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Editor's Corner

Steve Platnick

EOS Senior Project Scientist

The Aqua satellite mission celebrated the tenth anniversary of its launch on May 4, with a series of activities that took place at NASA's Goddard Space Flight Center (GSFC). At noon, **Joel Susskind**, **Chuck McClain**, and **Thorsten Markus** [all from GSFC] participated in the Sciences and Exploration Directorate's Director's Seminar and discussed recent advances and research results acquired from using Aqua data.

Later that afternoon, **Claire Parkinson** [GSFC—*Aqua Project Scientist*] gave an hour-long scientific colloquium that provided an overview of the mission and described what it has achieved, both scientifically and in the way of practical applications. Aqua data have provided, for example, the first global maps and global animations of mid-tropospheric carbon dioxide concentrations and the first global view of ocean chlorophyll fluorescence—the former is relevant to greenhouse-gas warming of the atmosphere, and the latter is relevant to phytoplankton physiology.

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When the Aqua satellite lifted off from Vandenberg Air Force Base on May 4, 2002, it wasn't clear how long the 2900 kg (-6400 lbs) spacecraft would last. There's much that can go wrong in the unforgiving environment of space.

When it was built, the design life was presented as 5–6 years. But Aqua has pleasantly surprised the experts and exceeded expectations!

Ten years later, the Aqua spacecraft is alive and well and four of its six instruments are fully functional. Aqua has collected a remarkable 29 million gigabytes (GB) of data throughout the last decade. For perspective, 1 GB holds the contents of about 10 yds (-9.1 m) of books on a shelf; 100 GB would hold a floor of books in an academic library.

The myriad data that flow from the Aqua satellite are used in a variety of ways that extend the mission's value well beyond the scientific community into the broader world we live in. Data are used to help monitor and forecast a broad range of natural hazards that affect all of us, ranging from severe storms, to dust storms and haze, to droughts, and crop health. **Credit:** Bill Ingalls and NASA's Earth Observatory



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The day's activities capped off with an evening event—sponsored by Aqua's spacecraft company Northrop Grumman—at the GSFC Visitor Center. Attendees heard remarks from NASA HQ and GSFC management, as well as several past and present members of the Aqua instrument and mission teams, who reminisced about Aqua's accomplishments.

Even though Aqua is well beyond its designed lifetime, four of its six Earth-observing instruments continue to operate exceptionally. This is a tribute to the efforts

of the various science teams and Earth Science Mission Operations. The hope is that Aqua will continue to collect data for years to come, as the spacecraft has enough fuel onboard to last into the early 2020s. Congratulations to all who have contributed to the success of the Aqua mission over the years, and best wishes for continued success!

I am very pleased to report that the Tropospheric Emission Spectrometer on Aura appears to have been “resurrected.” Over the past year TES had been plagued by problems with the Interferometer Control Subsystem (ICS) translator due to aging lubricants. The team had been working hard to coax as much life out of the instrument as possible, and to make maximum scientific use of the remaining life, but early in 2012 the translator stopped working entirely. After arduous months of testing and attempting to move the translator, on April 2 the ICS regained full translator motion. The working theory is that the successive attempts to restart the translator dislodged a piece of Teflon that had been obstructing movement. Translator movement following recovery is improved when compared with conditions one year ago, although indications of lubricant age remain evident. All TES standard data products were produced from observations obtained on April 25, demonstrating successful ICS recovery. Special observations over validation sites are planned starting April 29th.

Since April of last year we have been reporting on CloudSat's ongoing battery management recovery efforts that necessitated leaving the A-Train constellation *via* a June 2011 orbit-lowering maneuver. By early November the CloudSat team was able to manage satellite power such that the cloud radar could be fully operational during the daylight portion of the orbit. I am now delighted to report that CloudSat was successfully placed back in its A-Train control box on May 15 after the completion of a second orbit-raise maneuver. The only item remaining is an inclination maneuver set to occur in mid-July that will lock CloudSat's orbital node with respect to the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) mission. CloudSat's control box is now about 30 sec behind CALIPSO; formerly, it had been 30 sec ahead of CALIPSO. This location allows for concurrent observations with other A-Train instruments while ensuring safe constellation operations. Congratulations to the CloudSat team for this tremendous accomplishment. Welcome back to the A-Train!

In other A-Train news, congratulations to the Japan Aerospace Exploration Agency (JAXA) on the launch of the Global Change Observation Mission - Water (GCOM-W1) “SHIZUKU” satellite during the early hours of May 18, Japanese standard time. The Ad-

vanced Microwave Scanning Radiometer 2 (AMSR2) was successfully deployed later that day and the initial spin-up has been completed. AMSR2 is a follow-on to the AMSR-E instrument flown on Aqua. JAXA will take about 45 days to insert the satellite at the front of the A-Train orbit. Along with CloudSat, we look forward to returning to a five-satellite constellation, which last occurred in December 2009, when PARASOL maneuvered out of the A-Train orbit.

Meanwhile, even as our venerable EOS missions continue to show their merit and as the data returned lead to new science discoveries, new Earth science instruments are also being developed. One such example is the Cloud-Aerosol Transport System (CATS), being engineered for deployment on the International Space Station's Japanese Experiment Module—Exposed Facility (JEM-EF). The instrument is a pathfinder for both NASA and the U.S. It serves as a “testbed” for technologies that, if successful, will be part of future NASA space-based missions to study clouds and aerosols; it

also is only the second U.S. instrument to be deployed from the JEM-EF, so the lessons learned will be applied to future U.S. payloads from NASA and other agencies.¹ CATS builds on the heritage of the Cloud Physics Lidar airborne instrument, and will help continue the data record for atmospheric profile measurements begun by the CALIPSO mission. To read more about the CATS instrument, turn to **page 4** of this issue.

On the outreach front, in April, NASA celebrated the 42nd Earth Day on the National Mall in Washington, DC. The “NASA Village” on the Mall featured a number of activities and demonstrations that helped highlight topics in Earth science. To learn more about this event and NASA's involvement, see *Earth Day is Every Day at NASA* on **page 9** of this issue. ■

¹ The Cloud Physics Lidar has flown on board the NASA ER-2 for nearly 12 years and, more recently, has been deployed on flights of the Global Hawk unpowered aerial vehicle. Learn more about CPL in page 7 of this issue.

Discovery Trades Spaces with Enterprise

Having made more trips to space than any other Space Shuttle, *Discovery* landed for the final time at Dulles International Airport in Washington, DC on April 17, 2012—only this time, *Discovery* made the trek on the back of an extensively modified Boeing 747. Before touching down, *Discovery* made several passes over the Washington, DC area, including passes over the National Mall, NASA Headquarters, and NASA's Goddard Space Flight Center. Thousands of people gazed skyward to witness the ultimate “piggyback” voyage.

Discovery has since joined a host of other national treasures at the Smithsonian National Air and Space Museum's Steven F. Udvar-Hazy Center in Chantilly, VA. Replaced by *Discovery*, the prototype Space Shuttle *Enterprise* took its final “flight” on April 27, 2012 enroute to its new home at the Intrepid Sea, Air, and Space Museum in New York, NY.

Now the two shuttles have new missions, to inspire, educate, and pay homage to the remarkable discoveries and accomplishments that accrue to NASA's Space Shuttle program. To learn how the Shuttle program led to so many advances in Earth system science, please see *The Earth Observer's* September–October 2011 issue [**Volume 23, Issue 5**, pp. 4–17].



Space Shuttle *Enterprise* [left], and *Discovery* [right] face nose-to-nose during a welcoming ceremony held at the National Air and Space Museum's Steven F. Udvar-Hazy Center in Chantilly, VA on April 19. **Image credit:** NASA/Smithsonian Institution/Carolyn Russo

CATS: A New Earth Science Capability

Matthew McGill, NASA's Goddard Space Flight Center, matthew.j.mcgill@nasa.gov

Ellsworth Welton, NASA's Goddard Space Flight Center, ellsworth.g.welton@nasa.gov

John Yorks, Science Systems & Applications, Inc., john.e.yorks@nasa.gov

V. Stanley Scott, NASA's Goddard Space Flight Center, stan.scott@nasa.gov

The CATS payload will continue the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) data record, provide observational lidar data to improve operational modeling programs, and demonstrate the direct lidar retrieval of aerosol extinction from space.

Introduction

Aerosols are tiny atmospheric particles that are practically invisible to the naked eye, yet have a huge impact on Earth's climate. They exert a *direct effect*, as the particles scatter and absorb solar and long-wave radiation, thereby influencing Earth's radiation balance. Aerosols also exert an *indirect effect* on climate; they interact with clouds, altering the physical and chemical properties of both, and, in turn, changing their influence on the radiation balance. Indirect effects have also been shown to alter cloud formation and rainfall events. The relationship between aerosols and clouds and the resulting influence on Earth's climate is therefore complex, with impacts on Earth's energy balance, hydrologic cycle, and atmospheric circulation.

Aerosols and clouds are not homogeneously distributed in the atmosphere over the Earth's surface. They also have relatively short lifetimes, varied transport processes, and, as discussed above, complex interactions with each other. These factors have made aerosols and clouds more difficult to simulate in climate models than most other constituents.

In recent years routine measurements of aerosol and cloud distributions and properties obtained from instruments from the ground, the air, and space have helped to reduce some of the uncertainties. However, despite improvements in our knowledge of their impacts and an overall downward trend in the uncertainties, aerosol and cloud direct and indirect effects remain two of the areas of uncertainty for climate models. These large uncertainties make it difficult to quantify the extent to which human activities (pollution, burning, etc.) contribute to climate change.

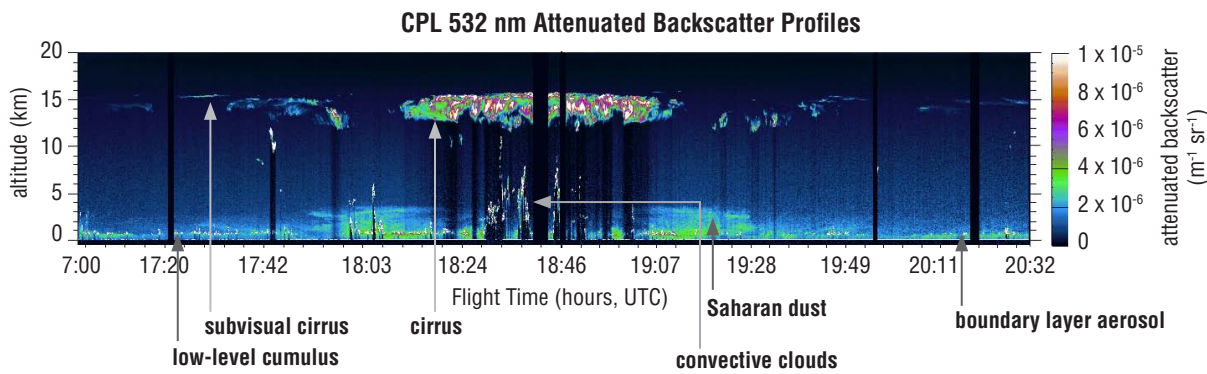
A Testbed for New Earth Science Technologies

The Cloud-Aerosol Transport System (CATS) is a lidar remote-sensing instrument designed to provide measurements of atmospheric particles; it is intended to help fill the anticipated "data gap" in acquiring such data—see *Mind the Gap* on page 6. The CATS instrument is funded by the International Space Station (ISS) National Laboratory program as a demonstration of ISS-based operational science capability. By allowing such payloads to be attached, the ISS provides a unique capability for demonstrating new technologies in space at a relatively low cost.



Figure 1. The Japanese Experiment Module-Exposed Facility (JEM-EF) on the International Space Station. Payloads, such as CATS, attach using "plug-in" ports located around the JEM-EF. **Image credit:** NASA

The CATS mission was therefore designed to take advantage of the ISS platform to provide new capabilities from space including operational aerosol forecasting and technology demonstration and risk reduction for future Earth science missions. The CATS payload will continue the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) data record, provide observational lidar data to improve operational modeling programs, and demonstrate the direct lidar retrieval of aerosol extinction from space.



Development of CATS also serves as a *pathfinder* for NASA, as it is the first NASA-developed payload for the Japanese Experiment Module-Exposed Facility (JEM-EF) on the ISS—see **Figure 1**. Furthermore, CATS is only the second U.S. payload ever to go to the JEM-EF. Designed to operate for at least six months and possibly for as long as five years, the CATS lidar will provide range-resolved profile measurements of atmospheric aerosol and cloud distributions and properties.

CATS Science

The impact of clouds and aerosols (e.g., pollution, dust, smoke) on global energy balance and climate feedback mechanisms is not yet fully understood. Obtaining a better understanding of cloud and aerosol coverage and properties is critical for understanding the Earth's systems and their climate feedback processes.

The CATS instrument uses a laser to obtain range-resolved information about the climate impacts of clouds and aerosols on a global scale. The ISS orbit is particularly suited to this measurement because the 51-degree inclination of the orbit puts ISS tracks over and along primary aerosol transport paths. The ISS orbit also permits study of *diurnal* (day-to-night) changes in aerosol and cloud effects—something unique compared with other Earth science satellite orbits. The CATS instrument uses a high-repetition-rate laser operating at three wavelengths (1064, 532, and 355 nm) to derive properties of cloud/aerosol layers, including layer height, layer thickness, backscatter, optical depth, extinction, and depolarization-based discrimination of particle type.

An important aspect of CATS science will be to provide real-time observations of aerosol vertical distribution to serve as inputs to global aerosol transport models. Current models tend to agree on total aerosol loading, but tend to disagree on the vertical distribution of the loading and the type of aerosols present. To begin to determine how much of the total aerosol load can be attributed to natural sources (e.g., dust) and how much can be attributed to human-induced sources (e.g., pollution), it is important to know how the aerosols are distributed through the atmosphere. In particular, the vertical distribution of aerosols is highly important, because their effects differ depending on whether the aerosol layer is below, mixed with, or above cloud layers. As mentioned earlier, aerosol–cloud interactions currently comprise the largest source of uncertainty in studies of climate forcing, so it is critical to ascertain the correct vertical distribution of aerosols.

Lidar remote sensing is particularly well-suited to profiling of aerosols and optically thin, but radiatively important, clouds—see **Figure 2**. In fact, the primary capability for CATS was adapted from the Cloud Physics Lidar (CPL) design—see *CATS Heritage: The Long-standing CPL* on page 7. The vertical profile information, particularly when determined at multiple wavelengths, and combined with depolarization information, provides height location of cloud and aerosol layers, information on particle size, and information on particle shape. The CATS instrument will provide measure-

Figure 2. Example of lidar profile data from the airborne Cloud Physics Lidar (CPL) instrument. The CATS instrument is a scaled-up version of the CPL, intended to produce similar-quality data. (See Sidebar on page 7 for more details on CPL.) **Image credit:** NASA

An important aspect of CATS science will be to provide real-time observations of aerosol vertical distribution to act as inputs to global climate models... To begin to determine how much of the total aerosol load can be attributed to natural sources (e.g., dust) and how much can be attributed to human-induced sources (e.g., pollution), it is important to know how the aerosols are distributed through the atmosphere.

The CATS instrument will provide measurements of cloud and aerosol profiles similar to CALIPSO—filling in the data gap described in the sidebar—so that this information can be used to improve climate models and our understanding of the Earth system and climate feedback processes.

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Risk Reduction and Objectives

To maximize operational lifetime, the CATS payload is designed to use two laser units¹, but with different capabilities and architecture.

One laser is based on a rugged Nd:YVO₄² crystal, with 1064/532-nm outputs. This laser is used for the backscatter measurements and is based on a heritage design to ensure long life. The second laser is also Nd:YVO₄-based, but incorporates two advanced features—*injection seeding* and *frequency tripling*—as demonstrations that might be incorporated in future space-based missions. Injection seeding provides narrow linewidth as required for high-spectral-resolution measurements; frequency tripling permits generation of 355-nm output in addition to the 1064- and 532-nm outputs, which will enable better differentiation between aerosol types.

The CATS instrument also provides the first in-space demonstration of high-repetition-rate lasers for Earth remote sensing. Operating at 5000 pulses per second, the CATS lasers emit a pulse every 1.5 m along-track. The Fabry-Perot interferometer in the high-spectral-resolution channel also is a prototype for high-fidelity, tunable-spectral filtering for future Earth science applications.

The CATS Payload, Inside and Out

All lidar remote-sensing instruments consist of a laser transmitter to generate probe photons, a receiver subsystem with a telescope to collect photons that backscatter from the atmosphere, and a data system to provide timing of the return photon events. Beyond that generalization, there are choices to be made in type of laser

¹ Fibertek Inc—an advanced laser technology company—provided both of the lasers.

² The neodymium doped yttrium orthovanadate (Nd:YVO₄) crystal is considered the most efficient laser host crystal currently existing for diode laser-pumped solid-state lasers. See www.u-oplax.com/crystals/crystals20-1.htm to learn more.

Mind the Gap

In 2006 NASA launched the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) spacecraft. A joint mission between NASA and the French Centre National d'Études Spatiales (CNES), CALIPSO is an Earth System Science Pathfinder mission designed to provide unique atmospheric profile measurements to improve our understanding of the roles played by aerosols and clouds in Earth's climate system. The CALIPSO lidar provides vertical distributions and properties of aerosols and optically thin clouds along the nadir flight track; the top heights of thicker clouds are also determined, but not profiled. CALIPSO provides two-wavelength (532- and 1064-nm) elastic-backscatter lidar profiling with linear polarization at 532 nm. However, the CALIPSO lidar has exceeded its three year prime mission and has been using its backup laser since 2009.

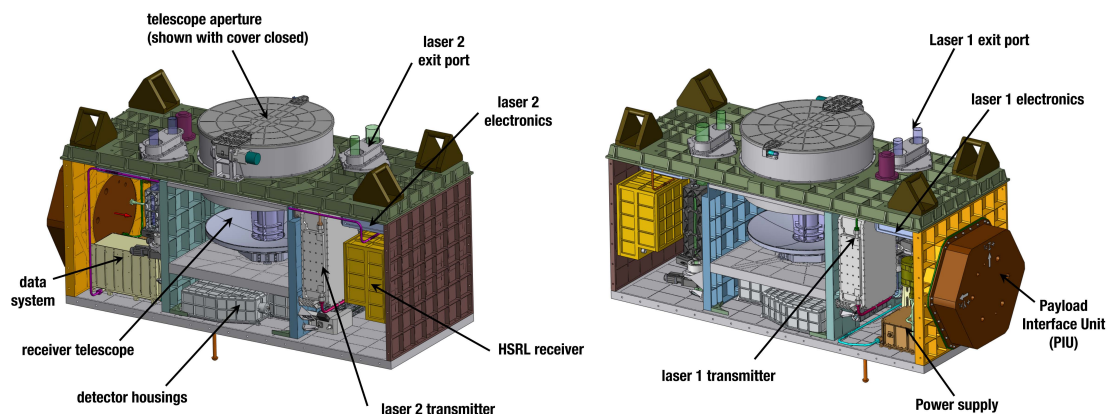
It is critical to continue the measurement capabilities of CALIPSO to better assess the climatological impact of aerosols and clouds. Such measurements are required over time scales that are much longer than a typical mission lifetime (~5–10 years). This is especially true for active sensors such as lidar, which have inherently shorter lifetimes than passive sensors. At the moment, there is no NASA mission in development to replace CALIPSO. The next mission contemplated—the Aerosols, Clouds, and Ecosystems (ACE) mission—is still in the pre-formulation and study phase, and is planned for a post-2020 launch date. As a result, the aerosol and cloud research community is facing a significant “data gap” in terms of continuing the CALIPSO data record. CATS will help mitigate this gap.

CATS Heritage: The Long-standing Cloud Physics Lidar (CPL)

The CPL was developed in 1999 at the specific request of the Earth Observing System (EOS) program. At the time, EOS was preparing for the Southern African Regional Science Initiative (SAFARI) field campaign, and wanted a new-generation lidar remote-sensing instrument for use on the high-altitude ER-2 aircraft. The CPL concept uses a high-repetition-rate laser and photon-counting detectors (see text for details on these terms), and set the stage for developing and flying a series of low-cost, fast-turnaround airborne lidar instruments over the next decade. “The CPL is an outstanding addition to airborne missions that focus on aerosols and clouds in the troposphere and lower stratosphere... Operating a high-powered laser with a fast detection system autonomously in the upper atmosphere is a significant engineering challenge,” said **David Fahey** [National Oceanic and Atmospheric Administration].

August 2012 will mark the twelfth anniversary of the SAFARI campaign. Many instruments don't live more than a decade, owing to several issues—e.g., harsh treatment in the aircraft environment, or loss of interest by the scientific community—but the CPL continues to provide valuable data to the research community. In fact, the CPL has proven so reliable and so important that another CPL was built for use on the unmanned Global Hawk aircraft. “CPL has clearly stood the test of time, and a new data user like myself reaps the benefits of the hard work over the years by the CPL team,” said **Tom Neumann** [NASA's Goddard Space Flight Center (GSFC)].

Hal Maring [NASA Headquarters] noted that CPL data continue to be heavily used. “Measurements of the vertical distribution of aerosols and clouds are useful in many diverse scientific disciplines such as climate studies, weather research and prediction, atmospheric geochemistry, aerosol impacts on the biosphere, as well as satellite and model calibration and validation,” said Maring. The longevity and demonstrated performance of the CPL instruments provided the basis for the CATS design. Leveraging the CPL heritage will provide maximum on-orbit lifetime to provide continuous measurements that benefit the Earth science community.



(e.g., wavelength, repetition rate, etc.) and complexity of receiver, which is dependent on the variables to be measured. There is also a fundamental choice for detection type, either by *analog detectors* or *photon-counting detectors*. Photon-counting detection generally drives requirements for receiver field-of-view to limit the solar background signal and laser pulse energy to avoid saturating the detector(s). In CATS, photon-counting and high-repetition-rate lasers are used; a narrow 100-microradian field-of-view minimizes the impacts of solar background. In airborne instrument use, the photon-counting detectors have proven easy to use and allow smooth calibration and thus quick turn-around of data products.

The CATS payload is based on existing instrumentation operated on the high-altitude NASA ER-2 aircraft. The payload is housed in a 1.5-m x 1-m x 0.8-m envelope that attaches to the JEM-EF. The allowed volume limits the maximum size for the collecting telescope to a 60-cm diameter. **Figure 3** shows the layout of the CATS payload, with the primary instrument components identified.

Figure 3. The CATS payload with primary components identified. The payload fits within a standard JEM-EF attached payload volume. **Image credit:** Design Interface, Inc.

The ISS and, in particular, the JEM-EF is an exciting new platform for spaceborne Earth observations. The ability to leverage existing aircraft instrument designs, coupled with the lower cost possible for external attached payloads, permits rapid and cost-effective development of spaceborne sensors.

There are three different operational modes for CATS:

- *Backscatter detection only, at 1064 and 532 nm, with depolarization measurement at both wavelengths.* The laser output is split into two transmit beams, one aimed 0.5° to the left and one 0.5° to the right, effectively making two tracks separated by 7 km (~4.3 mi) at Earth's surface. This operational mode will be used to ensure that minimum science requirements can be met for the maximum mission duration.
- *Demonstration of high-spectral-resolution aerosol measurements.* This mode uses the injection-seeded laser operating at 1064 and 532 nm to demonstrate a high-spectral-resolution measurement using the 532-nm wavelength.
- *Demonstration of 355-nm profiling.* This mode uses the injection-seeded laser operating at 1064, 532, and 355 nm to demonstrate 355-nm laser performance. Similar to the backscatter detection mode, there are depolarization measurements at each wavelength.

The CATS payload is being built on a 24-month schedule, with payload delivery targeted for April 2013. The current launch target is to be the Japanese H-II Transfer Vehicle, with launch in the early-2014 timeframe.

Conclusion

The CATS payload, currently under development for deployment to the ISS, will help bridge the looming data gap for NASA's program in active remote sensing of the Earth's atmosphere. The ISS—in particular the JEM-EF—is an exciting new platform for spaceborne Earth observations. The ability to leverage existing aircraft instrument designs, coupled with the lower cost possible for external attached payloads, permits rapid and cost-effective development of spaceborne sensors. Data from the CATS instrument will be used to improve aerosol transport models while simultaneously providing risk reduction for future Earth science missions. The downlink capability of the ISS will permit near-real-time assimilation of the CATS lidar data into numerical models. The ISS orbit over major aerosol transport routes and the ability to observe diurnal changes will provide new observations for Earth science applications.

Acknowledgements

The CATS payload is funded by NASA's International Space Station National Laboratory program. ■

Earth Day Is Every Day at NASA

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

From their vantage point in lunar orbit, the astronauts on Apollo 8 were afforded a view of Earth that no human had ever seen before. The image they saw as their spacecraft cleared the lunar horizon on its fourth orbit caught them by surprise and so captivated them that they were moved to take photographs. One of these, taken by Astronaut William Anders, became something of a global icon. Known as *Earthrise*, it shows Earth as it “rises” above the Moon’s surface. This image captured the public’s imagination and galvanized thinking about the impact we might have on our environment. It was so powerful that it has been called one of the most influential photographs in the history of environmental thought—and deed! Based on this impact, in 1969 Senator Gaylord Nelson, who had witnessed firsthand the ravages of an oil spill in Santa Barbara, CA, was inspired to take action. Taking advantage of the rising public consciousness that the *Earthrise* photograph had created, he managed to redirect the attention of the public toward issues related to air and water pollution.

The first Earth Day on April 22, 1970 was the result—the dawning of a new attitude towards our Earth. Since then, every year on April 22 people from around the world have participated in events that raise public awareness and appreciation for our planet. This year, to commemorate the forty-second Earth Day, thousands of participants helped NASA celebrate Earth Day on the National Mall in Washington, DC, from April 20-22.

For over a half-century, NASA has been observing our ever-changing planet from space. Currently, there are 16 Earth-observing satellites orbiting our planet, equipped with state-of-the-art instruments that collect unprecedented amounts of data on the Earth’s interior, oceans, land surfaces, atmosphere, and cryosphere—24 hours a day, 365 days a year.

The images and data collected from these spacecraft have forever changed the way we look at Earth—our home—and have led to some of the greatest discoveries about our planet ever made. This year’s three-day Earth Day event gave scientists and outreach personnel the opportunity to engage with the public to describe NASA’s role, specifically, in Earth science activities.

The “NASA Village” on the Mall featured a number of activities and demonstrations that helped highlight topics in Earth science, and extended to heliophysics and astrophysics—see **Images 1-5**. Earth Day participants had the opportunity to design and build their own satellites using *Lego* blocks, create their own ultraviolet radiation detection bracelets using specially designed ultraviolet-sensitive beads, piece together satellite-image puzzles picturing the Earth and Moon, and test their knowledge while playing *Earth Science Pursuit*. Demonstrations—ranging from exploring the lunar environment to identifying which scenarios best represent weather and which represent climate—allowed participants to apply NASA science concepts to real-world situations.

NASA’s “Green Theater” was designed to tell visual stories about our changing planet. Large images, created with data collected by NASA’s Earth-observing satellites and other missions, were displayed on large “curtains.” Daily presentations allowed scientists and other presenters to use the images to help inform the public about NASA’s most recent Earth science research results—see **Images 6-8**.

“Because of NASA’s commitment to Earth science, we have developed an understanding of our home planet that is unmatched in human history.”

—**Charles Bolden**
[NASA Administrator]



Earthrise. Image credit: NASA

On Saturday, NASA scientists took Earth Day attendees on a world tour from the vantage point of space, using images displayed in the Green Theater to provide an overview on the health of our planet. The one-hour event was streamed live, and can still be viewed online at youtu.be/Kfp29h20y-o. Also on Saturday, former NASA astronaut **Piers Sellers** [NASA's Goddard Space Flight Center (GSFC)—*Deputy Director, Sciences and Exploration Directorate*] signed autographs, while answering questions about what it was like to view Earth from space—see **Image 9**.

On Sunday—the official Earth Day—**John Grunsfeld** [NASA Headquarters (HQ)—*Associate Administra-*

tor, Science Mission Directorate] and **Waleed Abdalati** [NASA HQ—*NASA Chief Scientist*] gave a joint speech on the Earth Day stage, explaining how NASA missions are a critical part of Earth-science research—see **Image 10**. A video, including animations of NASA data, was also displayed on a large Jumbotron on the National Mall on Sunday.

NASA would like to thank all of those who participated in the events on the National Mall and those who came out to help NASA celebrate Earth Day. ■



Image 1. The 2012 Earth Day NASA Village was set up on the National Mall in Washington, DC, and featured a Demonstrations tent (or Earth tent), Activities tent, and Green Theater tent. **Image credit:** NASA



Image 2. Students worked together to piece together a puzzle of Earth. **Image credit:** NASA

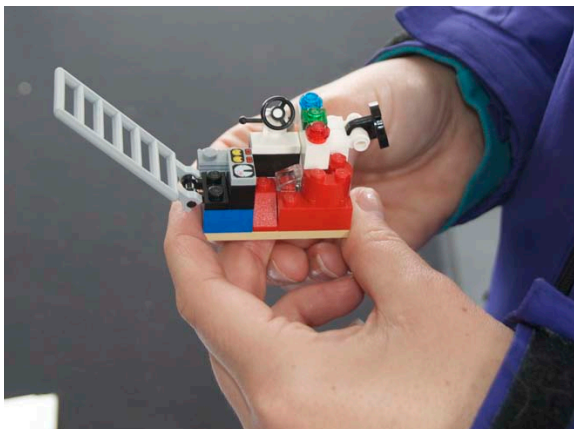


Image 3. Earth Day participants were able to take home their satellite after completing the *Engineer a Satellite* activity. **Image credit:** NASA



Image 4. **Cindy Trapp** [GSFC—*Outreach Coordinator*] helped participants assemble ultraviolet radiation detection bracelets in the Activities tent. **Image credit:** NASA



Image 5. One of Landsat's biggest maps of Washington, DC and the surrounding areas allowed participants to show off their geographic knowledge. **Image credit:** NASA



Image 6. Tom Wagner [NASA HQ—Cryosphere Program Manager] explained how NASA observes sea ice extent from space during a Green Theater presentation. **Image credit:** NASA



Image 7. Jack Kaye [NASA HQ—Associate Director for Research, Earth Science Division] described how global satellite images of Earth are made using data from NASA's newest Earth-science satellite mission—the Suomi National Polar-orbiting Partnership (Suomi NPP). **Image credit:** NASA



Image 8. Atmospheric scientist Elena Yegorova [GSFC] took questions from the audience about the presence of nitrogen dioxide in the air we breathe. **Image credit:** NASA



Image 9. Former astronaut Piers Sellers [GSFC—Deputy Director, Sciences and Exploration Directorate] signed autographs on Saturday. **Image credit:** NASA



Image 10. John Grunsfeld [NASA HQ—Associate Administrator, Science Mission Directorate] and Waleed Abdalati [NASA HQ—NASA Chief Scientist] spoke about NASA science on the Earth Day stage. **Image credit:** NASA

Students' Cloud Observations Continue to Help Validate NASA Satellite Data

Jennifer LaPan, NASA's Langley Research Center, jennifer.d.lapan@nasa.gov

S'COOL uses data from over 15,000 students who submit their cloud measurements, usually taken from their classrooms, to NASA. In return for their valuable cloud observations, S'COOL provides the students the satellite data they are helping to validate for use as an educational tool.

Young student scientists around the world have come out in droves in recent months to help check the accuracy of NASA satellite cloud observations. Luckily, they have arrived just in time for the inaugural measurements from NASA's newest climate satellite—Suomi National Polar-orbiting Partnership (Suomi NPP).

These student scientists are part of NASA's *Students' Cloud Observations On-Line (S'COOL)* program. S'COOL is a worldwide effort that involves students (ages 5-20+) in real-world science. They make and report *ground truth*¹ observations of clouds to assist in validating measurements from NASA's satellite-based Clouds and the Earth's Radiant Energy System (CERES) instruments.

S'COOL uses data from over 15,000 students who submit their cloud measurements, usually taken from their classrooms, to NASA. In return for their valuable cloud observations, S'COOL provides the students the satellite data they are helping to validate for use as an educational tool. This data report allows students to compare and contrast what they observed with what the satellite observed.

"We need students to help validate our satellites. If you look at a map, there are only 11 NASA centers from which we can validate our satellites from the ground. [On the other hand,] S'COOL observers span over 83 countries," said **Sarah Crecelius** [NASA's Langley Research Center/Science Systems and Applications Inc. (LaRC/SSAI)—*S'COOL Outreach Coordinator*]. "We do not have enough manpower at NASA to validate satellite data like S'COOL students can."

The number of students who have joined the S'COOL program in just two recent months is already a third of those that joined during all of last year. "That number does not even include the individuals who have submitted observations through the S'COOL *Rover* program," said Crecelius. Rover observations—made by individuals who are not in a classroom setting—are the newest feature of the S'COOL program. The S'COOL Rover program was designed for the citizen-scientist community, and allows participants to make observations from permanent and nonpermanent locations. Much like classroom S'COOL observers, Rover observers can compare their observations with those of other roving observers.

According to S'COOL team members, the influx of observers has come at a convenient time. At the end of last year, NASA launched its fifth CERES instrument—the instrument S'COOL focuses on validating—onboard Suomi NPP. This means student observers have another satellite with which to align their observations and to help validate.

"We just had our first intensive observation period with Suomi NPP from late January into February to collect initial observations," said Crecelius. "We asked students to collect observations for Suomi NPP every time their observations coincided with an overpass of the Aqua satellite." According to Crecelius, Aqua and Suomi NPP have similar overpass times. Although data from CERES on Suomi NPP have not yet been processed and made available for comparison with S'COOL participants' observations, they will eventually get their matches. In the meantime, the students' observations help NASA scientists get ready for initial validation of the CERES instrument on Suomi NPP.

¹ A *ground truth* observation is made when a person on the ground (or in an airplane) makes the same observation, at the same time, as a satellite instrument—in particular here, Clouds and the Earth's Radiant Energy System (CERES)—is passing over them.

“We have not received data on our side yet, either, so the science benefit has not yet been realized,” explained **Lin Chambers** [LaRC—*Lead for S’COOL*]. “But, as soon as they start processing Suomi NPP CERES data, this will give us a quick look at how the cloud algorithm is working.”

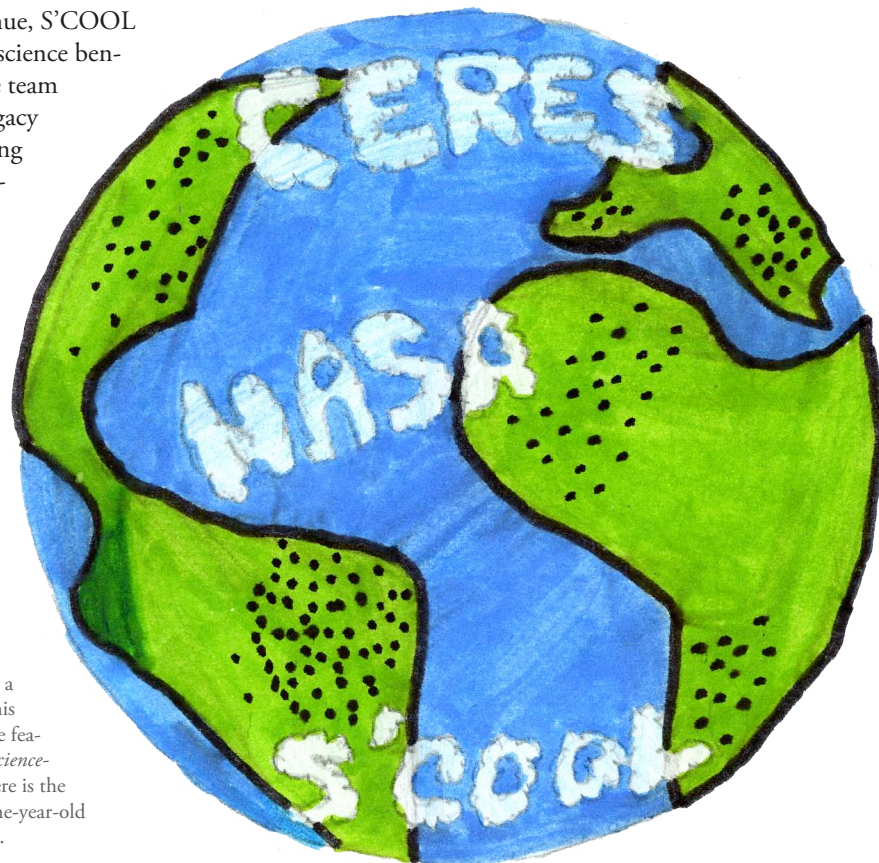
S’COOL observations have long helped scientists confirm the presence of clouds—especially over areas and under conditions that are challenging for satellite instruments. For example, students had submitted cloud observations that reported a single layer of clouds in their area while the corresponding satellite data reported clear skies. When the S’COOL team looked further into this discrepancy, they found that students were reporting a few thin cirrus clouds that were not detectable either by the CERES/Imager algorithms for the Tropical Rainfall Measuring Mission (TRMM) satellite or for the Terra and Aqua satellites. With student observations, scientists can now quantify how often satellites overlook cirrus clouds.

Another tricky task for satellites is observing clouds over areas with bright and/or complex surfaces. For example, there have been cases where the algorithm was not detecting thin clouds over mountainous regions with nonuniform snow cover. When students made observations in these areas, they were able to help scientists validate satellite capabilities against these difficult backgrounds.

As S’COOL’s network of student observers expands and observations continue, S’COOL team members say additional science benefits are sure to be gained. The team also plans to continue their legacy of promoting hands-on-learning in the classroom by taking students’ focus out of their textbooks and into real-world science at NASA.

For more information about the S’COOL program or to register as an observer, visit: science-edu.larc.nasa.gov/SCOOL.

On November 11, 2011, S’COOL received its hundred-thousandth cloud observation. To celebrate the occasion, a contest was held to design a new S’COOL banner. Each month this year, a new contest winner’s art will be featured on the S’COOL homepage at science-edu.larc.nasa.gov/SCOOL. Pictured here is the artwork from the March winner—nine-year-old **David Preizal** from Marseille, France.



As S’COOL’s network of student observers expands and observations continue, S’COOL team members say additional science benefits are sure to be gained. The team also plans to continue their legacy of promoting hands-on-learning in the classroom by taking students’ focus out of their textbooks and into real-world science at NASA.

Workshop on Land-Cover Land-Use Change in Southeast Asia

LeeAnn King, University of Maryland, College Park, mkinglee@hermes.umd.edu

Garik Gutman, NASA Headquarters, garik.gutman@nasa.gov

Chris Justice, University of Maryland, College Park, justice@hermes.geog.umd.edu

Miguel Castrence, East-West Center, castrenm@eastwestcenter.org

Jay Samek, Michigan State University, samekjay@msu.edu



LCLUC workshop participants.

Introduction

The annual international Land-Cover Land-Use Change (LCLUC) Science Team Meeting and Training Workshops were held jointly with the Monsoon Asia Integrated Regional Study (MAIRS) and the Global Observations of Forests Cover and Land Cover Dynamics (GOF-C-GOLD) programs in Hanoi, Vietnam, from November 5-11, 2011. The Center for Research and Ecological Studies of Hanoi University of Agriculture hosted the meeting, with contributions from the Global Change System for Analysis Research and Training (START) program; Vietnam Forestry University (VFU); University of Maryland, College Park (UMCP); Michigan State University (MSU); the East-West Center (EWC); and NASA. More than 100 participants representing eight countries attended the Southeast Asia (SEA) regional meeting. The goals of the meeting were to review LCLUC research conducted throughout Southeast Asia (SEA) by regional and international scientists, and to discuss the availability of satellite datasets and new research methodologies relevant to regional analysis.

This meeting was a follow-on to the Khon Kaen meeting held in Thailand in January 2009¹, and provided an opportunity for scientists to present and discuss research related to remote sensing measurement and

¹ The Khon Kaen meeting was described in the March-April 2009 issue of *The Earth Observer*, [Volume 21, Issue 2, pp. 22-24].

monitoring tools, and analysis related to land-cover and land-use change in the SEA subtropical and tropical regions. In particular, there have been several recent advances in remote-sensing methods that have been fueled by open access to Moderate Resolution Imaging Spectroradiometer (MODIS) and Landsat data archives, including NASA research contributions to near-real-time monitoring, systematic long-term monitoring, ground-based global positioning system (GPS)-photo sharing, unmanned aerial vehicles, forest age measurement capabilities, and forest rotation analysis.

These new methodological techniques and data are applicable to the study of land-use changes in the SEA region. Current LCLUC-funded projects that focus on this region raise awareness about available NASA assets; they also strengthen relationships with local scientists and regional networks to address emerging issues associated with rapid land-use/land-cover change. In addition, satellite programs in Thailand, China, Japan, India, and Vietnam also offer opportunities for national baseline development and monitoring of land-use change. Improving access to these national and regional datasets and land-cover products would benefit local and international research projects, alike.

Opening Presentations

The first three presentations provided context for the focus on scientific activities that followed.

Chris Justice [UMCP—LCLUC Program Scientist] explained that one of the international remote sensing community's priorities is to encourage data collectors and providers beyond those already involved—including national governments and private industry—to allow open access to datasets for research to foster the continued long-term availability of data and to support improved access to data through enhanced information networks and access to databases.

Garik Gutman [NASA Headquarters—LCLUC Program Manager] described the LCLUC Program and its relationship to the MAIRS program. MAIRS is an international research program in SEA that aims to enhance understanding of human–natural systems and the complex interactions within and between them, in the local and global context of sustainable development. MAIRS also coordinates integrated studies among institutions and stakeholders and builds capacity for observations, analysis, and modeling in the region. The LCLUC Program is one of several that provide support to regional science projects as a contribution to the MAIRS program. Several of these projects quantify land-cover land-use change in the SEA region using remote sensing techniques or methodologies, and include an evaluation of the socioeconomic and political drivers associated with the physical land changes observed.

Alikun [MAIRS—International Project Office] provided an overview of recent MAIRS initiatives in SEA, including a description of some of the currently funded regional studies. The MAIRS Megacity project is evaluating the potential health risks and hazards associated with increases in urban land area, urban populations, pollution, temperatures, and extreme weather events. This project uses comprehensive observational networks to establish relationships between climate change and urbanization, while modeling the impact of urbanization on regional and global climate. Another MAIRS project involves exploring environmental changes occurring in dryland Asia, focusing on the impact of global warming on water resources, the water cycle, and ecosystem services; the vulnerability of human–environmental systems from climate change; and the feasibility of resilient adaptation strategies for the region. Alikun explained that the goal of the MAIRS program is to improve land surface and terrestrial ecosystem models for the region through offline model intercomparisons.

Science Presentations

After these introductory remarks, the remainder of the meeting consisted of invited scientific presentations. The full meeting agenda, presentations, and posters are available at the LCLUC website at lcluc.umd.edu/meetings.php?mid=21. A few selected highlights follow.

Xiaoming Xiao [University of Oklahoma] provided a description of a methodology to fuse optical and microwave sensor data for land-cover mapping of the region using Phased-Array type L-band Synthetic Aperture Ra-



Local and regional scientists at the Science Team Meeting poster session in Hanoi, Vietnam.

dar (PALSAR), Landsat Enhanced Thematic Mapper Plus (ETM+), and MODIS 250-m datasets. Xiao also described methods used to measure cropping intensity in the region, providing an overview of the current LCLUC-funded project titled *Quantifying changes in agricultural intensification and expansion in monsoon Asia during 2000–2010*. The algorithm employed to describe cropping intensity calculates the number of crops per year using the Normalized Difference Vegetation Index (NDVI), Enhanced Vegetation Index (EVI), and Land Surface Water Index (LSWI). These field-scale data are then complemented with a recently developed community- and citizen-science data portal (www.eomf.ou.edu/photos) that archives georeferenced field photos of croplands in the region. The photos and field measurements are used to calibrate the model and to validate the algorithm. This approach will be used to map agricultural intensity around the world.

Nguyen Dinh Duong [Institute of Geography—Hanoi, Vietnam] presented a methodology used to develop a 14-category land-cover map for Vietnam for 2001–2003. This multitemporal, multispectral classification, using MODIS cloud-free composites, was based on fea-

tures of the spectral reflectance curve shape and total reflectance from different spectral bands. In this project, GPS photos were also used to provide more than 6000 ground samples of land cover. The classification, when compared to 100 random points, demonstrated greater than 85% accuracy. The resulting national statistical yearbook and the land-cover map for 2002 match well with one another.

Matt Hansen [UMCP] provided an overview of the use of MODIS and Landsat regional products to monitor forest cover. His presentation focused on mapping forest extent and recent changes in Indonesia. A national-scale forest-type map should be completed by the end of 2012; the map will include classification of primary/intact, primary/degraded, wetland, peatland, timber, and palm forest-cover types, with a description of the rates of change within and between categories. These forest themes can be characterized in a hierarchical manner to quantify change dynamics for use in national, policy-driven monitoring objectives. Hansen also mentioned the importance of automated preprocessing of large volumes of imagery for most humid tropical areas—needed because a considerable amount of imagery contains cloud cover that can interfere with analyses.

REDD+ Carbon Sequestration Initiatives

Many of the presentations at this year's international LCLUC meeting described the United Nations Collaborative Initiative on Reducing Emissions from Deforestation and forest Degradation (UN REDD+) program and related initiatives that build local capacity for measuring and monitoring carbon. Numerous *afforestation* programs have been initiated because of increasing incentives for forest conservation from the international community. According to the United Nations Food and Agriculture Organization, from 1990–2005 Vietnam and China afforested 1–5% of the countries' land area, while Cambodia experienced deforestation at the same rate, and Thailand, Laos, and Myanmar lost an average of 0–1% of forest land area. Recently established UN REDD+ programs will provide incentives for afforestation projects and reduce, or at least counterbalance, deforestation that is occurring in the region. **Chris Justice** explained that efforts need to focus on making linkages between conventional forest inventory and remote sensing methods. He also noted that recently developed practical methods for monitoring, reporting, and verification—all in the context of REDD+—could benefit national efforts.

Dave Skole [MSU] described the relationships between carbon, forests, and livelihoods, noting the importance of agroforestry and carbon sequestration carbon credits for the region's forest conservation initiatives. He provided examples of various marketable forest ecosystem

services, including the use of the subcanopy shrub plants from the *Indigofera* family for the production and sale of natural indigo dye, or the collection of edible mushrooms for sale at the local markets. These products can be included in mixed agroforest systems as secondary products to provide income and to ensure protection of carbon sequestering landscapes. Skole continued with a description of MSU's recently developed Carbon Benefits Project—funded by the United Nations Environment Programme—that models, measures, and monitors forest-cover change for carbon markets using high-resolution remote sensing data to enhance capacity at the national, state, and local levels for carbon-market participants. Thailand's Inpang Network uses the resources of the MSU *Carbon2Markets* project to evaluate the development of the pilot Tree Bank project.

Usa Klinhom [Maharakham University] described Tree Bank's pilot program, which has been established in one of the poorest areas of Thailand. The project assisted 4000 households in 890 villages from five provinces, raising the area's average annual income from \$1228 to \$3077—U.S. Dollars (USD)—by making the transition from monocropping products (like cassava and sugarcane) to teak plantations. The next step will be to expand the carbon credit from teak plantations to agroforestry, incorporating multiple-crop agroforestry and orchard areas of dipterocarp, longan, tamarind, and mango. To complete the project, as well as the measurement and monitoring strategies, the results of this pilot program will be assessed by submitting the results to the U.N. as a community-scale pilot program for REDD+.

Do Xuan Lan [Department of Science Technology and Environment, Ministry of Agriculture and Rural Development—Vietnam] described REDD+ measurement, reporting, and verification initiatives for Vietnam that have taken place since the approval of \$4.4 million (USD) from UN-REDD+. The U.N. funding has been used for REDD+ pilot program implementation at the district, province, and national levels to improve the institutional and technological capacity for nationally coordinated management of REDD+ activities. These activities include developing a payment scheme with equitable and transparent benefits for ecological services at the provincial and district levels, while incorporating a participatory carbon-stock (C-stock) monitoring system, and improving information networks to address the different approaches for reducing regional displacement of carbon emissions and regulation, and enforcement to combat the cross-border flow of illegal timber.

LCLUC Panel Discussion

After these presentations, a panel session took place, allowing regional representatives the opportunity to pres-

ent their views on their respective national priorities for LCLUC research. Scientists representing Vietnam, Thailand, Myanmar, Laos, China, and Indonesia participated in the discussion.

- **Nguyen Dinh Duong** [Institute of Geography—Hanoi, Vietnam] argued that incentives for remote sensing of LCLUC could be established for government investments if the research projects were associated with measuring or monitoring policy.
- **Thiha** [Walai Rukhavej Botanical Research Institute, Myanmar] explained that scientists must find a way to work within the government framework. He stated that there is no opportunity to conduct this research—either formally or informally—or to successfully implement sustainable management practices without the cooperation of government agencies.
- **Heqing Huang** [Chinese Academy of Sciences] described the value of models, particularly the utility of agent-based models, in understanding human vulnerability, resilience, and adaptation to Earth system changes and extreme weather events.
- **Wardoyo** [Ministry of Forestry—Indonesia] established that there is a regional need for high-resolution satellite data to quantify LCLUC, particularly for peatland forests and carbon monitoring.
- **Saphangthong Thatheva** [National University of Laos] expressed a need to share platforms to organize and distribute information about data availability and to whom requests should be made for further information on data from within and outside of Laos.

The panelists agreed on many other national and regional LCLUC priorities. These include long-term data archives; continued and increased support for data-sharing initiatives; photographic and field measurement data collection projects; commencement of within-nation negotiations for the release of data to the community; standardization of scale for the region; and increased emphasis on training and access to information and technology.

Suggestions for enhancing the regional network included restructuring the Southeast Asia Regional Research and Information Network (SEARRIN) to increase communication and coordination between the SEARRIN secretariat and other regional programs, organizations, and institutions like SEA-START, and to produce tangible opportunities for funding, linkages, education, and capacity building. Investments should be made to develop a synthesis of the results of prior research in the region and

research and development projects that meet the needs of emerging climate and carbon policy, forest investment policy, and agricultural and development policy, all while strengthening research that investigates the human dimension of and political influences on land-use change.

To conclude, **Chris Justice** provided a synthesis of the workshop, highlighting the LCLUC issues in the region that arose during the meeting. Regional issues include rapid expansion and landscape modification, loss and degradation of agricultural land, the lack of adequate public services (like water supply and sanitation), human health and livelihood issues, and increasing land values. There is some assessment of environmental impact, but little progress towards systematic monitoring and reporting of LCLUC impacts in the region. Justice explained that the changing face of agriculture resulting in increased field size, biofeed stocks, year-round agroforestry, and livestock, will continue to grow, and the associated ecological impacts of land-use change could benefit from more attention. Regional landscape fragmentation resulting from various economic development initiatives, government policies, land management, and effectiveness of policy enforcement could be helped by regional agreements to deter transboundary leakage and invite international investment. Resource disparities within and between provinces exist and are exacerbated by competition between the local peoples, private industry, and government institutions. Such conditions often result in an inability to manage LCLUC and to address the economic imbalance within nations and throughout the region.

LCLUC Workshop Training

Directly after the meeting, from November 9-11, 2011, two concurrent workshops, organized in collaboration with local universities, were held to train participants in LCLUC analysis, with emphasis on combining remote sensing, ground, and census data to describe afforestation, deforestation, and urban sprawl—all of which are major land-cover changes occurring in the area.

The first workshop, cohosted by the VFU and the Vietnamese Ministry of Agriculture and Rural Development (MARD), addressed remote-sensing and field-based estimation of C-stocks in tropical forests. More than twenty scientists from Vietnam, Indonesia, China, Thailand, Laos, Russia, and the U.S. participated in the training. This two-day gathering included both training in field-based data collection and computer laboratory work on remote sensing analytical techniques to quantify carbon in forest and agroforestry systems. On the first day of the workshop, participants collected field data in Bac Giang province, approximately 100 km (~62 mi) northeast of Hanoi; this area offers a complex, mosaic landscape of annual dryland

crops such as cassava and soybean, litchi orchards, wetland rice, and forested areas consisting of both production and protection forests. Land devoted to litchi production in Bac Giang has increased significantly since the mid-1980s. Reforestation for both production and protection forests has also increased over the past ten years. These landscape transitions over the past 20–30 years have resulted in higher landscape C-stocks, as long-lived woody perennials replace annual crops and degraded shrub land.

For the field component of the training, participants established biomass data collection plots in a litchi orchard and an acacia plantation. They also recorded GPS locations; examined canopy openness with a digital camera's fish-eye lens; and recorded tree biometric data with 30-m (~98-ft) tapes (to measure crown diameters), diameter breast height measurement tapes, and laser hypsometers. These data were used to cross-calibrate the measurement approaches and to validate the automated tree-crown area and forest fractional-cover products derived from remotely sensed satellite data, as well as to calculate biomass and carbon by using the tree biometry data. The laboratory training, held at the VFU on the second day of the workshop, included hands-on processing of Landsat ETM+ data for vegetation fractional cover as well as geographic information systems (GIS)

transformation of the tree-crown area output data (from high-resolution data) to polygon shapefiles; associated Carbon stock values were derived from a tree-crown-to-biomass allometric equation. This allometric equation was recently developed by MSU's Department of Forestry, VFU, and MARD. **David Skole** and **Jay Samek** [MSU] led the workshop with support from **Phung Van Khoa** [VFU] and **Do Xuan Lan** [MARD].

The second workshop session was led by **Jeff Fox** [EWC], and focused on training the eleven participants in mapping peri-urbanization with remote sensing and census data. The goal of this training was to teach two methods for mapping peri-urbanization. The training included lectures, discussions, hands-on computer exercises, and map-validating ground measurements. On the first day, participants learned methods for exploratory data analysis and visualization of census data. On the second day, participants learned methods for satellite image classification and change detection using the geospatial imagery processing and analysis application, ENVI. To complete the analysis, the participants traveled to three nearby communes that represented rural (Phu Dong), urban (Phuc Loi), and peri-urban (Co Bi) landscapes for ground measurements of the map classifications. ■



Carbon training workshop participants beginning field measurements in the Bac Giang province.

LANCE User Working Group Meeting Summary

Kevin Murphy, NASA's Goddard Space Flight Center, kevin.j.murphy@nasa.gov

Chris Justice, University of Maryland, College Park, justice@hermes.geog.umd.edu

Dawn Lowe, NASA's Goddard Space Flight Center, dawn.r.lowe@nasa.gov

Martha Maiden, NASA Headquarters, martha.e.maiden@nasa.gov

Diane Davies, Sigma Space, ddavies@iluci.org

The second Land Atmosphere Near-real-time Capability for EOS (LANCE) User Working Group (UWG) meeting was held on February 7-8, 2012, at the Holiday Inn Capitol in Washington, DC. LANCE is the near-real-time (NRT) component of the Earth Observing System Data and Information System (EOSDIS) that provides data and imagery from the Aqua, Terra, and Aura satellites to various end users—including the applications user community, scientists (see *Sidebar* on page 14) and operational agencies. Summaries of the first LANCE workshop, held in December 2009, and the first UWG meeting, held in November 2010, can be found in previous issues of *The Earth Observer*¹ or online at earthdata.nasa.gov/data/nrt-data/user-community/user-working-group-uwg.

The LANCE UWG is composed of representatives of the LANCE *user community*—comprising application developers, operational agencies, universities, and non-governmental organizations. The group provides advice to and helps steer future development of the LANCE program. In addition to UWG members or their designated alternates, other members of affiliated groups attended the meeting—either in person or online—representing NASA Headquarters (HQ), the Earth Science Data and Information System (ESDIS), and representatives of the LANCE elements mentioned above.

These user-community representatives gathered to address the primary objectives of the two-day meeting, which were to:

- Present current LANCE status and development activities;
- review the status of previous UWG actions;
- identify and discuss potential enhancements and upgrades to the LANCE system; and
- provide recommendations for future efforts.

To address these points, the two-day meeting was organized into presentations given by representatives from NASA HQ, ESDIS, and UWG, and an open session,

to discuss system changes and upgrades. The meeting closed with recommendations for future work.

Kevin Murphy [NASA's Goddard Space Flight Center (GSFC) ESDIS] opened the meeting, welcoming the attendees, identifying the scope and objectives of the meeting, and providing an overview of LANCE. **Martha Maiden** [NASA HQ] then highlighted the importance of UWGs generally, to provide necessary feedback and guidance for all components of EOSDIS.

Chris Justice [University of Maryland, College Park—LANCE UWG Co-Chair] said that the goal of LANCE is to get NASA data out to the user community quickly, noting, for instance, that for the agricultural monitoring community, timely delivery of NRT data is critical for effective crop monitoring. In this regard, he noted that from the users' perspective, LANCE is one of NASA's "big successes." After giving this context, he then asked the UWG to consider the following questions:

- How does LANCE build on previous investments made by NASA in the various Earth Observing System (EOS) mission and instrument science teams to develop products needed by the science community?
- How can rapid access to data from the LANCE program benefit society as a whole?
- How might we maintain and increase support for LANCE by the science community?

Justice also asked that when proposing recommendations, the UWG should try to represent the general needs of the broader user community, rather than their individual projects.

Brad Doorn [NASA Headquarters (HQ)—*Program Manager for Agriculture, Carbon, and Water Applications*] finished the morning's session with an overview of NASA's Applied Science Program and the applications context for the LANCE system, specifically. The program's strategy is *to discover and demonstrate Earth science applications to serve society*; the strategy is being achieved by:

- Enhancing applications research;
- increasing collaboration to leverage resources and to extend the program's reach and impact; and

¹ The summaries of the two meetings mentioned here can be found in the March-April 2010 issue [Volume 22, Issue 2, pp. 18-20] and the March-April 2011 issue [Volume 23, Issue 2, pp. 35-38] respectively.

- accelerating the process of identifying needed applications early in the mission lifecycle.

After the general section, **Kevin Murphy**, **Diane Davies**, and **Ryan Boller** [All from ESDIS] described key LANCE metrics, progress, user interactions, and new capabilities developed since the last UWG meeting. Accomplishments during this period include:

- Consistently meeting the three-hour *latency*² requirement for product generation;
- implementing of new/enhanced NRT products;
- making advances in data distribution;
- integrating/extending LANCE capabilities into the Moderate Resolution Imaging Spectroradiometer (MODIS) Rapid Response System;
- developing a Web Mapping Service (WMS) prototype, a Global Image Browse System (GIBS), and a new LANCE website; and
- establishing outreach activities at various venues to better inform the user community about LANCE.

To learn more about the latest LANCE capabilities, visit: earthdata.nasa.gov/lance.

Kevin Murphy then discussed recent upgrades to LANCE. These include:

- Integrating the LANCE website into the EOSDIS website—earthdata.nasa.gov—to leverage and coordinate EOSDIS-wide capabilities (e.g., science and NRT data);
- making the transition from the prototype LANCE User Registration System (URS) to an EOSDIS-wide URS;
- establishing enhancements to GIBS to allow direct access to the LANCE WMS;
- using the LANCE *datacasting* prototype to populate the EOS Clearing House (ECHO) metadata repository with NRT metadata; and
- integrating the Fire Information for Resource Management System (FIRMS) into LANCE/Earthdata by Spring 2012.

The UWG then welcomed two new members, who gave presentations on their use of LANCE NRT data. **Chris Vaughan** [Federal Emergency Management Agency (FEMA)] provided an overview of the geospatial resources they currently use; he reported that LANCE data would be an important added feed. **Mark Trice** [Maryland Department of Natural Resources] showed how they routinely use LANCE imagery and data to help monitor tidal water quality in the Chesapeake Bay.

The late afternoon session dealt with ground system upgrades and data continuity issues. **Bruce McLemore** [GSFC/Honeywell Technology Solutions Inc.—*EOS Data and Operations Systems (EDOS) Project Manager*] provided a summary of EDOS ground system upgrades that have helped reduce product latency by 15–30 minutes within the past year. EDOS plans to evaluate the potential for further latency reduction by testing ground station support at McMurdo Station in Antarctica, and by implementing a new “hybrid” architecture to decrease wide-area-network transfer time. These upgrades will clearly benefit not only LANCE, but future missions, as well.

Jim Gleason [GSFC—*Suomi National Polar-orbiting Partnership (Suomi NPP) Project Scientist*] presented a summary of the status of Suomi NPP; **Diane Wickland** [NASA HQ—*Terrestrial Ecology Program Scientist*] commented on data policy. NOAA is responsible for NPP data processing, production, distribution, and archive of Suomi NPP Sensor Data Records (SDRs) and Environmental Data Records (EDRs). The NASA science teams are evaluating SDRs and EDRs and recommending algorithm improvements to meet NASA science data needs. Since the Joint Polar Satellite System (JPSS) program is responsible for data quality, any questions regarding latency for NRT algorithms should be addressed to them. **Chris Justice** said that the Visible Infrared Imager Radiometer Suite (VIIRS) Science Team meeting, planned for June 2012, would be critical to allow users to voice needs that are not being met by the current system. He also wanted to make sure that NASA was aware of potential Suomi NPP NRT products that could meet the needs of the LANCE community.

Helen Conover [University of Alabama at Huntsville] presented information on the status of the Advanced Microwave Scanning Radiometer–EOS (AMSR-E) aboard the Aqua satellite. Data collection from AMSR-E stopped after an instrument anomaly in the fall of 2011. The Japan Aerospace Exploration Agency (JAXA) would like to restart AMSR-E near the scheduled launch of the Global Change Observation Mission–Water (GCOM-W1) satellite in May 2012 to calibrate AMSR2 (onboard GCOM-W1) with AMSR-E. Approval to resume AMSR-E operations will be made in

² For LANCE products, *latency* is defined as the difference in time between instrument observation and product availability for download and use.

collaboration with all Aqua components and the flight team. LANCE will restart production of AMSR-E NRT products if the health of the AMSR-E instrument and quality of its data products are acceptable.³

After these presentations, the UWG members were given the opportunity to provide comments on and to ask

³ UPDATE: NASA's Earth Science Mission Operations (ESMO) and the Japan Aerospace Exploration Agency (JAXA) collaborated in a successful effort to restart the Advanced Microwave Scanning Radiometer for EOS (AMSR-E) on February 6, 2012. Discussions are underway regarding whether to resume rotation of the instrument, and if so, when, and at what speed.

questions about LANCE products, services, and status in the context of the previous presentations. A question-and-answer session between UWG members and LANCE management followed, providing an opportunity to discuss program progress, next steps, and recommendations for the coming year.

The UWG agreed to meet every six months, alternating a telecon and a face-to-face meeting every year.

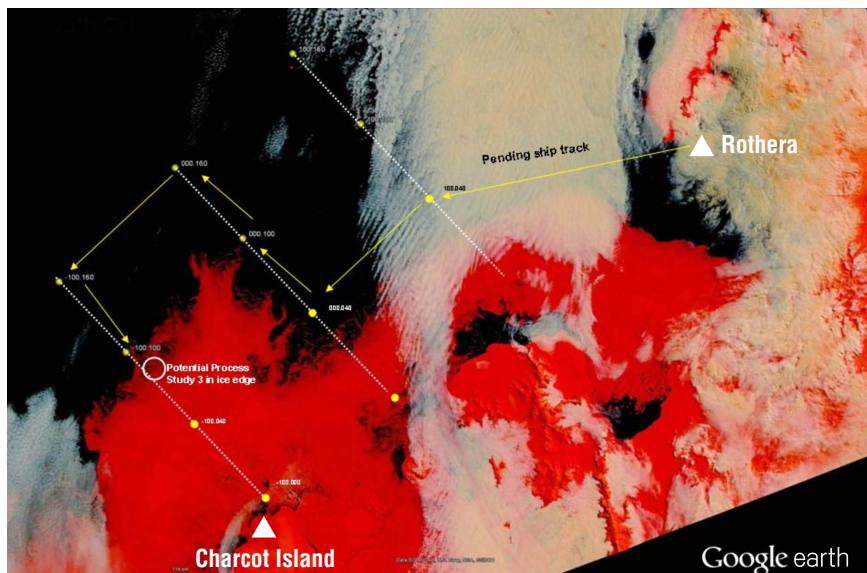
Materials from this meeting are available online at earthdata.nasa.gov/data/nrt-data/user-community/user-working-group-uwg. ■

An Example of LANCE Data in Use: Supplying Ships in Antarctica with the Latest Ice Conditions

Antarctica is the world's largest ice sheet and is surrounded by ice formed directly from ocean water. This sea ice can seasonally break up, providing an inconvenience (at least) for scientific vessels and a definite hazard for shipping. Near-real-time images from the Moderate Resolution Imaging Spectroradiometer (MODIS) provided by LANCE are being used in combination with other data to provide ships in the Antarctic with up-to-date information on ice conditions. **Paul Morin** [Polar Geospatial Center (PGC)] showed the group a practical example of how useful PGC finds LANCE MODIS imagery for advising ships of ice conditions in remote areas.

On January 19, 2012, Morin received the following request from the U.S. Antarctic Program's Antarctic Research and Supply Vessel, *Laurence M. Gould*. "We're trying to figure out where to go after we depart Rothera Sunday morning. Normally we would shoot straight to Charcot Island, but it seems to be deep in the ice, so an idea where the ice is, relative to our outer line stations, would really help."

Paul and his team at the PGC took a MODIS image (created by combining information from Bands 3, 6, and 7) that differentiates clouds from snow and ice, overlaid it on a *Google Earth* scene [above], and provided it to the science team on the *Gould*. Equipped with that information, they could plot a sampling route that saved time and money by avoiding the need to reduce speed to maneuver around sea ice. This is now a standard product used by the U.S. Antarctic Program fleet.



Shown here is a *Google Earth* map of sea ice in the Antarctic on January 19, 2012. By combining information from MODIS Bands 3, 6, and 7 it is possible to differentiate sea ice from clouds. Red shades indicate ice, while tan shades indicate clouds. Such information can be overlaid in *Polar View*, an earth observation portal that combines the latest satellite imagery for the poles. These data are routinely used to help ships safely plot their course through icy waters. **Image credit:** Paul Morin

Working with Suomi NPP VIIRS Data in ENVI and IDL

Mark Piper, Exelis Visual Information Solutions, mark.piper@exelisvis.com

*The inclusion of this article in **The Earth Observer** is meant to convey information on a seminar conducted at GSFC by a for-profit company that may be of interest to our readers—particularly the applications pertaining to the Suomi NPP Mission. It does **NOT** however imply our endorsement of these products.*

The Visible Infrared Imager Radiometer Suite (VIIRS), onboard the Suomi National Polar-orbiting Partnership (Suomi NPP) satellite, began acquiring data on November 21, 2011. The VIIRS instrument will collect visible and infrared views of dynamic processes at Earth's surface—such as wildfires, land changes, and ice movement—as well as data on clouds and sea-surface temperatures. In light of these new data, representatives from Exelis Visual Information Solutions (Exelis VIS) worked in coordination with **Dan Slayback** [NASA's Goddard Space Flight Center (GSFC)] to host a seminar on how to use Exelis VIS's industry-standard ENVI geospatial imagery analysis software and its powerful scientific programming language, IDL, to access and work with Suomi NPP VIIRS datasets. The seminar took place on March 16, 2012, with approximately 60 personnel from GSFC attending.

Guest speaker **Richard Ullman** [National Oceanic and Atmospheric Administration (NOAA)/NASA's Joint Polar Satellite System (JPSS) Ground Segment Project] opened the seminar with a summary of how Suomi NPP data will be distributed, explaining that all processed Suomi NPP data products will be delivered as Hierarchical Data Format 5 (HDF5) files. Ullman described the architecture of these files, focusing on the structure of NPP Level 1-B data—known as *Sensor Data Records* (SDR)—and Level-2 (or swath data)—known as *Environmental Data Records* (EDR). Each SDR or EDR may package multiple data products that share the same geolocation and temporal range. To maximize storage efficiency for NPP data products, floating point data are stored as unsigned integers with scale and offset factors. Most data products also include multiple bitpacked quality flags for each data element. Ullman concluded with an overview of the available VIIRS SDR/EDR products, including Imagery (I-) Band and Moderate-resolution (M-) Band data, as well as how to acquire these data from the NOAA Comprehensive Large Array-data Stewardship System (CLASS) server, accessible at www.class.noaa.gov.

Mark Piper [Exelis VIS] showed how to use IDL to read, analyze, and visualize VIIRS data, using a single I-band EDR downloaded from CLASS, which contained I-Bands 1-5 and georeferencing information.

He first demonstrated an IDL graphical tool that **Michael Galloy** and **David Fillmore** [Tech-X Corporation (Tech-X)] developed to browse the datasets contained in a VIIRS file. With a series of short programs, Piper then showed the group how to use IDL's HDF5 library to extract reflectance data—with their scale factors—from a VIIRS file and then construct an I-band (combining Bands 3, 2, and 1) false-color composite image. This band combination is similar to a Landsat 7 (5,4,3)-band false-color composite, which emphasizes vegetation. With another program, Piper adapted parts of a Landsat 7 cloud-cover algorithm to create a cloud mask for the scene using only the I-band data. He finished with a demonstration of a tool written in IDL to overlay the cloud mask on the false-color composite image, using the tool to control the transparency of the mask to visually assess its accuracy—see **Figure 1**. IDL's built-in HDF5 library, analysis routines, and visualization tools provide a straightforward approach to work with VIIRS data.

Thomas Harris [Exelis VIS] described how data access limitations must be overcome to allow wider application of geographic information systems (GIS) within the scientific community. He proposed a solution using IDL's built-in data format libraries to access data, and then to pass those data to ENVI and *ArcGIS* (a popular GIS developed by Esri) for downstream analysis, product creation, and dissemination. Harris used a programmatic extension to ENVI 5 that incorporated Piper's IDL programs to interactively read the I-band data from the VIIRS EDR; the extension could also be used noninteractively, in batch mode. Harris then used ENVI's built-in tools to quickly subset and *georectify* the data, visualizing the result as an I-band false-color composite image—see **Figure 2**. The large library of ENVI's prebuilt geospatial tools handle projecting, correctly displaying, and visualizing VIIRS data in a quick and efficient manner.

Seminar Outcomes

The seminar provided participants with an overview of the structure of Suomi NPP data files, IDL programs to read and visualize those data, and a demonstration of how to use ENVI to extend IDL by subsetting and georectifying VIIRS imagery data.

All seminar materials, including slides from the three presenters and example ENVI and IDL programs, can be downloaded from: exelisvis.com/esg/Seminars.aspx. For more information on ENVI and IDL, visit: exelisvis.com.

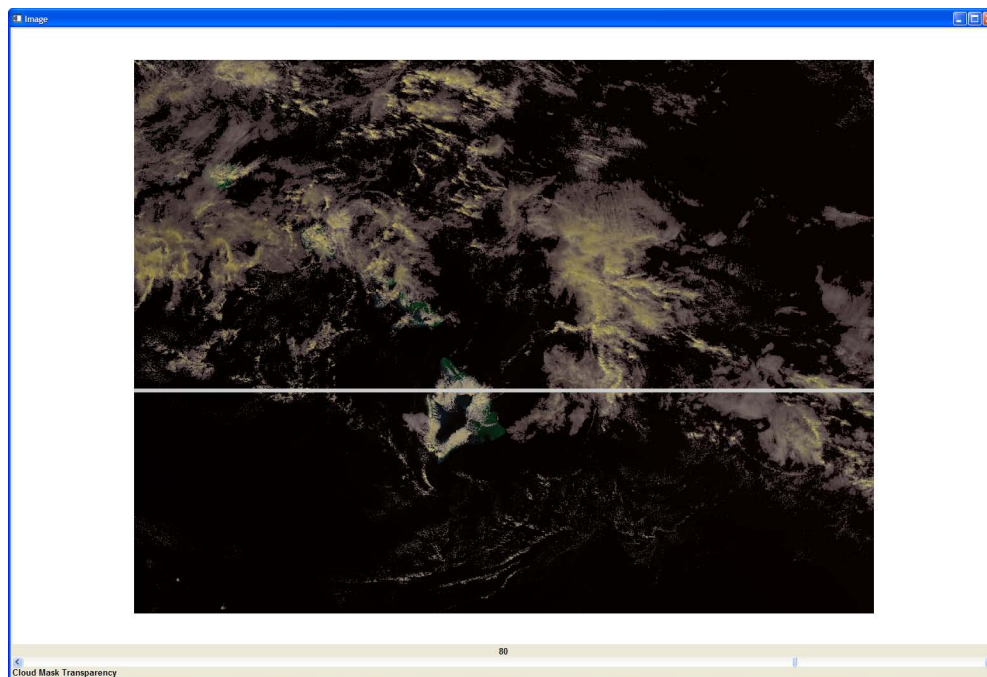


Figure 1. A false-color composite Suomi NPP VIIRS image and cloud mask, displayed using IDL. Image credit: NASA

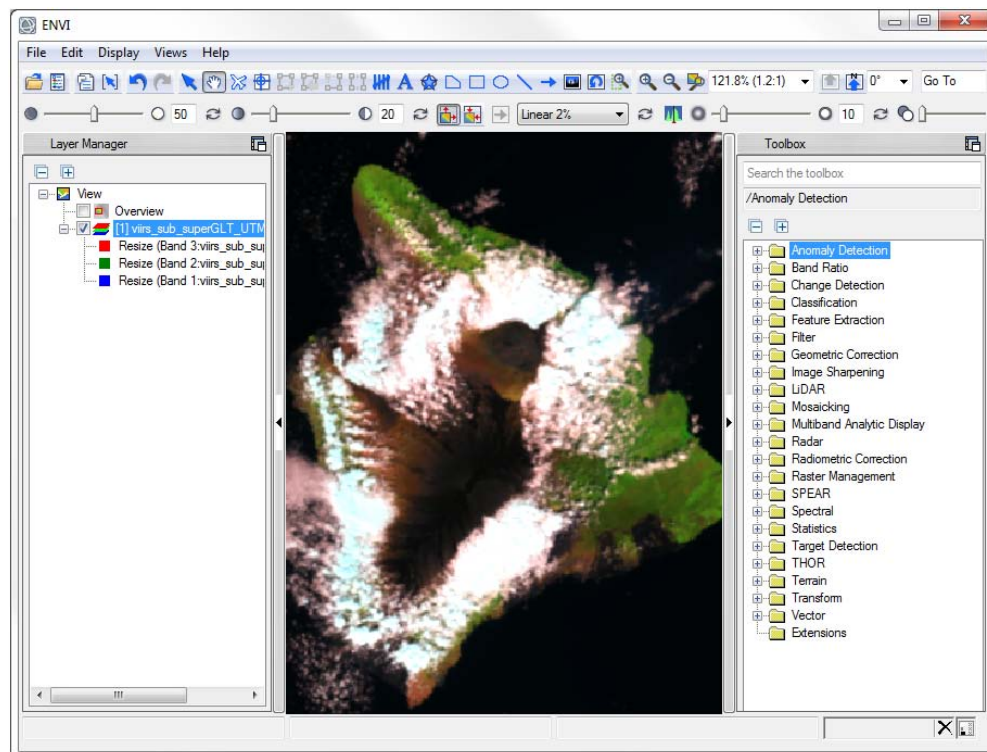


Figure 2. False-color composite Suomi NPP VIIRS imagery, georectified and displayed in ENVI. Image credit: NASA

Warm Ocean Currents Cause Majority of Ice Loss from Antarctica

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

Maria-Jose Vinas, NASA's Goddard Space Flight Center, mjvinas@nasa.gov

Warm ocean currents attacking the underside of ice shelves are the dominant cause of recent ice loss from Antarctica, a new study using measurements from NASA's Ice, Cloud, and land Elevation Satellite (ICESat) revealed.

An international team of scientists used a combination of satellite measurements and models to differentiate between the two known causes of melting ice shelves: 1) warm ocean currents thawing the underbelly of the floating extensions of ice sheets; and 2) warm air melting them from above. The finding, published April 26, 2012 in *Nature*, brings scientists a step closer to providing reliable projections of future sea-level rise.

The researchers concluded that 20 of the 54 ice shelves studied are being melted by warm ocean currents. Most of these are in West Antarctica, where inland glaciers flowing down to the coast and feeding into these thinning ice shelves have accelerated, draining more ice into the sea and contributing to sea-level rise. This ocean-driven thinning is responsible for the most widespread and rapid ice losses in West Antarctica, and for the majority of Antarctic ice sheet loss during the study period.

"We can lose an awful lot of ice to the sea without ever having summers warm enough to make the snow on top of the glaciers melt," said the study's lead author **Hamish Pritchard** of the British Antarctic Survey in Cambridge, United Kingdom. "The oceans can do all the work from below."

To map the changing thickness of almost all the floating ice shelves around Antarctica, the team used a time series of 4.5 million surface height measurements taken by a laser instrument mounted on ICESat—spanning October 2003–October 2008. They measured how the ice shelf height changed over time, and ran computer models to discard changes in ice thickness because of natural snow accumulation and compaction. The researchers also used a tide model that eliminated height changes caused by tides raising and lowering the ice shelves.

"This study demonstrates the power of space-based, laser altimetry for understanding Earth processes," said **Tom Wagner** [NASA Headquarters—*Cryosphere Program Manager*]. "Coupled with NASA's portfolio of other ice sheet research using data from our GRACE mission, satellite radars, and aircraft, we get a compre-

hensive view of ice sheet change that improves estimates of sea-level rise."

Previous studies used satellite radar data to measure the evolution of ice shelves and glaciers, but laser measurements are more precise in detecting changes in ice shelf thickness through time. This is especially true in coastal areas. Steeper slopes at the grounding line, where floating ice shelves connect with the landmass, cause problems for lower-resolution radar altimeters.

ICESat was the first satellite specifically designed to use laser altimetry to study the Earth's polar regions. It operated from 2003–2009. Its successor, ICESat-2, is scheduled for launch in 2016.

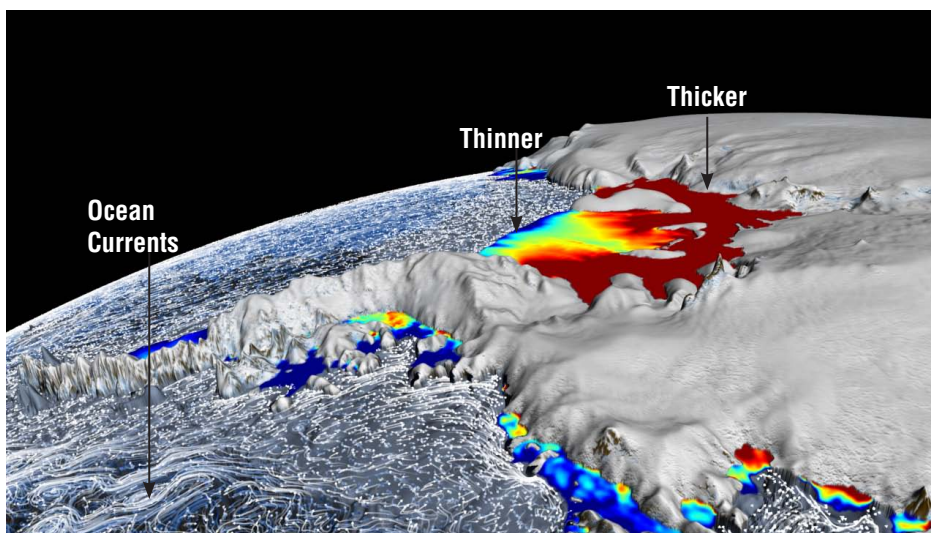
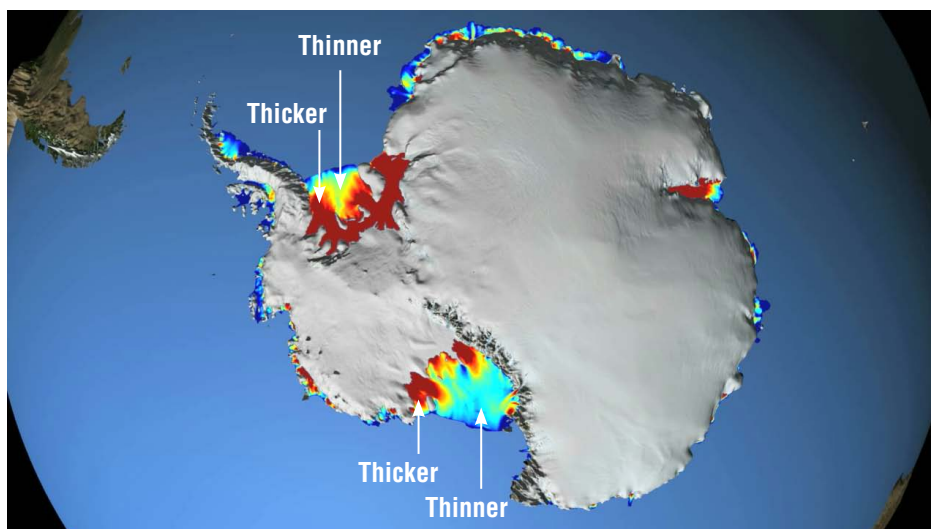
"This study demonstrates the urgent need for ICESat-2 to get into space," said **Jay Zwally** [NASA's Goddard Space Flight Center—*ICESat Project Scientist*]. "We have limited information on the changes in polar regions caused by climate change. Nothing can look at these changes like satellite measurements do."

The new research also links the observed increase in melting that occurs on the underside of a glacier or ice shelf, called basal melt, and glacier acceleration with changes in wind patterns.

"Studies have shown Antarctic winds have changed because of changes in climate," Pritchard said. "This has affected the strength and direction of ocean currents. As a result, warm water is funnelled beneath the floating ice. These studies and our new results suggest Antarctica's glaciers are responding rapidly to a changing climate."

A different picture is seen on the Antarctic Peninsula—the long stretch of land pointing towards South America. The study found that thinning of the largest ice shelf on the peninsula can be explained by warm summer winds directly melting the snow on the ice shelf surfaces. The patterns of widespread ocean-driven melting and summer melting on the Antarctic Peninsula can be attributed to changing wind patterns.

The study was carried out by an international team from the British Antarctic Survey, Utrecht University in Utrecht, Netherlands, the University of California in San Diego and the nonprofit research institute, Earth and Space Research in Corvallis, OR. ■



These images were taken from an animation that shows the circulation of ocean currents around the Western Antarctic ice shelves. The thickness of the shelves are indicated by shaded areas; red areas are thicker [greater than 550 m (~1804 ft)], while blue areas are thinner [less than 200 m (~656 ft)]. The animation can be viewed at www.nasa.gov/topics/earth/features/currents-ice-loss.html. **Image credit:** NASA's Goddard Space Flight Center, Scientific Visualization Studio

NASA Views Our Perpetual Ocean

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

The swirling flows of tens of thousands of ocean currents were captured in a scientific visualization created by NASA's Goddard Space Flight Center (GSFC).

“There is also a 20-minute long tour, which shows these global surface currents in more detail,” says **Horace Mitchell**, the lead of the visualization studio. “We also released a three-minute version on our *NASA Visualization Explorer* iPad app.”

Both the 20-minute and three-minute versions are available in high definition at svs.gsfc.nasa.gov/goto?3827

The visualization covers the period between June 2005–December 2007 and is based on a synthesis of a numerical model with observational data, created by a NASA project called Estimating the Circulation and Climate of the Ocean (ECCO). ECCO is a joint project between the Massachusetts Institute of Technology (MIT) and the NASA/Jet Propulsion Laboratory (JPL). ECCO uses advanced mathematical tools to combine observations with the MIT numerical ocean model to obtain realistic descriptions of how ocean circulation evolves over time.

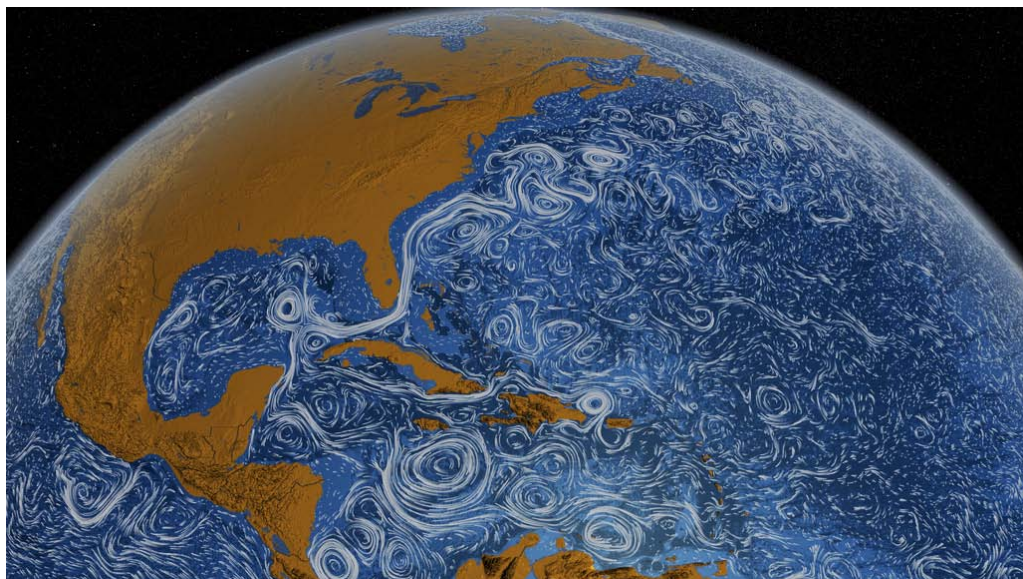
These model-data syntheses are among the largest computations of their kind ever undertaken. They are made possible by high-end computing resources provided by NASA's Ames Research Center (ARC).

ECCO model-data syntheses are being used to quantify the ocean's role in the global carbon cycle; to understand

the recent evolution of the polar oceans; to monitor time-evolving heat, water, and chemical exchanges within and between different components of the Earth system; and for many other science applications.

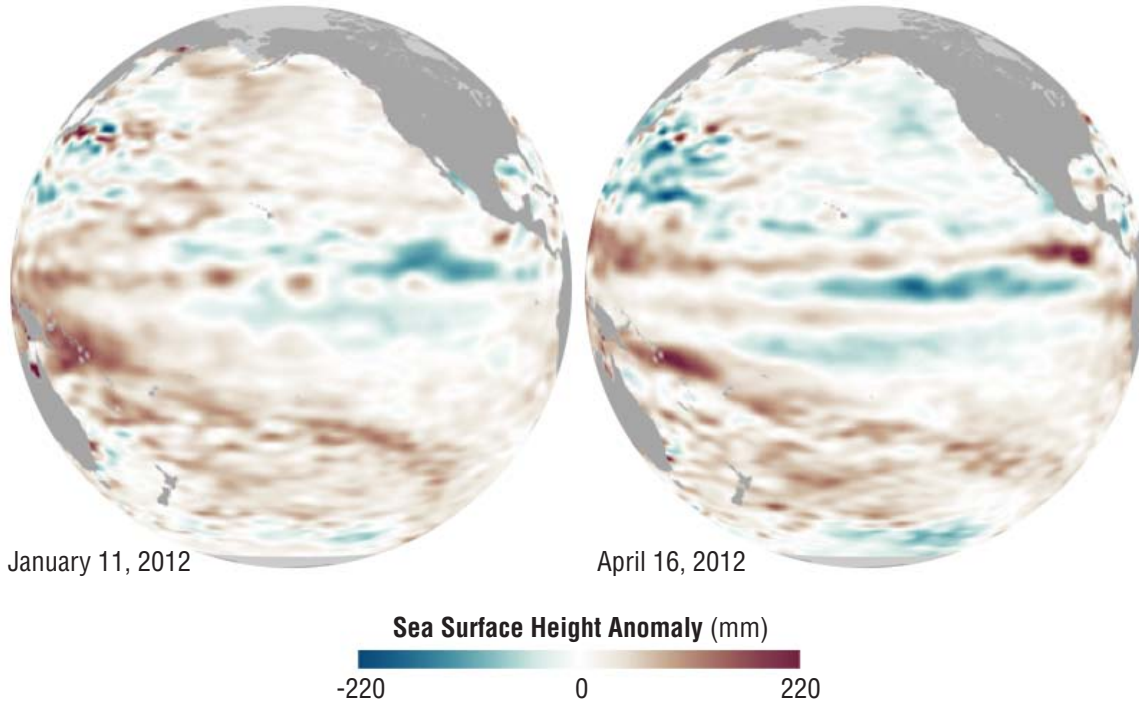
In the particular model-data synthesis used for this visualization, only the larger, ocean basin-wide scales have been adjusted to fit observations. Smaller-scale ocean currents are free to evolve on their own according to the computer model's equations. Due to the limited resolution of this particular model, only the larger eddies are represented, and tend to look more “perfect” than they are in real life. Despite these model limitations, the visualization offers a realistic study in both the order and the chaos of the circulating waters that constitute Earth's ocean.

Data used by the ECCO project include: sea surface height, from NASA's Topex/Poseidon, Jason-1, and Ocean Surface Topography Mission/Jason-2 satellite altimeters; gravity, from the NASA/German Aerospace Center, Gravity Recovery and Climate Experiment mission; surface wind stress, from NASA's QuikScat mission; sea surface temperature from the NASA/Japan Aerospace Exploration Agency, Advanced Microwave Scanning Radiometer-Earth Observing System; sea ice concentration and velocity data, from passive microwave radiometers; and temperature and salinity profiles, from shipborne casts, moorings, and the international Argo ocean observation system. ■



This image was taken from an animation of ocean surface currents from June 2005–December 2007. The visualization shows how bigger currents like the Gulf Stream in the Atlantic Ocean and the Kuroshio in the Pacific carry warm waters across thousands of miles at speeds greater than 4 mi/hr (~6 km/hr); how coastal currents like the Agulhas in the Southern Hemisphere move equatorial waters toward Earth's poles; and how thousands of other ocean currents are confined to particular regions and form slow-moving, circular pools called *eddies*. **Image credit:** NASA's Goddard Space Flight Center, Scientific Visualization Studio

La Niña Comes to a Close



After cooling the eastern-tropical Pacific for the second winter in a row—and teaming with other large-scale weather patterns to wreak havoc on North American winter—La Niña ended in April 2012. Researchers from the Climate Prediction Center of the U.S. National Weather Service reported on May 3 that the Pacific has transitioned to “*neutral* conditions, which are expected to continue through Northern [Hemisphere] summer 2012.”

La Niña and El Niño are alternating patterns of ocean and atmospheric circulation that have a distinct impact on weather around the Pacific basin. La Niña brings cooler waters and stronger trade winds to the tropical Pacific, boosting precipitation in western Pacific nations like Australia and Indonesia and drying out southern North America. The pattern can alter the path of the jet stream and other atmospheric phenomena.

These images depict sea surface height (SSH) anomalies for the Pacific Ocean in January and April 2012, as observed by the radar altimeter on the Ocean Surface Topography Mission (OSTM)/Jason-2 satellite. Blue shades show regions where the SSH is lower than the average, red shades show heights that are above average. Over yearly scales, the height of the ocean surface is driven by the temperature of the water—warmer water expands to a greater volume than cooler water—and by winds.

“Sea surface temperatures (SST) show the surface manifestation of La Niña and El Niño; this is what the atmosphere ‘feels,’” says **Bill Patzert** [NASA/Jet Propulsion Laboratory]. “Sea surface height shows how much heat has been redistributed in the equatorial Pacific. These are very complementary. SST shows what the atmosphere is responding to, while SSH shows how intense the event is.” **Credit:** NASA’s Earth Observatory



NASA Earth Science in the News

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

NASA Map Sees Earth's Trees in a New Light, February 17; *sciencedaily.com*. A NASA-led science team has created an accurate, high-resolution map of the heights of Earth's forests using lidar data from the agency's Ice, Cloud and land Elevation Satellite (ICESat). The map will help scientists better understand the roles forests play in climate change and how their heights influence wildlife habitats within them; it will also help scientists quantify the carbon stored in Earth's vegetation. "Knowing the height of Earth's forests is critical to estimating their biomass, or the amount of carbon they contain," said lead researcher **Marc Simard** [NASA/Jet Propulsion Laboratory (JPL)].

Calling Chicken Little: Clouds Getting Lower, February 24, *Wired News*. Cloud-top heights fell an average of 1% between March 2000–February 2010, according to measurements from the Multi-angle Imaging Spectroradiometer (MISR) mounted on NASA's Terra satellite. That 1% translates to a reduction of 30–40 m (–100–130 ft) in the average maximum cloud height during the decade studied. If there is indeed a consistent reduction in cloud height that isn't just due to natural variability, then Earth would begin losing heat to space more efficiently, reducing the surface temperatures and slowing the effects of climate change. "We don't know exactly what causes the cloud heights to lower," said lead author **Roger Davies** [University of Auckland]. "But it must be due to a change in the circulation patterns that give rise to cloud formation at high altitudes."

Loss of Arctic Sea Ice May Lead to Mercury Deposits: NASA Study, March 2, *Reuters*. A NASA-led study showed that significant declines in perennial Arctic sea ice over the past decade may intensify a chemical reaction that leads to deposits of toxic mercury. The study found that thick, perennial Arctic sea ice was being replaced by a thinner, saltier ice that releases bromine into the air when it interacts with sunlight and cold, said **Son Nghiem** [JPL].

Methane Gas Leak in Arctic Throws Scientists a Climate-Change Curveball, April 25, *U.S. News & World Report*. A newly discovered, naturally occurring meth-

ane leak over the Arctic Ocean could play a role in future climate change, according to postdoctoral fellow **Eric Kort** [JPL]. Scientists have long known that there are naturally occurring pockets of methane gas at many regions of the oceans' surfaces, but openings in Arctic sea-ice fields have allowed the gas to leak into the atmosphere. Kort says these leaks may play a "non-negligible" role in future global warming. "We didn't expect to see methane being emitted from the remote Arctic Ocean," Kort said.

***Warm Ocean Driving Antarctic Ice Loss**, April 25, *BBC News*. Most of the ice being lost from Antarctica is disappearing as a result of warm ocean water currents melting the fringes of the continent, scientists say. The researchers used a satellite-based laser to measure the thinning of ice shelves—the floating tongues of ice that jut out from the land. "What we realize now is that we're looking at a very sensitive system," says **Hamish Pritchard** [British Antarctic Survey (BAS)]. "Previously, you would have thought that we needed a lot of warming in the atmosphere to get a substantial loss of ice from Antarctica because it's such a cold place. But what we show is that that's not necessary; you don't need radical change." The BAS study was based on 4.5 million ice-elevation measurements from ICESat.

NASA Tests GPS Network to Monitor Earthquakes, April 26, *msnbc.com*. The satellite technology that allows the GPS components in your phone or car to provide location-based services could now have another purpose: NASA and other government agencies will see if it can be used to monitor and measure large earthquakes—see **Figure 1** on page 29. Studies have shown that high-precision, second-by-second measurements of ground displacements using GPS can reduce the time needed to characterize large earthquakes and to improve the predictions of subsequent tsunamis. This could help improve earthquake and tsunami early warning systems, particularly throughout the *Pacific Ring of Fire*—the areas of high tectonic activity bordering the Pacific Ocean—said **Craig Dobson** [NASA Headquarters—*Natural Hazards Program Manager*].

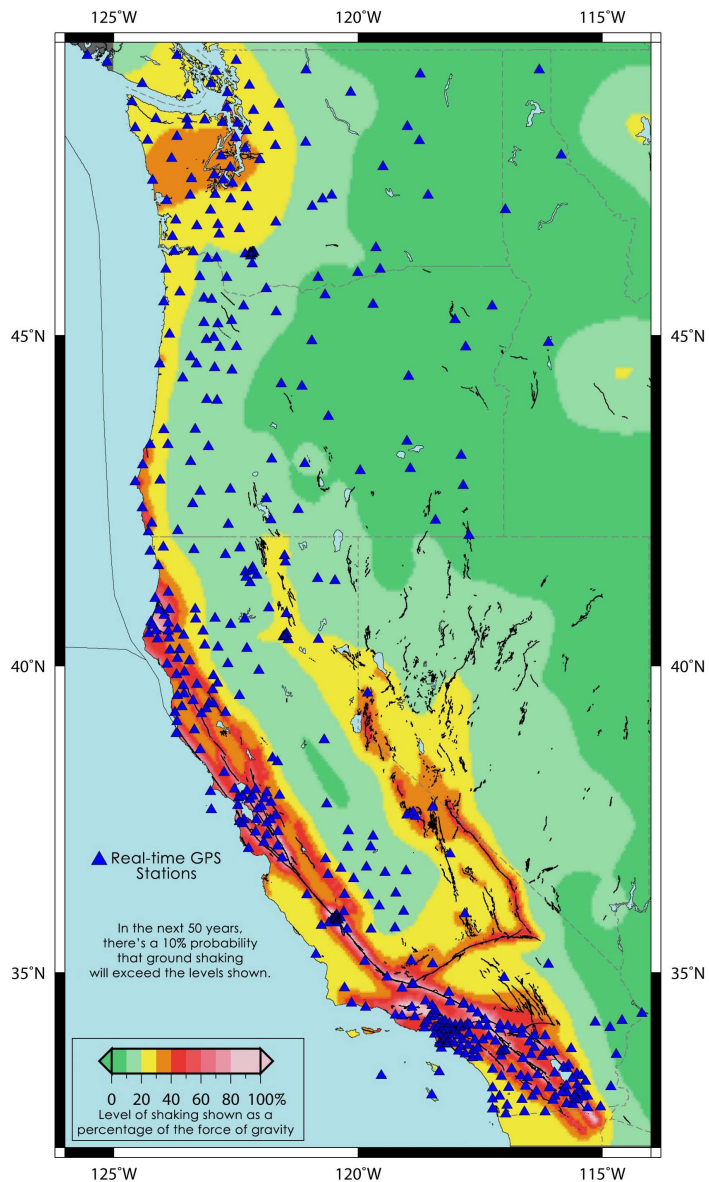
*See news story in this issue for more details.

Study Indicates a Greater Threat of Extreme Weather, April 25, *The New York Times*. New research suggests that global warming is causing the cycle of evaporation and rainfall over the oceans to intensify more than scientists had expected. This finding may indicate a higher potential for extreme weather in coming decades according to a new study led by **Paul Durack** [Lawrence Livermore National Laboratory]. By measuring changes in salinity on the ocean's surface, the researchers inferred that the water cycle had accelerated by about 4% over the last half-century. This amount is twice that

projected from computerized climate analyses. The article notes that NASA's Aquarius mission is well positioned to shed light on this topic.

*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. ■*

Figure 1. This map shows the location of more than 500 real-time GPS monitoring stations in the Western U.S. that make up the Real-Time Earthquake Analysis for Disaster Mitigation Network. The network's stations are overlain on a U.S. Geological Survey (USGS) seismic hazard map showing areas forecast to have a 10% probability of exceeding a certain level of ground shaking within the next 50 years. Red shading suggests stronger shaking. **Image credit:** USGS/University of California, Berkeley/ Scripps Institution of Oceanography



NASA Science Mission Directorate – Science Education and Public Outreach Update

Theresa Schwerin, *Institute of Global Environment and Society*, theresa_schwerin@strategies.org

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

NASA Postdoctoral Fellowships

Application deadlines—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 are awarded annually; appointments are renewable for up to three years. Annual stipends start at \$50,000, with supplements for specific degree fields and high cost-of-living areas. There is an annual travel budget of \$8,000; a relocation allowance; and financial supplement for health insurance purchased through the program.

Eligibility: An applicant must be a U.S. citizen; Lawful Permanent Resident, or foreign national eligible for J-1 status as a Research Scholar; and a recent or senior-level Ph.D. recipient.

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

My NASA DATA Lesson Plan 44: Think GREEN—Utilizing Renewable Solar Energy

My NASA Data on Atmospheric and Earth science for Teachers and Amateurs (DATA) has released a new lesson plan titled “Think GREEN—Utilizing Renewable Solar Energy.” Through this lesson plan, students use satellite data to determine the greatest potential for renewable energy resources in any given region. This process allows students—grades 7-12—to develop skills in constructing and reading graphs. Detailed procedures and materials, vocabulary linked to an online glossary, and teacher notes are provided at mynasadata.larc.nasa.gov/preview_lesson.php?&passid=78.

New “State of Flux” Gallery Available on NASA’s Global Climate Change Website

In celebration of this year’s Earth Day, NASA’s Webby-Award-winning Global Climate Change website has un-

veiled a new version of its popular image gallery, “State of Flux.” This gallery presents images, mostly from space, of our ever-changing planet, chronicling changes that take place over days to centuries. To view the gallery, visit: climate.nasa.gov/sof/Icedam_Alaska.jpg.

ESIP Teacher Workshop

July 17-18; Madison, WI

The Federation of Earth Science Information Partners (ESIP) invites teachers to attend a one-and-a-half-day workshop on Earth science education, with an integral strand dedicated to climate-change education. Participants will be able to choose from several breakout sessions that will demonstrate ways that Earth science tools and data can be used in science classrooms. Educators for grades 6-12 are eligible to receive a \$200 time-and-travel stipend. After the workshop, teachers are invited to stay for the ESIP conference plenary and poster reception. To register for the workshop, visit: www.regonline.com/Register/Checkin.aspx?EventID=1078265. To learn more about the ESIP summer conference, visit: esipfed.org/meetings.

Volunteer E/PO Coordinator for *Earthzine*

Earthzine is seeking a volunteer education and public outreach (E/PO) coordinator. *Earthzine’s* recent activities include an essay contest and virtual poster session, featuring students from NASA’s DEVELOP National Program. Responsibilities will include representing *Earthzine* across the E/PO community, coordinating contributions, and associated E/PO activities. *Earthzine* seeks an E/PO specialist with an interest in Earth science and experience with the international Earth-observation community. The successful candidate will be ambitious, love writing, and be an excellent communicator. This is a great opportunity to make contacts and to gain experience. Email a letter of interest with qualifications to **Paul Racette**, Editor-in-Chief at pracette@earthzine.org. To learn more about *Earthzine*, visit: www.earthzine.org. ■

EOS Science Calendar | Global Change Calendar

July 17–20, 2012

ESIP Federation Meeting, Madison, WI.
URL: www.regonline.com/Register/Checkin.aspx?EventID=1078265

September 17–21, 2012

GRACE Science Team Meeting, Potsdam, Germany.
URL: www.csr.utexas.edu/grace/GSTM

September 18–19, 2012

SORCE Science Team Meeting, Annapolis, MD.
URL: lasp.colorado.edu/sorce/news/meetings.htm

October 1–3, 2012

Aura Science Team Meeting, Pasadena, CA.
URL: *Not yet available*

October 16–18, 2012

HyspIRI Workshop, Pasadena CA.
URL: hyspiri.jpl.nasa.gov/events/2012-hyspiri-workshop

August 5–10, 2012

34th International Geological Congress, Brisbane, Australia. URL: www.34igc.org

August 6–10, 2012

2012 International Radiation Symposium: Current Problems in Atmospheric Radiation, Berlin, Germany. URL: www.irs2012.org

August 25–September 1, 2012

XXII Congress of the International Society of Photogrammetry and Remote Sensing, Melbourne, Australia. URL: www.isprs2012.org

September 11–14, 2012

ForestSAT 2012, Oregon State University, Corvallis, OR. URL: www.forestsat2012.com

October 6–12, 2012

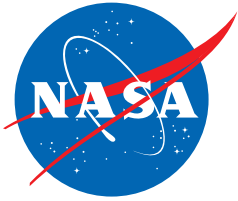
Land-Cover and Land-Use Change Dynamics and its Impacts in South Asia, Dehradun, India. URL: lcluc.umd.edu/meetings.php?mid=40

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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Articles, contributions to the meeting calendar, and suggestions are welcomed. Contributions to the calendars should contain location, person to contact, telephone number, and e-mail address. Newsletter content is due on the weekday closest to the 15th of the month preceding the publication—e.g., December 15 for the January–February issue ; February 15 for March–April, and so on.

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The Earth Observer Staff

Executive Editor:	Alan Ward (alan.b.ward@nasa.gov)
Assistant/Technical Editors:	Heather Hyre (heather.r.hyre@nasa.gov) Mitchell K. Hobish (mkh@sciential.com)
Technical Editor:	Tim Suttles (4suttles@bellsouth.net)
Design, Production:	Deborah McLean (deborah.f.mclean@nasa.gov)



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