



Editor's Corner

Michael King

EOS Senior Project Scientist

On January 4, the 110th United States Congress convened with the Democrats controlling a majority in both chambers for the first time since the 103rd Congress in 1993–1995. This congress will be making important decisions about the future of NASA. The new chairman of the House Science Committee (the committee that oversees NASA authorization) will be Bart Gordon (D-TN). In a recent editorial, Gordon expressed support for the President's *Vision for Space Exploration*, but emphasized the need for balance between the goal of returning to the moon and NASA's other important activities such as Earth and space science. Gordon said:

*I will work to ensure that our space program advances knowledge that benefits each of us. Human space exploration to the moon and beyond can and should continue as an important part of our overall space program, but we will need to make sure that it is carried out efficiently, safely and **in balance with NASA's other important missions.***

The full text of Gordon's editorial is available at www.tennessean.com/apps/pbcs.dll/article?AID=/20061223/OPINION01/612230312/1008.

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March 1, 2007, marks the beginning of the International Polar Year (IPY), a focused two-year international campaign to study the Earth's polar regions and determine how what goes on there impacts the rest of the planet. Shown here is the Moderate Resolution Imaging Spectroradiometer (MODIS) *Mosaic of Antarctica*. Antarctica is the seventh continent, with an area larger than the United States. It is the highest continent, the coldest continent, the windiest continent, and the brightest continent. More than 99% of Antarctica is covered in perennial snow and ice. For more information visit: earthobservatory.nasa.gov/Study/MOA/ **Credit:** National Snow and Ice Data Center (NSIDC) using data from the MODIS instrument on the Terra and Aqua satellites.



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In another show of support from Congress, the outgoing House Committee Chairman, Sherwood Boehlert (R-NY), in a letter to the Honorable Rob Portman, Director of the Office of Management and Budget (OMB), said:

Last, but not least, NASA needs additional funding if it is to move ahead with both the Vision for Space Exploration and the space science, earth science, and aeronautics research required by the NASA Authorization Act of 2005. There is no reason to launch the Orion Crew Exploration Vehicle before 2014, and there is every reason to retire the Space Shuttle in 2010, as planned.

Most important, NASA's science programs, which are its most successful and beneficial programs, must continue to thrive. The earth science program in particular is in danger of atrophying. At the very, very least, NASA's Science Mission Directorate must receive at least as much as was projected in the runout in the fiscal 2007 budget. Moreover, the "bread and butter" funding for NASA science, known as Research and Analysis, must be the top priority for funding.

In other agency news, I'm pleased to report that **Teresa Fryberger** has become the new Associate Director of Applied Sciences in the Earth Science Division at NASA Headquarters, replacing **Ron Birk**. Fryberger was previously detailed to the White House Office of Science and Technology Policy (OSTP) where she served as the Assistant Director for Environment and was a member of the United States Group on Earth Observations (USGEO), a subcommittee of the National Science and Technology Council (NSTC). Prior to joining OSTP in 2004, she was the Director of the Department of Energy's Environmental Remediation Sciences Division.

Fryberger was the Associate Laboratory Director for the Energy, Environment, and National Security (EENS) Directorate at Brookhaven National Laboratory (BNL). As head of three science departments at BNL, she managed and developed a diverse program in environmental sciences, energy sciences, national security, as well as applied chemistry and materials science. Prior to that, she was a senior manager at Pacific Northwest National Laboratory (PNNL). As Senior Deputy Director of PNNL's William R. Wiley Environmental Molecular Sciences Laboratory, she was responsible for managing environmental science programs and providing strategic direction for the overall management of this then-new National Scientific User Facility.

She earned her Ph.D. in Physical Chemistry from Northwestern University and her B.S. in Chemistry from the University of Oklahoma. I welcome Fryberger to NASA, and wish her success in her new position as Associate Director of Applied Sciences.

I would also like to call your attention to Research Opportunities in Space and Earth Sciences - 2006 (ROSES 2006) in which NASA establishes a new program element in Appendix E.5 entitled *History of the Scientific Exploration of Earth and Space*. The ROSES call states that, "the primary objective of the History of the Scientific Exploration of Earth and Space (HSEES) program element is to engage, inform, and inspire diverse public audiences by sharing historical knowledge about NASA's scientific exploration of the Earth and space by communicating NASA's unique contributions to the advancement of Earth and space science during the past 50 years. An essential component of communicating to the public is accurate, complete, well-written histories about the scientific exploration of space. The HSEES program

element solicits proposals to produce accurate, complete, interpretive, and readable histories of major activities in NASA's scientific exploration of Earth and space as supported by the Science Mission Directorate and its predecessor organizations since the establishment of NASA. This program element is broadly defined to include cooperative international activities in which these NASA organizations played a significant role. Notices of Intent to propose were due December 15, and proposals are due February 15, 2007.

In addition I would like to recognize the start of the International Polar Year (IPY) 2007-2008. IPY is a rather ambitious undertaking that seeks to bring together researchers from all over the world with expertise in a wide range of disciplines for an intense two-year research campaign that seeks to understand how changes in polar regions impact weather and climate worldwide. IPY also aims to educate and involve the public, and to help train the next generation of engineers, scientists, and leaders. Planning has been underway for IPY for several years and NASA will be actively involved; an opening ceremony is planned for March 1 in Paris and a new IPY website has been launched. For more informa-

tion on IPY please see the article on *page 4* of this issue and visit www.ipy.org.

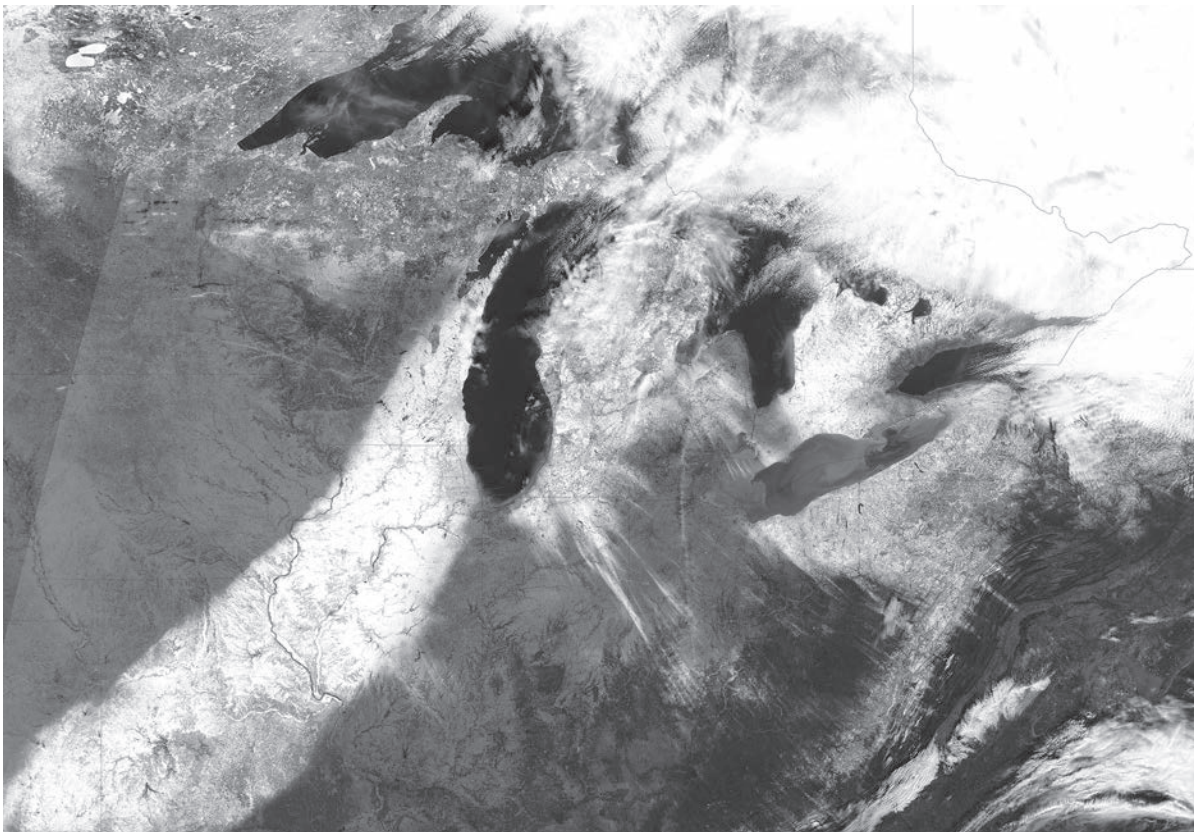
Lastly, I'm pleased to announce that the draft request for proposals (RFP) for the Landsat Data Continuity Mission (LDCM) has been released. LDCM will be in the same basic orbit as previous Landsat missions—705 km with a 16-day repeat cycle. All draft documents may be found at ldcm.nasa.gov/procurement.html.

Important dates for the LDCM RFP were announced at *Industry Day* on December 11.

- **Final RFP release date:** January 3, 2007
- **Proposal due date:** February 2, 2007
- **Target Operational Land Imager (OLI) contract award date:** June 2007
- **Target LDCM launch date:** July 2011.

As reported in the last issue of this newsletter, the USGS has funded an LDCM Science Team that held its first meeting January 9-11, 2007, in Sioux Falls, SD. We hope to have a report from that meeting in a future issue of *The Earth Observer*. ■

The Moderate Resolution Imaging Spectroradiometer (MODIS) on Terra acquired this photo-like image of the Midwest U.S. on December 9, 2006. The snow seen here came from two different storms. The broad swath of white extending from the left edge of the image to Lake Michigan was deposited on December 1 by a powerful winter storm that left thousands without power for many days. The snow on the southeastern side of the Great Lakes, however, fell on December 7 and December 8 as lake-effect snow. The signature of lake-effect snow is striking in this image. A field of white lines the southeastern shores of each of the Great Lakes. The strong winds that generated the snow left their imprint in the form of long streamers of snow that extend all the way to the Appalachian Mountains along the right edge of the image. To see a color version of this image and more details please visit: modis.gsfc.nasa.gov/gallery/individual.php?db_date=2006-12-18 **Credit:** Jeff Schmaltz, MODIS Land Rapid Response Team, NASA GSFC.



International Polar Year 2007-2008: The Opportunity of a Generation

Robin Elizabeth Bell, Lamont-Doherty Earth Observatory of Columbia University, robinb@ldeo.columbia.edu

Earth's poles are among the most desolate places on the planet. Distant, cold, and deserted, such regions are difficult to access but offer unique opportunities for Earth observations. Global circulatory systems for air and water reach the surface at the poles, as do the majority of the Earth's magnetic field lines. Thick glaciers have trapped air and water from ancient times that help us assess how Earth's climate is changing with time.

The International Polar Year 2007-2008 commences in March 2007 and brings together researchers from all over the world with expertise in a wide range of disciplines for an intense two-year research campaign that seeks to understand how what goes on in polar regions impacts weather and climate worldwide. IPY also aims to educate and involve the public, and help train the next generation of engineers, scientists, and leaders.

*The following summary of IPY was originally given by **Robin Elizabeth Bell** [Lamont-Doherty Earth Observatory of Columbia University—Senior Research Scientist] as testimony before the Subcommittee on Research, Committee on Science, U.S. House of Representatives on September 20, 2006. Bell serves as Chair of the Polar Research Board of the U.S. National Committee for International Polar Year Division on Earth and Life Studies, National Research Council. She has graciously agreed to allow **The Earth Observer** to reprint her testimony. The text has been slightly modified for the newsletter, but is largely unaltered from the original.*

Good Morning. Thank you very much for inviting me to speak about IPY 2007-2008. IPY is the scientific opportunity of a generation for our nation, for our society, and for our planet.

My name is Robin E. Bell, Ph.D. from Columbia University's Lamont-Doherty Earth Observatory, where I am a Doherty Senior Research Scientist. I am a geophysicist by training and at Columbia I lead major geophysical programs on the stability of ice sheets including subglacial lakes. I also direct Columbia's NSF-sponsored ADVANCE program, aimed at recruiting and retaining women in science. I was the first woman to lead a major aerogeophysical program from the Antarctic continent, and this has been the focus of much of my research for the past two decades.

In addition to my research, I chair the National Research Council's Polar Research Board, which acts as the national coordinating committee for IPY. The Research Council is the operating arm of the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine, chartered by Congress in 1863 to advise the government on matters of science and technology. I served as the Co-Chair of the International Council for Science's (ICSU) initial IPY Planning Group, which developed the first major international IPY planning document: *A Framework for International Polar Year*—www.ipy.org/development/framework/framework.pdf. I currently serve on the ICSU-

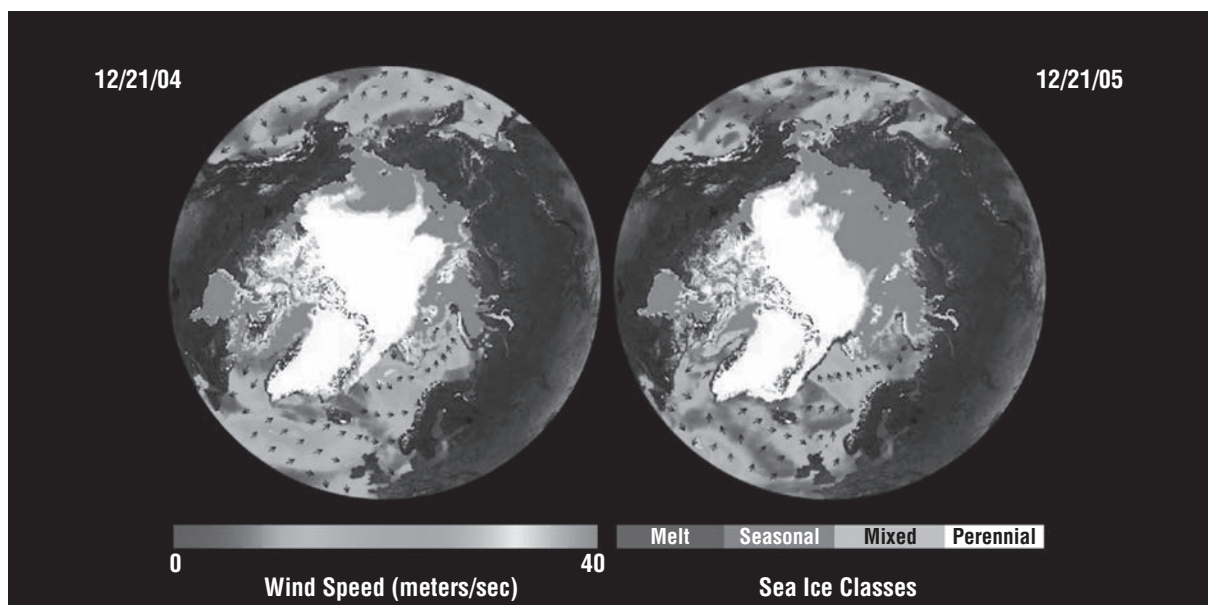


Figure 1. Satellite data gives improved detail and classification of sea ice type. The reduction in Arctic perennial, or year-round, ice cover is especially evident (white shading), when viewed by NASA's QuikScat satellite. Note the rather dramatic decrease in perennial sea ice between 2004 (left) and 2005 (right). For color image and more details please see: www.nasa.gov/vision/earth/environment/quikscat-20060913.html Credit: NASA/JPL.

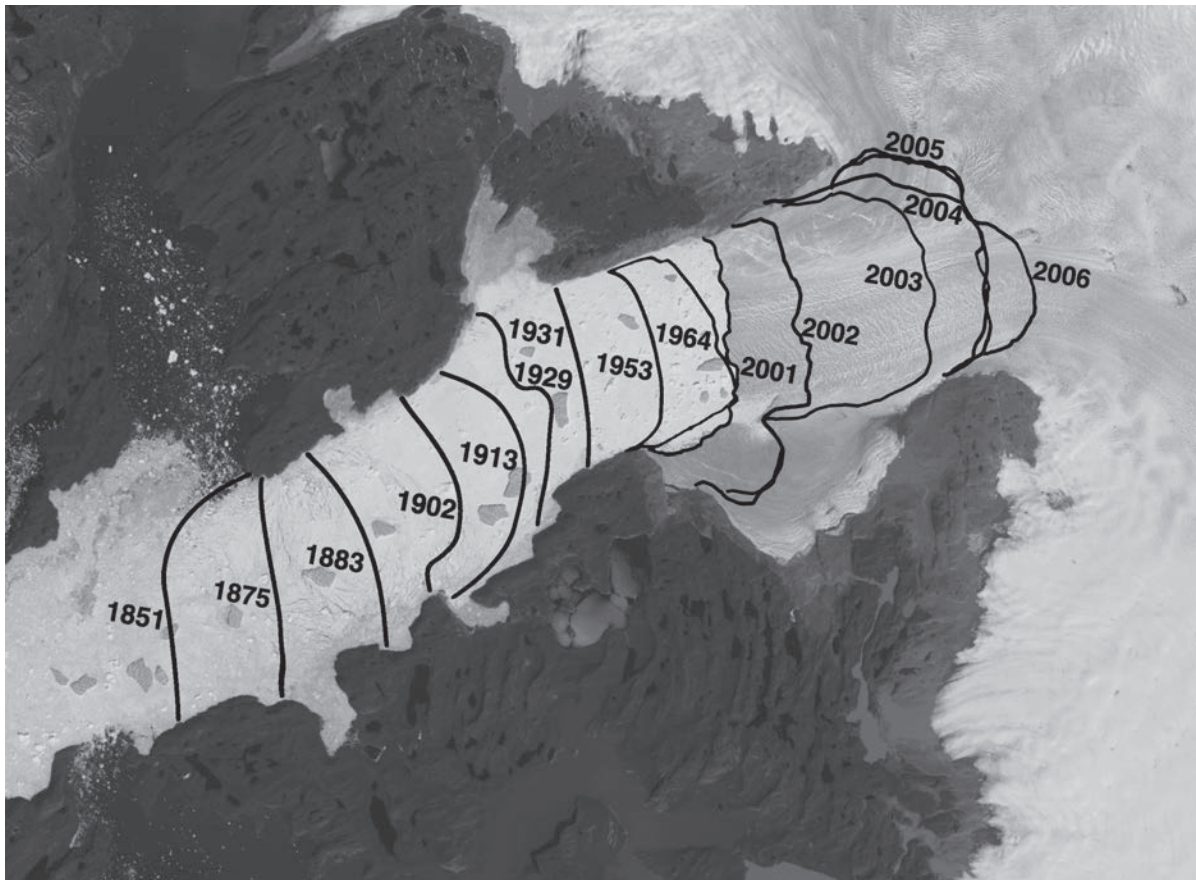


Figure 2. *Jakobshavn Glacier, Greenland.* This glacier gradually receded after 1850 and stabilized for the second half of the 20th Century. However, from 1997 to 2006, the glacier receded again, this time almost doubling in speed. **Credit:** Background image from the Landsat 7 satellite.

WMO Joint Committee for IPY, the main international planning group.

Today I will provide an overview of why IPY is happening and why it's important to us here in the U.S. What has motivated more than 5000 scientists from some 63 nations to decide to participate in a year devoted to polar studies and education? I'll highlight the major science questions that will be addressed, outline the role that U.S. scientists and science managers have been playing developing IPY, and conclude with thoughts on the many societal benefits that can result from the IPY.

In this era of instant communications and global connectivity, it might seem surprising that the global scientific community is so excited by a scientific strategy that was developed more than 100 years ago. Because it was indeed back in 1882-1883 that the idea of holding a focused, internationally-coordinated year of polar research—an International Polar Year—was first developed. At that point in history, the poles were blank white spaces on maps and the cutting edge communications technology was the telegraph. The decision to coordinate with other nations rather than compete, and to focus on research to understand polar phenomena rather than acquisition of territory, was something new

and exciting. That first IPY in 1882-83 and subsequent ones in 1932-33 and the so called International Geophysical Year (IGY) in 1957-58, drew great minds and generated great leaders; these “international years” set a precedent of cooperation in science that, while innovative at the time, is considered the norm today.

Today's scientists are similarly motivated by society's need for integrated global knowledge. There is still a fundamental human need to push the limits of our understanding about polar phenomena. The polar regions are integral components of the Earth system. As the heat sinks of the climate system they both respond to and drive changes elsewhere on the planet. While environmental change and variability are part of the natural pattern on Earth, the environmental changes currently witnessed in the polar regions are in many cases more pronounced than changes observed in the mid-latitudes or tropics. The Arctic sea ice cover is decreasing [see **Figure 1**]; some ice shelves in Antarctica are retreating and thinning [see **Figure 2**]; glaciers are shrinking at alarming rates; and ecosystems are changing, for instance, with plants flowering at earlier times. These changes are having human impacts: some Alaskan villages have been moved to higher ground in response to rising sea levels, and thawing of permafrost

is undermining roads and buildings in northern communities around the world. We must understand the implications of environmental change for the future of our global society.

Although we've made tremendous progress in all science over the past 100 years, in many ways, the polar regions still represent the frontiers of human knowledge. The maps aren't quite as blank as they once were, but the frontiers and unknowns have actually increased, and range from the molecular, to the ecological, to the continental. How is it that certain microbes can survive at -2°F , that certain nematodes live even when ice forms in their cells, that polar fish species have evolved with an antifreeze protein in their blood? What will happen to the unique under-ice ecological communities of the Arctic, which are the base of the Arctic food web, as ice conditions change and new species arrive from southern waters? In just the last 10 years we discovered more than 150 subglacial lakes that exist under the ice in Antarctica. These range in size from something similar to the reflecting pool on the Mall in Washington, DC, to a lake the size of Lake Ontario. Why are these lakes important? They are thought to contain exotic ecosystems; the water in these lakes is part of the subglacial plumbing system that can be thought of as the lubricant that makes the ice sheet flow faster.

At its most fundamental level, IPY 2007-2008 is envisioned to be an intense, coordinated field campaign of polar observations, research, and analysis that will be multidisciplinary in scope and international in participation. IPY will provide a framework to undertake projects that normally could not be achieved by any single nation. It allows us to think beyond traditional borders—whether national borders or disciplinary constraints—toward a new level of integrated, cooperative science. A coordinated international approach maximizes both impact and cost effectiveness, and the international collaborations started today will build relationships and understanding that will bring long-term benefits. Within this context, IPY will seek to galvanize new and innovative observations and research while at the same time building on and enhancing existing initiatives. IPY will serve as a mechanism to attract and develop a new generation of scientists and engineers with the versatility to tackle complex global issues.

In addition, IPY is clearly an opportunity to organize a range of education and outreach activities designed to excite and engage the public, with a presence in classrooms around the world and in the media in varied and innovative formats. The IPY will use today's powerful research tools to better understand the key roles of the polar regions in global processes. Automatic observato-

Earth Observing Satellites to Play an Important Role in IPY 2007-08

Alan B. Ward, NASA Goddard Space Flight Center, EOS/SMD Project Science Office, award@sesda2.com

Satellite remote sensing will play an extremely important role in IPY 2007-08. Fifty years ago, when the last "international year" occurred, the launch of Sputnik had just occurred and the satellite age was just beginning. Prior to Earth observing satellites, observations at the poles required long, difficult, and expensive journeys to some of the most desolate and inaccessible places on the planet. Consequently, even with the concentrated international cooperation and coordination that characterized previous IPYs, ground-based observations at the poles were difficult, and data on the climate at the poles remained scarce.

The Earth observing satellite era that began in the 1960s and continues today has opened up an entirely new vantage point for studying the Earth and revolutionized scientific observations. Satellite observations have been especially helpful for polar research. Satellites can view the poles from orbit and observe a much larger area much more frequently and continuously than conventional ground observations ever could. They can view areas where ground observations are difficult and expensive at best, and in many cases, impossible. The information returned from NASA missions such as Terra, Aqua, Landsat-7, Jason-1, QuikScat, the Ice Clouds and Land Elevation Satellite (ICESat), and the Gravity Recovery and Climate Experiment (GRACE) in the last few years has revealed much about the polar environment that was previously unknown. Satellite observations conducted as part of IPY 2007-08 will supplement and enhance the observations taken on the ground as part of the field campaign. Taken together, this new information is expected to continue to push back the frontiers of scientific discovery and make important contributions in helping IPY participants better understand the factors that drive environmental and social changes at high latitudes—i.e., how society is changing the poles and how changes at the poles impact society.

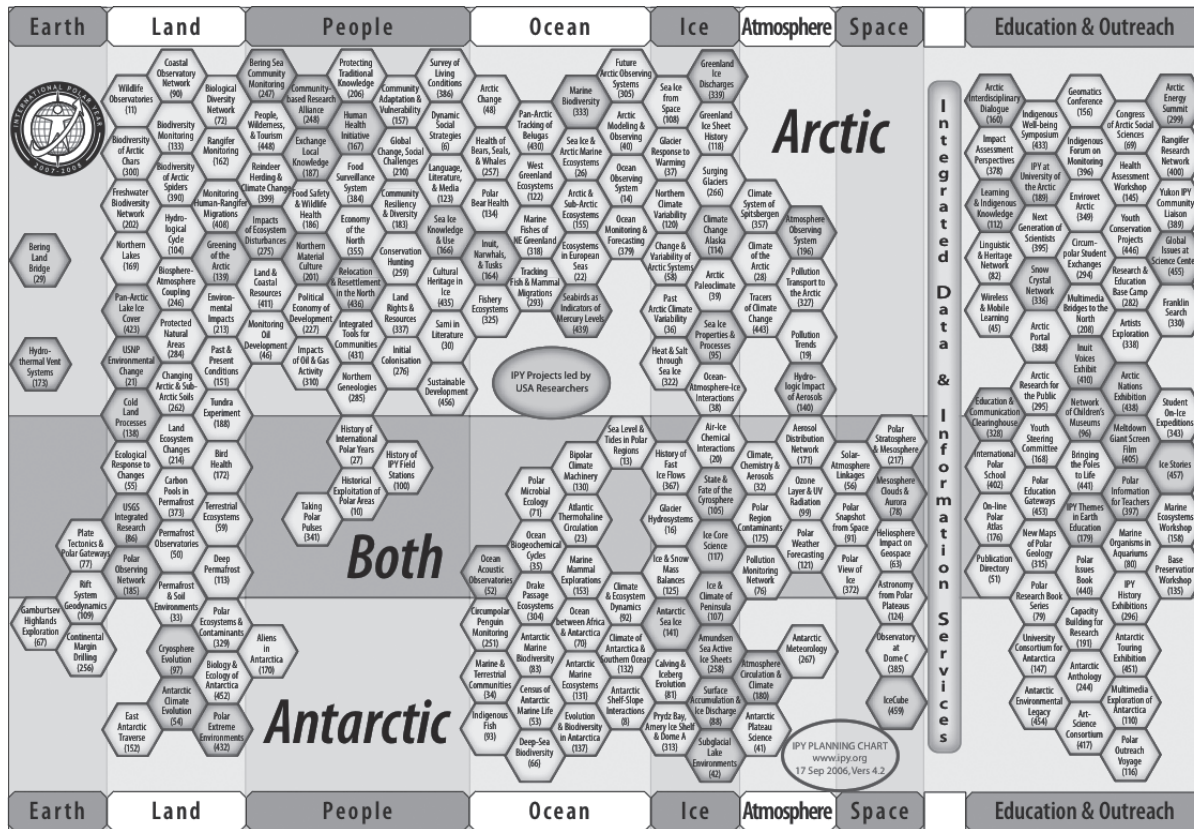


Figure 3. The diagram above illustrates the width and breadth of activities planned as part of IPY, both in terms of geographic location studied and in terms of discipline focus of the various activities. Activities are planned that focus on the Arctic, the Antarctic, and some which focus on both the Arctic and the Antarctic. The activities cover a wide range of disciplines including a large number of education and outreach activities. Each cell above represents a major program with an international team of scientists working together to increase our knowledge of our planet.

ries, satellite-based remote sensing—see *Earth Observing Satellites to Play an Important Role in IPY 2007-08*—autonomous vehicles, Internet, and genomics are just a few of the innovative approaches for studying previously inaccessible realms. IPY 2007-2008 will be fundamentally broader than past international years because it will explicitly incorporate multidisciplinary and interdisciplinary studies, including biological, ecological, and social science elements.

IPY 2007-2008 is an opportunity to deepen our understanding of the polar regions and their global linkages and impacts, and to communicate these insights to the public. IPY planners have identified five broad scientific challenges to be addressed:

- Assessing large-scale environmental change in the polar regions, with questions looking at both the physical and human dimensions of change and its impacts.
- Conducting scientific exploration of “new” frontiers, whether these are once inaccessible places beneath the ice sheet, or areas of inquiry that are now open because of advances in technology, such as how the tools of genomics now allow exploration of previously unanswerable questions about biological adaptation.

- Observing the polar regions in depth, with adequate coverage of the vast and challenging landscape, to provide a description of current conditions and allow for better future understanding of variability and change.
- Understanding human-environmental dynamics in a region where the connections are intimate and where the impacts of change are clear.
- Creating new connections between science and the public, using these regions that are inherently intriguing.

One of the major differences between the upcoming IPY 2007-2008 and its predecessors is the recognition that the physical world and the biological world and human society are intimately interrelated. This upcoming IPY is inherently about not just science, but science in support of human interests. It includes work in engineering, medicine, sociology, and human-environment interactions. The present map of 225 IPY projects—**Figure 3**—highlights the geographic and discipline breadth of the IPY 2007-2008. Each cell represents a major program with an international team of scientists working together to advance our knowledge of our planet, producing a tremendous multiplicative

effect. The net result will be a huge leap forward in our understanding of polar processes, physical, biological, and social, and their global connections.

Previous IPY efforts were characterized by very top-down planning and generally driven by the military. For example, under the oversight of Abraham Lincoln's son, Robert Todd Lincoln, then head of the Department of War, the Army led U.S. participation in the first IPY in 1882-83. The science priorities for the upcoming IPY, on the other hand, emerged from *grass roots* planning, international scientific groups, U.S. agency input, and help from the U.S. National Academy of Sciences and National Academy of Engineering.

Beginning in 2002, with the support of more than two dozen members, the National Academies invested some of its own endowment funds to launch the IPY planning process within the U.S. The chair of that first effort was Mary Albert of the Army's Cold Regions Research and Engineering Laboratory. She led a committee that sought wide input on whether the U.S. should participate in IPY and, if so, what we should hope to accomplish. The committee led a series of web discussions, gave talks at numerous professional meetings, met with agency leaders, hosted a multi-day workshop, and compiled contributions from 13 federal agencies into an initial planning document. The report, *A Vision for International Polar Year 2007-2008*—for a summary see dels.nas.edu/dels/rpt_briefs/ipy_final.pdf—was released early in 2004 and came to be the foundation for much of the international planning as well. This early investment of financial and intellectual capital put the U.S. in a position to play a leadership role in planning the IPY internationally.

The U.S. plays a leadership role in 52 of the 225 IPY projects (20%) and is participating in 80%. Right now, everything is still conceptual—what will actually happen on the ground is still being determined, both here and in other nations. There is an international IPY Programme Office, staffed by David Carlson and hosted in Cambridge, England, by the British Antarctic Survey. There is also an international planning committee, called the Joint Committee, of which I am a member, and various subcommittees devoted to data management, observation systems, and education and outreach. It's a very lean administrative organization for such a complex undertaking.

While planning for IPY started with the scientific community, all the federal agencies with cold regions responsibilities play roles in implementation. When the

National Academies hosted a workshop to encourage agency coordination in 2004, 13 agencies participated. At the request of the White House, the National Science Foundation serves as the lead federal agency. (In Alaska, the University of Alaska Fairbanks has stepped forward as the state-wide leader.) NSF has shown real leadership in its role, holding interagency planning meetings, initiating a multi-agency website—www.nsf.gov/od/opp/ipy/ipyinfo.jsp—and establishing mechanisms to fund science and education/outreach proposals. The National Academies continues to provide coordination through the Polar Research Board, which acts as the U.S. National Committee for IPY. The Polar Research Board hosts an IPY website—www.us-ipy.org—distributes an IPY e-newsletter, communicates information to and from the international Joint Committee, and holds meetings as needed to accomplish IPY planning and coordination. (In early October, the Polar Research Board hosted a meeting of the IPY secretariats so the staff working on IPY behind-the-scenes could coordinate.)

In conclusion, I want to think ahead about the societal benefits of the International Polar Year. Just as the IPY and the emerging science programs are multifaceted and multidisciplinary, the benefits of the IPY will be multifaceted and multidisciplinary. The IPY will advance our fundamental understanding of our planet—from the polar ecosystems to the subglacial terrains. The IPY will improve our understanding of the processes of change and that complex double-edged sword of how society is influencing change and how change is influencing society—especially the inhabitants of the north. The IPY will inspire a spirit of discovery across all ages and help us develop the next generation of our nation's leaders in science, engineering, education, industry, commerce, and government. At the international level, IPY will again show that even in the most difficult times, science can be an arena of international cooperation. IPY will foster the continued peaceful use of the polar regions, engage new partners in the global science community, and leverage precious scientific and logistical resources so that, in essence, we get more from our investments.

Why should the vast majority of us, who live in the warmer regions of the Earth, care about IPY? The polar regions, while physically distant, are critical links in the global climate system. Does this matter for the rest of the planet? Imagine holding an ice cube between your thumb and your forefinger. Beneath your fingers a pool of water forms quickly. The water will drip down your arms and down the ice cube. The changes at the end driven by the warmth of your fingers eventually impact

the entire ice cube. The relationship between the poles and the rest of the globe is analagous. The polar oceans play a critical role in maintaining ocean currents that keep coastal Europe much warmer than it would be otherwise, and the sea ice cover modifies Earth's surface temperature by reflecting solar energy. Melting ice sheets will raise sea levels, threatening coastal communities around the world. The polar regions are integral components of the Earth system that both respond to and drive changes elsewhere on the planet.

The polar regions also hold unique information of Earth's past climate history, and they are growing in economic and geopolitical importance. They are a unique vantage point for studies that will help scientists understand environmental changes in the context of past changes, which in turn will help us make informed choices for our future. The exploration of new scientific frontiers in the polar regions also will lead to new discoveries, insights, and theories potentially important to all people.

In summary, International Polar Year 2007-2008 will leave us important legacies:

- an improved understanding of environmental status and change;
- more comprehensive data and the ability to understand trends in the future;
- improved observation systems to capture future environmental change;
- a continued spirit of exploration into new frontiers of science;
- a new and inspired generation of scientifically literate citizens and leaders; and
- an enhanced level of international cooperation to address global scale issues.

ANNOUNCEMENT: IPY News

IPY Opening Ceremony

The Opening Ceremony for the International Polar Year 2007-2008 (IPY) will take place on Thursday March 1, 2007, in Paris at 1000 Greenwich Mean Time (GMT). The IPY Joint Committee, members of the IPY Programme Office (IPO), and guests will attend the ceremony. The IPO will issue an IPY international press release on February 26, as part of the lead up to the Opening Ceremony.

There will also be many national and regional launch events planned for the weeks leading up to and after the IPY Opening Ceremony. At the recent IPY Education and Outreach (EOC) sub-committee meeting, a temporary Launch Event Task Force was established. This group will look for ways to encourage and connect the many events. The Formal Education Working Group of the EOC sub-committee is also working on plans to involve as many schools as possible.

As your national and regional plans develop, please provide details to Camilla Hansen camilla.hansen@vr.se so that we can add these events to both the list of launch events and to the IPY calendar.

New IPY Website

The IPO launched a new website January 15, 2007, at dept.kent.edu/Polar/. In addition to introducing IPY and its projects, science, and history, there are specific pages for educators, media, youth, and IPY participants. There is a blog, calendar, and a section conveying the latest IPY news.

Cloud to Cloud: Forecasting Storm Severity with Lightning

Laura Naranjo, National Snow and Ice Data Center, naranjol@nsidc.org

Summertime in northern Alabama means sunny family picnics and lazy afternoons by the pool. But clear skies often rapidly fill with storm clouds that can produce tornadoes, hail, and lightning. While the sudden eruption of severe weather may thrill a storm chaser, it can make a forecaster cringe. Weather conditions can worsen rapidly, sometimes giving forecasters little time to assess a situation and even less time to issue a warning. Forecasters must monitor a variety of constantly changing factors affecting storm formation, but researchers have discovered that one in particular can reveal important clues about an impending storm's severity: lightning

Mapping the frequency of lightning

Richard Blakeslee has studied the relationship between lightning and storm development for more than 25 years. As a senior research scientist at the Global Hydrology and Climate Center (GHCC) in Huntsville, Alabama, Blakeslee has relied on a variety of methods to research lightning, and has helped develop satellite sensors to monitor lightning on a global scale. But to better understand how lightning can help make storm forecasting more accurate, he also conducts research in his own neighborhood, incorporating data from the North Alabama Lightning Mapping Array (LMA), a set of sensors that began operating in 2001.

"The Lightning Mapping Array maps out lightning discharges within the clouds, providing a three-dimensional map of the lightning as it develops," Blakeslee said. The network consists of 11 receivers that cap-

ture detailed lightning observations. The LMA was initially deployed to validate the Lightning Imaging Sensor aboard the Tropical Rainfall Measuring Mission (TRMM) satellite, but LMA data are also proving useful to regional forecasters on the ground. Every two minutes, data from this network are forwarded to the National Weather Service office in Huntsville responsible for forecasting in 11 northern Alabama counties and 3 southern Tennessee counties. The data are also provided to nearby forecast offices in Nashville, Tennessee; Birmingham, Alabama; and Jackson, Mississippi.

Using the new LMA data, Blakeslee and his colleagues studied two thunderstorms that occurred over northern Alabama in 2002, and discovered that lightning activity increased dramatically just before the storms intensified and became severe. The researchers also incorporated cloud-to-ground lightning data from the National Lightning Detection Network (NLDN). NLDN data are acquired by the Global Hydrology Resource Center (GHRC) from Vaisala, Incorporated, and made available to approved NASA Earth Observing System (EOS) and TRMM investigators. This combination of data allowed the team to observe the total lightning flash rate, including cloud-to-ground, intracloud, and cloud-to-cloud lightning.

By looking at the flash rate maps, the researchers discovered a pattern: **an increase in total lightning activity followed by a dramatic decline often indicated the development of strong storms.** This pattern of lightning activity often even preceded the occurrence of cloud-to-ground lightning strikes by several min-



Lightning illuminates a funnel cloud forming during a storm near Huntsville, Alabama, in April 2006. Alabama's turbulent weather gives scientists frequent opportunities to study lightning and storm development. **Credit:** © Wes Thomas Photography.

utes—information forecasters could use to issue earlier warnings to communities and airports in a storm's path.

From data to forecasts

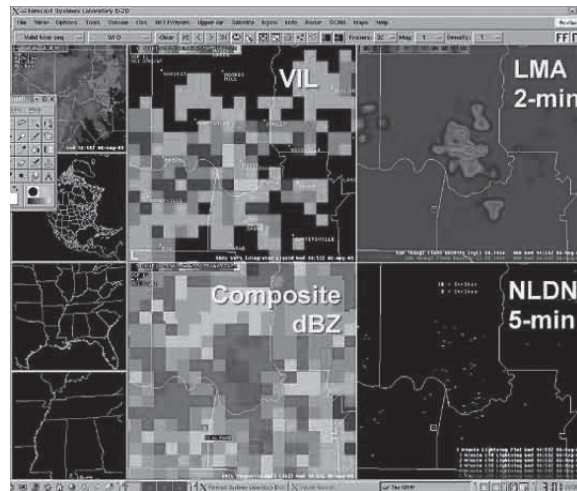
One of the challenges, however, was making the lightning maps accessible to forecasters. "Forecasters do not actually look at the data that the researchers look at. We had to get the data into a format that forecasters could understand," Blakeslee said. Weather service forecasters rely on the Advanced Weather Interactive Processing System (AWIPS), an interactive computer system that integrates meteorological, satellite, radar, and other data, often all in one display screen. "When the weather gets severe, forecasters are glued to their AWIPS displays. If the lightning data are not available there, they're not going to be used," Blakeslee said.

To develop a solution, the lightning team collaborated with **Chris Darden**, Science Operations Officer at the Huntsville National Weather Service office, which is co-located with GHCC. Darden was familiar with northern Alabama's unruly weather and understood the need for data that forecasters could use quickly and easily. Darden said, "The goal of the weather service is the protection of life and property, and that ties right back into the warning aspects for severe thunderstorms and tornadoes."

In addition, scientists at the Short-Term Prediction Research and Transition (SPoRT) Center, which is co-located with GHCC and the Huntsville National Weather Service Office, partnered in the project. Researchers at SPoRT focus on improving short-term weather forecasts by integrating NASA Earth science data. Darden said, "I worked with the SPoRT researchers and developers to look at the technology and data sets that they had available, and how the National Weather Service might use them operationally."

Together, they designed products from LMA data that could be used in the AWIPS displays. Although forecasters often prefer a single-gridded graphic of lightning density that conveys a lot of information, they can choose other ways to view the lightning data. "We can view the summary by itself or overlay it directly onto our radar or satellite data. Or, we can look at individual levels, ranging from ground level to 17 km (10.5 mi) above the surface," Darden said. Each of these levels is like looking at a "slice" of a storm. This allows forecasters to see lightning density at different altitudes and help them assess a storm's development. "We now utilize the LMA maps a lot when developing our early warning decisions," Darden said.

The lightning maps are also useful for weather prediction because their coverage overlaps that of radar and other data sources that forecasters rely on. Storms do



To track the progress of severe weather, forecasters rely on the Advanced Weather Interactive Processing System (AWIPS) display. This AWIPS display includes Lightning Mapping Array (LMA) data (upper right corner) as a single-gridded graphic showing lightning flash density. The display also shows National Lightning Data Network (NLDN) data, vertically integrated liquid (VIL) measurements, and radar reflectivity composites. **Credit:** SPoRT.

not always develop neatly within the circular sweep of radar beams. Blakeslee said, "Where a storm is located relative to the radar system may make it difficult for the forecasters to know exactly what's going on, meaning that they miss some of the details. But the lightning data can help compensate for some of that."

Predicting severity, protecting lives

Even with the most advanced equipment and data, summertime weather often poses special problems for forecasters. Not only are more people likely to be outdoors and vulnerable to severe weather, but short-lived storms, called *pulse storms*, are more common. Pulse storms are small, isolated storms that last less than thirty minutes. Darden said, "Pulse storms can develop and diminish quite rapidly. They evolve so quickly that it's difficult to provide much warning or lead time." Although pulse storms pose the greatest danger to aircraft, they can also produce hail, heavy rainfall, and weak tornadoes, endangering people and property on the ground. "On a particular day, forecasters may have to track 20 or 30 storms, but only one or two of them will produce severe weather," Darden said. Forecasters need an indicator to tell them which storms are more likely to become dangerous.

Lightning may be one of those indicators. Blakeslee said, "When forecasters are not quite sure about the severity of a storm, lightning data may tilt the balance one way or the other. **Lightning can be that confirming bit of observation that indicates we definitely need to issue a warning.**"

By taking advantage of the advance notice provided by the lightning maps, forecasters have been able to

more accurately predict the onset of severe weather. Darden said, "We can correlate flash rates directly to the strength of a building thunderstorm. In certain cases, we've issued a warning for a storm after seeing a surge in lightning rates." The additional few moments of warning may be especially useful when dangerous weather erupts over populated areas. Blakeslee said, "A tornado warning delivered five or ten minutes early might really make a difference in whether a person is able to get to shelter."

LMA data have also revealed some unexpected characteristics of electrical charges during storms. The data can sometimes indicate lightning in areas where forecasters would not normally expect it to be. "The data are showing occasional cloud-to-ground lightning strikes trailing a system, miles from the front, and well away from the really severe weather activity," Blakeslee said. When forecasters spot this additional lightning hazard, they can now alert people who may otherwise feel safe resuming outdoor activities after the worst part of a storm has passed.

The Huntsville weather forecast office also uses lightning maps to help issue weather warnings for the local airports and to develop aviation and terminal forecasts. "These kinds of systems are only now being explored in terms of how they can help with forecasting ramp and ground operations. I think we're going to see more of that kind of activity in the future," Blakeslee said. One such network is the DC Metro LMA in Washington, DC which began operating during the summer of 2006. Washington, DC is home to three major international airports, making this a high-profile project for studying lightning and aviation. Lightning and severe weather frequently affect flight schedules, so forecasters are interested in using lightning data to improve airport forecasts, particularly when potentially severe weather begins to develop. Advanced warning that severe weather is approaching gives air traffic controllers extra time to respond. They can halt departures and detour incoming flights, keeping passengers and crew out of dangerous weather. Likewise, advanced warning of severe weather gives ramp workers and other airline staff more time to get to shelter.

Learning from lightning

In addition to northern Alabama and Washington, DC, lightning mapping networks are operating in Texas, Oklahoma, Florida, and New Mexico. While scientists are still probing the many aspects of lightning, they have gleaned valuable information from studying LMA data. Blakeslee said, "We've learned a lot through the years about how storms generate electricity and how they operate."

Researchers like Blakeslee and Darden will continue to analyze data from a variety of sources, such as the LMA networks and satellite sensors. Whether they learn more about specific storms or about broader aspects of electrical discharges in the atmosphere, each new bit of knowledge about meteorological processes brings forecasters a step closer to more accurate weather predictions and more timely forecasts. And this knowledge might help forecasters and Alabama residents, alike, plan ahead for wayward summertime weather.

Reference

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Story originally published in *NASA: Supporting Earth System Science 2006* (Boulder, CO: National Snow and Ice Data Center). ■



On November 24, 2001, a series of tornadoes swept across Alabama, striking a mobile home community near New Hope. One tornado damaged 21 homes, completely destroyed 8, and overturned vehicles. The tornado path was 4.18 km (2.6 mi) long, and as wide as 275 meters (900 feet). While causing considerable damage, this tornado caused no fatalities or injuries. Several residents of the damaged mobile home community heard the National Weather Service Tornado Warning on television and were able to take cover in underground storm shelters. **Credit:** Birmingham National Weather Service.

Earth & Sky Promotes Earth Science

NASA is one of the sponsors of *Earth & Sky*, an award-winning syndicated radio program hosted by **Deborah Byrd** and **Joel Block** that is broadcast more than “six million times every day across the globe.” The program’s focus is on scientists “trying to understand and solve human challenges here on Earth.”

Block and Byrd interview hundreds of these scientists each year trying to build a bridge of understanding between the scientists and the general public. Over the years, numerous scientists associated with NASA’s Earth Observing System have been interviewed for a 90-second segment. For a recent interview with Steve Goodman, Science and Missions Systems Office, Marshall Space Flight Center, titled *Space-based lightning studies could save lives* go to www.earthsky.org/radioshows/50798/space-based-lightning-studies-could-save-lives go to www.earthsky.org/radioshows/50798/space-based-lightning-studies-could-save-lives. For a radio station that broadcasts *Earth & Sky* in your area go to www.earthsky.org/about/32/radio-affiliates.

Two EOS Scientists Receive 2006 Presidential Rank Awards For Meritorious Senior Professional

Michael D. King, [Goddard Space Flight Center, *EOS Senior Project Scientist*], and **Bruce A. Wielicki**, [Langley Research Center, *Principal Investigator for Clouds and the Earth’s Radiant Energy System*], were among the recipients of the 2006 Presidential Rank Award for Meritorious Senior Professionals. Each year, the President recognizes and celebrates a small group of career Senior Executives with the President’s Rank Award for exceptional long-term accomplishments. “Winners of this prestigious award are strong leaders, professionals, and scientists who achieve results and consistently demonstrate strength, integrity, industry, and a relentless commitment to excellence in public service.”

Award winners are chosen through a rigorous selection process. They are nominated by their agency heads, evaluated by boards of private citizens, and approved by the President. The evaluation criteria focus on leadership and results.

The *Earth Observer* staff and the entire scientific community congratulate King and Wielicki on this outstanding accomplishment.

Overview of the MODIS Science Team Meeting

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Introduction

Vince Salomonson [University of Utah—*Moderate Resolution Imaging Spectroradiometer (MODIS) Science Team Leader*] convened the 27th formal, recorded meeting of the MODIS Science Team (MST). The meeting was held in Adelphi, MD at the Marriott Inn and Conference Center, University of Maryland University College October 31 - November 2, 2006. Over 240 people formally registered for the meeting and total attendance was over 250. Plenary sessions occurred on October 31 and November 2. Ocean, atmosphere, land, and instrument status group meetings occurred October 31 through November 1. Overall there were approximately 90 poster papers presented, 22 oral presentations in plenary sessions and over 50 presentations in group meetings along with discussion of plans and upcoming objectives. The majority of the presentations, minutes, and the agendas for the meeting can be found at modis.gsfc.nasa.gov/sci_team/meetings/200610/.

Salomonson observed that there has been a lot of forward progress in development and distribution of MODIS products along with a continuing growth in uses of MODIS observations for science and applications. As metrics of the extent and use of MODIS data, he noted in his opening remarks that there are now approximately 1,300 refereed publications related to MODIS listed in the *Web of Science*, with about 1 refereed publication per day in the last two years. At the time of the MST meeting, 301 refereed publications were listed in the *Web of Science* during 2006 (373 by mid-December). In the last two months preceding the MST meeting, MODIS-related publications appeared in 19 different journals. In addition, over 150 Direct Broadcast Stations provide MODIS data to an estimated 800 or more entities for a wide variety of applications—see the presentation by **Liam Gumley** and **Pat Coronado** in the plenary session on the first day of the meeting at the website above. A major matter to be addressed in upcoming months is preparing proposals for extending the Terra and Aqua missions—both with MODIS on-board. As will be described later in this summary, a NASA (HQ) Headquarters Senior Review Panel will review these proposals in the spring of 2007.

The meeting covered a wide range of topics including programmatic and planning issues as well as a wide assortment of results related to science and applications uses for land, atmosphere, and ocean products. The following sections will provide summaries for the major elements covered in the meeting.

NASA Headquarters Views and Guidance.

Paula Bontempi [NASA HQ—*MODIS Program Scientist*], **Jack Kaye** [NASA HQ—*Associate Director for Research, Earth Sciences Division*], and **Steve Volz** [NASA HQ—*Program Executive for the NASA Headquarters Senior Review for extending science missions*] all provided valuable guidance to the Science Team on programmatic emphases, challenges, and directions. Additionally **James Gleason** [Goddard Space Flight Center—*NPP Project Scientist*] gave the team a comprehensive description of the status of the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) instruments and mission development.

Bontempi gave some comments at the beginning of the meeting that described the updated Headquarters organization and 10-year, advanced planning activities ongoing in the Science Mission Directorate (SMD). NASA has been tasked to develop a full 10-year science plan by the end of 2006. This plan will be delivered in December.

On a larger scale, the NASA/National Oceanic and Atmospheric Administration (NOAA)/U.S. Geological Survey (USGS)-initiated *decadal survey* being conducted by the National Academies will be delivered in January 2007. NASA will reconcile the recommendations from the *decadal survey* and science roadmaps and then use those conclusions to develop a funding roadmap.

Kaye gave a noon presentation on the second day of the meeting, and described the new NASA mission and vision statements. In the new NASA Strategic Plan, Goal 3 incorporates the science program and includes all four divisions in the SMD. NASA Earth Science supports multiple presidential initiatives, including the Climate Change Science Program, the Group on Earth Observations, and the Ocean Action Plan. Congressional direction links NASA and NOAA. NASA is involved in the NPOESS program, which is an important part of future space-based Earth observations. Unlike other areas in the SMD Earth Science ties its research and applications plans to the public good. Headquarters is now working toward a new science plan. The plan will explain missions that we have, why they are important, and then lists new priorities and rationale. Priorities are NPOESS, Landsat data continuity, ocean surface topography mission, etc. The plan must show what can be done with the budget we expect to have.

Volz discussed the upcoming senior review in the opening plenary session. He said that the aforementioned NASA Headquarters Senior Review conducted in 2005 was adopted from the process historically used by space science to evaluate missions that are in an extended mission phase. The 2005 review was the first such review for Earth science missions, but the individual missions, including the Terra mission, responded well to the call for proposals and, in fact, the Terra mission was prioritized quite highly in the final results of that review.

The next Senior Review is planned for the spring of 2007. In Earth science, nearly every mission (e.g., Terra and Aqua) will be part of the senior review this year except for the Aura and Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) missions. The 2007 review will establish the budget for fiscal years 2008 and 2009. The Senior Review Panel will be drawn from outside of NASA. The chair will be from the 2005 review panel, but the other panel members will be new and will be drawn from all research areas. The primary criteria for the 2007 review will still be scientific relevance. Secondary criteria include efficiency and cost effectiveness, risk management, multiple instrument and satellite utility of data products, quality and timeliness of baseline data products, and education and public outreach. The schedule for the 2007 review is as follows: the draft letter for proposals will be sent out by the end of November 2006; the final call for proposals is expected to be issued in mid-December 2006.

Bontempi, in the closing plenary session, again emphasized the importance of the ongoing future planning at HQ for NASA Earth science along with the NASA/NOAA/USGS decadal survey that will be released in early 2007.

Bontempi reported that 322 proposals have been received for the on-going process for the NASA Research Announcement (NRA) element on Terra, Aqua, AC-RIM, and NPP *Earth Observing System (EOS) Re-compete*. Panels will convene in January or February 2007, and will strive to conclude deliberations between May and July so as to be compatible with relevant grant and contract renewal dates.

In future *measurement teams*—as opposed to mission or instrument teams—there will be a challenge to continue evolving measurement streams. It is expected that there eventually will be one science team, competed periodically, that provides scientific guidance to present and future missions and to the utilization of past data sets. Future competitions will encompass MODIS and the Visible Infrared Imager Radiometer Suite (VIIRS) instrument on NPP.

On a related matter, Earth Science Data Records (ESDRs) are an essential method of maintaining data products that will yield new scientific understanding of planet Earth and how it is changing. Therefore, it will be necessary to decide what MODIS products are key for climate variability and change research. Not only does the team need to decide what products are necessary, they must also decide where to get funds for data processing, calibration, and validation efforts.

There is also a need for a plan to review Algorithm Theoretical Basis Documents (ATBDs) for new and alternative EOS algorithms. In addition, current algorithms and products need to be reviewed to see what needs to be updated, and ATBDs need to be prepared for new algorithms and data products.

In summary, Bontempi felt the interdisciplinary nature of the science she saw at the MST meeting was impressive. In terms of public outreach and publication, the process to get the message out seems to be more difficult than it should be. Perhaps there is a need for more than a news feature or press release. Perhaps a five-year NASA science update may be developed and the update could be interdisciplinary with a twist of applied science or focus on high latitudes for the International Polar Year. Overall Bontempi felt that accomplishments of the MODIS science team and maturity of the science is very good and should be continued as much as possible.

MODIS Atmospheres Overview

Michael King [GSFC—*MODIS Atmosphere Discipline Group Leader*] summarized some of the key advancements achieved in MODIS atmosphere algorithms, processing and scientific results during the opening plenary session. **Paul Menzel** [University of Wisconsin] provided a complementary, special presentation in the opening plenary session describing intercomparisons of MODIS, and Atmospheric Infrared Sounder (AIRS) results that were facilitated by the HYperspectral-viewer for Development of Research Applications (HYDRA), a special data analysis tool developed at the University of Wisconsin.

King described the overall status of the MODIS atmosphere products, focusing on *Collection 5*—the latest reprocessing of MODIS data—and Level 3 products. He showed examples from *Collection 5* and described changes from previous collections. The MODIS atmosphere team produces daily, weekly, and monthly products with all products in a single file. Starting with *Collection 5*, atmosphere products use internal hdf compression in all files, thus decreasing the file size for easier download and distribution. Product Quality Assurance (QA) statistics are on the web. Some properties

were added or changed in *Collection 5*. Cloud fraction day and night results are now very similar, where night cloud fraction was high over oceans in previous collections. One significant climate question had been: *what is the impact of cloudiness in the morning versus the afternoon?* From July 2002 to 2004, global cloud fraction was not that different between Terra (morning) and Aqua (afternoon) on average. King compared cloud top properties for *Collection 4* to those for *Collection 5*. Cloud top height is up a little over land. In terms of cloud optical thickness, liquid water clouds are higher over continents than over oceans. Ice clouds have higher optical thickness. The color bar for *Collection 5* products has been changed to make values easier to read. In the monthly mean cloud effective radius product, ice cloud particles are larger than liquid water cloud particles, and are better behaved in polar regions of both Hemispheres. A new property in *Collection 5* is the cloud effective radius uncertainty. Another new property in *Collection 5* is the assessment of multilayer clouds. King observed that this property could be profitably compared with CALIPSO and CloudSat data.

There have been substantial changes in the computation of the fine mode fraction in aerosol optical thickness over both ocean and land, although there is no significant difference in ocean aerosol optical thickness between *Collections 4* and *Collection 5*. Over land, however, there is a reduction in aerosol optical thickness over high latitudes where snow contamination has been eliminated. Ocean and land aerosol optical thickness matches much better in *Collection 5*. The fine mode fraction over land has improved dramatically, and the fine mode fraction over ocean saw a significant decrease as well, when compared to *Collection 4*.

The modeling and science community are interested in the *Deep Blue* algorithm for retrieving aerosol optical properties over bright reflecting surfaces, such as deserts, where the operational MODIS aerosol algorithm is not able to obtain a viable retrieval. The *Deep Blue* algorithm will be a part of *Collection 5* and will be delivered in January 2007. *Deep Blue* has been tested using Sea-viewing Wide Field-of-view Sensor (SeaWiFS) data as well as MODIS data. A new paper compares the use of the *Deep Blue* algorithm in observing Asian dust storms using MODIS and SeaWiFS with results obtained with the MODIS and Multiangle Imaging Spectroradiometer (MISR) operational algorithms.

The monthly mean precipitable water product is being produced with both near-infrared and thermal infrared bands. *Collection 5* results show that the thermal infrared technique yields larger column water vapor than the near-infrared method. Monthly mean temperature profiles and global temperature profiles as derived from MODIS data should be compared with AIRS data.

Level 3 global browse images are available on the web for several products. Several resources are available on modis-atmos.gsfc.nasa.gov. *Collection 5* enhancements and reprocessing are complete for Aqua; enhancements for Terra should be complete by early January 2007. Data are available on the Level 1 and Atmospheres Archive and Distribution System (LAADS) at ladsweb.nascom.nasa.gov.

King addressed the plenary session on the last day of the meeting and summarized findings obtained from the atmospheres group sessions. The atmosphere discipline group focused on data use and validation investigations with 23 presentations that included some cross-disciplinary talks and new science results—for details see the MODIS atmospheres group agenda at modis.gsfc.nasa.gov/sci_team/meetings/200610/atmos Agenda.pdf and the MST minutes. In addition the group discussed needs and plans for *Collection 6* and justification for mission extension.

King noted that new ATBD's describing *Collection 5* algorithms and characterization were released in the last few months. The last peer review was conducted in 1997, prior to launch, to aid the algorithm developers in making adjustments in their approaches to algorithms prior to launch. The new Algorithm Theoretical Basic Documents (ATBDs) are for aerosol properties, cloud mask, cloud top properties, and atmospheric profiles. A new QA plan with QA flags for *Collection 5* including flags for the *Deep Blue* product was recently completed and posted online at modis-atmos.gsfc.nasa.gov/reference_atbd.php.

The atmosphere team held an open discussion of senior review questions regarding Terra and Aqua for MODIS. The group outlined new science that has resulted from the unique capabilities of MODIS, and new applications developed due to the provision of MODIS instrument capabilities and accompanying data products. These applications include improvements in weather forecasts based on polar winds measured with MODIS water vapor, forecasts in air quality for the Environmental Protection Agency (EPA), strategic maps of aerosols, fires, and clouds for the military, and the growth of direct broadcast users.

The group outlined questions that they felt should be a part of the senior review for Terra and Aqua, including the following.

- What can an extended MODIS mission contribute to the modeling community?
- Do MODIS results indicate that models need to be improved?
- Do MODIS results offer ways to improve models? Why do we need two MODIS sensors?

- What new science could be done that requires 3 or more years of Aqua MODIS beyond the life of the mission?
- What new science results could be done with 3 more years of Terra MODIS?
- What new scientific objectives can be pursued if the Aqua and Terra missions (including MODIS) are extended?
- How important is it to extend Aqua and Terra in terms of climate data record?

MODIS Oceans Overview

Chuck McClain [GSFC—*Oceans Discipline Group Leader*] summarized in the MST opening plenary session the progress and status of ocean color, sea surface temperature (SST) products from MODIS, SeaWiFS, etc. In essence the report represented the fact that the group has taken on new responsibilities. The group now supports SeaWiFS, MODIS Aqua ocean color and SST, MODIS Terra ocean color and SST, NPP/VIIRS ocean color and SST, Aquarius, historical data, Glory mission data system development, and future mission concept development. New mission concepts include one called the Ocean Carbon, Ecosystems, and Near Shore mission (OCEaNs).

Since the last science team meeting, the ocean team has improved chlorophyll observations in coastal regions by incorporating high resolution land bands and short-wave infrared (SWIR) bands. (**Bryan Franz** reported on the results of this study as applied to the Chesapeake Bay later in this plenary session.) The ocean team also has incorporated a nitrogen dioxide (NO₂) absorption correction algorithm to improve coastal data. Near shore NO₂ levels can be high, and this affects data quality. The team is now working on developing a multi-sensor data set which includes a Global Ozone Monitoring Experiment (GOME), SCanning Imaging Absorption SpectroMeter for Atmospheric CHartography (SCIAMACHY), and Ozone Monitoring Instrument (OMI) time series.

The ocean team is reprocessing Coastal Zone Color Scanner (CZCS) and Ocean Color and Temperature Scanner (OCTS) data sets and updating current algorithms. A detailed description of these efforts is on the ocean color web site—oceancolor.gsfc.nasa.gov/. McClain also reported that the ocean team has been working with the NPP-NPOESS VIIRS ocean team to do Engineering Design Unit (EDU) testing and data analysis. The MODIS Characterization Support Team (MCST)—led by Jack Xiong—did a terrific job analyzing the Visible/Infrared Imager/Radiometer Suite (VIIRS) data in partnership with the ocean team.

McClain reported that work on processing MODIS Terra data for ocean color has started with a focus on

the most recent two years. Terra data are being processed because the team wants as many fully capable sensors on orbit as possible as the VIIRS launch date slips to increasingly later dates. Evaluation products are looking good. Work towards including Terra MODIS data in the ocean color data set is moving forward with Level 1 processing of data collected between January 2005 and the present. Evaluations of Terra data show some mirror side differences from Aqua data. The pattern of differences shifts seasonally which is indicative of uncorrected polarization sensitivity. McClain said work over the next few months will focus on resolving the differences between Aqua and Terra.

SeaWiFS is still working well and collecting global data. The primary high resolution data set is coming through NOAA. SeaWiFS has no orbit maintenance, so it has drifted to an afternoon orbit. As a result, the thermal environment is different, and the sensor sensitivity has changed as a result. SeaWiFS recently lost a GPS receiver and switched to a backup. After nine years, the sensor is still in good shape, but it is showing signs of wear and tear.

The Ocean Color Web site—oceancolor.gsfc.nasa.gov—is designed to provide a variety of services for the user community. Additionally the SeaWiFS Data Analysis System (SeaDAS) is constantly being enhanced.

Looking forward, the focus for the next few months will be on improving the data quality of Terra, revisiting the aerosol model suite, looking at the MODIS cloud mask for SST and possibly ocean color, working on refining SST products, reevaluating standard products, and thinking about reprocessing. The MODIS ocean team will work with the community to determine what kind of changes will be made for reprocessing.

McClain summarized the activities, reports, and discussions that occurred the previous days in the Oceans Discipline Group meeting—see the oceans group agenda at modis.gsfc.nasa.gov/sci_team/meetings/200610/oceansAgenda.pdf and the MST minutes for more details—in the closing plenary session. The ocean effort has moved forward in refocusing on measurements with tight connections to the MODIS calibration group.

Most of the discussion and presentations in the meeting were on topics other than MODIS. The University of Miami SST group—including **Peter Minnett** and **Bob Evans**—is making progress in improving the SST product. The SST efforts are using advanced radiometry at sea to validate products. Skin temperature measurements from the ship-based Mobile Atmospheric Emitted Radiance Interferometer (M-AERI) sensors are expanding significantly. The M-AERI has improved statistics on MODIS SST measurement biases, though

some systematic biases remain. The group is looking at other methods of validation to resolve the remaining biases, particularly at using microwave data. MODIS SST data are part of the global ocean data assimilation experiment. Notable improvements also have been made to the calcite product—e.g., **Barney Balch**, [Bigelow Laboratory for Ocean Sciences]—which is important in assessing inorganic carbon in the carbon cycle. Observations of calcite concentrations are also an important measure of climate change because of their connection to ocean acidification. Participation in four Atlantic Meridian Transect (AMT) cruises has been important in developing improved measurements of calcite.

The ocean group had a lengthy discussion about data merging. One debate in the group is what to do with CZCS. It is the only sensor that provided data before 1996, but the data aren't high quality and probably couldn't be used as part of a climate data record. The ocean group is trying to find ways to address the quality issues.

Significant progress has been made in data assimilation. Assimilating data into a coupled global ocean circulation-ecosystem model—e.g., **Watson Gregg**, [GSFC]—results in substantial improvements to the model, which could provide a large amount of information about the ocean.

The ocean group heard a report on a workshop about data requirements for the future. Workshop participants, many of whom are on the MODIS ocean team, wrote a plan on future missions and *in-situ* data collection strategies for the future. The group held a number of pigment analysis round robins, which developed into a good international activity. The analyses were needed because accurate field measurements are necessary for accurate satellite validation. The group discussed vicarious calibration for ocean color measurements, and discussed their potential role in maintaining VIIRS standards and capabilities—i.e., working with the Integrated Project Office (IPO) and Raytheon to insure VIIRS measurement accuracy meets oceans requirements—for ocean data and decided, though their exact future role is uncertain, they need to be prepared for the VIIRS mission. The oceans group is working to understand the VIIRS instrument as well as possible. They are involved in pre-launch testing and analysis so they are prepared to step up and process data down the road if required.

McClain also provided an overview of other significant developments.

Stephanie Maritorena [University of California/Santa Barbara] has developed a semi-analytic model of water leaving radiances that is being used to generate global

chlorophyll-a and other products. The model combines SeaWiFS and MODIS Aqua data. It is not ready to be used operationally because of differences between open ocean and coastal waters. The model needs to be more adaptive to account for these differences. Merging data increases the amount of daily coverage.

Stan Hooker [NASA/GSFC] reported that three pigment round robins have been completed and a fourth has been initiated. Twelve labs have been involved in the current round robin. As a result of round robins, labs have been improving their methods, which reduces noise and variability in field data sets. NASA-funded investigators currently submit pigment samples to one laboratory for analysis. Data from quality assured labs is consistently more accurate than data from non-quality assured labs. The round robin activity is expected to expand to other topics.

MODIS Land Overview

Chris Justice [University of Maryland College Park—*Land Discipline Group Leader*] summarized the progress and status of MODIS land products and *Collection 5* in the opening plenary session. **Steve Running** [University of Montana—*Member of the MODIS Land Team*] recently hosted an international workshop focusing on the current status of global vegetation monitoring. (Running gave a more detailed review of this workshop later in this plenary session.) The use of MODIS data for land studies has exceeded even our most optimistic expectations and has been an unprecedented success for NASA's terrestrial program. Justice showed an example video to illustrate the broad visibility of MODIS data. A national weather report in South Africa routinely includes MODIS fire distribution maps and MODIS imagery. Established users are getting more sophisticated in their use of the data, and new users continue to discover MODIS. The number of user inquiries about the land products is increasing and is placing an additional burden on the team. The numbers of practical applications of the data for societal benefit are growing and making a practical and real contribution to the international Global Earth Observing System of Systems (GEOSS). Many operational users are concerned about operational continuity of the data flow, and this matter needs to be given strong consideration by the Headquarters Senior Review Panel to be convened, as previously noted, in the spring of 2007.

Preparing for *Collection 5* has been a major effort for the MODIS land community. Justice reported that extensive testing has been done and this has resulted in a delay in the release date for *Collection 5*. The science testing included 7 major tests and 50 smaller tests that took longer than anticipated. *Collection 5* processing started in June, and Terra reprocessing is now progress-

ing. The change-over from *Collection 4* to *Collection 5* for forward processing occurs January 1, allowing a full calendar year of data to be available under *Collection 4* for 2006. Science improvements have driven the changes made for *Collection 5*. Testing was done in a more organized way than previously with global tests and time-series tests. Global tests were produced for 16-day data periods in 2003. Time series tests for distributed locations included data from a full year. Problems with the code that emerged during testing were fixed, and all changes have been posted on the web site. Land data evaluation also improved the time series. Changes in *Collection 5* include improved surface reflectance and an improved daytime/nighttime land surface temperature product. Artifacts that existed in *Collection 4* land surface temperature products were removed. Additionally *Collection 5* changes include an improved resolution albedo product, a regional tuning of the vegetation continuous fields product, a five-year product of vegetation change for the Amazon and the global burned-area product. *Collection 5* has also reduced all product sizes significantly. The land team is now planning a user outreach workshop for *Collection 5*, January 17-18 at the University of Maryland.

The MODIS data are extending into a significant time series. Compilation and analyses of various Level 4 data have been completed including, a mean annual Global Primary Productivity (GPP) the global Net Primary Productivity (NPP) time series, a Vegetation Cover Conversion (VCC) five-year change for some parts of the world, an Evapotranspiration (ET) six year product from *Collection 4*, including the anomaly product, and a Land Surface Temperature (LST) product time series. The majority of the land products are validated to Stage 2 but the need for validation continues. In particular, Justice reiterated the need to continue to link to data from *in-situ* networks and especially international observation networks. The team is concerned that the validation capabilities developed for MODIS can be extended to the VIIRS. The land team is working through the various international coordinating groups on observations to demonstrate the contribution from the MODIS land data. More information about validation is on the EOS Land Validation web site.

Justice summarized the deliberations that took place in the Land Discipline Group meeting at the closing plenary session—for more details see the Land Group agenda at modis.gsfc.nasa.gov/sci_team/meetings/200610/landAgenda.pdf and the MST minutes. The meeting included a series of science presentations and breakout groups. Participants discussed the upcoming HQ Senior Review at length and came up with a strong rationale for keeping Terra and Aqua operating. The Aqua/NPP overlap is a particularly compelling argument for extending the mission. When compared to

the data quality of European Meteorological Operational satellite's (METOP) Advanced Very High Resolution Radiometer (AVHRR), Terra MODIS offers significantly increased science value. Efforts should be made to extend the MODIS data record as long as both instruments can provide science quality data. The land discipline group recommended that NASA start ingesting and processing the global 1-km METOP AVHRR data into the current Long Term Data Record (LTDR) initiative, since METOP will be the only morning observing system after Terra MODIS. A data overlap would be advantageous for the time series. The land team suggested that an *EOS* special issue on MODIS achievements and the reasons for keeping the sensors operating should be developed based on work undertaken in support of the Senior Review.

Justice showed an example of recent fire validation utilizing NASA Unmanned Aerial Vehicles (UAV) from flights over current California fires. The Wild-fire Research and Applications Partnership (WRAP), conducted flights over the Esperanza fire in Southern California at the request of the Governor. At least part of the flight was coincident with a MODIS overpass. These data will be compared to MODIS fire counts for calibration and validation.

Justice also reported on critical deficiencies in MODIS land data. The land water mask needs to be improved with a 250-m mask. The land team endorsed a proposal to undertake that task. In early 2007, the VIIRS land group will undertake a summary assessment of the utility of VIIRS EDRs for NASA's land science. This will summarize the findings of the land component of the NPP science team.

The Mid-Decadal Global Land Survey (MDGLS) breakout group discussed the acquisition and orthorectification of science products from the planned global high resolution—i.e., Landsat class observations—land assessment. The group recommended that a Land Cover Land Use Change (LCLUC) workshop be held in early 2007 to develop science product requirements. A second breakout session discussed the utility of MODIS for modelers. There is precedent for this activity from the International Satellite Land Surface Climatology Project (ISLSCP) data initiative. To make MODIS data more model friendly, a consistent, common radiation modeling approach is needed. The group discussed how MODIS land data might meet modeling needs and recommended that modeling products be a topic for a community measurement team discussion.

Through previous MODIS land meetings, the emerging land measurement team developed a series of ESDR *white papers*. Justice listed the topics covered in the ESDR white paper available at lcluc.umd.edu/products/land_esdr/index.asp. Building on the *white papers*,

the discipline team identified the top two priority initiatives or activities needed for each measurement type. For surface reflectance, for example, the top priorities are to develop NPP surface reflectance data continuity and to generate consistent surface reflectance (SR) products between moderate and high resolution instruments. A common theme across all measurement types was the importance of maintaining long-term data records (LTDRs) between moderate resolution sensors. For land data product continuity to support science, NASA will need a VIIRS land data production capability and an increased emphasis on international cooperation. There is also a need to increase the emphasis on multi-instrument data fusion.

In the land discussions, the question arose as to how the community should organize around the HQ charge to move from missions to measurements. The land discipline group suggested a possible new organizational model centered on the NASA Science Focus Areas and Measurement Teams. The legacy EOS organization was centered on the Investigators Working Group (IWG), of which the MODIS science team was a subset and the associated EOS Science Working Group on Data. The land group suggested a possible approach for a new structure. The proposed new structure would result in a land measurement team that would include representatives from different measurement types and relevant science focus areas. Under the new model, cross-instrument working groups on instrument calibration and data would support the measurement teams. The team would need to keep a close working relationship with both the instrument calibration and data production. Justice noted that the roles of the measurement teams and ESDR requirements are expected to change as the science evolves. The land discipline group recommended that NASA move ahead on the evolution from missions to measurements, and the next meeting, to be held after the latest EOS-recompetition selection, should be focused on “getting organized on measurements.” The presentation can be found on the MODIS web page.

Calibration and Characterization of the MODIS Instruments Overview

Jack Xiong [GSFC—MODIS Project Scientist and leader of the MODIS Characterization Support Team (MCST)] chaired a two-hour session on the second day of the MCST meeting (see MST minutes for details along with the information in provided individual presentations). The first six presentations at the MCST group meeting were overviews of the status of the instrument including instrument operations, the status of Level 1B algorithms and Look-Up-Table (LUTs), on-orbit performance for the reflected solar radiation bands and the thermal emission bands, and future challenges.

The last six presentations are summarized below:

- **Kurt Thome** [University of Arizona] reported on vicarious calibration reflectance-based results for Terra and Aqua;
- **Gerhard Meister** [GSFC—*Ocean Color Processing Team*] showed reflectance-based results for Terra and Aqua analyses of image striping due to polarization correction artifacts in MODIS Aqua ocean scenes;
- **Chris Moeller** [University of Wisconsin] presented on Long Wave Infrared (LWIR) Band radiometric performance;
- **Simon Hook** [Jet Propulsion Laboratory] reported on in-flight cross validation of mid and thermal infrared remotely sensed data from MODIS and the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) using the Lake Tahoe automated validation site;
- **Peter Minnett** [University of Miami] showed results on validation of sea-surface temperatures from MODIS; and
- **Stuart Biggar** [University of Arizona] reported on MISR reflectance-based vicarious calibration.

Overall the operations of the MODIS instruments appear to be largely nominal with no indications of instruments experiencing harmful degradation. In addition the validation of the performance of the instruments by vicarious means seems to indicate that in large part the instruments are meeting, in some cases exceeding, radiometric and other performance specifications.

Data Archiving, Distribution, and Associated Analysis Tools Overview

The plenary session on the last day contained the bulk of presentations by the three entities archiving and distributing MODIS data products—details of these presentations can be seen at the MODIS home page, science team meetings section, as well as in the MST minutes.

- **Ed Masuoka** [GSFC] reported on the MODIS Adaptive Processing System (MODAPS) and the associated Level 1 and Atmosphere Archive and Distribution System (LAADS);
- **Gene Feldman** [GSFC] presented on the Ocean Color Data Processing System (OCDPS) that handles all MODIS ocean color and sea surface temperature processing and distribution;
- **Ted Maersperger** [Earth Resources Observation and Science (EROS) Data Center (EDC), Sioux Falls, SD] reported on the Land Processes DAAC, which handles all MODIS land data products, and
- **Ruth Duerr** [National Snow and Ice Data Center (NSIDC), Boulder, CO] reported on activities at NSIDC related to MODIS. NSIDC handles

all MODIS cryosphere (snow and sea ice) data products.

The presentations from each of these entities described the various impressive statistics achieved so far in processing and distributing data and the services offered to the user community via the relevant web pages and attendant analysis tools.

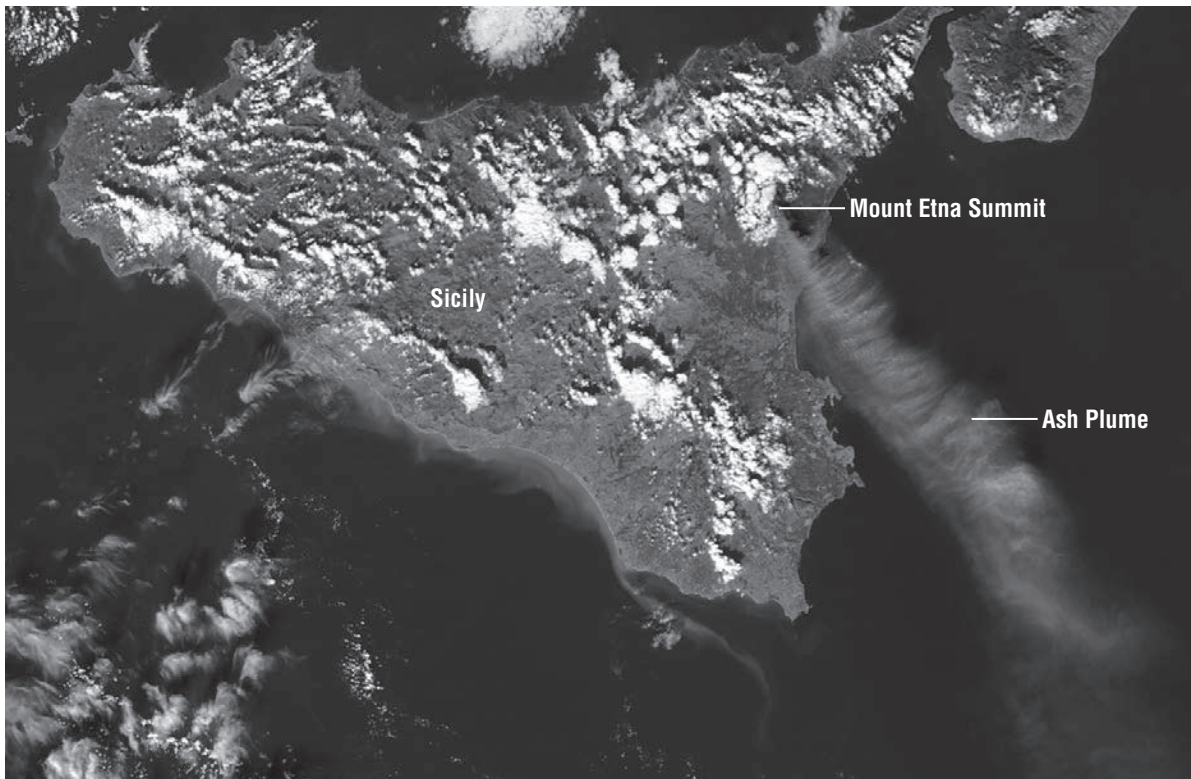
David Herring [GSFC] provided a description of progress on the NASA Earth Observations (NEO) analysis system—see neo.sci.gsfc.nasa.gov/Search.html. This capability has evolved considerably so as to allow easy viewing and access to MODIS data for formal and informal educators, museum and science center personnel, professional communicators, citizen scientists, and amateur Earth observers.

Martha Maiden [NASA HQ] described current plans and status for the long-term archiving of MODIS data. The USGS has the responsibility for the long-term archiving of land data and has established a long-term archive for satellite data. NOAA has the ultimate responsibility for the long-term archive of atmospheres and ocean data, etc., but the partnership with NASA and evolution to that state is evolving more slowly.

Overall Conclusions

Vince Salomonson concluded the meeting and thanked everyone for their contributions in the form of presentations and formal and informal discussions. There is no doubt that MODIS products are making sizeable and progressively increasing contributions to studies of the Earth systems and processes and related applications. Many presentations at the meeting described the use of multiple instruments in combination with MODIS to study land, ocean, and atmosphere processes—an evolution that is congruent with NASA Headquarters' directions to move from the historical emphasis on missions to an emphasis on measurements that combine to more comprehensively study and quantify processes and trends in the Earth-atmosphere system. Given this latter, evolving emphasis, the nature of future MODIS Science Team meetings is to be determined. In any case, it is not likely that another meeting involving science team members will occur until after the present review and selection process are completed in the late spring or early summer. With that the 27th, recorded MODIS Science Team meeting was adjourned about 1:00 P.M. on November 2. ■

Sicily's Mount Etna released a thick plume of volcanic ash on November 24, 2006. According to news reports, the volcanic activity forced an overnight closure of the Fontanarossa Airport, the main airport in eastern Sicily. The Moderate Resolution Imaging Spectroradiometer (MODIS) flying onboard NASA's Aqua satellite took this image on November 24. In this image, a large plume blows away from the volcano's summit toward the southeast, gradually dissipating as it goes. At the summit, MODIS has detected a hotspot, indicating surface temperatures much warmer than the surroundings. Common types of eruptions at Etna are explosive ash eruptions, small lava flows, and the ejection of cinder cones. For color image and more information see: earthobservatory.nasa.gov/NaturalHazards/shownh.php3?img_id=13985 Credit: Jeff Schmaltz, MODIS Land Rapid Response Team, NASA GSFC



How May We Help You: Summary of the 10th HDF and HDF-EOS Workshop

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The 10th Hierarchical Data Format (HDF) and HDF for the Earth Observing System (HDF-EOS) Workshop was held November 28-30 at the Raytheon Facility in Landover, MD. Over 90 people attended with varied backgrounds and perspectives—e.g., users, tool developers, and data producers. This year's theme was *How may we help you?* and the intent was to solicit feedback from the user community to see where the gaps were in their knowledge versus the state of tools that are available to help them.

The agenda with abstracts and presentations can be found at: www.hdfeos.org/workshops/us10/presentations/index.php.

The first day of the workshop included *A Crash Course in HDF5* and served as our annual tutorials session. Members of The HDF Group (THG), the nonprofit spinoff from the University of Illinois' National Center for Supercomputing Applications, provided in-depth information on all aspects of Version 5 of HDF (HDF5). Beginning with the Java-based *HDF-View* data browser, attendees learned how to install the tool onto their laptop and to read and create HDF5 data structures. Other presentations showed the details of what happens to data from the time it is created inside a user's program to when it is written to disk. Some of the presentations demonstrated ways to improve input/output performance as a function of how the data is written by the data creator. The presentations emphasized how important it is to consider how the users of data will access the product. What is efficient for a producer may not always be efficient for a user who needs to read the data in a different manner.

There were also discussions about tools on the first day, including an overview of the available HDF5 tools that summarized the capabilities provided by: Readers (*h5dump*, *h5diff*, *h5ls*, *h5check*, and *h5stat*), Writers (*h5repack*, *h5repart*, *h5import*, *h5jam/unjam*, and *h5copy*), and Converters (*h4toh5*, *h5toh4*, *gif2h5*, and *h5togif*). Online help for all these tools can be found at: www.hdfgroup.org/hdf5tools.html.

The first day wrapped up with a presentation showing all the new features of the upcoming HDF5 *Release 1.8* and a detailed description of the approach THG uses to document all their software. This includes not only

where everything can be found, but also how users can give input into upcoming releases and, of course, bug reporting for software they are using.

The second day of the workshop was dubbed *Status Day*, and was reserved for presentations relating to the status of projects and efforts which make use of HDF or HDF-EOS. Representatives from the Earth Science Data and Information System (ESDIS) Project, the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Integrated Project Office, THG, and Raytheon gave information on the current state of their development and maintenance efforts. Tool developers also provided information on the status of their wares.

The ESDIS Project described their goals for evolution and showed metrics detailing how much data has been stored and distributed by the Earth Observing System Data and Information System (EOSDIS) over the past four years. ESDIS also presented a summary of data format comments received in the third Customer Satisfaction Survey of the EOSDIS. These comments reinforce the ESDIS Project's evolution path that includes making data available to users in formats that match more closely with users' desires.

The Earth Science Data System Working Group described their efforts to standardize on HDF5 and HDF-EOS5. Currently, comments are being solicited for these formats. A summary of the comments received thus far shows generally positive support, but there are concerns expressed that relate to complexity, long-term support by NASA, and tool availability. It is expected that standardization will help meet the EOSDIS goals of EOS data interoperability.

The last day of the workshop was reserved for discussions of Missions, existing and future, and ended with a round-table talk addressing the need for a Common Data Model that can be used to encapsulate access of data from heterogeneously developed missions.

There was a discussion of the status and lessons learned from data validation efforts related to NASA's Aura and the European Space Agency's Environmental Satellite (ENVISAT) missions. There is an extensive network of ground-based atmospheric measurement data that is

used to validate data from ENIVSAT and Aura. The work to standardize around HDF4, and then HDF5 was presented. This concept will extend to the Afternoon Constellation or “A-Train”—which in addition to Aura, includes the NASA missions CloudSat and the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Operations (CALIPSO), and will later include Glory—and probably extend to the NPOESS Preparatory Project (NPP) mission.

Members of the NPOESS development team then showed the details of the data structure that has been designed to store their data. The structure is built assuming the HDF5 library of functions. The NPOESS Project will deliver all their official deliverable products for NPP and NPOESS in HDF5 format. An XML User Block will be included in the data so that users who aren't prepared to read with HDF5 can get a quick-look at what's inside. Strict performance goals and flexibility at the user end were the drivers for the design. Suggested improvements to the HDF5 Applications Programming Interface (API) were requested and THG is taking a look at making these changes.

The lead developer/maintainer of the HDF-EOS library gave an overview of the format, and showed *Grid*, *Point*, *Swath*, and *Zonal Average* structures, along with a description of the many compression schemes that are available. Finally, the developer gave a summary of the comments received from the Request for Comment (RFC) on HDF-EOS5.

The morning wrapped up with two presentations. The first presentation gave some ideas on how the National Imagery Transfer Format (NITF) could make use of HDF5 to meet its needs now and in the future. There

is an extensive operational community of NITF users, but the presentation showed that HDF5 could meet their needs in a variety of ways. The second presentation showed how HDF functions have been integrated into the data and services provided by the Goddard Earth Sciences Data and Information Services Center (GES-DISC). They rely on command-line tools as much as possible because of the ease of integration. The compression utility *hrepack* developed at NCSA (now THG) has helped pave the way for the evolution path of EOSDIS. Reformatters are needed to convert data in various formats (*GeoTIFF*, *netCDF*, *GRIB* and *ASCII*) into HDF to support the GES-DISC Interactive Online Visualization ANd aNalysis Infrastructure (Giovanni) a tool that provides server-side visualization and analysis capability.

The concept of a Common Data Model was the topic of discussion for the final afternoon of the workshop. Looking at the history of Earth science data, applications, and tools, there is a need to build a framework that can be used to simplify access to data from Earth science missions that is typified by having temporal and geospatial attributes. Work is needed for standardization of coordinate systems, and classifications of data types with services defined for them.

After the meeting a *Yahoo* group called HDF-GEO was established. The group is in the process of identifying the scope, requirements, and target community for a geospatial profile which would work on top of HDF5. The HDF-GEO group originated from discussions during the past several HDF and HDF-EOS Workshops. It is an independent initiative, although we hope to have active participation from individuals at The HDF Group, NASA, NOAA, and other active users of HDF and environmental data sets. ■

Goddard Team Honored for Achievements in Remote Sensing

Greenbelt, Md. – The Total Ozone Mapping Spectrometer (TOMS) team has won the **2006 William T. Pecora Award**. NASA and the Department of Interior give this prestigious Federal award to individuals and groups for significant achievements in remote sensing.

The TOMS team won the award for developing innovative techniques that have provided unique atmospheric ozone, sulfur dioxide, and aerosol data for more than 25 years. The presentation took place at the American Geophysical Union (AGU) Fall Meeting in December in San Francisco.

The Pecora Award has been presented annually since 1974 in memory of Dr. William T. Pecora, whose early vision and support helped establish what we know today as the Landsat satellite program. Dr. Pecora was Director of the U.S. Geological Survey (USGS) from 1965-71, and later served as Department of Interior (DOI) Undersecretary until his death in 1972.

The *Earth Observer* staff and the scientific community would like to congratulate the TOMS team on this outstanding achievement.

Summary of the 6th CERES II Science Team Meeting

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The sixth meeting of the Clouds and the Earth's Radiant Energy System (CERES-II) Science Team was held jointly with Geostationary Earth Radiation Budget (GERB) International Science Team (GIST) at the Hadley Centre for Climate Prediction and Research, U.K. Meteorological Office (UKMO) in Exeter, U.K on October 23-27, 2006. **Bruce Wielicki** [NASA Langley Research Center (LaRC)—*CERES Principal Investigator*] hosted the CERES part. **John Harries** (Imperial College, London) hosted the GERB portion. **Mark Ringer** (UKMO) served as the local organizer. The next CERES meeting will be held April 24-26, 2007 in Newport News, VA.

Major objectives of the meeting included science team review and approval of:

- Terra and Aqua shortwave (SW), longwave (LW), and total channel calibrations for *Edition-3*;
- cloud algorithm development and validation for *Edition-3*; and
- production of top-of-atmosphere (TOA) and surface averages (SRBAVG) daily products in addition to the monthly products.

In addition to the major objectives, the science team also reviewed the plans for producing Level-3 gridded version of the Surface and Atmospheric Radiation Budget (SARB) products, early results from Afternoon Constellation or "A-Train" instruments, comparisons between CERES and GERB results, CERES participation in Global Energy and Water-cycle Experiment (GEWEX) Radiative Flux Assessment (RFA) activity, and efforts of the data management group in transitioning CERES processing to commodity cluster-based computing.

Climate Program Overview

Bruce Wielicki [LaRC] presented an overview of a broad range of topics including the state of the U.S. Climate Change Science Program (CCSP), the Intergovernmental Panel on Climate Change (IPCC), CERES, the National Polar-orbiting Operational Environmental Satellite System (NPOESS), the NPOESS Preparatory Project (NPP), the "A-Train", and activities of the NASA/NOAA Research-to-Operations Panel. The CCSP Observation Working Group (OWG) held a retreat on climate observation requirements June 14-15. The resulting short-term plan is based on community assessment of impact vs. feasibility while the long-term approach is based on Observing System Simulation Experiments (OSSEs) using climate models. According to IPCC Assessment Report 4 (AR4), cloud feedback that changes planetary albedo remains the largest uncertainty in climate sensitivity.

At NASA Headquarters, **Mike Freilich**, is the new Director of the Earth Science Division and **Bryant Kramer** is his deputy. **Don Anderson** and **Hal Marling** are Modeling and Radiation Sciences leads respectively. The National Research Council report on the Earth Science decadal survey is scheduled for release in January-February 2007. Earth Science budgets beyond FY2006 are expected to remain flat. Significant increases in manned space flight costs have resulted in large cuts in Earth and Space Science budgets.

The scheduled launch of CERES Flight Model 5 (FM-5) instrument on the first NPOESS mission in 2010 is now likely to slip to 2014 because of budget and schedule problems. This delay greatly increases the gap risk in climate data record. The U.S. Office of Science and Technology Programs (OSTP) requested NASA and NOAA to develop a white paper with plans to deal with the increased gap risk in data record because of this delay. That plan recommends moving FM-5 to the NPP mission in 2010 and building copies of the CERES instrument for NPOESS flights in 2014 and 2019.

A congressional bill requires annual reports on progress in converting NASA research developments into NOAA operations, and utilizing NOAA operational data into NASA research. A Joint Agency Working Group was constituted to prepare and provide these reports, the first of which is due in February 2007.

Terra/Aqua Instruments and Calibrations

Kory Priestley [LaRC] presented operational and calibration/validation status of the four CERES instruments on Terra and Aqua. Both instruments on Terra and one (FM-3) on Aqua continue to function nominally. The SW channel of FM-4 on Aqua suffered an anomaly on March 30, 2005, and stopped taking radiometric measurements. He discussed how contaminant deposition caused spectral darkening of the SW channel of instruments operating in rotating azimuth plane scan (RAPS) mode and how *Revision-1* adjustment factors correct for the effects of darkening.

Grant Matthews [Analytical Services and Materials, Inc. (AS&M)] discussed a new mechanism of contaminant deposition and a polymerization model developed to explain its effects. This model uses direct comparison data between nadir footprints in conjunction with the stability metric of deep convective cloud albedo to derive instrument gains and spectral responses. This model provided results comparable to *Revision-1* adjustments but some assumptions used in this model seemed unphysical.

CERES Cloud Properties

Patrick Minnis [LaRC] presented the status of CERES cloud algorithms and products. He described the ongoing effort to intercalibrate sensors on Terra and Aqua satellites and to validate retrieved cloud products. Terra and Aqua retrievals were found to be very consistent except over polar regions. Comparisons with Ice, Cloud and land Elevation Satellite (ICESat), Geosciences Laser Altimeter System (GLAS), and Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) retrievals as well as Moderate-resolution Imaging Spectroradiometer (MODIS) team products showed only small differences. Minnis presented detailed plans for multiple improvements to be implemented for *Edition-3* processing and showed some early results.

CERES ADM and Albedo Analyses

Norman Loeb [LaRC] presented an overview of the methodology used to produce CERES Angular Distribution Models (ADMs) and plans for using these ADMs for *Edition-3* processing. He introduced a new product of merged CERES, MODIS, and Multi-angle Imaging Spectroradiometer (MISR) data and used it to derive instantaneous TOA SW flux uncertainties by the cloud type due to ADM errors. Loeb showed further how the merged product could be used to convert MISR Level-2 spectral albedos to broadband albedos. He also showed comparisons of TOA fluxes derived with new ADMs with those from CERES Earth Radiation Budget Experiment (ERBE)-like product.

Simple Surface Fluxes

Shashi Gupta [Science Systems and Applications, Inc. (SSAI)] presented a methodology for remedying overestimation of surface LW fluxes observed in simple surface flux model results over dry/arid regions. He showed that overestimation was occurring when surface skin temperature was much higher than the temperature of atmospheric layers above. Gupta presented a methodology for detecting such conditions in the temperature profiles and constraining the skin temperature under those conditions. He showed that application of this method remedied the overestimation.

Terra and Aqua SARB Products

Thomas Charlock [LaRC] presented the methodology used for deriving Surface and Atmosphere Radiation Budget (SARB) products in CERES using a radiative transfer model. He presented validation of SARB TOA fluxes using CERES observations, and that of SARB surface fluxes using surface observations from the CERES/Atmospheric Radiation Measurements (ARM) Validation Experiment (CAVE) database on instantaneous and monthly average bases. He presented

validation of SARB fluxes before and after the application of *Revision-1* adjustment factors. Charlock also presented comparisons of SARB albedo results with those derived in two global climate models and showed good agreement.

CERES TISA Activities

David Doelling [SSAI] discussed activities of the Time Interpolation and Spatial Averaging (TISA) Working Group and reported that a 5-year Terra-based SRBAVG dataset (*Edition-2D*) of regional monthly averages was available. The Geostationary Enhanced (GEO) version of this product was derived using geostationary-based fluxes and clouds to fill temporal sampling gaps while maintaining CERES calibration. Corresponding ERBE-like and non-GEO products were also available. Comparisons of GEO results with ground-based observations from 28 surface sites showed very good agreement. Doelling reported on the progress toward producing International Satellite Cloud Climatology Project (ISCCP)-D2 type and daily SRBAVG products.

Fred Rose [SSAI] presented a description of the methodology and preliminary results for a diurnally resolved synoptic SARB product known as SYNI resulting from a cooperative effort between SARB and TISA groups. This product is computed on an hourly basis with a radiative transfer code using CERES GEO TOA fluxes to constrain model results. Rose compared maps of SYNI SW and LW fluxes with observations for July 2002, and showed validation of the diurnal variability of fluxes over ARM Southern Great Plains (SGP) sites.

CERES Outreach

Bruce Wielicki [LaRC] reported on the status of the Students' Cloud Observations OnLine (S'COOL) project. The S'COOL database now has more than 55,000 observations from more than 2000 participants in all 50 states in the U.S. and 49 other countries. More than 22,000 observations are matched with a Terra or Aqua overpass with about 400 of those matched with both Terra and Aqua at the same time. Wielicki urged attendees to participate in S'COOL activities in their own communities.

Data Management Status

Mike Little [LaRC] presented an overview of the activities of the CERES Data Management Group, the changes underway, and those coming in the near future. These changes are driven mainly by considerations of costs and increasing data volume and complexity. The main objective is to be able to run all codes on multiple systems and ensure platform invariance of scientific results. The new set up will make use of the power of clusters of commodity-based computing hardware,

called Storage Area Networks (SAN) to provide large disk space, and new cluster management tools to reduce costs.

Invited Presentations

Nick Faull [University of Oxford, U.K.] reported on the activities of the *climateprediction.net* (CPDN) project underway at Oxford. The objective of this project is to involve the general public in a massive climate prediction effort and, in the process, improve public awareness and understanding of the climate prediction process and its uncertainties. It is designed to harness the power of idle home, school, and business computers. The public is invited to download a full resolution 3-D climate model and run a single member of a massive perturbed physics ensemble (PPE) on each computer. The project is currently running on about 60,000 computers.

David Sexton [UKMO] presented an overview of a methodology aimed at making climate predictions based on model results that are accepted to be imperfect. This is a part of the Quantifying Uncertainty in Model Predictions (QUMP) effort at the UKMO. The objective is to be able to provide policy makers concise statements regarding future climates based on probabilistic predictions. This can be accomplished by constructing joint probability distributions based on simulation results from PPEs. The ensembles can be taken from the IPCC AR4 or from other similar sources.

Mark Webb [UKMO] reported on the progress and plans of the Cloud Feedback Model Intercomparison Project (CFMIP) set up by the World Climate Research Program (WCRP) Working Group on Coupled Modeling (WGCM) for carrying out systematic intercomparisons of cloud feedbacks in Global Climate Models (GCMs). The purpose of this project is to identify key uncertainties in cloud-climate feedbacks and link them to cloud observations. The project currently has model results from 13 GCMs. The Program for Climate Model Diagnosis and Intercomparison (PCMDI) will make cloud diagnostics from these experiments available to the community.

Co-Investigator Presentations

Norman Loeb [LaRC] presented an overview of the variability of clouds, aerosols, and albedo between 2000 and 2005 from several data sources. He found no significant trend in TOA SW flux anomalies between 2000-2005, in contrast with recent results based on Earthshine reflectance measurements, and found excellent consistency between CERES TOA SW flux and Sea-viewing Wide Field-of-view Sensor (SeaWiFS) Photosynthetically Active Radiation (PAR) anomalies based on the first five years of CERES data. Separately, Loeb presented a summary of the overall errors in CE-

RES TOA and surface fluxes as a function of spatial and temporal scales. He also showed global mean fluxes and an error analysis of global net flux.

Moguo Sun [Stony Brook University] presented a study of cloud structure anomalies over the tropical Pacific Ocean and their relationship with outgoing LW radiation (OLR) variability during 1997-98 El Niño. Using Tropical Rainfall Measuring Mission (TRMM)/CERES SRBAVG and other data for January-August 1998, he showed that during the El Niño, clouds become thicker and more widespread over eastern Pacific, while the opposite occurs over western Pacific. All-sky OLR over eastern Pacific was driven primarily by cloud amount and altitude.

Takmeng Wong [LaRC] presented comparisons between ocean heat storage data and TOA net radiation data derived from CERES instruments. Earlier comparisons between these two datasets had shown that they tracked each other well. The latest ocean heat storage data show a significant drop in heat storage in the ocean after 2003 (about -1.7 W/m^2) while CERES net radiation data show little change (about -0.1 W/m^2). Also, Gravity Recovery and Climate Experiment (GRACE) data do not show any accelerated glacial ice-mass loss during 2004-2005. Wong concluded that further studies are needed to resolve this discrepancy.

Richard Allan [University of Reading] presented a study of the relationship between atmospheric clear-sky LW radiative cooling and precipitation using data from diverse sources. He showed a scatterplot between atmospheric clear-sky LW cooling and latent heat release in Hadley Centre GCM results and time series correlations between anomalies of SST, column water vapor (CWV), surface net LW flux, and clear-sky OLR obtained from different sources. The results above and anomaly time series of atmospheric LW cooling and precipitation rates over tropical oceans confirmed such a relationship.

Bruce Wielicki [LaRC] presented an overview of the GEWEX RFA project launched for the purpose of assessing the state of our understanding and ability to derive, validate, and simulate TOA and surface radiative fluxes using satellite observations, ground-based measurements, and radiation models. The current RFA archive has received data from a number of satellite projects (e.g., CERES, SRB, ISCCP-FD), ground-based observations, and modeling groups. Current plans call for completion of the assessment by the end of 2007.

Bing Lin [LaRC] presented a study of the climate feedback of tropical high clouds using CERES, Visible and Infrared Scanner (VIRS), and TRMM Microwave Imager (TMI) data for the January-August 1998 period. He reported that areal coverage of individual cirrus

clouds shows negative correlation with area of deep convective systems (DCS) on smaller spatial ($< 5^{\circ} \times 5^{\circ}$) and temporal (\sim days) scales because both have to exist within the same area. On larger spatial ($> 10^{\circ} \times 10^{\circ}$) and temporal (> 1 month) scales, areas of the two show a positive correlation because cirrus clouds are originally produced by the DCS.

Pam Mlynyczak [SSAI] presented a study of the diurnal cycle of cloud radiative forcing (CRF) of surface radiation budget (SRB) performed with the method of principal component (PC) analysis. The monthly average diurnal cycle was established for a climatological July using 3-hourly fluxes over a 21-year (1984-2004) period. The first PC explained about 96% of the variance of surface SW CRF and is related to the diurnal variation of surface insolation. The second PC, related to morning-afternoon cloudiness differences, explains only about 2% globally but can be large on a regional basis.

Seiji Kato [Hampton University] presented a study of the seasonal and meridional variation of cloud radiative effects performed using CERES single scanner footprint (SSF) and cloud radiative swath (CRS) data. The results showed that clouds cooled the surface and warmed the atmosphere in the tropics. Also, clouds cool the atmosphere and warm the surface in polar regions, especially in the winter hemisphere. Thus, cloud effects strengthen meridional energy gradient and enhance equator-to-pole energy transport.

Bruce Wielicki [LaRC] presented a discussion of OS-SEs as means for establishing requirements for climate observing systems by relating uncertainties in satellite observations to those of climate predictions. He framed basic questions regarding the needs of climate models, corresponding requirements of observing systems, and how to relate observation errors to climate prediction uncertainty. Wielicki suggested that model studies with PPEs of the type currently underway at CPDN followed by neural network analysis offer a possible solution.

Ernesto Lopez-Baeza [University of Valencia, Spain] presented comparisons of matched CERES and GERB measurements with observations made at Valencia and Alacant Anchor Stations during several validation campaigns. CERES data were obtained in the Programmable Azimuth Plane Scan (PAPS) mode to enhance angular matching with GERB measurements. The primary objective of this study was to assess capabilities of instrumentation at the anchor stations.

Takmeng Wong [LaRC] presented a comparison of radiation budget patterns between CERES/Terra ERBE-like results and National Centers for Environmental Prediction (NCEP) Reanalysis-II products over West African monsoon regions for a period of one year. CERES SW and LW data clearly showed seasonal migra-

tion of monsoon convection over the region. NCEP data represented these migrations fairly well but both outgoing LW and reflected SW fluxes were too high.

Michel Viollier [Laboratoire de Meteorologie Dynamique (LMD), France] presented comparisons of TOA radiation budget over Africa and surrounding ocean regions from different satellite missions of the last two decades. This included datasets from ERBE, Scanner for Radiation Budget (ScaRaB), CERES, ISCCP, and GEWEX-RFA archive. Scanner and ISCCP LW fluxes showed a slight upward trend while non-scanner LW fluxes showed no trend. SW fluxes from all sources showed slight downward trend.

Greg Schuster [LaRC] presented results from recent activities at the CERES Ocean Validation Experiment (COVE) site located about 25 km off the Atlantic coast in Virginia Beach, VA. This site deploys a number of solar, infrared, and aerosol instruments which provide data for the Baseline Surface Radiation Network (BSRN) and Aerosol Robotic Network (AERONET) archives. He showed results on the seasonal variability of aerosol optical depth and size distribution, and occurrence of soot particles.

Alessandro Ipe [Royal Meteorological Institute of Belgium (RMIB)] presented comparisons of *Edition-1/Version-3* GERB products with CERES Terra and Aqua cross-track ES-8 data for the March 25 to April 30, 2006 period. The Averaged Rectified Geolocated (ARG), Snapshot High-resolution Image (SHI), and Binned ARG (BARG) versions of GERB products were compared. All GERB versions showed overestimation of SW fluxes and underestimation of LW fluxes for both day and night.

Xiquan Dong [University of North Dakota] presented comparisons of cloud vertical distribution and overlap between radar-lidar observations from the Department of Energy's Atmospheric Radiation Measurement (ARM) program's Southern Great Plains (SGP) site, model simulations from a single column model (SCM), and CERES cloud retrievals from Terra MODIS data. Dong presented multiple comparisons between these datasets and showed that ARM data show a bimodal height distribution with peaks at about 1.0 and 8.5 km. The SCM was shown to underpredict cloud amount, especially for cirrus clouds. CERES retrievals showed good agreement with ARM radar-lidar data.

Kuan-Man Xu [LaRC] presented statistical analyses of physical and microphysical properties of cloud objects in TRMM observations, European Centre for Medium-range Weather Forecasts (ECMWF) forecast cloud fields, and the effects of cloud overlap assumptions on those properties. TRMM data for a total of 9 months (January-August 1998 and March 2000) and matched

ECMWF forecast cloud fields were used in the study. Cloud properties from TRMM and Terra were found to be significantly different. Microphysical properties of non-convective cloud objects were weakly affected by overlap assumptions.

Zhonghai Jin [SSAI] presented a procedure for correcting the bias observed in TOA SW fluxes in CERES CRS results. Analysis of SW fluxes over clear ocean showed these biases to be dependent on solar zenith angle and to be arising from the inadequacy of two-stream computation in handling the strong anisotropy of ocean surface reflection. A simple multi-stream procedure was developed and incorporated into CRS processing. This reduced the bias slightly, but the portion of the bias resulting from ADM error remained.

Bruce Wielicki [LaRC] presented a sampling of first results available from the CALIPSO mission that was launched on April 28, 2006, and joined the A-Train. CALIPSO carries the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP), a polarization lidar operating at 532 and 1064 nm, a 3-channel Imaging Infrared Radiometer (IIR), and a Wide Field Camera (WFC). He presented several charts indicating stable operation of all instruments and examples of data taken around the globe recording effects of phenomena like a volcanic eruption, biomass burning and resulting smoke, and polar stratospheric clouds. In a separate presentation, Wielicki also showed some early results from CloudSat that was launched along with CALIPSO. CloudSat is equipped with a 94 GHz cloud profiling radar (CPR) designed for measuring 3-D structure of clouds.

Sunny Sun-Mack [SSAI] introduced new integrated cloud, aerosol, and radiation datasets under development at LaRC by merging products from several A-Train satellites, namely, CERES and MODIS on Aqua, and CALIPSO and CloudSat. Profiles of broadband fluxes from CERES will be merged with passive imager clouds and aerosols from MODIS, active lidar clouds and aerosols from CALIPSO, and CPR clouds from CloudSat. These datasets will provide unprecedented ability to test and improve global 3-D cloud and aerosol models.

Alejandro Bodas-Salcedo [UKMO] presented description and preliminary results from a CloudSat radar reflectivity simulator developed at the UKMO. The objective of this study is to improve representation of cloud radiative properties in climate models and thereby reduce uncertainties in the prediction of climate sensitivity. The simulator is designed to generate the signal that CloudSat would measure corresponding to clouds produced in the model.

ADM/Inversion Working Group

Steve Hudson [University of Washington] presented a study of the bidirectional reflectance properties over Ant-

arctica at Dome C. He showed that the presence of cloud over a snow surface tends to enhance forward reflectance into large viewing angles while reducing it at and near nadir. He used radiative transfer theory and MISR measurements to illustrate the effect and hypothesized that clouds mask the shadowing effect of surface roughness to produce a stronger forward peak.

Cedric Bertrand [RMIB] presented plans to improve the accuracy of GERB SW flux estimates over snow/ice-covered surfaces. He plans to develop a snow/ice retrieval technique using Spinning Enhanced Visible Infrared Imager (SEVIRI) data and apply snow/ice-specific ADMs in radiance-to-flux conversion over snow/ice surfaces. Bertrand also presented a daytime multi-spectral threshold snow/ice detection algorithm.

Ernesto Lopez-Baeza [University of Valencia] presented a summary of a recent study to develop ADMs for the Earth Clouds Aerosols and Radiation Explorer (EarthCARE) broadband radiometers. He presented ADM scene types that will be used with the EarthCARE simulator and a 3-D SW module capable of reproducing observations for each EarthCARE sensor.

SARB/Surface-Only Flux Algorithms (SOFA) Working Group

Tom Charlock [LaRC] led the SARB/SOFA Working Group discussion that **Bill Collins** [National Center for Atmospheric Research (NCAR)] initiated regarding the need of the GCM community for a self-consistent cloud and radiation dataset that shows closure. CERES products would satisfy that need except that the CERES radiation budget at the TOA shows a disbalance of about 6 W/m². The group considered making minor adjustments to inputs of CERES processing to achieve the desired balance. Since multiple runs of the entire CERES processing are not practical, the group decided that an effort should be made to determine if a limited number of sites can be chosen to represent the behavior of the entire global dataset.

Cloud Working Group

Patrick Minnis [LaRC] led the Cloud Working Group discussion on potential applications of MODIS and CALIPSO data to enhance cloud studies using synergy between the two instruments. **Yong Hu** [LaRC] discussed his new technique for making accurate retrievals of ice-cloud optical depths when a water cloud is present below the ice cloud using a MODIS/CALIPSO dataset. Hu also discussed a multi-instrument data fusion method that allows cloud properties retrieved from CALIPSO lidar to be linked to footprints in the entire MODIS swath. ■

A Summary of the AARSE International Conference in Egypt

Steve Ambrose, NASA Headquarters, Disaster Management Program Element Lead, sambrose@nasa.gov

Introduction

The Disaster Management Program element of NASA's Applied Science Program participates in *Project WSSD*—a project in support of the objectives of the World Summit on Sustainable Development. The Disaster Management Program helps to fund *Project WSSD* and supports the overall objective of the Applied Sciences Program: *to expand and accelerate the economic and societal benefits from Earth science, information, and technology*. In pursuit of that goal, NASA sent a delegation to the the 6th annual Africa Association for Remote Sensing of Environment (AARSE) conference in Cairo to engage in dialogue with *end-users* of remote sensing data in Africa and better understand the decision support tools and systems they have in place and their associated requirements for Earth science research results. NASA sponsored the AARSE conference, which meant that through our contribution to the conference success, we were able to have an exhibit booth—*see article on page 32 of this issue*—and present a number of presentations, which were very well received by conference participants.

Summary

During the meeting, NASA representatives met separately with representatives from all points of the African continent. The representatives took part in informal meetings with the Regional Centre for Training in Aerospace Surveys (RECTAS), the Egyptian National Authority for Remote Sensing and Space Sciences (NARSS), the European Space Agency (ESA) TIGER project aimed at studying water resources in Africa, the International Institute of Geo-information Science and Earth Observation (ITC), the United States Geological Survey (USGS), and the Group on Earth Observations (GEO).

At each of these meetings, the representatives expressed strong interest in considering future collaborations with NASA to evaluate the utility of remotely sensed data for sustainable development in Africa. NASA also established contacts with many remote sensing *end users* in Africa; and will maintain information on their applications and requirements in the *Project WSSD* database.

There were a number of additional individual meetings between members of the NASA delegation and conference participants, which are summarized below.

Steve Ambrose and **Shahid Habib** met with **Olajide Kufoniya** [RECTAS—*Executive Director*] and **Tsehaj Waldai** [AARSE—*President*, also a member of ITC]. In



Pictured are some of the people who represented NASA at AARSE. From left to right, back row: Steve Ambrose, NASA HQ, Charles Ichoku, Ted Engman, Fritz Policelli, and Shahid Habib, all from NASA GSFC; front row, Winnie Humberson, NASA GSFC. Tim Suttles and Molly Brown, both NASA GSFC, are not pictured.

collaboration with ITC in the Netherlands, RECTAS trains the people actually implementing the Geo-information programs of the various government and other interested agencies in most of the member countries. Virtually all the external collaborations RECTAS—www.rectas.org—has had to date are with European Agencies. The NASA representatives agreed to convene future telecons with NARSS and with RECTAS to define possible areas of future collaboration. NARSS is limited to Egypt but RECTAS has a regional communications system with a number of West African countries and organizations. Using them as a central hub for NASA information would be valuable. Waldai was particularly interested in NASA collaborations with RECTAS. **Charles Luther**, the immediate past President of the *IEEE Geoscience and Remote Sensing Society* was also a participant in the RECTAS conversations.

NARSS showed particular interest in NASA, and organized a lunchtime meeting so that the NASA representatives—Habib, Ambrose, and **Fritz Pollicelli**—and the Director of NARSS could discuss partnership strategies. NARSS is an Egyptian government institute that has university ties in expanding Egypt's space science. An official collaboration is a long-term objective; in the meantime NASA will continue to work with this group to show them how NASA data and products could benefit their program and partnerships across Egypt and Africa.

Molly Brown met with **Evelyne Mbede** [University of Dares Salaam, Tanzania—*Dean of Faculty of Sciences*]. As the largest and oldest university in Tanzania, the university offers bachelors, masters, and doctoral

degrees and is the institution that trains many of the future decision makers in the country. Mbede plans on instituting geography courses as a core requirement for all students, regardless of major, where geospatial data and technology will be a primary focus. In addition, there is a strong focus on continuing education for current faculty who lack appropriate training in computers and information technology—such technology has only recently arrived in Tanzania. Brown promised to send Mbede educational materials and a contact at GSFC where she can send inquiries. The university has a strong web presence—www.udsm.ac.tz. NASA could do a great deal to improve the use of its data through working with institutions of higher education in Africa.

Brown also met with **Wilber Ottichilo** [Regional Center for Mapping and Resources for Development (RC-MRD), Nairobi, Kenya—*Director General*]. RCMRD has been growing rapidly over the past five years—reaching 80 employees in just the last six months—and is involved in many of NASA's regional projects, including three of its currently funded applications projects. (RC-MRD is a primary participant in the *SERVIR for Africa* idea under the Ecological Forecasting Program.) It is also involved in cadastral mapping to ensure correct private land deeds in the country, training and course work in Geographic Information Systems (GIS) and remote sensing in the region, has several primary feeds into U.S. data, including NOAA Advanced Very High Resolution Radiometer (AVHRR) and Moderate Resolution Imaging Spectroradiometer (MODIS) direct broadcasting capabilities. Ottichilo is a very efficient and effective personality, who can be a big asset to any NASA applied science activity in the region.

Brown met with **Alexeander Bohr** [European Union Coordination and Harmonization Project in Mozambique]. This unique project provides an electronic tool called *ODAmoz* that provides transparency and information about projects funded with European overseas development assistance (ODA) in Mozambique. The tool was created in response to the Paris Declaration that advocated strengthened coordination and harmonization among donors and alignment with the Government of Mozambique. *ODAmoz* enables users to track donors' and United Nations agencies' projects and programs in the country: where they are operating, who finances them, and which organization implements them. It is a user-friendly database, accessible to all through the Internet. The *Design your own report* function is quite helpful as it makes it easy to search for specific information through a set of predefined criteria—donor, sector, location, project status, funding type, and Millennium Development Goals (MDGs)—and offers tables and geographic maps (*ODAmaz*) for analysis. The URL for the tool is www.odamoz.org.mz

Brown met with **Aliou Dia** [University of Dakar, Senegal—*Department of Geography*]. Dia presented a paper on the effect of flooding on the extremely vulnerable historic city of Saint Louis, situated at the mouth of the Senegal River in the north of Senegal. He and his team have developed a 1 m Digital Elevation Model database for the city with several hundred relevant GIS layers to assess the impact of seasonal flooding on the city infrastructure. Dia and Brown have agreed to work together to develop a decision support tool for the Senegalese Ministry of Environment and of Water Resources, as well as the regional Organisation pour la Mise en Valeur du Fleuve Senegal (OMVS) in charge of cross-border management of the Senegal River Basin composed of Mali, Mauritania, Senegal, and Guinea Conakry. NASA data can also be used as input for a model, provided by the U.S. Geological Survey (USGS), that produces gridded rainfall and rainfall projections one to four months into the future. This model helps to give significant advanced warning of potential flooding events to ensure proper actions can be taken to secure lives and livelihoods in Saint Louis.

Charles Ichoku met with **Sives Govender** [EIS-Africa Network—*Director*]. EIS-Africa—www.eis.africa.org—is an organization that acts as a medium of communication of information on what is going on in Africa in the area of Geo-information, and had a display booth at the conference. They organize the biennial AfricaGIS conferences, which take place in alternate years with AARSE—one is planned for 2007. Govender indicated that EIS-Africa is willing to assist with the dissemination of information on any Africa-related Remote Sensing/GIS products that NASA may have.

Along similar lines, Ichoku spoke with **Marco Weber** from Austria, who works for the company that operates the *Terrasar-X* and the future *Tandem-X*, providing high (up to 1 m) resolution Synthetic Aperture Radar data that can help augment applications in the tropical belt with persistent cloud cover, which is a challenge for current optical sensors from NASA and other organizations. This data would be a nice complement to existing NASA data.

Brown and Ichoku spoke with **Lucy Edge** [Surrey Satellite Technology Ltd]. Surrey is the company that built several micro satellites for different countries that are flying in formation. Edge gave a presentation on the activities of her company in developing collaborative micro-satellite remote sensing technology for different countries in Africa and beyond—currently Algeria, Nigeria, Turkey, U.K., and China—under the Disaster Monitoring Constellation (DMC) initiative. Although she is not from Africa, her company's satellite technology is already making some impact on the African

continent. They are an interesting organization to work with in order to see how NASA's capabilities and theirs can complement each other in the effort to encourage remote sensing applications in Africa.

Ted Engman met with **Mohamed El Bastawesy** [NARSS—*GIS and Hydrologic Modeling*]. El Bastawesy has been looking at the signatures from flash floods—mostly using Landsat data—and inferring the maximum discharge from the flood by measuring the width of the high reflectance residuals from the flooding—high brightness resulting from the last deposited fine sands. He is also interested in using satellite data to estimate transmission losses from flood flows, an equally vexing problem in the Southwest U.S. Engman will follow up with this contact and connect him with U.S. scientists doing similar work—i.e., Larry Smith at University of California at Los Angeles (UCLA) and individuals at the U.S. Department of Agriculture's Natural Resource Conservation Agency. Bastawesy would be a good contact for future cooperative work in the Applied Sciences Water Management and Disaster Management program elements.

Engman also met with **Ibrahim Ragi Abdel-Hamid** [NARSS—*GIS and Water Quality*]. Abdel-Hamid is interested in using remote sensing for estimating water quality. Engman will follow up and send Abdel-Hamid a *white paper* on water quality estimates from remote sensing and will correspond with him as he develops a program.

Most of the team met with **Hazim M. Habib** [NARSS—*Water Engineering*] at some time during the conference. Engman will follow up with him via email to discuss possible applications of the Land Data Assimilation System (LDAS) and Land Information System (LIS) products for some of their applications. Habib showed us a wonderful evening in Old Egypt to do some shopping and dinner.

Engman also met with **Galal Hassan Galal** [Desert Research Center, Cairo—*Geophysics and GIS Department*]. Galal is interested in learning more about use of passive microwave data for desertification studies—e.g., Advanced Microwave Scanning Radiometer (AMSR), Special Sensor Microwave Imager (SSM/I) and Scanning Multifrequency Microwave Radiometer (SMMR).

Lastly, Engman met with **Abdilqziz Belal** [NARSS—*Soils department*]. Belal is interested in a *post doc* related to soils and precision agriculture. Engman could not be very encouraging but he will contact a few colleagues at U.S. Department of Agriculture (USDA) to see if they know of any possibilities.

Conclusion and Next Steps

Overall, the conference was quite successful. Our expectations of the conference and our participation were exceeded on a number of fronts. We were very successful in establishing some African contacts and contacts with other international agency organizations working in Africa. The items noted below were identified as areas requiring further action after AARSE.

- The number of contacts made through personal discussion, obtaining business cards, and obtaining information about decision support tools and systems was tremendous. We will continue to compile information about the participants and their decision systems and report on that this year.
- NASA agreed with ESA to review the current portfolio (15 projects) of ESA TIGER remote sensing applications projects in Africa to determine possible areas of collaboration. **Diego Fernandez** [ESA—*TIGER Program Lead*] invited NASA to participate in the TIGER projects where applicable.
- NASA will continue to communicate with RECTAS, NARSS, EIS-Africa, and TIGER to establish data, model, and product sharing as our *Project WSSD* activity grows in FY 2007.
- The results of the NASA Special Panel discussion will be discussed with data management leads, Data and Information Service Centers (DISCs), and others to relay suggestions for improved data access in bandwidth-limited Africa.
- Many of the discussions included the SERVIR project, which comes under the Ecological Forecasting Program Element. Conference participants will coordinate with **Woody Turner** [NASA HQ—*Ecological Forecasting Program Lead*] as well as with leads of the other program elements to coordinate our contacts and potential project area enhancements.
- GSFC, under the direction and funding of the Disaster Management Program, will continue to populate the *Project WSSD* database on potential *end users* and associated Decision Support Tools, with plans to provide a first report on the results to NASA HQ by March 31, 2007. We believe this database is a strong cross-cutting activity since the knowledge base will contain information for all 12 National Applications and the Rapid Prototyping Capability (RPC). ■

NASA Participates in International Conferences in Cairo and Beijing

Alan B. Ward, NASA Goddard Space Flight Center, award@sesda2.com

Introduction

Winnie Humberson and **Tim Suttles** [Goddard Space Flight Center (GSFC)/RS Information Systems—*Science Mission Directorate/Earth Observing System Project Science Office Support Office*] supported the NASA Exhibit at both the 6th Annual Conference of the Africa Association for Remote Sensing of Environment (AARSE) held in Cairo, Egypt—*see article on page 29 of this issue*—and the 2nd Conference of the Earth System Science Partnership (ESSP) entitled Global Environmental Change—Regional Challenges held in Beijing, China. A brief summary of the booth activities at each conference, based on Humberson's trip report, appears below.

Cairo

Humberson and Suttles arrived in Cairo on October 28 and spent the entire day on October 29 getting the NASA shipment delivered to the hotel. As often happens with international shipping, there were numerous hurdles that had to be overcome but by the end of the day on October 29 the exhibit was set up and ready to go.

Once the exhibit was set up, things went smoothly. Humberson and Suttles organized a NASA town hall meeting, at which Suttles gave a brief overview on NASA science—*see photo (right)*. After the presentation, participants had an opportunity to engage in open dialogue with NASA officials—**Shahid Habib**, **Steve Ambrose**, and **Fritz Pollicelli**. The goal of the dialogue was to make contact with the potential NASA data users, and to learn from attendees how NASA data can serve them. About 45 people participated in the NASA town hall, not a bad attendance for a relatively small conference. (Attendance was much greater at the town hall meeting than it was at the other exhibits running concurrently.) At the closing of the town hall, Humberson raffled NASA's exhibition artwork—they had prepared an extra set to give away. Steve Ambrose also brought with him copies of *Know Risk* and *Real Risk*, two NASA/ United Nations collaborative books, and these were included in the raffle. It was determined that shipping conference materials back to the U.S. could cost more than donating them to a local education institution; therefore, all remaining materials were given to NARSS, and they were ecstatic to receive such a gift from NASA.

The NASA booth received a steady flow of traffic over the entire four days. Ambrose, Habib, and Pollicelli

took turns helping Humberson and Suttles staff the booth, which provided even more opportunity for conference attendees to engage with NASA officials. The AARSE conference ended on November 2.

Beijing

On November 4, Humberson and Suttles left Cairo to fly to Beijing via Dubai, United Arab Emirates; arriving in Beijing on the evening of November 5 to participate in the ESSP conference. On November 6, Humberson contacted the point of contact from the *freight forward* company to retrieve the NASA shipment, only to find it was held up in Chinese customs because the shipment was shipped on a wooden pallet without an agriculture approval stamp, which is a violation of Chinese agricultural regulations. After considerable haggling, Humberson and the customs agents finally agreed on a compromise. They would destroy the wooden pallets before delivering the materials to the convention center.



At the AARSE meeting in Cairo, Winnie Humberson and Tim Suttles arranged a NASA town hall meeting. The meeting was held in the hosting hotel's nightclub. *Above*, Tim Suttles gives an overview presentation on NASA's satellite missions. *Below*, the audience engages in dialogue with the NASA delegation following Suttles' presentation.





At the ESSP meeting in Beijing, Jack Kaye, Director of NASA's Earth Science Research Program, participated in an interview for a local television station. The NASA exhibit can be seen in the background.

Luckily, however, the shipment arrived at the convention center in near perfect condition.

The conference exhibit officially began on November 8, complete with a swarm of local camera crews and reporters. NASA's booth was in the spotlight for the first two days of the meeting. **Jack Kaye** [NASA HQ—*Director of NASA's Earth Science Research Program*] witnessed the excitement of the NASA booth firsthand as he staffed the booth along with Humberson and Suttles. Humberson invited a local TV reporter to do an interview with Kaye, which Kaye graciously agreed to do—see photo above.

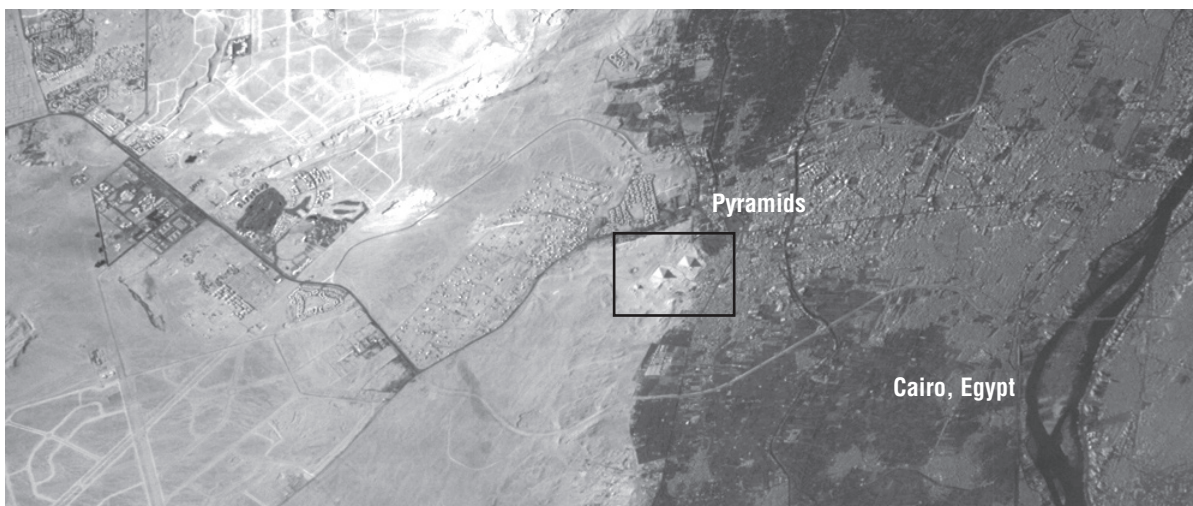
Humberson also put together an announcement for a live demo on *Giovanni* at the booth. *Giovanni* is the underlying infrastructure for a growing family of Web interfaces that allows users to analyze gridded data interactively online without having to download any

data. Through *Giovanni*, users are invited to discover and explore Earth science data using sophisticated analyses and visualizations. **Greg Leptoukh** [GSFC] was more than happy to take the opportunity to give a demo; however, there was a slight setback as many who came were expecting the demo to be given in Chinese. Fortunately, many conference attendees did speak English, so the half-hour demo did not go to waste, but it is a lesson learned for future international conference participation. Leptoukh also took advantage of the opportunity to showcase *Giovanni* to Kaye, who had not seen the demo before. The demo also highlighted the need to develop a publication to introduce data users to *Giovanni*. The SMD/EOSPSO Support Office staff will work with Leptoukh to develop some promotional materials for *Giovanni*.

Additionally, a Chinese publisher requested to translate the *NASA Earth Science Reference Handbook* into Chinese. The publisher will pay translation expense, and would like to sell the Chinese version for profit. NASA would of course receive royalties and copies. Kaye agreed to find out whether it would be permissible to accept such an offer.

Conclusion

All and all, both conferences were excellent opportunities to expose the conference attendees to NASA Earth science. This is especially important at international venues such as Cairo and Beijing where many people associate NASA with space shuttle launches and are not as aware that NASA does Earth science. The outreach materials were very well received, and the booth received constant traffic at each conference which gave some good exposure for NASA Earth Science. ■



Astronauts on board the International Space Station captured this digital photograph of the Pyramids of Giza and the surrounding area on August 18, 2003. Today, Giza is a rapidly growing region of Cairo, Egypt. Population growth continues to soar in the area, leading to new construction. New roads for large new developments are obvious in the desert hills northwest and southwest of the pyramids. Documenting patterns of urban growth around the world is a prime science objective for astronauts on the space station. For color image and additional information please visit: earthobservatory.nasa.gov/Newsroom/NewImages/images.php3?img_id=16292. **Image Credit:** NASA.

NASA Data Helps Pinpoint Wildfire Threats

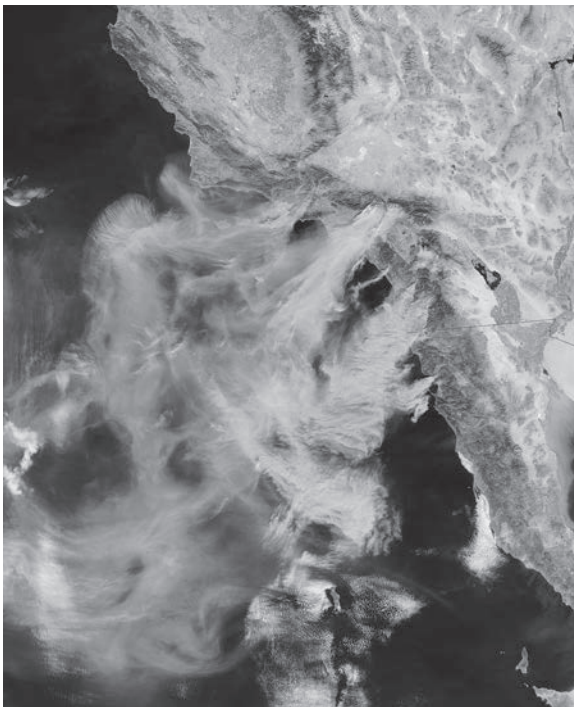
Mike Bettwy, NASA Goddard Space Flight Center, mbettwy@rsis.com

According to a recent study NASA data from Earth observing satellites is helping build the capability to determine when and where wildfires may occur by providing details on plant conditions.

While information from sophisticated satellites and instruments have recently allowed scientists to quickly determine the exact location of wildfires and to monitor their movement, this geoscience research offers a step toward predicting their development and could complement data from National Oceanic and Atmospheric Administration weather satellites used to help calculate fire potential across much of the United States.

By studying shrublands prone to wildfire in southern California, scientists found that NASA Earth observations accurately detected and mapped two key factors: plant moisture and fuel condition—or greenness—defined as the proportion of live to dead plant material. Moisture levels and fuel condition, combined with the weather, play a major role in the ignition, rate of spread, and intensity of wildfires.

“This represents an advance in our ability to predict wildfires using data from recently launched instruments,” said lead author **Dar Roberts**, University of



Whipped by the hot, dry Santa Ana winds that blow toward the coast from interior deserts, this image shows several wildfires in southern California, captured by the Moderate Resolution Imaging Spectroradiometer on NASA's Terra satellite on October 26, 2003. Credit: NASA/GSFC.

California-Santa Barbara. “We have come a long way in just the past 5 to 10 years and continue to gather much better data on the variables critical in wildfire development and spread.”

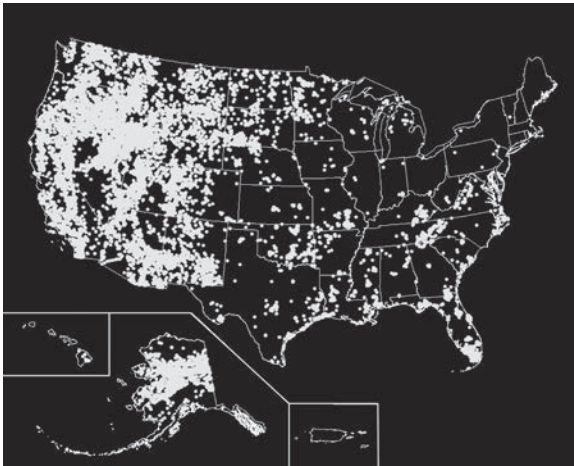
To find out how well NASA satellites could detect these factors, researchers first sampled live fuel moisture, a critical measure for assessing fire danger, from several different plant species in sites across Los Angeles County, CA. This ground-based data, collected by the Los Angeles County Fire Department over a five year period, were then compared to greenness and moisture measures from NASA's Moderate Resolution Imaging Spectroradiometer (MODIS). The space-based data were often closely linked to the field measurements, suggesting the instruments can be used to determine when conditions are favorable for wildfires.

“Improving the role of satellite data in wildfire prediction and monitoring through efforts like these is critical, since traditional field sampling is limited by high costs, and the number and frequency of sites you can sample,” said Roberts. “This new data on the relative greenness of a landscape also allows us to see how conditions are changing compared to the past.”

The satellite data worked best on landscapes where one plant type was dominant. The amount of vegetation cover in an area and its growth rate also influence the reliability of satellite data for wildfire prediction.

The study also found that in areas where branches and dead foliage often help spread fires, changes in the proportion of green vegetation to other plants may also indicate locations of potential fires, especially after moisture values fall below a critical level. The proportion of greenness determines the manner in which plants absorb and scatter sunlight and plays a major role in moisture retention.

Although scientists have long recognized the importance of moisture conditions in wildfire development, this research suggests that other variables may be just as significant. “While live fuel moisture values are critical in the development of wildfires, it's clearly not the last word. Even if vegetation is extremely dry, there are a number of other factors that influence whether a fire will develop and how quickly it spreads, including the ratio of live to dead foliage, plant type, seasonal precipitation, and weather conditions,” said Roberts. “In Southern California, if a strong Santa Ana wind event occurs before our first major rainfall in the fall or winter, the risk for wildfire is significantly heightened.”

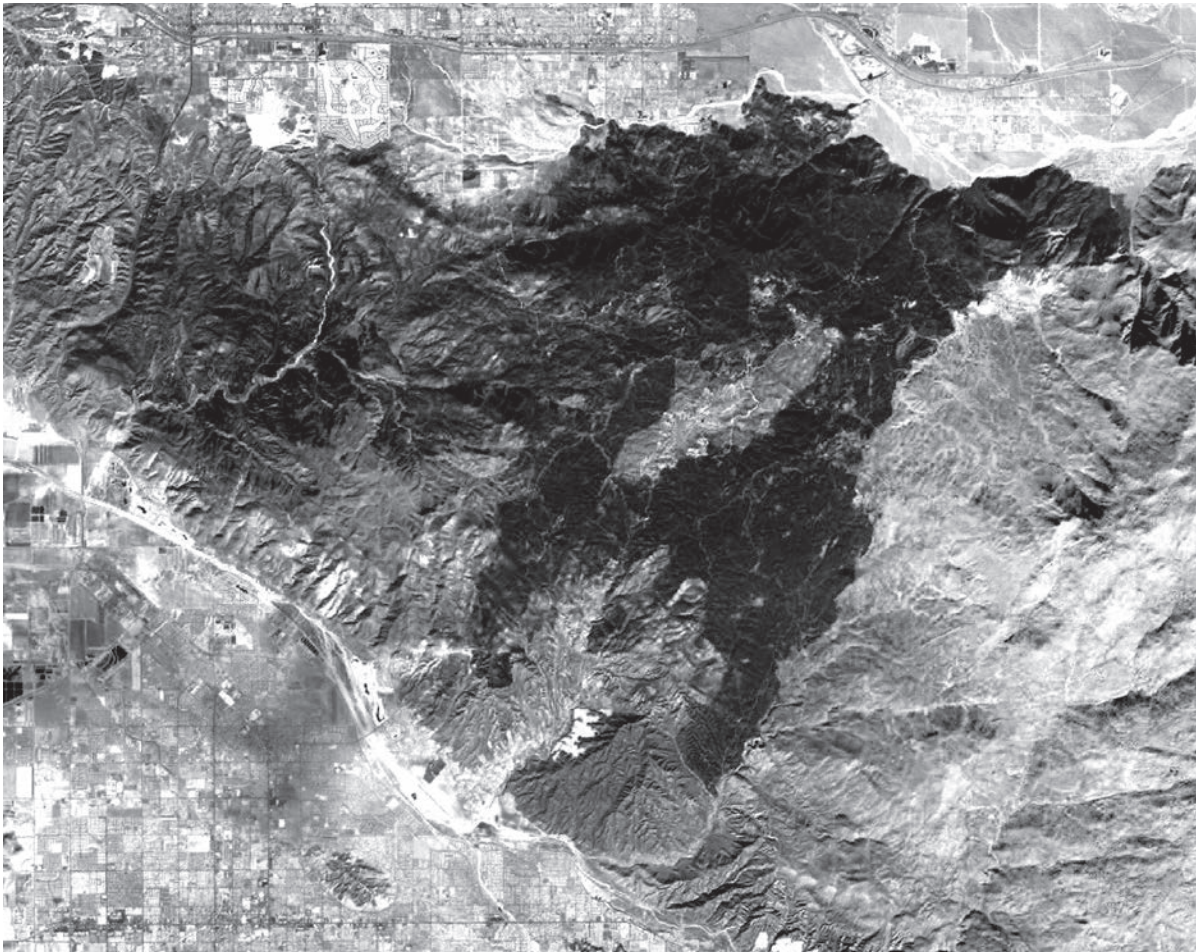


This map shows locations that experienced wildfires greater than 250 acres, from 1980 to 2003. **Credit:** Bureau of Land Management/U.S. Forest Service/U.S. Fish and Wildlife Service/Bureau of Indian Affairs/National Park Service/USGS.

As researchers continue to better understand wildfire development, they are also creating fire spread computer models that use wind speed and direction forecasts to determine where fires will travel. And in the near future, scientists will likely be able to map fire severity to get an indication of the overall impact of a wildfire on the landscape and environment, including the amount of carbon dioxide released into the atmosphere. As the data record from recent satellites continues to grow, scientists will also be able to better track historical changes that might modify fire danger to provide better information for decision makers.

This study, funded by NASA and the U.S. Joint Fire Science Program, was published in the August 30, 2006, issue of the American Geophysical Union's *Journal of Geophysical Research-Biogeosciences*. ■

The Esperanza fire started on October 26, 2006, in the dry brush near Palm Springs, CA. By the time it was contained 6 days later, the fire had consumed 40,200 acres, and destroyed 34 homes and 20 outbuildings. Racing through grass, brush, and timber, the blaze had forced hundreds to evacuate, and it killed five firefighters who were working to protect homes. Fire officials are reporting the cause of the blaze as arson. The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) flying on Terra acquired this composite image of visible and infrared bands on November 3, 2006. In this scene the burned region appears as very dark pixels. For color image and more information please see: asterweb.jpl.nasa.gov/gallery-detail.asp?name=esperanza. **Image Credit:** NASA/GSFC/METI/ERSDAC/JAROS, and U.S./Japan ASTER Science Team.



Smoke Plume Dispersal from the World Trade Center Disaster

Clare Averill, *Jet Propulsion Laboratory, Clare.Averill@jpl.nasa.gov*

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Rosemary Sullivan, *Jet Propulsion Laboratory, Rosemary.Sullivan@jpl.nasa.gov*

The collapse of the World Trade Center on September 11, 2001, and the fires that followed produced a noxious smoke plume—a complex mixture composed of tiny airborne particles and gases. Determining where humans may have been exposed to these contaminants and the amount of their exposure is very difficult. But recently, scientists from the Environmental and Occupational Health Science Institute Robert Wood Johnson Medical School and Rutgers University, in partnership with the Environmental Protection Agency and NASA's Jet Propulsion Laboratory (JPL) have created a detailed numerical model that shows the pollutant dispersion from "Ground Zero" to the surrounding New York - New Jersey region.

Air pollution in the urban atmosphere can damage human health, biological systems, and vegetation. A team of science assessment experts is using this new computer model to analyze the environmental and health impacts of this extreme event.

For example, researchers are using model results in studies of the birth weights of infants whose mothers were near the World Trade Center on September 11, 2001, when they were pregnant and of the incidence of asthma during the first weeks after the attack. The model helps them estimate human exposure levels based on where the plume was located, how much material it contained, and how long it remained.

To map the path of the plume of pollution from the World Trade Center, the researchers used mathematical models of micrometeorological atmospheric circulation and tracer transport, surface measurements, and space-based observations from the high-resolution Landsat imager and the Multi-angle Imaging Spectro-Radiometer (MISR) on NASA's Terra satellite.

While some airborne material circulated within the urban "canyons," much of the material was lifted above the buildings and transported great distances. As a result, surface level exposures were not as frequent and intense as they could have been under different meteorological conditions. To simulate the transport of pollutants in the plume, the researchers had to understand its behavior on scales ranging from tens of meters to several hundred kilometers. They calculated

atmospheric motions using a multi-grid regional atmospheric modeling system covering scales from 250 m to 300 km.

To calculate pollutant transport, they used a hybrid particle and concentration transport model. They evaluated their model's simulated pollutant concentrations, transport, direction, and timing, by comparing the results with fine-scale aerosol measurements routinely acquired from the roofs of New York City public school buildings.

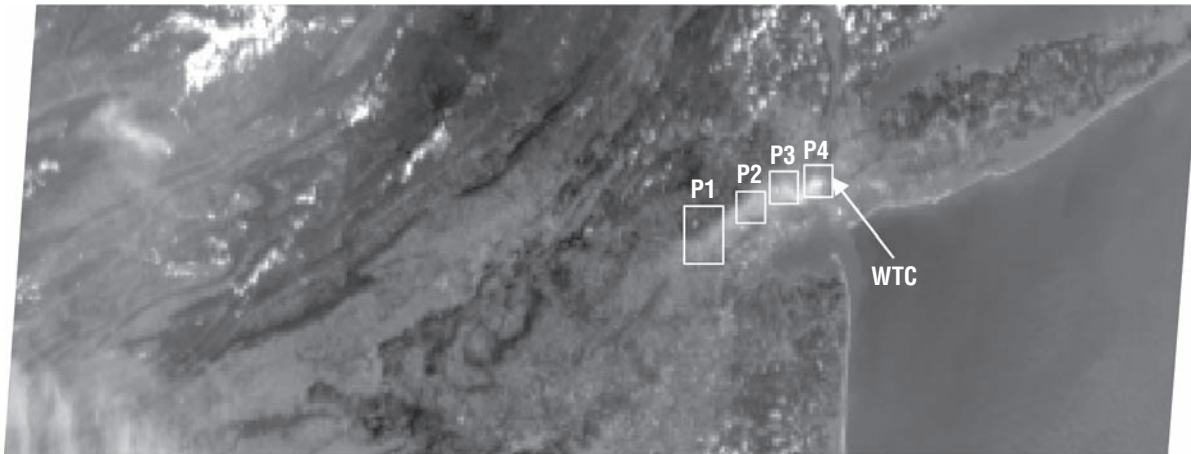
The researchers calculated the evolution of the plume using a *Lagrangian* transport model, which considers the plume to be a collection of parcels that flow downwind. They found that for the model results to match the observations, the peak aerosol emissions in the World Trade Center fire must reach about 35 - 350 kg of particles per hour—thus, the concentration of aerosols within the core of the WTC plume was higher than the routine aerosol pollution in the world's most polluted cities.

Since wind speed and direction can change dramatically at different levels in the atmosphere, knowing the height of the aerosol plume was a crucial part of ensuring that the model produced realistic results. JPL scientists used stereo images of the region acquired by the MISR instrument at about noon on September 12, 2001, combined with ground-based photographs of the plume, to determine the plume height. A natural color MISR image appears here (acquired by MISR's 70° forward-viewing camera on September 12) along with histograms of stereo-derived elevations at four points (P1, P2, P3, P4) progressing from the World Trade Center source to about 70 kilometers downwind.

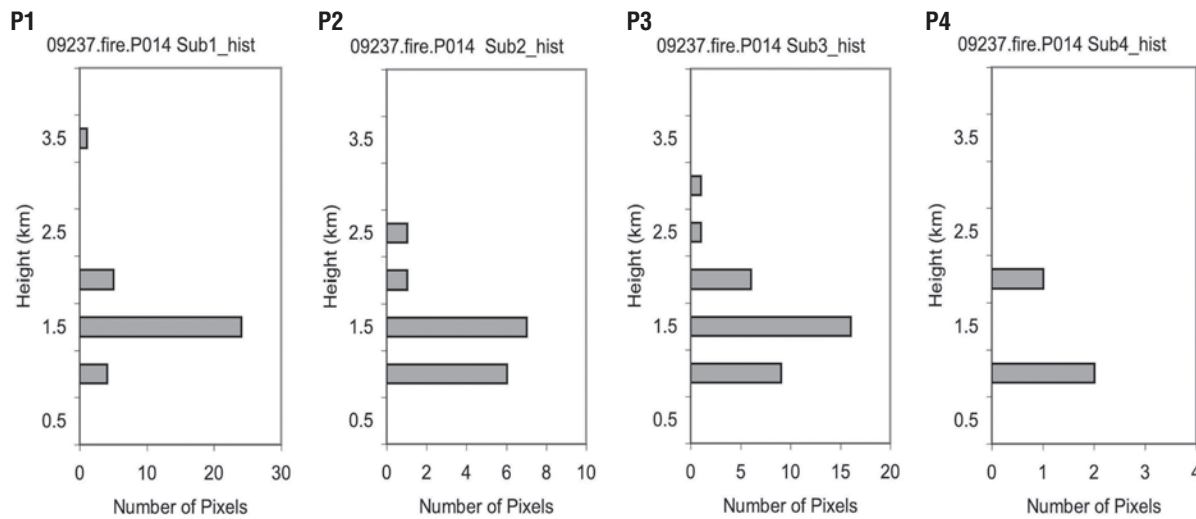
In addition to plume altitude and direction, MISR also provided information about plume evolution. Researchers could trace the plume's development by comparing the combination of airborne particles observed near the plume's source with particles that appear downwind in this MISR snapshot. The researchers also use MISR observations to check how well their model estimates the amount of particulate material the plume contained.

The scientists published their findings in the July issue of the journal *Environmental Fluid Mechanics*. The full citation is: Stenchikov, G., N. Lahoti, D.J. Diner, R. Kahn, P. Liou, and P. Georgopoulos (2006). Multiscale plume transport from the collapse of the World Trade Center on September 11, 2001. *Environmental Fluid Mech.*, doi 10.1007/s10652-006-9001-8.

MISR was built and is managed by JPL, for NASA's Science Mission Directorate, Washington, D.C. The Terra satellite is managed by NASA's Goddard Space Flight Center. JPL is a division of the California Institute of Technology. ■



This natural color image of the area around “ground zero” in New York city was obtained September 12, 2001 and comes from the 70° forward viewing camera on the Multi-angle Imaging Spectrometer (MISR). The boxes refer to the histograms shown below. **Image Credit:** NASA/GSFC/LaRC/JPL, MISR Team



Researchers assumed that the plume of dust from the World Trade Center was a collection of particles that flowed downwind. Using MISR imagery and ground-based photography they determined the height distribution of the plume on four different points along the path of the plume, ranging from “ground zero” to 70 km downwind. The locations are shown on the MISR image above.

Landsat Shows Shrinking Ponds in Alaska

Marie Gilbert, University of Alaska Fairbanks, fmeg@uaf.edu

A first-of-its kind analysis of 50 years of remotely sensed imagery from the 1950s to 2002 shows a dramatic reduction in the size and number of more than 10,000 ponds in Alaska. The analysis, by University of Alaska Fairbanks (UAF) scientists and published recently in the *Journal of Geophysical Research*, indicates that these landscape-level changes in arctic ponds are associated with recent climate warming in Alaska and may have profound effects on climate and wildlife.

Over the past 50 years, Alaska has experienced a warming climate with longer growing seasons, increased permafrost thawing, an increase in water loss due to evaporation from open water and transpiration from vegetation, and yet no substantial change in precipitation.

The shrinking of these closed-basin ponds may be indicative of widespread lowering of the water table throughout low-lying landscapes in interior Alaska, write the authors. A lowered water table negatively affects the ability of wetlands to regulate climate because it enhances the release of carbon dioxide by exposing soil carbon to aerobic decomposition.

“Alaska is important in terms of waterfowl production and if you have a lowering of the water table that could have a potentially huge impact on waterfowl production,” said **Dave Verbyla**, co-author and professor in the School of Natural Resources and Agricultural Sciences at UAF.

“This is an issue relevant to flyway management in terms of all the waterfowl that might use the Yukon Flats National Wildlife Refuge and overwinter elsewhere, and this is something that goes beyond the refuges in Alaska,” said **A. David McGuire**, co-author and professor of ecology at the Institute of Arctic Biology at UAF.

National Wildlife Refuges cover more than 77 million acres in Alaska and make up 81% of the national refuge

system. These refuges provide breeding habitat for millions of waterfowl and shorebirds that overwinter in more southerly regions of North America.

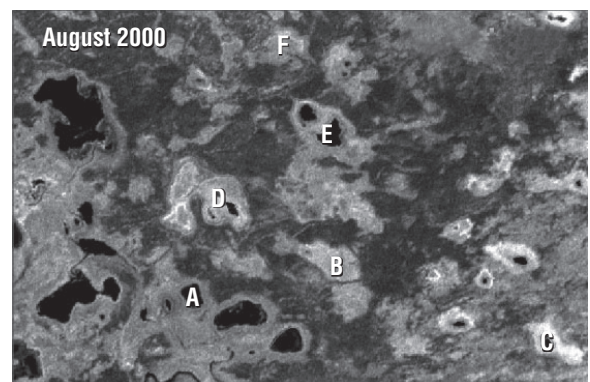
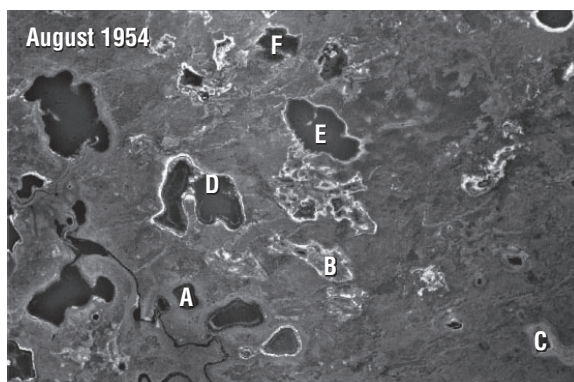
“No one has done a state water-body inventory of this magnitude,” said **Brian Riordan**, lead author and data manager for the Bonanza Creek Long-Term Ecological Research program at UAF. “It will allow land managers to stop speculating about possible water body loss and begin to address the implications of this loss.”

Using black and white aerial photographs from the 1950s, color infrared aerial photographs from 1978-1982, and digital images from the Landsat satellite from 1999-2002, Riordan outlined each pond by hand. “With automated classification your accuracy goes down,” Riordan said. Cloud shadows can look like water and Alaska rarely experiences a cloudless day, said Verbyla.

The most difficult part of the four-year project, said Riordan, was “having the patience to circle 10,000 ponds for each time period.”

The main study area was the subarctic boreal region of interior Alaska, which spans more than 5 million km² bounded on the north by the Brooks Range and on the south by the Alaska Range. To contrast the semi-arid, subarctic sites of discontinuous permafrost in interior Alaska, the authors also selected a study area in the Arctic Coastal Plain where the temperatures are much colder, the growing season much shorter, and the permafrost is continuous, and a more maritime site south of the Alaska Range.

All ponds in the study regions in subarctic Alaska showed a reduction in area of between 4 and 31%, with most of the change occurring since the 1970s. The ponds in the Arctic Coastal Plain showed negligible change. ■



Diminished lake sizes on Alaska's Yukon Flats are evident between 1954 (left: aerial photograph) and the 2000 (right: Landsat Enhanced Thematic Mapper Plus [ETM+] image). **Credit:** Institute of Arctic Biology, University of Alaska Fairbanks.

Public Release of CALIPSO Data Products

The Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) satellite mission is pleased to announce an initial release of its data products. CALIPSO provides new insight into the role that clouds and atmospheric aerosols (airborne particles) play in regulating Earth's weather, climate, and air quality. CALIPSO is a joint mission between NASA and Centre National d'Etudes Spatiales (CNES), the French space agency.

CALIPSO's payload includes an active lidar Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP), an active lidar, as well as a passive Infrared Imaging Radiometer (IIR), and a visible Wide Field Camera (WFC). This data release consists of data beginning in mid June 2006 and includes Level 1 radiances from each of the instruments. This release also includes the lidar Level 2 vertical feature mask and cloud and aerosol layer products. The CALIPSO data are available through the Atmospheric Science Data Center (ASDC) at NASA Langley Research Center and can be accessed at the following URL: eosweb.larc.nasa.gov/PRODOCS/calipso/table_calipso.html

Reference resources on the CALIPSO data set, including detailed data quality summaries and a data catalog are also available at the ASDC CALIPSO page.

For general information about CALIPSO, visit: www-calipso.larc.nasa.gov.

HOW TO CONTACT US:

For information regarding our data products or for assistance, please contact:

NASA Langley Research Center
Atmospheric Science Data Center
User and Data Services
Phone: 757-864-8656
E-mail: larc@eos.nasa.gov
<http://eosweb.larc.nasa.gov>

Public Release of CloudSat Data Products

CloudSat is a NASA Earth System Science Pathfinder Mission (ESSP) that provides the first global survey of cloud profiles and cloud physical properties from space, with seasonal and geographical variations.

The CloudSat Cloud Profiling Radar has been operational since June 2, 2006. The CloudSat Data Processing Center (DPC) has completed the reprocessing of 1B-CPR (radiometrically-corrected and geo-located reflectivity versus altitude), 2B-GEOPROF (cloud mask versus altitude), and 2B-CLDCLASS (cloud classification) products for the first five months of the mission.

To access the released data, use the DPC data ordering system interface found at: www.cloudsat.cira.colostate.edu/data_dist/OrderData.php

The "process description documents" for these products are still being updated; the on-line specifications are all current. The on-line product specifications pages are located at: www.cloudsat.cira.colostate.edu/dataSpecs.php.

If you have any questions concerning the ordering process, contact the DPC at cloudsat@cira.colostate.edu

Future releases are planned for other Level 2 products.

NASA Outlines Recent Changes in Earth's Freshwater Distribution

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

Recent space observations of freshwater storage by the Gravity Recovery and Climate Experiment (GRACE) are providing a new picture of how Earth's most precious natural resource is distributed globally and how it is changing.

Researchers are using GRACE's almost five-year data record to estimate seasonal water storage variations in more than 50 river basins that cover most of Earth's land area. The variations reflect changes in water stored in rivers, lakes, reservoirs; in floodplains as snow and ice; and underground in soils and aquifers.

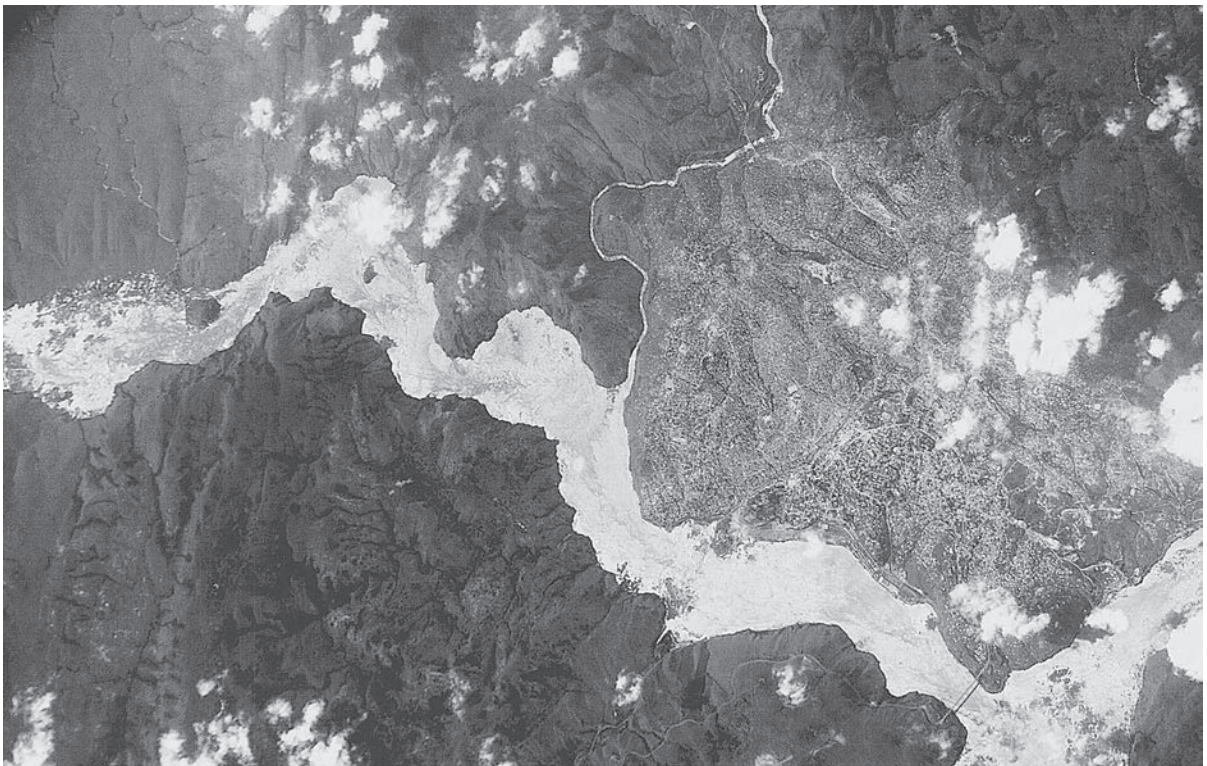
"GRACE is providing a first-ever look at the distribution of freshwater storage on the continents," said **Jay Famiglietti**, professor of Earth System Science, University of California, Irvine. "With longer time series, we can distinguish long-term trends from natural seasonal variations and track how water availability responds to natural climate variations and climate change."

Several African basins, such as the Congo, Zambezi, and Nile, show significant drying over the past five years. In the United States, the Mississippi and Colorado River basins show water storage increases during

that time. Such information is vital for managing water resources in vulnerable parts of Africa and Southeast Asia, since increasing populations and standards of living place demands on water resources that are often unsustainable. The data can be used to make more informed regional water management decisions.

The twin GRACE satellites monitor tiny month-to-month changes in Earth's gravity field that are primarily caused by the movement of water in Earth's land, ocean, ice, and atmosphere reservoirs. Hydrologists are analyzing GRACE data to identify possible trends in precipitation changes, groundwater depletion, and snow and glacier melt rates, and to understand their underlying causes.

Matt Rodell, a hydrologist at NASA's Goddard Space Flight Center, said GRACE data correspond well with ground observations. As a result, hydrologists can now apply GRACE data in ways that will impact regional water management. "GRACE data improve our understanding of the water cycle and simulations of soil moisture, snow, and groundwater in computer models," he said. "This is a key step toward better weather, stream flow, flood, drought, and water resource forecasts worldwide."



This photo of the Congo River was taken from the International Space Station on June 9, 2006. New results from GRACE show that the Congo is one of several African basins that have shown significant drying over the past five years. **Image Credit:** NASA

Michael Watkins, GRACE Project Scientist at NASA's Jet Propulsion Laboratory, said GRACE is the only element in NASA's broad water cycle research program that measures changes in all types of water storage. "GRACE detects water storage changes from Earth's surface to its deepest aquifers; water can't hide from it," he said.

GRACE's abilities to detect water are particularly vital for the emerging field of groundwater remote sensing. "Remote sensing of groundwater has been a Holy Grail for hydrologists because it is stored beneath the surface and is not detected by most sensors," said Famiglietti. "Outside of the United States and a few other developed nations, [groundwater] is not well monitored. It's been speculated that many of Earth's key aquifers are being depleted due to over-exploitation, but a lack of data has hampered efforts to quantify how aquifer levels are changing and take the steps necessary to avoid depleting them. With additional data, such as measurements of surface water and soil moisture, we can use GRACE to solve this problem."

GRACE is also allowing scientists to estimate another key component of the water cycle for the first time:

water discharged by freshwater streams from Earth's continents. Stream flow measurements are often not shared for economic, political, or national defense reasons. GRACE measurements of the total water discharged by continental streams are important for monitoring the availability of freshwater and understanding how surface water runoff from continents contributes to rises in global sea level.

Scientists from NASA and the University of California, Irvine, presented their research during the recent American Geophysical Union meeting in San Francisco, CA.

GRACE is a partnership between NASA and Deutsches Zentrum für Luft- und Raumfahrt (DLR), the German Aerospace Center. The University of Texas Center for Space Research, Austin, has overall mission responsibility. JPL developed the two GRACE satellites. DLR provided the launch, and the Geoforschungszentrum Potsdam, Germany, operates the GRACE mission. ■

Release of an Updated Version of the International MODIS/AIRS Processing Package (IMAPP) AIRS Level 2 Retrieval Software

Space Science and Engineering Center (SSEC) is pleased to announce the release of an updated version of the International Moderate Resolution Imaging Spectroradiometer (MODIS)/Atmospheric Infrared Sounder (AIRS) Processing Package (IMAPP) AIRS Level 2 retrieval software created at the University of Wisconsin-Madison. The regression based algorithm produces retrievals at single AIRS pixel resolution. The products should be considered clear sky retrievals, or valid only above cloud level. The output product is a binary file containing these parameters:

- Surface Skin Temperature [K]
- Atmospheric Temperature [K] at 101 pressure levels
- Total Precipitable Water Vapor [cm]
- Atmospheric Moisture [g/kg] at 101 pressure levels
- Total Ozone [Dobson units (DU)]
- Atmospheric Ozone [ppm v] at 101 pressure levels
- Surface Emissivity at 10 wavenumbers

Changes in this version include the use of dynamic ancillary data (*gdas1* - NCEP global numerical weather prediction grid file - surface pressure field) along with an automated data fetcher, new updated coefficients, and values below the surface now contain fill values. The implementation of this code has been updated as well. To use the run scripts which will automatically fetch the correct ancillary data, there is a file that must be sourced (either *bash* or *csb*) to set the correct environmental variables. Please see the *README* file for more information. Currently, the automated ancillary data script points to the IMAPP seven-day rolling archive ftp site at <ftp://aqua.ssec.wisc.edu/pub/terra/>. So it will not work on data sets that are older than seven days. We plan to extend the archive to cover the entire Aqua and Terra missions in the near future.

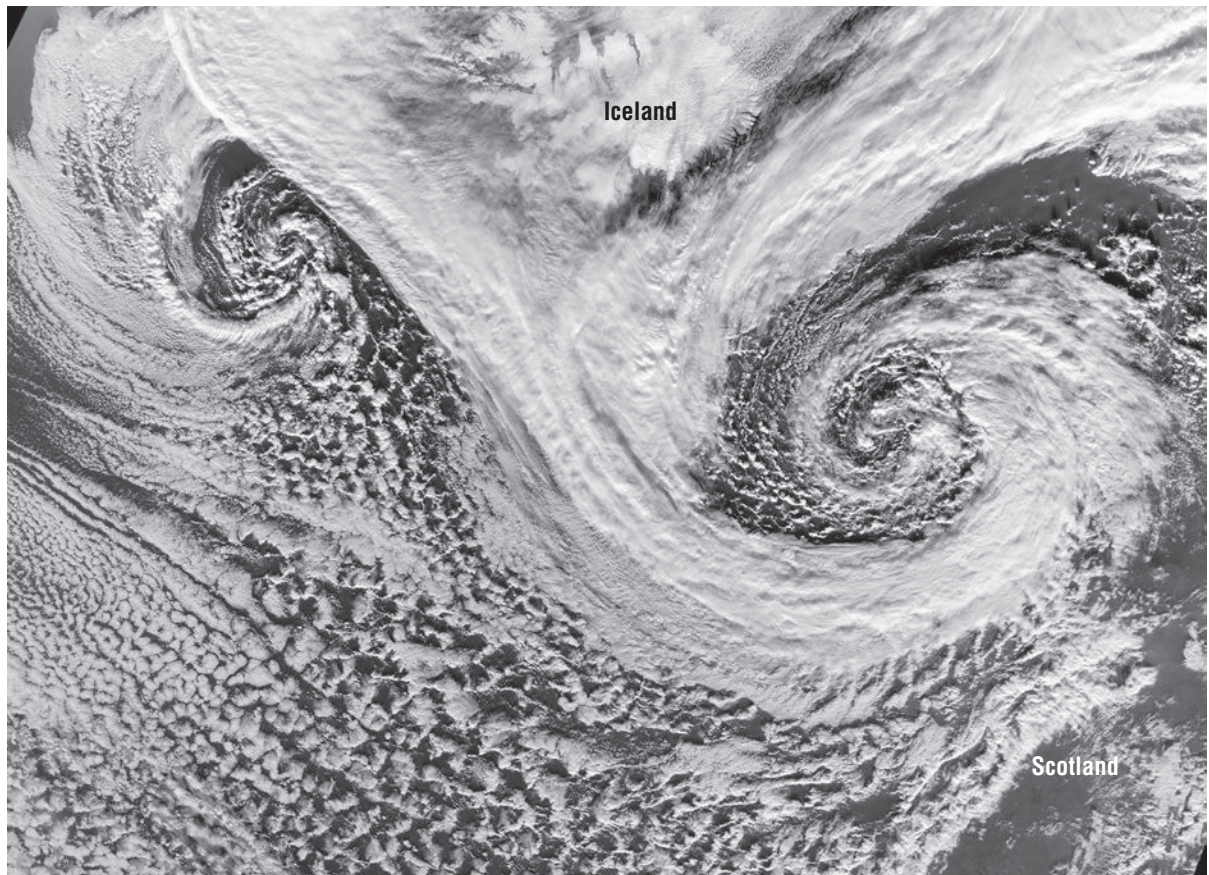
For access to the IMAPP ftp download site, please see:
<cims.ssec.wisc.edu/~gumley/IMAPP/>

Several EOS Scientists Chosen as 2007 AGU Fellows

The following members of the EOS community have been named Fellows of the American Geophysical Union (AGU) for 2007. AGU recognizes individuals who have made outstanding contributions to the advancement of the geophysical sciences, to the service of the community, and to the public's understanding. Not more than 0.1% of AGU members are given this designation each year.

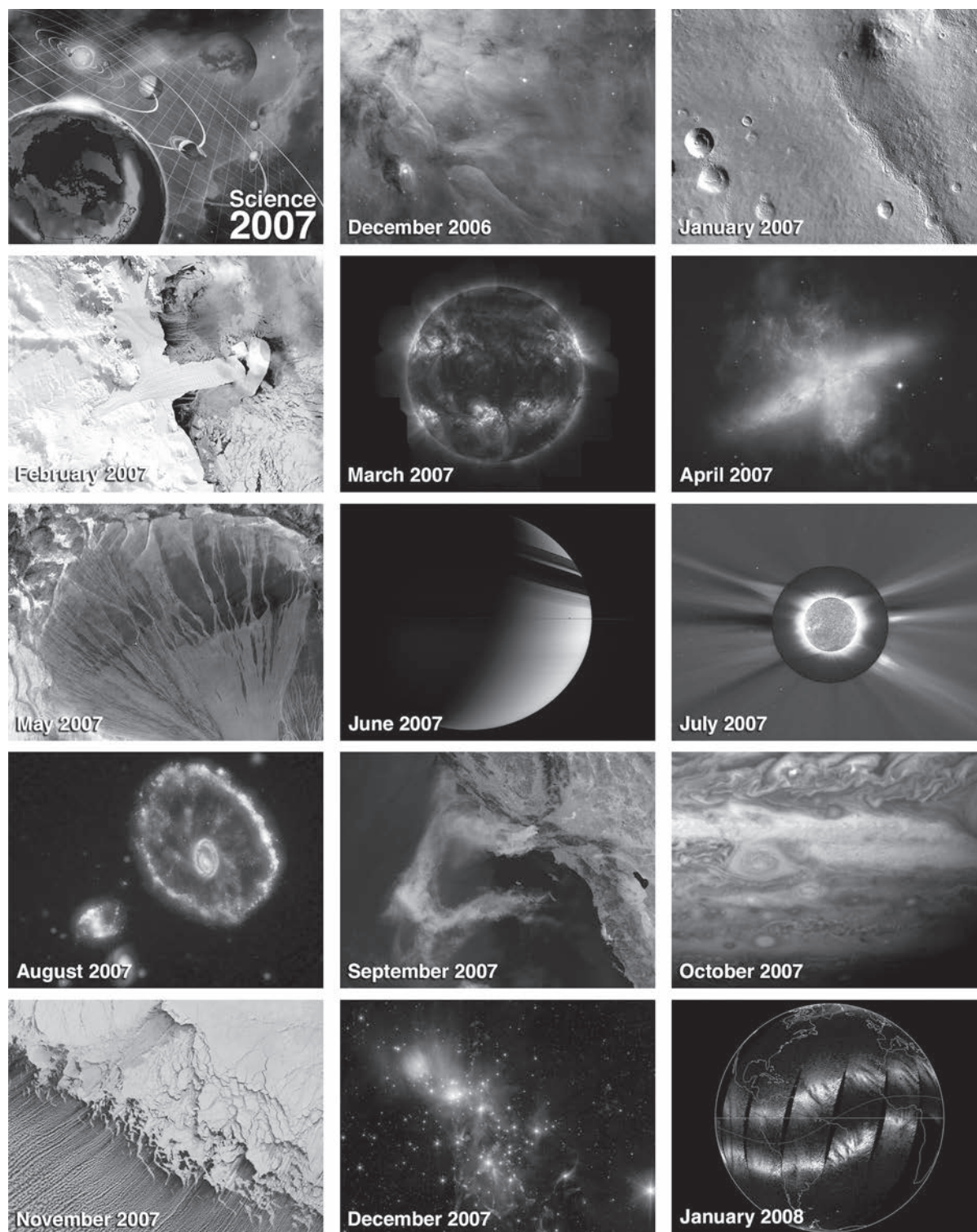
- **Dennis Baldocchi**, University of California, Berkeley, CA
- **Timothy S. Bates**, NOAA Pacific Marine Environmental Laboratory, Seattle, WA
- **Anne R. Douglass**, NASA Goddard Space Flight Center, Greenbelt, MD
- **John C. Gille**, National Center for Atmospheric Research, Boulder, CO
- **Umrans Inan**, Stanford University, CA
- **William K. Lau**, NASA Goddard Space Flight Center, Greenbelt, MD
- **William Parton**, Colorado State University, Fort Collins, CO
- **John Schaake**, NOAA National Weather Service, Silver Spring, MD
- **Kevin Trenberth**, National Center for Atmospheric Research, Boulder, CO
- **Douglas R. Worsnop**, Aerodyne Research, Inc., Billerica, MA

Awards will be presented at the 2007 Joint Assembly, May 22-25, in Acapulco, Mexico. *The Earth Observer* staff on behalf of the scientific community would like to congratulate these individuals on this outstanding accomplishment.



Extratropical Cyclones near Iceland. Although tropical storms most often come to mind, spiraling storms can also form at mid- and high latitudes. Two such cyclones formed in tandem near Iceland and Scotland. In the Northern Hemisphere, cyclones move in a counter-clockwise direction, and both of the spiraling storms in this image curl upwards toward the northeast then the west. The Moderate Resolution Imaging Spectroradiometer (MODIS) flying onboard NASA's Terra satellite took this image on November 20, 2006. For color image and more information see: earthobservatory.nasa.gov/NaturalHazards/natural_hazards_v2.php3?img_id=14041 **Image Credit:** Jesse Allen, NASA's Earth Observatory. Image interpretation provided by Dave Santek and Jeff Key, University of Wisconsin-Madison.

New Science 2007 Screen Saver Available!

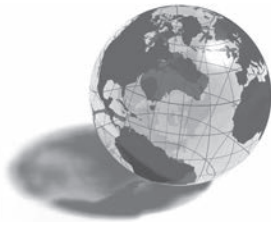


2007 NASA Science Mission Directorate Calendar Screen Saver

Download and install the stunning Earth, Sun, and Space Science images featured in the 2007 NASA Science Mission Directorate calendar. For optimal viewing we have created different sizes for the PC and the Mac.

You can download the screen savers at eos.nasa.gov

Announcement



EOS Scientists in the News

Mike Bettwy, mbettwy@rsis.com, NASA Earth Science News Team

Stephen Cole, scole@pop600.gsfc.nasa.gov, NASA Earth Science News Team

NASA Data Helps Pinpoint Wildfire Threats, December 20; *BBC, United Press International, Economist.com*. NASA-funded research led by **Dar Roberts** (University of California-Santa Barbara) shows how NASA data from space may soon help scientists predict when and where wildfires may occur.

NASA Tropical Ozone Studies Yield Surprises, December 14; *Innovations Report, Science Daily, Terra Daily*. Scientists **Kevin Bowman** (NASA JPL), **Baijun Tian** (NASA JPL), **Yuk Yung** (California Institute of Technology), and **Dylan Jones** (University of Toronto) studied ozone in the tropics using NASA satellite data to gain a fuller understanding of ozone chemistry and its impacts on pollution and climate change.

NASA Outlines Recent Changes in Earth's Freshwater Distribution, December 12; *Associated Press, Reuters, United Press International, ABC*. Space observations of freshwater storage by the Gravity Recovery and Climate Experiment are providing a new picture of how Earth's water resources are changing, say researchers **Matt Rodell** (NASA GSFC), **Michael Watkins** (NASA JPL), and **Jay Famiglietti** (University of California-Irvine).

NASA Research Reveals Climate Warming Reduces Ocean Food Supply, December 6; *Associated Press, Reuters, National Public Radio*. Using Sea-viewing Wide-Field of view Sensor (SeaWiFS) data, scientists **Gene Carl Feldman** (NASA GSFC) and **Michael Behrenfeld** (Oregon State University) have found that when Earth's climate warms, there is a reduction in the ocean's primary food supply.

Purveyors of the Cosmic 'Occult', November 30; *PhysOrg.com, SpaceFlight Now*. A relatively simple technology, developed by a team of scientists including **Tom Yunck** (NASA JPL), **Tony Mannucci** (NASA JPL), and **George Hajj** (NASA JPL) is at the heart of a new satellite network named Cosmic, a powerful, innovative tool for weather and climate forecasting.

Atlantic Hurricane Season Ends Quietly, November 30; *Los Angeles Times*. Forecasters predicted a very active Atlantic hurricane season, but at season's end only nine named storms had formed and **Bill Pazert** (NASA JPL) offers three reasons for the surprise.

Historic Volcanic Eruption Shrank the Mighty Nile River, November 21; *United Press International, Weather Channel, Washington Times, New Scientist*. Volcanic eruptions in high latitudes can greatly alter climate and distant river flows,

including the Nile, according to a recent study led by NASA-funded researchers **Luke Oman** (Rutgers University) and **Alan Robock** (Rutgers University).

NASA Snow Data Helps Maintain Nation's Largest, Oldest Bison Herd, November 2; *Earth & Sky Radio, Terra Daily, Fresno.com*. NASA funded-scientists **Fred Watson** (California State University-Monterey Bay) and **Rick Wallen** (Yellowstone National Park) recently developed a method using NASA satellite data and computer models to help track bison in Yellowstone National Park as they migrate with the melting snowpack.

NASA Explorers Search for Planetary Evolution Clues on Earth, October 27; *National Geographic, Space Daily, SpaceToday.net, SpaceRef.com*. A team of scientists, including **Nathalie Cabrol** (NASA ARC), mountain-climbers, and divers will explore the ecosystems of three high-altitude summit lakes to understand microbial life's adaptation to these challenging environments.

NASA Satellite Identifies the World's Most Intense Thunderstorms, October 26; *United Press International, BBC, Fox News, Science Daily*. By using data from the NASA Tropical Rainfall Measuring Mission satellite, researchers including **Edward Zipser** (University of Utah) and **Daniel Cecil** (University of Alabama in Huntsville) identified the regions on Earth that experience the most intense thunderstorms.

NASA Looks at Sea Level Rise, Hurricane Risks to New York City, October 25; *Associated Press, Christian Science Monitor, USA Today*. Using computer climate models, **Cynthia Rosenzweig** (NASA GISS) and **Vivien Gornitz** (NASA GISS) have assessed the potential impact of rising sea levels and hurricane storm surge on the New York metropolitan area.

NASA and NOAA Announce Ozone Hole is a Double Record Breaker, October 19; *Associated Press, Reuters, United Press International, USA Today*. NASA and the National Oceanic and Atmospheric Administration (NOAA) scientists, including **Paul Newman** (NASA GSFC), report this year's ozone hole in the polar region of the Southern Hemisphere has broken records for area and depth.

Interested in getting your research out to the general public, educators, and the scientific community? Please contact Stephen Cole on NASA's Earth Science News Team at scole@pop600.gsfc.nasa.gov and let him know of your upcoming journal articles, new satellite images or conference presentations that you think the average person would be interested in learning about. ■

NASA Science Mission Directorate – Science Education Update

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NASA EARTH AND SPACE SCIENCE FELLOWSHIP

Proposals for renewal applicants due: March 15, 2007

Applications are now being accepted for the NASA Earth and Space Science Fellowships (NESSF) for the 2007/2008 academic year. Students admitted to or already enrolled in a full-time Master of Science and/or doctoral program at accredited U.S. universities are eligible to apply. Students may enter the fellowship at any time during their graduate work. Students may also apply in their senior year prior to receiving their baccalaureate degree, but must be admitted and enrolled in a Master of Science and/or doctoral program at a U.S. university at the time of the award. The NESSF is open to all students enrolled fulltime at accredited U.S. institutions; however, U.S. citizens and permanent residents will be given preference when two or more proposals are of equal scientific merit. Students with disabilities and/or from under-represented minority groups are urged to apply. URL: nspires.nasaprs.com/external/solicitations/summary.do?method=init&solId=%7b090FD9C1-F91E-15E9-E3C0-21C939C6B9A9%7d&path=open.

UNDERGRADUATE STUDENT RESEARCH PROJECT

Applications for fall session due: February 28, 2007

Applications are now being accepted for NASA's Undergraduate Student Research Project that consists of a 10- or 15-week research experience at a participating NASA Center under the supervision of a NASA technical mentor. A stipend and travel expenses are also provided. Two sessions, one in summer and one in fall, are available. Applicants must be enrolled full-time in an accredited U.S. college or university and be rising juniors or seniors during the Spring 2007 semester or quarter. Highly qualified applicants must be pursuing an undergraduate degree or have demonstrated coursework concentration in engineering, mathematics, computer science, or physical or life sciences. URL: www.vsgc.odu.edu/Menu3_1_3.htm.

THE NATIONAL FEDERATION OF THE BLIND (NFB) YOUTH SLAM: A 2007 STEM LEADERSHIP ACADEMY

Applications due: April 1, 2007

From July 30-August 4, 2007, 200 blind and low vision high school students will stay at the Johns Hopkins

University in Baltimore, MD to be mentored by blind role models during fun and challenging activities meant to build confidence, expand leadership and advocacy skills, and increase science literacy. Participants will also attend various social events as well as workshops on topics such as leadership, career preparation, and advocacy. The NFB Youth Slam will culminate in a rally at Baltimore's Inner Harbor and a celebration at the center of innovation in the field of blindness—the NFB Jernigan Institute.

Candidates are encouraged to complete their applications early, as qualified participants will be selected on a first-come-first-serve basis. Students and mentors need not have a strong interest in science, technology, engineering, or math (STEM) in order to participate, enjoy, and benefit from this academy. URL: www.blindscience.org. Send questions about the NFB Youth Slam to youthslam@nfb.org.

2007 MY NASA DATA TEACHER WORKSHOP, NASA LARC, HAMPTON, VA, JULY 29-AUGUST 3, 2007

NASA Langley Research Center will host a hands-on workshop designed for the grade 6-12 educator that will focus on the implementation and use of Earth system science data sets developed for the pre-college education community as part of the MY NASA DATA program. A major component of the workshop will be the development of lessons incorporating one or more data sets. The data sets are derived from the archive of remotely-sensed data from NASA's Earth Observing System satellites. Participating teachers will explore topics in Earth system science (especially atmospheric science), educational application of data sets, and hands-on classroom activities, and will benefit from the expertise of nationally recognized atmospheric researchers. Participants will also explore how data sets can be used to enhance their curriculum and how students can utilize these data for inquiry-based learning and research. Earth science educators are particularly encouraged to apply. For more information, visit mynasadata.larc.nasa.gov/workshop.html.

NASA GODDARD OCEANOGRAPHY SITE SELECTED AS TOP TEACHER WEB PICK

daac.gsfc.nasa.gov/oceanolor/locus/index.shtml

The Goddard Earth Sciences Data and Information Service Center's (GESDISC) Laboratory for Ocean Color

Users (LOCUS) has been selected as the Teachers' Top Web Pick for December 2006 on the Bridge web site. The Bridge is the foremost source of online educational resources for oceanographic educators. LOCUS was submitted as an online data resource and received high marks from a Teacher Reviewer of Online Learning (TROLL). The reviewer stated that LOCUS "would be THE lab of choice that could be used for integration of data and to stimulate discussion on global issues that affect the ocean and therefore land as well."

The Bridge is jointly sponsored by the National Marine Educators Association (NMEA), the National Sea Grant Program, and the National Oceanographic Partnership Program (NOPP), and is based at the Virginia Institute of Marine Science. Visit www.marine-ed.org/bridge.

Education Calendar

March 15-17

International Technology Education Association (ITEA) 69th Annual Conference, San Antonio, TX. URL: www.iteaconnect.org/Conference/conferenceguide.htm.

March 21-24

National Council of Teachers of Mathematics (NCTM) 2007 Annual Meeting, Atlanta, GA. URL: www.nctm.org/meetings/atlanta/.

March 29-April 1 2007

National Science Teachers Association (NSTA) National Conference, St. Louis, MO. URL: www.nsta.org

New Hurricane Portal for Scientists, Students, and Applications Users Open for Business

Scientists, students, and applications users seeking satellite data on hurricanes now have a new place to turn—a web portal created by NASA Goddard Earth Sciences (GES) Data and Information Services Center (DISC). The new Hurricane web portal is designed for viewing and studying hurricanes with a variety of measurements from satellite-based NASA instruments.

The NASA GES-DISC Hurricane Data Portal can be found at: disc.gsfc.nasa.gov/hurricane/

This interactive website consists of several components, including:

- The *Latest Generated 3 Hour Rainfall Total Images* (right on the home page).
- The *Image Gallery* showing the latest maps and profiles of pre-selected regions, updated daily.
- Event-based data featuring pictures, animations and summaries of current and past tropical storms or hurricanes.
- The *Hurricane Viewer* disc.gsfc.nasa.gov/hurricane/HurricaneViewer.shtml which contains Flash animations (*very cool!*) of storms and hurricanes.
- The *Science Focus* which includes examples and stories describing the data used in hurricane monitoring and research.

The *Tools* section disc.gsfc.nasa.gov/hurricane/tools.shtml connects to NASA satellite data from the Tropical Rainfall Measuring Mission, Moderate Resolution Imaging Spectroradiometer, and Atmospheric Infrared Sounder instruments via the easy to use online analysis and visualization software system called GES-DISC Interactive On-line Visualization and ANalysis Infrastructure (Giovanni). Giovanni allows users to explore, visualize and analyze Earth sciences data interactively online without having to download any data.

Once data of interest is found, researchers can acquire hurricane-related data using the data retrieval tool, *Mirador*, which searches for data by date, parameter, instrument, or any keyword. Another ordering mechanism is the Web Hierarchical Ordering Mechanism (WHOM), which allows searching for data for a particular time and area. Both tools are also found from the *Tools* section.

EOS Science Calendar

March 27-30

AIRS Science Team Meeting, Pasadena, CA.

URL: airs.jpl.nasa.gov

April 24-26

CERES Science Team Meeting, Newport, News, VA,

Contact: Sashi Gupta, S.K.Gupta@larc.nasa.gov

October 1-5

Aura Science Team Meeting, Pasadena, CA.

URL: aura.gsfc.nasa.gov

Global Change Calendar

March 3-10

IEEE/AIAA Aerospace Conference: Global Earth Observation System of Systems (GEOSS), Big Sky, Montana. Call for Papers. Contact: Kathy Fontaine, Kathy.Fontaine@nasa.gov. URL: www.aeroconf.org

March 19-20

TUGIS 2007 20th Annual Geographic Information Sciences Conference, Towson, MD. URL: tugis.towson.edu/

April 17-20

IEEE Radar Conference 2007, Boston, MA.

URL: www.radar2007.org/

May 21-23

IEEE 3rd International Conference on Testbeds and Research Infrastructures for the Development of Networks and Communities, Orlando, FL.

URL: www.tridentcom.org/

May 22-25

2007 Joint Assembly of the American Geophysical Union (AGU), Acapulco, Mexico. Call for Papers.

URL: www.agu.org/meetings/ja07/

May 23-25

Joint CIG/ISPRS Conference on Geomatics for Disaster and Risk Management, Toronto, Ontario Canada.

URL: www.cig-acsg.ca/cig2007/english/home.htm

June 4-8

2007 International Waveform Diversity & Design Conference, Pisa, Italy. URL: www.waveformdiversity.org

June 25-29

32nd International Symposium on the Remote Sensing of the Environment (ISRSE), San Jose, Costa Rica.

URL: www.cenat.ac.cr/simposio/welcome.htm

August 6-10

4th International Conference on Mobile and Ubiquitous Systems: Computing, Networking and Services.

URL: www.mobiquitous.org

August 22-24

Second International Conference on Access Networks, Ottawa, Ontario, Canada. URL: www.accessnets.org/2007/

August 26-30

Earth Observing Systems XII (OP400), San Diego. URL: spie.org/Conferences/Calls/07/op/oeal/index.cfm?fuseaction=OP400

August 27-29

2007 IEEE International Workshop on Machine Learning for Signal Processing (formerly IEEE Workshop on Neural Networks for Signal Processing), Thessaloniki, Greece. URL: mlsp2007.conwiz.dk/

October 2-4

1st Annual OceanTech Expo, Providence, RI.

Contact: Rob Howard, Howard@marinelink.com



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