National Aeronautics and Space Administration

The Earth Observer. November - December 2010. Volume 22, Issue 6.

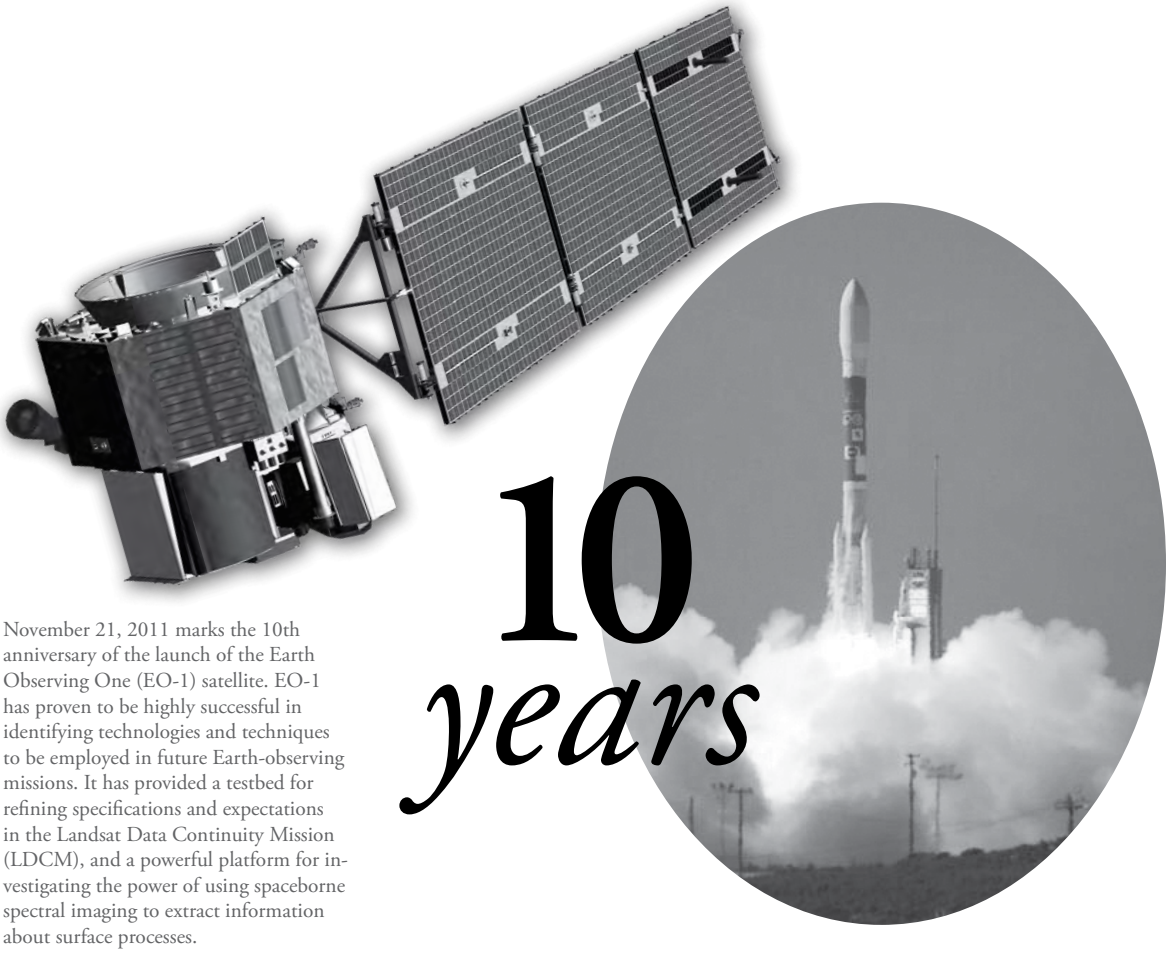
Editor's Corner

Steve Platnick
EOS Senior Project Scientist

The A-Train Symposium was held October 25-28 in New Orleans, LA. The symposium, a follow-on to one held in Lille, France in October 2007, provided an opportunity for both novice and experienced users to learn more about A-Train measurements and science. The meeting began with a well-attended one-day instrument user workshop. In addition to 574 science attendees and 23 students from the DEVELOP program, 75 teachers attended education workshops during the week. On Friday of the symposium week, scientists spoke at 14 schools in the greater New Orleans area. For those who couldn't attend, NASA Edge provided a live webcast along with several interviews with scientists that can be found at: *www.nasa.gov/multimedia/podcasting/nasaedge*. Workshop presentations are posted on the symposium website under the *Program* link: *a-train-neworleans2010.larc.nasa.gov*. Plenary and oral science theme presentations will be posted as they become available.

Many thanks to all those who participated in the symposium and contributed to its success. A detailed summary of the symposium is planned for our next issue. In that same time frame, we plan to welcome the newest A-Train member, *Glory*, with a current launch date of February 23, 2011.

continued on page 2



November 21, 2011 marks the 10th anniversary of the launch of the Earth Observing One (EO-1) satellite. EO-1 has proven to be highly successful in identifying technologies and techniques to be employed in future Earth-observing missions. It has provided a testbed for refining specifications and expectations in the Landsat Data Continuity Mission (LDCM), and a powerful platform for investigating the power of using spaceborne spectral imaging to extract information about surface processes.

the earth observer

www.nasa.gov

editor's corner

In This Issue

eos.nasa.gov

In this issue, we feature two articles highlighting programs that introduce college students to NASA Earth Science. The first of these focuses on the Student Airborne Research Program (SARP), an annual program that allows students to acquire hands-on research experience in all aspects of an airborne field campaign—see pages 7-11. During the past year, students had the opportunity to operate instruments on the DC-8 aircraft, sampling atmospheric gases and imaging land and water surfaces in multiple spectral bands. (SARP is a joint effort between NASA and the University of North Dakota's National Suborbital Education and Research Center.)

The second of the articles is the latest in a series that *The Earth Observer* has been running on NASA's DEVELOP Program—see pages 14-19. (DEVELOP is a NASA Science Mission Directorate Applied Sciences training and development program.) This installment describes how DEVELOP students mobilized in response to the *Deepwater Horizon* explosion and initiated public campaigns across the Gulf Coast that highlighted NASA's contributions to oil spill response, recovery, and research[1]. The DEVELOP Oil Spill Outreach team consisted of students from DEVELOP's offices at Stennis Space Center (SSC), Langley Research Center (LaRC), and the Mobile County Health Department (MCHD) in Alabama. The table on page 18 provides a nice summary of NASA assets used to date to monitor the Gulf oil spill.

In our last issue we reported that the Genesis and Rapid Intensification Processes (GRIP) field campaign took place from August 15–September 30. GRIP was designed to explore the formation of tropical storms and their transition into full-blown hurricanes—or, conversely, why so many tropical disturbances do not exhibit this evolution. Aircraft tracks were planned for direct incursion into storms and satellite underflights. On pages 20-24, we provide a summary of the GRIP campaign with additional background on the aircraft deployed and their payloads, software tools utilized during the mission, and some preliminary findings.

November 21 will mark the 10th anniversary of the launch of the Earth Observing-1 (EO-1) satellite. As a New Millennium Program (NMP) mission, EO-1 has served as a test bed for innovative instrument and spacecraft technologies that are high performance, but low cost and mass. EO-1 originally flew at an altitude of 705 km in concert with Landsat 7, crossing the equator one minute behind it. This formation flying allowed for cross comparisons of the instruments on both spacecrafts and led to the establishment of the *AM Constellation*, the first *constellation* of Earth observing satellites (Landsat, EO-1, the Argentine Satellite de Aplicaciones Cientifico-C (SAC-C), and Terra). Due to an altitude adjustment, the formation was broken and currently EO-1 flies at 690 km. EO-1's two main instruments are the Advanced Land Imager (ALI) and the Hyperion imaging spectrometer.

[1] **Michael Goodman** wrote an article in the May–June 2010 issue of *The Earth Observer* [**Volume 22**, **Issue 3**, p.3] describing NASA's ongoing response to the oil spill and we had additional coverage of NASA's spill response in the Editorial of the July–August 2010 issue [**Volume 22**, **Issue 4**, pp. 1-3].

The EO-1 mission has a number of notable accomplishments in the areas of science validation, spacecraft bus technologies, and operations (a list of EO-1 "firsts" is available at: *eo1.gsfc.nasa.gov/new/general/firsts/poster.html*). EO-1 observations have resulted in more than 50,000 archived images—used to study land cover diversity and ecosystem function, and catastrophic events such as floods, hurricanes, volcanoes, and other disasters. To read more about EO-1, please see the article on pages 25-26 of this issue.

As it has been done for many years, NASA will once again be participating in the Fall Meeting of the American Geophysical Union (AGU) that will take place December 13-17 in San Francisco, CA. NASA sponsors an exhibit that showcases the breadth of the Agency's activities at its various centers—including Earth Science. As in recent years, the exhibit will include a wide variety of science presentations, demonstrations, and tutorials on data tools and services. New this year will be a dynamic, interactive, nine-screen *hyperwall* that will showcase different NASA datasets throughout the week. If you plan to be in San Francisco for the AGU, we encourage you to take some time to visit the booth. To help you plan your visit, a daily agenda for presentations will be posted on the Earth Observing System Project Science Office website—*eos.nasa.gov*—in early December. We look forward to seeing you in San Francisco!

It hardly seems possible but another year is quickly drawing to a close. So on behalf of the entire staff of *The Earth Observer*, I want to thank everyone for their continued support of our publication and wish everyone all the best in the year to come. ■

From November 3-5, NASA participated in the Seventh Plenary Session of the Group on Earth Observations (GEO-VII) & Beijing Ministerial Summit in Beijing, China. NASA partnered with the Environmental Protection Agency in an exhibit featuring a nine-screen *hyperwall* that displayed continuous loops of five-day forecasts for a variety of different forecast parameters and showcased the combined agencies' weather forecasting and environmental health monitoring capabilities. Shown here is a picture of the ribbon cutting ceremony that opened the meeting. **Credit:** NASA

NASA Satellites Help Monitor the Pakistan Flooding: An Application of Near-Real-Time Satellite Observations

Amir AghaKouchak, amir.a@uci.edu
Soroosh Sorooshian, soroosh@uci.edu
Bisher Imam, bimam@uci.edu
Kuolin Hsu, kuolinh@uci.edu
Xiaogang Gao, gaox@uci.edu
Center for Hydrometeorology & Remote Sensing, The Henry Samueli School of Engineering, University of California Irvine

Pakistan has a well-established and maintained rain gauge network and weather radar system, but as is the case with any ground-based observation system, the system has spatial and temporal limitations as well as high terrain blockage issues. Satellite observations can help to overcome some of these limitations. From their vantage point in orbit satellites continuously monitor the entire region and aren't impeded by high terrain.

In late July and early August 2010, Pakistan experienced the worst flooding it has seen since 1929. Estimates indicate that over two thousand people died and over a million homes were destroyed in flooding and landslides caused by several weeks of almost continuous torrential rain. Press accounts of the current situation suggest that more than 4 million people are displaced, and the United Nations estimates that over 20 million people have been affected. The number of people suffering from this disaster exceeds the combined total of the Haiti earthquake (2010), the Kashmir earthquake (2005), and the Indian Ocean tsunami (2004).

In any natural disaster, mitigation plans and disaster relief operations are complex and challenging processes that require flexibility and near-real-time data for risk assessment and decision making. Pakistan has a well-established and -maintained rain gauge network and weather radar system, but as is the case of any ground-based observation system, there are spatial and temporal limitations as well as high terrain blockage issues. Satellite observations can help to overcome some of these limitations. From their vantage point in orbit satellites continuously monitor the entire region and aren't impeded by high terrain.

In collaboration with the United Nations Educational, Scientific, and Cultural Organization's (UNESCO) International Hydrological Program's (IHP) Water and Development Information for Arid Lands-A Global Network (G-WADI) initiative, the Center for Hydrometeorology and Remote Sensing (CHRS) at the University of California Irvine (UCI) has developed a *Geo-Server* that provides access to very-high-resolution (0.04°) satellite-based quasi-global precipitation products in near real time to worldwide users. The product is derived using the Precipitation Estimation from Satellite Observation using Artificial Neural Network with Cloud Classification System (PERSIANN-CCS). The algorithm uses the gridded infrared images from the global geosynchronous satellites provided by the Climate Prediction Center (CPC), National Oceanic and Atmospheric Administration (NOAA) as the main source of information. Using neural network classification/approximation procedures, infrared-based estimates are calibrated and adjusted based on microwave data from low-orbital satellites—e.g., Tropical Rainfall Measuring Mission (TRMM) Microwave Imager [TMI], Special Sensor Microwave Imager (SSM/I) flown by the Defense Meteorological Satellite Program (DMSP), Advanced Microwave Scanning Radiometer-Earth Observing System (AMSR-E) on the Aqua spacecraft, and the Advanced Microwave Sounding Unit-B (AMSU-B) aboard the NOAA satellite series. The algorithm runs at NOAA's National Environmental Satellite, Data, and Information Service (NESDIS); products are delivered to the G-WADI *GeoServer* precipitation mapping application.

Satellite-based precipitation estimates obtained from the PERSIANN-CCS system—shown in **Figure 1**—indicate that many areas, including the northern and southern parts of Pakistan, received a substantial amount of rainfall in 29 days (July 19, 2010–August 16, 2010). **Figure 2** shows rainfall totals for August 4 and August 9.

The G-WADI *GeoServer* can also give estimates of extreme (i.e., >25 mm) precipitation events. **Figure 3** shows 72-hr precipitation accumulations during August 7–9

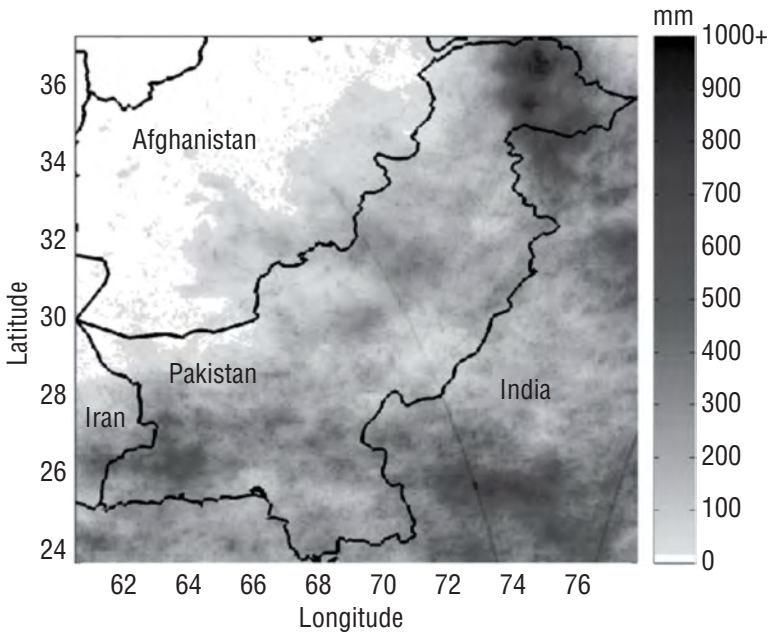


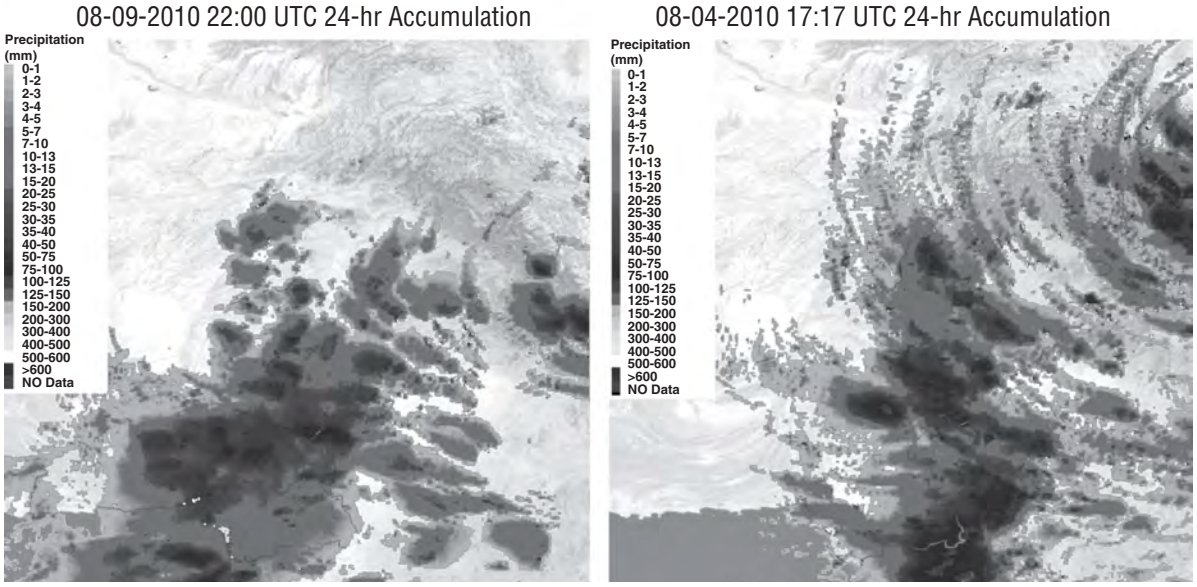
Figure 1. Rainfall accumulations from July 19, 2010–August 16, 2010 (measured in mm). These data were obtained from near-real-time precipitation estimates of PERSSIAN-CCS algorithm (*hydis.eng.uci.edu/gwadi/*).

[*left panel*] and August 2–4 [*right panel*] periods over Pakistan. As highlighted earlier, these maps can be generated within two hours of occurrence.

Another interesting feature of the G-WADI *GeoServer* (*hydis.eng.uci.edu/gwadi/*) is its ability to produce a "quick report" on observed precipitation with respect to historical records in near real time. This feature is illustrated in **Figure 4** where for a certain region [*see the box in the left panel*], precipitation accumulations [*upper right panel*] and long-term monthly climatological precipitation values [*lower right panel*] are presented. In the location of interest, 48-hr precipitation accumulation (57 mm) exceeds the monthly climatological precipitation (41 mm). **In one 72-hour period, the region received nearly four times the amount of the rainfall it normally receives in one month.**

There are many other capabilities available through the G-WADI *GeoServer* that can potentially be used not only for research, but also for disaster management—particularly as the data are made available in near real time. We predict that in the near future there will be continued improvements in the application of remote sensing in disaster mitigation and relief operations. We envision the potential utility of satellite-based

Figure 2. Daily precipitation accumulations for August 9 [*left panel*] and August 4 [*right panel*] across Pakistan.



observations in disaster-related operations to increase over the coming years. Therefore, more in-depth research is required to test and improve the quality of the current data and to develop other required datasets for global-scale applications.

References

Hong, Y., K. Hsu, X. Gao, and S. Sorooshian, 2004: Precipitation estimation from remotely sensed imagery using artificial neural network-cloud classification system. J. Appl. Meteorol., **43**, 1834-1853.

Disclaimer

The precipitation estimates provided in this article are solely based on satellite data and are not validated/adjusted with ground reference measurements. Be aware that satellite estimates are subject to various types of retrieval errors. ■

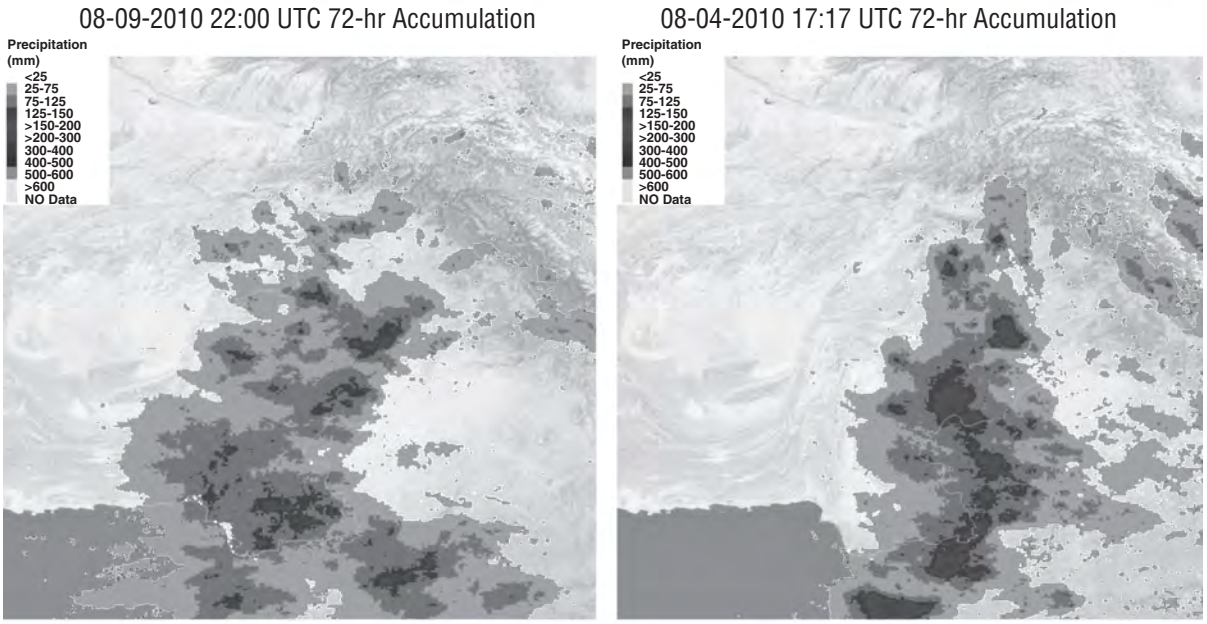


Figure 3. Total 72-hr precipitation accumulations over Pakistan for August 7–9 [*left panel*] and August 2–4 [*right panel*].

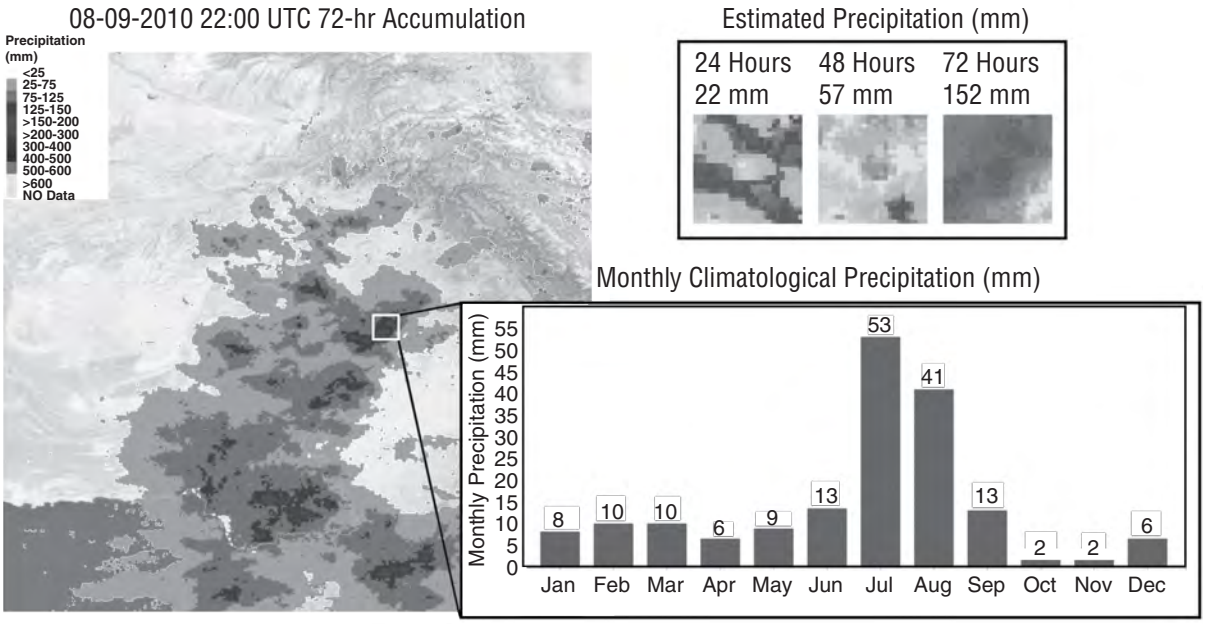


Figure 4. Shown here is an example of the G-WADI *GeoServer's* "quick report" generation capability. For a given precipitation event [*left panel*], precipitation accumulations [*upper right panel*] and long-term monthly climatological precipitation values [*lower right panel*] are shown to allow for easy comparisons with climatology.

The NASA–NSERC Student Airborne Research Program: Preparing Tomorrow's Earth System Scientists and Engineers

George Seielstad, Bay Area Environmental Research Institute, g.seielstad@nserc.und.edu
Rick Shetter, National Suborbital Education and Research Center, r.shetter@nserc.und.edu

There is now general agreement among scientists that human beings are having a major impact on Earth's climate. Many forcings influence climate, but evidence continues to mount that none has had as much influence on the climate in so short a time as human activity. So, while the bad news is that humans definitely appear to be part of the problem, the good news is that we can also be part of the solution. This summer, 28 students representing 25 U.S. colleges and universities took part in the 2010 Student Airborne Research Program (SARP) and had an opportunity to experience Earth science research first hand. NASA hopes that this experience will help to encourage more students to pursue careers in Science, Technology, Engineering, and Mathematics (STEM).

Why SARP?

Future generations must make critical decisions about the course of civilization in general, and in particular about how to respond to and mitigate Earth's changing climate. The decisions that must be made are complex and multi-faceted, and must be based on solid scientific evidence. The decision makers of the future will need access to timely and accurate information about the condition of our planet. NASA's Earth observing satellites and research aircraft are excellent sources of this kind of information, but in order to most effectively use these resources, a new generation of Earth system scientists and engineers will be needed to interpret the data—both as a consequence of pending retirements within the Agency and because the looming challenges and opportunities require the brightest minds. To help equip and train this new generation to assume their roles, a Student Airborne Research Program (SARP) was created with funding from NASA's Airborne Science Program. SARP is a joint effort between NASA and the University of North Dakota's National Suborbital Education and Research Center (NSERC).

SARP is an annual program designed to allow students to acquire hands-on research experience in all aspects of a scientific campaign, onboard the DC-8 and/or other NASA Airborne Science platforms. The DC-8 is a major NASA resource for studying Earth system processes, calibration–validation of spaceborne observations, and prototyping instruments for possible satellite missions. Students get the opportunity to operate instruments onboard the DC-8 aircraft to sample atmospheric chemicals and to image land and water surfaces in multiple spectral bands. At the culmination of the program, students present their scientific results to a select audience. The first campaign took place in 2009[1]; this article, however, will focus on the 2010 campaign.

SARP 2010

For SARP 2010, 28 students were competitively selected. The roster included representatives from 25 different colleges and universities scattered all over the U.S., and ran the gamut from small liberal arts colleges to major research universities. In addition to academic excellence, the program made a concerted effort to attract students for whom a world-class research experience would be novel. By exposing bright, motivated students to modern Earth science research techniques and to major scientific missions—especially some students who had no previous exposure—the hope was to enlarge the talent pool from which future Science, Technology, Engineering, and Mathematics (STEM) personnel could emerge.

By exposing bright, motivated students—especially some students who had no previous exposure—to modern Earth science research techniques and major scientific missions the SARP program seeks to enlarge the talent pool from which future Science, Technology, Engineering, and Mathematics (STEM) personnel could emerge.

[1] To view an informative video on SARP 2009, please visit: *www.nserc.und.edu/learning/SARP2009.html.*

The fact that Earth is a unified system dictated that the SARP 2010 roster be composed of students representing a variety of disciplines. The result was a mix of budding life, physical, and environmental scientists, as well as chemical and aerospace engineers, computer scientists, and even an economist.

The NASA DC-8 research aircraft was the platform used for two research instruments: NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) and Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Simulator [MASTER], and the University of California Irvine's Whole Air Sampler (WAS). The former is a remote sensing instrument, while the latter captures *in situ* air samples for subsequent analysis in the Rowland–Blake gas chromatography laboratory at University of California Irvine (UCI). Additional instruments from NASA's Active Sensing of CO_2 Emissions Over Nights, Days, and Seasons (ASCENDS) program "piggybacked" on the DC-8, giving students some insight into NASA's instrument development process. An advantage of the DC-8 is that its size allows all students to fly on the aircraft flights. For SARP, an instrument check flight and two, six-hour science data flights were flown. Atmospheric conditions were nearly perfect, and ample high-quality data were acquired.

Figure 1. Kent Dunwoody [University of California Santa Clara—*Senior Technician*] explains MASTER sensor installation (in the belly of NASA's DC-8 research aircraft), calibration, and operation to SARP students **Robert Carroll** [University of New Hampshire] and **Heather Sopher** [University of California Irvine].

Figure 2. The view from the NASA DC-8 of agricultural fields in California's Central Valley. One team of SARP students quantified evapotranspiration occurring in such fields; another inventoried the chemical composition of gaseous emissions to the atmosphere.

SARP's goal was to provide students with an end-to-end research experience, including selecting a project, acquiring the necessary data, analyzing and interpreting them, and presenting the results in a presentation modeled after those at conferences of professional societies—e.g., the American Geophysical Union. The effort was spread over six weeks, with the first week giving an overall orientation and description of the three general project areas, followed by a week spent integrating instruments on the aircraft (see **Figure 1**), preparing flight plans, and flying data-acquisition flights. The students spent the third week completing surface validation measurements; the fourth and fifth weeks were then devoted to analyzing and interpreting data. The final week was spent preparing and delivering their presentations. As to location, the second week of the program was held at the Dryden Aircraft Operations Center (for the actual research flights on the DC-8); a few days were spent in the field, but the bulk of the program took place at the UCI.

Students were assigned to one of three projects, where they worked in multi-disciplinary teams. **Susan Ustin** [University of California Davis (UCD)] led one of the projects, that sought to quantify evapotranspiration from almond and pistachio orchards in California's agriculturally rich Central Valley. This project combined multi-spectral remote sensing data captured using MASTER with in-field ground-truth measurements to correct for the fraction of land surface covered by leaves and other such effects—see **Figure 2**.

Donald Blake [UCI] (pictured in **Figure 3**) led a second project that studied air quality, and in particular focused on the measurement of concentrations of such trace gases as carbon dioxide, methyl bromide, trichloroethylene, and tetrachloroethene over the Central Valley. To locate the sources of emission for these trace gases, the DC-8 flew at low altitudes (approximately 1000 ft), and utilized the WAS to sample the air. Subsequent in-field measurements were used to help confirm the aircraft observations.

Clarissa Anderson and **Raphael Kudela** [University of California Santa Cruz (UCSC)] led the third project, to examine the extent and vigor of kelp beds in Monterey Bay and the Santa Barbara Channel. This effort relied upon measurements from multiple spectral bands of MASTER. Spectral signatures of kelp were acquired using a handheld spectroradiometer operated from a boat in the Santa Barbara Channel; MASTER bands were chosen to correspond to the most diagnostic wavelengths of the handheld instruments. Comparison with data acquired in past years may allow scientists to assess the effects that 2010's La Niña had on the kelp beds in that region.

Note that the projects related to land, atmosphere, and oceans (in the order they were presented above) were the same subdisciplines that comprise the MODIS Science Team. Although each student concentrated on one of the three, all students gained familiarity with the other two. This helps to reinforce the idea that Earth functions as a single, integrated *system of systems*.

Figure 3. Don Blake [University of California Irvine] explains operation of the Whole Air Sampler to the student team studying atmospheric emissions.

The students were particularly interested in the SARP 2010 projects because in addition to their intrinsic scientific value, each project also had direct relevance to society. For example, California's enormous agricultural productivity is heavily dependent on water, the supply of which is becoming increasingly scarce and faces multiple competing demands. Accordingly, irrigation needs to be highly efficient. Having more accurate measurements of the rate of evapotranspiration over the Central Valley will allow decision makers to calculate the quantity of irrigated water that will be necessary to replace the water that has been lost.

Figure 4. Nick Clinton [University of California Santa Cruz] mentors students from the kelp productivity team. [*Left to right*] **Christy Steffke** [University of Michigan Dearborn], **Casey Zakroff** [Florida Gulf University], and **Kathy Juranek** [Northern Arizona University].

The quality of the faculty and their commitment to the SARP students was another powerful motivator for the students, but equally crucial were the mentors for each project. These were: **Nicholas Clinton** [UCSC] (pictured in **Figure 4**) for the kelp study, and advanced PhD students **Shawn Kefauver** [UCD] and **Matt Gartner** [UCI] for evapotranspiration and anthropogenic emissions, respectively. The mentors worked with students continuously throughout the summer program, and provided sufficient guidance to support the students' research, but not so much that the methods were completely prescribed. The burden of answering particular research questions rested solely on the students.

The mentors worked with students continuously throughout the summer program and provided sufficient guidance to support the students' research, but not so much that the methods were completely prescribed. The burden of answering particular research questions rested solely on the students.

NASA's space research and its use of satellites are, of course, well-known, but many of the students (and probably many among the general public) were initially unaware of the Agency's major commitment to Earth science research. Most students were probably unaware of the significant role aircraft played in studying the Earth system. Several *enrichment lectures* and subsequent conversations with the lecturers helped illuminate this side of NASA for the SARP 2010 participants.

Perhaps the most enjoyable enrichment lectures in the series were the pair delivered by **Sherwood Rowland** [UCI] (pictured in **Figure 5**) who described his work on ozone depletion in the stratosphere, for which he received the 1995 Nobel Prize in Chemistry, as well as climate change occurring because of greenhouse gases emitted to the atmosphere. Other enrichment lecture speakers included: **Randall Albertson** [NASA Headquarters (HQ)—*Deputy Director of NASA's Airborne Science Program*, **Hal Maring** [HQ—*Program Manager for Radiation Sciences*], and **Jay Al-Saadi** [NASA Langley Research Center/HQ—*Program Manager for Tropospheric Chemistry*], all of whom touched on different aspects of NASA's Earth Science Program. All of these talks gave the SARP students, many of whom will be headed for graduate schools, exposure to research opportunities with which they were previously unfamiliar.

Figure 5. F. Sherwood Rowland [University of California Irvine] lectures SARP students about chlorofluorocarbon (CFC) research for which he shared the 1995 Nobel Prize in Chemistry.

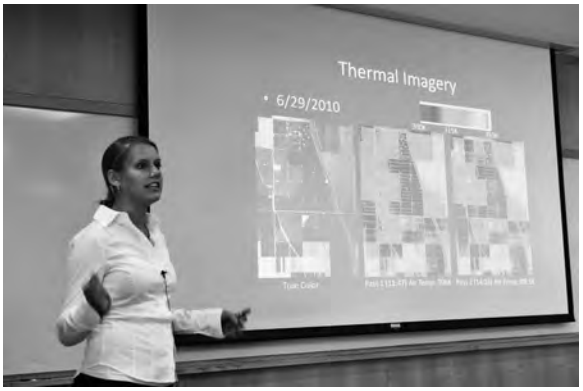


Figure 6. Amanda Rupiper [Creighton University] presents results of her research using multi-channel spectroscopy acquired by MASTER onboard NASA's DC-8 research aircraft.

The students also got a chance to experience all of the intricacies of a major research mission. Flight planning, for example, depends heavily upon knowledge of meteorology. **Henry Fuelberg** [Florida State University] described the importance of meteorology to airborne missions and applied it to flight planning for the two student flights. NSERC and Dryden Aircraft Operations Center personnel explained various aspects of instrument integration, onboard and air-to-ground communications systems, safety, and pre- and post-flight pilot briefings.

Benefits of the NASA–NSERC Student Airborne Research Program can be extended to far more than the summer participants through sharing of all lectures on the NSERC website (*www.nserc.und.edu/learning/SARPmm.html?2010*). The faculty lectures are excellent resources for many university courses. Particularly inspiring are the student presentations—see **Figure 6**—all of which are also posted. Readers can see the results of their research projects and can judge for themselves the degree of learning SARP students experienced.

Conclusion

Time will tell what results this program will lead to, but initial impressions formed by the quality of the students and their research performance indicate NASA's investment in SARP will pay large dividends in the future. The Earth system needs fresh minds to turn the challenges of the present into the opportunities of the future—see **Figure 7**. ■

Figure 7. Jack Kaye [NASA HQ—*Associate Director of NASA's Earth Science Division*] discusses presentations made by students in the NASA–NSERC Student Airborne Research Program with **Don Blake** [University of California Irvine]. To the right is **Raphael Kudela** [University of California Santa Barbara]. Blake and Kudela were faculty leads for two of the student research projects.

NOTE: *Another Student Airborne Research Program will take place in Summer 2011. Applications are available at:* ***www.nserc.und.edu/learning/SARP2011.html.***

Experience NASA Science at the 2010 Fall AGU

Please join us at the NASA booth (#111) during this year's Fall Meeting of the American Geophysical Union (AGU), where we will offer a wide variety of science presentations, demonstrations, and tutorials for a variety of data tools and services. This year's exhibit will feature a *hyperwall*—a dynamic, interactive, nine-screen display—that will showcase a variety of different NASA Science datasets throughout the week.

This year's program begins on Tuesday, December 14 and will continue through Thursday, December 16, 2010. Sixteen different programs and missions are scheduled to participate—representatives from Dryden, Ames, Jet Propulsion Laboratory, Goddard, Langley, and Wallops are expected.

Science presentations will focus on a diverse range of research topics, science disciplines, and programs within NASA's Science Mission Directorate. Interactive data-oriented demonstrations will include sessions on data accessibility and search-and-order capabilities, and will feature selected data visualization, data conversion, and other data manipulation tools.

A daily agenda will be posted on the Earth Observing System Project Science Office (EOSPSO) website—*eos.nasa.gov*—in early December.

We look forward to seeing you in San Francisco!

announcement

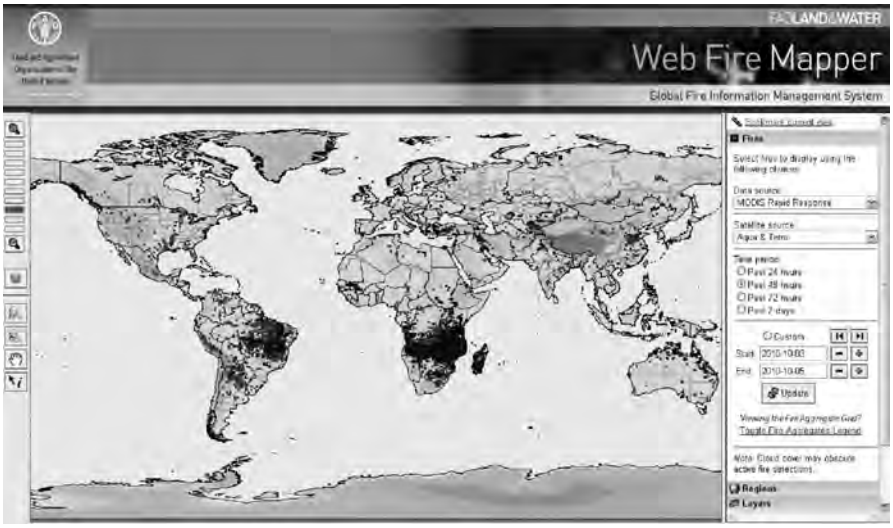
NASA Global Fire Information System Adopted by UN Food and Agriculture Organization

Diane Davies, University of Maryland, ddavies@hermes.geog.umd.edu
Chris Justice, University of Maryland, justice@hermes.geog.umd.edu
Gretchen-Cook Anderson, NASA Goddard Space Flight Center, gretchen.r.cook-anderson@nasa.gov

The Global Fire Information System (GFIMS) will help firefighters and natural resource managers improve response time and resource management.

Amidst some of the worst wildfires ever seen in Russia, the United Nations (UN) Food and Agriculture Organization (FAO) launched an online fire detection system, developed as part of NASA's Applied Sciences Program. The Global Fire Information System (GFIMS) will help firefighters and natural resource managers improve response time and resource management.

GFIMS and its precursor, the Fire Information for Resource Management System (FIRMS) at the University of Maryland, have already proved invaluable for those seeking information on the wildfires in Central Russia. On August 9, at the height of the fires, there were more than 26,000 visits to the FIRMS website. In addition to the large number of wild and peat bog fires identified using active fire locations from GFIMS and FIRMS, at least three fires were detected in the Bryansk region of Russia where large swaths of land were reportedly contaminated during the Chernobyl nuclear explosion in 1986. According to Greenpeace, the satellite-derived fire locations have been the "only reliable source of information on what has become one of the country's most severe environmental disasters."[1]



A snapshot of GFIMS shows fire data from the MODIS instrument on the Aqua and Terra satellites for a 48-hour period in October 2010. To view the GFIMS interface online, please visit: *geonetwork4.fao.org/firemap/.*

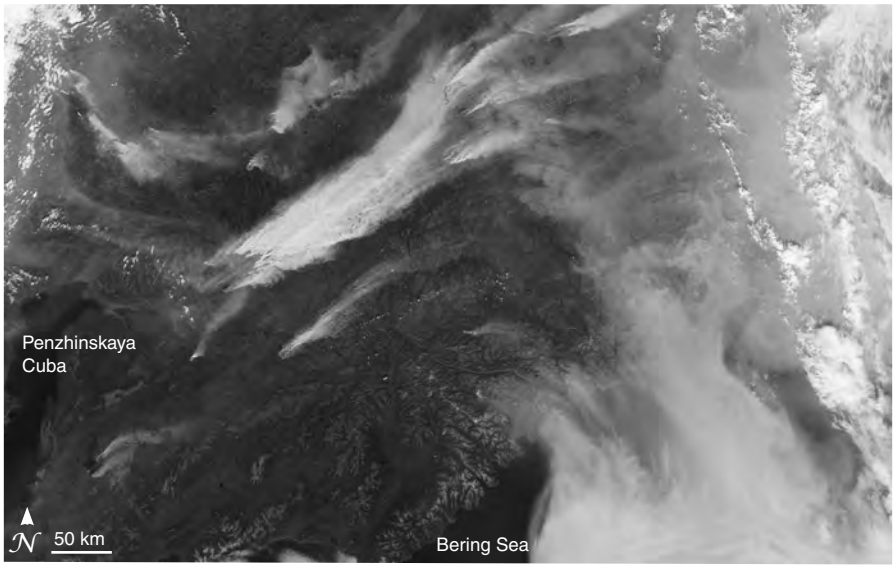
Beyond Russia's borders, Moderate Resolution Imaging Spectroradiometer (MODIS) users in over 120 countries routinely access active fire data. In concert with data from the MODIS Rapid Response Team System (*rapidfire.sci.gsfc.nasa.gov/*), fires are detected using data from the MODIS sensor aboard NASA's Terra and Aqua satellites. GFIMS/FIRMS then makes the fire locations available in easy-to-use formats, including: customizable interactive fire maps, where users can bookmark locations of fire interest; Keyhole Markup Language (KML) files, that allow the fire locations to be overlaid on *Google Earth*; and email alerts, reporting the quantity and coordinates of fires in a user-specified area of interest. These are all made available less than three hours after sensor overpass.

By making the information timely and easy to access, the system enables non-technical users to bypass the considerable challenges previously encountered in obtaining satellite-derived fire information. This is reflected in the increasing number of media

[1] To learn more, visit: *www.greenpeace.org/international/en/news/Blogs/nuclear-reaction/update-forest-fires-in-russia/blog/26179.*

and websites that pull the active fire locations and make them available to the general public during major fire events.

Although the number of visits to GFIMS/FIRMS peaks during big fire events, scientists and natural resource managers are also keen to use the system to better understand historic fire patterns and trends associated with climate change. To better facilitate this, GFIMS/FIRMS makes available the full archive of MODIS active fire locations (dating from November 2000 for data from Terra and July 2002 for data from Aqua) using data from the MODIS Data Processing System (MODAPS). This type of research has recently been enhanced by the addition of MODIS burned-area maps developed by **David Roy** and **Luigi Boschetti**, which can be viewed as part of the web-based mapping service. The burned area images allow users to get a better overview of the total area burned, as opposed to a snapshot of what is burning as the satellite passes overhead.



On July 25, 2010, the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite captured this image of fires raging in Eastern Siberia, sending a plume of thick smoke hundreds of kilometers wide over the Bering Sea. News sources attributed fires in the Russian Federation to drought, heat, and human activity.

To view this image in color, please visit: *earthobservatory.nasa.gov/NaturalHazards/view.php?id=44756*

Image credit: MODIS Rapid Response Team

GFIMS was launched at FAO headquarters in Rome, Italy on August 12, 2010. The FAO is already tailoring GFIMS to meet the needs of the broader United Nations' user community by adding country-specific reports and analyses. FAO also plans to implement a mobile phone Short Messaging Service (SMS), which will enable users from developing countries to receive fire alerts directly on their mobile phones. The service will be tested in Kenya, with the goal of expanding to other countries. GFIMS-derived information is available in English, French, and Spanish.

While GFIMS is being established at FAO, FIRMS will become part of NASA Land Atmosphere Near-real-time Capability for EOS (LANCE), continuing to meet NASA data-user needs. LANCE provides access to near-real-time data from the Atmospheric Infrared Sounder (AIRS), Advanced Microwave Scanning Radiometer for EOS (AMSR-E), Microwave Limb Sounder (MLS), MODIS, and the Ozone Monitoring Instrument (OMI). NASA data users, operational agencies, and researchers utilize these products for a wide range of purposes (e.g., from weather forecasting to natural hazard monitoring). These users often need data much sooner than routine science processing allows, and they are willing to trade science quality for timely access.

FIRMS was developed by **Diane Davies**, **Chris Justice**, **Shriram Ilavajhala**, **Minnie Wong ,** and **Giuseppe Molinario** at the University of Maryland, College Park, in collaboration with **Louis Giglio** and representatives from the MODIS Rapid Response Team. Funding for GFIMS was provided by program manager **Woody Turner** at NASA Headquarters. GFIMS is managed by **John Latham** at the FAO, Rome.

feature articles

NASA DEVELOP Students Rev Up Response to Gulf Oil Spill

Jason Jones, DEVELOP National Program, John C. Stennis Space Center, Jason.B.Jones@nasa.gov
Lauren Childs, DEVELOP National Program, Langley Research Center, Lauren.M.Childs@nasa.gov

*During the **Deepwater Horizon** oil spill crisis, DEVELOP students capitalized on their collective science research and community outreach skills to initiate a public outreach campaign across the Gulf Coast, highlighting NASA's contributions to oil spill response, recovery, and research.*

NASA Responds to the *Deepwater Horizon* Oil Spill

After the April 20, 2010 explosion aboard the *Deepwater Horizon* drilling rig in the Gulf of Mexico, the world witnessed one of the worst oil spill catastrophes in history. In an effort to mitigate the disaster, the U.S. government moved quickly to establish a unified command for responding to the spill. Some of the command's most immediate needs were to track the movement of the surface oil slick, establish a baseline measurement of pre-oil coastal ecosystem conditions, and assess potential air quality and water hazards related to the spill. To help address these needs and assist the Federal response to the disaster, NASA deployed several of its airborne and satellite research sensors to collect an unprecedented amount of remotely-sensed data over the Gulf of Mexico. Although some of these data were shared with the public via the media, much of the NASA data on the disaster was not well known to the Gulf Coast community. Government officials wanted to inform the general public about these datasets and help improve understanding about how NASA's science research was contributing to oil spill response and recovery. With its extensive experience conducting community-oriented remote sensing projects and close ties to organizations around the Gulf of Mexico, the NASA DEVELOP National Program was in a unique position to meet this need.

DEVELOP Initiates a Regional Public Outreach Campaign

DEVELOP is a NASA Science Mission Directorate Applied Sciences training and development program[1]. Mentored by science advisors from NASA and partner agencies, students conduct applied remote-sensing projects and demonstrate the relevance of their research to local policy-makers. During the *Deepwater Horizon* oil spill crisis, DEVELOP students capitalized on their collective science research and community outreach skills to initiate a public outreach campaign across the Gulf Coast, highlighting NASA's contributions to oil spill response, recovery, and research. The DEVELOP Oil Spill Outreach team consisted of students from DEVELOP's offices at Stennis Space Center (SSC) in Mississippi, Langley Research Center (LaRC) in Virginia, and the Mobile County Health Department (MCHD) in Alabama.

The team's first objective was to add value to some of NASA's existing online satellite data by making it easier for the public to interpret and understand. They accomplished this goal during the summer by creating visually appealing, simple animations of imagery from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor onboard NASA's Terra and Aqua satellites, and from the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) instrument onboard the CALIPSO satellite—a joint venture between NASA and the French space agency. Using select daily MODIS imagery from Goddard Space Flight Center's (GSFC) MODIS Rapid Response System, the students created a time-series animation showing how the surface oil slick changed shape and location throughout the summer. By modifying geographic information system (GIS) shapefile data acquired from the National Oceanic and Atmospheric Administration (NOAA), the students created cartographic contours that more clearly depicted the distance of the oil slick from well-known coastal cities, thereby improving previous visualizations. Combined with animated images, these contour lines can help the general public more easily interpret how the oil slick was moving—see **Figure 1**. Similarly, the students produced a video that takes viewers on

[1] To read more about the DEVELOP program, please see pp. 7-9 in *The Earth Observer's* March-April 2010 issue [**Volume 22, Issue 2**], pp. 11-13 in the May-June 2010 issue [**Volume 22, Issue 3**], pp. 10-12 in the July-August 2010 issue [**Volume 22, Issue 4**], and pp. 10-12 in the September-October 2010 issue [**Volume 22, Issue 5**].

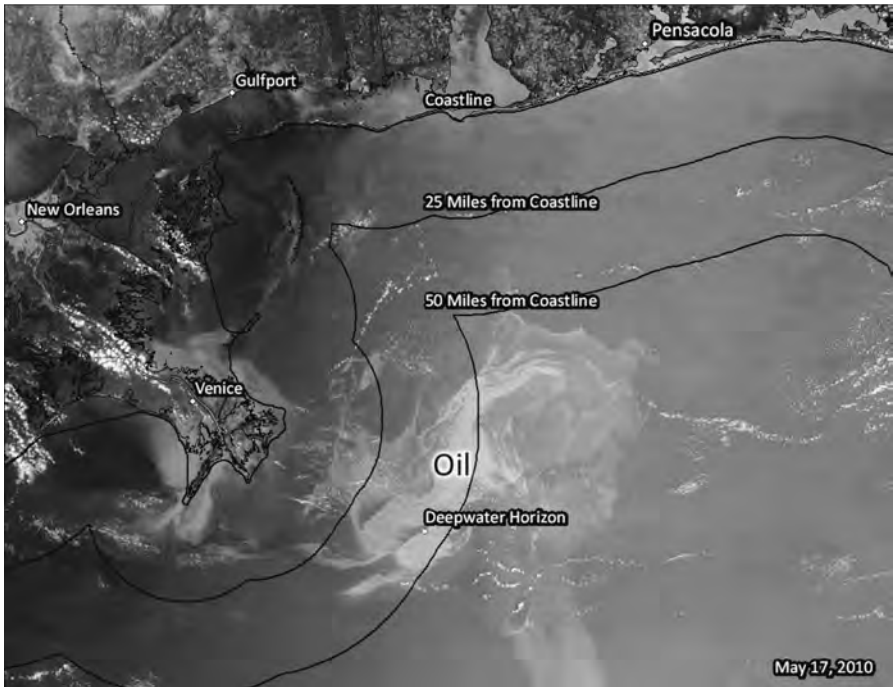


Figure 1. The *Deepwater Horizon* oil slick in the Gulf of Mexico is seen on May 17, 2010, in this Terra MODIS image. The black contour lines superimposed on the image help give an idea of how close the spill was to the coast. **Credit:** NASA/GSFC, MODIS Rapid Response **Cartography Credit:** NASA DEVELOP

Figure 2. In this still frame from DEVELOP's CALIPSO CALIOP visualization, CALIOP data tracks are overlaid on a background MODIS image.

a virtual flying three-dimensional (3-D) tour of CALIOP's atmospheric aerosol data over the Gulf of Mexico. Enhanced with background imagery from MODIS and even a 3-D model of the *Deepwater Horizon* drilling platform, the visualization helps users better understand how CALIOP aerosol data can be used to study potential air pollutants related to the oil spill—see **Figure 2**. These data visualizations can be accessed at the DEVELOP website: *develop.larc.nasa.gov*.

In addition to creating satellite data animations, the students also contributed to a "one-pager" fact sheet that the NASA Langley Public Outreach Office published highlighting NASA's oil spill imagery and research activities. Moreover, the DEVELOP team created a conference poster and presentation summarizing NASA's oil spill data products and some of the fascinating research being conducted using the data. Finally, the students drafted a public information sheet with lists of websites for oil spill information and data. Equipped with these outreach tools and science data visualizations, the team set out on a public awareness tour in Louisiana, Mississippi, Alabama, and Florida to educate Gulf Coast residents on ways that NASA science is making positive contributions to local communities.

Before reaching out to the general public, the team focused on informing scientific/technical staff from regional academic, government, and private-sector organizations about ways that NASA remote sensing data could enhance their oil spill response activities. To accomplish this goal, the students attended the Governor's Action Plan II Implementation and Integration Workshop in Biloxi, MS, organized by the Gulf of Mexico Alliance (GOMA) in early August. Consisting of membership from thirteen federal agencies, all five Gulf States, and four regional research organizations, GOMA promotes both the economic and ecologic well-being of the Gulf of Mexico and its surrounding states/countries. With representatives from each of GOMA's member states, agencies, and organizations present, the Governor's Action Plan II Implementation and Integration Workshop provided DEVELOP a platform for interacting with key stakeholders in the Gulf of Mex-

ico region. The students set up an information booth, presented a NASA oil spill poster, distributed NASA oil spill fact sheets, and answered attendees' questions regarding ways that NASA's remote sensing data products can benefit their organizations—see **Figure 3**. After the workshop, DEVELOP received requests from conference attendees for further information and data. The students were able to direct them to appropriate NASA officials who would answer their questions in detail and supply them with data.

Figure 3. Josh Stodghill [*left*] and **Jamie Favors** [*right*] represent DEVELOP at the Gulf of Mexico Alliance Governor's Action Plan II Implementation and Integration Workshop in Biloxi, MS on August 3, 2010. **Photo credit:** Jason Jones, NASA DEVELOP National Program

Figure 4. This ASTER image shows the oil slick (appearing as a white sheen) approaching the Mississippi River Delta in southeastern Louisiana on May 24, 2010. **Image credit:** NASA **Caption credit:** NASA DEVELOP

After attending the GOMA workshop, the DEVELOP team began their NASA oil spill "public outreach campaign, giving presentations at the University of New Orleans, the University of Southern Mississippi, the University of South Alabama, and the University of West Florida. They also presented at other venues including the Lions Club in Mobile, AL; the Mississippi Association for Spatial Technologies in Gulfport, MS; and the Coast Guard Auxiliary Flotilla in Pass Christian, MS. At each venue, the team presented an overview of the NASA data collected over the *Deepwater Horizon* oil spill and highlighted many of the ongoing scientific research projects that are benefitting from the datasets.

Examples of NASA Data Products and Research that DEVELOP Publicized

In response to the oil spill, NASA acquired imagery and data from numerous spaceborne and airborne sensors. Besides the MODIS and CALIOP data already mentioned, NASA also captured imagery from space using the Multi-angle Imaging Spectroradiometer (MISR), the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), the Thematic Mapper (TM), Enhanced Thematic Mapper Plus (ETM+), Jason-1, and the Ocean Surface Topography Mission (OSTM)/Jason-2. NASA also deployed several of its aircraft to collect data using the High Spectral Resolution Lidar (HSRL), the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS), and the Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR). **Figures 4**, **5**, **6**, and **7**, as well as **Table 1,** show examples of these sensors and their applications.

The data that NASA collected are useful for many oil spill applications. For example, NOAA image analysts used MODIS imagery when creating their daily oil slick location maps—see **Figure 7**. Scientists at NASA's Jet Propulsion Laboratory (JPL) experimented with radar data from UAVSAR to examine the impacts of beached oil on coastal wetlands, and researchers at LaRC tested the application of HSRL data for detecting sub-surface oil. Additionally, faculty from the University of California at Santa Barbara and the University of California at Davis worked with NASA and the U.S. Geological Survey (USGS) using AVIRIS imagery to map the thickness of the surface oil slick, characterize the vegetation species of Louisiana's coastal wetlands, and analyze the impacts of washed up oil on those coastal wetlands. These are only a few examples of work being done with NASA data. Several other research projects utilizing the data have also been completed or are currently in progress.

The Community Benefits from DEVELOP's Public Awareness Efforts

The DEVELOP team strove to dispel the notion that NASA focuses only on space and aeronautics research. Through their outreach, the students helped increase aware-

Figure 5. [*left*] NASA's Earth Resources-2 (ER-2) aircraft carries the AVIRIS sensor. **Figure 6.** [*right*] NASA's *Gulfstream* G-III aircraft has the UAVSAR mounted underneath. **Image credit:** NASA

ness among Gulf Coast citizens about NASA's extensive involvement with Earth science and the relevance of NASA science missions to their local communities. The team also informed their audiences about how other agencies and universities are benefitting from NASA's oil spill remote sensing data. For example, the students described how NOAA, the USGS, and several universities across the U.S. are conducting oil spill research using NASA remote sensing data products.

Communities benefitted from DEVELOP's outreach tour, the public gained a better understanding of NASA's Earth science missions and the impacts that NASA research activities have on their local communities.

DEVELOP Conducts Scientific Research Regarding Oil Spill Impacts to Gulf of Mexico Region

While DEVELOP's initial contribution to NASA's oil spill response was through forming a public outreach team, DEVELOP did not stop there. Several of the program's national teams also investigated opportunities for conducting their own scientific and technical research related to the oil spill's impact on the Gulf of Mexico's environment. The teams proposed multiple student projects to NASA's Applied Sciences Program focusing on a variety of topics. These included potential impacts of the oil spill on air quality and public health, fish populations, and barrier island ecosystems. DEVELOP received approval for five of these projects in Summer 2010 and conducted their research during the Fall 2010 DEVELOP project term. Many of the students will be presenting their work to partnering organizations and also at scientific and policy conferences nationwide.

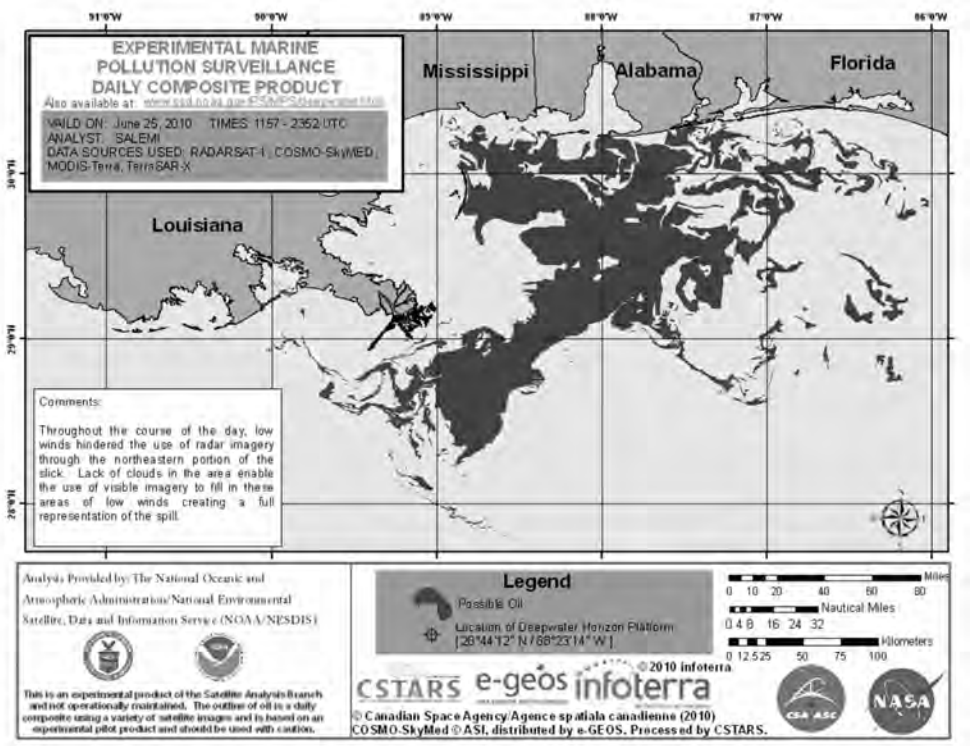


Figure 7. This example of a NOAA oil spill map was generated from MODIS and other sensor data. **Image credit:** NOAA

Table 1. Selected NASA airborne and spaceborne sensors, applications, and users

NASA Airborne Sensors:		
Sensor	**Relevant Applications**	**Users**
High Spectral Resolution Lidar (HSRL)	Tracking air pollution, detecting subsurface oil, and studying phytoplankton	NASA
Airborne Visible/Infrared Imaging Spectrometer (AVIRIS)	Analyzing surface oil thickness, mapping marsh grass species, and assessing coastal wetlands health	NASA, U.S. Geological Survey, University of California Santa Barbara, and the University of California Davis
Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR)	Evaluating oil impacts on coastal marshes	NASA
NASA Spaceborne Sensors:		
Sensor	**Relevant Applications**	**Users**
Moderate Resolution Imaging Spectroradiometer (MODIS)	Tracking surface oil location/movement, monitoring wetlands health, studying harmful algal blooms, etc.	NASA, National Oceanic and Atmospheric Administration, and the Naval Research Laboratory
Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP)	Studying air quality and detecting surface oil	NASA and the Naval Research Laboratory
Multi-angle Imaging SpectroRadiometer (MISR)	Delineating surface oil slick	NASA
Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)	Tracking surface oil and monitoring coastal wetlands health	NASA
Thematic Mapper (TM)/Enhanced Thematic Mapper Plus (ETM+)	Tracking surface oil and monitoring coastal wetlands health	NASA and the U.S. Geological Survey
Advanced Land Imager	Tracking surface oil and monitoring coastal wetlands health	NASA
Jason-1	Measuring sea surface height and studying ocean currents	NASA and the University of Colorado
Ocean Surface Topography Mission (OSTM)/Jason-2	Measuring sea surface height and studying ocean currents	NASA and the University of Colorado
International Space Station - Photographs	Delineating surface oil slick	NASA

Stennis Space Center DEVELOP Project

This project explored the applicability of using the Ozone Monitoring Instrument (OMI) and Tropospheric Emission Spectrometer (TES) onboard NASA's Aura mission, and the MODIS sensor onboard NASA's Terra and Aqua missions, to measure the concentration of atmospheric pollutants such as tropospheric ozone and particulate matter levels along the Gulf Coast in relation to the *Deepwater Horizon* oil spill. The team utilized the formaldehyde data product from OMI in conjunction with the ozone product from TES, as well as the aerosol optical depth (AOD) product. This project sought to create a methodology for enhanced air quality monitoring over large geographic areas where no *in situ* sampling data may be available, because such a methodology would be useful if a future oil spill disaster occurs. Upon completion of their project, the students shared their research results with the U.S Environmental Protection Agency (EPA) Region 6 Deepwater Horizon Oil Spill Air Committee.

Mobile County Health Department DEVELOP Project

The Mobile DEVELOP team focused two projects on oil spill-related topics in the fall of 2010. The first investigated the use of NASA remote sensing products for monitoring anthropogenic sand dune movement on Dauphin Island, AL. Sand was brought in as part of the oil prevention effort, but the impact on the island's ecosystems was unclear. The student team's research assessed the impact of the oil prevention project on the is-

land, and provided the partners (Dauphin Island Park and Beach Board and Dauphin Island Sea Lab) with methodologies to use NASA Earth Observing System (EOS) missions and instruments to assist in future land management and decision-making. The second project focused on creating an inventory and database of NASA remote sensing data products relating to the oil spill that can be referenced during future oil spills worldwide. They also collected public health records for correlation with the air quality measurements tracked by the SSC and LaRC air quality projects.

Langley Research Center DEVELOP Project

In cooperation with the Stennis Gulf Air Quality project, the Langley DEVELOP team investigated the use of CALIPSO's *Level 2 Version 3.01* Aerosol Extinction data to measure air quality in the oil spill area. The Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model was used to track smoke plume trajectories and their distance to populated areas in the Gulf Coast. The goal of the project was to assist the EPA Region 6 with enhanced aerosol monitoring capabilities where no *in situ* datasets were available and to assist in the improved regulation of oil spill burning in future spills.

Jet Propulsion Laboratory DEVELOP Project

The JPL DEVELOP fall project focused on the demonstration of synthetic aperture radar (SAR) data to detect oil floating on the surface of water and improve understanding of the *Deepwater Horizon* oil spill impact on the *Bluefin Tuna* breeding habitat. The team partnered with NOAA and Roffer's Ocean Fishing Forecasting Service, which is researching remote sensing capabilities of assessing *Bluefin Tuna* populations and reducing variance in spawning stock abundance in the Gulf of Mexico. This study assessed SAR contributions to decision support efforts relevant to commercial fisheries through improving the understanding of environmental conditions that affect *Bluefin Tuna*.

DEVELOP Plans Future Oil Spill Related Research

According to *Science Magazine*, the *Deepwater Horizon* oil spill caused approximately 185 million gallons of crude oil to flow into the Gulf of Mexico over an extended period of time. The full impact of this is yet to be seen, but the spill caused extensive damage to marine and wildlife habitats. Even the repercussions of protection schemes of containment and dispersants are not clearly understood. DEVELOP teams are continuing research in the Gulf of Mexico to improve understanding of the impact to wetlands, marshes, and endangered species' populations. DEVELOP teams continue to explore how NASA's Earth observations can assist in the decision making process and policy relating to future oil spills. The results of these future DEVELOP projects and others will be presented at local, state, and regional scientific and policy-oriented conferences in the upcoming months.

Conclusion

In the summer and fall of 2010, several DEVELOP teams worked to increase understanding of how NASA satellite data help mitigate effects of one of the worst oil spill disasters in history. These teams worked to make NASA satellite data from the *Deepwater Horizon* oil spill more accessible to the general public through the use of animated satellite imagery and one-page fact sheets. They also reached out to the science and technical communities to investigate the feasibility of using NASA satellites to enhance oil spill response activities. To examine the feasibility of using these sensors in oil spill response/recovery efforts, different DEVELOP teams focused on various aspects of the oil spill including water and air quality, *Bluefin Tuna* habitats, and public health records. DEVELOP will continue to work on understanding the impact that this oil spill has on the natural environment including wetlands and endangered species population through the use of NASA EOS data. ■

DEVELOP will continue to work on understanding the impact that the Gulf oil spill has on the natural environment including wetlands and endangered species population through the use of NASA EOS data.

feature articles

Getting a GRIP on the Great Wind

Mitchell K. Hobish, Sciential Consulting, LLC, Manhattan, MT, mkh@sciential.com

A great wind is blowing, and that gives you either imagination or a headache.

*—**Catherine the Great**, 1729-1796*

What is the largest engine on Earth?

No, it's not some mechanical monster; rather, it is the hurricane. According to Chris Landsea, of the National Hurricane Center, "…A fully developed hurricane can release heat energy at a rate of 5 x 10^{13} W, and converts less than 10% of the heat into the mechanical energy of the wind. **The heat release is equivalent to a 10-megaton nuclear bomb exploding every 20 minutes!**"[1] Clearly, this force is more powerful than a locomotive.

Translating this into human terms is all too easy: hurricanes cause human suffering and death, not to mention property damage, yearly. Some of the worst have socioeconomic effects that last for years beyond the event itself—such as Hurricane Katrina, which hit the Louisiana and Mississippi Gulf Coast in 2005. Clearly, understanding the origins, development, and lifetime of hurricanes is a worthy undertaking, and one that has a long history.

The first *planned* flight into a hurricane to gather meteorological data was made in 1943. Since then, aircraft known as *Hurricane Hunters* have been flying into hurricanes. Such flights have now become routine for the Air Force, which uses *Lockheed* WC-130J aircraft, and for the National Oceanic and Atmospheric Administration (NOAA), which uses *Lockheed* WP-3D *Orion* aircraft. While remote sensing satellite instruments provide important information about hurricanes, aircraft are key to acquiring the detailed *in situ* data that are essential to fully understand hurricane behavior. Such data include wind speed, barometric pressure, temperature, and humidity; and these data are not routinely measured by remote sensing.

The GRIP Field Campaign

It is against this background that the Genesis and Rapid Intensification Processes (GRIP) mission has been conceived of and implemented by NASA's Earth science community.

GRIP was designed to explore the formation of tropical storms and their transition into full-blown hurricanes—or, conversely, why so many tropical disturbances do not exhibit this evolution. Aircraft tracks were planned for direct incursion into storms and underflights of remote sensing satellites, including Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) and CloudSat. Other instruments whose data supported GRIP observations included NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) that flies on both the Terra and Aqua satellites.

The GRIP field campaign took place August 15–September 30, and was managed by a cross-organizational team that included: **Ramesh Kakar** [NASA Headquarters—*Program Manager*]; **Marilyn Vasques** [NASA Ames Research Center (ARC)—*Project Manager*]; **Michael Craig** [ARC—Deputy Project Manager]; **Scott Braun** [NASA Goddard Space Flight Center (GSFC)—*Mission Scientist*]; **Gerry Heymsfield** [GSFC—*Mission Scientist*]; and **Ed Zipser** [University of Utah—*Mission Scientist*].

The Aircraft and their Payloads

The types and amounts of aircraft deployed during GRIP are noteworthy, as their respective operational envelopes afforded capabilities well suited to the mission requirements. The aircraft included NASA's DC-8, based in Ft. Lauderdale, FL, and the WB-57, based

in Houston, TX, used in conjunction with a *Global Hawk* unmanned airborne system (UAS), based at the Dryden Flight Research Center (DFRC) in California.

The instrumentation being used on the aircraft during GRIP, the variety of direct data being gathered, and the investigators are summarized below.

On the DC-8:

The Airborne Second-generation Precipitation Radar (APR-2) is a 13–35 GHz dual-frequency Doppler radar that measures the vertical structure of precipitation and cross winds. The investigators are **Steve Durden** [NASA Jet Propulsion Laboratory (JPL)—*Principal Investigator (PI)*]**; Ziad Haddad** [JPL]; **Kwo-Sen Kuo** [GSFC]; and **Simone Tanelli** [JPL].

The Cloud Aerosol and Precipitation Spectrometer (CAPS) is a spectrometer and imaging probe that measures cloud and aerosol particle properties and size distribution. The Precipitation and Imaging Probe (PIP) is an imaging probe that measures direct particle size and distribution. The team for both instruments consists of **Andy Heymsfield** [National Center for Atmospheric Research (NCAR)—*PI*], working with **Aaron Bansemer** [NCAR] and **Yaitza Luna–Cruz** [Howard University].

The Doppler Aerosol WiNd Lidar (DAWN) is a Doppler lidar that determines backscattered light frequency *vs.* time/range. The team includes **Michael Kavaya** [NASA Langley Research Center (LaRC)—*PI*]; **Robert Atlas**, **Jeffrey Y. Beyon**, **Grady J. Koch**, **Upendra N. Singh**, **Bo C. Trieu**, and **Jirong Yu** [all from LaRC]; and **G. David Emmitt** [Simpson Weather Associates].

The DC-8 Dropsonde measures vertical profiles of pressure, temperature, humidity, and wind. The instrument team includes **Jeff Halverson** [GSFC—*PI*], working with **Henry Fuelberg** [Florida State University].

The Langley Aerosol Research Group Experiment (LARGE) is a group of *in situ* aerosol sensors that includes condensation nuclei counters, optical particle spectrometers, an aerodynamic particle sizer, multi-wavelength particle-soot absorption photometers, and integrating nephelometers. Together, these instruments measure condensation nuclei; aerosol particle size; cloud condensation nuclei spectra; scattering humidity dependence; absorption at 405, 532, and 781 nm; scattering at 450, 550, and 700 nm; black carbon mass and size; and soluble ion composition. The instrument team includes **Bruce Anderson** [LaRC—*PI*], accompanied by **Gao Chen** [LaRC]; **Robert Black** and **Jason Dunion** [both from NOAA's Hurricane Research Division (HRD)]; **Jack Dibb** [University of New Hampshire]; and **Thanos Nenes** [Georgia Tech].

The Lidar Atmospheric Sensing Experiment (LASE) measures water vapor mixing ratios, aerosol scattering ratios, and cloud distributions. The instrument team includes **Syed Ismail** [LaRC—*PI*], and Co-Investigators (Co-Is) **Richard Ferrare** and **Jonathan Hair** [both from LaRC].

In situ sampling for differential global positioning system (DGPS) positions, velocities, accelerations, pitch, roll, heading, angle-of-attack, angle-of-sideslip, dynamic total pressures, and total temperatures are performed by the Meteorological Measurement System (MMS). The team includes **Paul Bui** [ARC—*PI*], and Co-Is **Cecilia Chang** and **Jonathan Dean-Day** [both from the Bay Area Environment Research Institute (BAERI)].

On the WB-57:

The Hurricane Imaging Radiometer (HIRAD) measures brightness temperatures at 4, 5, 6, and 6.6 GHz. **Timothy Miller** [NASA Marshall Space Flight Center (MSFC)—

The types and amounts of aircraft deployed during the campaign are noteworthy, as their respective operational envelopes afforded capabilities well suited to the mission requirements. The aircraft included NASA's DC-8 and WB-57, used in conjunction with a Global Hawk unmanned airborne system (UAS).

PI] leads the team; **Eric Uhlhorn** [NOAA HRD] is the Co-I. Other team members include **Chris Ruf** [University of Michigan]; **Linwood Jones** [University of Central Florida (UCF)]; and **Mark James** [MSFC—*Lead Engineer*].

On the Global Hawk:

The *Global Hawk* UAS—see **Figure 1**—was pressed into unprecedented service in support of GRIP. Because of its capabilities for extended residence time on-scene, autonomous activities, and large payload capacity, *Global Hawk* was used extensively during the field campaign. The unmanned aircraft allowed scientists to collect data in regions over the Earth's surface previously inaccessible to piloted platforms or other, shorter-duration and smaller-payload robotic craft. Its 30-hour operational window (limited only by the need for refueling) and 65,000-foot operation ceiling make it ideal for missions such as GRIP[1]. Using *Global Hawk* in this way also provides its pilots opportunities to learn the craft's capabilities and idiosyncrasies in a new environment.

Figure 1. The *Global Hawk* soars over Edwards AFB during its first dropsonde test flight. **Image credit:** NASA

On the UAS, brightness temperatures in 21 channels are obtained using the JPL High Altitude Monolithic Microwave Integrated Circuit (MMIC) Sounding Radiometer (HAMSR), a microwave radiometer. The team includes **Bjorn Lambrigsten** [JPL—*PI*] and **Shannon Brown** [JPL—*Co-I*].

The High-altitude Imaging Wind and Rain Airborne Profiler (HIWRAP), a Doppler radar, is used to measure reflectivity; Doppler wind speed and direction; horizontal wind speed and direction in precipitation and cloud regions; and vertical wind. The team includes **Gerry Heymsfield** [GSFC—*PI*]; **James Carswell** [Remote Sensing Systems (RSS)]; and **Liua Li**, **Matt McLinden**, **Martin Perrine, Amber Reynolds**, and **Lin Tian** [all from GSFC].

The Global Hawk UAS was pressed into unprecedented service in support of GRIP. Because of its capabilities for extended residence time on-scene, autonomous activities, and large payload capacity, Global Hawk was used extensively during the field campaign.

Lightning, electric fields, and air conductivity are measured with the Lightning Instrument Package (LIP), and electric field mill and conductivity probe. The team includes **Rich Blakeslee** [MSFC—*PI*], **Monte Bateman** [Universities Space Research Association (USRA)—*Co-I*], and **Doug Mach** [University of Alabama, Huntsville].

GRIP Software Tools

In addition to making extensive use of Web-based information servers, several more-focused software tools have been pressed into service in support of GRIP.

The Real-time Mission Monitor (RTMM) integrates datasets from several sources—including instrumentation on-orbit, in the air, and on the ground—along with computer model output and the status of platforms, to provide a robust view of an entire field campaign. In a sterling example of how to leverage existing network capabilities, the second-generation RTMM integrates with a *Google* browser plug-in. Based on community standards and protocols, RTMM has a well-established heritage of proven utility, having been used in field campaigns since 2006.

The RTMM Waypoint Planning Tool (WPT) supports efforts to develop flight plans that provide optimum flight tracks and data gathering—see **Figure 2**. Programmed

[1] The GRIP *Global Hawk* instrument configuration and operational constraints of the long transit made 25 hours the maximum duration for this campaign.

in *Java*, WPT facilitates such planning with a point-and-click interface. All aspects of flight legs are automatically calculated, including altitude, latitude, longitude, leg distance, cumulative distance, leg time, and cumulative time. These results can be integrated with the RTMM to compare planned and actual performance.

Another *Google* plug-in-based tool is provided by the JPL GRIP Portal that allows access to and presentation of historical and current observational data from many sensors (both airborne and satellite-based), storm tracks, and model outputs, along with links to RTMM and WPT.

"NASA collaborated significantly with NOAA and NCAR, who are performing their own hurricane studies. We accomplished close flight coordination of the three NASA aircraft, the NOAA G-IV and P-3s, and the NCAR G-V as well as the U.S. Air Force C-130s as opportunities arose..."

Campaign Summary and Early Results

"NASA collaborated significantly with NOAA and NCAR, who are performing their own hurricane studies. We accomplished close flight coordination of the three NASA aircraft, the NOAA G-IV and P-3s, and the NCAR G-V as well as the U.S. Air Force C-130s as opportunities arose. In Hurricane Karl, there were an unprecedented six aircraft in the storm at the same time. As you might imagine, communication is the key to such a complex mission," said **Marilyn Vasques**, GRIP Project Manager.

The aircraft logged over 250 hours of combined flight time, the bulk of that time (approximately 140 hours) coming from 25 flights of the DC-8.

An excellent example of the integration of data is shown in the graphic below—see **Figure 2**.

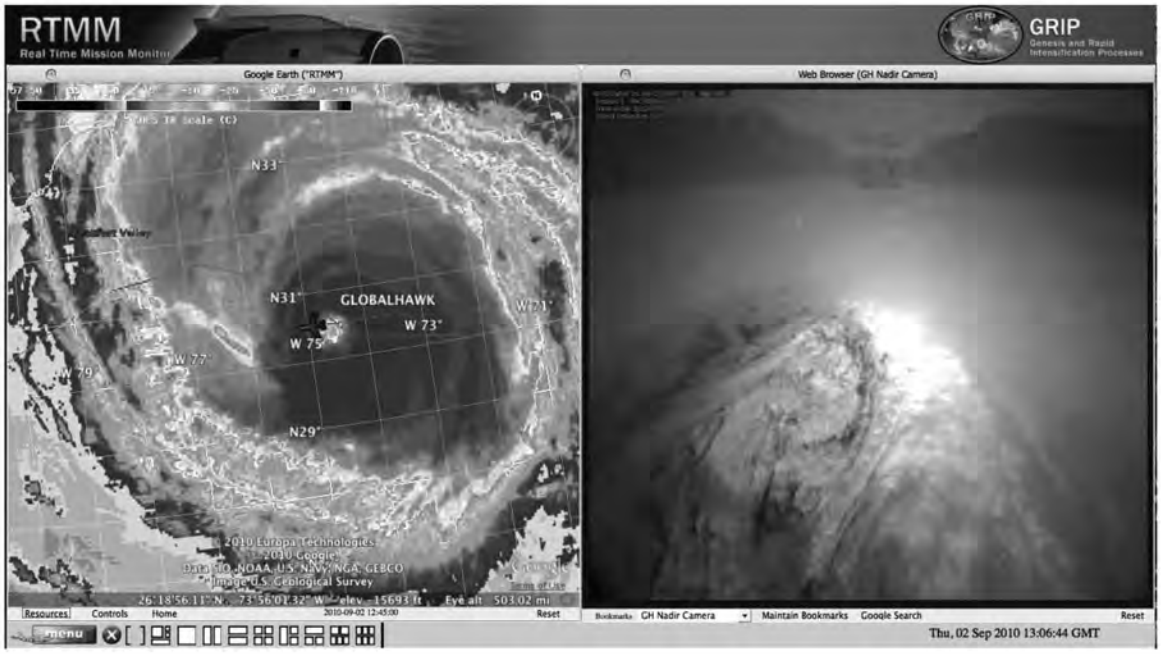


Figure 2. Shown here is the *Global Hawk's* flight track through Hurricane Earl on September 2, 2010 and infrared data from a GOES satellite [*left*], as provided by the Real-time Mission Monitor (RTMM) tool, and a visible-light view of the hurricane from the nadir-staring camera on Global Hawk [*right*].

Of particular interest was the opportunity to examine Hurricane Karl, and its intensification over a 9–12-hour period as it moved across the Gulf of Mexico on September 16-17, 2010. On the flip side was the opportunity earlier in the month to examine ex-tropical storm Gaston, which was forecast to reintensify back into storm strength, but did not. What makes for such differences in storm dynamics is a key scientific focus of GRIP.

Clearly, field campaigns such as GRIP that measure great winds provide ample opportunity for headaches, but the operational successes and the potential for knowledge to arise from the data analyses cannot help but stir the imagination.

By the time GRIP assets stood down, all operational and scientific measurement goals had been achieved. Still to be performed are the data analyses, which should provide significant insight into tropical storm formation, growth, and development into full-blown hurricanes, or why some storms do not so develop.

Clearly, field campaigns such as GRIP that measure great winds provide ample opportunity for headaches, but the operational successes and the potential for knowledge to arise from the data analyses cannot help but stir the imagination.

Resources and Additional Reading

GRIP Home
grip.nsstc.nasa.gov/index.html

GRIP Software Tools
grip.nsstc.nasa.gov/tools.html

NASA's Hurricane Page
www.nasa.gov/mission_pages/hurricanes/main/index.html

National Hurricane Center
www.nhc.noaa.gov/

Acknowledgments:

My thanks to **Marilyn Vasques**, GRIP Project Manager, and **Ed Zipser**, a GRIP mission scientist, for their review and comments.

Make Plans Now to Attend the 34th International Symposium on Remote Sensing of Environment

Sydney Convention and Exhibition Centre, Sydney, Australia
April 10-15, 2011

The ISRSE provides a unique opportunity for remote sensing practitioners, scientists, system engineers and policy makers to share their knowledge and gain an excellent coverage of the current status of a range of remote sensing applications and developments now critical for the sustainability of the Earth's environment. More details will be forthcoming about NASA's involvement, but begin making plans now to join us in Sydney! For more detailed information, please visit: *www.isrse34.org/default.asp*.

Earth Observing One (EO-1) Celebrates 10 Years

Stephen Ungar, NASA Goddard Space Flight Center, stephen.g.ungar@nasa.gov
Daniel Mandl, NASA Goddard Space Flight Center, daniel.j.mandl@nasa.gov
Petya Campbell, University of Maryland Baltimore County, petya.k.campbell@nasa.gov
Elizabeth Middleton, NASA Goddard Space Flight Center, elizabeth.m.middleton@nasa.gov

Launched from Vandenburg Air Force Base on November 21, 2000, the E One (EO-1) satellite is the first Earth observing platform of NASA's New Program (NMP). The NMP developed new technologies and strategies fo ing the quality of observations for NASA's future planetary and Earth miss while reducing cost and development time. EO-1 launched with Satellite Aplicaciones Cientifico–C (SAC-C), an Argentine Earth observing satellit onboard a *Delta-II* rocket.

The EO-1 mission has proven to be highly successful in identifying technologies and techniques to be employed in future Earth observing missions. It has provided a testbed for refining specifications and expectations in the Landsat Data Continuity Mission (LDCM), and a powerful platform for investigating the power of using spaceborne spectral imaging to extract information about surface processes.

The initial EO-1 orbit was slightly to the east of Landsat-7, with an equatorial crossing time one minute later than that of Landsat-7. EO-1 passed over the same ground-track as Landsat-7, one minute later, allowing for direct comparisons with the Landsat-7 sensor system. EO-1's formation-flying capability provided the basis for establishing the first *constellation* of Earth observing satellites—consisting of Landsat, EO-1, SAC-C, and Terra. This *AM Constellation* demonstrated the use of multiple observing platforms to examine electromagnetic radiation along the same ground track with different swath widths and ranges of spatial and spectral resolutions.

The EO-1 satellite contains two primary observing instruments supported by a variety of newly developed space technologies. The Advanced Land Imager (ALI) is a prototype for the Landsat Data Continuity Mission (LDCM) Operational Land Imager (OLI). The Hyperion Imaging Spectrometer is the first high-spatial-resolution imaging spectrometer to orbit Earth and is a prototype for procedures and products for the future NASA Decadal Survey Hyperspectral Infrared Imager (HyspIRI) mission. Even after a decade of operations, Hyperion is still the only source of spaceborne imaging spectrometer data available to the general research community.

The entire EO-1 validation mission data-gathering phase was scheduled to last one year, with the satellite having a design life of less than two years. The *Accelerated Mission* and the *Basic Mission* comprised the first two operational phases of the EO-1 validation mission. The *Extended Mission* began in February 2002 with the transfer of acquisition planning and scheduling, as well as data processing and distribution responsibilities, to the U.S. Geological Survey (USGS) Earth Resources Observation Systems (EROS) data center. Subsequently, in 2008, Goddard Space Flight Center (GSFC) resumed full responsibility for acquisition planning and scheduling.

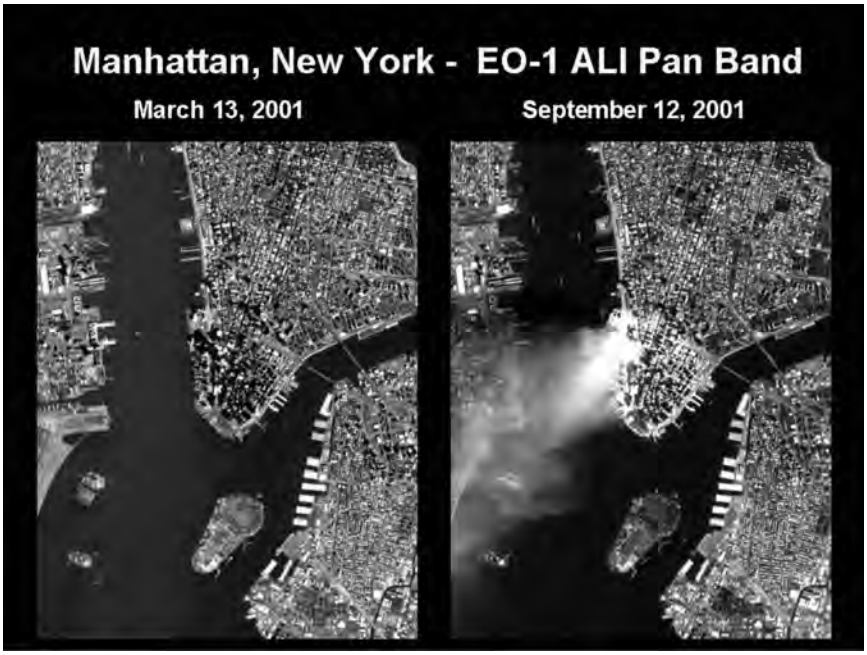
In response to many requests for data acquisitions beyond those collected for the validation activities, NASA decided to extend the mission, making the EO-1 resources available to the larger user community. The operational flexibility of the EO-1 satellite has presented opportunities for carrying on many unique experiments to help quantitatively analyze the performance of each of the instruments. Active illumination experiments, lunar views, planetary views, and stellar views have provided the ability to assess stray-light performance as well as the radiometric and geometric characteristics of ALI and Hyperion.

The EO-1 mission has proven to be highly successful in identifying technologies and techniques to be employed in future Earth-observing missions. It has provided a testbed for refining specifications and expectations in the LDCM, and a powerful platform for investigating the power of spaceborne spectral imaging to extract information about surface processes. Since EO-1 is pointable, it has proven to be a valuable tool for monitoring catastrophic events—see example on page 26. In addition,

the inherent band-to-band registration, due to the ALI chip design and platform yaw steering capability, facilitates the creation of pan-enhanced color composites.

From the onset, EO-1 has provided advanced technology capabilities, including extraordinary spacecraft agility, onboard intelligent processing, a variety of highly reliable support technologies, and unique passive optical imagery.

More than 50,000 images of targets all over the globe have been archived from each EO-1 instrument at EROS. Currently, 130-160 images are added to the archive each week. Hyperion data are being repetitively collected at established validation and calibration sites, in collaboration with the Committee on Earth Observing Satellites (CEOS), the Global Earth Observing System of Systems (GEOSS), and the International Spaceborne Imaging Spectroscopy Working Group (ISIS WG). EO-1's ALI scenes have routinely been collected to fill gaps in the missing Landsat-7 coverage, especially coral reef and atoll acquisitions, in support of NASA's Mid-Decadal Global Land Surveys. LDCM continues to rely on ALI as a testbed to resolve many questions regarding instrument and platform performance and calibration strategies. Researchers wishing to schedule acquisitions or order data acquired during all phases of the mission should access the EROS website at: *eo1.usgs.gov.*



The EO-1 Mission Science Office exploited EO-1 spacecraft's agility by commanding it to point to the World Trade Center on the next possible pass after the September 11, 2001 attacks. The March 13, 2001 image was drawn from the archive for comparative purposes.

The installation of onboard autonomic software onto EO-1 and the installation of ground-based Open Geospatial Consortium (OGC) SensorWeb Enablement (SWE)-compliant software have facilitated pathfinder experiments and/or demonstrations in the international disaster management community through the Group on Earth Observations (GEO) and CEOS. As a key component of the Global Flood Sensor Web Pilot, EO-1 was used extensively during the 2008 hurricane season by contributing observations to the USGS Hazards Data Distribution System (HDDS) for Hurricanes Fay, Gustav, Hannah, and Ike. EO-1 data are used by U.S. national and state disaster response agencies to improve situational awareness. Images of the flooding in Haiti were delivered to the Caribbean Disaster and Emergency Response Agency (CDERA) and were crucial to identifying the extent of the flooding in Gonaives. Going forward, the EO-1 team is leading the GEO Task—the Caribbean Flood Pilot—that will combine the use of satellite data with *in situ* measurements and local/regional infrastructure collections, in coordination with global providers and local emergency response/disaster management personnel.

The EO-1 mission has exceeded its primary goals to enable more-effective hardware and data strategies for Earth science orbital missions in the 21st century. From the onset, EO-1 has provided advanced technology capabilities, including extraordinary spacecraft agility, onboard intelligent processing, a variety of highly reliable support technologies, and unique passive optical imagery. Both the Hyperion and ALI have paved the way for future, essential Earth observing satellite missions, including LDCM planned for launch in 2012-2013, and HyspIRI. After 10 years, EO-1 is still fully functional and has enough fuel to last into 2012. After its fuel is expended, the mission can still continue data acquisitions, although the equatorial crossing time will begin to drift earlier than the current 10 AM mean local time. ■

Landsat Science Team Summary

Thomas R. Loveland, U.S. Geological Survey Earth Resources Observation and Science Center, loveland@usgs.gov
Thomas K. Maiersperger, SGT, Inc., USGS Earth Resources Observation and Science Center, tmaiersperger@usgs.gov
James R. Irons, NASA Goddard Space Flight Center, James.R.Irons@nasa.gov
Curtis E. Woodcock, Department of Geography and Environment, Boston University, curtis@bu.edu

Meeting Overview

The Landsat Science Team—sponsored by the U.S. Geological Survey (USGS) and NASA—met in Boise, ID, June 17–19, 2010. Landsat Science Team member **Rick Allen** [University of Idaho] and the staff of the Idaho Department of Water Resources hosted the meeting.

Tom Loveland and **Jim Irons** [USGS and NASA Goddard Space Flight Center (GSFC), respectively—*Landsat Science Team co-chairs*] opened the eighth meeting of the Landsat Science Team. They stated that the focus of the meeting was the review of Landsat and Landsat Data Continuity Mission (LDCM) status and the science and applications activities of the Landsat Science Team members. **Curtis Woodcock** [Boston University—*Landsat Science Team Leader*] added his perspective on the need to continue working toward operational status for the Landsat program. All presentations from the meeting are available at: *landsat.usgs.gov/science_june2010MeetingAgenda.php*.

Bryant Cramer [USGS—*Associate Director for Geography*] provided a summary of three recent Landsat events. First, he summarized USGS progress in developing the LDCM ground system. Because of budget issues, the ground system has been rescoped, redesigned, and rebudgeted, but it has not lost any functionality. The successful Critical Design Review is evidence of the positive impact of the ground system changes. Second, the recently released National Space Policy emphasizes the importance of operational land imaging and the importance of international cooperation. These emphases increase the importance of the technical and scientific discussions underway with the European Space Agency (ESA) on Sentinel-2 and LDCM operations compatibility. Cramer also noted that the operational land imaging element of the policy could be an important driver for Landsat 9 authorization. He stressed the importance of continuing Landsat as a science-driven mission, and he challenged the Landsat Science Team to define an acceptable risk of a data gap in an operational Landsat program (e.g., what is the cost of not having Landsat coverage for specific periods?). Finally, Cramer noted that the USGS is reorganizing: by fall, all programs will be aligned with science themes (i.e., climate variability and change, ecosystems, water, hazards, and energy and minerals) rather than disciplines.

Brad Doorn [NASA Headquarters—*Program Manager for Agriculture, Carbon, and Water Applications in the Applied Science Program*] followed with a NASA Headquarters perspective on Earth science and Earth observation. Doorn said that NASA is committed to a December 2012 LDCM launch. He also added that Cramer's push for Landsat 9 is important to all Earth science activities and that there was a need to better explain the benefits of links between Landsat observations and other Earth observation capabilities such as the Hyperspectral Infrared Imager (HyspIRI); Deformation, Ecosystems Structure and Dynamics of Ice (DESDynI); and Visible/Infrared Imager Radiometer Suite (VIIRS).

Landsat Updates and Related Reports

Kristi Kline [USGS—*Landsat Project Manager*] reported that Landsats 5 and 7 continue to add to the global archive. Due to recent problems with the Landsat 5 Traveling Wave Tube Amplifier (TWTA), a new collection schedule has been adopted using cloud avoidance and a 50% duty cycle. Collection schedules may change again in the future depending on TWTA status.

Rachel Headley [USGS—*Landsat Project*] provided status on the Landsat Global Archive Consolidation (LGAC). The goal of LGAC is to repatriate all internationally acquired Landsat data (estimated at over 3 million scenes) to the USGS archive. The USGS is engaged with the international ground stations and, as of June 2010, has repatriated 50,000 scenes.

Holly Miller, Natalie Sexton, and Lynne Koontz [all from USGS Fort Collins Science Center] presented survey results about users, uses, and the value of Landsat data in the U.S. Over 2,500 users responded to the survey, providing a rich dataset for trending and cost-benefit analysis.

Jeff Masek [GSFC—*LDCM Project Scientist*] summarized progress on the 2010 Global Land Survey (GLS). Acquisition of the required scenes is underway, with uniform processing of the GLS 2010 dataset planned for Spring 2011.

Noel Gorelick [Google.org] spoke about Landsat, cloud computing, and the *Google Earth Engine*.

Landsat Data Continuity Mission (LDCM) Status

Bill Ochs [GSFC—*LDCM Project Manager*] gave a detailed account of LDCM mission status and schedule. A successful Mission Critical Design Review (MCDR)

was conducted May 25-27. Operational Land Imager (OLI) hardware was moving toward integration and testing, and several important milestones were reported concerning the spacecraft build. In terms of schedule, total project funded reserve to launch stood at about six months, and the project remained committed to a December 2012 launch date.

Dennis Reuter [GSFC] reviewed progress on Thermal Infrared Sensor (TIRS) development. TIRS successfully completed a Critical Design Review (CDR) in April. All systems were meeting their requirements, and the schedule, while aggressive, was being met.

Dave Hair [USGS—*Acting LDCM Project Manager*] described significant progress on various elements of the Ground System (GS), leading up to a successful CDR in March. A series of Ground Readiness Tests (GRTs) were scheduled and underway. Hair reported sufficient budget and schedule reserve for successful GS development and implementation by the USGS.

John Schott [Rochester Institute of Technology] reported that the first simulated OLI images were being generated by the Digital Imaging and Remote Sensing Image Generation (DIRSIG) system, and that emphasis would be shifting to modeling of TIRS and other scene and sensor characteristics.

Idaho and Intermountain West Remote Sensing Activities

Nancy Glenn [Idaho State University], **Keith Weber** [Idaho State University], **Lee Vierling** [University of Idaho], **Alejandro Flores** [Boise State University], and **Brian Schwind** [U.S. Forest Service (USFS) Remote Sensing Applications Center (RSAC)] highlighted Landsat-related activities occurring in the meeting locale.

Science Team Member and Associates Presentations

Dennis Helder [South Dakota State University] described recent Landsat calibration activities. For Landsat 5, a relative gain update was derived to reduce striping. A Modulation Transfer Function (MTF) correction was presented that reduced blur in Landsat 4 imagery. Finally, Helder reported that with the recent completion of Multispectral Scanner (MSS) calibration, a consistent absolute radiometric calibration of all Landsat sensors had been accomplished.

Jeff Masek briefed the members on considerations for implementing an operational surface reflectance product for Landsat.

Eric Vermote [University of Maryland, College Park (UMCP)] provided an update of his work developing and evaluating Landsat atmospheric correction and cloud masking. Surface reflectance evaluation is ongoing through several independent efforts. The cloud-masking approach performs well, while cloud-shadow masking needs further investigation.

Feng Gao [Earth Resources Technology, Inc./GSFC] described results of a Landsat Advanced Very High Resolution Radiometer (AVHRR) data fusion study, and examined Landsat within-scene Bidirectional Reflectance Distribution Function (BRDF) effects. Landsat–AVHRR Normalized Difference Vegetation Index (NDVI) fusion products can be used to produce consistent phenological metrics, but AVHRR data quality is generally inferior to that from the Moderate Resolution Imaging Spectroradiometer (MODIS). Within-scene Landsat view angle effects were smaller than solar angle and seasonal phenology variations, but were significant enough to merit correction for some applications.

Lazaros Oreopoulos [GSFC] applied an approach developed for MODIS to a test set of Landsat scenes for discriminating between cloud, cloud shadow, vegetated land, non-vegetated land, water, and snow/ice. Cloud fraction estimates were similar to the Automated Cloud Cover Assessment (ACCA).

Rick Allen [University of Idaho] discussed several evapotranspiration (ET) investigations using Landsat. Satellite overpass frequency is a major factor in successful calculation of growing season ET. Probabilities for success were estimated at 80% (4-day return), 40–50% (8-day return), and 5% (16-day return). Allen also reviewed ET-based applications in water management, with emphasis on seven western states.

Martha Anderson [U.S. Department of Agriculture (USDA) Agricultural Research Service] presented results of data fusion approaches for ET mapping. MODIS–Landsat daily ET fusion appears feasible and can be optimized when MODIS and Landsat are flying in formation. Two or more Landsats collecting data continue to be a critical need. Consistent Leaf Area Index (LAI) products derived from MODIS and Landsat would also be valuable.

John Schott [RIT] spoke about LDCM's potential for monitoring inland and coastal waters. Schott demonstrated through modeling that improvements in OLI radiometry can reduce errors in estimating suspended material and organic matter concentrations by nearly a factor of four when compared to the Enhanced Thematic Mapper Plus (ETM+). The effects of over-water atmospheric corrections were also examined.

Bonnie Ruefenacht [USFS-RSAC] described a process for continental compositing of MODIS data and subsequent change detection to prioritize sketch mapping and aerial surveys for forest health applications.

Warren Cohen [USFS] surveyed the use of Landsat data in the U.S. Forest Service. The agency has a rich history of Landsat-based research and applications, including vegetation mapping, fire modeling, habitat studies, insect and disease risk mapping, disturbance monitoring, and forest inventory data integration. Landsat use has increased significantly over time and has now become a fundamental resource in meeting several agency requirements.

Randy Wynne [Virginia Tech] provided evidence that Landsat has become an essential tool for forest monitoring, modeling, and management. Analysis of data through time, including interannual chronosequences, has become increasingly routine. Landsat data also improve the precision and spatial specificity of ecosystem process models. State-of-the-art, Landsat-based decision-support tools are now feasible.

Jeff Masek presented a case study that used Landsat and other data to detect biome boundary shifts in Northern Quebec, Canada. Landsat, MODIS, and AVHRR data provided strong evidence for recent greening in the study area. The Landsat archive, when combined with other remote sensing and field data sources, provides the means for characterizing climate-driven shifts in global vegetation patterns.

Alan Belward [European Commission Joint Research Center] evaluated the impact of the GLS and USGS open archive policies on surveys of deforestation in the tropics. Belward concluded that open policies, archive depth, and robust products make Landsat the only viable means of measuring deforestation from the 1990 baseline to the present.

Sam Goward [UMCP] examined issues of cloud contamination and observation frequency in the context of operational monitoring of interannual land dynamics. Results suggested that for mid-latitude eastern North America, a daily overpass would be needed to yield near-weekly usable coverage.

Darrel Williams [Global Science & Technology, Inc.] introduced the Land Observations Globally in a Cost-effective Augmentation of Landsat (LOGICAL) concept. The general idea is that low-cost, small-satellite missions can be used effectively to augment Landsat's spatial and temporal coverage.

Jim Vogelmann [USGS] investigated Landsat image mosaics and composites from a user's perspective. Recommendations included generating monthly composites for predefined epochs, considering alternatives to maximum-value-based compositing, and extending current Landsat 7 approaches to include Landsat 5 and MSS data.

Curtis Woodcock described a Landsat–MODIS fusion method for monitoring land change in near-real time, which appears feasible at Landsat scale but depends on the use of every observation available, even scenes with a high degree of cloud cover. Woodcock finished by encouraging the group to be more systematic about providing a comprehensive history of the Earth's surface in the Landsat era and to keep moving toward real-time monitoring to better inform land management.

Mike Wulder [Canadian Forest Service] closed the meeting with the status on Landsat research and product development. Activities included feature-based change attribution, habitat modeling, fragmentation studies, long time-series analysis, and synthetic imaging. Composite and fusion products have advanced considerably, but further iterations are necessary to establish operational standard products that address community and policy needs.

Future Meetings

The next Landsat Science Team meeting will take place March 1–3, 2011 in Phoenix, AZ. The meeting will focus on LDCM development status and preparations for LDCM data use in 2013.

2010 CLARREO Science Team Meeting

Rosemary R. Baize, NASA Langley Research Center, Rosemary.R.Baize@nasa.gov
Amber Richards, Science Systems and Applications, Inc., Amber.L.Richards@nasa.gov
Debra Dajon, Science Systems and Applications, Inc., Debra.Dajon@nasa.gov
David F. Young, NASA Langley Research Center, David.F.Young@nasa.gov

A meeting of the Climate Absolute Radiance and Refractivity Observatory (CLARREO) Science Team was held from July 6-9 at the National Institute of Aerospace (NIA) in Hampton, VA. The meeting provided a forum to:

1. Share results from key science studies conducted during *Pre-Phase A*;
2. present mission options that the systems engineering team determined fit within the defined budget profile guidance and meet the required launch dates; and
3. discuss the development of a CLARREO science value framework that is being used to evaluate mission alternatives.

The meeting also was used to define a strategy for documenting these studies in upcoming journals. This was the final meeting of the *Pre-Phase A* "ad hoc" science team, which will be replaced by a formal, competitively selected Science Definition Team for *Phases A* and *B*. Approximately 90 attendees participated in the meeting, including representatives from NASA Headquarters (HQ) and the Earth Systematic Missions Program Office at Goddard Space Flight Center (GSFC). In addition, representatives from multiple NASA centers [e.g., GSFC, Langley Research Center (LaRC), and the Jet Propulsion Laboratory (JPL)]; other government agencies [e.g., National Oceanic and Atmospheric Administration (NOAA), National Institute of Standards and Technology (NIST)]; and academia [e.g., Harvard University, University of Wisconsin-Madison (UW), University of Colorado (LASP), University of California at Berkeley, and Imperial College (U.K.)]. Most presentations are posted on the CLARREO website: *clarreo.larc.nasa.gov*.

Workshop Introduction

Ken Jucks [NASA HQ—*CLARREO Program Scientist*] began the meeting by highlighting the importance of the CLARREO mission in the overall Earth Science (ES) portfolio. Jucks presented an overview of the Earth Science Flight Program as described in a recent NASA document[1]. The President's Fiscal Year 2011 budget request represents a sizeable increase in funding for the ES Program, enabling the acceleration of several critical missions, including CLARREO. The CLARREO mission included in this plan will have an initial launch readiness date (LRD) of 2017 for CLARREO-1, followed by a LRD of 2020 for CLARREO-2. CLARREO will be implemented within a defined cost constraint that supports the development of a scientifically viable mission.

Stephen Sandford [LaRC—*Mission Formulation Manager*] noted that the CLARREO Project is reformulating the mission in response to schedule and budget guidance released in early 2010. The project has been examining mission concepts that provide the most science within the schedule and budget constraints and remain aligned with the Decadal Survey vision. Key elements of the reformulated mission concept include:

- One spectrometer (either the infrared (IR) or reflected solar (RS)) and a Global Navigation Satellite System Radio Occultation (GNSS-RO) instrument flying on each observatory;
- observatories that are configured around a common spacecraft bus that accommodate either the IR or RS instrument; and
- smaller observatories that are compatible with a variety of launch vehicles (e.g., *Falcon 1e*, *Athena*, *Taurus XL*, and *Minotaur IV*).

The presented mission concept includes a 2017 launch that will include one observatory, followed by 2–3 observatories launched by 2020. Each will include a single IR or RS spectrometer along with GNSS-RO. CLARREO-1 and CLARREO-2 are both needed to achieve the full science objectives.

Dave Young [LaRC—*CLARREO Project Scientist*] reviewed the agenda and objectives, discussed expected outcomes of the meeting, and emphasized the importance of documenting the valuable work completed by the team during *Pre-Phase A*.

Bruce Wielicki [LaRC—*Mission Scientist*] reviewed the CLARREO science objectives and the derivation of requirements used in the mission formulation. CLARREO's primary objective is to make highly accurate and Système International d'Unités (SI)-traceable decadal change observations sensitive to the most critical, but least understood, climate radiative forcings, responses, and feedbacks. Wielicki outlined an overall approach for determining the accuracy required to detect decadal change trends and the associated time

[1] *Responding to the Challenge of Climate and Environmental Change: NASA's Plan for a Climate-Centric Architecture for Earth Observations and Applications from Space*, June 2010, *science.nasa.gov/media/medialibrary/2010/07/01/Climate_Architecture_Final.pdf*

to detect. A *perfect observing system* is only limited by natural variability and that sets a fundamental floor on the time to detect. As the observing system degrades in accuracy (e.g., measurement errors, sampling errors, etc.) relative to the perfect system, the time to detect will increase. The degradation in time to detect trends is only two-thirds of the amount of degradation in accuracy. Consequently, the CLARREO requirement is for climate change trend accuracy to be within 20% of a perfect observing system (in order to test climate predictions), and time to detect trends to be within 15% (to allow for societal decision making). This formulation represents a powerful method for rigorously defining the science, measurement, and mission requirements for CLARREO.

Eric Shirley [NIST Optical Technology Division] began with a discussion on the challenges associated with making accurate measurements and the role of national measurement institutes, like NIST. Shirley then reviewed specific NIST facilities/capabilities that are available to support CLARREO's testing needs [e.g., Primary Optical Watt Radiometer (POWR), Spectral Irradiance and Radiance Responsivity Calibrations using Uniform Sources (SIRCUS), Aperture Area Measuring Machine (AAMM), Hyperspectral Image Projector (HIP), and Controlled Background Spectroradiometry and Spectrophotometry System (CBS3)]. He concluded by stating NIST's commitment to supporting measurements relevant to climate studies.

Radio Occultation Science Studies

Stephen Leroy [Harvard University] described a new way to think about RO signals using a Hamiltonian formulation and an RO Topology Map. Leroy then discussed the Global Positioning System (GPS) signal architecture which includes codes that impose modulations (e.g., anti-spoofing, selective availability) that adversely impact retrievals. He recommended that CLARREO RO track L2C—the new frequency being used for civilian GPS measurements—using multiple code loops to preserve multi-signal amplitudes, and track deeper into the shadow region with a perpetual open loop. RO is a demonstrated benchmark in the 5–20 km region, but there is the possibility to extend the benchmark measurements into the lower troposphere with the changes mentioned above.

Tony Mannucci [JPL] discussed results of a February workshop at JPL to define requirements for the CLARREO RO instrument. Manucci then updated the attendees on the status of a new GNSS receiver [Tri-GNSS (TriG)] being developed at JPL for NASA HQ. He concluded with a discussion of the status of the Constellation Observing System for Meteorology Ionosphere and Climate (COSMIC) follow-on mission (LRD 2014).

Infrared Science Studies

Marty Mlynczak [LaRC—*CLARREO Deputy Project Scientist/IR Science Lead*] reviewed the IR agenda, and discussed the goals for the session.

Yi Huang [Harvard University] discussed an Observing System Simulation Experiment (OSSE) study [i.e., the Canadian Centre for Climate Modeling and Analysis (CCCMA) model with doubled carbon dioxide (CO_2) with MODerate resolution atmospheric TRANsmission (MODTRAN) code] of optimal fingerprinting to determine longwave forcing and feedbacks in all-sky conditions. Huang combined IR and GNSS-RO measurements to substantially reduce uncertainty in the derived trends in feedbacks of tropospheric temperature/water vapor, stratospheric temperature, and high clouds. Compared to the IR spectra-only case, the global mean errors were reduced by at least 50%.

Seiji Kato [LaRC] focused on detection of near-term changes (compared to doubled CO_2 conditions) using simulated CLARREO IR radiances derived from four years of observed cloud properties from the Moderate Resolution Imaging Spectroradiometer (MODIS) on Terra. The initial results are encouraging for separating the effects of global tropospheric/stratospheric temperature and humidity profile changes. However, additional work is required to improve agreement between the retrieved and truth values for cloud height and cloud fraction. Kato expects an improvement in the results when finer vertical resolution is used to compute the spectral kernels.

Xianglei Huang [University of Michigan] began with a discussion of some of the limitations of Global Circulation Models (GCMs). Huang then presented results from top-of-atmosphere (TOA) flux and cloud radiative forcing over each individual longwave absorption band from collocated Atmospheric Infrared Sounder (AIRS) and Clouds and the Earth's Radiant Energy System (CERES) measurements. The data show how spectral information can be uniquely valuable in evaluating GCM models.

Patrick Taylor [LaRC] evaluated model differences in seasonal feedback strengths. No seasonal variability was detected for global-mean seasonal contributions to the longwave (LW) feedbacks; however, differences were detected in the contributions to the shortwave (SW) feedbacks (i.e., surface albedo, cloud feedback). This finding has implications for how GCM responses should be used to investigate the CLARREO SW observations.

Dave Tobin [University of Wisconsin-Madison] presented results showing that CLARREO will be capable of performing reference intercalibration with uncertainty comparable to the CLARREO radiometric

accuracy. Tobin then briefly summarized the radiometric performance of the Cross-track Infrared Sounder (CrIS) Flight Model One (FM-1) instrument on the NPOESS Preparatory Project (NPP)[2]. This is the type of high-spectral-resolution sounder that will be on-orbit when CLARREO is launched. Finally, he showed results from the Infrared Atmospheric Sounding Interferometer (IASI) on the European Organisation for the Exploitation of Meteorological Satellite's (EUMETSAT) METOP satellite, and from AIRS simultaneous nadir overpasses (SNOs), which show good overall agreement. The main disagreement in the results is due to spatial sampling differences.

Richard Bantges [Imperial College, U.K.] presented modeled *clear-sky* IR variability from the European Center for Medium Range Weather Forecasting (ECMWF) Re-analyses [ERA] interim re-analyses. This work suggests that the CLARREO three-year mission lifetime may not be sufficient to fully sample natural variability (i.e., El Niño–Southern Oscillation records suggest five years is required). Bantges also presented clear-sky spectral signatures from the Infrared Interferometer Spectrometer (IRIS) on the Voyager spacecraft, Interferometric Monitor for Greenhouse Gases (IMG) on the short-lived Japanese Advanced Earth Observing Satellite (ADEOS), and AIRS on Aqua. The re-analysis of these datasets will be useful in simulating historical outgoing longwave radiation (OLR) measurements and eventually extending the re-analysis into the far-IR where there are currently no observations.

John Dykema [Harvard University] stressed the importance of the ongoing conversation within the remote sensing community to formulate a framework for testing uncertainty. If there is no SI-traceable on-orbit standard, then time can become an issue (i.e., owing to sensor drift, aging, atomic oxygen effects, etc.). If an SI-traceable on-orbit standard exists, time becomes a beneficial factor. Dykema then highlighted progress on on-orbit test/verification modules under UW and Harvard Instrument Incubator Program (IIP) activities.

Dan Kirk–Davidoff [University of Maryland] presented results that showed that highly accurate sampling of 15° x 15° regions of annual (or 3-month) mean brightness temperature is possible with two nadir-viewing satellites. For a single satellite the sampling errors increase—although not in all grid squares. A single satellite is sufficient for global-mean trend detection.

Hank Revercomb [University of Wisconsin-Madison] highlighted the importance of decades of progress in calibrated Fourier Transform Infrared (FTIR) instrument development (i.e., HIS, Atmospheric Emitted Radiance Interferometer (AERI), Scanning HIS, AIRS, IASI, and CrIS) and calibration. This knowledge, combined with new developments for CLARREO, make it a realistic goal to achieve <0.1 k=3. He reviewed the status of development efforts for key elements of CLARREO's on-orbit radiance verification system (i.e., on-orbit temperature calibration based on small phase change cells, and for emissivity measurements using the heated halo approach).

Marty Mlynczak began by reviewing the requirements for the IR instrument and major factors driving calibration. Radiometric modeling efforts conducted by three separate organizations show that the CLARREO accuracy requirements can be met. Next, he reviewed the design for the re-scoped IR instrument (mass: 76 kg, power: 124 W) which can be accommodated on a *Falcon 1e* launch vehicle. Mlynczak concluded by discussing plans to mature the instrument design (i.e., *breadboard* development, UW/Harvard/LaRC IIPs) in *Phase A,* and NIST's planned support of calibration activities.

Reflected Solar Science Studies

Kurt Thome [GSFC—*CLARREO Deputy Project Scientist/RS Science Lead*] reviewed the RS agenda and discussed the goals for the session.

Bill Collins [University of California-Berkeley] discussed the progress made in developing a SW OSSE, which outputs both clear-sky and all-sky spectral radiances. The initial results showed dramatic differences between forced and unforced (2090s–2000s Community Climate System Model (CCSM) scenario) reflectance spectra due to changes in sea ice, stratus clouds, and a shifting Intertropical Convergence Zone (ITCZ).

Zhonghai Jin [Science Systems and Applications, Inc.] introduced the concept of reflected solar *spectral kernels* [*Soden*, 2008] and their potential application to CLARREO solar benchmark measurements. Comparisons of monthly global mean reflectance anomalies using the kernel approach with observations from the ESA's Scanning Imaging Absorption Spectrometer for Atmospheric Cartography (SCIAMACHY) on ENVISAT showed good overall agreement. Analysis of interannual variability based on the kernels showed that the cloud amount and optical depth are the two most important factors responsible for the interannual variation of solar reflectance. Finally, Jin demonstrated the robustness of this approach by introducing small errors in sampling and kernel shape.

Kurt Thome [GSFC] presented an overview of the Traceable Radiometry to Underpin Terrestrial- and Helio-Studies (TRUTHS) instrument on behalf of **Nigel Fox**

[2] NPOESS stood for the National Polar-orbiting Operational Environmental Satellite System. The project has been reorganized into the Joint Polar Satellite System (JPSS). The name of the precursor, risk-reduction mission, NPP, has remained the same.

[National Physical Laboratory (NPL)]. The TRUTHS concept provides direct traceability in-flight to a primary standard-Cryogenic Solar Absolute Radiometer [Earth/Moon reflected spectral radiance 0.3%, 2 σ]. TRUTHS is complementary to CLARREO; together they can provide an international benchmark climate and calibration constellation.

Constantine Lukashin [LaRC] demonstrated that for the mission baseline concept all reference intercalibration (RI) goals are achievable based on sampling studies (assuming two-dimensional angular matching). The CLARREO RS instrument is in a polar 90° orbit that provides adequate sampling for monthly, seasonal, and annual intercalibration of the cross-track sensors on the JPSS as well as METOP. It is important to note, however, that polarization distribution models will be required to determine the sensitivity to polarization of the sensor being calibrated.

Dave Doelling [LaRC] noted that the time required to detect a significant climate trend depends upon four factors: natural variability, magnitude of the climate trend, calibration error, and sampling error [*Leroy*, 2008]. Using an approach outlined by Leroy, a goal is set to have the *sampling error ratio* (i.e., $\sigma_{sampling}/\sigma_{var}$) < 70%. Given this target, one polar 90° orbit satellite provides sufficient IR sampling (~25% sampling error ratio) for the zonal annual case. In comparison, one polar 90° orbit satellite just meets the required reflected solar sampling (~70% sampling error ratio) for the zonal annual case. The RS results improve slightly for a sun-synchronous orbit.

Dave Young [LaRC] discussed the process the CLARREO project followed to determine whether or not to recommend to NASA HQ the addition of an Aerosol Polarimetry Sensor (APS) as part of the CLARREO mission. Representatives from the Goddard Institute of Space Studies (GISS) submitted a *white paper* describing how the APS would augment CLARREO science; this paper was then reviewed by a panel of independent experts. Based on their inputs, NASA HQ determined that while there was a critical need for sustained direct aerosol radiative forcing measurements, it was not necessary to have the APS on the CLARREO platform. The CLARREO science was deemed to be compelling (e.g., infrared radiance, solar-reflected radiance, and GPS RO measurements) but that inclusion of the APS would result in increased mission costs and complexity.

Kurt Thome [GSFC] presented charts on behalf of **Greg Kopp** [LASP] and **Nigel Fox** [NPL] discussing different approaches for applying SI traceability to the RS instrument. Thome reviewed capabilities at NIST (e.g., SIRCUS and HIP) and how they will support highly accurate ground calibration. Key issues associated with establishing SI traceability of the CLARREO RS instrument at 0.3% absolute uncertainty include proof of transfer from ground calibration to orbit, attenuator characterization, and stray light.

Kurt Thome began by reviewing the requirements for the RS instrument. He then briefed the rescoped RS instrument design, which consists of a two-box spectrometer (mass: 87 kg; power: 97 W average) and can be accommodated on a *Falcon 1e* launch vehicle. Thome discussed the calibration approach and reviewed the error budget, which shows that the radiometric calibration requirements of the RS instrument can be met with currently available approaches. He concluded by discussing plans to mature the instrument design (i.e., *breadboard* development) in *Phase A* and NIST's planned support of calibration activities (i.e., detector-based transfer radiometers, SIRCUS, HIP).

Bruce Wielicki [LaRC] introduced an approach for determining the science value of a given CLARREO science objective based on five factors: science impact, trend accuracy, record length, verification, and risk. Key climate variables were assigned a *science impact weighting factor* proportional to their respective modeling uncertainties [IPCC 2007]. The *trend accuracy* was defined relative to *perfect climate observing* (discussed in Wielecki's earlier presentation) and includes the effects of errors in calibration, orbit sampling, and instrument noise. The *record length* was dependent upon launch vehicle, spacecraft, and instrument reliability, plus the number of launches for each type of instrument. The *verification factor* was determined via a simple relationship based on the likelihood of overlap between instruments on-orbit. Finally, the engineering team specified the *risk factor* based on currently assessed launch vehicle, spacecraft, and instrument risks which are roughly equal between the IR and RS observatories. Wielicki solicited feedback from the team on the components of the matrix and the relative weighting factors. This framework has been developed as an objective method for evaluating the cost and benefit of potential mission trades. The framework will be refined in *Phase A* and used as a management tool during the development phases of CLARREO.

Mission Options

On the final day of the meeting, **Marty Mlynczak**, **Kurt Thome**, and **Stephen Leroy** thanked the presenters and summarized the main points from each of their respective sessions.

Jim Corliss [LaRC—*CLARREO Chief Engineer*] reviewed the mission design strategy developed in response to the revised cost/schedule guidance provided by NASA HQ. The strategy incorporated smaller, single-

continued on page 38

NASA LCLUC/GOFC–GOLD/NEESPI International Regional Meeting on Boreal and Temperate Europe

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

The NASA Land-Cover/Land-Use Change (LCLUC) Science Team Meeting was held jointly with the Global Observation of Forest and Land Cover Dynamics (GOFC–GOLD) Northern Eurasia Regional Information Network (NERIN) and the Northern Eurasia Earth Science Partnership Initiative (NEESPI) in Tartu, Estonia from August 25-28, 2010. Hosted by the Tartu Observatory, with contributions from the Global Change System for Analysis, Research and Training Program (START), ScanEx Research and Development Center, and NASA, more than 80 participants representing 14 nations in and around the Baltic region attended. The meeting provided an opportunity for scientists to present and discuss their research on monitoring processes related to land-cover and land-use change in boreal and temperate regions of Central, Eastern, and Northern Europe. Directly preceding the meeting (August 21-23), a training session on *Quantitative Research Methods in Human Dimensions of Environmental Change within Eastern Europe* took place that Vidzeme University in Valmiera, Latvia hosted. Detailed information on the meeting and training session, including presentations and posters is available on the LCLUC website: *lcluc.umd.edu/meetings.php?mid=15*.

Forests and other biomes in boreal and temperate zones comprise about a half of the world's vegetation cover. Boreal and temperate countries are primarily composed of forests and agricultural lands. Political and socioeconomic change in these countries over the last few decades has led to changes in a number of land-use practices. To address processes in these ecosystems related to land-cover/land-use change and climate interactions, the Science Team Meeting was organized around three themes:

1. changes in ecosystems, their composition, and structure;
2. carbon and water cycle; and
3. human dimensions of land-cover and land-use change.

The overall goal of the meeting was to review research being undertaken by NASA and regional scientists on these topic areas and discuss the availability of satel-

lite data, products, approaches, and concepts for land monitoring in boreal and temperate ecosystems of Europe. Additionally, the meeting considered requirements for land-cover and land-use change characterization that address the needs of users in these regions and the community of scientists working on regional environmental issues.

Opening Remarks

Anu Reinart [Tartu Observatory—*Director*] and **Tõnis Lukas** [Minister of Education and Science] began the meeting with an introduction describing the extensive strides that remote sensing has made in understanding Earth's systems and the various possibilities for the future of this discipline. Lukas pointed out the important role of satellite technology in understanding global and climate change, and the importance of scientific exchange. **Chris Justice** [University of Maryland—*LCLUC Program Scientist*] described the role of remote sensing in land-change science, highlighting the need to examine the relationship between both human and environmental elements, including how the various changes in economic conditions, demographics, climate, and politics interact.

International and National Program Presentations

Garik Gutman [NASA Headquarters—*LCLUC Program Manager*] provided an update on the NASA LCLUC and NEESPI programs, highlighting the expanding program focus from forests to urbanization and agriculture. Gutman explained how NASA's global observations and data acquisition can help strengthen regional science and how regional science networks, with strong local expertise can strengthen global research programs. He emphasized one of the goals of the meeting—to improve regional and international networking in interdisciplinary Earth science research within Eastern Europe and the Baltic Sea region.

Olga Krankina [GOFC–GOLD/Oregon State University—*Regional Network Coordinator*] gave an overview of the international GOFC–GOLD program, stressing the importance of regional networks and their roles in providing the interface between global observations and data users in the region. Krankina stated that the primary roles of the regional networks include:

- Articulating and documenting regional Earth observation requirements;
- evaluating the utility of global satellite products for regional use;
- facilitating the use of remotely sensed data and products; and
- promoting lateral transfer of technology and collaborations within countries and regions.

Krankina emphasized the importance of defining requirements for land-cover and land-use characterization that address the needs of users working on regional environmental issues; exploring opportunities for coordination and collaboration among research teams; and ongoing projects for improved understanding of land-use and ecosystem change in boreal and temperate zones as well as their underlying processes and impacts.

Matti Mõttus [University of Helsinki—*Tartu Local Host Representative*] gave a brief description of LCLUC-related projects at Tartu Observatory, ranging from point measurements, to national, regional, and global studies. Of the 25 projects currently underway at the observatory, 15 are related to LCLUC. **Marcus Reckerman** [GKSS Research Centre—*International Baltic Sea Experiment (BALTEX) Secretariat*] provided an overview of the BALTEX program, working toward the development of comprehensive coupled regional models for the atmosphere, the land surface (including rivers and lakes), and the Baltic Sea (including sea ice), and capabilities for realistically modeling the water and energy cycles of the Baltic Sea basin. The program provides an arena for collaboration of more than 50 organizations and a steering group with representatives from all 14 countries in the region, producing frequent publications, program updates, and project reports.

National Overviews

The first day of the meeting also featured national overviews from countries throughout the region.

Urmas Peterson [Estonian University of Life Sciences] described how the regional land management practices in Estonia range from conservative to innovative methods, and how conservation and preservation of forests and natural landscape are fundamental values for the region. **Ilmars Krampis** [University of Latvia] provided an overview of the current land-cover and land-use research in Latvia, including the European Commission (EC) CORINE land-cover project, national forest statistical inventory project, the Forestry Geographic Information Systems (GIS) project, and the Global Forest Monitoring (GFM) project. **Sergey Bartalev** [Space Research Institute, Russian Academy of Science] gave an overview of land-use and land-cover monitoring in Russia, showing recent work using the Moderate Resolution Imaging Spectroradiometer (MODIS) to develop regional burnt area-, arable land-, and crop-cover-classification maps for the country.

Přemysl Štych [Charles University—Prague, Czech Republic] explained that there had been a modest governmental contribution to remote sensing and land-cover and land-use monitoring in the Czech Republic. Charles University has recently embarked on a program

A national panel on research priorities convened during the meeting and included [*from left to right*] **Sergey Bartalev**, **Anu Reinart**, **Tuomas Häme**, **Eva Konkoly Gyuró**, and **Premysl Stych**.

of land-use change research, through analysis using the CORINE database, from 1990, and the Land-use Land-Cover Change (LUCC) Czechia database dating back to 1845. Štych emphasized the importance of social driving forces, considering that restitution, transformation, and redistribution of land have all been key to recent changes in the Czech landscape.

Ivan Barker [Forest Research Institute—Slovak Republic] showed how historical land use in the Slovak Republic had resulted in poor aggregation of agricultural lands that are increasingly abandoned because of poor accessibility, steep slopes, inferior soil quality, and urban migration. **Tuomas Hame** [Finnish Forest Research Institute] discussed the VTT Technical Research Centre in Finland, the largest multi-technology applied research organization in Northern Europe, conducting remote sensing research since 1973 as a non-profit organization collaborating with governmental institutions, private organizations, and local universities. **Éva Konkoly-Gyuró** [University of West Hungary] highlighted a study using the CORINE database for land-cover mapping, comparing the Corine Land Cover (CLC) 50 to CLC 100 parameters and their utility in various analyses, including climatic effects, migration of species, and the biogeographic characteristics for Europe, including the Carpathian region.

Remote Sensing of Natural Ecosystems

A primary focus of this meeting was to improve the understanding of remote sensing technologies and to highlight current research on natural ecosystems. **Tiit Nilson** [Estonia Academy of Sciences] began the session with a discussion of the theoretical basis for monitoring vegetation, focusing on the contributions of Tartu scientists towards the understanding of radiative transfer through turbid media. **Curtis Woodcock** [Boston University—*Landsat Science Team* and GOFC–GOLD *Land-cover Co-Chair*] presented an overview of contemporary methods and their applications for boreal and temperate forest monitoring. Woodcock highlighted various research projects focused on biome boundary shifts, affirming, "The Landsat archive, when combined with other remotely sensed and field data sources, provides a critical tool for characterizing climate-driven shifts in global vegetation patterns."

Fernando Sedano [Joint Research Centre (JRC)—European Commission] discussed the methodology and results of the new JRC Pan-European Forest Type Map for 2006. The map provides data for regional analysis, and is valuable for policy makers, trans-boundary studies, as an input for large-scale modeling and fine spatial detail, and as a basis for deriving value-added products. This JRC product has been found to have 88% accuracy. It is available at the European Commission JRC website (*forest.jrc.ec.europa.eu/forestmap-download*)**.**

Terhikki Manninen [Finnish Meteorological Institute] gave a brief summary of field experiments and ground-truthing remote sensing research in Northern Europe, exposing the difficulties associated with cooler climates and significant snowfall. Specifically, Manninen presented results from the Snow Reflectance Transition Experiment (SNORTEX) campaign in Northern Finland that is directed at studying albedo changes of forested snow-covered areas under various conditions.

Olga Krankina [Oregon State University] and **Pekka Kauppi** [University of Helsinki] provided an overview of modeling forest productivity and carbon cycling under climate change and disturbance. Kauppi revealed that, spatially, deforestation has decelerated and forest seques-

tration has improved, and that changing forest management has been the dominant driver of these "transitions." Both Kauppi and Krankina agreed that current and future monitoring needs to focus on stem-size distribution to improve the understanding of global forest systems.

Human Dimensions of LCLUC

Pekka Kauppi and **Alexander Maslov** [ScanEx Research and Development Center, Institute of Forest Science of the Russian Academy of Sciences] gave an overview of forest exploitation in the Baltics and Northwestern Russia. They showed that forest carbon has expanded in all European Union (EU) countries except Estonia, as the forests are recovering from degradation—in Estonia, logging has been increasing leading to increased degradation. They showed that forest stocks in Finland have more than doubled in the last 90 years, highlighting the role of environment and management regime changes in forest transitions.

The meeting included a land-use field trip to a sphagnum bog in Northern Estonia.

Kirsten DeBeurs [University of Oklahoma] presented her research using multi-scale trend analysis to evaluate climatic and anthropogenic effects on the vegetated land surface in Russia. Using data from the last two decades, DeBeurs showed the relationship between increasing temperature, increasing productivity, and longer growing seasons. Using MODIS data, she also showed that since 2000 there has been decreasing vegetation productivity associated with climatic related disturbances—e.g., fires, droughts, and insect invasions.

Grigory Ioffe [Radford University] discussed transformations in Russian agriculture, highlighting the contraction of farmland, population migration, and landscape fragmentation in Russia in general—but emphasizing considerable regional diversity. **Tobias Kuemmerle** [University of Wisconsin-Madison] presented his work exploring the socioeconomic transformations and land-use change patterns and processes in Central and Eastern Europe. He explained that LCLUC is not always gradual; at times it can be rapid and drastic, as is the case for Eastern Europe, due to the collapse of socialism leading to farmland abandonment, logging, and areas of forest regeneration in the region. Kuemmerle found that land abandonment in the region has mainly been driven by marginality of farming and is often mediated by institutional factors. Logging rates were shown to be associated with the strength of institutions and land ownership patterns. However, there is large variability of land use within and among countries of the Baltic region across spatial scales.

A panel discussion was held on regional research issues and priorities; summaries of the discussion can be found at: *lcluc.umd.edu/meetings.php?mid=15*. Although different countries identified specific priorities, a number of common themes emerged. In this region there is a strong emphasis on the application of satellite data to pressing problems of societal relevance and an increasing awareness by national governments of the potential role of land remote sensing. Several countries have limited capacity for using satellite data for science research and applications. There is a need for increasing investment in research infrastructure and a number of countries are looking for international cooperation. Global processes are driving national land-use change, and in the EU countries, agricultural and land-management policies are strongly influencing land use.

Differences between EU and non-EU countries exist in the extent of land abandonment, rural depopulation, permanence, monitoring, reporting, and impacts. In Russia, attention is focused on monitoring forests, agriculture, and peatlands, with particular attention to logging, changes in cropland, and peat mining. Finland makes extensive use of fine-resolution data for forest monitoring, with an emphasis on research into automated techniques and data fusion (using data in the optical and microwave regions). There is considerable

interest in the capabilities of the next-generation sensors from NASA and the European Space Agency (ESA) and their potential synergy.

Closing Remarks

Chris Justice concluded the meeting with a summary of primary workshop deliberations with which to move forward toward planning and execution of regional goals. A major theme from the meeting was the abandonment of agricultural lands and the growth of urban areas. Although well recognized as a process within the region, an accurate and spatially explicit accounting of the extent of land abandonment through automated methods is of considerable interest. The causes of the abandonment are being studied, but relatively little work to date has been undertaken on the impacts of this type of land-use change on carbon cycle, water cycle, and livelihoods.

One possible means to improve research on ecosystem disturbance, climatic forest transitions, and agricultural abandonment would be to conduct a data validation campaign in the area. This would help to harmonize the various data products so they could be more effectively used to monitor forest change over the entire region. In addition, the investigation of pattern to process "drivers" is essential, as is understanding the role of national and international policies on land-use change, and differences between EU and non-EU states with respect to environments, socioeconomic conditions, and strengths of institutions.

There is a need for continued basic remote sensing research on forest structure, peatlands, wetlands extent and change, and agriculture land-use change and production. Justice emphasized the need for data fusion with new technologies and next generation sensing systems. He finished by stressing the importance of collaboration, education, and outreach to enhance regional research, international collaboration, and institutional strength for the discipline and the region. ■

2010 CLARREO Science Team Meeting

continued from page 33

spectrometer observatories that would be compatible with lower-cost launch vehicles (e.g., *Falcon 1e* and *Minotaur*). It also took advantage of block buys (e.g., common spacecraft bus and launch vehicle) to reduce costs. The reformulated mission design achieves the science objectives within the budget and schedule constraints.

Stephen Sandford [LaRC] finished the agenda with a discussion of potential partnering opportunities for CLARREO.

Dave Young [LaRC] wrapped up the meeting by thanking the attendees for the quality of the presentations and discussions during the four-day meeting, as well as for their valuable contributions during *Pre-Phase A*. He discussed plans for writing a *Pre-Phase A* science status report that will be used to document the science studies performed to date.

The meeting was a success and achieved all of its objectives. The CLARREO science has matured sufficiently to provide well-defined science objectives and mission requirements for the upcoming Mission Concept Review (MCR) on November 17, 2010.

References

IPCC, 2007. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp.

Leroy, S.S., Anderson, J.G., and G. Ohring. 2008. Climate signal detection times and constraints on climate benchmark accuracy requirements. *J. Climate,* **21**, 841–846. [*journals.ametsoc.org/doi/abs/10.1175/2007JCLI1946.1*]

Soden, B.J., Held, I.M., Colman, R., Shell, K.M., Kiehl, J.T., and C.A. Shields. 2008. "Quantifying Climate Feedbacks Using Radiative Kernels", *J. Climate.* 21, (14): 3504. ■

HDF/HDF-EOS Workshop Summary

Daniel Marinelli, NASA Goddard Space Flight Center, daniel.j.marinelli@nasa.gov

The 14th Hierarchical Data Format (HDF) and HDF for the Earth Observing System (HDF-EOS) Workshop was held September 28-30, 2010, in Champaign, IL—the home of the HDF Group. Sixty people with varied interests attended; among them were data users, data producers, and software tool developers. This year's theme was, *Improving Workflows that Use HDF Data*.

The agenda, with presentations and posters for all three days, can be found at: *hdfeos.org/workshops/ws14/workshop_fourteen.php*.

The first day of the meeting was dedicated to tutorials sessions. From the HDF Group (THG), **Mike McGreevy**, **Neil Fortner**, and **Peter Cao** provided in-depth information on all aspects of *version 5* of HDF (HDF5). The tutorial sessions focused on HDF5 data and programming models, advanced HDF5 features, and HDF5 tools.

Online help for HDF5 tools can be found at: *www.hdfgroup.org/hdf5tools.html*.

After breaking for lunch, the group toured the National Petascale Computing Facility. This facility will be home to the *Blue Waters* sustained petascale supercomputer. The building has been designed to efficiently use resources, thus lowering the cost of operating the facility. More information can be found at: *www.ncsa.illinois.edu*.

Abe Taaheri [Raytheon] gave an overview and demonstration of the HDF-EOS to *GeoTIFF* (HEG) conversion tool and the HDF-EOS plug-in library extension to *HDFView*. The HEG tool converts, subsets, resamples, and performs mosaicing on HDF-EOS data as it is converted to *GeoTIFF*. The HDF-EOS plug-in is a library that extends *HDFView*, a visual tool for browsing and editing HDF *version 4* (HDF4) and HDF5 files, for EOS applications. Information on the plug-in can be found at:

newsroom.gsfc.nasa.gov/sdptoolkit/HDFView/HDFView_hdfeos_plugin.html,

and information on the HEG tool can be found at:

newsroom.gsfc.nasa.gov/sdptoolkit/HEG/HEGHome.html.

Kent Yang [THG] provided an overview of the data access examples located in the *HDF Zoo* at: *hdfeos.org/zoo/*.

Users are encouraged to give feedback on these examples through the forum at: *hdfeos.org/forums* or via email to: *eoshelp@hdfgroup.org.*

Yang then presented a description and demonstration of HDF4 and HDF5 handlers for the Open-source Project for a Network Data Access Protocol (OPeNDAP). Examples can be found at: *hdfeos.org/zoo/hdf4_handler/* and *hdfeos.org/zoo/hdf5_handler/*.

Ed Hartnett [Unidata] presented some history and the current state of Network Common Data Form (netCDF). Hartnett described the capabilities of the newest version—*netCDF 4.1* as well as related tools and future 'aspirations'. Please visit the presentation materials referenced earlier to see if you would be interested in collaborating with Hartnett and the netCDF team on some of their future goals.

The first day wrapped up with **Albert Cheng** [HDF] providing an overview of *Parallel HDF5* with examples, tools, and performance tips.

The highlight of the second day was a keynote presentation by **Mike Folk** [HDF] called *HDF: Past, Present and Future*. From its germination at the University of Illinois at Urbana/Champaign (UIUC) National Center for Supercomputing Applications (NCSA) in 1986 to the present, the concept of HDF has continued to grow. Since the HDF Group separated from the UIUC in 2006, the number of funding projects has grown from 6 to 13, and the number of employees has doubled. Future plans are to work towards making the fledgling organization into a self-sustaining not-for-profit business while keeping to its goal of ensuring long-term accessibility of HDF data through sustainable development and support of HDF technologies.

The remainder of the morning's presentations focused on status updates for HDF and HDF-EOS development and the results of NASA's Earth Observing System Data and Information System (EOSDIS) User Survey for 2009, as well as changes made for the 2010 survey (ongoing at the time of the workshop).

The afternoon presentations consisted of talks on a variety of subjects of interest to our community, including *lightning* talks, and concluded with a roundtable discussion of data interoperability in the aspects of format, content/semantics, and issues with HDF5/*netCDF4* library interoperability.

During the morning of the final day, talks were dedicated to vendors from Environmental Systems Research Institute (ESRI) who described the current status of ArcGIS; ITT Visualization and Information Systems (ITTVIS) who described the current status of Interactive

continued on page 45

CERES Science Team Meeting Summary

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

The Fall 2010 meeting of the Clouds and the Earth's Radiant Energy System (CERES) Science Team was held jointly with the Geostationary Earth Radiation Budget (GERB) Science Team and the Scanner for Radiation Budget (ScaRaB) Science Team from September 13-16, 2010, at L'École Normale Supérieure (ENS) in Paris, France. **Norman Loeb** [NASA Langley Research Center (LaRC)—*CERES Principal Investigator*], **Remy Roca** [Laboratoire de Météorologie Dynamique (LMD)—*ScaRaB Principal Investigator*], and **Jacqueline Russell** [Imperial College—London, U.K.—*GERB Project Scientist*] convened the meeting. The major objective of the meeting was to bring the Earth radiation budget observation and modeling communities together to facilitate the exchange of information and ideas on this important area of Earth science. The agenda consisted of two parts: presentations from each of the three instrument teams on instrument, algorithm, and validation status; and invited and contributed science presentations.

Norman Loeb presented an overview and status of CERES, NASA, the Earth Observing System (EOS), Senior Reviews, the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project [NPP] and Joint Polar Satellite System (JPSS), and CERES *Edition 3* status. He gave an overview of the CERES project structure, data processing flow and data products, and discussed plans for CERES on NPP and JPSS Charlie 1 (C1). In addition, he revisited the CERES organization and working group leads, and gave an update on CERES *Edition 3* processing strategy. Loeb discussed a re-prioritization of CERES *Edition 3* data products due to delays in implementing the full suite of planned algorithm improvements for Level 1–3. He announced plans for an alternate *Edition 3* processing strategy comprised of a scaled-down version of *Edition 3* that includes only a subset of the algorithm improvements proposed in the 2009 Senior Review, and utilizes existing inputs that are "ready-to-go" now [e.g., Meteorology, Ozone, and Aerosol (MOA) dataset, Moderate Resolution Imaging Spectroradiometer (MODIS) dataset, gridded geostationary narrowband radiances (GGEO) dataset, and the Model for Atmospheric Transport and Chemistry (MATCH) dataset]. Loeb concluded with updates on the Afternoon Satellite Constellation (*A-Train*) and the National Science Foundation (NSF) Decadal Survey.

Kory Priestley [LaRC] gave an overview and update of the CERES Instrument Working Group, status reports on CERES Flight Model (FM) 1-6, and *Edition 3* calibration results. CERES on Terra and Aqua continue to operate nominally, and when combined with the CERES on the Tropical Rainfall Measuring Mission (TRMM), the instrument has a total of over 39 instrument-years of data collected. Instrument integration and the 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 unavailability of funding 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 the National Oceanic and Atmospheric Administration (NOAA) on strategies for implementing these improvements are ongoing.

CERES/GERB/ScaRaB Science Team meeting participants

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

- **Susan Thomas** [LaRC/Science Systems and Applications, Inc. (SSAI)] gave an update on CERES *Edition 3* calibration.
- **Patrick Minnis** [LaRC] reported on *Edition 4* cloud algorithm properties.
- **Shashi Gupta** [LaRC/SSAI] reported on recent improvements in CERES Surface-Only Flux Algorithms (SOFA).
- **Thomas Charlock** [LaRC] shared recent developments in Surface and Atmosphere Radiation Budget (SARB) calculations.
- **David Doelling** [LaRC] reported on Time Interpolation and Spatial Averaging (TISA) activities.
- **Moguo Sun** [LaRC/SSAI] reported on International Satellite Cloud Climatology Project (ISCCP) D2-like product updates.
- **Jonathan Gleason** [LaRC] reported on the activities of the CERES Data Management Team.
- **Susan Sorlie** [LaRC/SSAI] gave an update on the Atmospheric Science Data Center (ASDC).
- **Norman Loeb** spoke on behalf of **Lin Chambers** [both from LaRC] with an update on Students' Cloud Observations On-Line (S'COOL).

The second day began with a GERB technical session.

- **Gary Fowler** [European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT)] and **Nigel Morris** [Rutherford Appleton Laboratory (RAL)] presented a status of the Meteosat Second Generation (MSG) and GERB programs.
- **Jacqui Russell** reported on GERB unit level spectral responses, *Edition 1* and *2* calibration assessments, and product development status.
- **Jon Murray** [Imperial College] reported on GERB system level ground calibration.
- **James Rufus** [Imperial College] gave a GERB operations report.
- **Andy Smith** [RAL] gave a GERB Ground Segment Processing System (GGSPS) processing report.
- **Nicolas Clerbaux** [Royal Meteorological Institute of Belgium (RMIB)] gave a RMIB GERB Processing (RGP) status report.
- **Richard Bantges** [Imperial College] presented a comparison of GERB 1 and 2 data.

The second day ended with a ScaRaB technical session.

- **Remy Roca** gave an overview of the Megha-Tropiques Mission (MT).
- **Patrick Raberanto** [LMD] gave an overview of the ScaRaB instrument.
- **Olivier Chomette** [LMD] gave an overview of the MT/ScaRaB-3 algorithms and data products.

The third day began with presentations on CERES/GERB/ScaRaB instrument/algorithm validation strategy.

- **Michel Capderou** [LMD] described the Megha-Tropiques orbit and angular sampling.
- **Peter Szewczyk** [LaRC/SSAI] reported on CERES special operations for comparison with other ERB instruments.
- **Dave Doelling** reported on time-space averaging studies with CERES/GERB/ScaRaB.

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

Jean-Louis Dufresne [LMD] spoke on revisiting the greenhouse effect discovery and its analysis. Dufresne gave a short history of the greenhouse effect discovery, and an analysis of the greenhouse effect using *net exchange formalism* for both the Earth and Mars atmospheres. In studying Svante Arrhenius' estimate of the greenhouse effect, he contends that Arrhenius' estimation of carbon dioxide (CO_2) impact in the surface temperature is erroneous due to wrong absorptivity values and inadequacy of the single layer greenhouse model to saturated gases. Dufresne concluded by explaining how the net exchange formalism is a powerful tool to analyze radiative exchanges.

Sandrine Bony [LMD] spoke on a new era for the evaluation of climate models. Bony explained why cloud-radiative effects are so critical for climate modeling, and discussed strategies for evaluating of cloud-climate feedbacks in general circulation models. She stated that many important aspects of the simulated climate depend on the representation of cloud-radiative effects and cloud-climate feedbacks. Bony's preliminary results suggest very strong errors in the representation of low-level cloud properties in several models.

The remainder of the meeting was comprised of contributed science presentations by members of the CERES, GERB, and ScaRaB science teams. The topics discussed are summarized in the table on page 42. Please refer to the URL listed below for more details on each presentation.

Full presentations are available on the CERES website at: *science.larc.nasa.gov/ceres*. The next CERES Science Team Meeting will be held April 26-28, 2011, at the City Center at Oyster Point Marriott hotel in Newport News, VA. ■

Topic	Speaker	Institution
Relationships Between Clouds, Sea Surface Temperature (SST), and Circulation Over the Tropical Oceans	Mark Ringer	U.K. Met Office
Using GERB, CERES, and ScaRaB to Investigate Systematic Model Biases Relating to Cloud, Mineral Dust, and Aircraft Contrails	Richard Allan	University of Reading
Key Parameters to Estimate the Outgoing Longwave Radiation (OLR) Over Tropical Regions: Simple Models and Their Evaluation	Rodrigo Guzman	Laboratoire de Météorologie Dynamique
Climate Sensitivity and Top-of-Atmosphere (TOA) Net Radiation in Short-and Long-time Scales	Bing Lin	Langley Research Center
Use of Earth Radiation Budget (ERB) Data for Model Development, Evaluation, and Feedback Studies at the Met Office	Mark Ringer	U.K. Met Office
Tropical Diurnal Cycle Using CERES Synoptic Data	Patrick Taylor	Langley Research Center
Diurnal Variability of Cloud System Types as Seen from Terra and Aqua Satellites	Kuan-Man Xu	Langley Research Center
Analysis of OLR in Short Timescale over Africa	Kwun Chan	Imperial College
Modeling of the Aging Effects on Meteosat First Generation Visible Band	Ilse Decoster	Royal Meteorological Institute of Belgium
Unfiltering Study for the EarthCARE Broadband Radiometer (BBR)	Almudena Velazquez Blazquez	Royal Meteorological Institute of Belgium
Proposal of Flux Retrieval Methodologies for the BBR L2 Baseline Algorithms in the EarthCARE Framework	Carlos Domenech	Free University of Berlin
An Estimate of the Radiation Effect of Invisibly Thin Clouds	Wenbo Sun	Langley Research Center/SSAI
Analysis of Top-of-Atmosphere Radiation Budget from Multiple Datasets	Takmeng Wong	Langley Research Center
Extending TOA Radiation Back to 1978 Using Wide-Field-of-View Data	Edward Baudrez	Royal Meteorological Institute of Belgium
TOA and Surface Radiation Budget Derived from Cloud-Aerosol Lidar and Infrared Satellite Observations (CALIPSO)-, CloudSat-, and MODIS-Derived Cloud and Aerosol Properties	Seiji Kato	Langley Research Center
A Multi-Variable Statistical Description of Clouds Over the Tropical Ocean Using A-Train High Spatial Resolution Observations to Assess Cloud Process Parameterizations in Climate Models	Helene Chepfer	Laboratoire de Météorologie Dynamique
Mesoscale Convective Systems and the Radiation Budget in the Tropics	Rémy Roca	Laboratoire de Météorologie Dynamique
The EUMETSAT Satellite Application Facility on Climate Monitoring (CM-SAF) Meteosat-Based Climate Data Record for the Surface Solar Irradiance - Description and Evaluation	Joerg Trentmann	Deutscher Wetterdienst
NOAA's Plans for the Continuity of Earth Radiation Budget Observations and Climate Data Records	John Bates	NOAA
Surface Net Fluxes from Broadband and Narrowband Observations: CERES and Geostationary Operational Environmental Satellite-R Series (GOES-R)/Advanced Baseline Imager (ABI)	Istvan Laszlo	NOAA
CERES/ARM Validation Experiment (CAVE): a Web-Based Tool for Radiation Transfer and Display of CERES Data Product Validation Results	David Rutan	Langley Research Center/SSAI
Improvements to Standard CALIPSO Products and New Products	David Winker	Langley Research Center
Evaluation of the Global Cloud Cover Parameters Obtained from Geostationary Data in the Frame of the Megha-Tropiques Mission with CALIPSO Lidar Observations	Genevieve Seze	Laboratoire de Météorologie Dynamique
Cloud Property Comparisons between CERES and CALIPSO	Sunny Sun-Mack	Langley Research Center/SSAI
Validation of CERES Science Team (ST) Retrieved MODIS Cloud Properties Using Department of Energy (DOE) Atmospheric Radiation Experiment (ARM Mobile Facility [AMF])-China and Cloudsat Observations	Xiquan Dong	University of North Dakota
Comparisons of Multilayer Cloud Products from CERES MODIS, CALIPSO, and CloudSat Data	Fu-Lung Chang	Langley Research Center/SSAI
Long-Term Trend of Aerosol Optical Thickness in Support of Studying the Solar Dimming and Brightening	Xuepeng Zhao	NOAA
Picard: A New Mission Dedicated to the Sun and Our Climate	Steven Dewitte	Royal Meteorological Institute of Belgium

Fire-Breathing Storm Systems

Michael Finneran, NASA Langley Research Center, michael.p.finneran@nasa.gov

Pyrocumulonimbus is the fire-breathing dragon of clouds.

When smoke and heat from large fires—on the order of tens of thousands of acres—combine under appropriate conditions, you get a pyrocumulonimbus (pyroCb) storm cloud—similar in many ways to violent thunderstorms. In the process, these towering pyroCbs act like a chimney, and funnel their smoke into Earth's stratosphere, with lingering ill effects.

Global Impact

Researchers believe these intense storms may be the source of what previously was believed to have been volcanic particles in the stratosphere. They also suggest pyroCbs happen more often than thought, and say they're responsible for a huge volume of pollutants trapped in the upper atmosphere.

"An individual pyroCb can inject particles into the lower stratosphere as high as 10 miles," says **Glenn K. Yue**, an atmospheric scientist at NASA Langley Research Center.

Yue is one of eight authors of a paper on pyroCb in the September 2010 *Bulletin of the American Meteorological Society* (BAMS) titled *The Untold Story of Pyrocumulonimbus*.

Three "mystery cloud phenomena" were cited as examples that were actually the result of pyroCb storms, including one initially attributed to the 1991 eruption of Mount Pinatubo in the Philippines. This plume—thought to have been from Pinatubo—was, it turns out, from a pyroCb storm in Canada.

One reason for the misinterpretation, Yue said, is that scientists believed nothing less energetic than a volcanic eruption could penetrate Earth's *tropopause* in so short a period of time. (The *tropopause* is the nominal boundary between the lower atmosphere and stratosphere.)

"At the time, the thinking was that it was unlikely," said Yue.

SAGE II Data

Yue reevaluated data he'd analyzed years earlier from NASA Langley's Stratospheric and Aerosol and Gas Experiment (SAGE) II instrument on the Earth Radiation Budget Satellite. (SAGE II was launched in 1984 and turned off in 2005.)

A pyrocumulonimbus cloud towers over thick smoke from fires burning near Canberra, Australia, in 2003. The cloud's strong winds caused the fires to explode into the Australian city. **Credit:** New South Wales Rural Fire Service

"Our paper also shows that pyroCbs happen more often than people realize," Yue added. In 2002, for example, various sensing instruments detected 17 distinct pyroCb events in North America alone.

Humans have been responsible for many pyroCb storms, says **Mike Fromm**, lead author on the BAMS paper.

The worst fire in Colorado's history was set by a forestry officer. "...within 24 hours there was a pyroCb storm," says Fromm, a meteorologist at the Naval Research Laboratory. Whipped by the storm it had sparked, the 2002 fire swept across 138,000 acres (558.5 km^2) in four counties, drove more than 5,000 from their homes, and killed six people.

Whether human actions influence pyroCb activity enough to significantly impact the global climate is an open question. Human activity is believed to cause climate warming that leads to more wildfires.

"It's a compelling story line. We don't know enough now to say if there's enough supporting evidence of that," says Fromm.

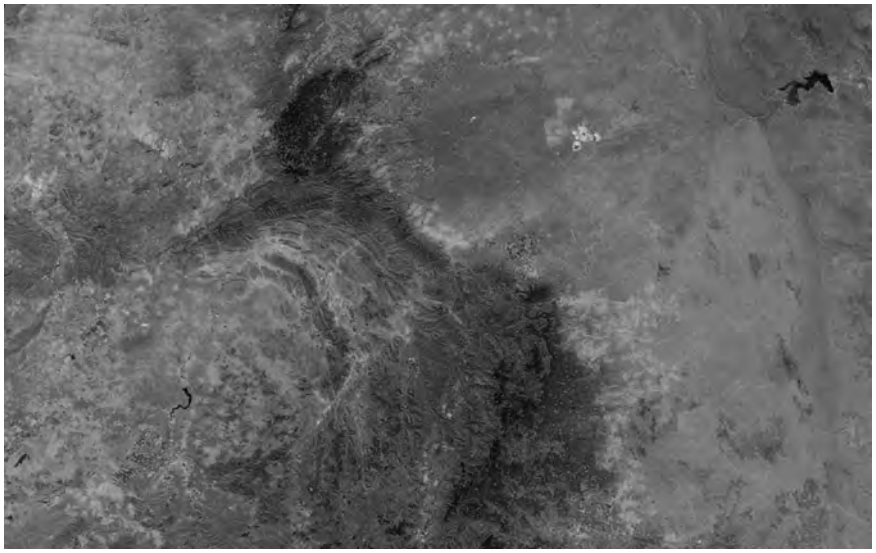
"There's lots of fairly convincing evidence that under a warming climate, there are forest areas of Siberia and Canada that will be under more heat stress than before. And it's reasonable to think that there will be more fires." ■

NASA Partnership Sends Earth Science Data to Africa

Alan Buis, NASA Jet Propulsion Laboratory, alan.buis@jpl.nasa.gov
Steve Cole, NASA Headquarters, Stephen.E.Cole@nasa.gov

A unique partnership between NASA and agencies in Africa and Europe has sent more than 30 terabytes of free Earth science satellite data to South African researchers to support sustainable development and environmental applications in Africa.

The data provide observations of Africa's surface and atmosphere, including vegetation structure, airborne pollution particles, cloud heights, and winds. Transfer of these data to a distribution center in Africa will make it broadly accessible to African users who have not been able to remotely download the large data files because of limitations in the continent's Internet infrastructure.



Downward-looking camera view of the area around Kruger National Park in northeastern South Africa, acquired August 18, 2010, by the MISR instrument on NASA's Terra spacecraft. The imaged area is 236 mi (380 km) wide. The bright white feature above and to the right of image center is the Palabora Copper Mine, and the water body near upper right is Lake Massingir in Mozambique. Kruger National Park lies between these landmarks and stretches from north to south for some 217 mi (350 km). To view this image in color, please visit: *www.nasa.gov/topics/earth/features/misr-img20101006.html*.
Image credit: NASA/GSFC/LaRC/JPL, MISR Team

The data are from the Multi-angle Imaging Spectroradiometer (MISR) on Terra. NASA's Jet Propulsion Laboratory (JPL)[1] built and manages the instrument, and NASA's Langley Research Center (LaRC), processes, archives and distributes the data.

MISR has been making continuous measurements of Earth's surface and atmosphere for more than a decade. MISR observes the sunlit portion of Earth continuously, viewing the entire globe between 82° N and 82° S latitude every nine days. Instead of viewing Earth from a single perspective, the instrument collects images from nine widely spaced view angles.

"NASA is committed to helping governments, organizations and researchers around the world make effective use of Earth observation data to aid in environmental decision making," said **Hal Maring**, a program manager in the Earth Science Division of the Science Mission Directorate at NASA Headquarters. "These efforts support the goals of the Group on Earth Observations, a partnership of international agencies that promotes collaborative use of Earth science data."

South Africa's Council for Scientific and Industrial Research (CSIR) in Pretoria will distribute the data at no charge to the research community in the region. CSIR will facilitate access to the large volume of MISR data as part of its broad strategy of educating, training, and transferring knowledge to the southern African research community.

"The data transfer can be seen as a birthday present from NASA to the newly formed South African National Space Agency," said **Bob Scholes**, CSIR research group leader for ecosystem processes and dynamics. "It will kick-start a new generation of high-quality land surface products, with applications in climate change and avoiding desertification." (*Desertification* is the gradual transformation of habitable land into desert due to climate change or destructive land-use practices.)

The partnership began in Spring 2008, when MISR science team member Michel Verstraete of the European Commission Joint Research Centre Institute for Environment and Sustainability (JRC-IES) in Ispra, Italy, participated in an intensive CSIR field campaign to

[1] JPL is managed for NASA by the California Institute of Technology.

study the environment around Kruger National Park, a major wildlife reserve in South Africa. The researchers studied the area using direct, airborne, and space-based measurements. During the campaign, Verstraete learned of the widespread interest by the South African research community in remote-sensing techniques and applications.

In response, JRC-IES and CSIR signed an agreement in July 2008 to facilitate the interaction and exchange of people, knowledge, data, and software.

NASA became involved in the collaboration in 2009 after a training workshop for MISR users in Cape Town, South Africa, organized by JPL and LaRC. Although the workshop sparked interest in the potential use of MISR data, it soon became apparent that accessing a large volume of data was a major hurdle for research and applications in developing countries in general and Africa in particular. While Internet connectivity in Africa has improved greatly in recent years, access and bandwidth remain too limited to support downloading vast data files. This led CSIR to host the data directly.

NASA shipped most of the data on high-density tapes this summer. The agencies will ensure the database stays updated with current MISR observations by upgrading connectivity and facilitating sharing of data among participating academic and research institutions.

"This multi-party collaboration will significantly strengthen academic and research institutions in Southern Africa and support sustainable development of the entire subcontinent," said Verstraete, who will spend six months in Southern Africa next year to help the regional remote-sensing community use the data.

For more information on MISR, visit: *misr.jpl.nasa.gov*. ■

HDF/HDF-EOS Workshop Summary

continued from page 39

Data Language (IDL); and SPADAC, who introduced and described their *EarthWhere* product that provides for enterprise management of geospatial data.

The remainder of the final day's presentations consisted of THG support status of the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project [NPP]/Joint Polar Satellite System (JPSS), the *HDF* as an *Archive Format* project, the role of data format in long-term preservation of Earth science data, and the status of development for high-performance HDF5.

The location of next year's workshop was not discussed, but the Program Committee will make an announcement sometime in April 2011. We encourage interested parties to serve on the Program Committee; please email any of the Program Committee members.

Program Committee

- **Dan Marinelli**, NASA Goddard Space Flight Center, *daniel.j.marinelli@nasa.gov*
- **Carol Boquist**, NASA Goddard Space Flight Center, *carol.l.boquist@nasa.gov*
- **Michael Folk**, The HDF Group, *mfolk@hdfgroup.org*
- **Elena Pourmal**, The HDF Group, *epourmal@ncsa.uiuc.edu*
- **Kent Yang**, The HDF Group, *ymuqun@ncsa.uiuc.edu*
- **Ebrahim Taaheri**, Raytheon, *Abe_Taaheri@raytheon.com*
- **Daniel Kahn**, Science Systems and Applications, Inc., *Daniel.A.Kahn@nasa.gov*
- **John Evans**, MathWorks, *john.evans@mathworks.com* ■

CERES/GERB/ScaRaB Science Team meeting participants

in the news

Arctic Sea Ice Extent Falls to Third-Lowest Extent; Downward Trend Persists[1]

Katherine Leitzell, National Snow and Ice Data Center, leitzell@nsidc.org

This September, Arctic sea ice extent was the third-lowest in the satellite record, falling below the extent reached last summer. The lowest- and second-lowest extents occurred in 2007 and 2008, respectively. Satellite data indicate that Arctic sea ice is continuing a long-term decline, and remains younger and thinner than it was in previous decades.

"All indications are that sea ice will continue to decline over the next several decades," said NSIDC Director **Mark Serreze**. "We are still looking at a seasonally ice-free Arctic in twenty to thirty years."

Over the summer of 2010, weather and ocean conditions in the Arctic ranged from warm and calm to stormy and cool. Overall, weather conditions were not extremely favorable to melt, but ice extent loss proceeded at a rapid pace. NSIDC scientist **Julienne Stroeve** said, "Sea surface temperatures were warmer than normal this summer, but not as warm as the last three years. Even so, the 2010 minimum rivaled that in 2008—this suggests that other factors played a more dominant role."

The amount of old, thick ice in the Arctic continues to decline, making the ice pack increasingly vulnerable to melt in future summers. While there was an increase this year in second and third year ice, which could potentially thicken over the next few years, the oldest and generally thickest ice (five years or older) has now disappeared almost entirely from the Arctic. This September, less than 23,000 mi^2 (60,000 km^2) of five-year-old or older ice remained in the Arctic Basin. In the 1980s, an average of 722,000 mi^2 (2 million km^2) of old ice remained at the end of summer. "**While the total coverage of multiyear ice is the third lowest on record, the amount of younger multiyear ice has rebounded somewhat over the last two years. A key question is whether this ice will continue to survive over the next couple of summers, perhaps slowing the overall decline in multiyear ice area**," said **James Maslanik**, a research professor in the Department of Aerospace Engineering Sciences at the University of Colorado, who provided the ice age data.

Arctic sea ice extent on September 19, the lowest point this year, was 1.78 million mi^2 (4.60 million km^2). Averaged over the month of September, ice extent was 1.89 million mi^2 (4.90 million km^2)—see **Figure 1**. This places 2010 as the third lowest ice extent both for the daily minimum extent and the monthly average.

Sea Ice Extent – September, 2010

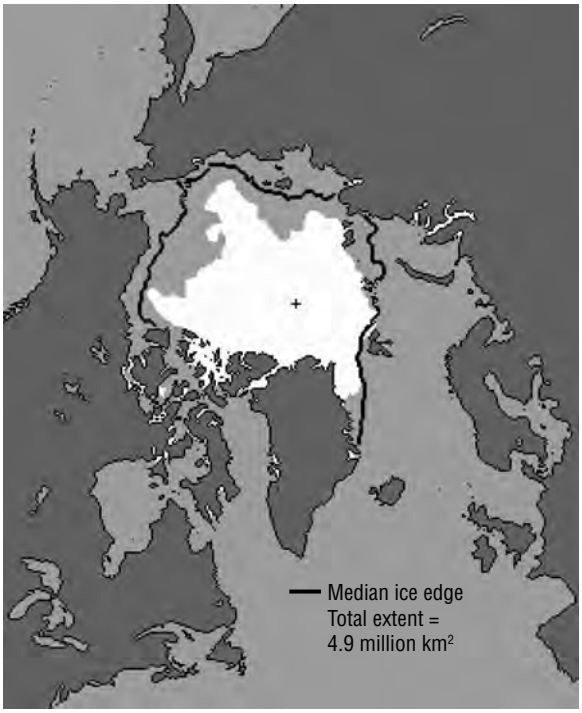


Figure 1. Arctic sea ice extent for September 2010 was 1.89 million mi^2 (4.90 million square km^2), the third-lowest in the satellite record. The bold black line shows the median ice extent for September from 1979 to 2000. **Credit:** National Snow and Ice Data Center

Arctic Sea Ice Extent – September
(Area of ocean with at least 15% sea ice)

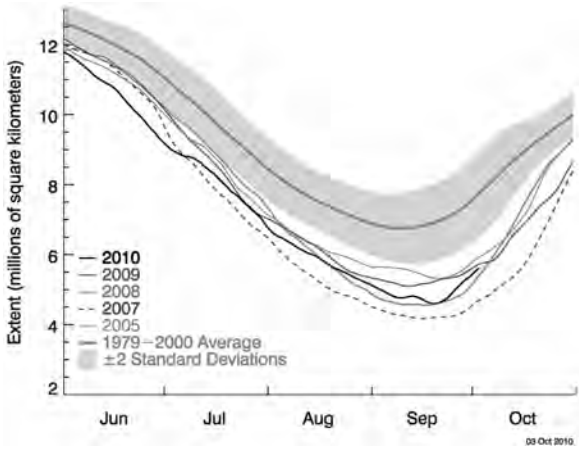


Figure 2. The updated time series plot puts this summer's sea ice extent in context with other years. **Credit:** National Snow and Ice Data Center

[1]This article was originally a press release from the National Snow and Ice Data Center (NSIDC), which is part of the Cooperative Institute for Research in Environmental Sciences at the University of Colorado at Boulder. Media Relations Contact: Katherine Leitzell, NSIDC: *leitzell@nsidc.org*

Ice extent fell below 2009 and was only slightly above 2008—see **Figure 2**.

After September 10, ice extent started to climb, apparently signaling the end of the melt season. However, uncharacteristically, it then declined again, until September 19. "The late-season turnaround indicates that the ice cover is thin and loosely packed—which makes the ice more vulnerable both to winds and to melting," said **Walt Meier**, NSIDC research scientist.

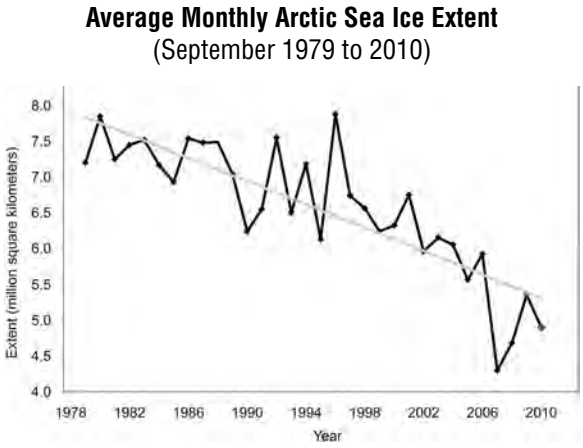


Figure 3. Average values of September Sea Ice Extent (1979–2010) continue to show decline. The September rate of sea ice decline since 1979 has now increased to 11.2% per decade. Sea Ice Index data can be found at the following link: *nsidc.org/data/seaice_index/*. **Credit:** National Snow and Ice Data Center

Arctic sea ice follows an annual cycle of melting through the warm summer months and refreezing through autumn and winter. Sea ice reflects sunlight, keeping the Arctic region cool and moderating global climate. While Arctic sea ice extent varies from year to year because of changeable atmospheric and ocean conditions, ice extent at the end of the melt season has shown a significant overall decline over the past thirty years. During this time, September ice extent has declined at a rate of 11.5% per decade during September (relative to the 1979–2000 average)—see **Figure 3**—and about 3% per decade in the winter months.

More Information

For further analysis and images, please see the related ***October post*** on Arctic Sea Ice News & Analysis website (*http://nsidc.org/arcticseaicenews/*).

*For a full listing of press resources concerning Arctic sea ice, including previous press releases and quick facts about why and how scientists study sea ice, please see "**Press Resources**" on the NSIDC Arctic Sea Ice News & Analysis web page.* ■

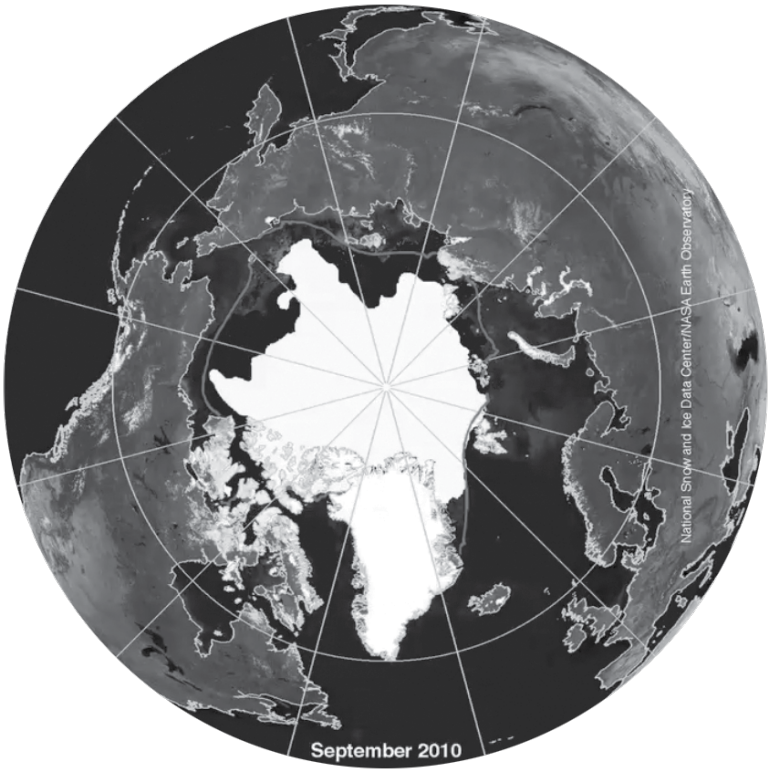


Figure 4. Sea ice extent for September 2010. This is one image from a time series of images that shows the decline in September sea ice extent over the thirty-year satellite record. The complete animation shows ice extent for each of the past thirty-one Septembers (1979–2010) and can be viewed at: *nsidc.org/images/arcticseaicenews/20101004_Figure7.mov*. Ice extent for Fall 2010 was the third-lowest in the satellite record. **Credit:** National Snow and Ice Data Center/NASA Earth Observatory

EOS Scientists in the News

Kathryn Hansen, NASA Earth Science News Team, khansen@sesda2.com

ICESat Takes a Plunge to Conclude Successful Mission, August 20; *Spaceflight Now.* **Jay Zwally** (NASA GSFC) describes the successes achieved by NASA's Ice, Cloud, and land Elevation Satellite (ICESat), which fell back into Earth's atmosphere after a seven-year mission to measure the thickness of the planet's land and sea ice.

Polar Ice Loss Rates May Need to be Lowered, Say Scientists, September 8; *EarthSky*. A study by **Xiaoping Wu** (NASA JPL) and colleagues shows that ice sheets at Earth's poles might be losing ice only half as fast as the high-end of previous estimates, and **Jay Zwally** (NASA GSFC) comments on the results.

Claire Parkinson on Pros and Cons of Geoengineering to Combat Climate Change, September 13; *EarthSky*. Climate researcher **Claire Parkinson** (NASA GSFC) talks with *EarthSky* about geoengineering, using technology to manipulate climate on a global scale.

Michael Lefsky: First-Ever Map of Height of All the World's Trees, September 13; *EarthSky*. **Michael Lefsky** (Colorado State University) used data from NASA's Ice, Cloud and land Elevation Satellite (ICESat) to create the first-ever map showing the height of all the world's trees, which will help scientists figure out what places in the world are holding onto a lot of carbon.

La Niña Expected to Bring Wet, Gray Winter to the Pacific Northwest, September 17; *The Olympian.* **Bill Patzert** (NASA JPL) says storms in the Pacific Northwest are expected to grow more severe in winter months as the La Niña climate phenomenon strengthens—good news for skiers and for salmon fishers, and for reducing the risk of wildfires.

Would Curbing Desert Dust Help the Colorado River? September 20; *Los Angeles Times.* The dark dust thrown up by human activity in the deserts of the southwestern U.S. hastens the melting of Rocky Mountain snow and ultimately reduces the amount of water flowing into the upper Colorado River by around 5%, reported a team of scientists led by **Tom Painter** (NASA JPL).

Steven Platnick: Clouds Both Cool and Warm Earth, September 27; *EarthSky*. Some clouds help cool the Earth, but other clouds help keep Earth warm—in part depending on how high up they are in our atmosphere, according to **Steven Platnick** (NASA GSFC), who studies clouds and how they connect with Earth's climate.

***NASA Planes Collect Data to Better Predict Storm Intensity**, September 28; *The Citizen (Bay Area).* **Tim Miller** (NASA MSFC) and **Chris Naftel** (NASA DFRC) discuss the conclusion of NASA's Genesis and Rapid Intensification Processes (GRIP) mission, a six-week study of the formation and strengthening of tropical storms in the Gulf of Mexico and western Atlantic Ocean.

***Studying Storms: NASA Looks for Hurricane's Secrets**, September 28; *National Public Radio*. For more than a month, scientists aboard a NASA DC-8 gathered data on storms in the Atlantic; radar expert **Simone Tanelli** (NASA JPL) commented on the intensity of rain observed during a flight over Hurricane Karl.

Summer of 2010 was the Fourth Warmest on Record, October 1; *Discovery News*. Global surface temperatures in the Northern Hemisphere summer of 2010 were slightly below 2009, but **Jim Hansen** (NASA GISS) reports that the season was still the fourth warmest in 131 years of records.

Tom Neumann on Whether Antarctica is Warming or Cooling, October 4; *EarthSky*. It's hard to say whether the southernmost continent has been getting warmer or colder—or staying more or less the same—since temperature measurements began just a few decades ago. There are complexities in the overall picture of warming and cooling in Antarctica that make simple conclusions difficult, according to **Tom Neumann** (NASA GSFC).

Claire Parkinson on Disappearing Sea Ice and Its Impacts, October 11; *EarthSky*. Sea ice has quite a few impacts, both on the rest of the climate system and also on ecosystems, according to **Claire Parkinson** (NASA GSFC), who explains some of those impacts as sea ice follows a long-term trend toward lesser coverage.

Study: CO_2 is 'Thermostat' for Earth, October 14; *United Press International.* **Andrew Lacis** (NASA GISS)

and colleagues conducted a study that shows while vapor and clouds are major factors in Earth's greenhouse effect, carbon dioxide will always be the ultimate culprit.

Jay Zwally on Melting at Greenland's Largest Outlet Glacier, October 18; *EarthSky*. Glaciologist **Jay Zwally** (NASA GSFC) talked to *EarthSky* about the progress of melting in Jakobshavn Glacier, the largest outlet glacier in Greenland, which discharges about 5% of the ice that leaves the Greenland ice sheet.

California Earthquake Drill Comes as Researchers Warn of Large-Scale Temblor, October 21; *KPBS*. California's annual earthquake drill comes at a time when scientists are warning that a large-scale earthquake is long overdue; many of the earthquakes this year were aftershocks from the 7.2 Easter earthquake, which **Eric Fielding** (NASA JPL) said built up pressure on the San Jacinto Fault, California's most active fault that runs through parts of San Diego.

Mission to Trace Antarctic Ice Set to Take Off, October 21; *Our Amazing Planet*. **Tom Wagner** (NASA HQ) explains how NASA's *Operation Ice Bridge*, an airborne science mission now making flights over Antarctica, will help scientists get a better picture of what is happening with the ice thanks to the aircraft's ability to support multiple lasers that will help create a more accurate image of the ice.

***Smoke from a Distant Fire**, November 6; *ScienceNews*. While it has been known for decades that large wildfires can create or enhance thunderstorm clouds, leading to what are called pyrocumulonimbus clouds, only recently have scientists discovered that the clouds can boost smoke into the stratosphere; **Nathaniel Livesey** (NASA JPL) talks about the aerosols injected into the atmosphere from some of these fires.

Interested in getting your research out to the general public, educators, and the scientific community? *Please contact Kathryn Hansen on NASA's Earth Science News Team at khansen@sesda2.com and let her know of your upcoming journal articles, new satellite images, or conference presentations that you think the average person would be interested in learning about.*

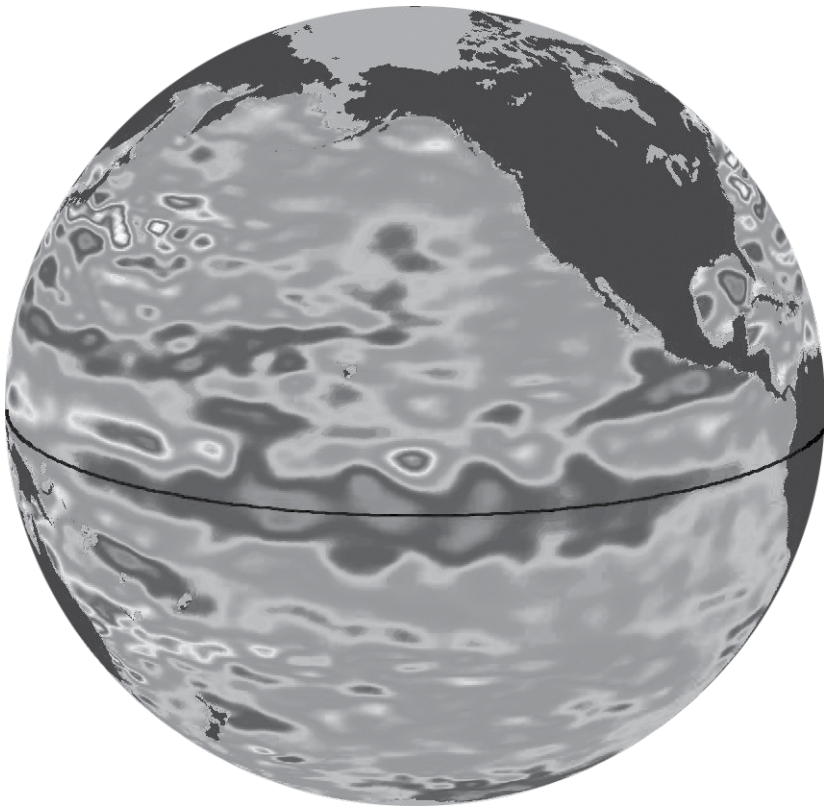
*See article in this issue ■

A Growing La Niña Chills Out the Pacific

The tropical Pacific Ocean has transitioned from last winter's El Niño conditions to a cool La Niña, as shown by sea surface height data collected by the U.S-French Ocean Surface Topography Mission (OSTM)/Jason-2 oceanography satellite.

This OSTM/Jason-2 image of the Pacific Ocean is based on the average of 10 days of data centered on September 3, 2010. Places where the sea surface is lower (cooler) than normal are shown in darker pixels. Sea surface height is an indicator of how much of the sun's heat is stored in the upper ocean.

For more information and to view this image in color, please visit: *sealevel.jpl.nasa.gov/science/elninopdo/elnino/index.cfm?FuseAction=ShowNews&NewsID=364.*



September 3, 2010

NASA Science Mission Directorate – Science Education Update

Ming-Ying Wei, NASA Headquarters, mwei@hq.nasa.gov
Liz Burck, NASA Headquarters, liz.b.burck@nasa.gov
Theresa Schwerin, Institute of Global Environment and Society (IGES), theresa_schwerin@strategies.org

Lifelines for High School Climate Change Education

Lifelines for High School Climate Change Education is a project to establish professional learning communities (PLCs) of high school teachers aimed at implementing effective teaching of climate change in existing courses. PLCs will identify the best resources to use and share best practices, have telemeetings, and explore techniques to achieve the most effective ways to communicate without travel. The objective is to teach while at the same time minimize environmental impacts. Presentations by climate scientists will also be included. If you are interested in joining a Lifeline PLC, please apply at: *www.lawrencehallofscience.org/gss/lifelines/*.

"Avatar" Director and NASA Focus on Earth Science Exploration

James Cameron, director of *Avatar*, (the most successful film ever released) is featured in a series of NASA public service announcements that describe the many contributions of the agency's Earth Science Program to environmental awareness and exploration of our home planet. To access the announcements, please visit: *www.nasa.gov/home/hqnews/2010/aug/HQ_M10-119_Cameron_PSA.html*.

***NASA GRIP Hurricane Mission and Hurricane Research Website**

The Genesis and Rapid Intensification Processes (GRIP) mission is a science field experiment conducted to better understand the formation and development of tropical storms into major hurricanes. The campaign employed several aircraft, including the unmanned aerial vehicle *Global Hawk*. To read more about GRIP and its findings, please visit: *www.nasa.gov/mission_pages/hurricanes/missions/grip/main/index.html*.

In addition, the NASA Hurricane Research Website provides resources on hurricane development, including images, video, and news. To visit the website, please go to: *www.nasa.gov/mission_pages/hurricanes/missions/index.html*. NASA hurricane research can be followed on Twitter at: *twitter.com/NASAHurricane*.

2011 NASA College and University Faculty Workshops

December 11–12	San Francisco, CA
January 18–19	Minneapolis, MN
February 24–25	San Diego, CA

Applications are now being accepted for the 2010-2011 Faculty Institutes for NASA Earth and Space Science Education (FINESSE). These two-day workshops are to assist university and community college science and education faculty in preparing future teachers in science. NASA Earth and space scientists and educators share authentic inquiry activities, data, and resources related to key topics from the national science standards. The 2011 Institutes will incorporate the theme of *Our Solar System in a New Light*, in conjunction with the upcoming *Year of the Solar System*. The workshops are free, and participants receive a $300 stipend and lunch, and development implementation plans. To apply, and for more information, please visit: *www.lpi.usra.edu/education/facultyInstitutes/*.

A Day at Goddard: Opportunity for DC Metro Teachers (Grades 8-12)

Teachers in the Washington DC Metropolitan area are invited to bring their students to NASA Goddard Space Flight Center for a day spent learning what it's like to work for NASA. Field trips include a meet-and-greet at the visitor's center featuring a scientist and engineer, a demonstration of the *Science on a Sphere* program, a tour of the satellite testing facility, and an inquiry-based science lab activity. Programs are highly customizable, teacher friendly, and designed for grades 8-12. Contact **Aleya Van Doren** (*aleya.vandoren@nasa.gov*) with your desired date and class information to reserve your spot. Slots fill up quickly so register today!

*See article in this issue

EOS Science Calendar

March 1–3, 2011
Landsat Science Team Meeting, Phoenix, AZ.

April 26–28, 2011
CERES Science Team Meeting, Oyster Point Marriott, Newport News, VA. URL: *ceres.larc.nasa.gov/ceres_meetings.php*

Global Change Calendar

December 13–17, 2010
American Geophysical Union Fall Meeting, San Francisco, CA.
URL: *www.agu.org/meetings/fm10/*

January 19–21, 2011
NCSE 11th National Conference on Science, Policy, and the Environment, Washington, D.C.
URL: *communities.earthportal.org/ncseoceans2011/*

January 23–27, 2011
American Meteorological Society 91st Annual Meeting, Seattle, WA. URL: *www.ametsoc.org/meet/annual/*

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

March 27–31, 2011
American Chemical Society Spring Meeting. Anaheim, CA. URL: *portal.acs.org/portal/acs/corg/content*

April 10–15, 2011
34th International Symposium on Remote Sensing of Environment (ISRSE): *The GEOSS Era: Towards Operational Environmental Monitoring*, Sydney, Australia.
URL: *isrse34.org/*

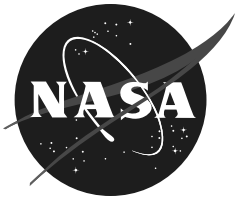
May 1–5, 2011
American Society for Photogrammetry and Remote Sensing 2011 Annual Conference, Milwaukee, WI.
URL: *www.asprs.org/milwaukee2011/*

June 21–24, 2011
Annual Air and Waste Management 104th Annual Conference and Exhibition, Orlando, FL. URL: *www.awma.org/ACE2011/*

June 27–July 8, 2011
XXV International Union of Geodesy and Geophysics General Assembly: *Earth on the Edge: Science for a Sustainable Planet*, Melbourne, Australia. URL: *www.iugg2011.com*

August 1–5, 2011
2011 IEEE International Geoscience and Remote Sensing Symposium, Sendai, Japan. URL: *igarss11.org/*

October 24–28, 2011
World Climate Research Programme Open Science Conference, Denver, CO. URL: *www.wcrp-climate.org/conference2011/*



Code 610
National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, MD 20771

PRSRT STD
Postage and Fees Paid
National Aeronautics and Space Administration
Permit 396

Official Business
Penalty for Private Use: $300

(affix mailing label here)

eos.nasa.gov

The Earth Observer

The Earth Observer is published by the EOS Project Science Office, Code 610, NASA Goddard Space Flight Center, Greenbelt, Maryland 20771, telephone (301) 614-5561, FAX (301) 614-6530, and is available on the World Wide Web at *eospso.gsfc.nasa.gov/eos_homepage/for_scientists/earth_observer.php* or by writing to the above address. Articles, contributions to the meeting calendar, and suggestions are welcomed. Contributions to the calendars should contain location, person to contact, telephone number, and e-mail address.

To subscribe to *The Earth Observer*, or to change your mailing address, please call Steve Graham at (301) 614-5561, or send a message to *Steve.Graham@nasa.gov*, or write to the address above. If you would like to stop receiving a hard copy and be notified via email when future issues of *The Earth Observer* are available for download as a PDF, please send an email with the subject **"Go Green"** to *Steve.Graham@nasa.gov*. Your name and email address will then be added to an electronic distribution list and you will receive a bi-monthly email indicating that the next issue is available for download. If you change your mind, the email notification will provide an option for returning to the printed version.

The Earth Observer Staff

Executive Editor: Alan Ward (*alan.b.ward@nasa.gov*)

Assistant Editor: Nicole Miklus (*nicole.m.miklus@nasa.gov*)

Technical Editor: Tim Suttles (*4suttles@bellsouth.net*)
Mitchell K. Hobish (*mkh@sciential.com*)

Design, Production: Deborah McLean (*deborah.f.mclean@nasa.gov*)

Printed on Recycled Paper