airquality.gsfc.nasa.gov* or *water.gsfc.nasa.gov*, respectively.

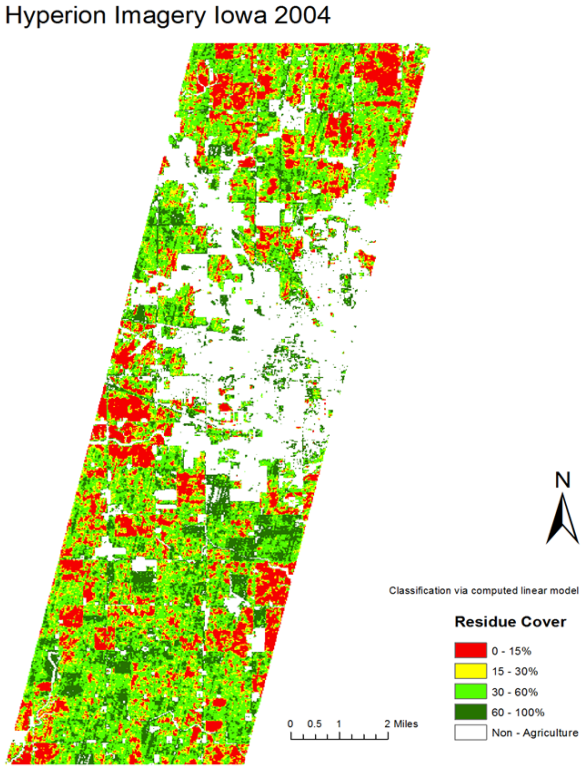


Figure 3. A classification of Hyperion imagery delineating the percentage of residue cover of an agricultural region in Iowa, which correlates with tillage practices. This information can be used to monitor tillage types and measure carbon sequestration. **Image credit:** NASA

While the DEVELOP and Earth Observation Training programs enable participants to apply NASA data to real-time projects, SERVIR and the Gulf of Mexico Initiative apply NASA data directly to issues in regions that could benefit from incorporating Earth observations into decision-making activities.

[2] SERVIR is a Spanish acronym for the Regional Visualization and Monitoring System and is also the Spanish verb for "to serve."
[3] Several of the DEVELOP projects mentioned in this article have been described in the July-August 2011 issue of *The Earth Observer*, [**Volume 23**, **Issue 4**, pp. 16-21].

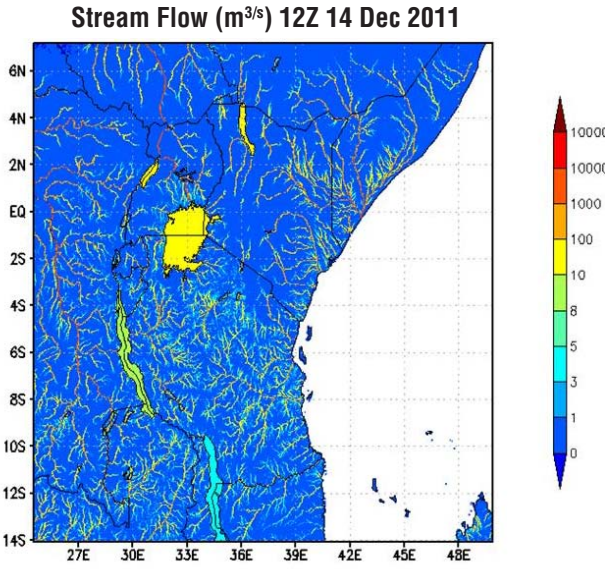


Figure 4. Using the CREST hydrologic model and near-real-time TRMM datasets, SERVIR-East Africa produces streamflow maps at approximately 3280 ft (1 km) spatial resolution for eight East African countries. **Image credit:** NASA

SERVIR is a NASA- and U.S. Agency for International Development (USAID)-sponsored initiative that integrates satellite observations, ground-based data, and forecast models to help developing nations monitor, forecast, and respond to environmental changes. Using Earth-observing satellite data, SERVIR enables managers, educators, scientists, media outlets, and policy implementers in the Mesoamerican, East African, and Himalayan regions to better respond to a wide range of environmental issues.

For example, in East Africa, water management is a critical concern. The SERVIR-East Africa team and the Kenya Meteorological Department (KMD) are teaming to give decision makers flood forecasts with longer lead times. SERVIR has provided KMD with a hydrological model developed by NASA's Goddard Space Flight Center and the University of Oklahoma, which incorporates landforms, evapotranspiration, soil infiltration, and precipitation to predict where floods are likely to occur.

The model is called the Coupled Routing and Excess Storage water balance model (CREST)—see **Figure 4**. It incorporates a combination of locally gathered water levels, KMD-generated weather forecasts, and ten years of historical precipitation data from the Tropical Rainfall Measuring Mission (TRMM) satellite to identify areas where flooding or droughts could occur. Originally confined to one watershed in the Lake Victoria Basin, SERVIR has cooperated with KMD and other nations to expand the range of the CREST model predictions to eight nations. Countries in the region plan to use this information in decision support systems to provide agricultural communities with seasonal forecast of soil moisture, stream flow, and potential crop yields, given the seasonal rainfall forecasts.

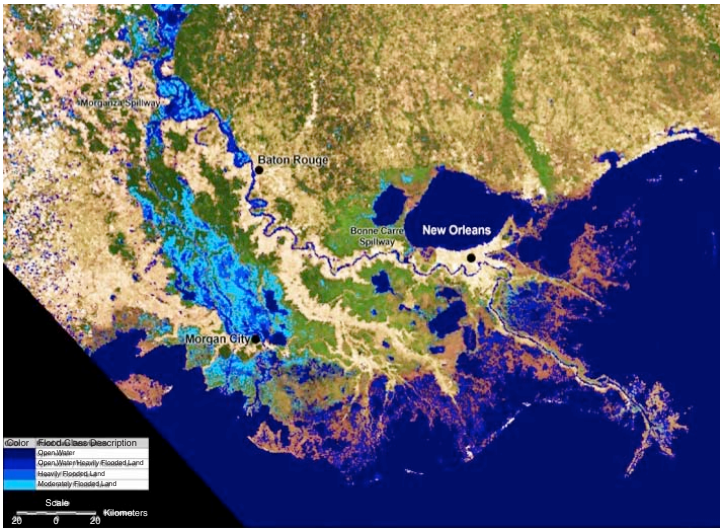


Figure 5. The Morganza Spillway was opened to prevent flooding in Baton Rouge and New Orleans in May 2011. NASA scientists used satellite data to monitor the resulting flooding in the Atchafalaya River basin. **Image credit:** NASA

The Gulf of Mexico Initiative was formed to help the U.S. Gulf Coast Region use Earth observations in the recovery efforts required after the impacts of two devastating hurricanes—Katrina and Rita—in 2005, and to address future coastal management issues. Today, the Gulf of Mexico Initiative focuses on the regional priorities defined by the Gulf of Mexico Alliance and the Gulf Coast Ecosystem Restoration Task Force to enhance the ecological and economic health of the Gulf region, and to assist in long-term restoration and recovery activities.

Specifically, the Gulf of Mexico Initiative projects use NASA Earth observations to aid in decision-making activities involving ecological forecasting, water management, public health, weather, and disasters. Some current Gulf of Mexico initiative projects include: monitoring coastal marshes for persistent flooding and salinity stress, use of NASA satellite data to improve coastal cypress forest management—see **Figure 5**—remote sensing to assess microbial water quality at beaches and shellfish beds, and short-term storm forecasting over the Gulf of Mexico by blending satellite-based extrapolation forecasts with numerical weather prediction results.

Expanding Application Reach

The National Research Council's Earth Science Decadal Survey—*Earth Science and Applications from Space*—recommended future satellite missions that will serve the nation's scientific and applications objectives. The Decadal Survey stated that the planning for practical benefits (applications) from these missions should play a strong role in addition to acquiring scientific knowledge about Earth.

Existing and past missions have demonstrated the value of NASA satellite observations to end-users, and the user community has applied the datasets with increasing sophistication to serve national interests. As NASA's Applied Sciences Program continues to support projects within the four application areas and the four capacity-building programs, the program hopes to expand the reach of its applications, the number of end-users who use the applications, and the number of people (application specialists) working on applications-based projects. One way the program achieves these goals is by becoming more involved in satellite mission planning.

In preparing for future Earth-observing satellite missions, there is a need for the applications community to identify potential data applications early in mission lifecycles. The Applied Sciences Program responds to this need by having application specialists become involved in early-phase mission planning, so the applications community can conceptualize and anticipate potential applications, become familiar with simulated data, and be prepared to use the data as soon as possible after the mission has been launched.

In its use of the data, the applications community may have perspectives on the mission's data products. Community experience and feedback may be able to identify ways to improve the data products, which can in turn support the scientific community.

The Applied Sciences Program has been and continues to be a bridge that connects NASA's investment in acquiring accurate and comprehensive Earth-observing data to the end-users who apply those data in their everyday decision-making activities. From enforcing air-quality standards, to developing malaria early-warning systems, to enabling better monitoring systems for drought, weather, and more, projects funded by the Applied Sciences Program are actively benefitting society. By building capacity in enabling the next generation of application specialists, training decision makers, helping remote regions apply NASA data to issues of concern, and using NASA Earth observations to recover after destructive storms, the program is building skill sets and uses for NASA Earth science data both nationally and international.

To learn more about the Applied Sciences Program, its Application Areas, and Capacity Building Activities, visit: *appliedsciences.nasa.gov.* ■

From enforcing air-quality standards, to developing malaria early-warning systems, to enabling better monitoring systems for drought, weather, and more, projects funded by the Applied Sciences Program are actively benefitting society.

feature articles

The NASA-GPM and DOE-ARM Midlatitude Continental Convective Clouds Experiment (MC3E)

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The MC3E field experiment took place in central Oklahoma from April 22–June 6, 2011, focused on and around the ARM Southern Great Plains (SGP) Central Facility (CF), where an extensive array of both airborne and ground-based instrumentation was deployed.

Introduction

The development and validation of physically-based, over-land precipitation retrieval algorithms for satellite-based remote sensing requires the collection of detailed cloud and precipitation observations. Similarly, improving the representation of convective clouds in numerical weather prediction and climate models requires detailed observations and analysis of convective cloud processes. These synergistic needs underpin a collaborative effort led by NASA's Global Precipitation Measurement (GPM) and the U.S. Department of Energy (DOE)'s Atmospheric Radiation Measurement (ARM) programs to conduct the Midlatitude Continental Convective Clouds Experiment (MC3E).

The MC3E field experiment took place in central Oklahoma from April 22–June 6, 2011, focused on and around the ARM Southern Great Plains (SGP) Central Facility (CF), where an extensive array of both airborne and ground-based instrumentation was deployed—see **Figure 1**. The overarching goals of the field effort were to provide a complete three-dimensional characterization of precipitation microphysics in the context of improving the reliability of GPM precipitation retrievals over land, and to advance understanding of the primary physical components that form the basis for models that simulate convection and clouds.

The GPM mission, currently scheduled for launch in February 2014, was initiated by NASA and the Japanese Aerospace Exploration Agency (JAXA). GPM is a global successor to the Tropical Rainfall Measuring Mission (TRMM) that will provide the next generation of observations of rain and snow over the entire Earth every three hours. The GPM concept centers on deploying a "core" satellite carrying two instruments, the multichannel GPM Microwave Imager (GMI) and the K_u/K_a-band Dual-frequency Precipitation Radar (DPR), to set a new reference standard for precipitation measurements from space. Precipitation retrievals from these instruments require algorithms to transform the radar reflectivities (Z) and brightness temperatures (T_B) into precipitation information. Observations from aircraft and ground-based instruments, such as those taken during the MC3E field campaign (described below) are required both to improve and validate the science of the instrument retrieval algorithms for the radar and radiometer. The data from the GPM Core Observatory will then serve as a transfer standard to unify precipitation measurements made by an international network of partner satellites to provide near-real-time observations of rain and snow worldwide.

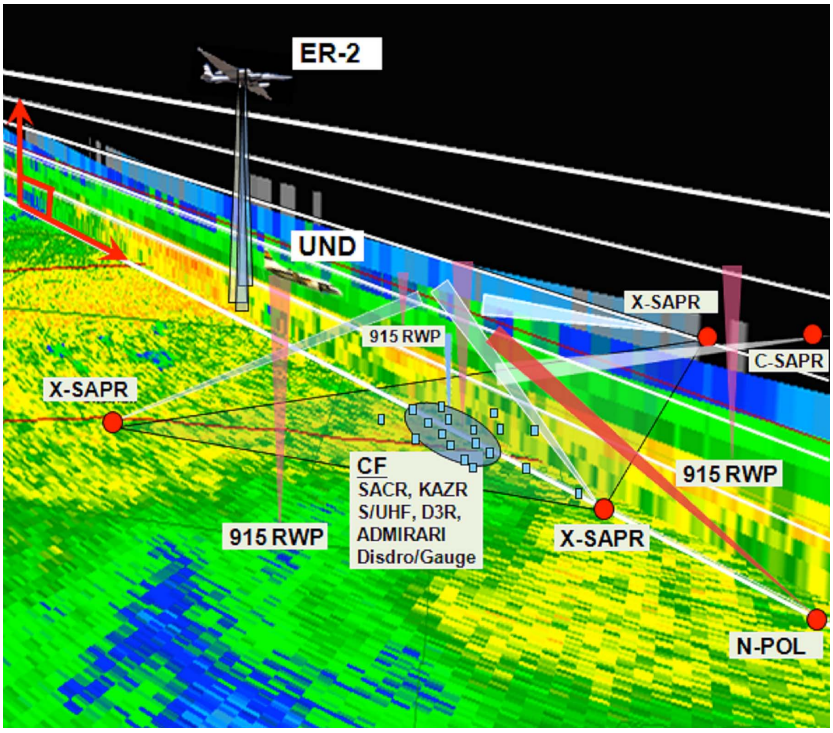


Figure 1. *Conceptual 3-D "top-down" sampling strategy for MC3E.* Sampling from aircraft [ER-2 and University of North Dakota (UND) Citation aircraft] occurred over a nested multifrequency ground-based network of radars (see full article for more details) and 915 MHz Radar Wind Profilers (RWP), covering a dense array of disdrometers and rain gauges. **Note:** Acronyms used in figure are defined in text.

MC3E Science Objectives

The MC3E science objectives were driven by the NASA GPM

and DOE ARM programs' need to acquire a more complete understanding of the complex and interconnected physical processes driving mid-latitude convection, clouds, and precipitation production. GPM science objectives were crafted to validate precipitation retrieval algorithm physics, and coupled cloud-resolving model (CRM) and land-surface model (LSM) databases to advance passive microwave (PMW) and DPR over-land precipitation retrieval algorithm development, and to test those algorithms (i.e., to act as satellite simulators). Specific GPM objectives for MC3E included:

- *Collection of cloud physical properties that vary in space and time.* Such properties include cloud liquid and ice water contents, rain drop and ice particle size distributions, particle size distributions, melting layer structure, and precipitation rates in a midlatitude continental environment during the varying "regimes" of transition from spring to summer in the Northern Hemisphere.

- *Collection of coincident high altitude, dual-frequency radar, and microwave radiometer measurements with concomitant (nearly simultaneous) ground and airborne microphysical measurements.* These measurements would be used to support algorithm cloud database development and retrieval testing.

- *Construction of accurate large-scale forcing environments for CRM/LSM simulations*. These environments—with observed cloud properties—would be used to evaluate the fidelity and improve the physics of coupled model simulations—e.g., satellite simulator models (SSM).

- *Evaluation of the core complement of GPM Ground-Validation (GV) instrumentation.* This instrumentation (e.g., aircraft, radars, profilers, disdrometers, etc.), would be evaluated to assess sampling methodologies and associated measurement error characteristics.

- *Further establishment of CRM space-time integration capability.* This capability would be used for quantitative precipitation estimation.

- *Observation of land-surface properties.* Such properties—including microwave radiative fluxes, temperature, and soil moisture—would be used to better understand land-surface emission properties.

DOE science objectives addressed three fundamental components of convective simulation and microphysical parameterization in numerical models:

- *Definition of the pre-convective environment in relation to convective initiation*. Prior to and during convective initiation, activities would define the vertical and horizontal structure of the atmospheric thermodynamic state and its evolution, with emphasis on boundary layer structure.

- *Identification of updraft and downdraft dynamics.* Available radar networks and multiple analysis techniques would be used to estimate three-dimensional (3-D) air motions within convective cloud systems, and to relate draft statistics to lower tropospheric instability and thermodynamic properties.

- *Characterization of precipitation and cloud microphysics*. Multi-frequency radar observations, combined with polarization capabilities, would be used to to quantify cloud and precipitation particle size distributions, total water contents, and cloud/precipitation particle phase.

The complementary nature of these science objectives provided DOE and NASA researchers a common framework around which they could design a field experiment that provided maximum benefit to both agencies but with only minor accommodation of sampling approaches to achieve the objectives.

Observations from aircraft and ground-based instruments, such as those taken during the MC3E field campaign are required both to improve and validate the science of the instrument retrieval algorithms for the radar and radiometer.

feature articles

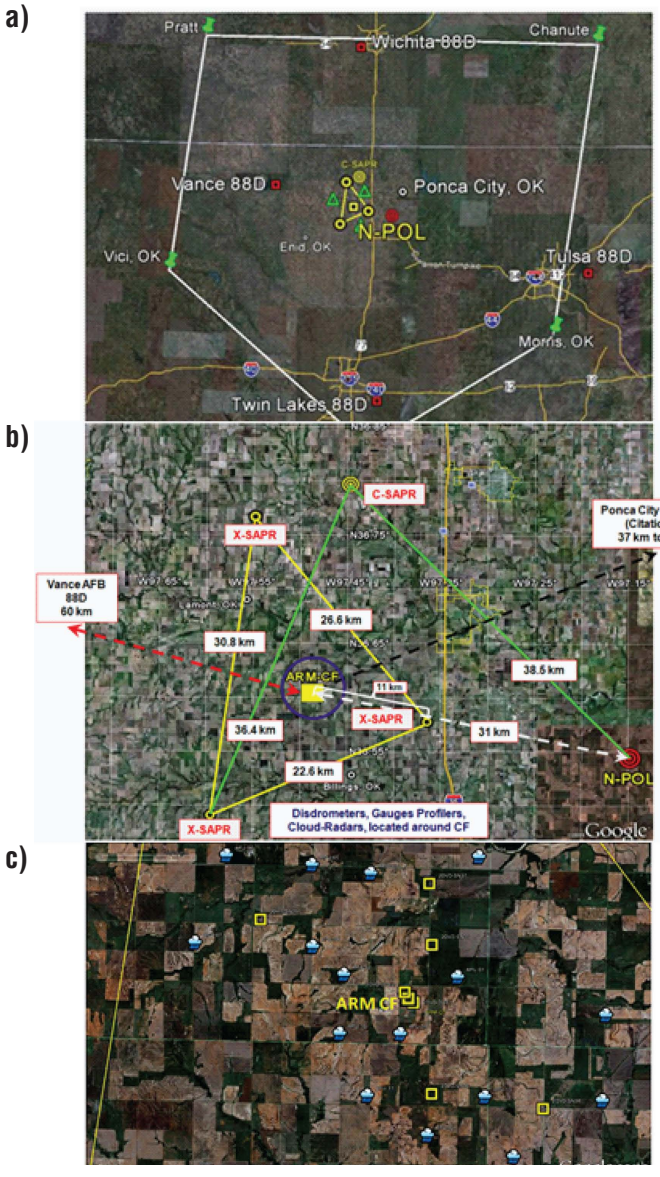


Figure 2. *MC3E Experiment design.* These images show: (a) The sounding network that encircled the central radar array (NPOL, C-SAPR, triangular array of X-band radars in yellow; 915-MHz profilers, green triangles) and the SGP CF; (b) a close-up of the central scanning-radar network showing the relative positions and distances between the NPOL radar, the DOE X and C-SAPR radars, and the Vance Air Force WSR-88D radar; and (c) the spatial distribution of APU and collocated rain gauges shown as green rain clouds, and 2DVD, indicated by white squares, within the X-SAPR radar array and surrounding the CF, shown as a purple circle in (b). For additional details please see the text.

Field Experiment Strategy, Instruments, and Operations

MC3E employed a "top-down" multiscale observing strategy—see **Figure 1**—that was implemented via the deployment of nested instrument networks and airborne platforms centered on the ARM SGP CF site in northern Oklahoma—see **Figure 2**. At the top of the sampling domain (i.e., ~12 mi (20 km) altitude), the NASA ER-2 aircraft carried the High-Altitude Imaging Wind and Rain Airborne Profiler (HIWRAP), the Advanced Microwave Precipitation Radiometer (AMPR), and the Conically Scanning Microwave Imaging Radiometer (CoSMIR)—compare to **Table 1**. From their high-altitude vantage point, these instruments provided a dataset more consistent with the viewing angles and radar and radiometer measurements that will be characteristic of the GPM Core satellite.

Within and under the coverage of the ER-2 aircraft instrumentation, the University of North Dakota Citation aircraft sampled coincident cloud microphysical properties through the atmospheric column with special attention paid to sampling ice and mixed-phase particle characteristics—see **Table 2**.

The airborne measurements that have been described were conducted within the broad coverage of a nested ground-based instrumentation network—see **Figures 2a-c**. At the largest scale (186 mi; 300 km)—**Figure 2a**—a network of radiosondes were deployed to quantify regional temperature, wind, and humidity properties of the environment surrounding the ARM SGP CF. Over 1200 coordinated radiosonde launches from six sites took place at a nominal frequency of four per day to resolve the diurnal cycle, and eight per day during periods of intensive aircraft and ground-based operations. These data will form the basis of CRM and column model forcing datasets.

Nested within the radiosonde network was a smaller array—separations < 37 mi (60 km)—of seven multiparameter radar platforms. Anchoring the network were the recently upgraded NASA S-band scanning dual-polarimetric radar (NPOL) and the new DOE ARM X and C-band scanning dual-polarimetric radars (X-SAPR and C-SAPR, respectively). The C-SAPR radar provided customized but steady volumetric sampling of precipitation systems over the broader radar observation domain—nominal 50-mi (80-km) range. In turn, the NPOL radar was used as a reference to provide targeted, detailed, and relatively unattenuated sampling of precipitation processes over length scales ranging from approximately 0.16–62 mi (0.25–100 km). NPOL operations emphasized high temporal and vertical resolution dual-polarimetric sampling of precipitation rates and particle size distributions in coincident volumes of atmosphere sampled by the aircraft and other higher-frequency radar, disdrometer, and gauge instrumentation located in the immediate vicinity of the ARM SGP CF. The three X-SAPR radars provided convective scale multi-Doppler velocity observations for retrieval of 3-D wind fields and a higher-frequency dual-polarimetric

measurement within the coverage domain of the aircraft, NPOL, and C-SAPR radars. Surrounding the SGP CF, was a dense network of 18 Autonomous Parsivel disdrometers (APU), 16 rain gauge pairs, and seven two-dimensional (2D) Video Disdrometers [2DVD]. These instruments sat within a radius of approximately 3.7 mi (6 km) of the CF. The APUs and rain gauges measured rainfall and drop size distribution (DSD) correlation properties at kilometer scales. The 2DVDs provided a DSD reference measurement to the APU network and were used to calibrate dual-polarimetric radar measurements and DSD retrievals. At finer scales and within the SGP CF, the full suite of ARM cloud, radiation, and atmospheric state instrumentation is available including the Scanning ARM Cloud Radar (SACR), Ka-band vertically pointing radar (KAZR), and micropulse lidar enhanced by the NASA Micro Rain Radar (MRR) and Advanced Microwave Radiometer for Rain Identification (ADMIRARI). The National Oceanic and Atmospheric Administration (NOAA) S-band/UHF profiler provided continuous vertically pointing measurements of precipitation and clear air velocity within the SGP CF. As operated, the S-band/UHF profiler provided a well-calibrated measurement of precipitation rate and DSDs that serve as a comparison to similar quantities estimated using dual-polarimetric radar platforms like the NPOL.

Table 1. NASA ER-2 Instrumentation

Instrument	Characteristics
AMPR	Passive microwave radiometer
Frequencies	10.7, 19.35, 37.1, 85.5 GHz; all channels H/V
Resolution at 12.4-mi (20-km) range	0.37 mi (0.6 km) (85.5 GHz),0.93 mi (1.5 km) (37.1 GHz), 1.74 mi (2.8 km) (10.7-19.35 GHz)
CoSMIR (Radiometer)	Passive microwave radiometer
Frequencies	52, 89 (H/V), 165.5 (H/V), 183.3+/-1, 183.3+/-3, 183.3+/-8 GHz
Resolution at 12.4-mi (20-km) range	0.87-mi (1.4-km) footprint at nadir
HIWRAP Radar	Profiler radar
Frequencies	13.91/13.35 GHz, 35.56/33.72 GHz
Transmit peak power	30 W (K_u), 10 W (K_a)
3-dB beamwidth	2.9° K_u, 1.2° K_a
Minimum reflectivity at 0.04-mi (60-m) resolution, 3.3-ms chirp pulse, 6.2 mi (10 km)	0.0, -5.0 dB_{Ze}

Table 2. UND Citation Instruments

Instrument	Measurement
Particle Measuring Systems Inc. (PMS) King Liquid Water Sensor	Cloud liquid water
PMS Two-dimensional (2D)-Cloud Imaging Probe (CIP)	Cloud and precipitation particle spectra
High-volume Precipitation Spectrometer (HVPS)	Precipitation particle spectra
Cloud Particle Imager (CPI)	Cloud particle images
Cloud Droplet Probe (CDP)	Cloud droplet spectra
Nevzorov Water Content Probe	Total water content
Rosemount icing probe	Supercooled liquid water
Condensation Nuclei (CN)/Ultra-high-sensitivity Aerosol Spectrometer (UHSAS)	Aerosol characterization

The MC3E *Dream Scenario*

Early in the morning of May 20, an intense north-to-south oriented convective line called a *mesoscale convective system* (MCS) moved over the CF and was extensively sampled by the ground-based instruments. Shortly thereafter, carefully orchestrated flights of the ER-2 and Citation sampled the MCS stratiform region over and near the CF. Finally, several long ER-2 transects were flown normal (perpendicular) to the direction of the MCS convective line and over stratiform precipitation as it moved eastward out of the sampling domain. These observations—shown in **Figure 3**—represent one of the best examples of the coordinated sampling strategy obtained throughout the entire MC3E campaign.

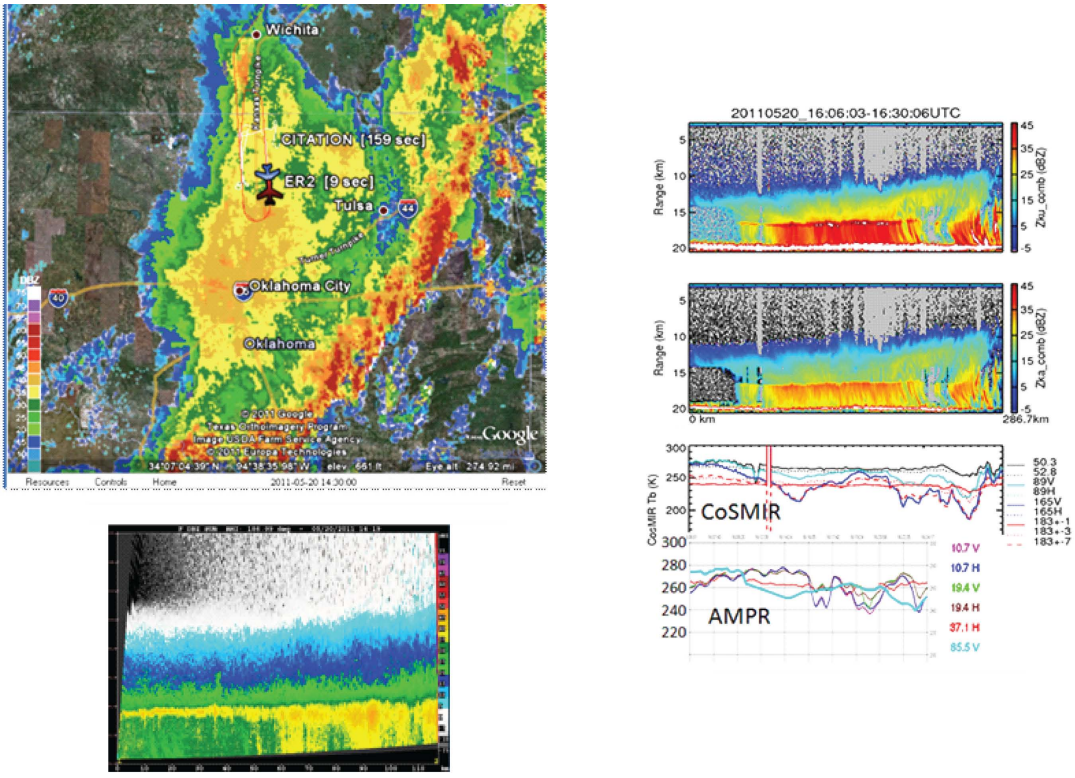


Figure 3. *The MC3E "Dream scenario" for coordinated airborne sampling*. The image shown at top-left is an example of ER-2 (red) and Citation (white) flight leg coordination overlaid on radar reflectivity from 1430 UTC on May 20, 2011. A vertical cross section (RHI; 1419 UTC) of radar reflectivity from the C-SAPR oriented approximately along the Citation/ER-2 flight tracks is shown bottom-left. The right panels show, from top to bottom, the 1606-1630 UTC ER-2 transect of coincident HIWRAP Ku-band, Ka-band reflectivity, and CoSMIR and AMPR radiometer brightness temperatures. This sample was collected in a line-normal flight leg over MCS stratiform precipitation and across the intense leading convective line. *HIWRAP and CoSMIR figure on right courtesy Gerry Heymsfield [NASA's Goddard Space Flight Center].*

Data Collection Summary and Example Observations

Airborne and ground-based precipitation instruments took a wide variety of coordinated measurements during MC3E. Several ER-2 and UND Citation missions with "stacked" sampling flew within 62 mi (100 km) of the SGP CF. These flights were of considerable importance to GPM—see **Table 3**—because they provided the best opportunity to fully describe column cloud and precipitation characteristics within the observational domain of a high-altitude GPM Core satellite simulator (i.e., the ER-2). In addition to these cases, numerous other airborne missions occurred that: a) provided coincident, and much needed, K_a-K_u band radar and 10–183-GHz radiometer datasets in view of other ground radars (including one mission conducted in concert with the Colorado State University CHILL radar in northeastern Colorado); b) allowed for detailed microphysical profiling; c) conducted cloud sampling; and d) facilitated HIWRAP, AMPR and CoSMIR sampling of the land surface with the goal of testing new approaches for unmasking precipitation signals from a background signal of strongly varying land-surface emission.

Table 3. Summary of Aircraft Flights During MC3E

Airborne Case Type	Dates
Coordinated ER-2, Citation within 62 mi (100 km) of CF	April 25, May 11, May 18, May 20, and May 23
ER-2/Citation outside CF coverage (i.e., NE Kansas)	June 1
Citation-only microphysics missions	April 27, May 1, May 10, May 24
Citation cloud missions	May 27, June 2
ER-2 Land Surface	April 25, May 8, May 29
University of Tennessee Space Institute (UTSI) Piper-mounted Marshall Airborne Polarimetric Imaging Radiometer (MAPIR)	Nine missions between May 21–June 2 (including a coordinated flight with ER-2 on May 29)

In addition to the coordinated operations with aircraft flights during MC3E, ground-based radar and disdrometer operations also focused on targeted high-resolution sampling of 3-D microphysical processes. For example, the NPOL radar was placed into a special 45-second scanning cycle on several occasions that consisted of range-height vertical cross-sections and low-level, plan-view elevation scans. When combined with the disdrometer data, these scans provide a means to map the full 3-D evolution and variability of DSD characteristics, which are fundamental to GPM radar and combined radar/radiometer algorithm retrievals. In particular, the polarimetric properties of the NPOL and DOE radars provided a means to discriminate liquid from ice-phase precipitation, and to examine how different liquid and ice processes impacted DSD properties in terms of the drop size and number concentration. **Figure 4** demonstrates this principal for an event observed on May 11. During this event the NPOL, 2DVD, and MRR observed momentary broadening of the DSD associated with occasional large raindrop production. High-temporal-resolution range-height indicator (RHI) scans collected by the NPOL suggest that at least some population of the observed larger drops were produced as a result of descending regions of melting hail and graupel.

These flights were of considerable importance to GPM because they provided the best opportunity to fully describe column cloud and precipitation characteristics within the observational domain of a high-altitude GPM Core satellite simulator (i.e., the ER-2).

Future Analysis Directions

After completion of data quality control and archiving (targeted for completion in December 2011), the MC3E dataset will yield a rich data source from which to conduct detailed precipitation and cloud physical process studies, test GPM algorithm

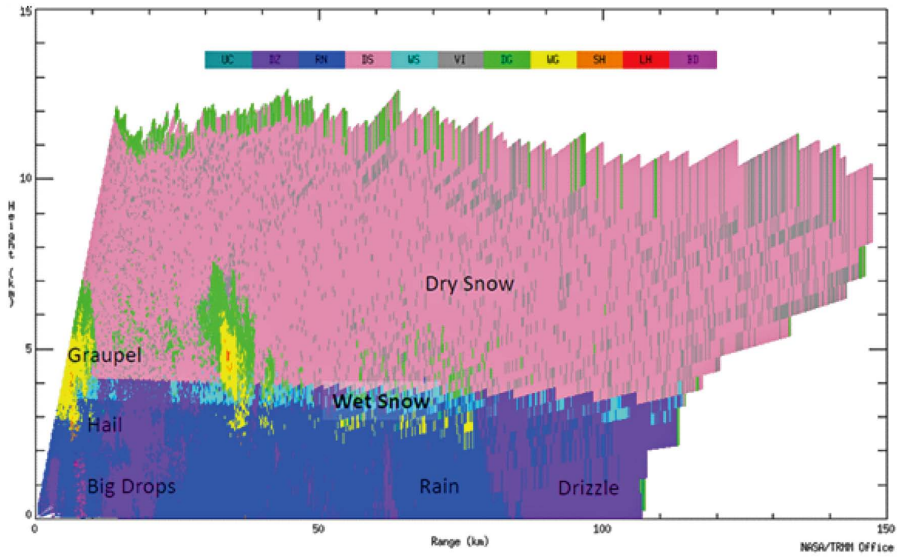


Figure 4. *Production of large rain drops by the melting of hail and graupel.* Color shading represents different hydrometeor (precipitation) types as identified using NPOL polarimetric radar variables observed in a range-height indicator scan taken at 1806 UTC on May 11, 2011. Of particular interest is the transition zone in the far left of the figure, where graupel (yellow) transitions to small hail (orange) and then to rain and large drops (blue and light purple respectively). **Image credit:** Brenda Dolan [Colorado State University].

physics and assumptions regarding those physics, and create CRM and SSM validation datasets. A focused effort to synthesize campaign measurements will be made in order to provide:

a) Model forcing datasets derived from the radiosonde array.

b) Precipitation microphysical characteristics (e.g., hydrometeor types, DSD parameters and rain rate covariance properties) concomitantly diagnosed from the array of W- through S-band polarimetric radars, disdrometer, and profiler observations.

c) Unified airborne radar, radiometer, and aforementioned ground-based microphysical measurements.

d) Two-dimensional and three-dimensional wind retrievals from multi-Doppler radar observations.

For more information about the GPM mission and Ground Validation activities please consult the GPM website: *gpm.nasa.gov*. For information regarding datasets please visit the GPM Ground Validation Data Portal: *gpm.nsstc.nasa.gov.* ■

In Memoriam

It is with deep sorrow that we report the death of Greg Leptoukh. He passed away unexpectedly on January 12 of cardiac arrest.

Greg joined NASA's Goddard Earth Sciences Data and Information Services Center in 1997 and quickly became known for his leadership in linking science and technology. He was passionate about making Earth science data more readily accessible to the end-user and later, was a pioneer of *Giovanni*—a Web-based application tool that provides a simple and intuitive way to visualize, analyze, and access vast amounts of Earth science remote sensing data (e.g., data from instruments aboard the A-Train satellites). Greg's work brought together data from several Earth Observing System satellite missions and provided a means for easy distribution of NASA Earth science data to policy makers, teachers, students, modelers, researchers, and the like.

Greg will be greatly missed by the NASA community and by his many collaborators and colleagues around the world. *The Earth Observer* staff wishes to express our condolences.

Blog Log

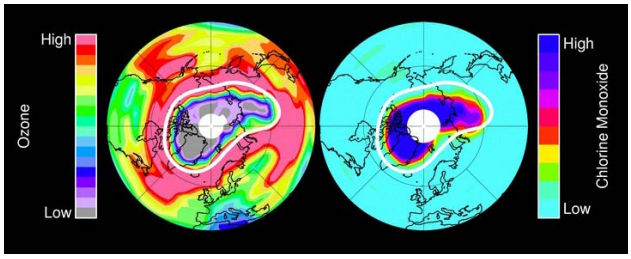
Heather Hyre, NASA's Goddard Space Flight Center/Wyle, heather.r.hyre@nasa.gov

Blog introductions are modified text from featured blogs; images are also from featured blogs.

This periodic installment features new blogs about NASA Earth science research and fieldwork, and provides links where you can access the full blog and view color photographs online. In this issue, we highlight a new blog—*Earth Matters*—and invite you to revisit an older blog—*What On Earth*—to read about some fascinating topics trending in Earth science. If you're looking for something a bit *cooler*, check out the Pine Island Glacier 2011 or Satellite Era Accumulation Traverse blog and learn how scientists are measuring how much snow falls in Antarctica. If you know of any blogs that should be shared in our next installment of the *Blog Log*—perhaps, one of your own—please let us know!

Earth Matters

Earth is an amazing planet, and the one that matters most to us. We love watching it in all of its beauty and fury, its texture and color, its history and its future. The *Earth Matters* blog offers an ongoing conversation about our planet and invites *you* to participate! The blog is composed by the science writers, data visualizers, Web developers of NASA's Earth Observatory and Earth Science News Team, and of course, you.



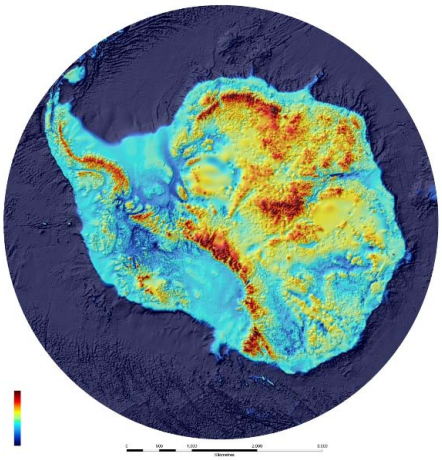
[*Image left*] Ozone in Earth's stratosphere at an altitude of approximately 12 mi (20 km) in mid-March 2011, near the peak of the 2011 Arctic ozone loss. [*Image right*] Chlorine monoxide—the primary agent of chemical ozone destruction in the cold polar lower stratosphere—for the same day and altitude. **Image credit:** NASA/Jet Propulsion Laboratory-Caltech

Earth Matters discusses what we see—and some things we cannot see—from the view of NASA's satellites, orbiting the Earth. The goal is to try to answer your questions; offer unique resources and perspectives; and update you on Earth news and events that might not show up in your local media. So, what's interesting about your corner of the world? Join the conversation at: *earthobservatory.nasa.gov/blogs/earthmatters/.*

What On Earth

The science writers, producers, and educators who cover NASA from the inside compose the *What On Earth* blog. The goal of the blog is to provide glimpses of the everyday aspects of Earth science—the field campaigns, lab experiments, and technology developments–that illuminate the work behind the breakthroughs.

Recently, science writers—**Adam Voiland** [NASA's Goddard Space Flight Center (GSFC)], **Maria-Jose Vinas** [GSFC], and **Heather Hyre** [GSFC]—traveled to San Francisco, CA, in search of interesting topics related to NASA's Earth science generated activities at the 2011 Fall Meeting of the American Geophysical Union (AGU). The goal was to share news about recent advancements in Earth science, and the practical application of NASA science in society. To check out posts from AGU, along with other interesting entries, visit *blogs.nasa.gov/cm/newui/blog/viewpostlist.jsp?blogname=whatonearth* and experience the thrill of watching NASA science as it happens.



A new, updated map reveals how the Antarctic continent looks under the ice. **Image credit:** BEDMAP Consortium

Pine Island Glacier 2011

Antarctica's Pine Island Glacier has nearly doubled its displacement speed in the past 15 years and is thinning at rates of nearly 30 ft (10 m) per year. It alone is responsible for 7% of the total global rate of sea level rise. After years of

blog log

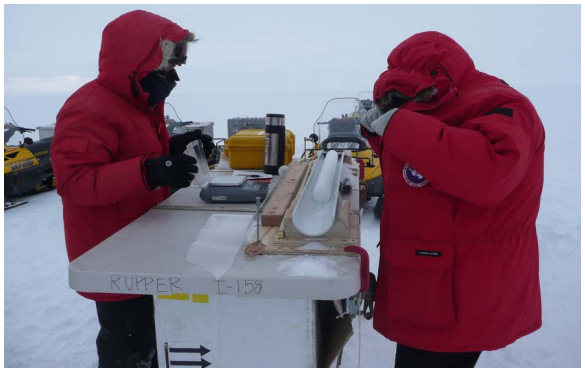
waiting—including hundreds of e-mails, scores of telephone conferences, and a handful of face-to-face meetings to iron out a mountain of details—it's finally time to go! More than a dozen scientists' will travel to Pine Island Glacier—one of the most remote regions on Earth—intent on unlocking critical mysteries within the light-less, frigid void beneath this thick floating plate of ice.

By following this blog, you'll learn about the scientists who traveled to Antarctica to study the glacier, what they plan to do and, inevitably, how their initial plans changed as they wrestled with Mother Nature. To find out about the latest updates from the field, visit: *earthobservatory.nasa.gov/blogs/fromthefield/category/pine-island-glacier-2011*.

Picture of the Pine Island Glacier project members taken in November 2009 following successful drilling test program at Windless Bight, near McMurdo Station. [*Left to right*] **Bob Bindschadler** [NASA's Goddard Space Flight Center (GSFC)], **Jim Stockel** [GSFC], **Martin Truffer** [University of Alaska Fairbanks (UAF)], **Tim Stanton** [Naval Postgraduate School], **Dale Pomraning** [UAF], and **Alberto Behar** [NASA/Jet Propulsion Laboratory]. **Image credit:** NASA

SEAT: Satellite Era Accumulation Traverse

Lora Koenig would like to welcome you to the Satellite Era Accumulation Traverse blog. It's a mouthful, so we will call it the SEAT blog. Until mid-January, Lora and her colleagues will post about their science and adventures, from preparing their gear in the U.S. to riding snowmobiles across West Antarctica in order to study how much snow falls in Antarctica—in particular, at a place called Byrd Station. You'll learn about the team's journey to Antarctica and the science they're conducting in the coldest, driest, remotest and (forgive the pun) coolest continent on Earth. So have a SEAT, grab a hot drink, and enjoy the blog by visiting: *earthobservatory.nasa.gov/blogs/fromthefield/category/seat-satellite-era-accumulation-traverse.* ■



Jessica Williams [Brigham Young University] and **Michelle Koutnik** [University of Copenhagen} process an ice core that was drilled to a depth of 55.1 ft (16.8 m), which corresponds to about 40 years of snow accumulation history. **Image credit:** NASA

announcement

CloudSat Data Products Released to General Science Community

The CloudSat Data Processing Center (DPC) has released the R04 versions of the *surface precipitation occurrence and intensity* (2C-PRECIP-COLUMN) and *profiles of precipitation liquid and ice water content* (2C-RAIN-PROFILE) products to the general science community. This is a reprocessed version of 2C-PRECIP-COLUMN for R04, hence, the product file names include P1_R04. This is the first production run of 2C-RAIN-PROFILE for R04; therefore, its product file names include P_R04.

All data users are asked to review the associated documentation. As of this writing there are no known issues with these products, before using these products in publications or presentations, users are advised to visit the "Data Issues" page of the DPC website for updates on data quality and any issues that may have arisen. This page is located at *www.cloudsat.cira.colostate.edu/dataIssues.php*.

The online product specifications for these products are located at *www.cloudsat.cira.colostate.edu/dataSpecs.php*. To access the released data, use the DPC data ordering system interface found at *cloudsat.cira.colostate.edu/data_dist/OrderData.php*. In addition, we ask that you report any anomalies or questions to the DPC at *cloudsat@cira.colostate.edu*.

Summary of the International Year of Chemistry Symposium on Stratospheric Ozone and Climate Change

Margaret Hurwitz, NASA Goddard Earth Sciences Technology and Research, Morgan State University and NASA's Goddard Space Flight Center, margaret.m.hurwitz@nasa.gov

The International Year of Chemistry Symposium on Stratospheric Ozone and Climate Change took place from November 7–10, 2011, in Washington, DC. The symposium brought together scientists, policy officials, and members of the private sector to showcase the achievements of the Montreal Protocol (1987) and Clean Air Act Amendments (1990) in protecting air quality, the ozone layer, and Earth's climate. The objective of the symposium was to gain insight from the science and politics that led to these two agreements in hopes of furthering efforts to mitigate greenhouse gas-related climate change.

The symposium boasted an impressive list of speakers including: **Michael McPhaden** [American Geophysical Union (AGU)—*President*]; **Jonathan Malay** [American Meteorological Society (AMS)—*President*]; **Nancy Jackson** [American Chemical Society (ACS)—*President*], **Jeremiah Lengoasa** [World Meteorological Organization (WMO)—*Deputy to the Secretary-General*]; **Mario Molina** [Nobel Laureate]; Chairs of the Intergovernmental Panel on Climate Change (IPCC) and WMO Ozone Assessments, **Paul Newman** [NASA's Goddard Space Flight Center (GSFC)], **A. R. Ravishankara** [National Oceanic and Atmospheric Administration (NOAA)-University of Colorado, Boulder], and **Susan Solomon** [NOAA]; **Ralph Cicerone** [National Academy of Sciences—*President*]; and a video address by former **President George H. W. Bush**.

Panel discussions, formal lunches, and poster sessions encouraged interaction between the scientists and policy experts, and allowed the participants to share their views of the roles for science and scientists in shaping climate policy. The deliberations resulted in several positive messages, as described below.

The Montreal Protocol was a success in protecting both the ozone layer and Earth's climate.

Atmospheric concentrations of most chlorofluorocarbons (CFCs) have decreased since the ratification of the Montreal Protocol in 1987, stated **Steven Montzka** [NOAA]. In developed countries, CFCs have been replaced by hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs). Other symposium attendees, including **Mario Nappa** [DuPont] and **Mark Spatz** [Honeywell], stated that new refrigerants, foam-blowing agents, and other products with very low global-warming potential and no ozone-depleting potential will replace the functionality of CFC and HCFC compounds, without any deleterious ozone or climate impacts. **Guus Velders** [National Institute for Public Health and the Environment, Netherlands] and Newman said that model simulations show that the restrictions on the production of ozone-depleting substances, as legislated by the Montreal Protocol and subsequent amendments, prevented severe ozone loss and substantially reduced present-day radiative forcing by greenhouse gases.

The ozone layer is expected to recover later this century, due to reduced levels of ozone-depleting substances. At the South Pole, there are already signs of ozone stabilization and recovery, stated **Birgit Hassler** [NOAA]. **Ted Shepherd** [University of Toronto] and **Darryn Waugh** [Johns Hopkins University] said that the timing, magnitude, and structure of future ozone changes would depend on climate forcing by greenhouse gases. The record-breaking Arctic ozone loss observed in 2011 [**Michelle Santee**, NASA/Jet Propulsion Laboratory], exemplifies the importance of understanding climate variability as the ozone layer recovers. Many speakers stressed the need to continue monitoring emissions and climate by using remote-sensing and ground-based instruments.

There are new, effective strategies for communicating climate and ozone science.

The symposium participants debated the need for climate scientists to serve as climate communicators, and the role of scientists in shaping climate policy. Speakers emphasized that clear communication is especially important when discussing the aspects of climate change that are most uncertain, such as the roles of aerosols, clouds, and feedback processes.

Speakers noted that relating climate change to economic issues such as job creation and home energy costs is an effective way to get policymakers' attention. One participant's suggestion was to frame climate change issues to policymakers as "problems they can solve."

Another approach is to communicate ozone and climate science directly to the public. McPhaden presented new research suggesting that climate communicators should appeal to the public's values and personal experiences. For example, **Drusilla Hufford** [EPA] reported that the U.S. Environmental Protection Agency's (EPA) Sun Wise program educates children and communities about Sun safety. New media, such as blogs and social networks, allow scientific messages to be conveyed immediately and to large audiences, and provide opportunities for feedback between scientists and the public.

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meeting/workshop summaries

2011 GRACE Science Team Meeting Summary

Srinivas Bettadpur, GRACE Science Operations Manager, University of Texas Center for Space Research, srinivas@csr.utexas.edu

The Gravity Recovery And Climate Experiment (GRACE) will celebrate ten years in orbit on March 18, 2012. This joint NASA–DLR[1] mission continues to improve our understanding of the Earth's dynamical system, making precise measurements of the gravity signals associated with exchange of mass between the Earth system's components, and, hence, changes in Earth's gravity field. Over 900 science articles have been published on geodesy, oceanography, hydrology, cryospheric sciences, and other science applications of GRACE data since 2004.

The 2011 GRACE Science Team Meeting was held August 8-10 in Austin, TX—at the peak of a blistering heat wave. The meeting, attended by over 95 scientists and engineers, was held at the University of Texas Center for Space Research (UTCSR), and consisted of 44 presentations and posters in moderated discussions on seven main topics:

- science applications to multidisciplinary problems;
- cryosphere;
- oceans;
- hydrology;
- the solid Earth;
- the GRACE follow-on mission; and
- geodesy and analysis techniques, including complementary applications of GRACE and the European Space Agency's Gravity field and Ocean Circulation Explorer (GOCE).

Each session consisted of invited and contributed presentations, and included a period for questions and answers. In addition, posters relevant to each topic were posted for discussion throughout the meeting. The GRACE science team meeting program, abstracts, along with a document containing the presentations and posters are available on the GRACE website at: *www.csr.utexas.edu/grace/GSTM/2011/*

The meeting opened with a brief *Project Status* session, which addressed the status and plans for the GRACE mission. The contributions of the GRACE mission and plans for extended operations harmonize with the proposed Integrated Climate Plan presented to the U.S. Congress, including plans for the GRACE Follow-On mission (discussed in more detail below) within the NASA Climate Continuity Initiative.

The GRACE mission is being operated in a manner designed to maximize its operational lifetime. The altitude decay due to atmospheric drag and the thruster use for orbit adjustment are not concerns. The battery operations require regular monitoring and management to maintain routine operations, with approximately one month of data outage every six months. The mission successfully passed the NASA 2011 Senior Review process, and was approved for an additional four years of operation. The new U.S. GRACE Science Team selections (under ROSES-2010) were announced. The developments in the formulation of the GRACE Follow-On mission were updated. This session closed with a summary of progress towards the next release of Level-1 and Level-2 data products. Presenters in this session included: **Byron Tapley** [University of Texas Center for Space Research (CSR)—*GRACE Principal Investigator*]; **John LaBrecque** [NASA Headquarters]; **Mona Witkowski** [NASA/Jet Propulsion Laboratory (JPL)]; **Gerhard Kruizinga** [JPL]; **Srinivas Bettadpur** [CSR]; **Frank Flechtner** [GeoForschungsZentrum (GFZ)—German Research Center for Geosciences]; and **Michael Watkins** [JPL].

The *Multidisciplinary* session included diverse studies on the synergy between GRACE and other geodetic and remote sensing datasets. GRACE-derived mass variability was shown to correlate with climate indices globally. Regional studies show that observations of Eurasian water storage variability developed from GRACE data are linked to vegetation productivity, while in the Brazilian Cerrado, it was shown to be consistent with findings on land-use patterns—using data from the Tropical Rainfall Measuring Mission (TRMM) and Moderate Resolution Imaging Spectroradiometer (MODIS). GRACE results were combined with other geodetic data from Global Navigational Satellite System (GNSS) measurements and geophysical models in a joint inversion scheme for all modes of mass variability in the Earth system. The team also learned about mission concepts for the Geodetic Reference Antenna in Space (GRASP)—a fundamental geodetic observatory[2]. Presenters in this session included: **Steve Nerem** [University of Colorado (CU)]; **Jean Dickey** [JPL]; **Frank Wu** [JPL]; **Jinjun Tong** [University of California Irvine (UCI)]; and **Laerte Ferreira** [Laboratoire de Processamento de Imagens e Geoprocessamento (LAPIG)—Brazil].

Presentations in the *GRACE Geodesy* session focused on improvements to GRACE-related data methods, algorithms, and results, and on data analysis and error assessments for the European Space Agency's Gravity-field and Steady State Ocean Circulation Explorer (GOCE). GOCE is now funded through 2012, and technical resources permit operational lifetime until late 2013. All GOCE flight systems show nominal performance, and the gradiometer performance can only be verified

[1] German Aerospace Center

[2] This mission has been proposed in response to the Earth Venture-2 (EV-2)Announcement of Opportunity.

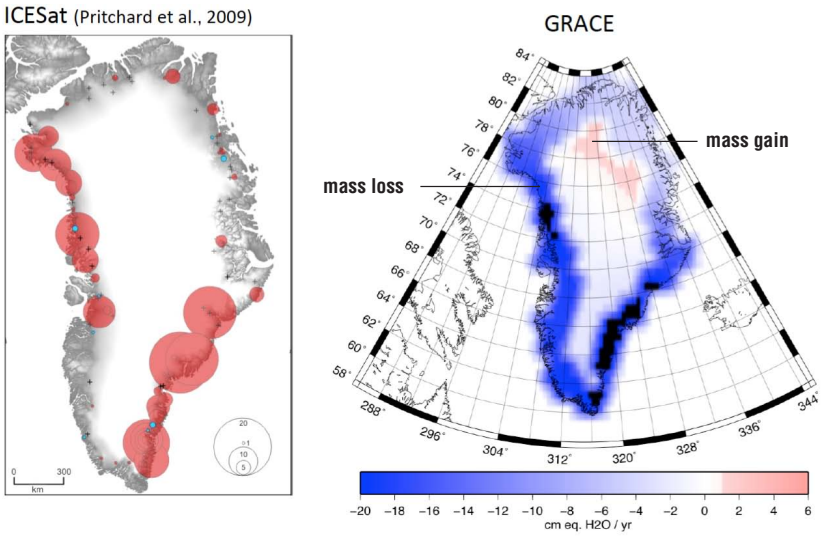

Figure 1. GRACE and ICESat Measure Greenland Ice Loss

Dynamic thinning refers to the process of reduction of glacier thickness due to warm weather ice-melt. These maps show the rate of dynamic thinning and dynamic thickening and amplitude of the mass loss in Greenland derived from GRACE gravity measurements [*image right*] and ICESat altimetry measurements [*image left*] in meters/year. The red circles on the ICESat map are centered on the Greenland glaciers, and the radius of each circle is proportional to the rate at which the ice is thinning in that location. These two maps from different sources show similar results—Greenland is losing ice mass at a rapid rate. The GRACE data show significant mass loss at the coasts with minimal mass gain in the interior. Data such as these help scientists understand the processes that are behind the Greenland ice-sheet melt rate patterns. **Image credit:** Scott Luthcke

to twice the nominal expected precision. Reprocessed GOCE data will be released in late 2011. The team also learned about two new mean Earth gravity field models that show improvements relative to their predecessors. The relationship between data quality and the relative weighting of heterogeneous datasets was shown to be important in determining the quality of these fields. This session also included presentations that assessed GRACE flight regimes and their impact on Level-1 data, and methods of processing data collected in non-nominal flight configurations. Presenters in this session included: **Thomas Gruber** [Technical University, Munich (TUM)]; **John Ries** [CSR]; **Christoph Foerste** [GFZ]; and **Christoph Dahle** [GFZ].

The *Oceanography* session opened with a discussion of the present status of the sea-level budget reconciliation between GRACE, radar altimetry, and ARGO float data records, which highlighted the global applicability of GRACE data. There was lengthy discussion of the results from these three sources, which had been reconciled through 2009, but which have diverged since then. The anomalous decline in the 2010 global mean sea level (GMSL) was linked to El Niño/Southern Oscillation (ENSO)-related variations in the mass and steric components of the GMSL. On a regional scale, GRACE was shown to track transport variability in the Antarctic Circumpolar Current (ACC) to smaller spatial scales and shorter time scales than previously studied. Meanwhile, at the other pole, the interannual variability signals in the Arctic Ocean, derived from GRACE, from ocean bottom pressure recorders, and from oceanographic models, were compared at interannual scales as a means to understand the relationship between circulation variability in the Arctic Ocean—which is a reflection of changes in diverse climate variables. Presenters in this session included: **Eric Leuliette** [National Oceanographic and Atmospheric Administration (NOAA)]; **Don Chambers** [University of Southern Florida (USF)]; **Jennifer Bonin** [USF]; **Jessica Makowski** [USF]; **Carmen Boening** [JPL]; and **Cecilia Peralta-Ferriz** [University of Washington].

The *GRACE Follow-On* (FO) session included discussion of the planned GRACE-FO mission, which may launch as early as 2016, and other potential future mission configurations, such as using two pairs of GRACE-type satellites to provide substantial improvements in resolving mass variations from hydrologic and ocean-bottom pressure changes, and from earthquakes. Technology concepts for the GRACE-FO mission were discussed, including laser interferometers, accelerometers, and advances in satellite-to-satellite tracking. Additional concepts presented included ocean reflectometry using GPS, and prospects for extending data records using historical satellite–laser ranging (SLR) tracking data. Presenters in this session included: **Michael Watkins** [JPL]; **Benjamin Sheard** [Albert Einstein Institute (AEI) Hannover—Germany]; **Michelle Stephens** [Ball Aerospace]; **Bernard Foulon** [Office National d'Etudes et de Recherches Aérospatiales (ONERA)—French Aeronautics and Space Research Center]; **Richard Biancale** [Centre National d'Études Spatiales (CNES)]; **Peter Bender** [CU]; **Minkang Cheng** [CSR]; **Christoph Dahle** [GFZ]; and **Georg Beyerle** [GFZ].

The next session addressed the *Cryosphere*, and included a review of the accuracy of ice sheet mass balance estimates, showing improved agreement on mass loss rate results from different methods—see **Figure 1**. The team heard a report on the application of radio occultation data for atmospheric mass corrections over Antarctica, showing that errors in interannual atmospheric pressure variability were influencing the ability to assess ice mass

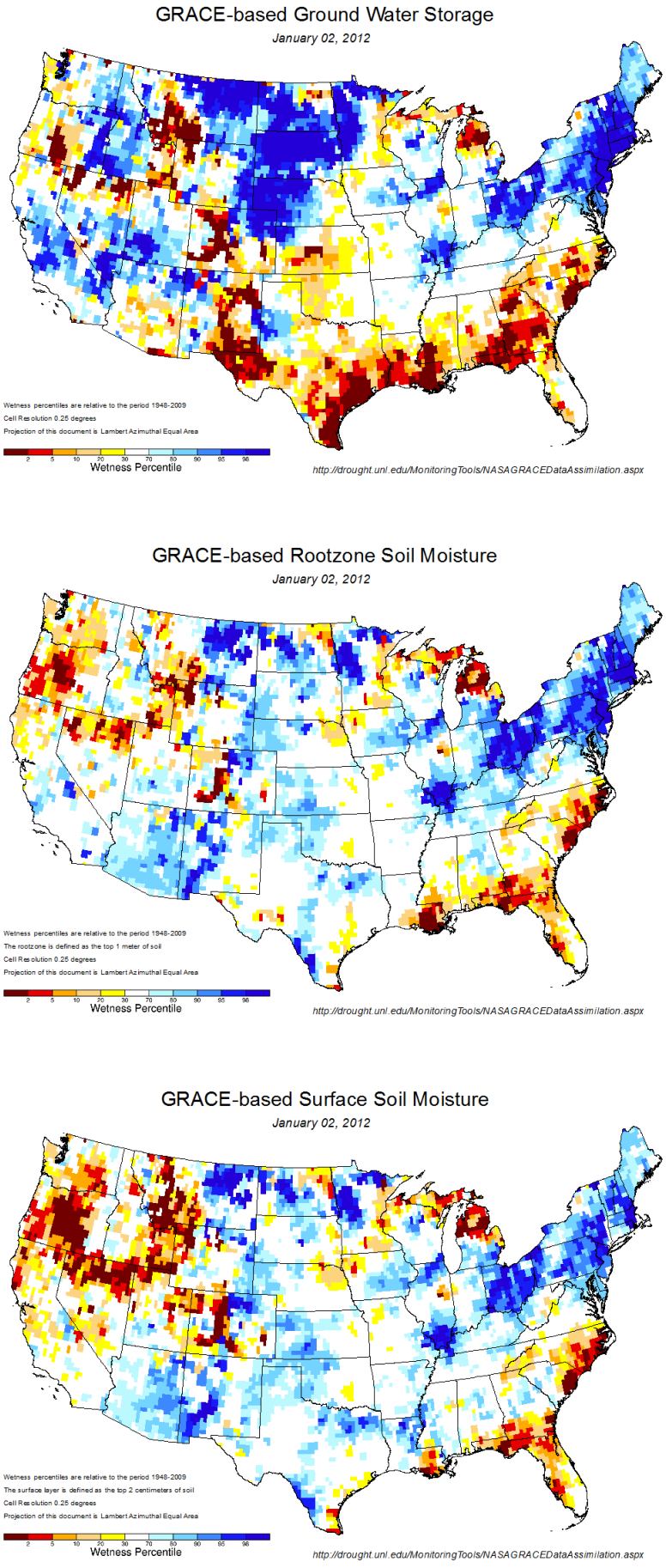

Figure 2. GRACE Data Help Monitor Drought

GRACE can detect small changes in the Earth's gravity field caused by the redistribution of water on and beneath the land surface. Scientists use a sophisticated computer model to combine the information on water storage derived from GRACE with long-term meteorological records of precipitation, temperature, solar radiation and other ground- and space-based measurements. The result is a continuous record of soil moisture and groundwater that stretches back to 1948.

The color-coded maps show how much water is currently stored deep beneath the surface as groundwater [*top*], at the root zone [*center*], and at the surface [*bottom*] as a probability of occurrence as compared to *normal*—i.e., compared to average values from 1948–present. Dryer than normal regions are shown as "warmer" colors while shades of blue denote wetter than normal areas.

NOTE: The maps are meant to depict drought associated with climatic variability, as opposed to depletion of aquifers due to groundwater withdrawals that exceed recharge. There are several aquifers in the U.S. that have been depleted in that way over the past century, such as the southern half of the High Plains aquifer in the central U.S. If the groundwater drought indicator map accounted for human-induced depletion, such regions would be light shades all the time, which would not be useful for evaluating current wetness conditions relative to previous conditions. On time scales of weeks to ten years—not over multi-decadal scales—these maps should be reasonably well correlated with measured water table variations over spatial scales of 16 mi (25 km) or more.
Image credit: Matthew Roddell

loss over that period. The observed trends in SLR-derived measurements of the Earth's oblateness parameter (J2[3]) over the GRACE observation period can be attributed to ice-mass loss in Greenland and Antarctica. Because of the close connection between the signals of present day melt and the Glacial Isostatic Adjustment (GIA), presentations in the *Solid Earth* session (see below) also shed light on the cryosphere. Presenters in this session included **Peter Bender** [CU]; **Scott Luthcke** [NASA's Goddard Space Flight Center (GSFC)]; **Pangaluru Kishore**, [UCI]; **Isabella Velicogna** [UCI]; and **Steve Nerem** [CU].

Most of the presentations in the *Hydrology* session focused on regional assessments of total water storage estimates from GRACE. The relationship between well-water levels and ground-water stores in aquifers depends on the nature and dynamics of the aquifer, which can complicate comparisons of well-water levels with GRACE. While GRACE data compares favorably with well-water measurements over California's Central Valley, after 2007, there is considerable divergence between the two in the High Plains Aquifer. In the Lena River basin in Siberia, GRACE observations showed an increased total water storage signal centered in the area of discontinuous permafrost. The observed water storage excess was hypothesized to arise from an intensification of precipitation due to shifting Arctic Oscillation. In the southern Murray–Darling basin (Australia), a net decline in total water storage between 2003–2010 was linked to an increase in agricultural and domestic water consumption. Changes in the Three Gorges Dam (China) impoundment and the related changes in ground water storage were evident in GRACE data. Presentations in this session also addressed product validation and hydrological signal identification using advanced statistical methods. A survey of the hydrological applications placed GRACE data within the context of NASA's Energy and Water Cycle Study (NEWS) State of the Water Cycle program, as well as its use in developing a *drought monitoring index*—see **Figure 2.** Presenters in this session included **Bridget Scanlon** [Univesity of Texas at Austin (UT)]; **Isabella Velicogna** [UCI]; **Jianli Chen** [CSR]; **Matthew Roddell** [GSFC]; **Mohamed Sultan** [Western Michigan University]; **Xianwei Wang** [UCI]; **Stephanie Castle** [UCI]; and **Ehsaan Forootan** [GFZ].

The *Solid Earth* presentations focused on using time-variable gravitational signals to study the Earth's crustal structure. The GlA signal in Antarctica is of great concern for two reasons: (1) its value has not yet been determined from independent data, and (2) that uncertainty makes it difficult to determine how much of the observed Antarctic ice-melt from GRACE can be attributed to GIA. A survey of the available information, coupled with GIA modeling challenges, demonstrated the difficulty of GIA modeling in the Antarctic. By contrast, the large elastic signals due to water-load variations in Bangladesh and an assessment of the sediment structure underneath that load could be studied in great detail using an extensive surface and ground water monitoring network coupled with GPS-based deformation measurements**.** Studies of the crustal structure following earthquake events in Sendai, Japan—see **Figure 3**—and

[3] Because the Earth is not a perfect sphere, the gravitational acceleration varies with latitude. J2 is the dimensionless quantity that quantifies the major impacts of the Earth's *oblateness*—i.e., how it deviates from what it would be if it were a perfect sphere—on its orbit.

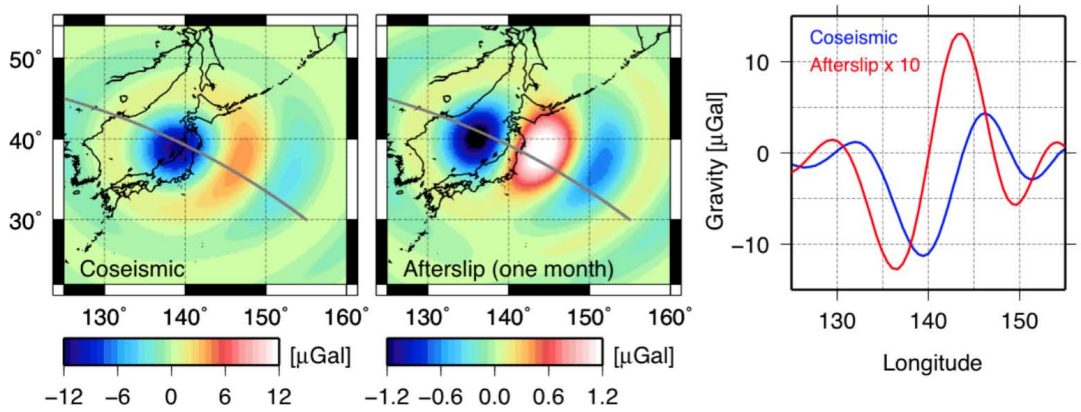

Figure 3. GRACE Detects the Impact of the Japan Earthquake

GRACE is able to detect the slight fluctuations in the gravity field caused by a major earthquake. As it did following the 2004 Sumatra–Andaman and the 2010 Maule, Chile earthquakes, GRACE data have been used to measure *crustal dilation* resulting from the 2011 Sendai, Japan earthquake. GRACE data, when analyzed in combination with other seismic data, offers the possibility of more accurately determining an earthquake's *seismic moment*—a parameter used to measure the size of a quake based on a variety of factors.

The maps shown here depict the gravity change measured by GRACE during the 2011 Sendai quake [*left*] and one month afterward [*center*] in *microgals*. (A *gal* or "Galileo" is a non-Systeme Internationale measure of gravitational acceleration equal to 0.01 m/s^2; 1 μgal = 1 x 10^{-8} m/s^2.) The right panel shows the gravity difference between the *coseismic* (during the earthquake) and *afterslip* (a month after the earthquake) along the gray line depicted in the left and center panels. Note that for ease of interpreation, the afterslip values have been mulitplied by 10. **Image credit:** Shin-Chan Han

in Chile showed how GRACE data help constrain the range of the *seismic moment* parameters. Presenters in this session included: **Eric Ivins** [JPL]; **Michael Steckler** [Lamont-Doherty Earth Observatory (LDEO)]; and **Shin-Chan Han** [GSFC].

The next GRACE Science Team Meeting will be held jointly with the German Special Priority Program Mass Transport in the Earth System, in Potsdam, Germany, from September 17-21, 2012. Further information will be available from the GSTM website: *www.csr.utexas.edu/grace/GSTM*. ■

The Atmospheric Sciences Data Center at NASA's Langley Research Center in Collaboration with the CERES Science Team Announces the Release of a Revised Dataset

Revised Dataset: CER-NEWS_CCCM_Aqua-FM3-MODIS-CAL-CS_RelB1

Funded by NASA's Energy and Water Cycle Study (NEWS), the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO), CloudSat, CERES, MODIS (CCCM) dataset integrates measurements from CALIPSO Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP), CloudSat Cloud Profiling Radar (CPR), Clouds and the Earth's Radiant Energy System (CERES), and the Moderate Resolution Imaging Spectroradiometer (MODIS). A new version of the CCCM product has been generated. The new version can be identified by a change in the configuration code from 905905 to 905906. Researchers who previously downloaded the 905905 version, are asked to download the *revised* 905906 version. There were no changes to the algorithm, but additional MODIS, CALIPSO, and CloudSat data were included in generation of the new products. A checking of staged CALIPSO and CloudSat data files was not explicitly included in the script, generating a specific granule of CCCM. The scripting error and problems with staging the input data caused production of CCCM files without using CALIPSO and CloudSat data, even though they exist in the archive. Affected dates are the first and last days of the month and all dates in June 2009. New data (905906) covering the period July 2006–February 2010 were reprocessed for consistency with version 905905.

The problem mentioned above can be identified using variables included in the file, "total number of good CloudSat profiles (CCCM-8)" or "total number of good CALIPSO profiles (CCCM-11)." When the problem occurs, one or both of these variables are set to zero. If one of the instrument files were missing, it affects, for example, the cloud fraction due to the cloud detection sensitivity difference between CALIOP and CPR. Again, although the effect on global and monthly mean cloud fraction is minimal, we ask researchers who downloaded the 905905 version to obtain the *revised* version 905906, which is available online at *eosweb.larc.nasa.gov/PRODOCS/ceres-news/table_ceres-news.html*. We apologize for any inconvenience.

For more information on this announcement, please visit: *eosweb.larc.nasa.gov/PRODOCS/ceres-news/Quality_Summaries/CER_NEWS_RelB.html*

For information regarding data holdings or for assistance in placing an order, please contact:

NASA's Langley Research Center Atmospheric Science Data Center Users and Data Services

Mail Stop 157D, 2 S. Wright Street
Hampton, VA 23681-2199

Phone: (757) 864-8656

Email: larc@eos.nasa.gov

Land-Cover/Land-Use Change Science Team Session at the 2011 NASA Carbon Cycle and Ecosystems Joint Science Workshop: Observations and Data for Land-Use Change with a Focus on Agriculture

LeeAnn King, University of Maryland, mkinglee@umd.edu
Chris Justice, University of Maryland, justice@hermes.geog.umd.edu
Garik Gutman, NASA Headquarters, garik.gutman@nasa.gov

The 2011 Carbon Cycle and Ecosystems Joint Science Workshop, held from October 3-7, 2011, at the Hilton Alexandria Mark Center in Alexandria, VA, included a focus group meeting to discuss observations and data for land-use change. The one-day focus group meeting, organized by the NASA Land-Cover/Land-Use Change (LCLUC) program that took place on October 6, 2011, with over 60 participants. The meeting included presentations by LCLUC Science Team members and invited scientists, a breakout session organized for discussion of the future program focus and direction, and a poster session.

Garik Gutman [NASA Headquarters (HQ)—*LCLUC Program Manager*] opened the proceedings, presenting an overview of the LCLUC program status, discussing its current focus, and describing initiatives to shape the future of the program. Gutman highlighted the currently funded projects that address regional and global land use. He stated the necessity for *synthesis initiatives* to develop the conceptual underpinnings of LCLUC science based on funded studies during the last several years on land-cover and land-use processes, drivers, and impacts. He described particular developments related to the education and outreach initiatives of the program, including the recent research opportunity for early-career scientists to undertake LCLUC research. Gutman concluded with an overview of programmatic issues, including strengthening the social science component of LCLUC projects, the need to prioritize the science while maintaining some thematic and geographic programmatic balance, and the necessity for the program to foster the generation of global products, including a synthesis of global forest products from the Global Land Survey (GLS) projects and a new generation of global land-use products for use in integrated models.

Chris Justice [University of Maryland, College Park (UMCP)—*LCLUC Program Scientist*] followed with a review of LCLUC observations, data, and recent advances in moving from a land-cover to land-use focus. Justice noted that since its inception, 30% of the program funding has been allocated to observations, detection, monitoring, and data products. Emphasis to date has been primarily on land cover (e.g., forests and carbon), but the evolving science of global change, which addresses the impacts of climate change and adaptation, requires a broader view to include land use. With increasing human pressure on Earth's systems, the linkages between land use and food, water, and energy must be better understood. Emerging policy-relevant, integrated land-use models will need a new suite of global and regional land-use change products. Justice finished with a restatement of the meeting's purpose: *to summarize recent advances and new opportunities in land-use observations and products, and to provide an opportunity for input in terms of the program's future direction.*

LCLUC Projects

The first session of the meeting included presentations of the ongoing LCLUC projects. **Matt Hansen** [UMCP—*LCLUC Principal Investigator*] provided an update on his project titled "Advancing Methods for Global Crop Area Estimation," which is directed at estimating global soybean area using Moderate Resolution Imaging Spectroradiometer (MODIS) data, and developing a turn-key model for sub-regional/national soybean cultivation, using subpixel percent-cover training data with Landsat and RapidEye samples. Global crop-type mapping is a context-critical input to agricultural monitoring.

David Roy [South Dakota State University] presented early results from his project titled "Changing Field Sizes of the Conterminous United States: A Decennial Landsat Assessment," describing the importance of field size as an indicator of agricultural management practices such as intensification, and as a lens on the drivers of rural land-use change. Roy's analysis included applying automated object-based crop identification using multiple vegetation indices, textural features, and crop phenology to his ~100 ft resolution Web Enabled Landsat Data (WELD) product. He showed his preliminary global multi-temporal WELD product, generated in collaboration with the NASA Earth Exchange (NEX) system at NASA's Ames Research Center (ARC).

Xiaoming Xiao [University of Oklahoma (OU)] presented results from his project titled "Quantifying Changes in Agricultural Intensification and Expansion in Monsoon Asia during 2000-2010," which involves modeling cropping intensity on a global scale using MODIS surface-reflectance composites. Temporal pro-

files for individual pixels are used to derive the crop calendar and cropping intensity for a particular area. Xiao summarized the challenges posed by the identification of land cover in monsoon regions, including savannas and summer drought-affected grassland vegetation.

Kirsten de Beurs [OU] concluded the session, discussing "Land Abandonment in Russia: Understanding Recent Trends and Assessing Future Vulnerability and Adaptation to Changing Climate and Population Dynamics." De Beurs discussed the research methods and preliminary findings on land-use/land-cover change for four study regions in rural European Russia. A logistical model has been developed to link MODIS land-surface phenology estimates to Landsat-based, land-cover estimates to describe cropping intensity; individual land-owner production surveys from regional statistical offices are used to complement the model. De Beurs explained that there are several drivers with varying degrees of influence associated with agricultural abandonment and resurrection in the study region, including growth in the agricultural sector and improved productivity.

Chris Justice [University of Maryland, College Park] presented a review of LCLUC observations, data, and recent advances in moving from a land-cover to land-use focus.

Abstracts for LCLUC projects, including those mentioned above, are available on the LCLUC Program webpage at *lcluc.umd.edu/projects.php*.

LCLUC Program

The second session included several invited presentations relevant to the LCLUC program. **David Skole** [Michigan State University] described his research on carbon, agroforestry, and trees on farms for the Carbon Benefits Project: Modeling, Measurements, and Monitoring. The project combines satellite and field observations in a Web-based geographic information system (GIS) framework for carbon monitoring, reporting, and verification (MRV) purposes. The project includes use of fine-resolution (<1-m) imagery for mapping tree occurrence and crown size; field sampling, to determine biomass growth rates; and an online data management system to allow project participants to upload inventory data and perform carbon calculations to show carbon sequestration in each project area.

Steffen Fritz [International Institute for Applied Systems Analysis] stated the importance of improving the accuracy of current cropland datasets, and outlined a new Cropland Mapping Initiative in the framework of the Group on Earth Observations (GEO) Agricultural Monitoring Task to generate the best available current global cropland map. He provided a comparison of existing global land-cover products, highlighting extensive disagreement between data from MODIS, GlobCover, and Global Land Cover (GLC)-2000 with respect to cropland distribution. He described a community-driven data sharing portal, GEO-Wiki, which provides an online arena to foster data sharing, validation, and product cross-comparison. Fritz emphasized the need for a concerted international effort to provide accurate global cropland maps and change on a periodic (five-year) basis, with annual monitoring of areas undergoing rapid change.

George Hurtt [UMCP] gave a presentation on the requirements for land-use information to parameterize and calibrate global land-use models. The requirements included spatially explicit data on land-use distribution (with a spatial resolution of 0.5°), disturbance, and annual land-use transitions including wood harvest and regrowth. Hurtt explained that the next generation of terrestrial models will require improved land-use classification and subannual land-use transition data at one-hectare[1] resolution. He made several recommendations to the LCLUC community, including combining satellite-based and national inventories and separating land-use classes into multiple fractional categories; constraining model reconstructions of land use with data; and

[1] 1 hectare is 2.47 acres

generating new products that address important land-management issues, including distribution and characterization of mechanization, irrigation, and fertilizer application, to prepare for the next generation of fully integrated Earth System Models (e.g., iESMs+).

Chris Neigh [NASA's Goddard Space Flight Center (GSFC)] gave a presentation describing the new National Geospatial Agencies (NGA) commercial archive, and the GSFC fine-resolution data initiative. This initiative provides high-resolution commercial data from U.S. vendors to the NASA project investigators (PIs) in National Imagery Transit Format (NITF). Conversion to other formats and software for conversion are available upon request. Neigh stressed limitations on data sharing, but indicated that imagery or derived products could be shared with local, state, and national government and nongovernmental organizations supporting U.S. government interests, and suggested that reduced-resolution, derived products could be posted on the Website as a community resource.

Luigi Boschetti [UMCP] gave a presentation on progress towards operational, fully automated, fine-resolution mapping using a two-stage, land-cover classification system that includes a fully implemented *a priori* knowledge decision-tree classifier—the Satellite Image Automatic Mapper (SIAM) technology—and traditional techniques, including image clustering, segmentation, and supervised classification algorithms. This would result in a purely spectral, discrete, and finite six-target category land-cover classification scheme. At fine resolutions, accurate land-cover mapping can provide an analyst with information on land-use and land-management practices. Boschetti noted that the SIAM technology is capable of processing data from all calibrated multispectral sensors that have spectral bands overlapping with those of Landsat's Thematic Mapper (TM), and the number of spectral categories detected depends on the bands and the sensor. Systematic evaluation is ongoing, and successful tests have been conducted for single-date (e.g., forest/nonforest) and multitemporal applications (e.g., burned-area mapping and detection of field boundaries). Development of a single-date classifier for Landsat data and object recognition for very-high-resolution data is underway.

Breakout Sessions

The breakout sessions that followed focused on how to expand the land-use aspect of LCLUC, with questions involving the speed, direction, and focus of the program over the next 10 years, and any additional recommendations for program management. Suggestions included using ancillary data to supplement remote sensing studies including, but not limited to, models, census information, surveys, and the fusion of multi-sensor data at various temporal and spatial scales. Others recommended moving away from coarse-spatial-resolution sensors in favor of increasing sensor spatial and temporal capabilities, particularly for global analysis. Everyone acknowledged that description of land use, such as multicropping, seasonal variation, and land-cover change, requires time-series, coarse-resolution data. One suggestion included using the coarse spatial resolution that is presently available, and incorporating finer-resolution data into the analysis as such data become accessible. Some research could already benefit from recently released fine-resolution satellite data available to LCLUC Science Team members from NGA commercial archive found at *cad4nasa.gsfc.nasa.gov*.

Meeting attendees agreed that the land-use aspect of the LCLUC program should be strengthened; several priorities for such improvement were discussed. One predominant suggestion during the breakout session was to improve land-use definitions and methodological development. This may lead to the scientific community gaining a stronger understanding of the relationship between land cover and land use and the tools needed to identify associated phenomena. A clearer definition of what is really needed to conduct various LCLUC analyses could provide the framework for shaping future satellite and sensor missions and the role of the LCLUC community in land-use analysis.

Workshop Outcomes

A number of priorities for land-use science were identified, including climate impacts, vulnerability and adaptation to rapidly changing conditions, and the increasing stresses on agricultural production and water, while working towards sustainable resource use. It is also important to improve our understanding of land management to help identify issues surrounding sustainability. High-resolution data with higher temporal frequency are necessary for Integrated Assessment Models (IAM), and could be used to gain insight into patterns and processes. Continued outreach to the modeling community to obtain a more complete description of necessary inputs to drive IAMs seems warranted. The group recognized that the relevance of land-use science is increasing, and that NASA should consider increasing the LCLUC budget to enable additional or broader annual research solicitations to fulfill the needs of the growing LCLUC and modeling communities in the context of adaptation science. ■

meeting/workshop summaries

Passive Microwave Data Set Management Workshop

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A Passive Microwave Data Set Management Workshop, sponsored by NASA's Earth Science Data and Information System (ESDIS) Project, was held May 17-19, 2011, at the Global Hydrology Resource Center in Huntsville, AL. Passive microwave (PM) datasets are particularly important in the Earth Observing System Data and Information System (EOSDIS), and have been provided since the early 1970s. Over the years, widespread use of PM datasets at several different Earth science data centers has led to different approaches in documentation and levels of service.

To help rectify these differences, the main goal of the PM workshop was for data producers and distributors to review the distribution of PM data holdings across NASA's Distributed Active Archive Centers (DAACs), and to determine the extent of information available for datasets. Workshop participants representing the DAACs and NASA-funded data producers reviewed all primary (Level 1-3) PM datasets from NASA and non-NASA sensors held by the DAACs, as well as high-value datasets from other NASA-funded organizations. For the purposes of this review, datasets were categorized by discipline and instrument.

The primary objectives of the PM workshop were to:

- Identify where PM datasets are duplicated and why each specific instance of a dataset is important to a given user community;
- discuss possible changes to levels of service for some datasets; and
- discuss ways in which data providers can more clearly describe and document PM data, with the intent to harmonize semantics, formats, and documentation to the benefit of data users.

PM Workshop Findings

A full PM workshop report[1] was produced, which includes findings specific to various discipline categories such as cryospheric, land, and atmospheric datasets. Many findings were common across multiple discipline categories, and are applicable to other types of Earth science data.

General findings are listed below.

- Only a few duplicate PM datasets were identified; however, a lack of documented differences between similar datasets can cause user confusion.
- Some PM datasets are available from both the data producer and the archive-of-record. Generally, data producers make data available on a temporary basis to a smaller community, and the archive-of-record provides longer-term stewardship and broader community distribution, and may provide higher level of service.
- In several instances, information about the source data from which datasets were derived and/or the algorithm and version used was absent or not clear.
- There are significant differences in the levels of documentation among different PM datasets. In particular, these differences were found between Earth Observing System (EOS) datasets [e.g., Advanced Microwave Scanning Radiometer for EOS (AMSR-E) and TRMM Microwave Imager (TMI) datasets] and others, such as Special Sensor Microwave/Imager (SSM/I) and Special Sensor Microwave Imager/Sounder (SSMIS) datasets.
- While ESDIS does provide guidelines for dataset documentation, the guidelines are not consistently applied.
- Several datasets are readily available that have been or will be superseded by newer datasets, often located at the same data center or producer site.

PM Workshop Recommendations

The PM Workshop Committee assembled high-level recommendations in collaboration with the other attendees. It is likely that the recommendations apply to datasets from other types of instruments and/or other disciplines, as well. The full set of recommendations in the workshop report is organized by data center in order to facilitate review by the relevant DAAC User Working Groups. The high-level recommendations are as follows:

- Provide clear documentation and cross-referencing between related PM datasets. Digital Object Identifiers can help clarify whether datasets are identical.

[1] The *Report from the Passive Microwave Data Set Management Workshop* was published in December 2011 as NASA Conference Publication NASA/CP–2011-215885, and is available online at *earthdata.nasa.gov/library/2011-passive-microwave-data-set-management-workshop-report*.

- For all NASA datasets, document the lineage clearly. In particular, versions of both the dataset and the algorithm(s) need to be verified, documented, and clearly visible. Also, the source and version of the dataset(s) used as input to the product need to be identified, noting when the source data were published and especially when the version of the source data changed.

- Compile a checklist of required documentation for datasets, based on existing requirements and guidelines. Review and update documentation for PM datasets, coordinating across DAACs holding similar data.

- Develop common NASA Data Center practices for retiring superseded datasets.

PM Workshop Results

All participants—representing DAACs, data producers, and ESDIS—found this exercise to be valuable, and recommend that other instrument/discipline groups host similar workshops. Over the coming year, DAACs will present workshop findings and recommendations to their User Working Groups, and develop plans to address recommendations specific to their data holdings.

In addition to detailed recommendations, the full workshop report contains a complete list of all datasets considered (along with related tools and services), and a survey of other NASA and non-NASA PM datasets. ■

Summary of the International Year of Chemistry Symposium on Stratospheric Ozone and Climate Change

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U.S. political consensus on environmental issues is achievable.

In an era when Republican support for environmental issues is rare, the session on the Clean Air Act Amendments (CAAA) was an uplifting experience for many of the symposium participants. A presentation given by former EPA administrator, **William Reilly**, summarized the following reasons for unified, congressional support for the CAAA: clear environmental impacts of poor air quality (e.g., increased incidence of asthma); a large benefit-to-cost ratio (e.g., healthcare costs); and technologies available to support the new legislation (e.g., scrubbers for coal power plants). Similar political consensus was achieved with the Montreal Protocol, in which the ozone science was well understood and CFC alternatives were readily available.

While U.S. climate change legislation faces a divided congress, policy specialists offered several alternatives to national climate legislation, including enlargement of the existing regional cap-and-trade emissions programs and corporate involvement in international climate assessment, mitigation, and adaptation efforts. Symposium participants were reminded that scientists and policymakers view uncertainty differently. While 80% confidence is not good enough for most scientific applications, 51% confidence is motivation enough for a politician to act. That is, there is no need to have complete knowledge of the future global climate to initiate societal action.

Young scientists make a valuable contribution to the ozone-climate-policy community.

Approximately 50 young scientists presented their work in poster sessions, as well as oral presentations in a special Young Scientists' Forum held at the end of the symposium. Susan Solomon's inspiring talk will likely motivate many young scientists to pursue research careers and develop new skills, by participating in a field mission or serving on a committee of a professional society for example.

The intimate nature of the symposium facilitated interactions between young scientists and the more established members of the scientific community, many of whom made the crucial first steps in understanding the Antarctic ozone hole and stratospheric chemistry. Furthermore, the symposium introduced young scientists to several environmental career options, thanks to impressive presentations by economists, attorneys, negotiators, and administrators. ■

in the news

NASA Finds Japan Tsunami Waves Merged, Doubling Power

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Steve Cole, NASA Headquarters, stephen.e.cole@nasa.gov

NASA and Ohio State University researchers have discovered the major tsunami generated by the March 2011 Tohoku-Oki quake centered off northeastern Japan was a long-hypothesized *merging tsunami*. The tsunami doubled in intensity over rugged ocean ridges, amplifying its destructive power at landfall.

Data from NASA and European radar satellites captured at least two wave fronts that day. The fronts merged to form a single, double-height wave far out at sea. This wave was capable of traveling long distances without losing power. Ocean ridges and undersea mountain chains pushed the waves together along specific directions from the tsunami's origin.

The discovery helps explain how tsunamis can cross ocean basins to cause massive destruction at some locations while leaving others unscathed. The data raise hope that scientists may be able to improve tsunami forecasts.

Research scientist **Yuhe Tony Song** of NASA/Jet Propulsion Laboratory, and professor **C.K. Shum** of The Ohio State University, Columbus, discussed the data and simulations that enabled them to piece the story together at a media briefing on December 5, at the American Geophysical Union meeting in San Francisco.

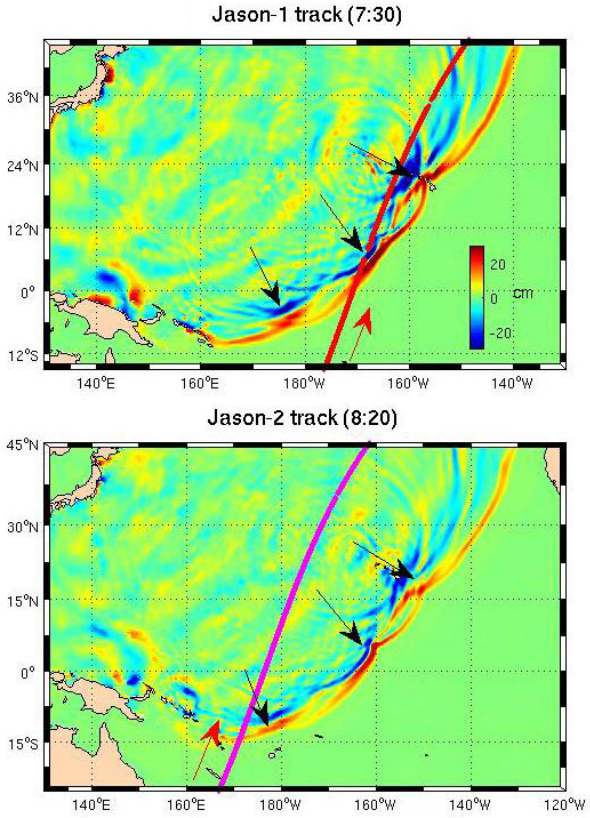
"It was a one in 10 million chance that we were able to observe this double wave with satellites," Song said. He is the principal investigator in the NASA-funded study.

"Researchers have suspected for decades that such 'merging tsunamis' might have been responsible for the 1960 Chilean tsunami that killed about 200 people in Japan and Hawaii, but nobody had definitively observed a merging tsunami until now," Song said. "It was like looking for a ghost. A NASA/Centre National d'Etudes Spaciales (CNES) satellite altimeter happened to be in the right place at the right time to capture the double wave and verify its existence."

The NASA/CNES Jason-1 satellite passed over the tsunami on March 11, as did two other satellites: the NASA-European Jason-2 and the European Space Agency's EnviSAT. All three satellites carry radar altimeters that measure sea level changes to an accuracy of a few centimeters. Each satellite crossed the tsunami at a different location, measuring the wave fronts as they occurred.

"We can use what we learned to make better forecasts of tsunami danger in specific coastal regions anywhere in the world, depending on the location and the mechanism of an undersea quake," Shum said.

The researchers think ridges and undersea mountain chains on the ocean floor deflected parts of the initial tsunami wave away from each other to form independent jets shooting off in different directions, each with its own wave front.



NASA satellite altimeter data on the major and destructive tsunami generated by the March 11, 2011, magnitude 9.0 Tohoku-Oki earthquake off Japan's northeastern coast were used to confirm the existence of long-hypothesized *merging tsunamis* capable of traveling long distances without losing power. The NASA/CNES Jason-1 satellite [*top*] passed over the tsunami 7 hrs and 30 min after the earthquake and was able to 'see' a large wave resulting from merging tsunami jets. The NASA/European Jason-2 satellite [*bottom*] passed over the region 8 hrs and 20 min after the earthquake and observed the normal tsunami wave. **Image credit:** NASA/JPL

The sea-floor topography nudges tsunami waves in various directions and can make its destruction appear random. For that reason, hazard maps that try to predict where tsunamis will strike rely on sub-sea topography. Previously, these maps considered only topography near a particular shoreline. This study suggests scientists may be able to create maps that take into account all undersea topography, even sub-sea ridges and mountains far from shore.

Song and his team were able to verify the satellite data through model simulations based on independent data,

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NASA's GRACE Helps Monitor U.S. Drought

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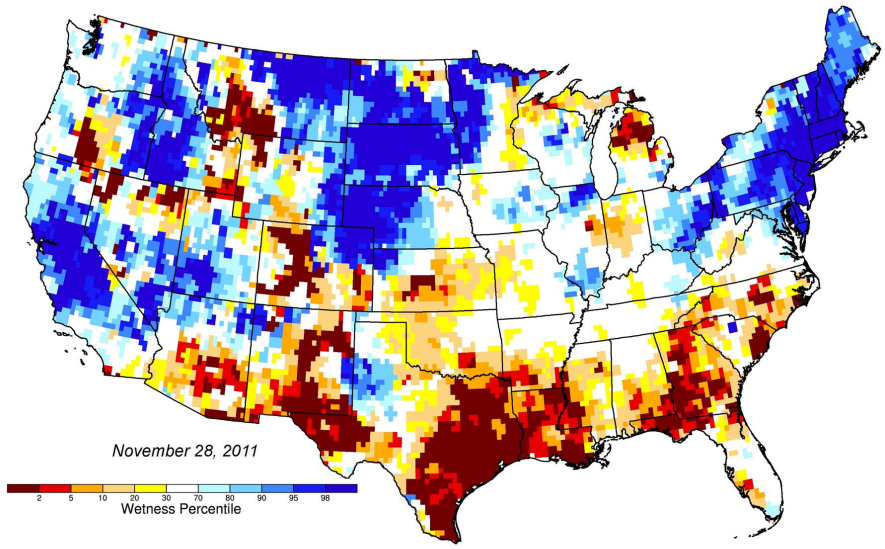
The record-breaking drought in Texas that has fueled wildfires, decimated crops, and forced cattle sales has also reduced groundwater levels in much of the state to the lowest levels in more than 60 years, according to new national maps produced by NASA using data from the NASA/German Aerospace Center Gravity Recovery And Climate Experiment (GRACE) mission. The maps are distributed by the National Drought Mitigation Center at the University of Nebraska-Lincoln.

The latest groundwater map, released on November 29, shows large areas of light shading over eastern Texas, indicating severely depressed groundwater levels. The maps, publicly available on the Drought Center's website at *go.unl.edu/mqk*, are generated weekly by NASA's Goddard Space Flight Center using GRACE gravity field data calculated at NASA/Jet Propulsion Laboratory (JPL), and the University of Texas Center for Space Research, Austin.



New groundwater and soil moisture drought indicator maps produced by NASA are available on the National Drought Mitigation Center's website. They currently show unusually low groundwater storage levels in Texas. The maps use an 11-division scale, with blues showing wetter-than-normal conditions and a yellow-to-red spectrum showing drier-than-normal conditions. **Image credit:** NASA/National Drought Mitigation Center

"Texas groundwater will take months or longer to recharge," said **Matt Rodell**, a hydrologist based at GSFC. "Even if we have a major rainfall event, most of the water runs off. It takes a longer period of sustained greater-than-average precipitation to recharge aquifers significantly."

To make the maps, scientists use a sophisticated computer model that combines measurements of water storage from GRACE with a long-term meteorological dataset to generate a continuous record of soil moisture and groundwater that stretches back to 1948. GRACE data go back to 2002. The meteorological data include precipitation, temperature, solar radiation, and other ground- and space-based measurements.

The color-coded maps show how much water is stored now as a probability of occurrence in the 63-year record. The light shades over eastern Texas, for example, shows that the level of dryness over the last week occurred less than two percent of the time between 1948 and the present.

The groundwater maps aren't the only maps based on GRACE data that the Drought Center publishes each week. The Drought Center also distributes soil moisture maps that show moisture changes in the root zone down to about 3 ft (~1 m) below the surface, as well as surface soil moisture maps that show changes within the top inch (2.54 cm) of the land[1].

"All of these maps offer policymakers new [insight] into subsurface water fluctuations at regional to national scales that has not been available in the past," said the Drought Center's **Brian Wardlow**. The maps provide finer resolution and are more consistently available than other similar sources of information. Having the maps for the three different levels (surface layer, root zone, and groundwater) should help decision makers distinguish between short-term and long-term droughts.

"These maps would be impossible to generate using only ground-based observations," said Rodell. "There are groundwater wells all around the United States, and the U.S. Geological Survey does keep records from some of those wells, but it's not spatially continuous and there are some big gaps."

The maps also offer farmers, ranchers, water resource managers and even individual homeowners a new tool

[1] To learn more about how these maps are constructed please see **Figure 2** on pp 24 of this issue.

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in the news

Satellite Data Shows that Kirtland's Warblers Prefer Forests After Fire

Aries Keck, NASA's Goddard Space Flight Center, aries.c.keck@nasa.gov

Kirtland's warblers are an endangered species of lightweight little birds with bright yellow-bellies that summer in North America and winter in the Bahamas. But be it their winter or their summer home, a new study using data from NASA-built Landsat satellites shows that these warblers like to live in young forests and often forests that have been on fire.

The U.S. Fish and Wildlife Service listed Kirtland's warblers as endangered in 1967 after a startling decline of over 50% in less than ten years. The little birds prefer to nest on the ground amidst large areas of relatively young jack pine trees that need fire to reproduce. When fires were dramatically suppressed in the 1960s across northern Michigan, Wisconsin and southern Ontario, Canada, the warbler's habitat became scarce.

After an intensive recovery program that focused both on combating invasive cowbirds and managing controlled forest burns—thus creating warbler-friendly jack pine habitat—the Kirtland's warbler made an impressive comeback. By 1995 their numbers had tripled.

The Kirtland's Warbler spends its summers in North America and its winters in the Bahamas. **Image Credit:** Dave Currie

But those extensive efforts only occurred at the Kirtland's summer home, so a team of researchers reviewed the conditions of many a warbler's winter home—the Bahamian island of Eleuthera.

Since tropical islands typically have lots of cloud cover, this was no easy endeavor. Landsat Science Team Member, **Eileen Helmer**, explained that the team had to painstakingly "stitch" together many Landsat images with scenes where the clouds were in different places to create one image of clear forest (Helmer works for the U.S. Department of Agriculture Forest Service International Institute of Tropical Forestry).

The researchers did this not just once, but ten times, obtaining a record that spans a 30-year time period. According to Helmer, this allows them to tell how long it had been since the forest was last disturbed by fire, crops, or grazing.

What the scientists discovered was that, like in their summer homes, Kirtland's warblers are found in young forests. On Eleuthera, these forests only occur after a disturbance of some sort—like fire, clearing for agriculture, or grazing. And grazing turns out to be a disturbance the warbler can live with just fine. Old forest whose underbrush has been munched on by goats provides the most suitable habitat for warblers, said Helmer.

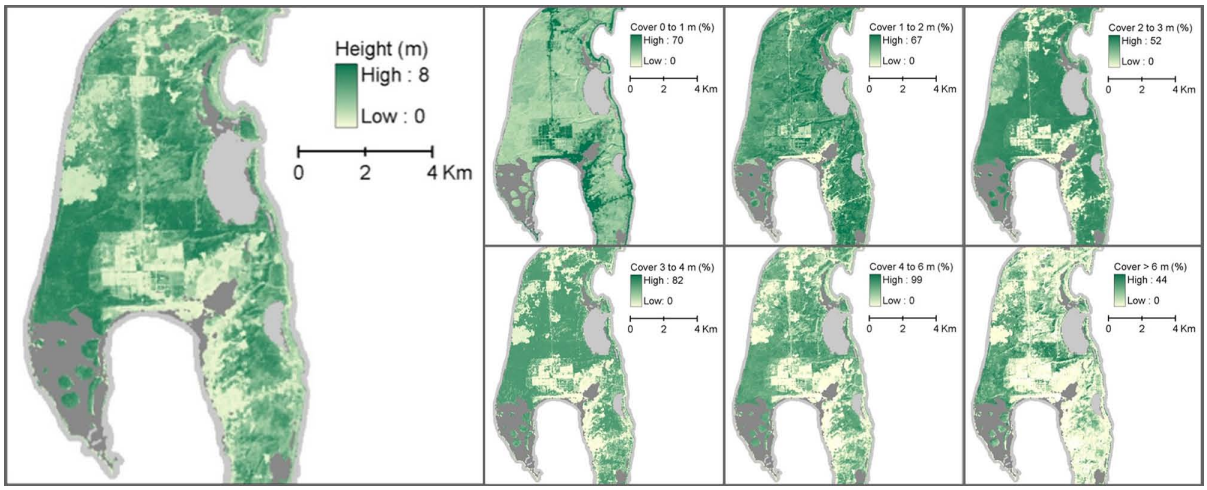
The results, published in this month's issue of *Biotropica*, suggest that goat grazing stunts the forest regrowth, so that the tree height doesn't exceed the height beyond which important fruit-bearing forage tree species are shaded out by taller woody species. Helmer said that understanding how and where the warbler's winter habitat occurs will help conservation efforts in the Bahamas.

Helmer said that a unique feature of warbler's winter habitat is that the age of this forest correlates very strongly with its height. By tracking the age of the forest after a disturbance, she and her team determined forest height at different times. Helmer said they used image time-series data from Landsat and the Advanced Land Imager (ALI) sensor aboard the Earth Observing-1 (EO-1) satellite to essentially "stack" many images over time. This project is the first time that forest height profiles have been successfully mapped by satellite imagery at a medium resolution that shows a broad area but still resolves human impacts on the land. As in the warbler case, understanding how a forest is put together in three dimensions is important for ecological studies. Helmer adds that this tool may be applied elsewhere around the world due to Landsat's global coverage and policy of free access to data. (Helmer discussed mapping forest height at the 2011 American Geophysical Union conference in San Francisco, CA).

The Landsat Program is a series of Earth-observing satellite missions managed jointly by NASA and the U.S. Geological Survey. Landsat satellites have been consistently gathering data about our planet since 1972.

They continue to improve and expand this unparalleled record of Earth's changing landscapes for the benefit of all.

For more information on Landsat, visit: *www.nasa.gov/landsat* and *landsat.usgs.gov* ■



A profile of Kirtland's warbler's winter home. Height of trees, derived from Landsat data, over a portion of the Bahamian island of Eleuthera. In the left-most image, shading indicates tree height. In the right-hand image series, green indicates the density of trees at different heights. Dark gray indicates unforested areas or water. **Image credit:** Eileen Helmer

NASA Finds Japan Tsunami Waves Merged, Doubling Power

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including GPS data from Japan and buoy data from the National Oceanic and Atmospheric Administration's Deep-ocean Assessment and Reporting of Tsunamis program.

"Tools based on this research could help officials forecast the potential for tsunami jets to merge," Song said. "This, in turn, could lead to more accurate coastal tsunami hazard maps to protect communities and critical infrastructure."

For more information on Jason-1 and Jason-2, visit: *sealevel.jpl.nasa.gov*. ■

NASA's GRACE Helps Monitor U.S. Drought

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to monitor the health of critical groundwater resources. "People rely on groundwater for irrigation, for domestic water supply, and for industrial uses, but there's little information available on regional to national scales on groundwater storage variability and how that has responded to a drought," Rodell said. "Over a long-term dry period, there will be an effect on groundwater storage and groundwater levels. It's going to drop quite a bit, people's wells could dry out, and it takes time to recover."

The maps are the result of a NASA-funded project at the Drought Center and GSFC to make it easier for the weekly U.S. Drought Monitor to incorporate data from the GRACE satellites. The groundwater and soil moisture maps are updated each Tuesday.

To learn more about the GRACE mission, visit: *www.csr.utexas.edu/grace/* and *grace.jpl.nasa.gov*. ■

NASA Earth Science in the News

Patrick Lynch, NASA's Earth Science News Team, patrick.lynch@nasa.gov

Monster Iceberg Forming in Antarctica, November 4; *BBC News*. Scientists and engineers aboard NASA's DC-8 during Operation IceBridge flights over Antarctica spotted a large rift spreading across the ice shelf of Pine Island Glacier, and flew directly over the rift at 3000 ft (~914 m) to make lidar and radar measurements. "It is very exciting to see this while it is happening," said **Michael Studinger** [NASA's Goddard Space Flight Center (GSFC)—*IceBridge Project Scientist*].

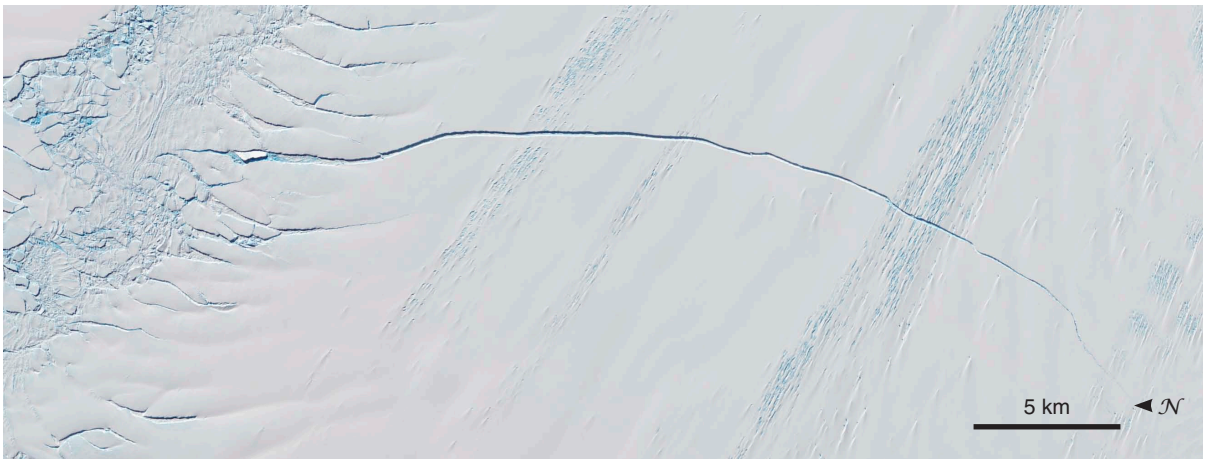
When Weather Makes Climate, November 4; *Discovery News*. Short-term weather anomalies over the North Atlantic can force changes in ocean circulation that alter the region's climate for decades. Atmospheric blocking patterns divert the usual airflow to the north and south, which results in a dramatic reversal of rotating air masses at either side of the jet stream. "You add these things up over years and decades and they can really make a difference," said **Sirpa Hakkinen** [GSFC].

Antarctic Adventure: Drilling Through Untouched Ice, November 9; *Our Amazing Planet*. A team of 13 scientists will spend six weeks living out on the Pine Island Glacier ice shelf—a vast plain of floating ice nearly 1640 ft (500 m) thick—in an attempt to see what forces are at work beneath the shelf that are causing the glacier that feeds it to slide ever more rapidly into the sea. "This is where Antarctica is hemorrhaging ice and raising sea levels, and this is where we have to go," said **Robert Bindschadler** [GSFC], leading the largely NSF-funded campaign.

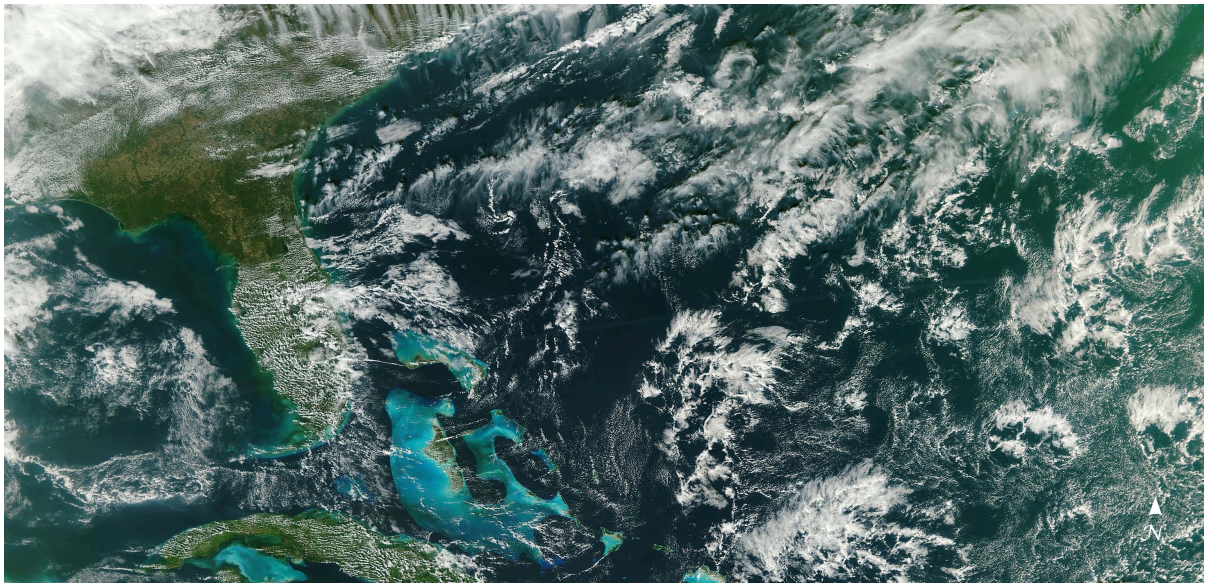
Ocean Temperatures Can Predict Severity of Amazon Fires, November 11, *wired.com.* A NASA-funded research team led by scientists at the University of California, Irvine, has created a model that can successful predict the severity and distribution of fires in the Amazon rainforest months in advance by analyzing satellite data. Researchers analyzed nine years of fire activity data collected by Moderate Resolution Imaging Spectroradiometer (MODIS) instruments. They compared those data to the National Oceanic and Atmospheric Administration's records of sea surface temperatures and changes in precipitation patterns measured by the Tropical Rainfall Measuring Mission (TRMM) satellite.

Student Cloud Observations Help Validate NASA Satellites, November 19, *spacedaily.com.* The Students' Cloud Observations On-Line (S'COOL) program received its 100,000th cloud observation, prompting a look into what NASA has been doing with all of these cloud observations. "We often hear about how NASA satellite data help students, but there are also quite a few things the students do for us," said **Lin Chambers** [NASA's Langley Research Center], the lead for the S'COOL program. S'COOL ground observations help scientists confirm the presence of clouds in areas and under conditions that are challenging for satellite instruments.

The Beautiful First Image of Earth from NASA's NPP Satellite, November 23; *Popular Photography.* A team at the Space Science and Engineering Center, University of Wisconsin, Madison, compiled data from RGB



In mid-October 2011, NASA scientists working in Antarctica discovered a massive crack across the Pine Island Glacier, a major ice stream that drains the West Antarctic Ice Sheet. Extending for 19 miles (30 kilometers), the crack was 260 feet (80 meters) wide and 195 feet (60 meters) deep. Eventually, the crack will extend all the way across the glacier, and calve a giant iceberg that will cover about 350 square miles (900 square kilometers). **Image credit:** NASA's Earth Observatory



The Visible Infrared Imaging Radiometer Suite (VIIRS) onboard the NPOESS Preparatory Project (NPP) satellite acquired its first measurements on November 21, 2011. The image shows a broad swath of eastern North America from the Great Lakes to Cuba. **Image credit:** NASA/NPP Team at the Space Science and Engineering Center, University of Wisconsin, Madison.

channels of the Visible Infrared Imaging Radiometer Suite (VIIRS) to create the instrument's "first-light" image. The instrument flies onboard the recently launched NPOESS Preparatory Project (NPP) satellite. The lens on this machine has a 19.1-cm aperture and 114-m focal length, and is capable of resolving detail down to 0.65 km, which accounts for the stunning detail.

***NASA Satellites Find Texas Aquifers at Record Low,** November 30; *Associated Press.* Data from NASA's Gravity Recovery and Climate Experiment (GRACE) satellites, combined with information from the University of Nebraska's National Drought Mitigation Center, confirmed that prolonged drought has significantly depleted aquifers under Texas. "People rely on groundwater, especially in times like this when it's dry, because groundwater provides a reserve of water when it doesn't rain," said hydrologist **Matt Rodell** [GSFC]. "But we're in a deficit now. We're drawing down our bank account."

NASA Confirms Sharp Decline in Pollution from U.S. Coal Power Plants, December 1; *Medical Daily.* An instrument on NASA's Aura satellite confirmed a sharp decline in pollution from coal power plants in the eastern U.S. Using data from the Ozone Monitoring Instrument (OMI), a group of scientists from Environment Canada, the U.S. Environmental Protection Agency, and NASA found a 40% decline in sulfur dioxide levels since 2005, consistent with the 46% reduction observed by instruments inside power plant smokestacks.

Earth Likely to Become Increasingly Hostile to Agriculture, December 6, *scientificamerican.com.* With the frequency of droughts expected to triple in the next 100 years, researchers fear the resulting variability and stress to agriculture and civilization could prove destabilizing for many regions. "We should take it seriously," said **Dorothy Peteet** [NASA Goddard Institute for Space Studies].

Warming to Lead to Global Sea-Level Rise, December 7; *USA Today*. Ice-age geologic records suggest Earth's climate will warm faster than expected, pushing the global sea level perhaps more than 3 ft (1 m) higher within this century. Each degree of warming raises the risk of sea-level rise from melting ice sheets on Greenland and Antarctica. "We cannot double carbon dioxide," said climate scientist **James Hansen** [GSFC]. "We will be sending the climate back to a state very different from what humanity is used to."

***Scientists Discover That The Japanese Tidal Wave Was a 'Merged Tsunami'–The First Ever Observed,** December 6, *Time*. Scientists from NASA and Ohio State University now say that the waves of the March 2011 tsunami were actually a "merged tsunami," and that the phenomenon doubled the power of the disaster. Satellites from NASA and European agencies show at least two wave fronts created by the quake. "Nobody had definitively observed a merging tsunami until now," said **Tony Song** [NASA/Jet Propulsion Laboratory].

* See news story in this issue for more details.

*Interested in getting your research out to the general public, educators, and the scientific community? Please contact **Patrick Lynch** on NASA's Earth Science News Team at **patrick.lynch@nasa.gov** and let him know of your upcoming journal articles, new satellite images, or conference presentations that you think the average person would be interested in learning about.* ■

NASA Science Mission Directorate – Science Education and Public Outreach Update

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Morgan Woroner, Institute of Global Environment and Society, morgan_woroner@strategies.org

NASA Postdoctoral Fellowships
Application deadlines—March 1, 2012; July 1, 2012; November 1, 2012

The NASA Postdoctoral Program offers scientists and engineers unique opportunities to engage in NASA research in space science, Earth science, aeronautics, space operations, exploration systems, lunar science, and astrobiology.

Awards:
- Approximately 90 fellowships awarded annually;
- appointments renewable for up to three years;
- annual stipends start at $50,000, with supplements for specific degree fields and high cost-of-living areas;
- annual travel budget of $8,000;
- relocation allowance; and
- financial supplement for health insurance purchased through the program.

Eligibility:
- Must be U.S. citizens, Lawful Permanent Residents, or foreign nationals eligible for J-1 status as a research scholar; and
- recent and senior-level Ph.D. recipients.

Fellowship positions are offered at several NASA centers. To obtain more information and to apply for this exciting opportunity, please visit: *nasa.orau.org/postdoc*.

AMS DataStreme Earth's Climate Systems Professional Development Course for K-12 Educators
Apply January–April 2012

The American Meteorological Society (AMS), with support from NASA and in partnership with the State University of New York's College at Brockport, is developing a national cadre of K-12 teachers highly trained in climate science, and familiar with climate modeling. Teachers are trained through DataStreme Earth's Climate System (ECS), a semester-long, graduate-level, pre-college teacher professional development course. DataStreme ECS uses NASA Earth Observing System (EOS) data and visualizations, and introduced the Educational Global Climate Modeling (EdGCM) developed by the NASA's Goddard Institute for Space Studies, to explore the fundamentals of climate change. Teachers completing the course construct and execute a Plan of Action to advance public climate science literacy and affect curriculum change within their local schools and districts.

DataStreme ECS is administered through 21 course Local Implementation Teams (LITs) across the country. The course is free to all participants, and the teachers are awarded three graduate credits upon successful completion of the course. For more information, including a listing of course offerings by state, and an application form, visit: *ametsoc.org/amsedu/ECS/index.html*.

AMS Climate Diversity Project Course Professional Development for Undergraduate Faculty
Apply by March 15; Workshops held May 20–25, 2012 in Washington, DC and January 5–8, 2013 in Austin, TX

The American Meteorological Society (AMS) invites minority-serving institutions (MSIs) to offer an introductory-level climate science course, *AMS Climate Studies*. This course explores the scientific principals governing Earth's climate system, climate variability and change, and also introduces societal and sustainability challenges. The lesson format allows students to explore real-world climate data, thereby becoming more-informed citizens. Professional development training is offered at no cost to designated climate course instructors through a NSF Opportunities for Enhancing Diversity in the Geosciences grant. Workshops will cover climate science training, course implementation strategies, and issues related to enhancing diversity in the geosciences. Workshops will be held in conjunction with the AMS Annual Meetings. For more information and to apply, please visit: *www.ametsoc.org/amsedu/online/climateinfo/diversity.html*.

NASA Earth and Space Science Fellowship Program for Graduate Students
Deadline for new applicants—February 1, 2012; for renewal applicants—March 15, 2012.

NASA announces a call for graduate fellowship proposals to the NASA Earth and Space Science Fellowship (NESSF) program for the 2012–2013 academic year. This call for fellowship proposals solicits applications from accredited U.S. universities on behalf of individuals pursuing master of science or doctoral degrees in Earth and space science, or related disciplines. The NESSF call for proposals and submission instructions are located at the NESSF 12 solicitation index page at *nspires.nasaprs.com*. ■

EOS Science Calendar

April 11–13, 2012
Aquarius/SAC-D Science Team Meeting, Bueno Aires, Argentina. URL: *TBA*

May 1–3, 2012
CERES Science Team Meeting, Newport News, VA. URL: *ceres.larc.nasa.gov*

September 17–21, 2012
GRACE Science Team Meeting, Potsdam, Germany. URL: *www.csr.utexas.edu/grace/GSTM*

October 1–3, 2012
Aura Science Team Meeting, Pasadena, CA (no URL has been provided at the time of publication)

October 16–18, 2012
HyspIRI Workshop, Pasadena CA. URL: *hyspiri.jpl.nasa.gov/events/2012-hyspiri-workshop*

Global Change Calendar

February 16–20, 2012
AAAS Annual Meeting, Vancouver, Canada. URL: *www.aaas.org/meetings/2012*

February 20–24, 2012
2012 Ocean Sciences Meeting, Salt Lake City, UT. URL: *www.sgmeet.com/osm2012*

March 5–9, 2012
12th Specialist Meeting on Microwave Radiometry and Remote Sensing of the Environment (Microrad2012) Frascati, Italy. URL: *www.microrad2012.org/*

March 19–23, 2012
ASPRS 2012 Annual Conference, Imaging and Geospatial Technologies—Into the Future, Sacramento, CA. URL: *www.asprs.org/Conferences/Sacramento-2012/*

March 26–29, 2012
Planet Under Pressure 2012, London, England. URL: *www.planetunderpressure2012.net/location.asp*

April 17–19, 2012
HDF & HDF-EOS Workshop XV, Riverdale, MD URL: *hdfeos.org/workshops*

May 7–11, 2012
The 44th International Liège Colloquium on Ocean Dynamics, Liège, Belgium. URL: *modb.oce.ulg.ac.be/colloquium*

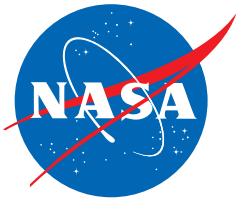
May 7–11, 2012
4th WCRP International Conference on Reanalyses, Silver Spring, MD. URL: *icr4.org/index.html*

August 6–10, 2012
2012 International Radiation Symposium: Current Problems in Atmospheric Radiation, Berlin, Germany. URL: *www.irs2012.org*

September 11–14, 2012
ForestSAT 2012, Oregon State University, Corvallis, OR. URL: *www.forestsat2012.com*

November 5–9, 2012
PORSEC-2012: Water and Carbon Cycles, Kochi, India URL: *www.porsec2012.incois.gov.in*

December 3–7, 2012
American Geophysical Union Fall Meeting, San Francisco, CA. URL: *www.agu.org/meetings*



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