National Aeronautics and Space Administration

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the earth observer

Editor's Corner

Steve Platnick
EOS Senior Project Scientist

On May 27, NASA announced five new aircraft missions, the first investigations that will be funded under the new *Venture Class* series. The Earth Venture (EV) missions were established last year, and are part of NASA's Earth System Science Pathfinder program. These relatively small missions provide targeted science investigations that complement NASA's satellite and research program. In 2007, as part of its Earth Science decadal survey report, the National Research Council recommended that NASA create these types of low-cost, regularly solicited, quick-turnaround projects, with a goal to foster innovation and provide a training ground for future space-based efforts. Although this year's selections are all airborne investigations, future Venture proposals plan to include small, dedicated spacecraft and instruments flown on other spacecraft.

The EV-1 missions will be funded for five years at a total cost of not more than $30M each. The cost includes initial development and deployment through data analysis. Approximately $10M was provided through the American Recovery and Reinvestment Act toward the maximum $150M funding ceiling.

The five missions chosen for funding were selected from 35 proposals submitted in response to the NASA EV-1 Research Announcement[1]. The selected proposals—which encompass research on hurricanes, air quality,

[1] The *ESSP Venture-class Science Investigations: Earth Venture-1* solicitation was announced in July 2009 as a new proposal opportunity funded under element A.39 of the 2009 NASA Research Announcement: Research Opportunities in Space and Earth Science (ROSES).

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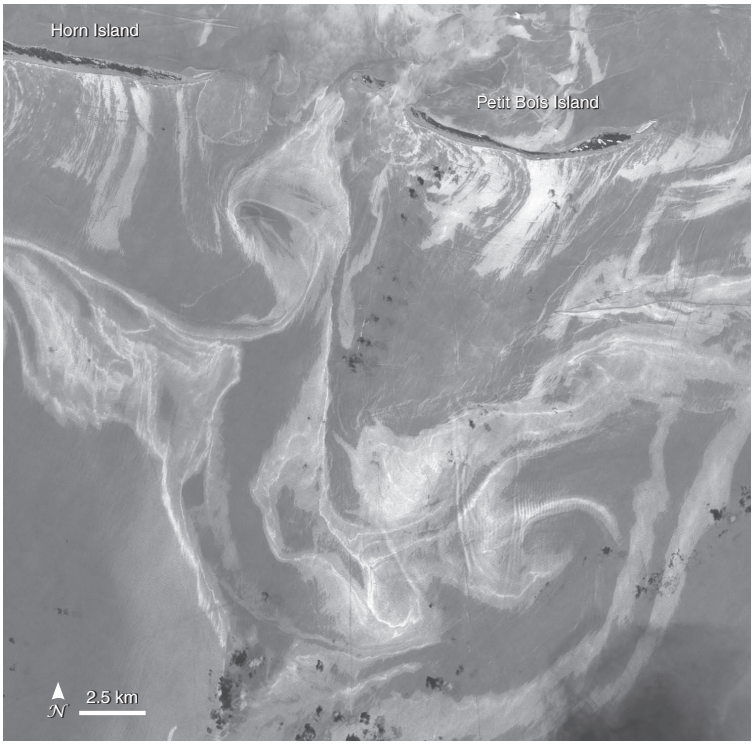
NASA Earth Observing-1 Satellite Sees Oil Slick Around Mississippi Barrier Islands

As of June 27, 2010, the entire gulf-facing beachfront of several barrier islands in eastern Mississippi (offshore of Pascagoula) had received a designation of at least *lightly oiled* by the interagency Shoreline Cleanup Assessment Team that is responding to the disaster in the Gulf of Mexico. A few small stretches of Petit Bois Island had been labeled heavily or moderately oiled.

This high-resolution image shows Petit Bois Island *[top right]* and the eastern end of Horn Island *[top left]* on June 26. In general, oil-covered waters are silvery and cleaner waters are darker gray. This pattern is especially consistent farther from the islands. The intensely bright patches of water directly offshore of the barrier islands, however, may be from a combination of factors, including sediment and organic material, coastal currents and surf, and oil. For more information and to view this image in color, please visit: *earthobservatory.nasa.gov/IOTD/view.php?id=44466.*

Credit: NASA's Earth Observatory and EO-1 Team



editor's corner

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In This Issue

Arctic ecosystems, and tropospheric–stratospheric exchange—include:

- *Airborne Microwave Observatory of Subcanopy and Subsurface* – Principal Investigator (PI): Mahta Moghaddam, University of Michigan;
- *Airborne Tropical Tropopause Experiment* – PI: Eric Jensen, NASA's Ames Research Center;
- *Carbon in Arctic Reservoirs Vulnerability Experiment* – PI: Charles Miller, Jet Propulsion Laboratory;
- *Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality* – PI: James Crawford, Langley Research Center; and
- *Hurricane and Severe Storm Sentinel* – PI: Scott Braun, Goddard Space Flight Center—*Project Scientist, Tropical Rainfall Measuring Mission*.

Collectively, the missions make use of NASA's Global Hawk, *Gulfstream-III*, and P-3B aircraft, as well as *King Air* B-200 and *Twin Otter* aircraft. Six NASA centers, twenty-two educational institutions, nine U.S. or international government agencies, and three industrial partners are involved in these missions. Congratulations to the awarded teams. We plan to provide more details on these Venture Class missions in upcoming issues of *The Earth Observer*.

In our last issue, we reported in detail on NASA's response to the oil spill in the Gulf of Mexico that resulted from the failure of the *Deepwater Horizon* rig on April 20. Efforts to contain the spill are progressing, but, as of this writing, the oil continues to hemorrhage from the well nearly a mile beneath the sea surface. NASA continues to support the effort to monitor this ongoing environmental disaster. According to **Michael Goodman**, Natural Disasters Program Manager in the Applied Sciences Program at NASA Headquarters, satellite observations from instruments aboard Terra, Aqua, CALIPSO, and Earth Observing-1 continue to monitor the extent of the slick. Since our last issue, additional aircraft flights have been flown, providing more detailed observations of the oil slick and the impact it is having on the shoreline and coastal wetlands[2].

- The NASA *Gulfstream-III* equipped with the JPL Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) flew three missions over the region on June 22-23 to study the use of radar for determining the extent of oil penetration into sensitive coastal ecological zones, in particular, to map the spread of oil from the coastline into coastal wetlands. The observations will also be used to develop and validate algorithms for improved discrimination of oil slicks on water and collect data that will enable us to better determine oil properties from radar backscatter returns.
- A Twin Otter aircraft equipped with the JPL Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) flew eight missions over the Gulf region from July 1-12 conducting both coastal ecosystem and oil spill observations—additional flights may

[2] See page 3 of the May–June 2010 issue of *The Earth Observer* [**Volume 22, Issue 3**] for more details on the satellite and aircraft observations mentioned here.

take place later this summer. This deployment was focused primarily on acquiring measurements to support science investigations into coastal ecosystem responses that are of interest to both NASA and U.S. Geological Survey scientists. Other flights were over the oil spill to understand the importance of the AVIRIS data to USGS scientists for development and refinement of algorithms to characterize oil spill properties and to provide information useful for response[3].

- A *King Air* B-200 equipped with the LaRC High Spectral Resolution Lidar (HSRL) and the GISS Research Scanning Polarimeter (RSP) flew two missions on July 9-10 to characterize the surface reflectance of the oil and the optical properties of smoke from two controlled oil burns. The data will be used to correlate and validate lidar measurements from the CALIPSO satellite.

A reminder that the international **A-Train Symposium** is planned for October 25-28 in New Orleans, LA. The "A-Train" (Afternoon Constellation) is an evolving formation of Earth observing satellites that allows coordinated multi-instrument measurements of the Earth system. The symposium, a follow-on to the first one held in Lille, France in October 2007, will provide an opportunity for new and veteran users to learn more about A-Train measurements and to engage colleagues with similar interests. This Symposium is structured along four themes:

- atmospheric composition and chemistry;
- aerosols, clouds, radiation, and the hydrological cycle;
- atmospheric, oceanic, and terrestrial components of the carbon cycle; and
- weather and other operational applications.

An additional objective of the symposium is to better inform new and present users on recent enhancements to A-Train data sets and subtleties related to their use. Because the instruments employ different measurement techniques, fusing the observations and/or data products can be challenging. Consequently, another important objective is to highlight key issues and strategies for combining the diverse measurements.

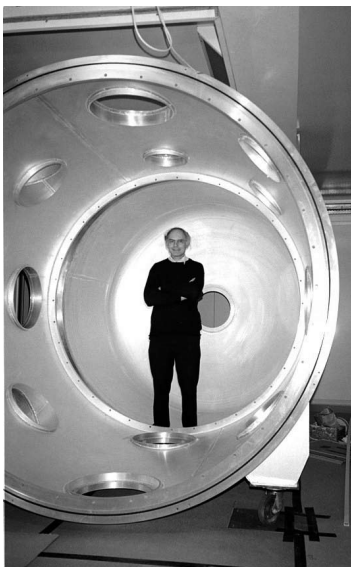
The meeting will begin with a one-day user workshop on October 25 focusing on instrument data products and their use. The remaining three days (October 26-28) will be dedicated to a symposium that will emphasize science capabilities and advancements realized through the A-Train multi-sensor system. General plenary sessions featuring invited speakers will take place each morning of the symposium. Afternoon sessions will be separated into the four theme areas for a limited number of focused oral presentations on data fusion and science analysis; a general poster session will be held each afternoon. A series of A-Train education and public outreach activities are being planned throughout the symposium as well.

Registration, abstract submission, and hotel information are available via the symposium web site at: *a-train-neworleans2010.larc.nasa.gov/*. Note that the deadline for abstract submissions is fast approaching—**August 15, 2010**. Travel assistance for students is available. Please plan to join us in the heart of New Orleans—just a few steps from the historic French Quarter—for this important meeting! ■

[3] AVIRIS previously flew on the high altitude *Lockheed* ER-2 during the period May 6-25 and was used to quantify the oil spill characteristics and surface oil flow rate. AVIRIS data was used by the National Incident Command's Flow Rate Technical Group to calculate the amount of oil on the surface of the ocean.

In Memoriam

John Barnett, U.K. Principal Investigator for the Aura High Resolution Dynamics Limb Sounder (HIRDLS) experiment, died peacefully at his home, surrounded by his family, on July 2 after a long illness. Barnett had a long history of involvement in space experiments at Oxford, going back to Nimbus 4, and in the use of data from these experiments in atmospheric investigations. He was an innovative experimenter, creating many inventions. At the beginning of EOS, NASA and the Natural Environment Research Council suggested that his Aura experiment be combined with a similar U.S. experiment. Barnett readily assented, and was an excellent colleague, rendering the resulting international partnership a resounding success. He led many areas of the design of HIRDLS, most notably the intricate sun-shields to prevent direct sunlight from entering the instrument aperture. He was also the driving force behind the calibration chamber at Oxford, and all the mechanisms and procedures used for the rigorous instrument calibration and characterization. After launch, Barnett led many analyses of data to understand what had happened, and worked extensively to command the instrument to improve its performance.



John with the HIRDLS calibration chamber

Barnett was a kind, witty, intelligent, and gentle person with a whimsical sense of humor, a skillful innovator with great scientific insights. The entire Aura team and *Earth Observer* staff mourns his passing.

feature articles

Aquarius: A Brief (Recent) History of an International Effort

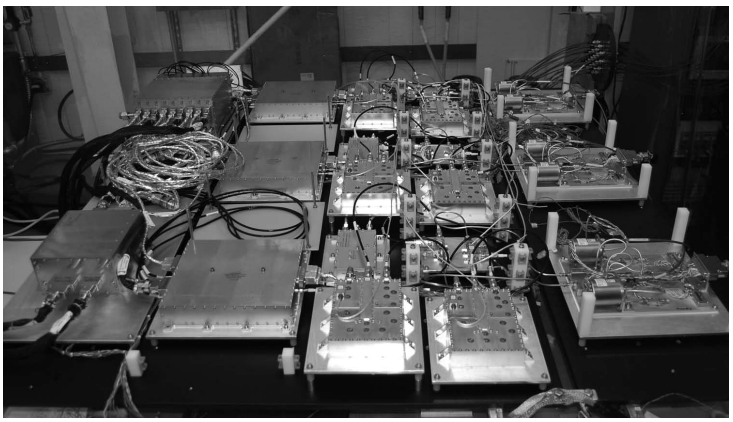
Annette deCharon, University of Maine, School of Marine Sciences, annette.decharon@maine.edu

The Aquarius instrument is making its journey towards launch onboard the SAC-D spacecraft in Spring 2011. This brief article provides an overview of the mission, Aquarius instrument status, selection of the science team, and "next steps" for the Aquarius/SAC-D observatory.

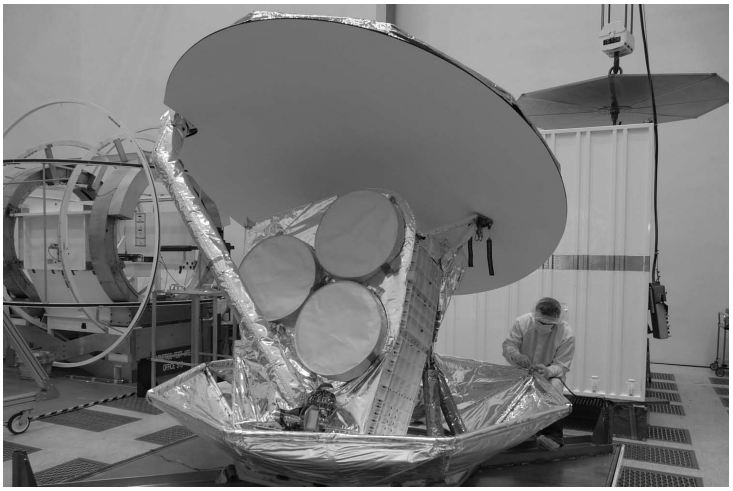
From Maryland to California to Argentina to Brazil and back to California for launch, Aquarius is making its way towards a sun-synchronous orbit 408 miles (657 kilometers) above Earth's surface. With its global perspective on sea surface salinity, Aquarius will provide information critical to improving our understanding of Earth's water cycle and ocean circulation.

Mission Overview

NASA and Argentina's Comisión Nacional de Actividades Espaciales (CONAE) are international partners on the Aquarius/Satélite de Aplicaciones Científicas (SAC)-D mission, scheduled to launch in Spring 2011. Aquarius/SAC-D will carry a suite of instruments into space onboard the Argentine-built spacecraft. NASA's sensor, Aquarius, is the primary instrument on the mission. Aquarius is designed to provide monthly global maps of how salinity varies on the ocean surface—variations in ocean salinity are a key indicator of ocean circulation and its role in climate change. Seven CONAE-sponsored instruments—including sensors from the French Space Agency (Centre National d'Etudes Spatiales) and another from the Italian Space Agency (Agenzia Spaziale Italiana)—will provide environmental data for a wide range of applications, including natural hazards, land processes, epidemiological studies, and air quality issues.



The Aquarius radiometer spent four years in development before it made its way from Goddard to JPL in January 2008. **Credit:** NASA



The Aquarius instrument in the JPL "clean room" prior to being air-shipped to Bariloche, Argentina in June 2009. **Credit:** JPL/Ban Tieu

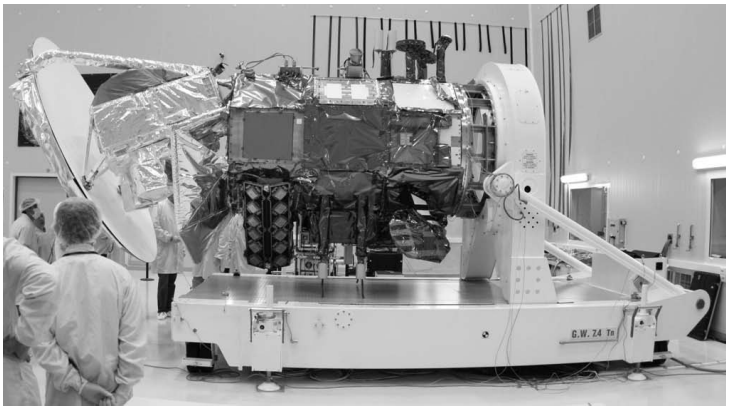
Aquarius Instrument Development, Test, and Integration

In January 2008, after a four-year development effort, NASA's Goddard Space Flight Center (GSFC) delivered the Aquarius radiometer to NASA's Jet Propulsion Laboratory (JPL) for integration with the instrument. The microwave radiometer (1.413 GHz; L-band) is sensitive to salinity and designed to be stable enough to achieve the required accuracy of 0.2 practical salinity units (psu) on a monthly basis.

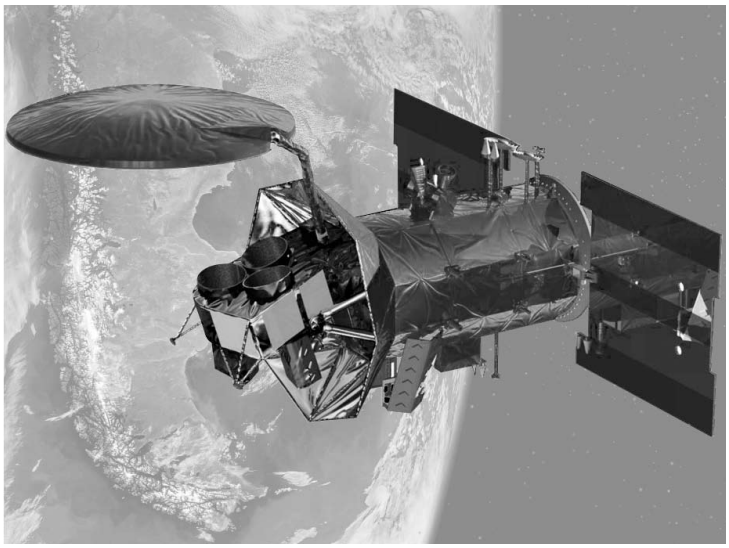
The Aquarius instrument also includes a scatterometer that will measure the *ocean surface roughness*—information required to adjust the radiometric data. Electrical and mechanical integration of the Aquarius instrument took place at JPL with a full functional test conducted during Summer 2008. In Fall 2008, the Aquarius boom and 2.5-meter reflector were mechanically integrated. Over subsequent months, a series of electrical, vibration, acoustic, and thermal tests took place at JPL. The Aquarius instrument was air-shipped to Bariloche, Argentina in June 2009 for integration with the SAC-D service platform.

International Science Team

In October 2009, the International Science Teams were selected for the Aquarius/SAC-D mission. NASA and CONAE conducted a joint solicitation and selection of scientific investigations and innovative application demonstration projects using Aquarius/SAC-D observations. Thirty projects were funded that included investigators from the U.S., Argentina, Chile, and Brazil. An additional ten proposals were selected from scientists in Italy and Japan. The primary focus of the selected projects is to prepare the scientific community to use Aquarius/SAC-D data to better understand the interactions between global ocean circulation, the water cycle, and Earth's climate. Several projects will concentrate on socioeconomic applications of the mission's observations in such areas as fisheries management, disease and flood forecasting, and monitoring volcanic eruptions and fires.



The Aquarius/SAC-D integrated observatory at INVAP before being transported to the INPE Integration and Testing Lab in Brazil in June 2010. **Credit:** JPL/Simon Collins



A visualization of the Aquarius/SAC-D spacecraft on orbit after launch. **Credit:** NASA

Integration of Aquarius with SAC-D

By the end of January 2010, the Aquarius electrical integration process at the INVAP—a technology company—facility in Bariloche, Argentina had reached several milestones. The Aquarius electrical interfaces had successfully been connected to the SAC-D Service Platform (S/P); the instrument was receiving power and commands from the S/P and Aquarius telemetry and high-rate data were being returned via the S/P. In April 2010, the JPL and INVAP integration teams successfully completed the mechanical installation of the Aquarius instrument onto the SAC-D spacecraft. Over a month of functional testing of the full observatory followed, including testing the performance of the Aquarius instrument in "continuous mission mode."

Next Steps

June 2010 marks the conclusion of the integration and test of the Aquarius instrument with the SAC-D spacecraft. The next stop is the Brazilian National Institute for Space Research's—Instituto Nacional de Pesquisas Espacias (INPE)—Integration and Test Lab, located in São José dos Campos (near São Paulo). At INPE, the Aquarius/SAC-D observatory will undergo its final environmental testing before the penultimate destination of its journey: Vandenberg Air Force Base in California. The launch of Aquarius/SAC-D onboard a *Delta II* rocket is scheduled for April 2011. Once on orbit, mission operations will be conducted at the CONAE ground station in Córdoba, Argentina. The Aquarius ground system will reside at GSFC, including instrument operations and data processing. GSFC will also manage the operations phase of the Aquarius mission.

For more information on Aquarius, please visit: *aquarius.nasa.gov*.

References: NASA Press Release (03.17.08), JPL Press Release 2009-149, Aquarius Project Reports.

feature articles

NASA Follows Nature Trail'R to Michigan

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The 2010 Odyssey of the Mind World Finals marked the tenth year NASA's Earth Observing System Project Science Office (EOSPSO) sponsored a long-term problem.

Students from all around the world gathered to participate in the 31st Odyssey of the Mind (OM) World Finals, a creative problem-solving competition held May 26-29 at the Michigan State University in East Lansing, MI. These students had advanced from competitions held earlier in the year at local, regional, state, or country levels and were in Michigan to compete for the title of World Champion.

The 2010 World Finals marked the tenth year NASA's Earth Observing System Project Science Office (EOSPSO) sponsored a long-term problem. This year's problem, *Nature Trail'R*, required teams to design, build, and drive a human-powered vehicle and camper to go on a camping trip. When the vehicle arrived at the campground, the camper had to be disconnected and then the vehicle had to travel on a team-created Nature Trail. On the Nature Trail, the vehicle had to overcome an obstacle, clean up the environment, encounter wildlife, and undergo a repair. The performance required the inclusion of a character that was in or near the camper that explained the experience as part of its role.

OM participants, coaches, and parents sample the outreach publications on display inside the NASA Science "Earth Tent." The Earth jigsaw puzzle is always a big hit with "students" of all ages. **Photo credit:** Mark Malanoski

NASA-featured activities at World Finals included a NASA Science exhibit at the Creativity Festival and the Earth Science *E-Theatre*[1]. The exhibit featured a large 40'x40' Earth Tent, the *Dynamic Planet* digital video globe, the *ViewSpace* multimedia presentation system, and a wide-array of outreach materials.

Over the past year, NASA supported OM's preliminary competitions by posting Earth science information on a special web site hosted on NASA's Earth Observatory—*earthobservatory.nasa.gov. The Earth Observatory* serves as a host to many teacher and student learning modules. Web links were provided to assist students in developing solutions to problems facing Earth.

Out of the 151 teams participating in *Nature Trail'R* at the World Finals, the following won top honors in their division:

Division 1

1st Place: Rea View Elementary School Team A—*Waxhaw, NC*
2nd Place: Horizon Elementary School—*Johnston, IA*

[1] The Earth Science E-Theatre is a dynamic theater-style presentation that showcases Earth observations and visualizations in high-definition format. The presentation features satellite launch animations, as well as visualizations made from NASA Earth science satellite data.

3rd Place: Poinciana Elementary School—*Boynton Beach, FL*
4th Place: Roguewood Elementary School—*Rockford, MI*
5th Place: Puckett's Mill Elementary School—*Dacula, GA*
6th Place: Antheil Elementary School Team A—*Ewing, NJ*

Division 2

1st Place: Foshan Jiujiang Town Middle School—*Guandong, China*
2nd Place: North Rockford Middle School Team B—*Rockford, MI*
3rd Place: Highland School—*Highland, WI*
4th Place: Gimnazjum NR 45 Warszawa—*Warsaw, Poland*
5th Place: Mill River Union High School—*North Clarendon, VT*
5th Place: Johnston Middle School—*Johnston, IA*
6th Place: McKinley Elementary School—*Elkins Park, PA*

Division 3

1st Place: Pine Bush High School—*Pine Bush, NY*
2nd Place: Charlotte Latin School Team A—*Charlotte, NC*
3rd Place: Bear River High School—*Grass Valley, CA*
4th Place: Charlotte Latin School Team B—*Charlotte, NC*
4th Place: Mission San Jose High School Team A—*Fremont, CA*
5th Place: Corunna High School—*Corunna, MI*
5th Place: J.P. Stevens High School Team C—*Edison, NJ*
6th Place: Sherburne Earlville High School—*Sherburne, NY*

Division 4

1st Place: Davenport University—*Grand Rapids, MI*
2nd Place: Penn State University—*State College, PA*

NASA reaches over two million students, teachers, parents, and coaches around the world through its sponsorship of an OM problem, stimulating interest in learning about Earth system science among all ages. The OM program, founded in 1978, is an international educational program promoting team effort and creative problem solving for students from kindergarten through college. Over 800 teams from the U.S. and other countries, including China, Poland, Canada, South Korea, Singapore, Mexico, and Germany, participated in the World Finals this year.

For the 2011 OM Competition, NASA's EOSPSO will sponsor **Problem 5**: *Full Circle*. To access the OM official web site, visit: *www.odysseyofthemind.com.* ■

NASA reaches over two million students, teachers, parents, and coaches around the world through its sponsorship of an OM problem, stimulating interest in learning about Earth system science among all ages.

Visitors patiently wait in line to enter the "Earth Tent" at OM's Creativity Festival.

NASA Celebrates the 40th Anniversary of Earth Day

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From April 17–25, 2010, NASA participated in the 40th anniversary celebration of Earth Day on the National Mall in Washington, DC. **Jack Kaye** [NASA Headquarters (HQ)—*Earth Science Division Associate Director*] opened the *NASA Village* with a ribbon cutting ceremony and some brief remarks in front of the Earth dome (see top photo below). Three tents—science, cinema, and technology—offered exhibits, multimedia presentations by NASA scientists, and hands-on demonstrations and activities. NASA's extensive involvement allowed the public to learn about how NASA science and technology are used to understand Earth and our environment.

Below are some image highlights of the nine-day celebration. To view more and/or these images in color, please visit the *ScienceAtNASA* gallery at: *www.flickr.com/photos/scienceatnasa/sets/*. The schedule of events that took place is available at: *www.nasa.gov/topics/earth/earthday/earthday_mall.html*.

On April 17, **Jack Kaye** and others kicked off NASA's involvement with a ribbon cutting ceremony. **Photo credit:** NASA/Ryan Barker

The *NASA Village* science tent featured hands-on demonstrations, activities, and handouts to illustrate the capabilities of Earth science research. Here, **Brent Holben** [Goddard Space Flight Center] staffs a demonstration on the Aerosol Robotic Network (AERONET). **Photo credit:** NASA/Chris Chrissotimos

Visitors line up to enter one of the *NASA Village* tents. **Photo credit:** NASA/Chris Chrissotimos

Contestants test their knowledge of Earth Science in a fun trivia game. **Photo credit:** NASA/Chris Chrissotimos

Visitors to the science tent spent some time putting together puzzles of the Earth to understand how data from satellites are processed to create visualizations. **Photo credit:** NASA/Chris Chrissotimos

Anita Davis [Goddard Space Flight Center—*Landsat Education and Outreach Coordinator*] interacts with students from one of the school groups that visited on Earth Day. **Photo credit**: NASA/Chris Chrissotimos

Visitors make tracings to examine the decline in Arctic sea ice over time. **Photo credit:** NASA/Chris Chrissotimos

Marit Jentoff-Nilsen [Goddard Space Flight Center] assists visitors with the *Dynamic Planet* exhibit. **Photo credit:** NASA/Chris Chrissotimos

Violinist **Kenji Williams** performs *BELLA GAIA* (Beautiful Earth) accompanied by stunning Earth imagery in the background. **Photo credit:** NASA/Chris Chrissotimos

During the final day of the event, **Tom Wagner** [NASA HQ—*Cryosphere Program Manager*] addresses the public during the Climate Rally held on the National Mall main stage venue. **Photo credit:** NASA/Chris Chrissotimos

feature articles

DEVELOP Students Use NASA Satellite Imagery to Monitor Gulf Coast Disasters

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DEVELOP, part of NASA's Applied Sciences Program, is challenged with extending the use of NASA Earth observing sensors to society and broadening the community of those benefiting from NASA technology.

NASA DEVELOP interns at Stennis Space Center (SSC) know firsthand the type of natural and human-induced disasters that can take place in the Gulf of Mexico region. Since the team's establishment in the fall of 2002, DEVELOP students have witnessed such disasters as Hurricane Katrina in 2005 and the recent *Deepwater Horizon* oil spill. They have seen the major impact of these events on the Gulf Coast environment and economy, as well as the resulting changes in policy and decision making. DEVELOP, part of NASA's Applied Sciences Program, is challenged with extending the use of NASA Earth observing sensors to society and broadening the community of those benefiting from NASA technology.[1]

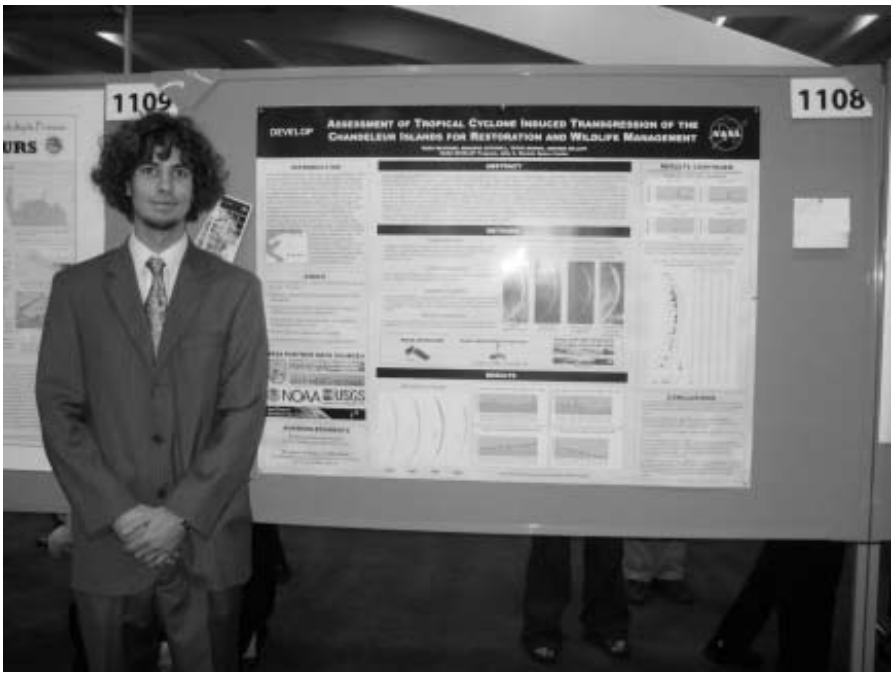
In the past two years, students from universities located near SSC, such as the University of New Orleans, University of Southern Mississippi, and University of South Alabama, have completed over a dozen science research projects. These projects have focused on environmental issues concerning the Gulf Coast such as deforestation, offshore oil seeps, degraded water quality, increased fire occurrence, and hurricane-induced habitat loss. Student teams, working under the guidance of science advisors **Kenton Ross** [Goddard Space Flight Center (GSFC)/Science Systems and Applications, Inc.—*Senior Research Scientist*] and **Joe Spruce** [SSC/Universities Space Research Association—*Senior Research Scientist*], demonstrated how NASA's satellite measurements could address these problems with research outcomes potentially used in local partner organizations decision support and policy making.

Stennis DEVELOP interns present their work at NASA Headquarters in August 2009. Left to right: **Brandie Mitchell**, **Kate Woods**, **Madeline Brozen**

When the eye of Hurricane Katrina passed directly over Stennis Space Center in 2005, DEVELOP students experienced firsthand the destruction and damage left in the storm's wake. As the U.S. Forest Service (USFS) Forest Inventory and Analysis (FIA) Program struggled to assess forest damage in the area using field surveys, students found the perfect opportunity to utilize NASA satellite imagery to evaluate forest vegetation degradation and loss in the area. Students employed the Geoscience Laser Altimeter System (GLAS) on NASA's Ice, Cloud and land Elevation Satellite (ICESat)—created primarily to measure polar ice sheet mass and cloud property information—to detect changes in forest canopy height as an indicator of post-hurricane forest disturbances. The team also used the Moderate Resolution Imaging Spectroradiometer (MODIS) fire detection products to track the

[1]To read more about the DEVELOP program, see pages 7-9 in *The Earth Observer's* March-April 2010 issue [**Volume 22, Issue 2**] and pages 11-13 in the May-June 2010 issue [**Volume 22, Issue 3**].

increased fire activity in the area due to intensified fuel availability, and Landsat Thematic Mapper (TM) to analyze how land cover change affected the above ground carbon availability in the study area.



Stennis DEVELOP intern **Ross Reahard** presents his team's work at the AGU Fall Meeting in December 2009.

The students created maps and graphs of the project results to show the spatial occurrence of fire activity, fire occurrence by forest fuel type, canopy height change by county, and correlation to carbon change in relation to area. "The students had a special stake in this research. They personally experienced the destruction and loss caused by Hurricane Katrina, and wanted to help the Gulf Coast recovery efforts. Their research showed how NASA technology could be applied to post-hurricane damage assessments and the environmental changes that followed," said **Cheri Miller** [SSC—*DEVELOP Gulf Coast Regional Manager*].

Six months before the *Deepwater Horizon* oil spill disaster, DEVELOP students partnered with the Minerals Management Service (MMS) to investigate a potential application of MODIS true color *sun glint* products. The team tested the ability of the products to detect natural oil seeps in the Atlantic Ocean off the coast of Virginia and North Carolina. The Atlantic Ocean has been closed to gas and oil drilling since 1982, however, recent proposals for offshore drilling leases led to research into the location of potential deposits. Students utilized the MODIS *off nadir sun glint* imagery to detect oil slicks in an area that had not previously been surveyed for natural oil seeps using satellite remote sensing. This methodology of detecting natural oil seeps

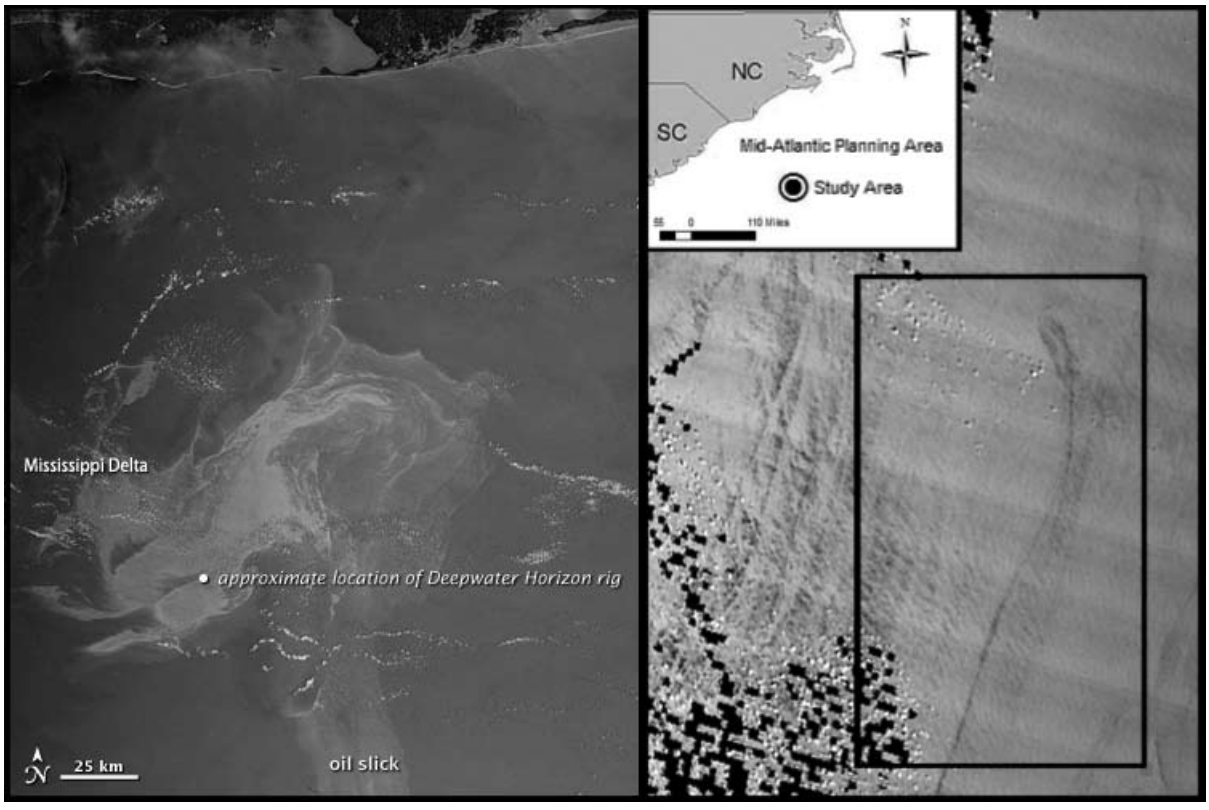
The 2009 Fall Term Stennis DEVELOP team: *[standing L-R]* **Kenton Ross** (science advisor), **Joe Spruce** (science advisor), **Jason Jones**, **Ross Reahard**, **Cheri Miller** (NASA Gulf Region Manager), **Anthony Ojada** *[sitting L-R]* **Lucas Lee**, **Kate Woods**, **Mark Mitchell,** and **Brandie Mitchell**

remotely was useful to the MMS and their decision-making process, representing a potential tool for aiding field surveys and focusing exploratory drilling.

Following the *Deepwater Horizon* spill, NASA and other monitoring organizations used the same methodologies and MODIS products to examine the extent of the disaster. This case study demonstrated the relevance of previous Stennis DEVELOP projects to current issues and events impacting the Gulf of Mexico region. At that time, the students had no idea that the research they were doing would soon be used to examine the impact of a real-life disaster.

This summer, the Stennis DEVELOP team is working on two new projects, both with Gulf Coast study areas. The first partners with the Environmental Protection Agency (EPA) *Region 6* and uses MODIS, Landsat TM, and Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) data to measure air quality related to sugarcane burning in Louisiana. The second study utilizes NASA's Tropical Rainfall Measuring Mission (TRMM) sensor to measure precipitation patterns during La Niña and El Niño oscillations in the Florida panhandle, for assistance in agricultural planning and management. The team will present project results at NASA Headquarters at the end of the summer term, as well as at the American Geophysical Union (AGU) Fall Meeting in December in San Francisco, CA.

For more information on the DEVELOP Program, please visit: *develop.larc.nasa.gov.*



The right image is from the Stennis DEVELOP team's natural oil seep detection project in the Atlantic Ocean using the MODIS sun glint product. The image on the left is the same type of imagery, but displays the *Deepwater Horizon* oil spill in the Gulf of Mexico. The MODIS instrument onboard the Terra spacecraft collected the image on May 17, 2010.

The New HDF-EOS Tools and Information Center Website

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The Hierarchical Data Format for the Earth Observing System (HDF-EOS) Tools and Information Center website was totally revamped over the past year. The site is comprised of a *Home Page*, *Examples*, *Software*, *Workshops*, *User Forum*, *References*, and a *Help Page*.

In addition to an introduction to HDF-EOS data, the *Home Page*—see **Figure 1**—includes a new feature called "Success Stories." The stories, excerpted from NASA websites, highlight recent research using data archived in an HDF format.

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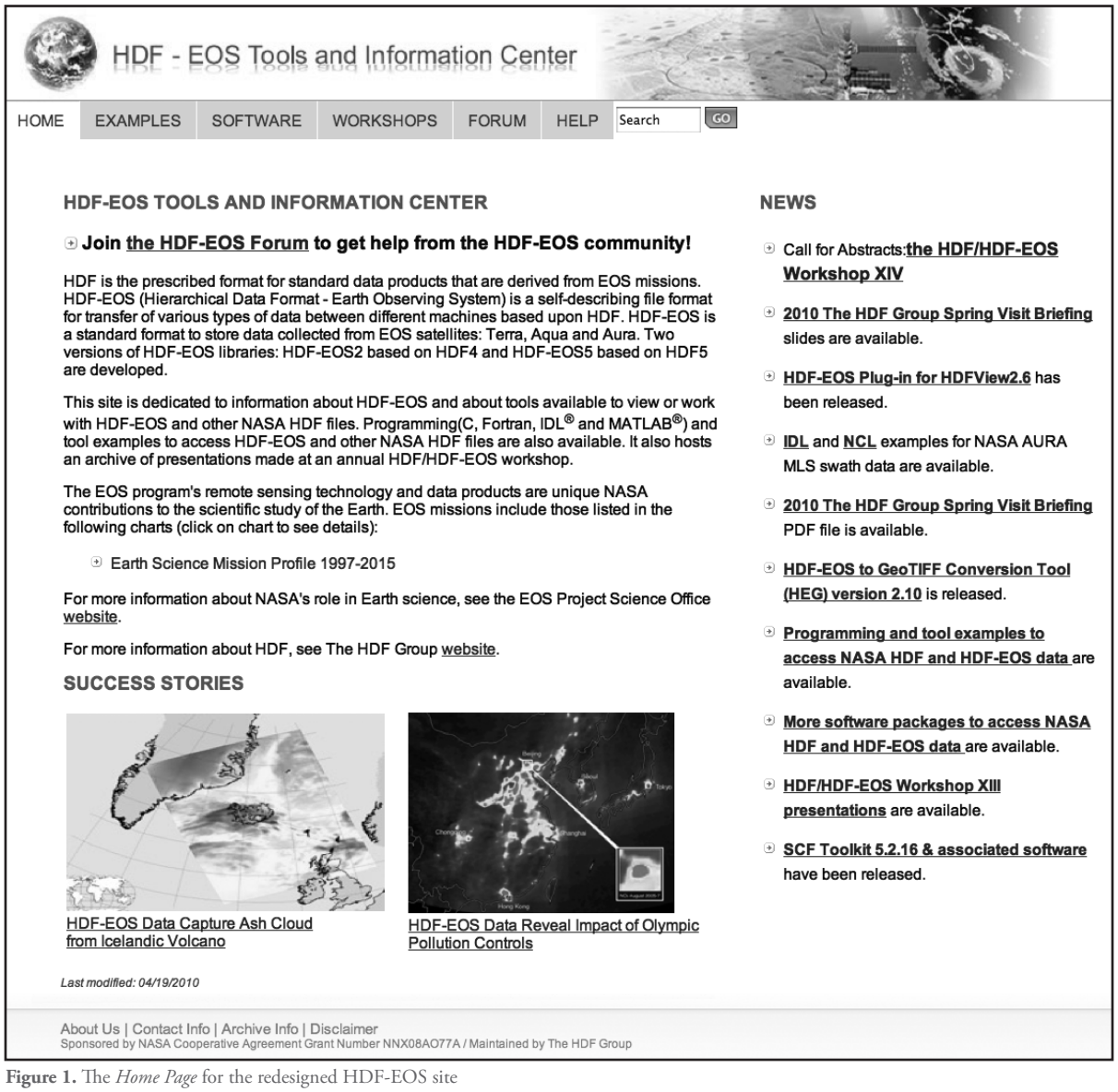

Figure 1. The *Home Page* for the redesigned HDF-EOS site

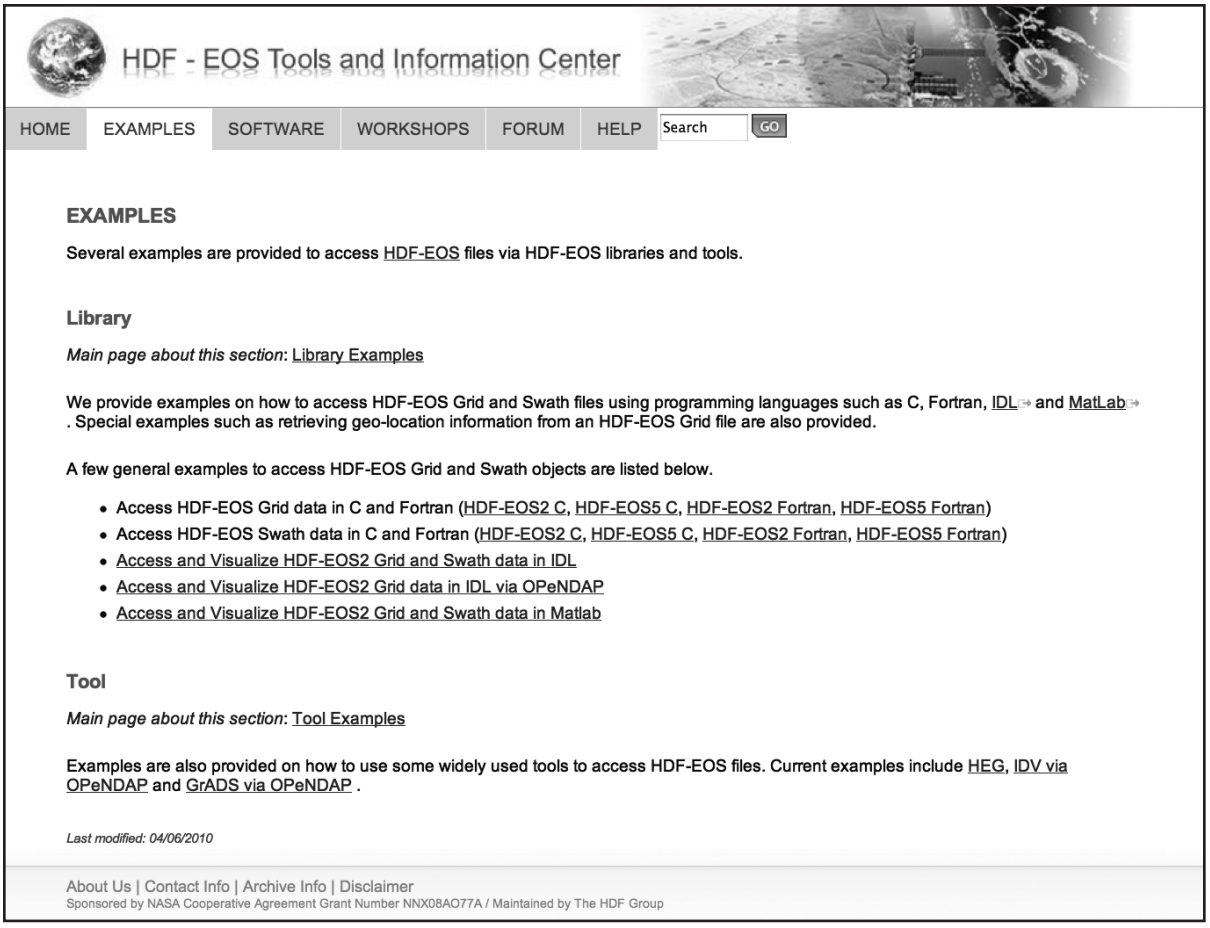

Figure 2. The new *Examples* section of the revamped HDF-EOS website

The HDF and HDF-EOS file formats are flexible; they were designed to accommodate differences required by NASA EOS data products.

A major addition to the website is the *Examples* page, which is divided into "Library" and "Tool" sections—see **Figure 2**. Examples include accessing HDF-EOS Grid and Swath files using programming languages such as C, Fortran, NCL, GrADS, IDL®, and Matlab®, and retrieving geo-location information from an HDF-EOS Grid file—see **Figure 3**. There are also NCL, IDL®, and Matlab® example codes and corresponding plots available for many NASA EOS data products including the Atmospheric Infrared Sounder (AIRS), the Moderate Resolution Imaging Spectroradiometer (MODIS), the Multiangle Imaging Spectroradiometer (MISR), the Advanced Microwave Scanning Radiometer (AMSR), Clouds and the Earth's Radiant Energy System (CERES), the Tropical Rainfall Measuring Mission (TRMM), the Sea-viewing Wide Field-of-view Sensor (SeaWIFS), the Quick Scatterometer (QuikSCAT), etc. (These example codes were needed because not all HDF and HDF-EOS data products can be accessed with a single method.) The HDF and HDF-EOS file formats are flexible; they were designed to accommodate differences required by NASA EOS data products.

The *Software* section also is divided into "Library" and "Tool" sections. HDF staff evaluated 35 tools and libraries, added 11 widely used tools and libraries, and provided detailed descriptions for all of them. The library section not only includes references to HDF-EOS libraries but also includes widely-used third-party packages such as the Python interface (PyHDF) and the Geospatial Data Abstraction Library (GDAL). Tools include widely used visualization and analysis tools, dumper utilities, and converters. The detailed descriptions include instructions on how to use these packages to access HDF/HDF-EOS data. Installation and limitation information are also included.

Although the HDF-EOS Tools and Information Center website provides comprehensive information regarding accessing and processing HDF/HDF-EOS data, it cannot include information on everything that users may encounter in this unique and increasingly diverse information technology environment. The HDF-EOS *User Forum* was added to provide a communication channel for HDF-EOS users. The forum includes a wealth of information including an archive of all the contents from its predecessor. Although the HDF-EOS forum does not require registration for searching the forum contents, a simple registration step is required for posting messages. Tutorials are available for both the forum registration and subscription processes. Forum members include HDF/HDF-EOS software developers, data distributors, and Earth scientists.

The HDF-EOS User Forum was added to provide a communication channel for HDF-EOS users. The forum includes a wealth of information including an archive of all the contents from its predecessor.

The goal of the newly revamped website is to provide comprehensive and up-to-date information on HDF-EOS data as well as to promote the use of valuable NASA Earth Science data for scientific research, applications, and education. The HDF group will continue improving the new website to increase its utility. ■

Displaying the world map with the **geoshow** function also requires the longitude range starting from -180 degree and ending at 180 degree. So the longitude needs to be translated from '2.5 degree to 357.5 degree' to '-177.5 degree to 177.5 degree'. The latitude also needs to be translated from "north to south"(decreasing of the latitude) to "south to north"(increasing of the latitude) with the **geoshow** function. Accordingly, the latitude needs to be translated from '67.5 degree to -67.5 degree' to '-67.5 degree to 67.5 degree'.

Also the lower left corner in Matlab is treated as the origin of the coordinate. However, as we can see from the information obtained by **gridinfo**, the origin is defined as the upper left corner in the file. Hence, we need to flip **rrland** before passing it to the **contour** function. The code section is listed below.

Figure 8 Adjusting the data and geo-location information

```
ts = transpose(rrland);
halfx= floor(xdimsize/2);
ts_reverse = [ts(:, (halfx+1):xdimsize) ts(:, 1:halfx)];
data = flipud(ts_reverse);

lon_offset = -180;
lon_value = lon_offset + lon_value;
lat_value = fliplr(lat_value);
```

Finally, one can use the **contour** function to draw a plot using **data**, **lon** and **lat** calculated above. Since Many options are provided for using the **contour** function, users may need to refer to MATLAB's detailed document for more information about this function.

Figure 9 Visualizing a data field

```
contour(lon, lat, data)
geoshow('landareas.shp', 'FaceColor', [0.4 0.4 0.4])
```

You can see the complete code from here. Figure 10 shows the result.

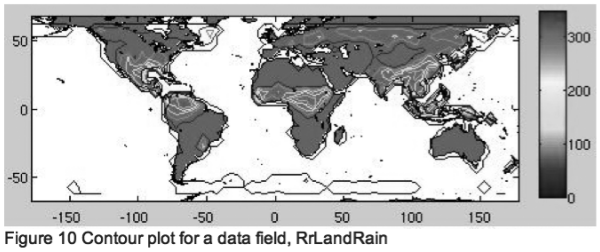

Figure 10 Contour plot for a data field, RrLandRain

Figure 3. The *Examples* section features *example* codes and corresponding plots from a number of different software packages to help with processing various kinds of EOS data. The example shown here is from Matlab®.

meeting/workshop summaries

SORCE Science Team Meeting Summary

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Approximately 80 scientists gathered for the 2010 Solar Radiation and Climate Experiment (SORCE) Science Team Meeting, *Solar and Anthropogenic Influences on Earth: The Current Solar Minimum and Predictions for Future Decades***,** May 19-21, in Keystone, CO. The discussions covered a wide range of current solar and Earth science research.

A summary of the meeting, including PDF versions of many of the presentations, is available at: *lasp.colorado.edu/sorce/news/2010ScienceMeeting/index.html.*

Introduction and Meeting Overview

Relative to the past three solar minimum epochs of the space era (1976, 1986, and 1996) the current solar minimum (2008–2009) between Solar Cycles 23 and 24 was unusually prolonged with record numbers of sunspot-free days, record low solar polar magnetic fields, and record high levels of cosmic ray flux. Evidence is accumulating that there have been broad ranging terrestrial responses to the extended inactivity of the sun. Reduced solar ultraviolet (UV) irradiance and corresponding lower ozone levels may be obscuring the recovery from anthropogenic ozone depletion by chlorofluorocarbons (CFCs). In the upper atmosphere and ionosphere, temperatures are anomalously cool and densities are reduced relative to previous solar minima; but these changes may also be related to accumulated greenhouse gas cooling in the upper atmosphere.

Key questions addressing the current state of and future expectations for the integrated Sun-Earth system are:

- Are spectral and total solar irradiance levels lower now than during past minima, and how much will they increase during Solar Cycle 24?
- Can we identify anomalous behavior in the solar dynamo and surface flux transport to help understand the recent minimum?
- How are heliospheric changes altering incident cosmic ray fluxes and the Earth's near-space environment?
- Can we reliably discern the terrestrial signatures of the recent minimum—at the surface, in the stratosphere, and in space weather?

Session 1: Total Solar Irradiance (TSI): Comparison of Solar Cycle Minima and Recent Validation Results

Keynote speaker **David Hathaway** [NASA Marshall Space Flight Center] kicked off the meeting with *Meridional Flow Variations: Implications for flux transport models*. Hathaway discussed the uniqueness of the recent solar minimum with impressive videos to show that the meridional flows from weakening polar fields in Cycle 23 are the cause of a weak beginning to Cycle 24.

The meeting's first session reviewed recent progress on understanding the differences between on-orbit total solar irradiance (TSI) instruments and to what level of accuracy changes between the recent and prior solar minimum can be discerned.

Richard Willson [NASA/Jet Propulsion Laboratory (JPL)—*Active Cavity Radiometer Irradiance Monitor (ACRIM) Principal Investigator (PI)*] started the TSI instrument talks with an overview of the importance of continuity in past and recent TSI observations, while contrasting the three currently operating TSI instruments. Willson's talk elicited several questions on an annual cycle in the ACRIM III data that is not apparent in other concurrent TSI instruments, and his team is studying possible solar and instrumental effects of this cycle. **Claus Fröhlich** [Physikalisch-Meteorologisches Observatorium (PMOD)—Davos, Switzerland] discussed the differences between the last three solar minima and described a four-component model he uses to fit observed TSI variations.

Wolfgang Finsterle [PMOD] discussed the PREcision Monitoring Sensor (PREMOS) package onboard the PICARD satellite (launched June 15, 2010) and their calibration campaigns at both the National Physical Laboratory (NPL) and the recently operational TSI Radiometer Facility. This facility compares a TSI instrument against a cryogenic radiometer calibrated at the National Institute of Standards and Technology, providing the first ever end-to-end irradiance comparisons under vacuum and at full solar power levels to such a reference.

Steven Dewitte [Royal Meteorological Institute of Belgium] gave a status report on the SOlar Variable and Irradiance Monitor (SOVIM), and described the measurement differences between the Solar and Heliospheric Observatory (SoHO) DIfferential Absolute RADiometer (DIARAD) and Variability of Solar Irradiance and Gravity Oscillations (VIRGO). **Greg Kopp** [Laboratory for Atmospheric and Space Physics (LASP), University of Colorado (CU)] summarized the results of recent inter comparisons of the Glory, SORCE, PICARD, and VIRGO/Physikalisch–Metorologisches Observatorium (PMO) TSI instruments to the new Glory-funded TSI Radiometer Facility at LASP. These intercomparisons may help to explain and diagnose causes of differences between instruments and show that uncorrected scatter off the front or interior of TSI instruments could well account for erroneously high TSI measurements.

Devendra Lal [Scripps Institute of Oceanography, University of California] estimated solar activity over the past 35,000 years based on magnetic flux and solar plasma emitted by the sun. **Alexander Shapiro** [PMOD] concluded the session by sharing the PMOD/World Radiation Center's (WRC) COde Solar Irradiance (COSI) physical model, which allows researchers to reconstruct annually averaged total and solar spectral irradiance measurements back to the Maunder Minimum. His results indicate a 6 W/m^2 decrease in TSI at the Maunder Minimum, indicating forcings in TSI as large as 1 W/m^2.

Session 2: Climate Changes: What's the Future Going To Be?

Keynote speaker **Georg Feulner** [Potsdam Institute for Climate Impact Research—Germany] described sun-climate interactions, and presented results of simulations with a fully coupled climate model forced with solar irradiance corresponding to past Grand Minima (of which he models four over the last 1000 years). Feulner extrapolated future scenarios for global warming, showing that a new prolonged Maunder Minimum would only slightly decrease future global warming, with a -0.3°C effect due to lower solar irradiances being swamped by anthropogenic induced increases of 4°C.

Through researching ice sheet response to climate, **Waleed Abdalati** [Cooperative Institute for Research in Environmental Sciences (CIRES), CU] explained how *in situ* observations and robust process models are helping us understand the nature of the changing ice cover, the processes that govern it, and what the implications may be for life on Earth. He gave an interesting perspective that even the fast present day ice melts pale compared to some historical melts in terms of their effects on sea level rise.

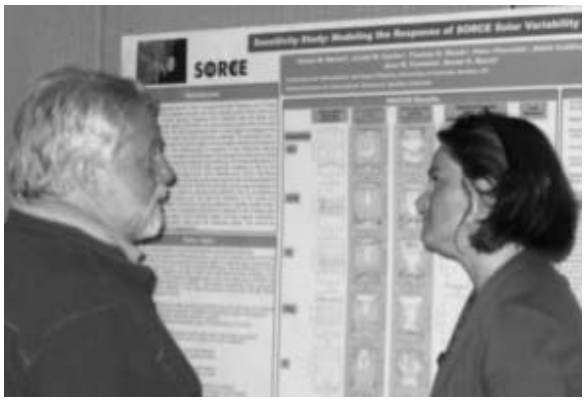
Session 3: Solar Spectral Irradiance (SSI): Solar Cycle Variation and Model Comparisons

Session chair **Tom Woods** [LASP, CU] began with a short tribute to **Richard (Dick) Donnelly**, who passed away in August of 2009. Donnelly was a physicist at the National Oceanic and Atmospheric Administration/Space Environment Center (NOAA/SEC) for thirty years where he made significant contributions to the solar-terrestrial community.

Richard (Dick) Donnelly

Jerry Harder [LASP, CU—*SORCE LASP Project Scientist*] led the session with a talk entitled *Measured and Modeled Trends in Solar Spectral Irradiance Variability in the Visible and Infrared.* The Spectral Irradiance Monitor (SIM) measurements show rotational modulation of spectral irradiance due to the evolution of solar activity. SIM observations indicate trends in solar spectral irradiance (SSI) over solar cycle time periods that are both in and out of phase with the TSI. **William Ball** [Imperial College—London, U.K.] discussed how the SIM measurements have been used in the Spectral and Total Irradiance Reconstruction (SATIRE) model, comparing data from April 2004–November 2009. The results show good agreement with short-term detrended spectral regions, but his model cannot explain the long-term trends in the UV and near infrared (NIR). A comparison by **Matt Deland** [GSFC/Science Systems and Applications, Inc.] of datasets from different satellite instruments and results are showing both absolute offsets and time-dependent differences that vary between spectral ranges. DeLand has generated a new UV composite from these multiple datasets, and sees no difference between the minimum values for Solar Cycles 21 and 22 within the uncertainty of the data. **Cassandra Bolduc** [University of Montreal] has used the quiet sun, sunspots, and faculae to construct both total and spectral irradiance time series. The differences are used to estimate the network contribution to the spectral irradiance variations down to 60 nm at different cycle phases.

Tom Woods [LASP, CU—*SORCE PI*] discussed how the current solar cycle minimum was clearly different than the last few minima in that open magnetic flux was about 30-40% lower, solar wind pressure was about 40% lower, EUV was 15% lower, and there were more low-latitude coronal holes. **Jeff Hall** [Lowell Observatory] described spectral variations of the sun using Lowell's Solar Spectral Spectrograph measurements of the sun and stars. He noted that young stars vary inversely with activity in the B and Y spectral bands, surprisingly similar to what SIM observes in solar cycle variations. **Gérard Thuillier** [Laboratoire Atmosphères, Milieux, Observations Spatiales-Centre National de la Recherche Scientifique (LATMOS-CNRS)—France] showed a composite spectrum from three missions, giving the Atmospheric Laboratory for Applications and Science (ATLAS) spectral solar irradiance composite with an accuracy of about 3%, and discussed possible causes of the differences between ATLAS 3 and Solar Spectrometer—International Space Station (SOLSPEC-ISS) in the infrared, although their agreement in the UV and visible is very good.



Aimee Merkel [LASP, CU] discusses her research on modeling the SORCE solar variability into the Whole Atmospheric Community Climate Model (WACCM) with **Robert Cahalan** [GSFC] during an afternoon poster session. Over 20 posters were featured in the session.

Session 4: Atmosphere and Ozone Changes: Has the Ozone Recovery Started Yet?

Session 4 was dedicated to the present understanding of the influences of solar spectral irradiance variations on atmospheric and ozone processes. **Rich Stolarski** [NASA Goddard Space Flight Center (GSFC)] kicked off Thursday morning describing the impact of solar variability on stratospheric ozone and temperature. When comparing the simulations of the effects with analysis of the long-term ozone data records, results reveal that the global average response to the UV solar variability (S_{max}-S_{min}) shows that the ozone response to lower stratospheric heating is much smaller (and opposite) to the photolysis response (which dominates). **Joanna Haigh** [Imperial College] shared her research using SORCE SIM measurements in a two-dimensional stratospheric climate model to explore the impact of solar spectral variability on solar radiative forcing of climate and ozone photochemistry. This is one of the first detailed investigations using the full solar spectrum out to the near-IR in detailed coupled climate and chemistry modeling. The results show that incorporation of the SORCE spectral variability produces a reduction of lower mesospheric ozone and an increase in the mid- to upper-stratosphere at higher solar activity. If correct, this type of spectral variability may have had significant impact on previous solar cycles, or on longer timescales, requiring an entire revision of the attribution of causes to observed variations in temperature throughout the atmosphere. **Ka-Kit Tung** [University of Washington] discussed the annual rate of warming from solar minimum to solar maximum in relation to that due to greenhouse gases and the need to establish the significance of a near Earth's surface response to solar-cycle variability. Finally, the session chair, **Robert Cahalan** [NASA GSFC] presented *Modeling the Temperature Responses to Spectral Solar Variability on Decadal and Centennial Time Scales.* Central to the analysis was the incorporation of the SORCE SIM results during the declining phase of Solar Cycle 23.

Graduate student **Jean-François Cossette** [University of Montreal] explains his poster, *Thermodynamic Signature of Magnetic Cycles in Global Simulations of Solar Convection*, to **Gerard Thuillier** [LATMOS-CNRS]. This year's meeting drew more students than ever before.

Session 5: Space Weather Effects Observed During This Solar Cycle Minimum

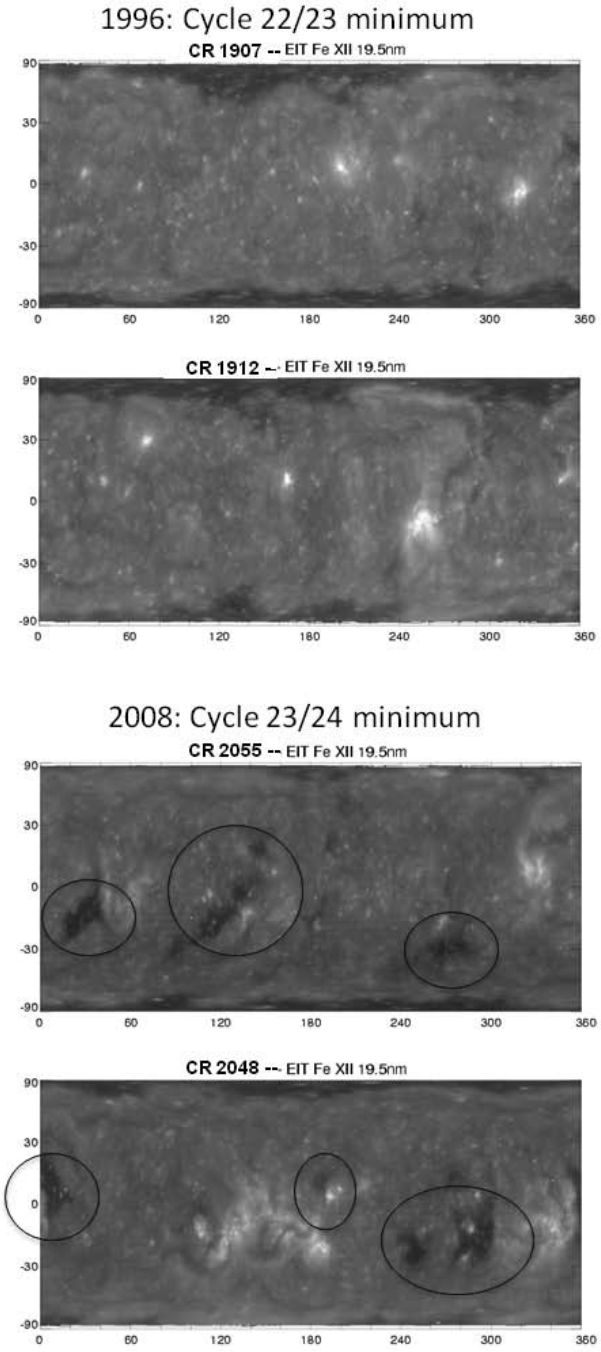
Before the session began, **Robert Cahalan** [NASA GSFC] presented a thoughtful tribute to John Allen "Jack" Eddy who passed away in June 2009. Cahalan acknowledged that Jack Eddy was extremely influential in solar physics. There was open audience participation and fond reflections from many of Jack's former colleagues over a long and uniquely interdisciplinary scientific career. Eddy was a careful and unselfish researcher that will truly be missed.

It was also noted that there is presently a petition, submitted to the solar physics Division of the American Astronomical Society, to name the next significant solar minimum *The Eddy Minimum* to honor his contributions to the long-term solar record.

John Allen "Jack" Eddy

John Emmert [Naval Research Laboratory] opened Session 5 with a discussion of *Observations of Record-low Thermospheric Density During the Current Minimum*. Emmert described how global-average thermospheric total mass density, derived from the drag effect on the orbits of many space objects, is being used to study the behavior of the thermosphere during the prolonged Cycle 23/24 solar minimum. Anomalously low density appears to have started in 2005, when solar extreme ultraviolet irradiance was well above the prolonged low levels of the Solar Cycle 23/24 minimum. **Liying Qian** [High Altitude Observatory, National Center for Atmospheric Research (HAO, NCAR)] discussed the thermospheric and ionospheric response to the recent prolonged solar activity minimum. During the 2007–2009 solar minimum period the upper atmosphere and ionosphere were cooler, lower in density, and consequently lower in altitude (back to about 1970). Moreover, a study including the Carrington rotational analysis of the low-latitude coronal holes showed that polar coronal holes were ~20% smaller in 2008 compared to the 1996 minimum, but large mid- and low- latitude holes persisted during this extended minimum.

Eduardo Araujo-Pradere [Cooperative Institute for Research in Environmental Sciences (CIRES), CU and NOAA, Space Weather Prediction Center] discussed comparisons obtained by modeling the thermosphere and ionosphere neutral and plasma parameters with a physical model to a range of observations used to judge the abnormality of the last solar minimum. The comparisons between model and data determine if model drivers, such as EUV input or magnetospheric sources, have to be outside the range expected from past climatology. **Giuliana de Toma** [HAO, NCAR] presented her analysis of the evolution of the polar magnetic fields and coronal holes during the extended solar minimum between Cycle 23 and 24, and their implications for the solar wind and effects on the Earth's near-space environment. In the final talk of the session **David Webb** [Boston College] discussed the Whole Heliosphere Interval (WHI), an in-depth study of the Sun–Earth system for a solar rotation in March–April 2008 and the Whole Sun Month (WSM) campaign in August–September 1996. The recent solar minimum was exceptionally quiet, with sunspot occurrence the lowest in 75 years, solar wind density and interplanetary magnetic field (IMF) strength at the lowest values ever observed, and geomagnetic indices and solar EUV fluxes the lowest in three solar cycles.



The diagrams here show the locations of coronal holes on the sun's surface. The top two images are from 1996 during the last solar minimum; the bottom two images are from 2008 during the current solar minimum. See text for discussion. **Credit:** Liying Qian, HAO, NCAR

Session 6: Solar Physics: What Do We Learn About the Sun from this Unique Cycle Minimum?

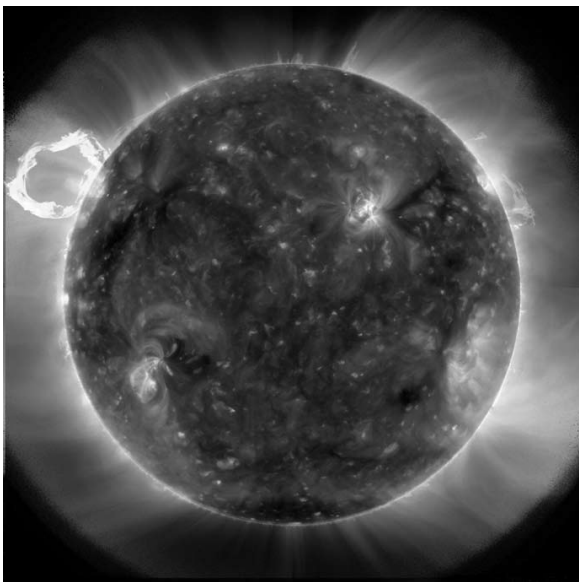
Gary Rottman [LASP, CU—*Original SORCE Principal Investigator*] chaired Thursday afternoon's session which featured keynote speaker **Oran R. (Dick) White** [LASP, CU]. White began with a historical perspective on research in the field of solar variability over a long and distinguished career, and finished with some recent results on the decreasing contrast of sunspots in the current solar cycle. The discussion of changes in the properties of sunspots continued with **Ken Tapping** [Herzberg Institute of Astrophysics—British Columbia, Canada] discussing the relationship of F10.7 cm radio flux to sunspot number. **Eva Robbrecht** [Royal Observatory of Belgium—Brussels] gave a presentation on how the polar field strength is almost 50% weaker in Cycle 23. **Leif Svalgaard** [Stanford University] presented on uncertainties in predicting the strength of the next solar cycle for a variety of indicators.

The next few presentations changed gears from observations to models. **Paul Charbonneau** [University of Montreal] gave a talk on his global MagnetoHydroDynamics (MHD) model that starts from first principles of physics. The group then received an update of the solar cycle prediction from **Mausumi Dikpati's** [HAO, NCAR] flux transport dynamo model and how it compares to the NRL surface flux transport model. A vigorous discussion followed, and **Tom Woods** [LASP, CU] suggested that there should be a dedicated splinter session to discuss this topic at a future meeting.

Returning to measurements rather than models, **Joan Feynman** [JPL] presented observations of the cosmic ray flux that showed how the peculiar behavior of the current solar cycle actually started decades previously. **Andrés Muñoz–Jaramillo** [Montana State University] discussed the consequence of changes to the meridional surface flows affecting the solar cycle. **Marty Snow** [LASP, CU] then presented irradiance results that show that the dominant activity in the declining phase of the solar cycle appears to rotate with a period 26.4 days, and that this active longitude persists for the last three solar cycles. The final talk in the session was another discussion of the record high cosmic ray fluxes seen during 2009 and 2010 from **Richard Mewaldt** [California Institute of Technology]. Mewaldt also showed a comparison to the Beryllium-10 (Be^{10}) record which indicated that the cosmic ray fluxes for the previous 50 years were anomalously low compared to the entire data record.

Session 7: Recommendations for the Future: How to Improve the Climate Data Record?

The final session was dedicated to looking forward and how long-term records of solar irradiance measurements are needed to advance critical aspects of the scientific understanding of the Earth climate system. The session began with keynote speaker **John Bates** [NOAA, National Climate Data Center] giving an excellent overview of the path forward and the challenges for maintaining continuity for climate measurements and the challenges for the development of new observation technologies. While NOAA is making major contributions to the nation through existing climate services, there is a rising demand for expanded climate services across a broader, social, economic, ecological, and resource framework. The group discussed future opportunities for long-term solar irradiance monitoring using the NOAA/NASA Joint Polar Satellite System (JPSS), as well as alternate flight options that are under study to ensure sensor overlap. In the following talk, **Peter Pilewskie** [LASP, CU] continued on this theme and discussed the importance of the Total and Spectral Solar Irradiance Sensor (TSIS) program toward achieving an accurate long-term total and spectral irradiance Climate Data Record (CDR). Central to this is a time series of measurements of sufficient length, consistency, and continuity to determine climate variability and change. Given the present restructured program's uncertainties and the fact that the first flight of TSIS is yet to be determined, there is serious concern that delays beyond 2014 will increase the probability of a measurement gap in the TSI record. **Madhulika (Lika) Guhathakurta** [NASA Headquarters] presented an overview of the present and future goals of the NASA *Living With a Star* (LWS) Program with regard to effectively addressing those aspects central to the connected Sun–Earth system that directly affect life and society. Guhathakurta also presented an overview of the diversity of educational programs and opportunities for the next generation of researchers including heliospheric textbooks, summer school pro-



Composite Solar Dynamics Observatory Atmospheric Imaging Assembly (AIA) image capturing early solar activity during the onset of Solar Cycle 24. AIA produces eight images every 10 sec—that's 70,000 images a day! **Credit:** Dean Pesnell, NASA GSFC

grams, and visiting scientist and postdoctoral fellowship programs. In the final presentation of the session, **Dean Pesnell** [NASA, GSFC] gave an excellent overview of the recently launched Solar Dynamics Observatory (SDO) Mission. Pesnell showed stunning data from all of the instruments including the Extreme ultraviolet Variability Experiment (EVE), the Atmospheric Imaging Assembly (AIA), and the Helioseismic and Magnetic Imager (HMI). Ultimately, the SDO science investigations will help determine how the sun's magnetic field is generated and structured and how this stored magnetic energy is released into the heliosphere as the solar wind, energetic particles, and variations in the solar irradiance.

Meeting Conclusion / Discussion

To conclude the SORCE Science Meeting, **Tom Woods** [LASP, CU] summarized the presentations and science discussions that had occurred over the previous 2.5 days. The workshop raised several intriguing questions that we may hope to answer as we embark on a new solar cycle with unprecedented new measurement capabilities.

- *What is the long-term trend in TSI observations?* The recent trends at current solar cycle minimum suggest that the solar Modern Maximum period might be on the decline. Continued observations by the SORCE Total Irradiance Monitor (TIM) and new TSI measurements from NASA Glory, European Space Agency (ESA) SOLAR, and ESA PICARD are expected to continue the TSI record into Solar Cycle 24.

- *What is the solar cycle variation in the near-infrared (NIR)?* The SORCE Spectral Irradiance Monitor (SIM) data yield an inverse relationship with solar cycle with higher near infrared levels during cycle minimum. New validation is anticipated for the SSI measurements with the ESA SOLAR instruments recently installed on the International Space Station.

- *How big will Solar Cycle 24 be?* There are interesting, but conflicting, predictions for both high and low levels for the next maximum in 2012-2013. Time will tell which prediction, if any, is correct.

The SORCE team extends a warm thanks to all participants for making this meeting another success. Future plans are to meet again in Fall 2011. As new information becomes available, it will be posted to the SORCE Science Meetings website: *lasp.colorado.edu/sorce/meetings.html*.

Pre-Meeting Activities

Before the official SORCE Science Meeting began, there was a full day of pre-meeting events on May 18. The morning featured two parallel workshops.

Jerry Harder [LASP, CU] led a workshop on *Solar Spectral Irradiance (SSI) and Climate Modeling*. The workshops goals were to: 1) promote the use of SSI and its variability in a variety of applications including climate, chemistry, and radiative transfer; 2) emphasize climate processes and mechanisms of climate response to SSI variability, with the ultimate goal of improving understanding of SSI-climate interactions; and 3) foster new interactions between the modeling community and the SORCE science team. Approximately 20 scientists were in attendance.

Greg Kopp [LASP, CU]) led a workshop on *Total Solar Irradiance (TSI) Validation* that focused on the status of on-orbit TSI instruments and plans for ground validations such as those that have been done on or are being planned for LASP's TSI Radiometer Facility (TRF). The ultimate goal was to share current status and discuss ideas to improve the TSI record.

Oran R. (Dick) White [LASP, CU] was the guest of honor on Tuesday afternoon at a special seminar entitled, *Where did the first 50 years go?* **Gary Rottman** [LASP, CU] organized and emceed the program which began with a talk from **Kim Malville,** who was a graduate student at the same time as White. **Bill Livingston** [National Optical Astronomy Observatory, National Solar Observatory] described the early ground-based work that he and White did at Kitt Peak National Observatory and Sacramento Peak Observatory. White also spent many years at NCAR's High Altitude Observatory, and **Tom Bogdan** [NOAA, Space Weather Prediction Center] entertained the audience with his memory of White's many contributions. **Gary Rottman** [LASP, CU] concluded the program with a general recollection of White's many significant contributions to solar physics research, before opening the floor to attendees to share their memories and heartfelt appreciation for White and all he has accomplished in his career (thus far). ■

Oran R. (Dick) White surrounded by his wife, **Patricia Johnson**, and his son, **Will White**, following a special seminar in his honor to kick off the 2010 SORCE Science Meeting.

meeting/workshop summaries

Landsat Science Team Summary

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Meeting Overview

The Landsat Science Team, sponsored by the U.S. Geological Survey (USGS) and NASA, met at the Computer History Museum in Mountain View, CA, January 19–21, 2010[1]. Landsat Science Team members Jennifer Dungan and Rama Nemani [NASA Ames Research Center] hosted the meeting. All presentations from the meeting are available at: *landsat.usgs.gov/science_january 2010MeetingAgenda.php*.

Tom Loveland and **Jim Irons** [USGS and NASA Goddard Space Flight Center (GSFC), respectively—*Landsat Science Team co-chairs*] opened the seventh meeting of the Landsat Science Team with an identification of the issues requiring the team's attention:

- increased focus on the evaluation and utilization of Landsat Data Continuity Mission (LDCM) datasets;
- greater collaboration between LDCM and the European Space Agency's Sentinel-2 mission;
- better understanding of both requirements and technical/scientific readiness for advanced Landsat science products; and
- continued advancement of operational land imaging with the authorization of Landsat 9 and beyond an urgent priority.

Curtis Woodcock [Boston University—*Landsat Science Team Leader*] also emphasized the importance of these topics and credited the team for their efforts to advance these topics over the past three years. While progress is being made on many fronts, he stressed that authorization of Landsat 9 is still the most urgent issue and that the Landsat Science Team must continue to make it the focal point. Woodcock also noted European Space Agency participation in this as well as the June 2009 meeting, and encouraged an open dialog on topics that will lead to greater coordination between LDCM and Sentinel-2.

Bryant Cramer [USGS—*Associate Director for Geography*] provided an update on a range of USGS Landsat activities. He noted the attention that Landsat is receiving in the Department of the Interior. The USGS is scheduling a congressional briefing during the spring to address the importance of Landsat for a wide range

[1] This meeting took place in January but publication of the report in *The Earth Observer* was delayed, therefore it should be noted that a number of the events mentioned in this summary as *upcoming* have now taken place.

Landsat Science Team meeting participants

of science and applications topics, and to emphasize the importance of an operational Landsat capability. Cramer acknowledged the importance of a long-term NASA role in science and technology development but said that the USGS should also play a key role in operational terrestrial Earth observation. He said that NASA, USGS, and NOAA must work together to coordinate the linkages between each agency that ensure a strong U.S. Earth observation capability.

Cramer also commented that Web-enabled Landsat data are a "smash-hit." With the nearly 2.5 million Landsat scenes in the U.S. archive available at no cost, the ability for remote sensing to revolutionize resource management and advance global change science has never been greater. He concluded by asking the Landsat Science Team for help in prioritizing the measurements and processing needed to make Landsat an essential component of terrestrial science and applications.

David Jarrett [NASA Headquarters—*Landsat Program Executive*] introduced himself as the newest member of the Landsat leadership group. Jarret noted that the December 2009 LDCM Mission Confirmation Review was successful and NASA is now proceeding toward a December 2012 launch.

Bruce Quirk [USGS—*Land Remote Sensing Program Coordinator*] provided an update to the team on other USGS remote sensing developments. The USGS recently signed a contract with SPOT Image Corporation to acquire Satellite Pour l'Observation de la Terre (SPOT) 4 and 5 satellite data over the U.S. and parts of Canada and Mexico for the next twelve months. The Earth Resources Observation and Science (EROS) Center is already receiving electronic deliveries of SPOT scenes, and a direct reception capability will be implemented at EROS in the spring. SPOT data can be accessed over the Internet at no charge for U.S. federal civil agency and U.S. state and local government users. Quirk also described USGS interests in obtaining the GeoEye OrbView-3 archive. GeoEye has offered the USGS the opportunity to purchase over 500,000 images collected between 2003–2007. The collection includes 1-m panchromatic and 4-m multispectral images; 50% of these images have less than 10% cloud cover. The Landsat Science Team advised the USGS that this collection would have significant scientific value as a calibration and validation reference source for land change studies.

Landsat 5 and 7 Status

Tom Kalvelage [USGS EROS—*Data Management Branch Chief*] updated the team on Landsats 5 and 7 operations. Both satellites continue to acquire global imagery. Landsat 7 service has now exceeded ten years. Although the ETM+ Scan Line Corrector failed in 2003, the mission continues to aggressively collect global coverage. A recent orbit conflict with the Taiwanese Formosat 3D resulted in a Landsat 7 avoidance maneuver, which removed the risk of collision. The burn maneuver has no impact on the end-of-mission prediction (post-December 2012) for Landsat 7.

Landsat 5 is approaching its 26th year in orbit acquiring Thematic Mapper data. The flight operations team has confronted and is tracking several problems. In August 2009, saturated gyro rates caused the satellite to tumble into a critical state. However, operators recovered from the problem and Landsat 5 acquisitions returned to normal less than two days after the event. In December, the redundant Traveling Wave Tube Amplifier (TWTA) failed and was not recoverable. The redundant TWTA had been used since the primary TWTA failed in 1986. In early January, the flight operations team successfully reestablished functionality to the dormant primary TWTA. The collection of science data resumed on January 10, 2010.

Kalvelage also reported that there is significant user demand for free Landsat data. Approximately 25,000 scenes were processed each month in 2009, and over 100,000 scenes per month were downloaded. The Landsat Project is experiencing periods in which processing requests are creating backlogs, but efforts are underway to continue to improve EROS Landsat processing capabilities. An important step is the conversion of Landsat Multispectral Scanner (MSS) process from the legacy National Land Archive Production System (NLAPS) to the Landsat Product Generation System (LPGS) so that Landsat MSS, Thematic Mapper (TM), and Enhanced Thematic Mapper (ETM+) products are consistently processed. The conversion to LPGS will be completed in September 2010. Other physical improvements underway include moving the Level Zero-R Archive (L0Ra) currently stored on tape to online disk, updating storage area network throughput, and expanding storage space for file transfer protocol (FTP)-accessible processed Landsat scenes. In addition, planning is underway to improve *metadata* so that the processing levels and calibration updates are identifiable. Finally, Kalvelage announced that on-demand access to Landsat Level Zero-R Processed (L0Rp) data was instituted in January 2010. Users needing access to L0Rp data should contact EROS Customer Services.

Gene Fosnight [USGS—*Landsat Data Acquisition Manager*] briefed the team on processing changes associated with Landsat MSS in particular, and on full-resolution browse and thermal products in general. MSS processing is being migrated from NLAPS to LPGS to create Level 1 products and *metadata* that are consistent with TM and ETM+. MSS LPGS processing will use cross-calibrated gains, biases, and time dependent variables to map the MSS archive data to radiance using

the Normalized Radiance method developed at South Dakota State University (SDSU). A hierarchical image registration approach is being refined to achieve more robust and effective geometric processing, and a product verification module is being developed to evaluate and document the positional accuracy of Landsat Level One-T (L1T) data against GLS 2000 reference. Three MSS LPGS processing releases are planned through August 2010, after which a consistent, cross-calibrated archive of Landsat data will be available. The Landsat Project is also working toward a goal of having consistent radiometric calibration of all Landsat data from 1972 to the present. The final step in achieving this goal is to complete the calibration of the MSS record.

Dennis Helder [South Dakota State University] has led the MSS calibration research. Helder is calculating cross-calibration gains and biases using the whole lifetime response of the MSS sensors. He reported that the absolute gains of the five MSS sensors (Landsats 1–5 carried MSS instruments) exhibit a maximum difference of 17%, which has been reduced to less than 1% in Band 1, 2% in Band 2, 3% in Band 3, and 5% in Band 4. Spectral differences within MSS sensors can contribute errors approaching 2%. Helder also concludes that spectral differences between MSS and TM sensors can lead to 10% errors with vegetated targets. Helder's radiometric calibration results will be part of the LPGS MSS processing capabilities that will be released in September.

Landsat Global Archive Consolidation

One of the top priorities of the Landsat Science Team is Landsat global archive consolidation. An estimated 1.3 petabytes of Landsat data are held in up to 20 international archives, and a significant percentage of these data are unique and not part of the U.S. Landsat archive at EROS. In addition, a considerable amount of data is in danger of being lost due to storage conditions and obsolete media.

Tom Kalvelage summarized recent USGS planning for an initiative to recover as much of this international data as possible. The initiative is challenging because a wide range of data formats, storage media, and storage practices exist. Essentially, each of the 20 international Landsat stations must be treated as a unique project. To scope the activity, the USGS has contacted all international stations and has requested archive metadata. Data from China, Pakistan, Ecuador, and Canada have been received and analyzed. The Pakistan station has requested help in reading old tapes and will send sample tapes to the USGS in early 2010. Communications with the Ecuador station are underway to initiate efforts to move their data to the USGS. Kalvelage pointed to the Pakistan and Ecuador activities as important first steps toward the goal of consolidating as much international data into the USGS as possible.

Global Land Survey (GLS) Update

Jeff Masek [NASA—*Deputy LDCM Project Scientist*] and **Garik Gutman** [NASA HQ— *Land Cover and Land Use Change Program Manager*] provided an update on the overall Global Land Survey (GLS) activity. GLS 2005 was completed in September 2009 when Brazil and Indonesia delivered the last scenes to the USGS and NASA. This dataset consists of 5,764 Landsat 7 ETM+ scenes and 2,425 Landsat 5 TM scenes. In addition, the datasets include 555 Earth Observing-1 (EO-1) Advanced Land Imager (ALI) scenes covering islands and reefs. Masek said that the acquisition of images for the GLS 2010 dataset is now underway. As with the 2005 collection, Landsat 5 TM, Landsat 7 ETM+, and EO-1 ALI images will be acquired. The acquisition window is 2009–2010 and will include Landsat International Cooperator station participation, as well as up to eight campaign stations. All data will be processed to the L1T standard by the USGS and NASA will *gap-fill* the Landsat 7 scenes. The complete GLS 2010 dataset will be available by late 2011.

LDCM Status

Bill Ochs [GSFC—*LDCM Project Manager*] reviewed the progress of the primary LDCM systems. Ball Aerospace and Technologies Corporation (BATC) is progressing with development and construction of the Operational Land Imager (OLI). Alignment and thermal vacuum and vibration testing has been completed. Testing of the focal plane array engineering development unit and the flight solar calibration subsystem is also complete, as is stray light testing. Functional tests of the flight focal plane electronics are now underway and the flight software has passed qualification tests. The flight focal plane assembly and frame are ready for module delivery. The thermal control system thermal balance test is also ongoing.

Ochs also updated the team on the status of some detector performance issues he had discussed at a previous meeting, and he also identified some more recent issues that have come up. Because of these issues, OLI delivery could slip two months, reducing the overall OLI reserve to less than four months. NASA and BATC are working together to identify *mitigations* that could recover more reserve time and lower schedule risk.

Ochs further reported that all major procurements are in place for the second LDCM instrument—the Thermal Infrared Sensor (TIRS). TIRS is progressing satisfactorily, but the LDCM team continues to examine the schedule to identify parallel development paths and compress the overall delivery schedule.

General Dynamics Advanced Information Systems is designing the LDCM spacecraft, which passed its

Critical Design Review in October 2009. Upcoming development issues include accommodating TIRS (this instrument was a late addition to LDCM), spacecraft to ground risks, spacecraft structure qualification, and jitter assessment.

There was a Critical Design Review for the mission operations element in November 2009. Ochs reported that the mission operations center ribbon cutting was also held in November, and *Build-2* of the mission operations element (developed by the Hammers Company) was delivered to the mission operations center at GSFC ahead of schedule. At this point, the flight operations team is on site and supporting early spacecraft integration and testing and procedure development, ground readiness test planning, and development of operations documentation.

Ochs concluded by reporting that the LDCM mission recently reached a major milestone in its development as it was confirmed by NASA. The process for confirmation began with the July 2009 mission Preliminary Design Review and concluded with the Key Decision Point–C meeting with NASA's Program Management Council in December 2009. As part of this confirmation, a non-advocate review of LDCM readiness took place. This later review included the generation of a joint confidence level estimate, which consists of an evaluation of the LDCM schedule and budget in order to verify that NASA can meet its obligations to mission stakeholders. Based on the analysis, the conclusion was reached that a December 2012 launch is *"aggressive but achievable"* and LDCM was given the authority to proceed with a December 2012 launch readiness date. However, an external commitment date of June 2013 was communicated to Congress along with the explanation that the LDCM team was striving for a December 2012 launch. Ochs summarized by stating that the team continues to be committed to the December 2012 launch date and that great progress has been made so far, but he acknowledged that there are still many challenges ahead. The mission Critical Design Review is scheduled for Spring 2010.

Dave Hair [USGS EROS—*Acting LDCM Ground System Manager*] provided an update on the status of the ground system development. The USGS has adopted a ground system approach and architecture that takes advantage of existing capabilities to the greatest extent possible. Hair reported that both the overall ground system and data processing and archive system Preliminary Design Reviews were successfully completed in September 2009. In addition, the first delivery of the Collection Activity Planning Element (CAPE 1.0) occurred in January 2010. This release includes the majority of the functionality associated with scheduling science data acquisitions via implementation of the Long Term Acquisition Plan (LTAP). The Critical Design Reviews for both the overall ground system and data processing and archive system are planned for Spring 2010. Ground readiness testing begins in Summer 2010 and concludes with final data processing and archive system readiness testing in Summer 2012.

USGS and NASA Outreach Activities

Anita Davis [NASA GSFC—*Education and Public Outreach*] reviewed a number of educational activities addressing Landsat and other aspects of environmental remote sensing. Davis reviewed the *Earth to Sky* initiative in which NASA is working with the National Park Service and U.S. Fish and Wildlife Service in ways that enrich the visitation experiences of park and refuge visitors. Davis also described the Integrated Geospatial Education and Technology Training (iGETT) project, which is focused on training two-year college faculty in the integration of remote sensing into GIS programs.

Ron Beck [USGS—*Land Remote Sensing Program*] summarized USGS efforts to increase the visibility of Landsat within education, professional, and congressional venues through the development of information articles, exhibit materials, brochures, and fact sheets.

Sentinel-2

Bianca Hoersch [European Space Agency—*Sentinel-2 Third Party Mission Manager*] presented an update on Sentinel-2 development. Sentinel-2 is part of the European Global Monitoring for Environment and Security (GMES) initiative that provides operational services needed for emergency management, air quality monitoring, land monitoring, and ocean and sea ice monitoring. Sentinel-2, a Landsat-class multispectral imaging mission focused on land applications, has the following key attributes:

- thirteen spectral bands (VIS, NIR, and SWIR);
- spatial resolutions of 10, 20 and 60 m with a 290-km swath;
- a five-day repeat cycle (cloud free) with two satellites;
- a sun synchronous orbit at 786-km mean altitude; and
- a seven-year design lifetime, consumables for 12 years.

Sentinel-2 is scheduled to launch in May 2013, with operational imaging available by Summer 2013. The mission concept calls for the systematic imaging of the global land surface. A range of products are planned including:

- **Level 0** and **Level 1A**: system products corresponding to raw compressed and uncompressed data;
- **Level 1B**: radiometrically corrected data;

- **Level 1C:** orthorectified top-of-atmosphere reflectance; and
- **Level 2A:** orthorectified bottom-of-atmosphere reflectance that includes enhanced cloud screening and atmospheric corrections.

Hoersch also reviewed the Sentinel data policy, which calls for full and open access to Sentinel data to all users. The European Space Agency member states approved the proposed data policy in September 2009 but the European Commission still must give its approval.

In the discussion following the Sentinel-2 presentation, there was a consensus among Landsat Science Team members that significant attention should be given to opportunities for synergy between programs, both as a means to reduce risk and to increase coverage and interoperability.

Landsat Science Products Requirements

Previous Landsat Science Team meetings have addressed the need for higher level Landsat science products. **Bruce Quirk** [USGS Land Remote Sensing Program Coordinator] introduced the session on science products with an update on USGS interest in moving beyond orthorectified multispectral products. **The USGS believes that terrestrial *essential climate variables* produced from Landsat data are needed to understand human impacts on the Earth and the status of natural ecosystems and looks to the Landsat Science Team for recommendations on data priorities and processing requirements.** Quirk's remarks were followed by presentations by members of the Landsat Science Team and guests on science product topics.

John Schott [Rochester Institute of Technology] described the Digital Imaging and Remote Sensing Image Generation (DIRSIG) modeling approach and applications in support of LDCM. DIRSIG is being used to model OLI/TIRS imaging capabilities. Modeling geometric effects are a top priority, with radiometric modeling planned for future releases. A fusion of Digital Globe, Hyperion, Landsat, ASTER emissivity, and Digital Elevation Model (DEM) data are used to establish virtual truth datasets. A first release is anticipated in early 2010 and will include the first DIRSIG-modeled OLI image, orbital geometry, and angular detection locator. The first DIRSIG-generated TIRS image is planned for soon after, with future development releases on a semi-annual basis. Each DIRSIG release will improve sensor and scene fidelity.

Lazaros Oreopoulos [NASA GSFC] presented a decadal reassessment of Landsat 7 LTAP cloud avoidance. Terra Moderate Resolution Imaging Spectroradiometer (MODIS) cloud data products were valuable for assessing past performance of the Landsat 7 LTAP for cloud avoidance, for formulating an improved Automated Cloud Cover Assessment simulator for the LTAP model, and for potentially improving the LTAP by replacing the International Satellite Cloud Climatology Project D2 nominal climatology database.

Eric Vermote [University of Maryland] updated the team on his work on surface reflectance products for Landsat. The Landsat Ecosystem Disturbance Adaptive Processing System (LEDAPS) code has been tested, evaluated, and updated. Surface reflectance estimates produced from LEDAPS for Landsats 5 and 7 were highly correlated with MODIS surface reflectance products over Africa (overall correlation coefficient (R^2) = 0.98), indicating extensibility of the approach outside North America. The LEDAPS internal cloud mask is conservative for cloudy scenes and performs well for clear scenes with a few exceptions. Cloud shadow validation remains an issue.

Curtis Woodcock [Boston University] discussed a number of considerations for cloud and cloud shadow masking. Many approaches have been developed. These range from single-date, scene-level cloud estimation (e.g., Automated Cloud Cover Assesment) to multi-date, pixel-level cloud and cloud shadow mask generation. A comparison of results from a number of approaches against a refined truth dataset was proposed.

David Roy [South Dakota State University (SDSU)] provided the status of the Web-enabled Landsat data (WELD) project. WELD products include composited large-area mosaics that are updated at the pixel level using all available acquisitions. Systematic calibration, geolocation, cloud screening, gap-filling, and radiometric correction are used to generate the products, which are similar to MODIS products but have Landsat resolution. *Version 1.3* of the products are currently available online at *landsat.usgs.gov/WELD.php*. Additional data processing and distribution capabilities (developed at SDSU) are scheduled to be ported to USGS EROS during 2010.

Greg Asner [Carnegie Institution] described the Carnegie Landsat Analysis System—Lite (CLASlite). The goal of CLASlite software is routine deforestation and degradation mapping in the tropics. The software provides powerful functionality, including image preprocessing, calibration, and correction routines, but is packaged such that a low level of remote sensing expertise is required to generate the final maps. CLASlite dissemination and capacity building has been extended to over 240 users from more than 70 agencies in six countries. An online version of CLASlite is running on *Google Earth* Engine.

Rebecca Moore [Google.org] demonstrated the *Google Earth* Engine concept and prototype. *Google* is very

interested in providing greater access to Landsat data and providing capabilities for users to generate forest products that can be used to monitor deforestation. The prototype enables online observation and measurement of forest change by combining Landsat data, CLASlite, and cloud computing technology. The concept may be extended to other types of science questions, satellite data, and processing algorithms.

Robert Kennedy [Oregon State University] presented tools to tap the Landsat archive for monitoring and validation. Landscapes are dynamic, and the Landsat data record captures important change phenomena. *LandTrendr* is an algorithmic approach for segmenting Landsat time series into pixel-level change vectors. The segments provide information about state change, cyclical change, and condition change on the landscape. Validation is critical, and the *TimeSync* approach allows for robust validation of change information extracted from Landsat time series.

Eileen Helmer [USDA Forest Service] summarized work using Landsat (TM and ETM+) and EO-1 (ALI) time series imagery to map forest disturbance and structure. Seamless, cloud-cleared image mosaics were generated using a *regression tree* approach, and these data were invaluable for the mapping and change detection approaches used.

Matt Hansen [SDSU] described global forest monitoring approaches. Satellite-based capacity for monitoring forest change at national to global scales is maturing quickly, and generic methods to ensure consistency among regions are now feasible. Data used for monitoring must include systematic global acquisitions and easy no-cost access. Discussion of future sensing systems should begin with data policy, not engineering specifications.

Mike Wulder [Canadian Forest Service] presented multi-resolution data blending to enable wide area synthetic-Landsat coverage, predictable product development, and change detection. Seamless, high temporal resolution, pixel-based mosaic products are feasible. Sensor data with high temporal and spatial resolutions can be integrated. High-frequency change and other information products can be generated, but care should be exercised with respect to factors such as input dates and change attribution.

Chengquan Huang [University of Maryland] reported progress on an Earth Science Data Record (ESDR) for global forest cover change. The approach is characterized by a mass processing capability (covering four Global Land Survey epochs), radiometric adjustment and atmospheric correction using LEDAPS code, automated change mapping, and consistency and quality assurance. Challenges include coverage gaps and calibration difficulties with certain GLS epochs.

NASA Ames Activities

Rama Nemani [NASA Ames Research Center (Ames)] presented his research on the use of Landsat for developing biophysical datasets for use in monitoring, modeling, and forecasting. His project, *Ecocast*, is using the Terrestrial Observation and Prediction System (TOPS) to deliver environmental data and assessments from local to global scales. This activity takes advantage of the NASA Advanced Supercomputing Division processing capabilities. Nemani described his efforts to use the MODIS leaf area index (LAI) strategy to develop a global 30-meter LAI dataset from the GLS 2000 and 2005 Landsat data. He is using the Landsat Ecosystem Adaptive Processing System to process Landsat scenes to a surface reflectance standard prior to calculating LAI. After his presentation, Nemani and **Jennifer Dungan** [Ames] led a tour of the NASA Advanced Supercomputing facilities.

Open Discussion on Higher Level Products

Following the science product presentations, **Curtis Woodcock** led a discussion on the needs and priorities for higher level Landsat science products. He noted the overall interest and need and concluded that the immediate priority should be to improve cloud and shadow masking of Landsat data and to generate surface reflectance and temperature products. Also, since the limitations of Landsat coverage will challenge product generation in many parts of the world, the team noted the potential for developing basic multispectral fusion products. Such processing advances are a necessary foundation for developing higher level science products such as terrestrial *Essential Climate Variables*. The Landsat Science Team members agreed with Woodcock's assessment and stressed the importance of biophysical measures such as leaf area and land cover and land cover change. The group recognized that there are major definition and methodology issues that will need resolution and will require continued research. However, the team concluded that there is a need to develop surface reflectance and temperature products as quickly as possible.

Next Meeting

The next meeting of the Landsat Science Team will be in Boise, ID, June 15–17, 2010. The meeting will be hosted by the University of Idaho and Idaho Department of Water Resources. ■

meeting/workshop summaries

Atmospheric Infrared Sounder Science Team Meeting Summary

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The Atmospheric Infrared Sounder Science Team meeting took place April 21-22, 2010, in Pasadena, CA.

Session 1: Project Overview ***[Chair**: Tom Pagano]*

Mous Chahine [NASA/Jet Propulsion Laboratory (JPL)—*AIRS Science Team Leader*] opened the Spring 2010 meeting with a welcome and introduction to all participants. He is very pleased with the many scientific discoveries with the Atmospheric Infrared Sounder (AIRS)/Advanced Microwave Sounding Unit (AMSU) system and conveyed the importance of this project to NASA and the scientific community.

Tom Pagano [JPL—*AIRS Project Manager*] presented the AIRS Project status, indicating that the AIRS instrument is in good health. The science is continuing strong with over 325 peer-reviewed publications to date using AIRS data. Pagano remembered Wallace McMillan and mentioned the memorial on the AIRS web site in his honor. He stressed that the team needs to more precisely define their requirements for future sounding observations.

Steve Friedman [JPL] discussed the status and plans for *Version 6* processing. Improvements to the spectral calibration algorithm in the Level 1B (data) have been made but do not warrant a re-release of the *Version 5* Level 1B. Level 1C will include a more sophisticated spectral calibration and channel-filling algorithm. Level 1C files are larger, so a decision needs to be made whether to process and distribute Level 1C for the entire mission, or provide the software tools to convert the Level 1B into Level 1C so users who already have Level 1B will not need to download the entire dataset. Friedman discussed the progress made in *Version 6* Level 2 development, what work still remains, and a schedule for completion.

Denis Elliot [JPL] presented the instrument and spacecraft operations status. Elliot described the anomalous shutdown of AIRS on January 9, 2010, and the method for recovery. Apparently, the shutdown occurred when a *Single Event Upset* activated a circuit designed to protect instrument circuitry. AIRS health remains good since restart in late January, with no significant change in telemetry. However, the AMSU Channel 5 continues to degrade. Twelve of the other fifteen channels are stable. The Aqua spacecraft is also in good health with only a few minor anomalies over the past years; Aqua has sufficient fuel to stay in orbit until 2017.

Session 2: Science Highlights ***[Chair**: Hartmut Aumann]*

Ed Olsen [JPL] gave an update on 7.5 years of AIRS mid-tropospheric carbon dioxide (CO_2). AIRS data are used to make about 15,000 CO_2 measurements each day. The data between 60° S and 90° N are now publicly available. Validation using aircraft and surface data indicates root-mean-squared agreement within 2 parts per million by volume (ppmv). Contrary to numerical models of the atmosphere, CO_2 is not horizontally well mixed in the troposphere, but appears driven by large-scale weather patterns. The complexity of the Southern Hemisphere carbon cycle calls for an expanded validation effort.

Junjie Liu [University of California Berkeley] described the assimilation of AIRS CO_2 observations with an Ensemble-Kalman-Filter (EnKF) in a Carbon Climate Model. The preliminary surface flux estimation from assimilating AIRS CO_2 and conventional CO_2 observations using the EnKF are encouraging.

Alex Ruzmaikin [JPL] provided a statistical overview of the AIRS Level 3 data (monthly means on a 1° grid). Ruzmaikin used temperatures at 400 hPa to show that the mean and standard deviation provided in the current Level 3 algorithm does not fully capture the Level 2 retrieval information. He proposed using distribution estimates based on clustering as a potentially better representation than simple means.

Jie Gong [JPL] made a presentation on gravity wave (GW) properties and propagation derived from AIRS radiances using stratospheric sounding channels. The GW growth and propagation with height derived from the AIRS data are consistent with GW climatology. AIRS and the Microwave Limb Sounder (MLS) together provide a full picture of wave propagation in

the zonal and meridional directions. The magnitudes of mountain GW observed by AIRS are stronger than the GW observed by MLS, whereas the magnitudes of convective waves are comparable between the two instruments. On the other hand, the quasi-biennial GW signal at 30 and 80 hPa is much more pronounced in the MLS data than it is in the AIRS data.

Bin Guan [JPL] described local and synoptic-scale characteristics and impacts of *atmospheric rivers* (AR)—narrow bands of strong moisture transport in the lower troposphere that are believed to contribute as much as 90% of the transport of moisture from the tropics to California. Guan investigated the relationship between surface air temperature (SAT) and snow water equivalent (SWE) in the Sierra Nevada mountains for 29 wintertime AR. AIRS SAT are more consistent with *in situ* observations in representing the close relationship between SAT and change in SWE than the European Centre for Medium Range Weather Forecasting (ECMWF) Interim Reanalysis.

Session 3: Science *[**Chair**: Eric Fetzer]*

Sean Casey [JPL] described regional differences in *congestus* clouds from CloudSat and their surrounding environment and AIRS. Casey found more frequent congestus in the northeast Pacific, but more frequent deep convection to the Western Pacific. He attributed the cloud differences to vertical water vapor structure, with a significantly drier middle troposphere in the northeast Pacific. Neither temperature nor heating rate differences were significant.

King-Fai Li [California Institute of Technology] described intraseasonal variability of lower tropospheric water vapor in the Eastern Pacific observed with AIRS water vapor and other data sources. Li showed that zonal wavenumber-time spectra from AIRS were consistent with equatorial Rossby waves, though much of the variability was also associated with the Madden-Julian Oscillation (MJO).

Baijun Tian [JPL] gave an update to his analysis of vertical moist thermodynamic structure of the MJO in AIRS observations, and showed comparisons to ECMWF interim reanalyses. Tian applied a methodology published in 2006 using 2.5 years of AIRS data to a seven-year record. The results from the two AIRS time periods that he studied were similar. The ECMWF reanalyses showed similar structure, but generally larger amplitudes. The AIRS structure was more realistic in the near-surface boundary layer.

Sun Wong [JPL] assessed the hydrologic and thermodynamic budgets associated with precipitation variability of the south Asian monsoon. Wong used a combination of AIRS temperature and water vapor data, and Modern Era Reanalysis (MERRA) winds, to infer moisture and heat sources and sinks. He showed realistic variations across the eastern Indian and western Pacific Oceans, and broad consistency with rainfall observations.

Session 4: Atmospheric Composition
*[**Chair**: Fredrick Irion]*

Fred Prata [Norwegian Institute for Air Research] described the utility of AIRS data in monitoring the plume from Iceland's Eyjafallajökull volcano—which was erupting at the time of the talk. Prata also presented AIRS-retrieved ash and sulfur dioxide amounts from a variety of volcanoes, and discussed the implications for air transport.

Robert Vincent [Bowling Green State University] discussed measurement of methane content in the lower troposphere from space and from aircraft as a means of detecting plumes from unstable methane clathrates in the continental shelf and slope areas offshore, and in tundra regions onshore. Vincent pointed to a recent finding by *Shakhova et al.*[1] in the March 5, 2010 issue of *Science* that showed evidence of Arctic waters north of Eastern Siberia already becoming supersaturated with methane.

Larrabee Strow [University of Maryland Baltimore County (UMBC)] presented work detecting ammonia (NH_3) and deuterated water vapor (HDO) in AIRS spectra. Results for NH_3 indicated excellent spatial correlation with agricultural use. The AIRS spectra showed HDO signatures in the shortwave channels, and the AIRS HDO retrieval could prove valuable in understanding the water cycle. Strow noted that significant work would be required before routine retrieval of either gas would be possible.

Fredrick W. Irion [JPL] gave an update on retrievals of CO_2 using optimal estimation techniques, and showed good seasonal and latitudinal correlation with aircraft measurements over the western Pacific Ocean.

Xun Jiang [University of Houston] used AIRS mid-tropospheric CO_2 to examine inter-annual variability of CO_2. During El Niño events, mid-tropospheric CO_2 over the central Pacific Ocean is enhanced whereas it is reduced over the western Pacific Ocean as a result of the change in the Walker circulation. Variation of AIRS CO_2 in the high latitudes of the northern hemisphere is closely related to the strength of the Northern Annular Mode. These results contribute to a better understanding of the influence of large-scale dynamics on tracer distributions.

[1] *Science* 5 March 2010: **327.5970**, pp. 1246-1250; DOI: 10.1126/science.1182221.

Session 5: Water Vapor, Clouds, & Radiation ***[Chair**: Brian Kahn]*

Brian Kahn [JPL] showed variance spectra of moist conserved variables from the A-Train, using AIRS temperature and water vapor, CloudSat liquid water content, and analogous quantities in ECMWF reanalyses. The observations show that dominant scales depend upon the quantity considered, and also height and latitude. The model fields show significant differences with observations.

Liming Li [University of Houston] described the recycling rate (inverse residence time) of atmospheric moisture between 1988–2008 using AIRS, Special Sensor Microwave Imager, general circulation model, and NASA Water Vapor Project data. Li showed a slow decrease in recycling rate in the global mean, but with significant regional differences.

Joel Susskind [NASA Goddard Space Flight Center (GSFC)] showed how AIRS *Version 5* products verify and explain recent downward global outgoing longwave radiation (OLR) trends observed by Clouds and the Earth's Radiant Energy System (CERES). Susskind attributed most of the OLR decrease to increases in water vapor associated with El Niño/Southern Oscillation (ENSO) modulation—though cloud effects were also important.

Qing Yue [JPL] presented results of a study of *stratocumulus* clouds from CloudSat and associated AIRS temperature and water vapor retrievals. Yue showed consistency in mean boundary layer structure from AIRS, and from routine weather observations when low clouds are present. This structure includes well-defined inversion structures in several regions.

Session 6: ***Version 6*** **Product Development and Test Status** ***[Chair**: Steve Friedman]*

Fredrick Irion [JPL] described recent studies of well-established bias trends (i.e., cooling) in AIRS temperature profiles, and attributed part of the trend to the first step regression solution. Irion also compared known clear AIRS footprints within scenes of nine footprints and showed consistency with corresponding cloud-cleared radiances.

Larrabee Strow [UMBC] described bias and trend characteristics of AIRS cloud-cleared radiances, using ECMWF as a standard. Strow showed large outliers, especially in window channels, consistent with large outliers in the retrieved surface temperatures. He also showed bias trends consistent with known trends in temperature profiles. Strow also presented an evaluation of AIRS radiative transfer algorithm (RTA) errors versus viewing angle, and showed slight biases. He suggested angle-dependent bias corrections to the current RTA.

Eric Maddy [National Oceanic and Atmospheric Administration] presented the status of AIRS *Version 6* upgrades at NOAA's National Satellite, Data, and Information Service (NESDIS). Upgrades include a variable frequency cloudy RTA, mitigation of spurious trends (as described by **Irion** above), improved regression coefficients, an optimal estimation carbon monoxide retrieval algorithm, and the inclusion of convective instability parameters.

Evan Manning [JPL] described several issues with using the ECMWF forecasts as a standard for comparison with AIRS. These include trends in ECMWF ocean emissivity, poor tropopause properties prior to 2006, questionable polar stratospheric water vapor, and changes in the diurnal cycle in 2009. Nevertheless, the ECMWF includes a wide variety of useful variables for comparison.

Thomas Hearty [GSFC] presented comparisons between AIRS and MERRA. He found evidence for sampling biases in the AIRS Level 3 products, which vary by region and possibly by season.

Joel Susskind [GSFC] presented on the status of the changes planned for *Version 6*. Susskind recommended an improvement in regression that does not depend upon AMSU Channels 4 and 5—since these channels are expected to continue degrading. He also recommended using a neural network regression solution to reduce the known bias trends.

Van Dang [JPL] showed AIRS cloud retrievals, including tests of *Version 6*. Dang showed spikes in histograms of cloud top pressure in *Version 5* that are not seen in *Version 6*. She also showed that retrieved cloud top pressures have a scan angle dependence, and that different cloud types may have larger deviations between regression and final retrieval solutions.

Eric Fetzer [JPL] described plans for AIRS *Version 6* validation and testing. The plans include exploiting the wide variety of *in situ* observations available since the AIRS launch. This will enable understanding AIRS retrievals over a wide range of geographic and geophysical conditions.

Peter Bauer [ECMWF] discussed assimilation of data from AIRS, as well as from the Infrared Atmospheric Sounding Interferometer (IASI) on MetOp, at ECMWF. Several million observations per day from these two hyperspectral infrared instruments are assimilated by ECMWF each day. These data represent the most valuable single instrument type for Numerical Weather Prediction but must be complemented by other data sources.

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CERES Science Team Meeting Summary

Jim Closs, NASA LaRC/Science Systems and Applications, Inc., james.w.closs@nasa.gov

The Spring 2010 meeting of the Clouds and the Earth's Radiant Energy System (CERES) Science Team took place April 27-29, 2010, at the City Center at Oyster Point Marriott hotel in Newport News, VA. **Norman Loeb** [NASA Langley Research Center (LaRC)—*CERES Principal Investigator*] hosted the meeting.

Full meeting presentations are available on the CERES web site at: *science.larc.nasa.gov/ceres*.

Major objectives of the meeting included review and status of CERES instruments, data products, and related activities including:

- a report on the status of CERES, NASA, the Earth Observing System (EOS), the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project [NPP], and beyond;
- an overview of the NPP Mission and the new Joint Polar Satellite System (JPSS)[1];
- reports on Terra and Aqua Shortwave/Longwave/Total channel calibration for *Edition 3*;
- an update on CERES Flight Model (FM) 5 and 6;
- an update on CERES *Edition 3* cloud algorithm development and validation;
- an update on Clouds and Radiative Swath (CRS) *Edition 3* algorithm development progress and *Edition 2* validation of CRS and synoptic datasets;
- a report on efforts to work towards an early release of 10 years of climate-quality Level 3 (L3) daily and monthly CERES Top-of-Atmosphere fluxes–CERES "Lite" Products;
- an update on synoptic/averaged/zonal-averaged datasets: the L3 gridded version of Computed Top-of-Atmosphere (TOA)/Atmosphere (ATM)/Surface (SFC) fluxes;
- a report on International Satellite Cloud Climatology Project (ISCCP)-like Moderate Resolution Imaging Spectroradiometer (MODIS) and Global Earth Observation (GEO) data products;
- a report on a new prototype CERES Subsetting/Visualization/Ordering tool for L3 data products;
- an update on the Global Energy and Water Experiment (GEWEX) radiative flux assessment;
- an update from the Data Management Team—including reports from Terra, Aqua, and NPP;
- an update from the Atmospheric Sciences Data Center (ASDC); and
- an update on CERES education and public outreach.

In addition to CERES-specific science reports by science team members, **Stephen Schwartz** [Brookhaven National Laboratory] and **Minghua Zhang** [Stony Brook University] gave invited presentations.

Norman Loeb [LaRC] presented an overview and status of CERES, NASA, EOS, Senior Reviews, NPP and NPOESS, and the National Science Foundation (NSF)-recommended Decadal Survey missions. Loeb gave an overview of the CERES project structure, data processing flow, and data products, and also discussed plans for CERES on NPP and NPOESS. In addition, he revisited the CERES organization and working group leads, and gave an update on selected CERES science results. A popular research topic has been efforts to account for the apparent lack of global atmospheric warming over expected amounts, and the ability of CERES to directly measure the Earth's energy budget as key to closure on this issue. Loeb concluded with updates on upcoming CERES missions, and an overview of the Climate Absolute Radiance and Refractivity Observatory (CLARREO) mission.

Kory Priestley [LaRC] gave an overview and update of the CERES Instrument Working Group, status reports on CERES FM1–FM6, and *Edition 3* calibration results. CERES on Terra and Aqua continue to operate nominally, and when combined with CERES on the Tropical Rainfall Measuring Mission (TRMM), has a total of over 37 instrument years of data collected. The fabrication, assembly, and test program for CERES FM5 on NPP is complete, and assembly of CERES FM6 from spare parts has begun. One note of concern is the lack of funds for needed improvements to the Shortwave Internal Calibration Source (SWICS) and the Mirror Attenuating Mosaic (MAM), which may result in FM6 observational requirements not being met. Discussions with NOAA on strategies for implementing these improvements are ongoing.

The next series of presentations provided updates on various CERES subsystem activities.

- **Patrick Minnis** [LaRC] reported on *Edition 3* cloud algorithm activities.
- **Dave Kratz** and **Shashi Gupta** [both at LaRC] reported on Surface-Only Flux Algorithm (SOFA) development.
- **Thomas Charlock** [LaRC] shared recent developments in Surface and Atmosphere Radiation Budget (SARB) products.
- **David Doelling** [LaRC] reported on Time Interpolation and Spatial Averaging (TISA) activities.
- **Takmeng Wong** [LaRC] presented a comparison

[1] JPSS is the name for the reformulated NPOESS program. The "Editor's Corner" of the March–April 2010 issue of *The Earth Observer* [**Volume 22, Issue 2**, page 2] summarizes the changes to the program.

of Top-of-Atmosphere (TOA) radiation budget data with the GEWEX Radiative Flux Assessment Archive.
- **Jonathan Gleason** [LaRC] reported on the activities of the CERES Data Management Team.
- **John Kusterer** [LaRC] gave an update on the Atmospheric Science Data Center (ASDC).
- **Lin Chambers** [LaRC] provided an update on Student's Cloud Observations On-Line (S'COOL).

Day two began with breakout Working Group sessions, including the SARB/SOFA Working Group led by **Thomas Charlock**, and the Cloud Working Group led by **Patrick Minnis**.

A pair of **invited presentations** highlighting exciting new science and programs followed.

Stephen Schwartz [Brookhaven National Laboratory] spoke on the challenge of achieving 1% per mil (or 0.1%) accuracy in satellite measurements of the Earth's energy imbalance to determine true climate sensitivity. Schwartz stated that accurate knowledge of Earth's climate sensitivity is enormously important to planning the world's energy future, and that present uncertainty in climate sensitivity does not constrain even the sign of how much more carbon dioxide (CO_2) can be added to the atmosphere before exceeding any given warming commitment. He contends that the warming discrepancy is due mainly to climate sensitivity lower than the Intergovernmental Panel on Climate Change's (IPCC) best estimate and/or is offset by aerosol forcing, with little contribution from lack of equilibrium.

Minghua Zhang [Stoney Brook University] gave an overview of the Cloud Feedback Model Intercomparison of Large-Eddy and Single Column Models (CGILS) project to understand climate feedbacks of low clouds. The project led to a workshop held March 1-2 to understand the physical mechanism of cloud feedbacks in climate models, with the goal of interpreting climate sensitivities of IPCC 5th Assessment Report models. The study concluded that the models simulated the intended types of low clouds and the range of cloud feedbacks, and that negative feedbacks are due to larger turbulent water transport to the upper boundary layer. Vertical resolution in current models is insufficient for low clouds, and the interaction of turbulence, convection, stratiform clouds, and radiation needs to be better understood.

Following the invited presentations, there were a series of **co-investigator reports** with updates on new data products and science results. The topics discussed are summarized in the table below. Please refer to the URL listed below for more details on each presentation.

Topic	Speaker	Institution
Using CERES in Developing Shortwave Radiation Budget Algorithms from the Geostationary Operational Environmental Satellite (GOES-R)	Istvan Laszlo	NOAA and the University of Maryland
Radiation Fluxes of NCEP/Climate Forecast System Reanalysis Validated with CERES	Shi-Keng Yang	NOAA
Update on the Coupled Model Intercomparison Project Phase 5 (CMIP5) Observation Data Base	Jerry Potter	Goddard Space Flight Center
Preliminary Results Using a Cloud Object Simulator	Zachary Eitzen	Langley Research Center/Science Systems and Applications Inc. (SSAI)
Estimating the Global Cloud Feedback in FlashFlux Data	Andrew Dessler	Texas A&M University
Biases in Observationally Estimated Cloud Radiative Forcing from Multi-Year High-Resolution Global Circulation Model (GCM) Simulations	Xianglei Huang	University of Michigan
Climate Sensitivity and Short-Term Relationship of Top-of-Atmosphere Net Radiation and Surface Temperature	Bing Lin	Langley Research Center
Response of Deep Convective Clouds to Increases in Particle Burdens	James Coakley	Oregon State University

Boundary Layer Lapse Rate used in CERES *Edition 3* Processing	Sunny Sun-Mack	Langley Research Center/SSAI
Validation of MODIS Derived Cloud Properties and Modeled Irradiances using CALIPSO/Cloudsat/CERES Merged (C3M) Processes	Seiji Kato	Langley Research Center
Comparison of Arctic cloud properties derived from CERES–MODIS, Cloudsat, and Atmospheric Radiation Measurement (ARM) radar	Xao Dong	University of North Dakota
Update on Evaluating CERES *Edition 3* Overlap Cloud Properties	Foulung Chang	Langley Research Center/National Institute of Aerospace (NIA)
Estimating Radiation Effect of Invisible Clouds with a Synergy of CERES, MODIS, CALIPSO, AIRS, and AMSR-E Data	Wenbo Sun	Langley Research Center/SSAI
Effects of Clouds and Aerosols on the Radiation Balance Inferred from CloudSat, CALIPSO, and MODIS Observations	David Henderson	Colorado State University
Development of a Unified Aerosol Retrieval System for Past, Current, and Future Satellite Imagers	Xeupeng (Tom) Zhao	NOAA/NCDC
Aerosol Forcing at Niamey, Niger from the CERES perspective	David Rutan	Langley Research Center/SSAI
Far-Infrared Observations of the Radiative Greenhouse Effect (FIRST) Chile Deployment	Marty Mlynczak	Langley Research Center
Tropospheric Spectral Infrared Radiative Cooling Rate from In-situ Net FLux within the AtMsophere of the Earth (INFLAME)	David Johnson	Langley Research Center
Measuring Earth's Radiation Budget using a Constellation of Sensors on Iridium NEXT	Om Gupta	Iridium
NPP Overview and Joint Polar Satellite System (JPSS) Update	James Gleason	Goddard Space Flight Center

Norman Loeb led a final wrap-up and discussion of action items from the meeting. Loeb reiterated the importance of adopting a three-month *Edition 2* gains delivery schedule, and *Edition 3* instrument improvements. The Clouds Team is expected to deliver *Edition 3* algorithms in July 2010, and continue *Edition 3* validate efforts with Cloudsat, CALIPSO, and ARM. The SOFA Working Group will refine cloud transmittance calculations, and examine the reason for large differences with the C3M product over oceans. The SARB team will focus on *Edition 3* improvements and CRS methodology and validation papers. TISA will release 10-year Terra and Energy Balanced and Filled (EBAF) datasets as soon as possible, and go live with the new CERES data ordering tool. The Data Management Team will complete Terra *Edition 2* processing through March 2010, and *Edition 2* SSF processing for January 2008–March 2010, as well as develop scripts for all CERES Product Generation Executives (PGE) to perform input file checking.

The next CERES Science Team meeting will be held September 13-16 in Paris, France. The meeting will be held jointly with the Scanner for Radiation Budget (ScaRaB)/Geostationary Earth Radiation Budget (GERB)/Laboratoire de Météorologie Dynamique (LMD) projects. ■

meeting/workshop summaries

The Spring 2010 NASA Land-Cover Land-Use Change Science Team Meeting

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

The Spring 2010 NASA Land-Cover Land-Use Change (LCLUC) Science Team Meeting took place from April 20-22, 2010, in Bethesda, MD. The meeting involved 120 attendees, providing an opportunity for investigators to present their research results in the form of review talks and posters, and discuss the enhancement of the NASA Landsat Global Land Survey (GLS) projects. The presentations, posters, and breakout group reports from the meeting can be downloaded from: *ftp://ftp.iluci.org/LCLUC/LCLUCMeetings/2010_APR/*.

Opening Remarks

Garik Gutman [NASA Headquarters (HQ—*LCLUC Program Manager*] opened the meeting with an overview of the LCLUC program outlining the current relationships with other NASA programs and the national and international land cover related programs, as well as his plans for program expansion. Gutman expressed the need to refine the current scope of the LCLUC program to further enhance the social science component, while balancing the program thematically and geographically and with greater emphasis on non-forest land cover types. He noted the current tension between straight-line funding for the program and an increasing interest in this research area by the community—as indicated by the large number of submissions. Gutman asked for feedback on the program's two-step approach to the Research Opportunities in Space and Earth Sciences (ROSES) proposals, which is aimed at increasing the funding success ratio for the program.

Chris Justice [University of Maryland—*LCLUC Program Scientist*] identified a number of emerging issues for science team consideration, including:

- Higher order data products from the Landsat Data Continuity Mission (LDCM) and potential synergy with the European Space Agency (ESA) Sentinel 2 mission;
- the Committee on Earth Observation Satellites (CEOS) Land Surface Imaging Constellation;
- Land-Cover Change and the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD);
- the Group of Earth Observations (GEO) Forest Carbon Tracking Task;
- the United Nations Framework Convention on Climate Change (UNFCCC) Essential Climate Variable process; and
- the possibility of a fine-resolution science data initiative with the National Geospatial-Intelligence Agency (NGA). Justice introduced a new *Hot Spots of Land-Use Change* initiative on the LCLUC program web page and invited program Principal Investigators (PIs) and their students to participate.

LCLUC 2010 Spring Meeting participants

Jonathan Smith [U.S. Geological Survey (USGS)] delivered an overview of the U.S. Global Change Research Program (USGCRP) and the activities of the Land Use Inter-Agency Working Group (LUIWG). The USGCRP is establishing new program management and has an emphasis on adaptation, mitigation, decision-support, and climate services. Smith emphasized continued participation by the various agencies in coordinating land-use research, demonstrating the importance of observations, refining global change dataset requirements, and enhancing national data collection capabilities.

Science Presentations

LCLUC in the Monsoon Asia Integrated Regional Study (MAIRS)

Atul Jain [University of Illinois, Urbana-Champaign] and **Hanqin Tian** [Auburn University] described two LCLUC projects which incorporate modeling to study land-cover changes and regional carbon and nitrogen interactions in monsoon and Southeast Asia. A land surface Integrated Science Assessment Model (ISAM) is being used to understand the impacts of LCLUC on ecosystems and carbon and nitrogen dynamics and emissions, and a Population-Economy-Technology (PET) model links trade to the biophysical feedbacks. A combination of Landsat, Moderate Resolution Imaging Spectroradiometer (MODIS), and Indian Remote Sensing Satellite (IRS) data is being used to quantify land-cover change and the associated carbon fluxes in India. This research points to the importance of nitrogen deposition and secondary forests as a major carbon sink in this region. Land-use change studies are projecting regional changes in the area of agricultural, primary, and secondary forest through to 2050 and evaluating the associated dynamics of surface roughness, irrigation, albedo, and latent heat.

Deforestation and urbanization are two key components of land-use change in monsoon Asia. **Annemarie Schneider** [University of Wisconsin-Madison] and **Peilei Fan** [Michigan State University] gave a review of urbanization in China describing the economic drivers of these changes and a climate modeling study being used to examine the impact of land-use changes since 2000. **Jefferson Fox** [East West Center] gave a review of LCLUC in mainland Southeast Asia, highlighting the importance of understanding both the biophysical and socioeconomic processes associated with LCLUC. Fox explained the widespread use of swidden agriculture and the recent expansion of rubber plantations. He emphasized that land-use change is pervasive throughout the region, much of which cannot be detected solely with remote sensing. Fox stressed the need to address the social and environmental consequences of LCLUC holistically, rather than through a series of individual case studies.

LCLUC in the Northern Eurasian Earth Science Partnership Initiative (NEESPI)

Volker Radeloff, with input from **Mutlu Ozdogan** [University of Wisconsin] and **Kirsten de Beurs** [Virginia Polytechnic Institute], described multi-scale influences of institutional change including open markets, subsidy withdrawal, and privatization, on farmland abandonment and logging in Eastern Europe. The extent and impact of institutional change is vastly different between countries in the region, although rural depopulation and agricultural sector decline are common. The strength of the institution appears to be the strongest explanatory variable. Permanent changes from complete farmland abandonment and decreased agricultural intensity are occurring in all countries of the region, with the highest abandonment rates closer to cities and at lower elevations on low slopes. Logging rates changed rapidly after the collapse of the Soviet Union, caused by several factors including decreased forest management and enforcement.

LeeAnn King, **Chris Justice**, and **Alyssa Whitcraft** [University of Maryland]

Bruce Forbes [University of Lapland] with input from **Skip Walker** [University of Alaska, Fairbanks] presented land-use changes and sea-ice cover decline in the Yamal Peninsula. Air temperature has warmed in the area over the last 30 years, adding to the changing social pressures of economic development. These factors are negatively affecting habitat of the reindeer population and thus the livelihood of the indigenous population. The research identified an average loss of 25% of sea ice, with as much as a 44% reduction resulting from the increase in summer warm temperatures.

Keith Eshleman [University of Maryland], with input from **Alexander Shiklomanov** [University of New Hampshire], **Vladimir Aizen** [University of Idaho], and **Sassan Saatchi** [NASA/Jet Propulsion Laboratory (JPL)/University of California, Los Angeles (UCLA)], presented the progress of projects at various scales and

with multiple data streams that are evaluating the effects of LCLUC and climate change on hydrological processes in the NEESPI region. A historical analysis has been undertaken on changes in components of the water cycle and the associated impacts of land cover and water use. The analysis points to the importance of climate change, although comparison of scenarios generated by different global climate models have exposed a wide variability in precipitation projections for the region. In general though, projections of future water balance show a wetter climate and higher runoff for most of the NEESPI region. This is in contrast to the overall drier conditions projected for Central Asia and Southern Europe. Further investigation of the drivers and impacts of LUC in the region are needed.

Breakout Sessions

Three breakout discussions groups were formed to discuss the role of case study *synthesis* in the LCLUC program, the LCLUC science needs for higher-order Landsat class products, and scoping adaptation and vulnerability research in the LCLUC program. Findings from these breakout sessions are outlined below and summarized in the meeting presentations.

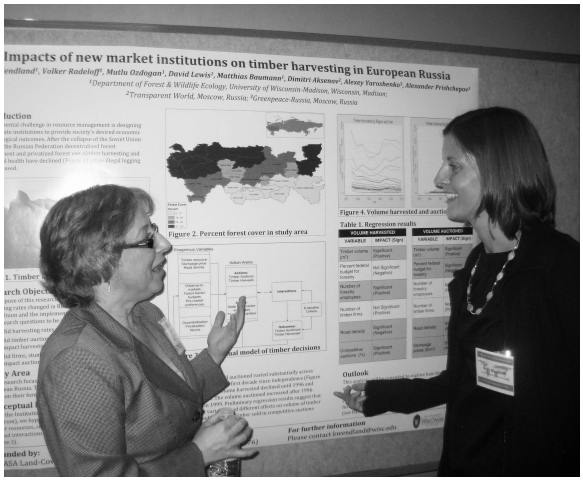
The *Case Study Synthesis* breakout group, co-chaired by **Jefferson Fox** and **Dave Skole** [Michigan State University], proposed to build *synthesis* by generalizing with an emphasis on causes and feedbacks. Two types of *synthesis* were identified: *vertical*, where social and physical studies are combined for an area; and *horizontal*, where various research projects of a similar nature are compared across a region. In general, the theme for LCLUC *synthesis* is understanding the drivers and consequences, their commonalities, and differences. The goal is to understand the implications of land management on land cover and use, biogeochemistry and climate, and the coupled natural/human systems. This type of synthetic analysis requires interdisciplinary collaboration from both social and physical sciences and is necessary, for example, for the study of carbon and hydrology in the various biomes and land-use systems.

The framework for *synthesis* could include across-scale analyses integrating from local to regional, urban, and rural interactions, land/water interfaces, and data integration and fusion. One approach suggested was to provide funding support for two to three larger integrated teams specifically for *synthesis*. Each regional team would be required to include individuals or groups with strong social science, natural science, modeling, and remote sensing. Linking established groups together on regional *synthesis* projects, rather than relying on individuals to incorporate *synthesis* within one project, could provide enhanced collaboration. Such integrated teams would require proof of already established and funded collaboration between social and physical scientists, producing quantitative results in the LCLUC arena. Suggested *synthesis* topics included interactions between urban and rural land-use and agriculture and forests. To facilitate such projects, the group expressed the necessity of having a community LCLUC model, identifying emerging or increasingly important drivers along with data synthesis in support of the model. Some near-term synthesis support activities were suggested including data exchange, mini-workshops for regional synthesis working groups, and targeted special issues.

The *Adaptation and Vulnerability* breakout group, co-chaired by **Kirsten de Beurs** and **Volker Radeloff**, identified a number of challenges associated with evaluating *adaptation* and *vulnerability* at any scale, including the varying definitions and contexts. The question was raised on how to focus adaptation and vulnerability for LCLUC. The discussion resulted in a working definition of *adaptation* as long-term changes in land-use as a response to changes in institutional policy, economic development, and climate and their interactions, with ranging impacts on agriculture, grazing, forestry, etc. A land-use *adaptation* matrix was developed to help guide program implementation. Additional dimensions of *vulnerability* and *adaptation* identified included the social scale, the temporal scale, regional variability, and differences between developing and developed countries, etc.

A key *adaptation* question is to establish which stressors trigger the most land-use change and identify the main *adaptations* to each stressor. A synthesis workshop series was suggested for the LCLUC program to identify past examples of *adaptation* using the strength of the satellite data record to identify where the major *adaptations* will take place in the future and which areas are most vulnerable to each stressor/land-use combination. These workshops would each result in a review paper.

The *LCLUC Requirements for Higher-order Landsat-class Products* breakout group was co-chaired by **Jeff Masek** [NASA Goddard Space Flight Center (GSFC)] and **David Roy** [South Dakota State University]. The group identified the current Landsat products being generated by the USGS and the Global Land Survey Project, as well as the evolving plans for LDCM to generate standard *surface reflectance* products. It was pointed out that a suite of higher order science products could be developed from LDCM, as was done for MODIS, but that some products would require other data fusion, integration, or calibration to be generated reliably. The group recognized that L1T processing, atmospheric and bidirectional reflectance distribution function (BRDF) correction, cloud and snow masks, and per pixel quality assurance are all prerequisites to the generation of higher order products. Pan-sharpened imagery are needed as standard products.



Kelly Wendland [University of Wisconsin-Madison] and **Olga Krankina** [Oregon State University]

The group also identified the need for individual path-row products, as well as continental mosaics, composited and near-real-time products, and the recent progress in these areas. The group noted that the NASA Earth Science Data Record (ESDR) Whitepaper for Land Cover and Change is still relevant in terms of products and that there is a growing expectation for *Essential Climate Variables* to be generated at Landsat resolutions. A number of new products associated with LCLUC were identified. The group identified areas for research on new product development, including automated change detection and object oriented classification. It was recognized that further research is needed to develop the standard products that could be generated in the LDCM era and that some of the underpinning product development could be supported under LCLUC projects.

Fellowship Presentations

NASA Earth and Space Science Fellowship (NESSF) fellows gave short presentations explaining their LCLUC related research topics and the progress made since their NASA funding began. **Marcia Macedo** [Columbia University] presented her project aimed at improving the understanding of how land-use change effects the connectivity of streams and the health of freshwater fish communities. **Maxim Dubinin** [University of Wisconsin-Madison] presented his work on evaluating the effect of land-use change on fire, vegetation, and wildlife dynamics in arid grasslands of Southern Russia. Presentations were also provided by scientists receiving funding from NASA's New Investigators Program. **Yufang Jin** [University of California, Irvine] described fire-induced changes in albedo and the associated radiative forcing for boreal Canada and the Australian tropical savannas. **Robert Kennedy** [U.S. Forest Service] is working to detect differences in anthropogenic and natural changes in landscape vegetation of national parks in the western United States.

The Global Land Survey (GLS) and Related Product Research

Major objectives of the meeting included review and status of projects supported to develop regional land cover and change products utilizing the GLS. **Jeff Masek** gave an overview of the GLS program. Project updates were then presented by:

- **Matt Hansen** [South Dakota State University], on regional scale estimation of forest-cover change in humid tropics using multi-scale data;
- **Dave Skole**, on using Landsat data to enhance global observations and information on tropical forest change;
- **John Townshend** [University of Maryland, College Park], on LCLUC and NASA Making Earth System data records for Use in Research Environments (MEASURES) funded research that evaluates three decades of forest-cover change in the Americas using Geocover and GLS datasets;
- **Chandra Giri** [USGS], on the global mapping of mangrove forests;
- **Xiangming Xiao** [University of Oklahoma], on the development of classification products for monsoon Asia using Landsat and Advanced Land Observing Satellite (ALOS)/Phased Array type L-band Synthetic Aperture Radar (PALSAR) imagery; and
- **David Roy,** on the status of a MEASURES Web-enabled Landsat data (WELD) project that generates continental scale Landsat composites. An open discussion on LCLUC data initiative priorities and future steps followed. There was a consensus that LCLUC should continue the development of the GLS, the use of multiple sources of Landsat-class data, and the associated regional and continental scale higher-order science products.

Landsat, Data Gap Studies, LDCM, and Beyond

Presentations provided an overview on sensor performance for LCLUC observations, discussing data gap and data fusion studies, and systematic geometric effects. **Gyanesh Chander** [Earth Resources Observation and Science (EROS) Data Center] reported on the evaluation and comparison of IRS-P6 Advanced Wide Field Sensor (AWiFS) and the Landsat sensors while **Mary Pagnutti** and **Robert Ryan** [Innovative Imaging and Research] explained BRDF impact in AWiFS data. **Sam Goward** [University of Maryland] presented analysis on the assessment and removal of systematic geometric effects on IRS AWiFS/Satellite Pour l'Observation de la Terre (SPOT) images.

Jim Irons [GSFC] discussed the status of Landsat 5/7 and the progress of the LDCM. The NASA Agency Management Council confirmed that the LDCM is ready for the final design and fabrication phase of mission development following a December 16, 2009 review. The confirmed LDCM payload now includes a Thermal Infrared Sensor (TIRS) in addition to the Operational Land Imager (OLI) with a target December 2012 launch date. **Curtis Woodcock** [Boston University—*Landsat Science Team and Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD) Land Cover Co-Chair*] presented the priorities of the Landsat science team and his work on systematic land-cover validation, explaining that the maturity of the land-cover community results in an increasing emphasis on validation and accuracy, which is essential for progress.

Gyanesh Chander reported on recent developments with the CEOS Land Surface Imaging Constellation.

Bryant Cramer [USGS] presented different aspects of USGS involvement with Landsat. Current efforts include developing a multi-source data acquisition plan to mitigate a potential Landsat data gap and augmenting the single data stream from LDCM. In the latter context, USGS is working with the ESA on possible joint operations of LDCM and Sentinel 2. He noted that additional funding is needed for USGS LDCM operations and any data buys associated with filling a Landsat data gap; he also stated that the funding pathway for an operational Landsat program is not evident. Following his talk, there was an animated discussion from the community on the need to build two OLI instruments while a plan for the future of U.S. land imaging is being formulated; the need for NASA to stay actively engaged at the highest level in the future of the Landsat program; the requirement for higher temporal frequency from Landsat class observations (2-3 day coverage); and the comparatively rapid deployment of Landsat class systems by other nations.

Garik Gutman made concluding remarks for the meeting. Gutman emphasized the need for continued community participation in developing the LCLUC Program through science team meetings and welcomed feedback on: the program direction and research priorities, the observations and datasets needed for LCLUC, the current two-step proposal process, and the format for the meetings. He highlighted plans for future meetings and, in particular, the Fall LCLUC Regional Science Workshop in Tartu, Estonia (August 25-28, 2010). ■

Atmospheric Infrared Sounder Science Team Meeting Summary

continued from page 30

Sharon Ray [JPL] described recent AIRS education and public outreach activities. These include AIRS views of the eruption material from Iceland's Eyjafallajökull volcano, a "Best of Green 2010" Award from *TreeHugger.com* for CO_2 data, and a press conference at the Fall AGU meeting that led to articles in the New York Times and other national media outlets.

Session 7: Calibration Status ***[Chair**: Denis Elliott]*

Denis Elliott [JPL] summarized the development of a new set of calibration coefficients to be used in the *Version 6* Level 1C software. The primary reason for the new coefficients is to improve the absolute calibration of AIRS and associated uncertainties. The new coefficients result in small changes to AIRS radiances that have no impact on the use of AIRS for weather prediction, but do have the potential for improving AIRS' utility for the detection of climate trends.

Evan Manning [JPL] described Level 1B and Level 1C status. Level 1B for *Version 6* will have an improved determination of instantaneous channel frequencies. Changes include real-time monitoring of narrow spectral lines and better monitoring of dead and very noisy channels. These changes will be implemented in *Version 6* Level 1B. Manning also described Level 1C spectral processing using ECMWF as a stability standard. Tests of the new spectral calibration show that the cleaning and resampling algorithms work very well.

Steven Broberg [JPL] described a proposed on-board channel-by-channel gain and circumvention threshold table for the AIRS instrument. The table has been replaced three times since launch—but has not been updated since November 2003. Since then, the build up of total radiation dosage and degraded noise performance have led to the loss of some channels. Analysis of special calibration sequences showed that 163 channels could be significantly improved by the proposed weight changes.

Session 8: Version 6 Wrap Up and Action Items; Version 7 Ideas and Plans ***[Chairs**: Tom Pagano and Steve Friedman]*

This session was a group discussion of additional changes to *Version 6* and possible modifications for *Version 7*. ■

Adios El Niño, Hello La Niña?

Alan Buis, NASA Jet Propulsion Laboratory, alan.buis@jpl.nasa.gov

The latest image of Pacific Ocean sea surface heights from the NASA/European Ocean Surface Topography Mission/Jason-2 oceanography satellite, dated June 11, 2010, shows that the tropical Pacific has switched from warm to cold during the last few months. The lightest area in the center of the image depicts the recent appearance of cold water hugging the equator, which the satellite measures as a region of lower-than-normal sea level. Remnants of the El Niño warm water pool, shown here in dark pixels, still linger north and south of the equator in the center of the image.

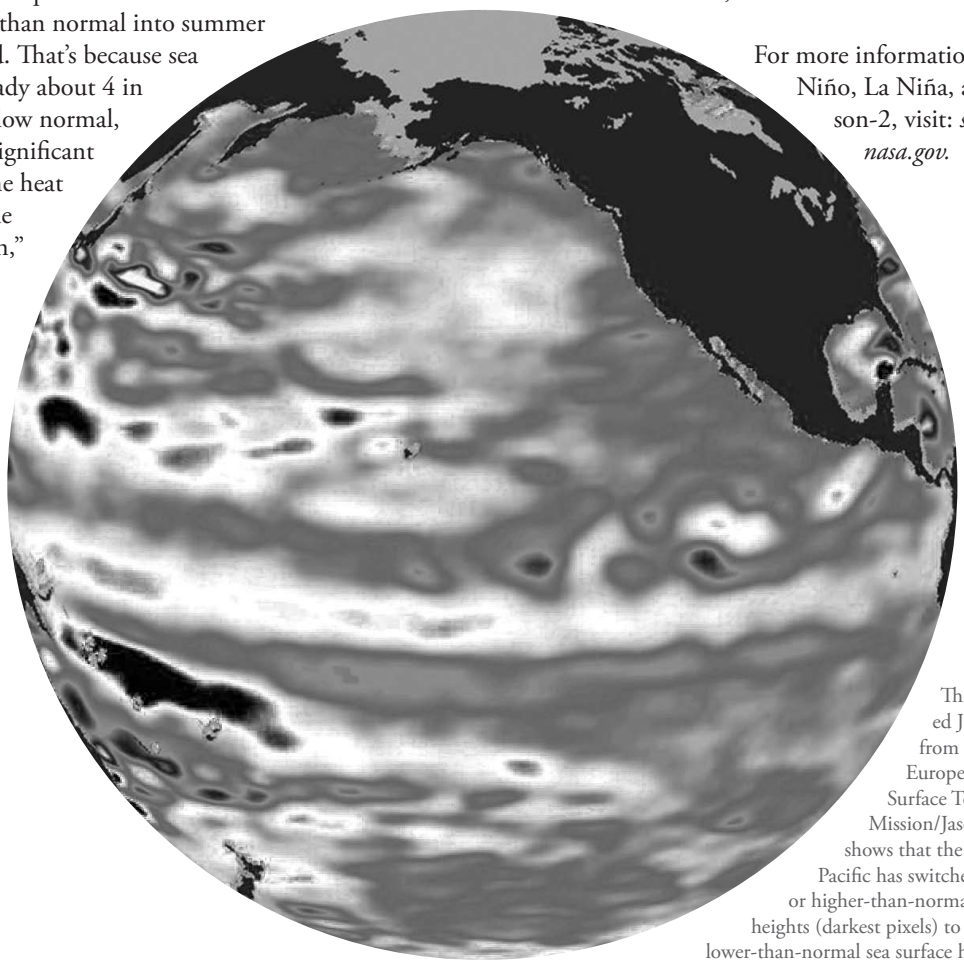
The image shows sea surface height relative to normal ocean conditions. The darkest areas are about 4 in (10 cm) above normal. Mid toned areas indicate near-normal conditions. Lightest areas are 2–5 in (5–13 cm) below normal.

"The central equatorial Pacific Ocean could stay colder than normal into summer and beyond. That's because sea level is already about 4 in (10 cm) below normal, creating a significant deficit of the heat stored in the upper ocean," said JPL oceanographer and climatologist **Bill Patzert**. "The next few months will reveal if the current cooling trend will eventually evolve into a long-lasting La Niña situation."

A La Niña is essentially the opposite of an El Niño. During a La Niña, trade winds in the western equatorial Pacific are stronger than normal, and the cold water that normally exists along the coast of South America extends to the central equatorial Pacific. La Niñas change global weather patterns and are associated with less moisture in the air, resulting in less rain along the coasts of North and South America. They also tend to increase the formation of tropical storms in the Atlantic.

"For the American Southwest, La Niñas usually bring a dry winter—not good news for a region that has experienced normal rain and snowpack only once in the past five winters," said Patzert.

For more information on El Niño, La Niña, and Jason-2, visit: *sealevel.jpl.nasa.gov.* ■



This image, dated June 11, 2010, from the NASA/European Ocean Surface Topography Mission/Jason-2 satellite shows that the tropical Pacific has switched from warm, or higher-than-normal sea surface heights (darkest pixels) to cold, or lower-than-normal sea surface heights (shown in lightest pixels) during the last few months. To view this image in color, please visit: *www.nasa.gov/topics/earth/features/laninaImage20100622.html.* **Image Credit:** NASA/JPL Ocean Surface Topography Team

in the news

Lasers Help Researchers Predict Birds' Preferred Habitat

Gretchen Cook-Anderson, NASA's Earth Research Team, Goddard Space Flight Center, gretchen.r.cook-anderson@nasa.gov

Every spring, migratory birds like the Black-throated Blue Warbler journey from tropical Caribbean or South American refuges to North American forests. But which forest patch will they call home this year? And, how can researchers predict where they choose to nest?

Ecologists studying biodiversity and conservationists preserving habitats have asked these questions for more than 50 years, but with limited and imprecise means to answer them. Now a team of NASA-funded researchers has completed an experiment to remotely sense and predict where certain birds are most likely to live and breed.

In the late 1950s, Princeton University ecologist **Robert MacArthur** proposed that bird species choose their habitat according to the structure of a forest—that is, the tree canopy height, branching structure, leaf spread and abundance, and the presence of low-lying shrubs.

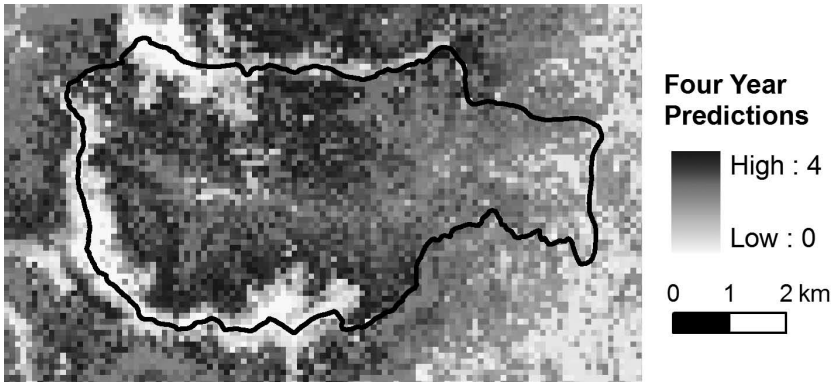
To determine the habitat where particular species bred, ornithologists had to trek deep into forests and used everything from binoculars to suspended vines to observe leaves and twigs and extrapolate the make-up of forest areas. They could spend thousands of painstaking hours analyzing plots as small as 100 ft^2. As recently as May 2010, an Oregon State University doctoral student dislocated her shoulder while using a rudimentary pole to demonstrate how scientists once measured tree branches from the ground—and to show how and why the science of studying birds has changed.

"Most of the time, the data weren't very good, and didn't cover broad areas of land," said landscape ecologist **Matt Betts**, an assistant professor at Oregon State University in Corvallis.

A Black-throated Blue Warbler sings from a perch in its preferred habitat of low-lying shrubbery at the Hubbard Brook Experimental Forest, West Thornton, NH, in July 2007. **Credit:** Matt Betts/Oregon State University

A research team led by **Scott Goetz** of the Woods Hole Research Center has helped bring habitat sensing into the 21st century. The researchers combined satellite data, a ground-based bird census, light detection and ranging (lidar), and a new modeling technique to correctly predict the presence of songbirds in a forest. Their results were published this week in the journal *Ecology*.

"The study of bird habitats has entered a new era," said Goetz. "Until recently, predicting bird habitat was limited. We've known for many years that the composition of trees and shrubs determines habitat quality, which in turn influences a species' presence and population density. But this study uses remote sensing to accurately predict which habitats birds prefer to use year after year, over many square miles of complex terrain."



A map Goetz's team generated from a forest's model indicates predicted Black-throated Blue Warbler habitat based on four years of LVIS data. **Credit:** Scott Goetz/Woods Hole Research Center

According to Goetz, NASA's Laser Vegetation Imaging Sensor (LVIS, pronounced Elvis), was key to the team's success. The instrument sends pulses of laser light down from an airplane toward the forest canopy and records the points at which signals bounce back from leaves, branches, and land surfaces. Goetz and colleagues analyzed the data to confirm things like *canopy height*—the difference between the top of a tree and the ground—and the top-to-bottom density of tree canopies.

"We're doing the same thing our predecessors did, but in much more detail and over a much broader area," said Betts. "We have new metrics now that just weren't possible before."

When combined with data from the NASA-built Landsat satellite—which can indicate seasonal changes in the amount of vegetation—the LVIS data indicated not only the height of the trees but whether they have mostly high branches or lots of canopy layers beneath tree tops.

For the study published June 2010, the team made field observations of the Black-throated Blue Warbler, a small songbird that prefers lower-lying vegetation. Using four years of LVIS data, the researchers ranked various forest habitats as "good", "fair", or "poor" based on canopy structure. Their "good" rankings for the warbler matched actual ground data—showing the actual presence of the species in each habitat—90% of the time.

"For predicting species across broad landscapes over time, this lidar technology is incredibly valuable," said Betts, a co-author of Goetz's study. "We can now conduct higher-quality estimates of the relative importance of climate versus habitat structure in affecting animal populations. And this technique should transfer to predictions of other animals whose habitats are associated with canopy structure, like flying squirrels or martens. If we can track downed logs on the forest floor, we could even model habitats for salamanders." ■

The underside of tree canopies at the Hubbard Brook Experimental Forest in New Hampshire provides preferred habitat for the Black-throated Blue Warbler songbird according to both ground-based observations and Goetz's team's remotely sensed findings based on LVIS laser data. **Credit:** Matt Betts/ Oregon State University

in the news

NASA Embarks on Arctic Voyage to Probe Ocean, Climate Changes

Steve Cole, NASA Headquarters, Stephen.E.Cole@nasa.gov

NASA's first dedicated oceanographic field campaign has begun and will take an up-close look at how changing conditions in the Arctic are affecting the ocean's chemistry and ecosystems that play a critical role in global climate change.

ICESCAPE takes to the sea on the U.S. Coast Guard Cutter *Healy*, the United States' newest and most technologically advanced polar icebreaker. **Credit:** U.S. Coast Guard photo by Petty Officer Patrick Kelley

The Impacts of Climate on Ecosystems and Chemistry of the Arctic Pacific Environment (ICESCAPE) mission will investigate the impacts of climate change on the ecology and biogeochemistry of the Chukchi and Beaufort seas along Alaska's northern coast. ICESCAPE takes to sea onboard the U.S. Coast Guard Cutter *Healy*, the United States' newest and most technologically advanced polar icebreaker. The *Healy* conducts a wide range of research activities and is designed to break four-and-a-half feet of ice continuously at three knots.

A key focus of the mission is to examine how changes in the Arctic may be altering the ocean's ability to absorb carbon from the atmosphere. The greenhouse gas carbon dioxide is a leading cause of global warming.

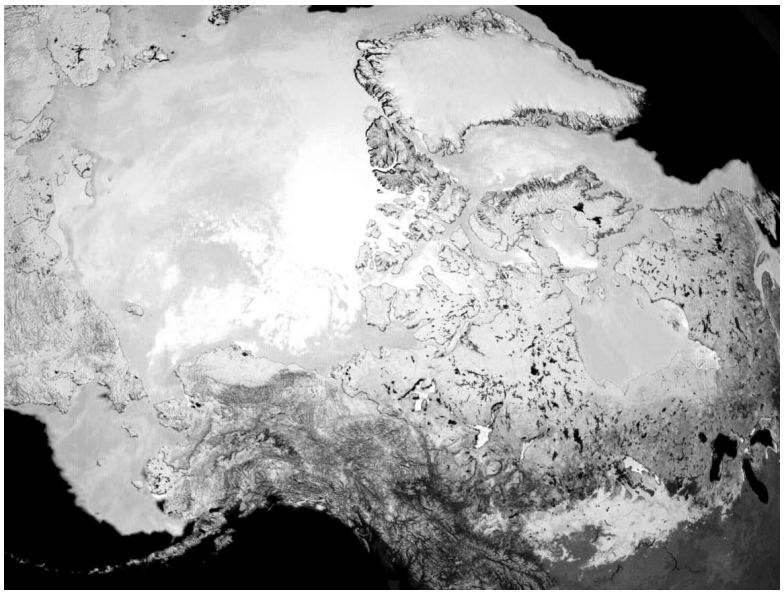
Predictions of future climate change depend on knowing the details of how this carbon cycle works in different parts of the world. NASA's Earth science program conducts research into the global Earth system using satellite observations. Identifying how Earth's ecology and chemistry are influenced by natural processes and by humans is a key part of this research.

The Arctic Ocean, unlike other oceans, is almost completely landlocked, making it an ideal location to study ongoing climate changes in a marine ecosystem already heavily impacted by declining sea ice cover, ocean acidification, and an increase in incoming solar radiation. These changes are likely to modify the physics, biogeochemistry, and ecology of this environment in ways that are not well understood. Satellite remote sensing has provided some insight into these changes which ICESCAPE is designed to advance.

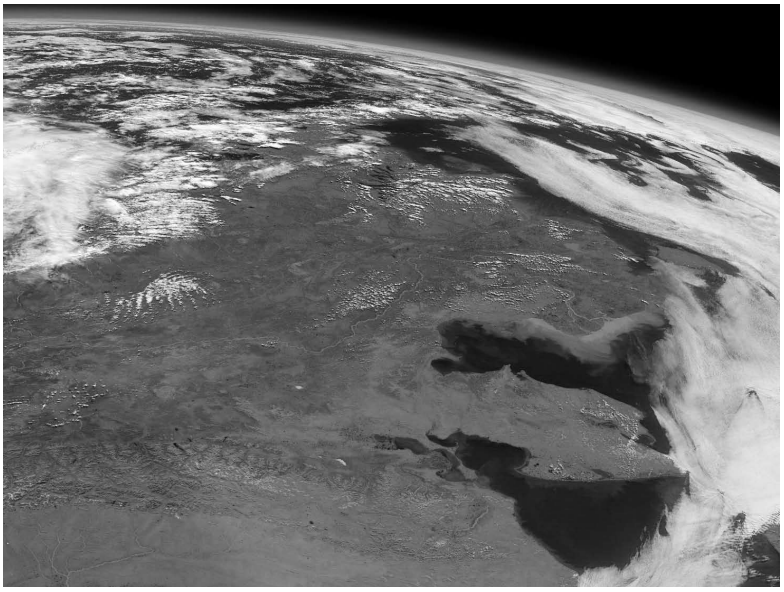
"The ocean ecosystem in the Arctic has changed dramatically in recent years, and it's changing much faster and much more than any other ocean in the world," said ICESCAPE chief scientist **Kevin Arrigo** of Stanford University. "Declining sea ice in the Arctic is certainly one reason for the change, but that's not the whole story. We need to find out, for example, where the nutrients are coming from that feed this [phytoplankton] growth if we are going to be able to predict what the future holds for this region."

The *Healy* left Dutch Harbor in Alaska's Aleutian Islands on June 15 and headed to the Bering Strait where it began ocean sampling. The voyage continued across the southern Chukchi Sea and into the Beaufort Sea along northern Alaska's ocean shelf. In early July the *Healy* will head north into deeper waters to sample thick, multi-year sea ice and take samples within and beneath the ice. For more on the campaign's activities follow the ICESCAPE blog at: *blogs.nasa.gov/cm/newui/blog/viewpostlist.jsp?blogname=icescape.*

More than 40 scientists will spend five weeks at sea sampling the physical, chemical, and biological characteristics of the ocean and sea ice. A variety of instru-



Declining Arctic sea ice is one factor affecting the region's changing ocean ecosystem. This image based on data from NASA's Aqua satellite shows the extent of sea ice in March 2008. To view this image in color, please visit: *www.nasa.gov/images/content/461972main_SEAICE.jpg.* **Credit:** NASA



Looking southward from high over the Arctic Ocean, NASA's Aqua satellite reveals coastal phytoplankton blooms in the Chukchi Sea along northern Alaska *[foreground]* stretching into the Bering Strait in September 2006. To view this image in color, please visit: *www.nasa.gov/images/content/461970main_OCEANCOLOR.jpg.* **Credit:** NASA

ments will be used onboard the *Healy* and deployed into the ocean and on the sea ice.

An automated microscope onboard will take continuous digital photographs of phytoplankton cells for near-real time observations of the quantity of different species. Floats with near-real time satellite communication will be placed in the ocean to measure temperature and various biological and optical properties. Scientists also will work on the sea ice several hundred yards from the ship to study the condition of the ice and sample the ocean ecosystem beneath it.

Satellite observations are a key part of the ICESCAPE mission. NASA uses its satellite observations to monitor the microscopic plant and animal life in the world's oceans. This *ocean color* data give scientists a global view of a critical ecosystem that regulates the flow of carbon into and out of the sea. Similar observations of the Arctic waters collected from the *Healy* during ICESCAPE will be used to improve the accuracy of the satellite data over the entire region.

ICESCAPE is sponsored by the Earth Science Division's Cryospheric Sciences and Ocean Biology and Biogeochemistry programs in NASA's Science Mission Directorate. A second ICESCAPE voyage is planned for 2011. ■

EOS Scientists in the News

Adam Voiland, NASA Earth Science News Team, avoiland@sesda2.com

NASA Study Sheds Light on Ozone Hole Chemistry, April 28; *Pasadena Now.* A team of scientists led by **Michelle Santee** (NASA JPL) have examined how nighttime temperatures affect chlorine monoxide, a key chemical involved in ozone destruction; Santee and her team published their findings—based on data from the Microwave Limb Sounder instrument on Aura—in the *Proceedings of the National Academy of Sciences (PNAS)*.

Oil Spill Progress Tracked by Satellites, April 30; *Discovery News.* **Holli Riebeek** (NASA GSFC) is quoted in an article that highlights how Terra, Aqua, and other NASA satellites are being used to monitor the spread of the Gulf oil spill.

NASA Satellite Discovers Life on Earth, Which Could Help it Find Life Elsewhere, May 6; *Popular Science.* In a find that could help astrobiologists search for life elsewhere, the Advanced Land Imager (ALI)—an instrument managed by **Ralph Welsh** (NASA GSFC) on the Earth Observing-1 satellite—detected a patch of yellow ice in the Canadian Arctic that is the only known place on Earth where sulfur is pumped to the surface by natural processes.

NASA Traces Molecular Characteristics That Heat Earth, May 6; *Space Fellowship.* Astrochemist **Timothy Lee** (NASA Ames) argues that to protect Earth's climate, we need to understand the inherent molecular properties that determine heat absorption, and design molecules that are more environmentally friendly; Lee recently had a study published in *PNAS* that looks at the ability of various molecules to absorb Earth's radiated heat.

Oceans Warmed in Recent Decades, May 19; *Science News.* Earth's upper ocean warmed substantially between 1993–2008, though the rate of warming from 1993–1998 was slow, a study co-authored by **Joshua Willis** (NASA JPL) has shown. *"Oceans are the bellwethers of how much we're changing the global climate,"* says Willis.

The Most Endangered Glaciers, May 29, *Newsweek* Scientists—including **Jim Hansen** (NASA GISS)—are studying whether warm, southerly monsoon winds are depositing black carbon on Himalayan glaciers and hastening glacial melting; the region, with some 46,298 glaciers, is home to the largest non-polar ice mass in the world.

World is at Warmest on Record, June 2; *Businessweek.* **Jim Hansen** (NASA GISS) and colleagues announced the global temperature this year is the warmest on record based on a 12-month-rolling average. *"As for the calendar year, it is likely that the 2010 global surface temperature in the GISS analysis also will be a record,"* Hansen noted.

Eight Ways New York City is Preparing for Climate Change, June 1; *Smartplanet.* The New York City Panel on Climate Change, a committee comprised of scientists and experts and led by **Cynthia Rosenzweig** (NASA GISS), has released a new report that outlines ways the city plans to adapt to climate change.

NASA Uses Supercomputer to See Weather In Future, June 2; *WJZ.* NASA Goddard Space Flight Center unveiled a new supercomputing climate simulation center this summer that's capable of doing 160 million arithmetic operations per second, **Phil Webster** (NASA GSFC) told WJZ.

NASA Langley Satellite Studying Oil Spill, June 3; *Daily Press.* NASA scientists—including **Yongxiang Hu** (NASA LaRC) and **Christ Hostetler** (LaRC)—are using CALIPSO and aircraft instruments to pioneer ways to study the amount of oil lingering beneath the surface of the Gulf.

NASA Developing System to Better Predict Size of Tsunamis from Quakes, Reduce False Alarms, June 15; *Los Angeles Times.* Using a prototype system that combines global and regional real-time data from hundreds of GPS sites, a team led by **Y. Tony Song** (NASA JPL) successfully predicted the size of the tsunami triggered by the February 27 magnitude-8.8 Chilean earthquake.

Imager for More Than Weather, June 15; *UPI.* After a worrisome electrical short caused the Solar X-Ray Imager (SXI) aboard the GOES-15 satellite to

malfunction, the instrument has now provided first light to researchers. **Andre Dress** (NASA GSFC), deputy project manager for the GOES system, said instruments like the X-ray imager are valuable to weather scientists, flight planners and defense officials alike.

Planes Can Trigger Snowfall, June 16; *U.S. News & World Report.* Under just the right conditions, aircraft can substantially boost precipitation by seeding clouds as they fly through them, a new study led by researchers at the National Center for Atmospheric Research discovered.

Patrick Minnis (NASA LaRC) commented on the research, noting that it strengthens the suspicion that aircraft cause the holes in canal clouds.

Interested in getting your research out to the general public, educators, and the scientific community? *Please contact Adam Voiland on NASA's Earth Science News Team at avoiland@sesda2.com 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.* ■

OPeNDAP for Aqua AIRS Data

The Goddard Earth Sciences Data and Information Services Center (GES DISC) features new capabilities in the Open Source Project for a Network Data Access Protocol (OPeNDAP) that enhance visualization of Aqua Atmospheric Infrared Sounder (AIRS) data, including AIRS *Level-2* and *Level-1B* datasets. The new capabilities in OPeNDAP enable user tools such as the Integrated Data Viewer (IDV) and Panoply to open and visualize a greater variety of data, particularly including Hierarchical Data Format—Earth Observing System (HDF-EOS) *Level-1*, *Level-2*, and *Level-3* data. Also, the Grid Analysis and Display System (GrADs) handles AIRS *Level-3* data with a simple *sdfopen* call. The new capabilities make it considerably easier for researchers to analyze and comprehend the AIRS data via OPeNDAP servers.

Users can obtain the above mentioned tools at the following sites:

IDV from *www.unidata.ucar.edu/software/idv/* and Panoply from *www.giss.nasa.gov/tools/panoply/.*

To access AIRS data through OPeNDAP, you can go directly to the OPeNDAP tree for the AIRS products by beginning at *disc.sci.gsfc.nasa.gov/AIRS/data-holdings/by-access-method.* However, as much of the newly available data are scene-based, you may want to do a space-time search to find your scenes of interest. The *Mirador* search tool (*mirador.gsfc.nasa.gov/*) allows you to conduct that search and then link through to the corresponding OPeNDAP Uniform Resource Locators (URLs) (Data Access Form) corresponding to individual data files in your results.

The *Data URL* from the OPeNDAP Server Data Access Form can be cut and pasted into the Data Chooser for URLs, e.g.: *airspar1u.ecs.nasa.gov/opendap/Aqua_AIRS_Level2/AIRX2RET.005//2010/158/AIRS.2010.06.07.150.L2.RetStd.v5.2.2.0.G10159122120.hdf.* The data source type is *Grid files (netCDF/GRIB/OPeNDAP/GEMPAK)*, even for the Level 1 and Level 2 swath.

These new OPeNDAP capabilities were developed by the HDF Group (*www.hdfgroup.org/*).

Questions can be sent to GES DISC at *help-disc@listserv.gsfc.nasa.gov.*

NASA Science Mission Directorate – Science Education Update

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New Articles on the Ocean Motion Web Site

What are ocean garbage patches? Where are they located? How does plastic get from your shopping cart into our ocean? While 5% of the plastic we create is recycled and 50% is buried in landfills, the rest of it is not accounted for, and often washes out to the ocean. Follow the path of plastic to the ocean gyres. Read about what happens to plastic after it circles the ocean gyres for decades. Find out how it damages our marine ecosystems and what happens when it enters the marine food chain. Learn about the current research of scientists such as **Curt Ebbesmeyer**, **Nikolai Maximenko**, and **Kara Lavender Law**, who are tracking ocean debris. To learn more, please visit: *www.oceanmotion.org/html/impact/garbagepatch.htm*.

What will happen to the oil escaping from the *Deepwater Horizon* drill site? Once in the ocean, the oil is subject to the whims of winds and ocean currents. Read about what may happen to oil as it is entrained in the Loop Current. Will it flow into the Florida current and then be swept up the East Coast of the United States by the Gulf Stream? Learn about the current research of scientists including **Robert Hetland** and **Robert Leben**, who are studying the Gulf of Mexico. To view the article, please visit: *www.oceanmotion.org/html/impact/gulfoilspill.htm.*

Before or after reading the articles, investigate ocean surface current patterns in Lesson #1: Navigating the Ocean Teacher Guide using the Drifter Data model at *www.oceanmotion.org/guides/n_1/n_teacher_1.htm#ADrifterModel.*

Earth Math: Using Mathematics to Teach Earth Systems Science and Global Climate Change

This book explores a few of the many concepts that frequently come up in the study of Earth systems and global climate change. It shows that the underlying basis for many of the environmental issues that now confront society have simple mathematical underpinnings. This book serves as a companion guide to standard Earth science and mathematics courses at the middle and high school level. The problems need not be executed in the order presented. Each problem page contains from two to eight subsidiary math problems related to each of the 40 main topics. Students can complete the problems in any order and not all problems need to be completed to gain an understanding of global climate change. You can download the book from: *spacemath.gsfc.nasa.gov/SMBooks/SMEarthV2.pdf.*

Easy Ways to Obtain NASA Education Materials

NASA's Office of Education works collaboratively with NASA experts to promote education as a component of NASA research and development missions. These efforts result in innovative and informative educational materials that engage student interest in science, technology, engineering, and mathematics. To learn how teachers can access the materials, please read this flier at: *www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Easy_Ways.html.*

Hurricane Katrina: A Problem-Based Learning Module

Because it recognizes the importance of U.S. coastal areas to the nation's economy, the U.S. National Ocean Service has formed a task force that is studying the trends and impacts of hurricanes on coastal regions. They have invited students to participate. In this activity, students are tasked with conducting an Earth systems analysis of Hurricane Katrina that will help answer the question: is global warming causing an increase in hurricane frequency and intensity? To join in, please visit: *www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Hurricane_Katrina.html.*

EOS Science Calendar

September 13–16
CERES Science Team Meeting, Paris, France.
URL: *science.larc.nasa.gov/ceres/meetings.html*

September 27–30, 2010
Aura Science Team Meeting, Boulder, CO. URL: *www.joss.ucar.edu/events/2010/aura/index.html*

September 28–30
HDF and HDF-EOS Workshop XIV Improving Workflows That Use HDF and HDF-EOS Data, Champaign, IL. URL: *hdfeos.org/workshops/ws14/workshop_fourteen.php*

November 11–12, 2010
GRACE Science Team Meeting, Potsdam, Germany.
URL: *www.csr.utexas.edu/grace/GSTM/*

Global Change Calendar

July 25–30, 2010
2010 IEEE International Geoscience and Remote Sensing Symposium, Honolulu, HI.
URL: *www.igarss2010.org/*

August 8–13, 2010
AGU Meeting of the Americas, Iguassu Falls, Brazil.
URL: *www.agu.org/meetings/ja10/*

August 25-28, 2010
Fall LCLUC Regional Science Workshop, Tartu, Estonia. URL: *lcluc.umd.edu/meetings.php?mid=15*

October 2–7, 2010
35th Annual Meeting of the National Weather Association, Marriott University Park Hotel, Tucson, AZ.
URL: *www.nwas.org/events.php*

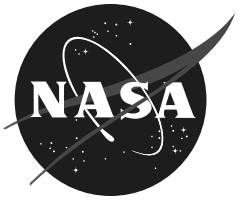
October 25–28, 2010
International Symposium on the A-Train Satellite Constellation 2010, Sheraton Hotel, New Orleans, LA.
URL: *a-train-neworleans2010.larc.nasa.gov/*

November 16–20, 2010
2010 National Association for Interpretation National Interpreters Workshop, Las Vegas, NV.
URL: *interpnet.com/workshop/*

January 27–28, 2011
International Year of Chemistry (IYC), Opening Ceremony: *Chemistry—Our life, Our future*, UNESCO HQ, Paris, France. URL: *www.chemistry2011.org/*

Registration Now Open

An international A-Train Symposium is planned for October 25-28 in New Orleans, LA. The "A-Train" (Afternoon Constellation) of satellites allows coordinated multi-instrument measurements of the Earth system. The symposium will provide an opportunity for new and veteran users to learn more about "A-Train" measurements and to engage colleagues with similar interests. On-line registration is available at: *a-train-neworleans2010.larc.nasa.gov*.



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