National Aeronautics and Space Administration

the earth observer

The Earth Observer. March - April 2009. Volume 21, Issue 2.

Editor's Corner

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March marks the 20^{th} anniversary of *The Earth Observer* newsletter. The first issue came out in March 1989[1] and was intended to be a *"periodical of timely news and events,"* to keep readers abreast of new developments in the rapidly evolving EOS program. The EOS Program has a long and rich history and *The Earth Observer* has been there to report much of that history. When the first issue came out in 1989, EOS was just getting started, the Announcement of Opportunity having come out in 1988. Budget cuts and other programmatic changes and directives have resulted in many alterations from the original concept over the years but our newsletter has done its best to keep up with the changes and report them to you.

Back issues of *The Earth Observer* contain a virtual treasure trove of written history of our program[2]. Contained in the pages of those old newsletters are detailed summaries from most if not all of the Investigators Working Group (IWG), Payload Panel, Instrument Team, Science Team, and other meetings. Many of these meetings (especially during the 1990s) were where important decisions were made that would shape the EOS program

[1] The current bi-monthly publication schedule for *The Earth Observer* began with the March/April 1991 issue [**Volume 3, Issue 3**]. Prior to that the production schedule was somewhat irregular with the very first issue [**Volume 1, Issue 1**] coming out in March 1989.

[2] Back issues of *The Earth Observer* from 1995–Present are available at: *eospso.gsfc.nasa.gov/eos_homepage/for_scientists/earth_observer.php*. Hard copies of issues prior to 1995 are available and can be obtained from the EOS Project Science Office—see contact information on the back of the newsletter.

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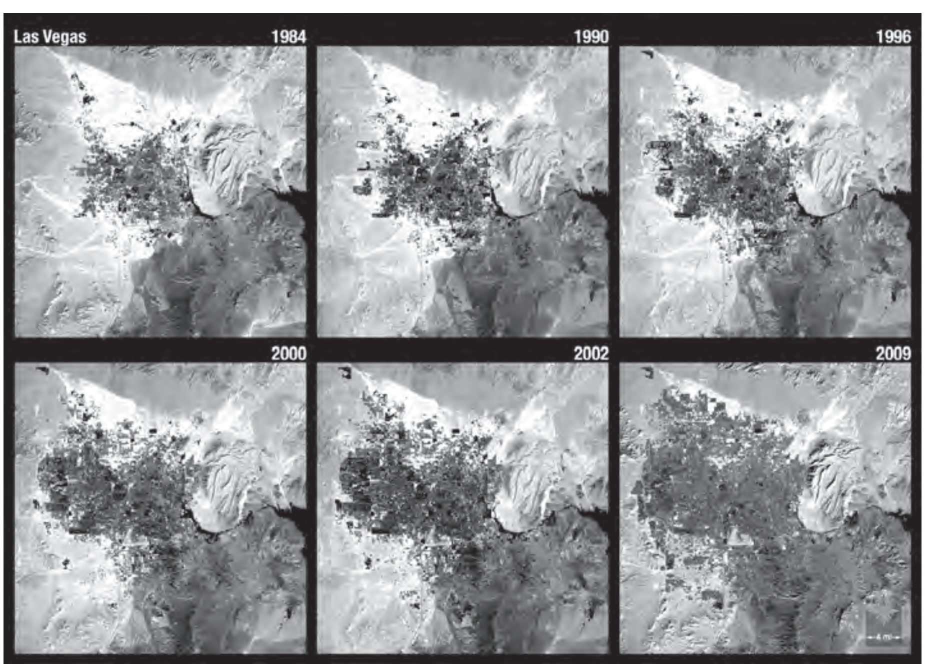

The Earth-Observing Landsat 5 satellite turned 25 on March 1, 2009—a remarkable 22 years beyond its three-year primary mission lifetime. In the 25 years that Landsat 5 has been in orbit, the desert city of Las Vegas has gone through a massive growth spurt. The outward expansion of the city is shown here in this series of images. The grid pattern of city streets and irrigated areas—indicated by dark pixels—grow outward in every direction into the surrounding desert. To view the images in color please visit: *www.nasa.gov/topics/earth/features/landsat25/index.html.*

eos.nasa.gov

In This Issue

into what it has become today[3]. The archived newsletters also contain stories on research projects, field campaigns, and other news of the day.

In our ongoing series, *Perspectives on EOS*, we have been attempting to unearth some of that long-forgotten "treasure" and report the history from the perspective of those who were actually involved in making it.

We are pleased to hear from **Greg Williams** [NASA Headquarters] in this issue. From December 1993 to September 2004, Williams was the senior policy analyst in the variously-titled Earth science organization at NASA Headquarters and thus brings a unique perspective to our series. During those years, much of what was written in defense of EOS for Congress, the National Research Council, and NASA Headquarters began at his keyboard. Williams gives us a very clear sense of the difficult journey that EOS took in going from vision to reality. Along the way, budgetary hurdles were frequent. In reading Williams' article, a couple of things came to mind. First, I was surprised that enough creative ways were found to use the prefix *re-* to describe significant EOS de-scoping actions. Second, even the best of well thought-out and community-accepted programmatic science visions will be impacted by evolving political and fiscal realities, and a flexible and responsive organization is essential for coping in such a changing environment. I believe this serves as an important lesson-learned as NASA plans the way forward toward implementing a new era of missions. We hope that you enjoy reading Williams' article on page 4 of this issue.

We're delighted to recognize *The Earth Observatory* website, on the occasion of its 10th anniversary on April 29. **Rebecca Lindsey**, editor for the site, has shared with us the story of how *The Earth Observatory* evolved from its humble beginnings to the site it is today. *The Earth Observatory* is now an award-winning showcase of images and scientific stories, but its origins can be traced back to a taxicab discussion on a crowded L.A. freeway in the late 1990s. To learn more please see "NASA's Earth Observatory Turns 10" on page 18 of this issue.

Landsat 5 celebrated its 25th anniversary on March 1. Landsat 5 is one of seven Landsat missions that have been launched since 1972; all—except Landsat 6—were designed, built, and launched by NASA, and all were operated by the U.S. Geological Survey (USGS). Remarkably, the satellite is still functioning 22 years beyond its three-year primary mission lifetime, and continues to collect valuable scientific data each day! Landsat 5's longevity turned out to be especially fortuitous given the failed launch of Landsat 6 in 1993. Had Landsat 5 only lasted for the three years of its prime mission, it would have been what Landsat Project Scientist **Darrel Williams** calls *"a scientific disaster,"* as there would've been a 12-year data gap between the end of Landsat 5 and the launch of Landsat 7. Continuous observations are crucial for scientists to identify and assess changes in the Earth's land surface resulting from human activities and natural events. The longevity of Landsat 5 is a tribute to a team that has worked so hard to keep the mission going. A three-minute video featuring comments from Williams, Berrien Moore, Jim Irons, Steven Covington, Dennis Helder, Sam Goward, and Brad Doorn can be viewed on *YouTube* at *www.youtube.*

[3] In the March–April 2008 issue of *The Earth Observer* [**Volume 20**, **Issue 2**, page 4-8] Alan Ward wrote an article called "The Earth Observer: 20 Years Chronicling the History of EOS." The first two paragraphs are adapted from that article.

com/watch?v=ArLvDtsewn0 (or simply do a search on "Landsat satellite.")

There is also news to share about new missions. On February 6, the NOAA-N Prime mission successfully launched from Vandenberg Air Force Base in California. The new satellite was renamed NOAA-19 once it reached orbit. NASA builds and launches these Polar-orbiting Operational Environmental Satellites (POES) satellites for NOAA; NOAA takes over operational control 21 days after launch. As it orbits the Earth, NOAA-19 will collect data about the Earth's surface and atmosphere that are vital inputs to NOAA's weather forecasts.

NOAA-19 is the sixteenth and last satellite in a series of polar-orbiting satellites dating back to 1978. A new generation of environmental satellites called the National Polar-orbiting Operational Environmental Satellite System (NPOESS) will become operational after the POES satellites complete their mission. NPOESS is a tri-agency (NOAA, U.S. Department of Defense, NASA) program. The NPOESS Preparatory Project (NPP) and the first NPOESS satellite are slated for launch in 2010 and 2013, respectively.

I regret I must also mention that on February 25, the Orbiting Carbon Observatory (OCO) launched from Vandenberg Air Force Base in California but subsequently fell into the ocean near Antarctica. Preliminary indications are that the fairing on the *Taurus XL* launch vehicle failed to separate and the satellite was unable to reach orbit. A Mishap Investigation Board, led by Rick Obenschain, Deputy Director at Goddard Space Flight Center, has been convened to conduct a thorough investigation of the launch failure. This is a painful blow to NASA's climate change program as we lose a mission that held promise for helping us better understand the sources and sinks of atmospheric carbon dioxide and their temporal changes. I want to extend my sympathies to **David Crisp**, Principal Investigator for OCO, and to the entire team who invested so much of their energy, time, and careers into the mission.

On February 26, the President's Fiscal Year 2010 Budget was released. The budget provides $18.7 billion for the National Aeronautics and Space Administration (NASA) which, when combined with the $1 billion provided for NASA in the Recovery Act, is more than $2.4 billion above the 2008 level. While specific budget details, including exact funding levels for Earth Science, are not expected until next month, the language emphasizes the desire for climate change research and monitoring "using the National Research Council's recommended priorities for space-based Earth science research as its guide."

Finally, I would like to mention that our EOS Project Science/Science Mission Directorate Support Office recently submitted some of our outreach products to the Washington D.C. Chapter of the *Society for Technical Communication's* "2008–2009 Technical Art Competition." The **Science Mission Directorate Calendar** received an *Award for Excellence* and our **series of four Earth Science posters (Air, Ice, Land, Water)** received an *Award for Merit*. The team continues to produce high-quality outreach material that plays an important role in promoting science at NASA. Congratulations to the team! ■

This "first light" image from the NOAA-19 Advanced Very High Resolution Radiometer (AVHRR/3) Automatic Picture Transmission (APT) image was acquired by Fred E. Piering from orbit 4 on February 6, 2009 at 1814 Zulu Time (1:14 p.m. EST). Piering used a home built antenna and receiver. He describes himself as a weather satellite hobbyist and has been active in APT data capture since 1971. The dual images are from channels 1 and 2 of the AVHRR/3. Among the areas recognized in this image are the northern tip of South America, Cuba, the eastern Gulf of Mexico, Florida, the Chesapeake Bay, the Great Lakes, the east coast of the U.S. and Canada. **Image Credit:** Fred Piering.

featured articles

A Washington Parable: EOS in the Context of Mission to Planet Earth

Greg Williams, NASA Headquarters, gregory.j.williams@nasa.gov

NASA's Mission to Planet Earth evolved out of the Agency's ongoing program in Earth Science and Applications, which included a core of scientific research, development and launch of weather satellites for NOAA, development of focused satellite and Space Shuttle payloads, and limited data analysis and distribution efforts.

This article continues our ongoing *Perspectives on EOS* series. In this series, we have asked a variety of individuals who were actively involved in the early years of the EOS Program and/or who are involved today to share their particular *perspective* on EOS. We hope these reports help to shed light on the history of NASA's Earth Science Program while also providing some lessons-learned for future Earth observing missions.

For this issue, *The Earth Observer* is pleased to offer the perspective of **Greg Williams**. From December 1993 to September 2004, Williams was the senior policy analyst in the variously-titled Earth science organization at NASA Headquarters and thus brings another unique perspective to our series of articles. Much of what was written in defense of the Earth Observing System (EOS) before Congress, before the National Research Council, and for NASA Headquarters use more broadly during these years began as depressions on his keyboard.

Other articles in this series have shared inspiring personal stories of how colorful and brilliant characters moved to make EOS one of the world's major scientific successes. Williams tells another side of the story as he shares the frightful tale of how EOS was battered and bruised by the powerful and chaotic forces that swirl inside the Washington Beltway before emerging victorious as the highly successful program it is today. His article reminds us that even the best of programmatic science visions can be impacted by budget and political realities. We hope you enjoy reading his article.

Conceiving a Mission to Planet Earth: 1982-1990

NASA's *Mission to Planet Earth* (MTPE) evolved out of the Agency's ongoing program in Earth Science and Applications, which included a core of scientific research, development and launch of weather satellites for NOAA, development of focused satellite and Space Shuttle payloads, and limited data analysis and distribution efforts. NASA had been in the Earth science business from its very beginnings as a Federal agency. In 1960, NASA launched the first weather satellite—the Television and Infrared Observation Satellite (TIROS-1). Other early missions such as the Landsat series (originally known as Earth Resources Technology Satellites), Seasat, and the Nimbus series revealed a tremendous potential for Earth observation from space. Meanwhile, scientific and societal imperatives for the study of global change were growing. Measurements of atmospheric carbon dioxide (CO_2) made by Charles Keeling beginning in 1958 (and continuing to this day) and the discovery of the Antarctic ozone hole added a global dimension to existing environmental concerns. NASA's scientific leadership on the ozone issue and the rising importance of the view from space in understanding the global nature of environmental change positioned NASA as a key player in global change research.

As early as 1982, NASA leadership was interested in pursuing Earth science from space on the grand scale it would require. NASA Administrator **James Beggs** proposed such an endeavor at the 1982 United Nations Conference on Peaceful Uses of Outer Space, with the intellectual underpinnings initially documented in a NASA-charted study led by Harvard's **Richard Goody** discussing *"the viability of a major research initiative in the area of global habitability[i]"* (Goody was also a founding leader of the International Geosphere–Biosphere Program which was getting underway at this time.) The study asserted that *"NASA can do it and no other Federal agency can"* ("*As*

Greg Williams

only NASA can" would later be a short-lived NASA tagline.) It proved premature, however, as the requisite coordination with potential partners and stakeholders had not taken place. Administrator Beggs was undeterred, however, and directed the head of NASA's Office of Space Science and Applications, **Bert Edelson**, to build a program and constituency in global change research[ii]. Edelson appointed an Earth System Sciences Committee under the auspices of the NASA Advisory Council to undertake an extensive study of the scientific imperatives and programmatic possibilities. **Francis Bretherton** of the National Center for Atmospheric Research (NCAR) chaired the Committee. Their seminal report *Earth System Science*[iii] was released in two volumes: an "Overview" (1985) and "A Closer View" (1988). The "Bretherton Report" was the crucible for both the interdisciplinary field of Earth System Science and NASA's Earth Observing System.

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The Bretherton Report articulated the goal and challenge that define in the most concise terms what the Committee meant by *Earth System Science*:

> "**The Goal of Earth System Science**: To obtain a scientific understanding of the entire Earth System on a global scale by describing how its component parts and their interactions have evolved, how they function, and how they may be expected to continue to evolve on all time scales.
>
> **The Challenge to Earth System Science**: To develop the capability to predict these changes that will occur in the next decade to century, both naturally and in response to human activity."

Earth System Science is the study of Earth as a planet—one that is particularly complex and dynamic due to its active lithosphere, the presence of water in all three phases, biogeochemical cycles, stable climate with internal variability, and life in great diversity. Studying Earth as a planet requires the view from space. While several other Federal agencies lead research in various disciplines of Earth science, NASA took up the challenge to advance interdisciplinary Earth System Science.

Between the publication of the "Overview" and "A Closer View", NASA and the nation experienced the *Challenger* disaster. In the aftermath of that tragedy, the NASA Administrator **James Fletcher** commissioned an internal study on the future of NASA led by former astronaut **Sally Ride**. Her report *Leadership and America's Future in Space*[iv] recommended a *Mission to Planet Earth* as the first among "four bold initiatives" to serve as the basis for the Agency's future planning. In 1990, an external advisory group led by Martin Marietta CEO **Norman Augustine**[v] endorsed the theme of *Mission to Planet Earth* as a core mission of NASA. That same year, the Congress passed the Global Change Research Act[vi] creating the interagency U.S. Global Change Research Program.

The principal provider of global observations for both *Mission to Planet Earth* and the U.S. Global Change Research Program would be NASA's Earth Observing System. In scope, approach, and scale, EOS was unlike previous, more incremental efforts in Earth science. Originally conceived as part of the polar platform of the Space Station

Program, EOS soon became a program in its own right, and was envisioned as being composed of multiple satellites launched over two decades and the largest science information system ever conceived[1]. After years of planning, the EOS Announcement of Opportunity (AO) was released in 1988, seeking proposals for instruments and science teams. In early 1990, NASA announced selection of 30 instruments to be developed for EOS, along with their science teams, and 29 Interdisciplinary Science (IDS) investigation teams.

The magnitude of this undertaking was enormous. Prior to EOS, scientists wishing to study the Earth from space had one or two research satellites to work with at any one time; the Landsat series and the Earth Radiation Budget Experiment in the 1980s, and the Upper Atmosphere Research Satellite (UARS) and the Ocean Topography Experiment (TOPEX)/Poseidon in the early 1990s. By the time the EOS first series was complete in 2004, 19 satellites, some carrying several instruments, were in orbit generating 3 terabytes of data per day. But the journey from *here to there* was fraught with peril…

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"Re"-assessing the EOS Program: 1990-1994

In the movie *The Princess Bride*, the hero Westley recounts his days serving as a cabin boy on the pirate ship *Revenge*. At the end of each day, he would hear the dread pirate Roberts tell him, *"Good work. Good night. I'll most likely kill you in the morning."* And so it went daily for three years...

Our Government is not nearly so capricious in nature, but each and every year, Congress has the opportunity to weigh each Federal program's merits and decide if it should *die* (whether in part or in total) this day or some other. In response to these annual Congressional reviews the EOS program evolved substantially from how it was envisioned when it received its "New Start" in 1990, both in terms of program content and budget. In each instance, when the Agency was required to replan the program, NASA sought the assistance and advice of the external science and engineering communities. It also sought to preserve the fundamental contributions of the program to global change science and its commitments to the objectives of the U.S. Global Change Research Program. What follows are highlights in the program's early history. (These "re"-exercises are briefly summarized below; they have previously been described in more detail in other publications[2].)

New Start (1990). The Earth Observing System and Earth Probes were both approved as "New Starts" by Congress in late 1990 as part of the FY91 budget. At the time, the program had a runout budget of $17 billion through 2000 and divided the 30 EOS instruments into three groups: EOS-A and EOS-B series large spacecraft designed to be launched on the most capable expendable launch vehicles available (Titan-class), and attached payloads for the Space Station. The first launch for the program (EOS A-1) was planned for December 1998.

Restructuring (1991). In March 1991, NASA initiated an external study effort to examine the planned implementation for the part of the program designed to fly as part of the EOS-B series. As the EOS External Engineering Review Committee was preparing for its primary session in July 1991, the Senate Veterans' Affairs, Housing and Urban Development, and Independent Agencies (VA-HUD-IA) Appropriations

[1] Dixon Butler discusses the origins of EOS in his article in the *Perspectives on EOS* series: "The Early Beginnings of EOS: *System Z* Lays the Groundwork for a Mission to Planet Earth" in the September–October 2008 issue of *The Earth Observer* [**Volume 20, Issue 5**, pp. 4-7.]
Piers Sellers shares "Reflections on the Early Day of EOS: A Biased and Unexpurgated History" in the January–February 2009 issue of The Earth Observer [**Volume 21, Issue 1**, pp.4-8.]
[2] The *1995 Reference Handbook*, pp. 14-23, and the *1999 EOS Reference Handbook*, pp. 15-19 reported extensively on these revisions to and reviews of EOS, their purpose, guiding principles, and outcome. To learn more please refer to these volumes.

Subcommittee marked up the FY92 NASA budget request with report language directing NASA to:

- focus EOS science objectives on the most important problem of global change—global climate change;
- increase resilience and flexibility of EOS by flying instruments on multiple smaller platforms, rather than a series of large observatories; and
- reduce the cost of EOS across the board (i.e., spacecraft, instruments, data system, science) from $17 billion through 2000 to $11 billion.

Based on this guidance, NASA developed rough flight options that were reviewed by the External Engineering Review Committee[vii] (chaired by **Edward Freiman** of the Scripps Institution of Oceanography) and endorsed as "proof of concept" for an EOS that contained a *"favorable measure of resiliency."* With input from the Committee and detailed recommendations from the EOS Payload and Science Panels, NASA configured EOS to fly 17 instruments on a series of intermediate (3), medium (1) and small (2) spacecraft and focused the program on climate change. The launch of the first EOS spacecraft (EOS-A-1 was now renamed EOS AM-1) was accelerated to June 1998. As part of the restructuring process, NASA also deferred or deleted a number of the original instruments in the program.

Rescoping (1992). Even as the restructured program was being reviewed by Congress as part of the FY93 budget proposal, the new NASA Administrator **Daniel S. Goldin** recognized that the Agency's out-year funding targets were unrealistic and tasked the various programs to look for means of reducing long-term costs. He set a reduction target of 30% for the exercise and commissioned a variety of internal "blue" and "red" teams to examine program implementation. As one of the major agency programs, EOS was one of the main participants in this "rescoping" exercise.

Out of this effort came a proposal to reduce the runout EOS budget through 2000 from $11 billion to $8 billion, a proposal that was later incorporated by the Congressional appropriations committees in their report language with the FY93 budget. Under the rescoping proposal, EOS retained its emphasis on long-term (15 years) data continuity and the general structure developed during the 1991 restructuring. One large instrument—High Resolution Imaging Spectrometer (HIRIS)—was dropped from the program (saving both development and data system costs), though the deletion was partially predicated on a new partnership between NASA and the Department of Defense (DoD) for the development of Landsat 7 [3]. The funding constraints imposed by the rescoping led NASA to depend more heavily on international partners for some of the EOS measurements, as well to reduce the overall level of contingency funds available during program development (thus, potentially increasing program risk). Some instrument flights were delayed and the number of at-launch data products was reduced. The program also decided to use a *common spacecraft* bus for all of the intermediate-class missions after EOS AM-1, i.e., the AM, PM, and CHEM series.

Rebaselining (1994). The first NASA budget of the Clinton Administration assumed additional reductions to the agency in recognition of constrained resources for the out-years. The proposed funding levels for EOS through 2000 would drop from $8 billion to $7.25 billion, about a 9% decrease. Over the course of 1994, NASA worked with outside science and review groups to identify the most prudent way of incorporating the reduction. The *EOS Payload Panel* played an integral role in these deliberations, eventually endorsing a plan to adjust mission schedules (advancing some measurements, delaying others) and content, to shift to smaller spacecraft for the *common spacecraft* missions, to adjust the repeat cycles for the spacecraft from five

[3] Darrel Williams discusses this short-lived "Landsat on AM-1" idea in his article in the *Perspectives on EOS* series: "Reflections on the Early Days of EOS: Putting Socks on an Octopus" in the May–June 2008 issue of *The Earth Observer* [**Volume 20, Issue 3**, pp.4-5.]

years to six, to fly a number of important small instruments as *flights of opportunity* [including several flights of the Stratospheric Aerosol and Gas Experiment (SAGE)], and to accept a number of cost-saving measures for the Earth Observing System Data and Information System (EOSDIS). NASA asked an external panel of senior scientists from across the U.S. to review the NASA plans, and their report was generally favorable. As with the rescoping exercise, the rebaselining outcome emphasized the need to rely on interagency and international partners. In late summer 1994, the Congress appropriated an extra $38 million for MTPE in the final FY95 budget. The final results of the rebaselining were incorporated into NASA's FY96 budget submission.

Reshaping (1995). With a goal of preserving the interdisciplinary nature of the program and maintaining the required long-term measurement set, NASA embarked on a study in Spring 1995 designed to consider how new strategies and technologies could be employed to reduce the long-term cost of EOS. The reshape effort sought to accomplish several interrelated objectives:

- Substantially reduce EOS life-cycle costs relative to the Government Accountability Office (GAO) estimate while preserving the basic measurement set;
- provide now for technology infusion so that it will be available for the second and third EOS series;
- provide new science opportunities through small satellites prior to 2000; and
- adjust program management to an evolutionary approach.

While NASA planned for the future, opponents of EOS in Congress chose this time to launch an all out assault to cut funding for the program. If fact, the years 1995 and 1996 might well be called, "The Long Season of Congress' Discontent."

Securing the EOS First Series: 1995-1996

While NASA planned for the future, opponents of EOS in Congress chose this time to launch an all out assault to cut funding for the program. If fact, the years 1995 and 1996 might well be called, "The Long Season of Congress' Discontent." During these years, the MTPE/EOS program faced its toughest challenges as it ascended the peak of the funding curve required for EOS mission development. In the end, the program survived but it was not without a fight… and substantial additional reductions to the budget.

During the early years of EOS development the acquisition approach afforded few opportunities for new entrants. The AO resulting in selection of EOS instruments and interdisciplinary investigations "locked in" a decade-long program of mission development and research, with selected proposers 'in' and others 'out'. This "narrowly focused" approach to the program was a major hindrance to gaining widespread acceptance of NASA's leadership of EOS among the broader scientific community. One result of all the reviews taking place in 1995 was that NASA made significant changes to the EOS program that would broaden participation. For example, NASA created the Earth System Science Pathfinder program to succeed the old Earth Probes program. (NASA would follow this in the late 1990s with a re-competition of the EOS Interdisciplinary Science investigations, and of the EOS science teams in the early 2000s.)

In addition, in 1996, Administrator Goldin changed the name to the Earth Science Enterprise to parallel the Space Science Enterprise. He found the concept of *Mission to Planet Earth* difficult to convey concisely to Members of Congress and other stakeholders. About this time, the *Washington Post* columnist **Charles Krauthammer** wrote an article criticizing the notion of a *Mission to Planet Earth* in the context of advocating the exploration of Mars.

As a result of these changes, NASA was able to gain validation for its program direction from external groups, and made substantial progress on the EOS program in 1996. This was only the second year since the program was approved in 1990 that there was not a major restructuring exercise. An impending Presidential election made the budget process for FY97 far less contentious than in FY96.

Also in this time frame, NOAA pulled out of the Landsat 7 program after unsuccessfully seeking funds for satellites operations through the Department of Commerce in the budget development process. NASA moved to cover ground system development costs, and the U.S. Geological Survey stepped up to the plate to operate Landsat 7, taking over the relationships with the International Ground Stations.

Launching the EOS Era: 1997-1999

After 1997, the Congress became more comfortable with NASA's approach to and level of involvement in Earth Science. While pressures remained from the larger Federal budget context, and specific items such as Triana became points of contention, the fundamental support for Earth Science in Congress was sound. One reason for this change was the taming of the "uncosted" monster. The Enterprise defined a healthy level of uncosted carry over (6 months for research, 2 months for development, and 1 month for operations) and committed to reach that level by the end of FY99. This equated to about $470M, and this target was achieved on schedule.

After 1997, the Congress became more comfortable with NASA's approach to and level of involvement in Earth Science.

But that did not mean the end of all budget pressures—just the external ones. Internally, the program was headed up to the peak of the development cycle for EOS missions. The first major EOS mission, AM1 [renamed "Terra" in 1998 as a result of an American Geophysical Union (AGU)-sponsored naming contest] had long been scheduled for a June 1998 launch. However, in early 1998, a storm cloud that had been brewing over the horizon came overhead to rain on Terra's parade toward launch. EOSDIS, the data management system for EOS, had been a management concern for a long while, and especially when it missed a key delivery in 1997 in support of the Tropical Rainfall Measuring Mission (TRMM); the TRMM program and the Langley Research Center (LaRC) Distributed Active Archive Center (DAAC) scrambled to put a system in place to process TRMM data independent of the EOSDIS Core System. With several satellite missions at or near the peak of their development funding curves, the Enterprise had little flexibility to throw new money at EOSDIS. A variety of options were developed to descope EOSDIS Core System (ECS) requirements, and in the end, the option chosen involved engaging individual EOS instrument Principal Investigators in the initial processing of their data outside ECS, with distribution and archiving handled by EOSDIS DAACs. In March 1998, it became known that the Flight Operations Segment (FOS) of EOSDIS, which was supposed to command and control EOS spacecraft, would not be successful. Incredibly, a $1.4 billion spacecraft would be delayed in launch for an entire year for lack of a ground-based satellite operations system. The delay in launch for the Terra program came at a cost of $4 million per month.

In 1998, Raytheon acquired Hughes Information Sciences Corporation. Raytheon brought its own satellite control system, *Eclipse*, which it was able to modify for use with Terra. *Eclipse* was also adopted for use with PM-1 and other Goddard Space Flight Center-managed EOS spacecraft. Terra's problems were not over, however. In mid-1999, the normally reliable *Atlas II* AS experienced a failure in its *Centaur* upper stage on an Air Force launch. The problem, in the RL-10 engine built by Pratt & Whitney, would not be cleared for launch for several months, affecting both Terra and NOAA's Geostationary Operational Environmental Satellite (GOES-L).

In the meantime, other budget pressures added to the list of internal challenges. The failure of Japan's Advanced Earth Observing Satellite (ADEOS I) spacecraft seven months after its launch in 1996 meant the loss of NASA's contributed instruments, NASA Scatterometer (NSCAT) and Total Ozone Mapping Spectrometer (TOMS). The orbit of the recently launched TOMS Earth Probe was shifted to make up for the loss, and another had been scheduled for launch in 2000. But NSCAT, which had been returning valuable ocean winds data, had no such ready fix. The Associate Administrator decided that, both to make up the data and to demonstrate the robustness of the Enterprise, a Quick Scatterometer (QuikSCAT) mission would be implemented using early hardware from the future SeaWinds mission and a spacecraft selected under GSFC's new Rapid Spacecraft Development Office. The result was a mission ready to go 13 months after the decision to proceed, and QuikSCAT was launched in June 1999. The Landsat 7 partnership continued in flux; USGS took over NOAA's role, but NASA had to find funds to operate the satellite through FY2000. Landsat 7 was successfully launched in April 1999. The TOMS planned for FY2000 was to be launched by Russia on a *Meteor 3* spacecraft. However, in 1999, Russia informed NASA they would not be able to proceed with both TOMS and SAGE III, so NASA opted to keep SAGE III on the Russian spacecraft and the decision was made to pull TOMS and proceed with a Quick Total Ozone Mapping Spectrometer (QuikTOMS) mission in the same manner as QuikSCAT.

In the meantime, development of EOS missions such as PM-1 (later renamed Aqua), Jason-1, the Ice, Clouds, and land Elevation Satellite (ICESat), and Chem-1 (later renamed Aura) continued. In the midst of all of this activity, the Enterprise's posture changed from one of defining and selling mission concepts to one of developing and launching missions. The Seagoing Wide Field-of-view Spectrometer (SeaWiFS) ocean color instrument, funded by NASA in a commercial data purchase arrangement with Orbital Sciences Corporation (OSC), was launched in August 1997 on OSC's Seastar satellite. The Earth Probes program, predecessor of the ESSP program, produced TRMM, a joint U.S./Japan satellite launched from Tanagashima Space Center in November 1997. Results from both SeaWiFS and TRMM greatly exceeded expectations. In 1999, Landsat 7 was launched in April, QuikSCAT in July, and in a flurry of year-end activity, Terra and the Active Cavity Radiometer Irradiance Monitor on ACRIMSAT in December.

The EOS era had now begun. Like so many "journeys of discovery" of the past, the journey from "good idea" to reality for EOS was long and difficult—see timeline at the end of this article. But with the launch of Terra, Earth System Science slowly began the move from a "data-poor environment" to a "data-rich environment".[viii] At times along the way it must have seemed like it was destined to fail, and I'm sure those involved experienced many frustrations at each setback along the way. But EOS persevered and succeeded against the odds, and the world is a better place because of those "pioneers of Earth System Science" who refused to give up hope and helped guide EOS successfully through its perils.

[i] Global Change: Impacts on Habitability – A Scientific Basis for Assessment, JPL D-95, July 7, 1982 (see pages 1-2).

[ii] See "NASA and the Environment: The Case of Ozone Depletion", W. Harry Lambright, NASA SP-2005-4538 May 2005, for this discussion and a description of the ozone research program that was a large piece of the foundation for NASA's future in Earth System Science.

[iii] Earth System Science: Overview (1986) & A Closer View (1988), Earth System Sciences Committee of the NASA Advisory Council, NASA.

[iv] "Leadership and America's Future in Space", Sally K. Ride, NASA, August 1987.

[v] "Report of the Advisory Committee on the Future of the U.S. Space Program", Norman R. Augustine, et.al., GPO December 1990.

[vi] P.L. 101-606, Global Change Research Act of 1990, November 16, 1990.

[vii] Report of the Earth Observing System (EOS) Engineering Review Committee", Edward Freiman, et.al., September 1991.

[viii] The program's critics in Congress thus began to take the tack that Earth scientists had more data than they could effectively use. Congressman Dana Rohrbacher reiterated this concern in the April 28, 2005 House Science Committee hearing on Earth Science at NASA. One of the science witnesses in that hearing, Berrien Moore, responded that while this may have been valid a few years ago, computational modeling capacity had advanced such that this was no longer an issue. ■

Appendix 1: Timeline of Events in the History of Earth Science at NASA Since 1982

1982	United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS) & NASA report *Global Change: Impacts on Habitability* (Goody report)
1982	National Research Council (NRC) Report: *Strategy for Earth Science from Space*, Vol. 1
1984	Landsat Commercialization Act (control of program shifted to NOAA)
1984-85	Earth Observing System (EOS) Mission Requirements Study
1984	EOS Science Steering Committee Report
1985	NRC Report: *Strategy for Earth Science from Space*, Vol. 2
1985-88	EOS *Phase A* Studies
1986	Earth System Science: *Overview* (Bretherton report); loss of Space Shuttle *Challenger* on January 28
1987	EOS Science Steering Committee Report
1988	Earth System Science: *A Closer View* (Bretherton report)
1988	EOS Polar Platform Contract awarded (EOS-A)
1988	EOS Announcement of Opportunity (AO) issued
1988	Leadership and America's Future in Space (Ride report)
1988-90	EOS *Phase B* studies
1988	NRC report: *Mission to Planet Earth (MTPE)*
1989	Our Changing Planet: *A U.S. Strategy for Global Change Research*
1989	EOS AO proposal selection
1990	NRC Report: *The U.S. Global Change Research Program*
1990	EOS-Investigators Working Group recommends EOS-A payload complement
1990	EOS *New Start* approved by Congress (FY91)
1990	Global Change Research Act (Public Law (PL) 101-606)
1990	Report of the Advisory Committee on the Future of U.S. Space Programs (Augustine)
1991	EOS-A payload and investigators selected by NASA
1991	EOS Engineering Review Committee Report (Frieman)
1991	Restructuring of the EOS program ($17B to $11B)
1992	National Space Policy Directive on Space-based Global Change Observing System
1992	Rescoping of EOS program ($11B to $8B)
1992	Remote Sensing Policy Act (PL 102-555); Management of Landsat 7 by NASA & Department of Defense (DoD)
1993	Earth Observing System Data and Information Systems (EOSDIS) Core System contract signed
1993	NRC Report: *Review of EOSDIS* (Zraket committee)
1994	Restructuring of Landsat Program Management (DoD withdraws; NOAA comes in)
1994	Presidential Decision Directive on converging civil and military polar weather satellites
1994	Rebaselining of EOS ($8B to $7.25B)
1995	Reshaping of EOS
1995	House of Representatives budget resolution calling for $2.7B (5 yrs) reduction in MTPE
1995-96	NRC Board on Sustainable Development Congressionally-mandated review of U.S. Global Change Research Program (USGCRP) and MTPE/EOS
1996	MTPE Science Research Plan
1996	FY96 budget approved without the $2.7B reduction; (January 1996 government shutdown)
1996	First Earth System Science Pathfinder AO released
1996	NOAA pulls out of Landsat 7 program; U.S. Geological Survey (USGS) steps up as operator
1997	Earth Science Information Partner Federation created
1997	MTPE Biennial Review; proposes whole new approach to implementing 2nd EOS series
1997	Mission to Planet Earth becomes the Earth Science Enterprise (ESE)
1998	EOSDIS Flight Operations System failure becomes apparent; delays EOS-AM1 launch
1998	Vice-President Al Gore has a dream, and the Triana mission is born
1998	Earth Science Systems Program Office at GSFC disestablished
1998-99	Post-2002 Baseline Mission Scenario Planning (Easton process)
1999	Administrator Goldin letter to the Office of Science and Technology Policy (OSTP) Director Neal Lane recommending establishment of a national policy for long-term monitoring of the Earth from space

Appendix 1: Timeline of Events in the History of Earth Science at NASA Since 1982 *(continued)*

1999	NRC Report: *Global Environmental Change: Research Pathways for the Next Decade*
1999	EOS-AM1, renamed Terra, launched; four EOS launches in one year (including Landsat 7)
2000	ESE Research Strategy (variability/forcing/response/consequence/prediction paradigm)
2000-01	EOS-II report to Congress quashed by Office of Management and Budget (OMB)
2001	President Bush announces Global Change Research and Technology initiatives
2001	NASA budget initiative on Climate Change Research presented the day after 9/11
2002	Administrator O'Keefe announces new Vision and Mission for NASA
2002	Third round of ESSP missions selected
2002	Full cost accounting implemented in NASA budget (with FY04 request)
2003	Loss of Space Shuttle *Columbia* on February 1
2003	Strategic Plan for the U.S. Global Change Research Program
2003	First Earth Observation Summit (July 31, Washington, DC)
2003	Earth Science Enterprise Strategy document
2003	NASA requests the NRC conduct a decadal survey for Earth science from space
2004	President Bush announces the *Vision for Space Exploration* on January 14
2004	Launch of Aura completes the Earth Observing System 1st series

EOS Scientists Elected to NAE

Claire L. Parkinson [Goddard Space Flight Center (GSFC)—*Senior Scientist and Aqua Project Scientist*] and **Moustafa T. Chahine** [Jet Propulsion Laboratory (JPL)—*Senior Research Associate and Atmospheric Infrared Sounder (AIRS) Team Leader for Aqua*] were among the 65 new members elected this year to the National Academy of Engineering (NAE).

Claire L. Parkinson

Founded in 1964, the NAE is an independent, nonprofit institution that provides engineering leadership in service to the nation. Election to the NAE is one of the highest professional distinctions accorded to engineers and scientists.

Parkinson was elected for her leadership in understanding sea-ice changes through remote measurements and for leading the Aqua mission. Chahine was selected for his leadership in using space observations to determine the structure and composition of the Earth's atmosphere. The *Earth Observer* staff and the entire scientific community congratulate Parkinson and Chahine on this tremendous achievement.

Moustafa T. Chahine

Winter Camp: A Blog from the Greenland Summit

Lora Koenig, NASA Goddard Space Flight Center, lora.s.koenig@nasa.gov

When temperatures turn cold, some people travel to a tropical destination to stay warm. Instead, ***Lora Koenig****—a remote-sensing glaciologist at NASA's Goddard Space Flight Center—donned layer upon layer of extra clothes to brave the harsh Arctic at the National Science Foundation's (NSF) Greenland Summit Camp. Koenig lived and worked at the research station from November 2008–February 2009, making ground-truth measurements of the Greenland Ice Sheet to validate data collected by NASA's Aqua, Terra, and Ice, Clouds, and land Elevation Satellite (ICESat) satellites. Koenig described her experience at Summit in a weekly blog, with excerpts from the first seven weeks of her stay presented here. Look for Part II of the story of Koenig's "Journey to Greenland's Frozen Summit" in the May–June 2009 issue of* ***The Earth Observer****. The complete blog with color photos, along with a question & answer by Koenig, is available at:* ***earthobservatory.nasa.gov/Features/GreenlandBlogKoenig/****.*

Week One
November 3, 2008

Introduction

Hello! I'm a remote sensing glaciologist in the Cryospheric Sciences Branch at the NASA Goddard Space Flight Center (GSFC). My research uses satellites to monitor ice sheets and compares measurements from space to those taken on the ground.

These interests have led me to spend this winter at Summit, Greenland (Latitude 72.5°N, Longitude 38.5°W). Over the course of this weekly blog, I will tell you about my life and science, in the middle of the Greenland Ice Sheet, in the middle of the winter. First, a quick introduction:

The winter-over team from left to right: Lora Koenig, Bill McCormick, Kat Huybers, and Brad Whelchel.

In June of 2008, I finished my PhD in Geophysics at the University of Washington. My dissertation focused on passive microwave remote sensing of *firn*—snow on ice sheets that has persisted through one melt season or year old snow. For my dissertation, I took many field measurements during summer trips to both Greenland and Antarctica, but I still had some questions about how these measurements would change if they were taken in the winter. When I was given an opportunity to spend November 2008–February 2009 at Summit, Greenland I took it.

Three other people are staffing the camp with me are: Bill McCormick—Polar Field Services, our camp manager who has spent many seasons working in Antarctica; Brad Whelchel—Polar Field Services, our mechanic new to working on "the ice"; and Kat Huybers—National Oceanic and Atmospheric Administration (NOAA). Kat and I are the science techs maintaining the year round science at camp during the winter.

Summit is quite a different place in the winter when there are only four people staffing the camp. In the summer, when most scientists come to Summit, there can be up to 40 people in camp. Go to *www.summitcamp.org* to see a live webcam of the camp and to learn more about the weather and ongoing science here.

Week Two
November 16, 2008

Temperature:
-27°C/-16.6°F

Getting to Summit and Goodbye Sun

I left Washington D.C. and flew to Copenhagen, Denmark on October 30, 2008. From Copenhagen, I took an *Air Greenland* flight to Kangerlussaq—once an American military base and now the host of Greenland's international airport. From Kangerlussaq, we all piled into a chartered *Air Greenland Twin Otter* airplane with skis attached and took the approximately three hour flight to Summit.

During the flight I sat next to Brad. It's his first time on an ice sheet and I enjoyed sharing in his excitement. When instruments in the cockpit read 20 minutes left in the flight, we all watched out the window for the first sight of camp. Fifteen minutes later, we were squealing with the first sight of the Big House, our kitchen area, and the Swiss Tower, a tower housing atmospheric sampling equipment. Upon landing, the current four-person staff greeted us. The air was cold, about -40°C/-40°F, and the wind was blowing mildly.

After using its skis to land at Summit, the *Twin Otter* is unloaded on the ice sheet.

We spent last week doing *turnover*—a training period where the four people who were staffing camp train the new crew. This training ensures that all science experiments are conducted in a consistent manner. As this blog continues, I will highlight different science projects in more detail.

The biggest news of the past week was that on November 13, 2008 we no longer had an official sunrise. This doesn't mean we don't have light—from about 9:00 am to 1:00 pm local Greenland time there is light on the horizon, but the sun never actually rises. This is called *civilian twilight*. As we get deeper into the winter we will have less twilight.

Week Three
November 23, 2008

Hello from the Summit

There are two areas on an ice sheet, the *ablation area* and the *accumulation area*. The *ablation area*—near the edge of the ice sheet—is where snow and ice are lost from melting and calving. The *accumulation area*—near the center of the ice sheet—is where snow falls and ice accumulates. NASA scientists monitor the accumulation and ablation areas of Greenland and Antarctica using measurements from the ICESat satellite (*icesat.gsfc.nasa.gov/*). The mass balance of the ice sheet, determined from accumulation and ablation measurements, is used to estimate changes in sea level.

Summit, located in the *accumulation area* of the Greenland Ice Sheet, is amassing about 65 cm of snow per year. This means that the height of the ice sheet rises about 65 cm a year and the buildings are buried by 65 cm of snow per year. The buildings must be raised every few years to stay on the surface of the ice sheet.

There are three main buildings: the Big House, the Green House, and the Shop. The Big House is where we cook, eat, exercise, and entertain ourselves. It has a TV, DVD player, library, a huge kitchen, and exercise equipment. It's elevated on stilts to stay above the accumulating snow. The Green House has science labs, computers, a small kitchen, and the berthing module, where our rooms are. They have desks, beds,

The Big House rests above the snow surface with stilts.

shelves, and lots of coat hooks! The Green House is starting to get buried by snow accumulation and drifts. It's scheduled to be raised soon but for now we get in and out using a tunnel that Brad and Bill built. The Shop contains a large generator that provides the camp's power. It also has a snow melter, two snowmobiles, a Caterpillar, and other tools necessary to fix any problem that may arise in camp.

A few small buildings around camp house science equipment. The Temporary Atmospheric Watch Observatory (TAWO) building houses NOAA instruments that measure temperature and wind speed. Beside the TAWO are towers that hold the meteorological (met) instruments.

Week Four
November 30, 2008

Temperature:
-46°C/-50°F

What can you eat at the Summit?

We had a festive and busy week here at Summit. Kat and I planned our Thanksgiving menu in advance. We have a spreadsheet of all the food that is on station on the computer. Everything at Summit is inventoried so we know exactly what we have and what we need to order. Since we only get flights every three months in the winter, it's important not to forget to order the things we need. (Imagine if you could only go to the grocery store every three months!) Most of our food here is frozen and must be defrosted. It's stored in large snow caves underneath the Green House and beside the Big House for the winter season.

This week wasn't all about food; there was quite a bit of science as well. Each day, Kat and I go through a routine of daily science tasks, checking machines to make sure they are running and gathering data. Data from the instruments on the TAWO tower are used to validate surface temperature measurements taken from satellites.

Lora cleaning *rime* off the TAWO tower. The tower and cable have lots of *rime* but the wind bird (top) and the temperature sensor enclosure (middle), are *rime* free and gathering good data. Photo by Brad Whelchel.

Met instruments on ice sheets are constantly being attacked by *rime*—an icy build-up formed when a supercooled droplet of water in the air freezes. When rime accumulates on temperature sensors, it can insulate the sensors and cause incorrect air temperatures to be recorded. On wind sensors, rime slows the rate of instrument spin and gives an incorrect wind speed.

Kat and I climb the TAWO tower daily to brush the rime off the instruments. It's difficult to move in all the clothes we wear and it's hard to grip the tower wearing large mittens. (Next time you are near a set of monkey bars, try crossing them wearing the biggest mittens you have!)

Week Five
December 7, 2008

Temperature:
-38°C/-36°F

Are you cold?

One question I get when doing field work in Greenland is: *Are you cold?* Most of the time, no, but my fingers often get very cold. When Kat and I head out to clean the towers, collect snow samples, measure accumulation stakes, and launch weather balloons, we will spend 2–3 hours outdoors. A normal day's outfit includes one thin pair of thermal underwear pants, one thick layer of thermal underwear pants, two thermal underwear tops, one thin insulated jacket, a pair of insulated bibs, a down parka, two pairs of socks with toe warmers, a pair of big snow boots, one pair of glove liners, one pair of mittens with hand warmers, a face mask, and a hat.

A snow pit used to analyze the top two meters of firn. If you look closely, you can see the different snow layers in the pit wall deposited by different snow storms. This picture was taken at Summit in Summer of 2007, hence the sun and sunglasses.

This week we took monthly snow samples of the top meter of firn in a snow pit. Usually snow pits are between one and two meters deep. One face of the pit is smoothed to study and sample the snow. This face makes it easy to see the different layers of snow or firn deposited from either snowfall or blowing snow. Each layer of snow/firn has unique characteristics—temperature, the size and shape of snow crystals, the density, the degree of bonding or hardness, and chemical composition. If you were to take the different layers of snow into a lab you would realize that each layer has different chemical properties dependent upon the chemistry in the atmosphere when the snow was deposited. What is learned today about how the atmosphere interacts with the snow surface helps scientists interpret the chemical signals in ice cores like the Greenland Ice Sheet Project (GISP) II ice core drilled here at Summit that goes back over 100,000 years.

Week Six
December 14, 2008

Temperature:
-37°C/-35°F

Drifting

It was another stormy week with winds upward of 20 kts (23 mph) for 4 days. We recorded the highest winds since we have been here at upwards of 55 kts (63 mph). This week's storms were different than previous storms; the winds were coming from the East (usually winds are from the South). The East winds caused very large drifts to form near the garage doors of the shop and on the tunnel entrance to the Green House. The garage doors to the shop had drifts almost as high as the roof and drifts had buried the tunnel entrance to the Green House with a foot of snow.

Kat and Lora following the flag line to the Big House on a very stormy day. Photo by Brad Whelchel.

The drifts sent Brad and Bill outside to shovel. They spent a day digging out the garage doors and hours digging out the tunnel. Bill raised the tunnel entrance hatch above the height of the Green House roof so it wouldn't be buried by drifts.

The storms also made visibility difficult. When everything around you is snowy and in polar darkness, it is quite easy to lose your way. On ice sheets we use *flag line*—lines of poles about 15 feet apart—to mark the routes between buildings. We had to use the flag lines a lot this week because we couldn't always see the other buildings in the blowing snow.

The other big news at camp is that with all the indoor time we started decorating for the holidays. We found four strands of fir bow garland in a few boxes of holiday decorations left here at Summit. They are the beginnings of my project to make a Christmas Tree.

Week Seven
December 21, 2008

Temperature:
-48°C/-56°F

Solstice Celebrations and a Temperature Experiment

Happy Solstice! We celebrated our shortest, darkest day with a mile fun run. A mile may not seem like far under normal circumstances, but we are at a pressure altitude of 11,500 ft (3,500 m). We were all breathing very hard by the end!

One of my science experiments here at Summit is to monitor temperature. If Greenland continues to warm, additional melting will cause sea level to rise. There are a very limited number of weather stations across Greenland due to the extremely harsh conditions and difficulty in keeping ground-based stations operating year-round. Temperatures over Greenland are most easily monitored by satellites.

Thermal infrared channels on satellite sensors are used to record direct measurements of surface temperatures over Greenland on cloud-free days. Infrared wavelengths cannot penetrate clouds, so on cloudy days, the satellite temperatures are masked, or removed, from the surface temperature datasets. The Moderate Resolution Imaging Spectroradiometer (MODIS) sensor (*modis.gsfc.nasa.gov*) on board both the Terra (*terra.nasa.gov*) and Aqua (*aqua.nasa.gov*) satellites is a NASA sensor used to monitor surface temperatures.

Three Thermocron ibuttons placed on the snow surface to monitor the surface temperature and compare to the 2-m air temperature.

As MODIS travels over Greenland, the sensor measures and records the *irradiance*, or temperature, of the very top surface layer of snow. Most weather stations only measure the air temperature at 2-m off of the snow surface. In general, the 2-m air temperature compares well with the surface snow temperature but there are limited measurements.

I am investigating the use of small, inexpensive temperature sensors—called *Thermocron ibuttons*—to measure the 2-m air temperature and the snow surface temperature. I am testing these sensors to see if they can withstand cold temperatures, rest on the surface of the ice sheet, and record accurate temperatures when compared to the more expensive temperature sensors.

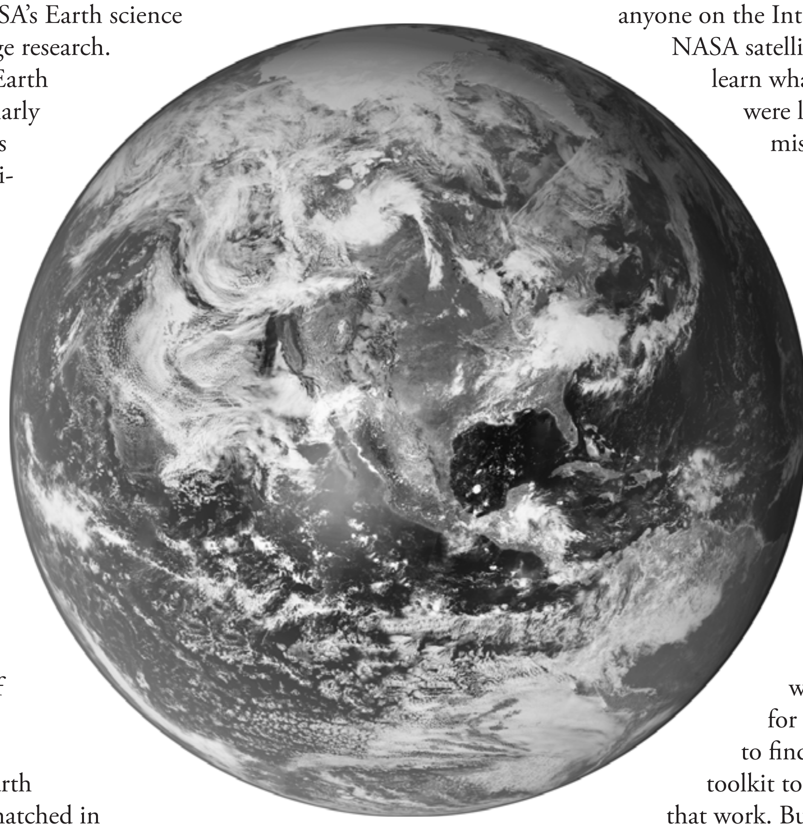
I check the sensors everyday to make sure they stay right at the surface, measuring the same temperature as the infrared satellite sensors. Even with the heavy drifting snow last week, the ibutton sensors stayed at the snow surface. With their low cost and ease of use, we hope that the ibuttons can be used more extensively on Greenland to help validate satellites.

*Stay tuned to the May-June 2009 issue of **The Earth Observer** for the second half of Koenig's story.* ■

NASA's Earth Observatory Turns 10

Rebecca Lindsey, Editor, NASA's Earth Observatory, NASA Goddard Space Flight Center, Science Systems & Applications, Inc., Rebecca.E.Lindsey@nasa.gov

April 29, 2009, marks the 10th anniversary of the launch of NASA's Earth Observatory Website (*earth-observatory.nasa.gov*). Over the past 10 years, the Earth Observatory has worked with scientists and education and outreach partners from across the agency to publish thousands of images and hundreds of articles about NASA's Earth science and climate change research. Images from the Earth Observatory regularly appear in the mass media, popular science magazines, textbooks, and blogs. Continuing the legacy of the Apollo 8 *Earthrise* photos as cultural icons, the Earth Observatory team's satellite-based *Blue Marble* —shown right— even appears on the welcome screen of the iPhone.



The idea of the Earth Observatory was hatched in the late 1990s during an impromptu brainstorming session between the late **Yoram Kaufman**, then the Terra mission's project scientist, and **David Herring**, whom Kaufman had hired to be the Terra mission outreach coordinator. Returning from a conference at NASA's Jet Propulsion Laboratory, the two found themselves stuck in the back of a cab on an L.A. highway when an intense rainstorm brought traffic to a standstill for more than an hour.

Herring, now the communications director at NOAA's Climate Program Office, says he was always impressed with how easily Kaufman could talk to anyone—scientists or non-scientists—about the importance of NASA's Earth science missions. "He was so passionate about it, and everyone responded to that," remembers Herring. In his talks, Kaufman often compared the Earth to a middle-aged patient whose doctor had started paying more attention to his vital signs. Satellites, he would say, are the equivalent of a doctor's stethoscope or thermometer. As the rain pounded down on their cab, Herring and Kaufman talked about how to use that metaphor to help people understand why we need to study the Earth and to see for themselves the critical role NASA satellites play in monitoring our planet's vital signs. They wanted to create a virtual observatory, where anyone on the Internet could see what NASA satellites were seeing and learn what NASA scientists were learning from EOS missions.

On the wish list of features for the new site was giving people the ability to view and compare custom movies of monthly, global images of Earth science data sets. "Today," says **Kevin Ward**, the site's information architect, "it would be pretty easy for a web programmer to find an application or toolkit to make an idea like that work. But back then, they didn't exist." Right off the bat, there was a lot of challenging programming that had to be done from scratch. **Michael Heney**, who at that time was providing technical support to the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument science team, made it happen.

Over the past ten years, the Earth Observatory has come to seem like a fixture of NASA Earth science outreach, but the project started small, with a handful of people working part time. The most popular part of the site, the *Image of the Day*, began as just a *Featured Image*. According to art director, **Robert Simmon**, "It was an *image of the week*—if that." Within a year or so, the team's own ability to make and interpret images improved, and the number of collaborators across the agency increased. Production stepped up to five days a week and from there to an *Image of the Day*. In 2002, a close partnership with the MODIS Rapid Response Team, which provides daily, near-real-time MODIS images, allowed us to begin tracking worldwide natural hazards and posting multiple images a day of newsworthy natural events around the world.

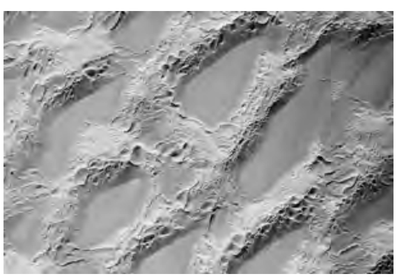
As the site has matured, a community of regular readers has grown up alongside it. More than 50,000 people—the number grows each week—subscribe to the Earth Observatory's mailing list, and more than 650,000 unique visitors stop by each month. Those numbers have climbed toward one million during major events like Hurricane Katrina in 2005 or the California wildfires of 2007. Earth Observatory images and stories also reach a wider audience through partners who syndicate or re-package the site's content for distribution, including the NASA portal, the Space Telescope Science Institute, and the geospatial browser *Google Earth*. Five times in the past six years, the Earth Observatory earned a *People's Voice* or *Webby* award from the International Academy of Digital Arts and Sciences for best science or education site on the Web.

From the beginning, the Earth Observatory has been funded out of EOS mission and project science office budgets, and scientists from within and outside the NASA EOS community enthusiastically work with the Earth Observatory's writers and data visualizers to ensure the quality and accuracy of what we publish. That "embedded" relationship between the Earth Observatory team and the science community remains our most important asset.

The Earth Observatory's current staff wants to thank the past and present EOS scientists who have supported and advised us, and we want to thank our education and outreach partners at NASA centers and beyond who have shared their expertise and creativity and helped to make the Earth Observatory such a success. The names of all the people who have played and are playing a role in this effort could probably fill a whole page of this newsletter; please visit us online to see them all.

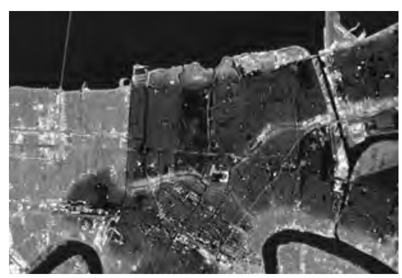
In honor of our 10th anniversary, the Earth Observatory will be publishing a series of image essays documenting changes on Earth that EOS satellites have observed during the site's history. We'll also be holding a month-long contest to identify our readers' top ten favorite images. Please stop by and remind yourself of all the great science that NASA's EOS satellites and scientists have made possible in the past decade. But don't worry; we won't insist that you learn anything. We know the view from space is amazing; it's fine if you just want to look at the pictures. ■

The images shown below are a small sampling of the spectacular imagery that has been featured on NASA's Earth Observatory Website since it began in 1999.



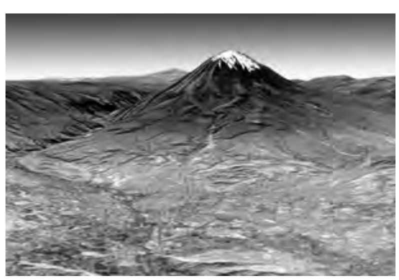
January 19, 2009
Sand Sea, Libya

October 24, 2007
Fires in Southern California

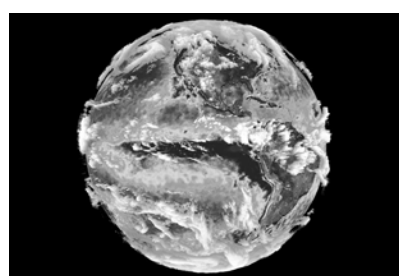


September 15, 2005
Hurricane Katrina Floods New Orleans

November 13, 2003
Breakup of World's Largest Iceberg



December 31, 2001
El Misti, Peru



November 1, 1999
Global Data

JASON Project Connects Students with the "Infinite Potential" of Science

Tiffany Reedy, JASON Project Media Officer, pr@jason.org

Anthony Lopez is an active 16-year-old. The 10th grader from Charlotte, NC is involved with Boy Scouts, rugby, basketball, and many volunteer activities. And he just got busier, courtesy of a program that is tapping into his growing interest in science and technology.

This past September, Lopez took some time out of his hectic schedule to visit the Johnson Space Center in Houston, TX with **Constance Adams**, a *National Geographic* Emerging Explorer and Space Architect, on a science mission with The JASON Project, a nonprofit subsidiary of National Geographic Society.

"I have always felt like I might want to become an engineer and JASON has made me consider that even more now," Lopez said.

Adams led Lopez, two other students and a teacher, on a research expedition to investigate renewable and other energy resources, and how these resources are used for energy needs. Accompanied by a video production crew, the students and teacher helped Adams build a solar heater, as well as design model components of structures and vehicles that could be used for space modules. Their work will be featured in JASON's upcoming energy unit, *Operation: Infinite Potential,* scheduled for release in Summer 2009.

"We believe that by connecting students with great explorers like Constance Adams and great events like this research expedition, we light a spark of inspiration that motivates them to learn science," said **Caleb M. Schutz**, President of The JASON Project. "When they become self-motivated, they will work to overcome any obstacle to achieve their goals, whether in the classroom or in life."

Adams helped design *TransHab*, a prototype that would provide living quarters for astronauts on Mars. She is known for her interdisciplinary approach in design and problem solving, drawing on expertise in disciplines from architecture and engineering to industrial design and sociology.

JASON's theory of science education is based on inspiring students through sustained connections with "great explorers and great events," as Schutz describes them. Embedding these connections in core science curriculum will, JASON believes, generate deeper student engagement, increased motivation and higher achievement.

To accomplish this, JASON embeds the cutting-edge research of its partners—NASA, National Oceanic and Atmospheric Administration (NOAA), *National Geographic*, the U.S. Department of Energy and other organizations—into standards-based curriculum units. Scientists from those organizations serve as *Host Researchers* and "headline" each chapter. Taped on location working side by side with *Argonauts*, such leaders as Adams come to life in the classroom and in an online global community, challenging students to apply their knowledge to the same real-world scenarios that scientists face everyday.

To prepare for his expedition, Lopez took part in an intense weeklong training in Washington, DC, in June, as he and 12 other *Argonauts*—named for the crew that sailed aboard *Argo* with Jason, the mythological Greek explorer—learned the basics of research procedures. This included how scientists work in the field, the tools and instruments used to gather information, and proper collection and analysis of data samples.

While in Houston, the Argonauts applied their training to study energy as it relates to a spacecraft and how to apply energy efficiency in design. Adams explained to the group the difference between a scientist and a designer or architect and how she has pursued the unique career as space architect.

Anthony Lopez—2009 JASON National Argonaut.

Hannah Zierdan, Cynthia Parish, Constance Adams, Anthony Lopez and Madhu Ramankutty (L to R), work together to construct a solar heater in Houston, TX.

"Constance Adams explained to us that a scientist finds solutions like creating energy efficient insulation," said Lopez. "An architect then takes that insulation and figures out where to place it in the aircraft to maximize its efficiency."

As part of his two-year JASON internship, Lopez will also help develop and review components of *Operation: Infinite Potential,* which includes videos, podcasts, and Web casts, live interactive sessions and computer games. And though he is midway through his internship, he is already grateful for his experience with JASON.

"Being a JASON Argonaut has inspired me to think about my career," he said. "The JASON Project and the topic we are studying—energy—has taught me the importance of how something as simple as turning out the lights can impact the planet and society. Our energy needs for the future are huge and we have to figure out ways to power the world in the future."

JASON has collaborated with NASA for more than 15 years to inspire and motivate middle school students to become proficient in science. The agency's scientists, researchers, technologies and mission themes have been prominently featured in JASON curricula and professional development, while NASA centers have served as hubs to distribute the curricula to local school districts and hosted workshops to train teachers in its use. ■

Three Earth Scientists Named AGU Fellows

Patrick Minnis [Langley Research Center (LaRC)—*Senior Research Scientist*], **Richard Ray** [Goddard Space Flight Center (GSFC)—*Geophysicist*], and **Compton Tucker** [GSFC—*Senior Earth Scientist*] were among the 52 scientists named as 2009 Fellows of the American Geophysical Union (AGU)—an international organization of Earth and space scientists.

Fellows—nominated by AGU members and chosen by committees—are selected based on their exceptional contributions to the Earth and space science fields. Only 0.1% of AGU members are bestowed with this honor each year. The *Earth Observer* staff and the entire scientific community congratulate Minnis, Ray, and Tucker on this accomplishment.

Two EOS Scientist's Publications Reach Over 1000 Citations!

Two publications of Goddard Space Flight Center (GSFC) scientists **Brent Holben** and **Compton Tucker** have been cited over 1,000 times, according to the Web of Science®. The Web of Science® provides access to citation indexes, showing in what journal and by which author(s) a particular scientific publication has been cited.

Holben's publication is: **Holben, B.N.**, F. Eck, I. Slutsker, D. Tanre, J. P. Buis, A. Setzer, E. Vermote, J. A. Reagan, Y. J. Kaufman, T. Nakajima, F. Lavenu, I. Jankowiak, and A. Smirnov. 1998. AERONET-A Federated Instrument Network and Data Archive for Aerosol Characterization, *Remote Sensing of Environment*, 66: 1-16.

Tucker's publication is: **Tucker, C.J.**, 1979. Red and Photographic Infrared Linear Combinations for Monitoring Vegetation, *Remote Sensing of Environment*, 8: 127-150.

Emerging Science Themes from the LCLUC Science Team Meeting on Land-Cover/Land-Use Change Processes in the Monsoon Asia Region

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The Meeting Structure and Its Objectives

The NASA Land-cover and Land-use Change (LCLUC) Program Science Team Joint Meeting with Monsoon Asia Integrated Regional Study (MAIRS), Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD), and Southeast Asia SysTem for Analysis, Research and Training (SEA START) Programs on Land-cover and Land-use Change Processes in the Monsoon Asia Region was held January 12-17, 2009, in Khon Kaen, located in northeastern Thailand. The Mekong Institute of Khon Kaen University hosted the meeting. The Mekong Institute is an inter-governmental organization involved in the development of the region and coordinated with governments within the greater Mekong sub-region, including Cambodia, Lao People's Democratic Republic (PDR), Myanmar (Burma), Thailand, Vietnam, and the Yunnan Province and the Guangxi Autonomous Region of China. Over 100 participants joined the meeting representing Cambodia, Canada, China, Finland, India, Indonesia, Japan, Lao PDR, Malaysia, Myanmar (Burma), Philippines, South Korea, Switzerland, Thailand, United States, and Vietnam. The meeting also included a National Science Foundation (NSF)–Asia Pacific Network (APN) for Global Change Research working session on Carbon Dynamics and Forest Functioning.

The objectives of this meeting were to provide an inter-agency and international forum for scientists to discuss recent research findings and methods in tropical regions, as well as to share information on programs and satellite and ground-based observing systems, with an emphasis on Southeast Asia. The education component is an important part of all the programs holding this joint meeting. On the last day of the meeting **Jiaguo Qi** [Michigan State University], **Mutlu Ozdogan** [University of Wisconsin—Madison], **Piyachat Ratana** [University of Arizona], and **Alfredo Huete** [University of Arizona] gave a training session on LCLUC and climate change that included sessions on geospatial technologies, geospatial methods, and applications for forest mapping, change detection, biophysical retrievals and validation in tropical regions and hydrology. The agenda for this meeting, as well as presentations and posters, can be found at the LCLUC website at: *lcluc.hq.nasa.gov*. The following passages summarize the scientific issues presented and discussed at the meeting.

LCLUC Drivers in Southeast Asia

The meeting focused on the use of satellite data to study land-use change in Southeast Asia, with particular emphasis on the human dimension, which is extremely important in this densely populated region. The meeting highlighted the need for increased collaborative and cooperative research in order to better understand inter-connections within the region. The land-use science themes for the meeting included urban and agricultural expansion and the resultant deforestation. Population growth in Southeast Asia drives rapid urban expansion in the region, which often occurs on rural and agricultural lands. Population increases paired with loss of agricultural lands to urban expansion lead to further deforestation in order to clear land for new fields to meet agricultural demand. A recent rise in the prices for commodity crops such as rubber and palm has further complicated this issue and led to reduced food production and increased food costs. Large-scale land-cover conversion for agriculture leads to altera-

LCLUC Meeting participants pose for a group photo at a local-scale farm in Kham Muang village, Khao Suan Kwang district, Khon Kaen, Thailand.

Meeting participants visited a banana grove intercropped with vegetables and learned about subsistence agriculture in Thailand. **Photo credit**: Kelley O'Neal

tions in the carbon cycle and degraded air quality from increased biomass burning and the associated particulate emissions.

The population of Southeast Asia is growing rapidly and most of that growth is occurring in urban areas. In 2000, approximately only 30% of the Asian population lived in urban areas, but by 2015 it is predicted that 15 mega-cities with populations exceeding ten million will be located in Asia [**Fu** (*Chinese Academy of Sciences*) and **Ailikun** (*Chinese Academy of Sciences*)]. This rapid urban population growth occurs in response to economic growth and job availability. In addition, privatization of housing, development of the land market, domestic and foreign investment, and increased motorization all lead to population growth in cities [**Schneider** (*University of Wisconsin—Madison*)]. Although the current economic downturn may slow the rural exodus somewhat, the long-term trend is likely to continue. Current scenarios of urban expansion often indicate encroachment on agricultural lands and green spaces at the urban and rural interface, but progressive urban planning policies offer hope for mitigating these losses in the future [**He** (*Beijing Nor¬mal University*)].

An interesting exception to this trend toward population growth in urban centers can be found in many rubber growing regions in Southeast Asia. In these areas, the increased global demand for rubber drives up the price of rubber and actually drives local-scale population migrations from cities to rural areas [**Mongkolsawat** (*Khon Kaen University*)].

Agricultural expansion is necessary to generate the food required to support population increases in the region, replace fields lost to urban expansion, and respond to new pressures from the increasing prevalence of commodity crops. The effect of commodity crops on food production in the region is parallel to the biofuels situation in the U.S., where decreased food production has led to an increase in food prices. Currently, rubber is an important cash crop in Southeast Asia. The crop offers economic returns that have nearly quadrupled since 1998, during which time the land planted with rubber increased from 20,000 ha to 380,000 ha [**Mongkolsawat**]. Global demand and the resultant economic boost in rubber return have driven local-scale village farm decisions to supplement food crops with rubber as a cash crop and large-scale agriculture operations to clear more forested land for rubber cultivation [**Thongmanivong** *(National University of Laos)*]. Since rubber requires several years to reach harvest maturity, most local-scale village farms choose to intercrop rubber with food crops, such as cassava, as an investment for the future [**Vityakon** *(Khon Kaen University)*].

Meeting participants got a chance to witness these conditions firsthand as they travelled to two agricultural areas in the region: a *local-scale village farm* and a *subsistence farm*—see photos accompanying this article. At the *local-scale village farm*, participants got a chance to walk through fields planted with eucalyptus, cassava, and cassava intercropped with rubber. They also had a chance to talk with the farmers about the agricultural practices they use. At the *subsistence farm*, participants toured the land and saw vegetable gardens intercropped with bananas, rice paddies, and a fishpond. The host family talked to them about the economic problems that they face and how they are working to reduce their debt. The field trip offered contrasting views of village-scale farming practices. The *local-scale village farm* contained subsistence food crops as well as cash food and commodity crops while the *subsistence farm* strived to be a sustainable system but offered little additional income.

Deforestation is also occurring rapidly within the region and is driven primarily by the need for additional agricultural lands. The montane forests of Southeast Asia are of particular concern as they offer ideal growing conditions for rubber [**Fox** *(University of Hawaii)*]. The primary method of deforestation is slash and burn, which results in increased greenhouse gas emissions, and degrades air quality during burning events. One particularly hazardous air quality event occurred in August 2005 in Malaysia when PM10 levels reached almost 600 $\mu g/m^3$ due to slash and burn deforestation on Sumatra [**Mahmud** *(Universiti Kebangsaan Malaysia)*].

Cattle graze in harvested rice paddies near Kham Muang village. **Photo credit**: Kelley O'Neal


Meeting participants walked through a cassava field intercropped with young rubber trees and spoke with village farmers about agricultural practices. **Photo credit**: Kelley O'Neal

Carbon exchange programs in the region seek to use offsets and crediting as a poverty reduction tool, which in turn will help reduce deforestation in the region [**Skole** *(Michigan State University)*]. Meeting participants were particularly interested in discussing the scientific underpinning of the international initiative to Reduce the Emissions from Deforestation and Degradation (UN REDD). The emerging science themes from the meeting highlight the importance of the human dimension in driving land-cover changes in Southeast Asia.

The Role of Remote Sensing and Modeling in Regional Studies

The processes and impacts of land-use change, driven largely by regional and global economies, continue to play a central role in regional science. The importance of hotspot identification and quantifying local-scale processes are emerging as paths to a better understanding of the interactions between land use, ecosystems, and carbon cycling within the region. Satellite data at all resolutions, but especially the Landsat archive and hyper-spatial data, play an important role in land-cover mapping and monitoring. South and Southeast Asian countries (e.g., India, China, and Thailand) are leading a revolution in satellite remote sensing with the increasing number of low-cost satellites launched and planned; the missions are providing valuable data for current and future LCLUC research. Data processing methods and accuracy assessments are becoming standardized, and automated change-detection methods are emerging with multiple resolution data sources. Participation of Asian international space agencies in programs such as the Global Land Survey-2010, led by NASA and the USGS, are particularly important. A coordinated acquisition strategy to ensure adequate time-series data for land-cover monitoring is a high priority for international programs, such as GOFC-GOLD and the Group on Earth Observations (GEO).

Land-use information is now being included in land-atmosphere interaction studies and coupled models to better understand human–environment interactions such as Asian Brown Cloud and Monsoon processes. There is increasing interest in sustainability issues concerning food and water supply, urban development, and conversion of subsistence agriculture to monoculture as well as in land-use projections for future planning and mitigation. Land-use science is integral to understanding regional processes and promoting sustainable practices in the Southeast Asia region. In addition to strengthening on-going collaborations in the region with NASA LCLUC scientists and initiating a number of new collaborations, the meeting provided a firm foundation for an enhanced land-use component to the international MAIRS program.

Future Plans

This meeting gave a boost to activities in SEA START and GOFC-GOLD/South East Asia Regional Information Network (SEARIN). Several steps were discussed to enhance the structure and functioning of MAIRS. Collaborative efforts will continue at the Fall LCLUC Science Team Meeting conducted jointly with GOFC-GOLD/Northern Eurasia Regional Information Network (NERIN) and MAIRS to be held September 15-20 in Almaty, Kazakhstan. This meeting will focus on monitoring land cover, land use, fire and water resources in agricultural and arid regions of Northern Eurasia. The upcoming Spring LCLUC Science Team Meeting will be held March 31–April 2, 2009 at the Bethesda North Marriott located in Bethesda, MD (see *lcluc.hq.nasa.gov* for details.)

Meeting Presentations Referenced in the Article

Fox, J. *The role of land-cover change in MMSEA in altering regional hydrological processes under a changing climate*.

Fu, C. and Ailikun. *MAIRS overview and progresses*.

He, C. *Modelling urban expansion scenarios in Beijing, China under the restriction of the water resource and land use policy*.

Mahmud, M. *Land use change research projects in Malaysia*.

Mongkolsawat, C. *A comparative study of land use changes along the Mekong River at the border of Thailand and the Lao PDR*.

Schneider, A. *Monitoring and modeling urbanization in China: A mixed methods and multi-scale approach*.

Skole, D. *Carbon2Markets: Value chains from carbon and agro-forestry products in Southeast Asia*.

Thongmanivong, S. *Land cover and land use change in Sing District, Luangnamtha Province, Lao PDR*.

Vityakon, P. *Land-use change and its impact on soil and land resources in Northeast Thailand*.

Ocean Surface Topography Science Team Meeting

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Introduction

The 2008 Ocean Surface Topography Science Team (OSTST) meeting was held jointly in Nice, France from November 9-12, 2008, with the annual International Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) Service (IDS) and the final Global Ocean Data Assimilation Experiment (GODAE) meetings. More than 470 participants gathered to participate in these events. This document summarizes the OSTST meeting. For more detail, a full OSTST report is available online at *sealevel.jpl.nasa.gov/OSTST2008/OSTST-nice2008.html*. Reports for the IDS and GODAE meetings are available at *www.ostst-godae-2008.com*.

The OSTST meeting assembled for the first time the new principal investigators (PIs) and co-investigators (Co-Is) selected by the Centre National D'Etudes Spatiales (CNES) and NASA in 2008. Held only a few months after the launch of the Ocean Surface Topography Mission (OSTM) on the Jason-2 satellite (hereafter referred to as Jason-2), it was mainly dedicated to the preliminary analysis of the post-launch calibration and validation results and the on-orbit mission performances. **Sophie Coutin-Faye** [CNES—*Head, Altimetry Department*] welcomed the participants in an official opening session and dedicated the meeting to the memory of **Yves Ménard** [CNES—*Co-chair, OSTST*], who passed away in October 2008 after a long and difficult fight against cancer.

Program and Mission Status

As Jason-2 was developed in collaboration between four agencies—CNES, NASA/JPL, the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), and the National Oceanic and Atmospheric Administration (NOAA)—representatives from each of these agencies presented their respective oceanography programs.

Eric Lindstrom [NASA Headquarters (HQ)—*Physical Oceanography Program Scientist*] recalled the main events of the past year including the selection of a new Ocean Surface Topography Science Team, and the initiation of studies for the Surface Water and Ocean Topography mission (SWOT). Recommended by the recent National Research Council Earth Science Decadal Survey, SWOT is to be a high resolution wide swath altimeter for global oceanography and hydrology.

François Parisot [EUMETSAT] and **Stan Wilson** [NOAA] spoke largely about the on-going effort to secure approval for a successor to Jason-2. A Jason-3 mission, based on a recurring design from Jason-2, is the preferred solution, but some funding issues are not resolved yet. This makes the objective of launching a Jason-3 satellite by the end of 2012 (required to insure continuity in the high-accuracy altimetry time series) uncertain.

Eric Thouvenot [CNES—*Ocean Program Manager*] reported on CNES ocean observation programs and, more specifically, on altimetry missions. Currently under development: ALtiKa/Satellite with ARgos and Alti-Ka (SARAL) is a Ka-band altimeter to be launched [in cooperation with Indian Space Research Organization (ISRO)] in mid- to late 2010. CNES is also planning to participate in the Jason-3 program, the European Space Agency (ESA) Cryosat-2 and Sentinel-3 programs, the SWOT mission, and the Chinese Hai Yang (HY-2A) mission—Hai Yang means ocean in Chinese. CNES participation in altimetry is not limited to space systems, but also encompasses support for activities such as the Segment Sol Multimission Altimetry and Orbitography/Archiving Validation and Interpretation of Satellites Oceanographic (SSALTO/AVISO) multi-mission ground segment, the Mercator oceanographic forecasting center, and the DORIS contributions to Earth reference systems.

Jérôme Benveniste [ESA] presented an overview of ESA programs in ocean observation.

Hans Bonekamp [EUMETSAT] and **John Lillibridge** [NOAA] gave the first keynote presentation on the applications of near-real-time data products from ocean altimetry missions. Two series of operational products are distributed by the Jason-2 mission: near-real-time Operational Geophysical Data Record (OGDR) with 3-hour latency, and short-time-critical Interim Geophysical Data Record (IGDR) with 1-2 day latency—the time it takes for data from the satellite to make it into a product. The presenters gave numerous examples of data product applications for wind and wave monitoring and forecasting, hurricane intensity forecasting, ocean surface currents observations, ocean modeling, and data assimilation.

Current Altimetry Missions

Gérard Zaouche [CNES—*Jason-2 System Engineer*] presented the status of Jason-2, recalling the main events since launch on June 20, 2008. Jason-2 reached its final orbit on July 11, 2008, and, except for some planned calibration exercises, has been delivering data nominally since then. Jason-2 has been flying 54 seconds behind Jason-1—see illustration on page 28—,

allowing for comprehensive cross-validation of the two missions. Overall the system is performing as planned and the preliminary error budget is already within the performances requirements.

Glenn Shirtliffe [JPL—*Jason-1 Project Manager*] presented the status of the Jason-1 mission. Now in its 7th year, NASA and CNES have approved extended operations for Jason-1 up to 2011. The satellite continues to perform very well, and the data production is within requirements both in terms of availability and latency and with regards to the error budget. However, most of the redundancies have already been lost, so the system is now quite vulnerable. Jason-1 will move to an interleaved orbit at the end of the Jason-2 calibration and validation (cal/val) phase [as was done for TOPEX/Poseidon (T/P)]. Two remaining open points remain regarding the desired duration of the cal/val *formation flying phase* and the relative phasing between the two satellites once in interleaved orbits. The OSTST assembly will decide these two remaining points during the meeting.

Phil Callahan [JPL] presented the status of TOPEX/Poseidon reprocessing activities. JPL performs this task with the help of CNES in order to provide a full data set of the T/P mission compatible with the latest standards used by Jason-1 and Jason-2. This includes getting new orbits [from Goddard Space Flight Center (GSFC)] and correction fields consistent with the Jason products, and also performing a retracking of the entire series of waveforms, correcting for instrument variations. The latter is a challenging task as T/P data processing did not include retracking, and the Jason retracking algorithm is not suited for T/P waveforms.

Science Keynotes

Anny Cazenave [CNES/Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS)] focused on the value of sea level measurements for climate change studies. Altimetry is a key tool in monitoring global sea level rise, and is complemented by *in situ* and gravity field measurements [e.g., from the Gravity Recovery and Climate Experiment (GRACE) mission] to differentiate between the different sources of sea level rise— i.e., steric effect versus melting of ice sheets.

Ted Strub [Oregon State University] presented a panorama of coastal altimetry, a fairly recent field that developed as a result of improvements and on-going efforts to get high quality altimeter data closer to the coastline. He focused on the work presented at the Second Coastal Altimetry Workshop held in Pisa, Italy, the week before the OSTST meeting.

Charon Birkett [University of Maryland] presented the growing use of altimetry data for land hydrology (i.e., to study rivers and lakes). Although altimeters were not designed to target inland waters, in areas where the data are available, they prove to be useful, thanks to their capability of covering remote areas.

Two groups of students from two junior high schools in France (Amiens and Nice) presented work they performed as part of a science class project on altimetry. The presentations were remarkably well delivered. OSTST participants were quite impressed with the talks given by the teenagers.

Splinter Sessions

The bulk of the meeting was devoted to splinter sessions on the following topics:

Precise Orbit Determination (POD) and Geoid

Chairs: **John Ries** [University of Texas], **Jean-Paul Berthias** [CNES]

The geodetic standards for POD were upgraded for the Jason mission to be consistent with Jason-2. While the orbit error is approaching 1 cm, the temporal variability of the Earth's gravity field must be considered in the POD process. The POD performance of Jason-2 was assessed and a slight improvement over the Jason-1 performance was observed.

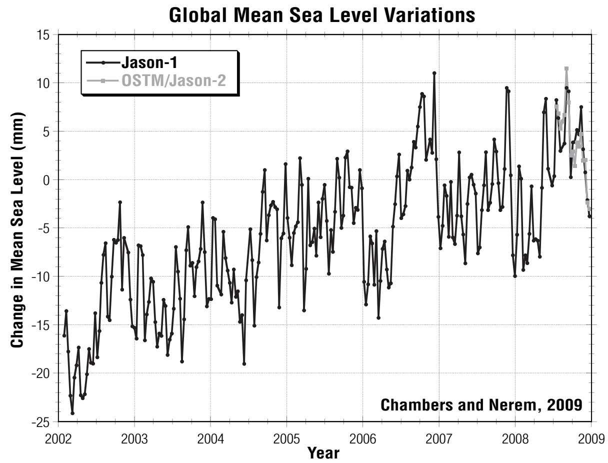
Local and Global Calibration/Validation (Cal/Val)

Chairs: **Pascal Bonnefond** [Observatoire de la Côte d'Azur], **Bruce Haines** [JPL], with help from **Nicolas Picot** [CNES], **Shailen Desai** [JPL], **Steve Nerem** [University of Colorado]

The primary goals of this session were to evaluate the accuracy of the Jason-2 measurements and their consistency with Jason-1 and T/P. The cal/val group was also charged with making recommendations on the length of the Jason-1/Jason-2 cal/val tandem mission as well as the relative phasing of the interleaved orbits of Jason-1 and Jason-2 after the completion of the cal/val tandem mission.

Because of the smooth operation of Jason-2 and its early successful engineering check-out, sufficient overlap data with Jason-1 were available for the evaluation. The cal/val group was confident that the mission's performance has met the science requirements.

There was a proposal made to initiate the orbit maneuver sequence as soon as possible after the end of Cycle 20 (~January 26, 2009), but not before. This ensures a minimum of six months from beginning of Cycle 1 (July 12, 2008), and is also responsive to needs of the operational oceanographic community. The phasing of the interleaved orbits was also discussed, but the recommendation was deferred to the closing plenary discussion.



Global mean sea level variations from Jason-1 and OSTM/Jason-2 showing the consistency in measurements between the two missions.

Instrument Processing

Chairs: **Phil Callahan**, **Juliette Lambin** [CNES], **Shannon Brown** [JPL]

This session was the forum for varied topics from on-board features of the Poseidon-3 altimeter to ground processing of the instrument data, Jason Microwave Radiometer for wet tropospheric corrections, altimeter raw data for additional processing, etc.

Education/Outreach

Chairs: **Vinca Rosmorduc** [Collecte Localisation Satellites (CLS)], **Margaret Srinivasan** [JPL]

This session focused on educational activities, and the importance of the website as outreach medium. The goals of the ocean altimetry outreach effort incorporated into this session included:

- Increasing public awareness of NASA/CNES satellite oceanography missions;
- featuring operational and research applications (altimeter and multi-sensor);
- promoting societal benefits;
- providing oceanography content for formal and informal education; and
- promoting ocean and climate literacy.

Operational Applications, Wind/Waves, Coastal/Inland and associated Cal/Val Studies

Chairs: **Charon Birkett**, **Hans Bonekamp**, **Emilie Bronner** [CNES]

This session covered a wide range of topics, including the application of the Jason-2 Near-Real-Time data products. Other topics included wind/waves, coastal processes, inland water storage, sea-ice/snow, hurricane forecasting, wave modeling, storm surge monitoring, water resources monitoring, big wave monitoring (e.g., surfing), and aspects of natural hazard monitoring in terms of long-term droughts and flood observation.

Closing Plenary Discussion

Several important topics were discussed in the closing plenary session.

1. The quality of the Operational Geophysical Data Record (OGDR)

The results presented in the meeting indicated that the quality of the OGDR has met the mission's requirements. OSTST recommended that OGDR is ready for dissemination to public users for operational applications.

2. The need for a seamless transition between the different versions of Jason-1 GDR (Geophysical Data Record) products

Following previous OSTST recommendations, CNES and JPL implemented a new version of GDRs (GDR-C) in June 2008. However, shortly after this production started the programmers detected an anomaly in the use of some of the time-varying gravity field parameters for orbit determination. Therefore, project teams took the initiative to process the data into a GDR-C′ version. The occurrence of three different versions (GDR-B, GDR-C, and GDR-C′) in a short amount of time led to some confusion for users. CNES and JPL recalled that the GDR-C′ standard is produced using the best algorithm available today. Reprocessing of all the Jason-1 data archive in GDR-C′ is on-going and will provide a fully consistent data set. In addition, the standards used for GDR-C′ are also used for Jason-2 processing, and some effort is made to provide reprocessed TOPEX/Poseidon data with consistent standards.

3. The remaining duration for Jason-1/Jason-2 cross-calibration phase

The debate was mostly fueled by two opposite views. As global intercomparisons between Jason-1 and Jason-2 showed that the consistency between the two missions was very good, some people were advocating for a shorter duration than the six months initially planned. However, other scientists were concerned that the continuity of the long-term record (i.e., sea level rise) and our ability to identify and monitor any relative drift might be compromised should the cross-calibration phase be shortened. The group decided to require that the cross-calibration phase be extended for 20 full cycles, and let the project teams choose a convenient time for switching Jason-1 to an interleaved orbit no sooner than January 26, and preferably no later than February 15.

4. Phasing between Jason-1 and Jason-2 once on interleaved orbit

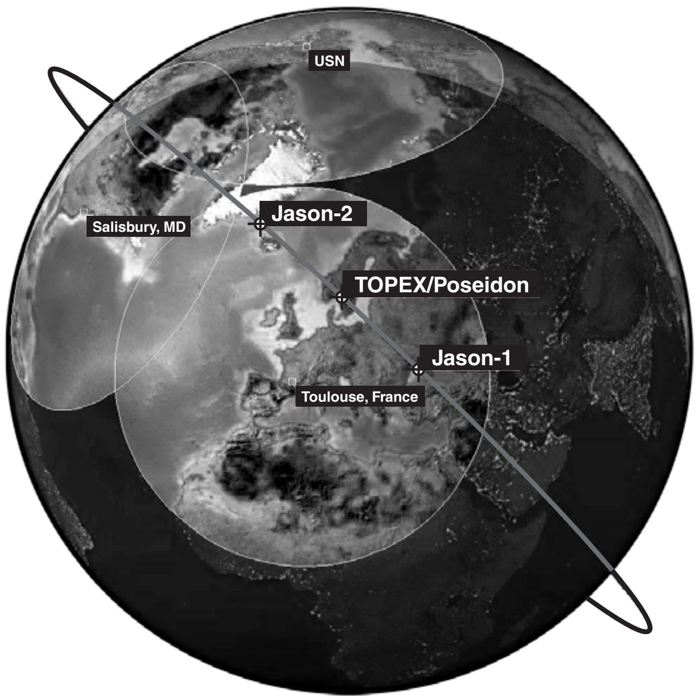
There was a proposal to place Jason-1 further apart in orbit from Jason-2 than the distance between TOPEX/Poseidon and Jason-1. The proposed phasing would mean that adjacent ground tracks for Jason-1 and Jason-2 occur five days apart, allowing for better sampling at short time scales. This appeared to be the optimal sampling for operational applications, although other options in the phasing might have been marginally better for other applications.

5. Recommendations for future altimetry missions

Raymond Zaharia [CNES], on behalf of *Club des Argonautes*, expressed two recommendations to be considered by the OSTST. In the light of the recent and successful launch of Jason-2, and the current programmatic uncertainties regarding follow-on programs, the OSTST decided to fully endorse the following two statements:

- **The four-agency Project Team should be commended for the accomplishments it has made**, especially during the rather short development period between 2004 and 2008. Overall, the decision process for Jason-2 took approximately 7 years; the first proposal for Jason-2 was issued in a CNES scientific prospective workshop in coordination with NASA, NOAA, and EUMETSAT representatives in March 1998. Meeting all the requirements, including a four-year delivery time, was only achievable with a recurrent spacecraft.

- Considering the recommendations of the *Purple Book* published 16 years ago by members of the first TOPEX/Poseidon Science Working Team, and considering the extraordinary way in which this vision has been implemented—thanks to the talents of our colleagues from the respective project teams—we now have a 16-year high-accuracy time series. **Whatever the brilliant future of multiple altimetry missions such as Sentinel-3, Jason-CS, or ALtiKa/SARAL, the reference altimetry mission would experience an irrecoverable loss with the present threat of postponement or cancellation to Jason-3**.



NASA's ocean surface topography *family portrait* shows the Ocean Surface Topography Mission (OSTM)/Jason-2 and its grandfather missions, Jason-1—launched in 2001—and Topex/Poseidon—launched in 1992. Scientists took advantage of the still healthy propulsion system on the Jason-1 satellite to put it into the same orbit as OSTM/Jason-2—about five days behind the newer satellite launched in June 2008. Jason-1 flies over the same region of the ocean that OSTM/Jason-2 flew over five days earlier, giving detailed measurements needed to map rapidly-changing surface currents and eddies. This tandem mission is different from that of Jason-1 and Topex/Poseidon; Topex/Poseidon traveled slightly farther ahead of Jason-1 than Jason-2, with its ground tracks midway between those of Jason-1. Topex/Poseidon and Jason-1 collected data simultaneously until Topex/Poseidon ceased operation in 2006. For more information and to view this image in color please visit: *sealevel.jpl.nasa.gov/newsroom/features/200902-1.html.*

34th ASTER Science Team Meeting Report

Elsa Abbott, Jet Propulsion Laboratory/California Institute of Technology, Elsa.Abbott@jpl.nasa.gov

The 34th Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Science Team Meeting was held December 8-11, 2008 in Pasadena, CA. ***M. Abrams*** *[Jet Propulsion Lab (JPL)—U.S. Aster Science Team Lead] and* ***H. Tsu*** *[Earth Remote Sensing Data Analysis Center (ERSDAC)—Japan Aster Science Team Lead] welcomed approximately 55 U.S. and international team members and guests.*

Opening Plenary Session

M. Abrams updated the audience on U.S. ASTER and related activities including planned budget cuts, the upcoming Senior Review of Terra, an ASTER publication summary, and reports on the Hyperspectral Imager (HypsIRI) proposed as part of the recent Earth Science Decadal Survey, the Landsat Data Continuity Mission moving toward a planned launch in 2011, and other highly visible ASTER milestones.

T. Sato [Japan Resources Observation System Organization (JAROS)] reported on instrument status, noting that ASTER is now nine years old, and has outlived its nominal lifetime by four years. Only the Shortwave Infrared (SWIR) detector is showing its age. (The SWIR is currently unavailable due to its detector temperature rising—see discussions below.) Sato made note of the design lifetimes of various components of the other telescopes and the gradual decline in radiometric responses of the Visible–Near Infrared (VNIR) and Thermal Infrared (TIR) detectors.

M. Hato [ERSDAC] reported on the status of ASTER observations and data processing, reporting that since launch 1,593,045 scenes (an average of 440 granules per day) have been acquired. Hato also reported on the status of Level 1A (L1A) reprocessing—all motivated by SWIR-related-issues, the status of ASTER Global Digital Elevation Model (GDEM) production, and SWIR status. Validation is taking place at ERSDAC and the Land Processes Distributed Active Archive Center (LP-DAAC) with release due in the first quarter of Japan's fiscal year. After a number of *on-off* cycles and *stroke length* changes, the temperature of SWIR continued to rise. At this time the cooler remains off and discussions continue for possible solutions.

T. Tachikawa [ERSDAC] made a detailed report on the SWIR history and status and consequences of losing SWIR data, including cloud assessment limitations and inter-telescope registration concerns. He also gave a detailed discussion of the GDEM production.

M. Fujita [ERSDAC] reported on the general status of data acquisition including a discussion of the difficulty of not being able to assess cloud cover data due to loss of SWIR. He reported on the status of the third round of global mapping, the second round of nighttime global mapping, the missing GDEM data observations, and the attempt to fill in data gaps at high latitude. Fujita also reported on the observation status of urgent data requests and acquisition requests associated with ground campaigns. The consumption rate for TIR pointing resources has been monitored and the rate was confirmed to be reasonable.

B. Bailey [U.S. Geological Survey (USGS)] gave a report on the LPDAAC including their new website, switch to the Warehouse Inventory Search Tool (WIST), global DEM validation activities and plans for distribution. He showed statistics on the ingest and distribution of ASTER data products and covered several miscellaneous items including upgrade to *Version 3.2* processing, a back-up strategy for L1A data, and the discontinuation of hard media option for data distribution.

Y. Yamaguchi [Nagoya University] reminded the audience of issues to be addressed in the splinter groups: 1) what to do about a SWIR retry plan; 2) how to improve the cloud assessment without SWIR; and 3) whether to stop or renew global mapping.

Operations and Mission Planning Working Group

T. Sato presented recommendations from the instrument operations team to do another recycle of the SWIR, which prompted a long discussion of the possible outcomes and risks. In the end, the group recommended only one recycle be performed using predetermined parameters and schedule.

T. Tachikawa discussed the impact of cloud assessment error due to problems with SWIR from July–September 2008. All Science Team Acquisition Requests (STARs) during this period were affected, but the problem has been addressed and data acquired during this period have been reprocessed. He also presented an analysis of cloudy scene statistics based on metadata contained in the global DEM data set with maps showing areas of poor coverage. The committee recommended that a new STAR be submitted to fill in these gaps.

M. Fujita reported on the status of the nighttime TIR STAR and announced that they are waiting for a report from the Temperature Emissivity Separation group for recommendations on possible changes. He also reported on the status of the recently completed global DEM STAR, where 14,000 cloud-free scenes were added to the archive. It is now about 80% complete, but the Gap Filler STAR still remains quite incomplete due in part to the cloud assessment problem, and will be resubmitted.

Level 1/ DEM Working Group

H. Fujisada [Sensor Information Laboratory Corporation (SILC)] reported on, among other things, the status of the Level 1 software that was modified to correct radiometric calibration to account for the unusable SWIR data. Nighttime TIR geolocation accuracy has decreased to 300–500 m in longitude (reduced from 100–200 m earlier), and the error is always in the same sense. The inter-telescope and intra-telescope registration are fine. Fujisada also described in detail the procedure he used to fill voids and replace anomalous DEM values in the global DEM with data from existing DEMS—e.g., the Shuttle Radar Topography Mission (SRTM), the Canadian Digital Terrain Elevation Data (DTED), and USGS Alaska data. He showed examples of data before and after anomaly correction. The metadata plane of the GDEM shows which data set has been used. Fujisada reported that SILC had completed and delivered the *beta* version of GDEM to both ERSDAC and JPL for the LPDAAC. The new version has 22,600 tiles and has been corrected for anomalies.

M. Hato is designing the distribution system for the GDEM; the suggested release date is June 1, 2009. He went over the status of agreements between the Japanese Ministry of Economy, Trade, and Industry (METI) and NASA on conditions for public release of the GDEM.

T. Tachikawa and **A. Iwasaki** [Tokyo University] reported on the GDEM validation over Japan. The plan is for the Ground Data System (GDS) to use a combination of precision ground control points and high resolution DEMS for this validation.

T. **Sohre** [LPDAAC] reported on GDEM distribution plans by the LPDAAC. The first phase will be to use the Warehouse Inventory Search Tool (WIST) system, and possibly the USGS Global Visualization Viewer (GLOVIS) to meet the planned June 1 release date. Future tools may be implemented via a seamless system.

B. Bailey described the Earth Resources Observation Systems (EROS) Data Center (EDC) plan to validate the GDEM over the conterminous U.S., using a combination of high resolution DEMs and ground control points. EDC released a Request for Proposals (RFP) for international participation in the validation and he described the terms and conditions of this RFP.

R. Crippen [JPL] reported on preliminary observations based on analysis of ASTER data over South America, and presented qualitative comparisons with SRTM data. Both sets had strengths and weaknesses that generally complemented one another.

Temperature-Emissivity Separation Working Group

H. Tonooka [Ibaraki University] reported on an updated method of optimizing temperature–emissivity separation by *Bayesian inference*. He also reported on the status of the East Asia Emissivity Mosaic and on a method for cloud assessment for nighttime scenes using cloud masks generated from the Moderate Resolution Imaging Spectroradiometer (MODIS) *MOD35* cloud mask product.

M. Fujita gave an update on the nighttime TIR global map, which is an ongoing activity.

A. Gillespie [University of Washington] reported on new findings on emissivity spectra accuracy addressing why the emissivity spectra of water can be too low and distorted. The spectra may be too low due to the temperature–emissivity separation (TES) algorithm, in particular the regression. However, the distortion is not due to TES since model spectra from the *AST09T* (surface radiance) product (not run through the TES algorithm) are also distorted. This effect is most likely due to calibration inaccuracy or atmospheric correction errors or both.

S. Hook [JPL] showed results of in-flight validation of ASTER TIR bands using the Lake Tahoe CA/NV automated validation site. The site now uses an automated processing system that extracts field data from the Level 2 database and automatically does forward calculations. Validation results indicate a problem over high emissivity targets due to a recent change in the ASTER TES algorithm. Therefore, over water targets Hook recommends using a split window approach for the time being. He also announced that the Salton Sea, CA validation site is now fully operational. Additionally, Hook announced a new version (*v2.0*) of the ASTER spectral library.

A. French [U.S. Department of Agriculture (USDA)] reported on a study using ASTER and MODIS to detect temporal changes in thermal infrared emissivities. He said that the emissivity data is used in hydrological modeling for measuring surface temperature, net longwave radiation, surface roughness, and land cover type and condition. Emissivity temporal variations over vegetation/soil systems were observed at three scales including: daily observations from rainfall, seasonal observations from cropping types and phenology, and inter-annual observations from changing densities of perennial vegetation.

G. Hulley [JPL] showed the current version of his North American ASTER land surface emissivity database, which is a mean-seasonal emissivity product with an improved ASTER cloud mask. The products used are land surface emissivity and temperature for mean summer months (July–August–September) and mean winter months (January–February–March) for 2000–2008. He described the major new algorithm developments which are the aggregation algorithm and the cloud mask algorithm. He selected 10 sand dunes to use as validation sites.

M. Ramsey [University of Pittsburgh] presented a compositional analysis by laboratory thermal infrared spectroscopic methods of synthesized *quartzofeldspathic* glasses of a type common on the Earth and other planetary surfaces. These glasses can have immediate importance because they occur at volcanic sites which are intrinsically hazardous. He described the synthesization and microprobe analysis of the glasses and the spectroscopic methods used. Observations are consistent with other glass compositional studies.

Ecosystems/Oceans Working Group

G. Geller [JPL] reported that one new STAR was submitted since the last meeting and that it comprised about 25% of the total STARs.

H. Shimazaki [National Institute for Environmental Studies] reported on a new research project to study the Mekong River basin. Land use and land cover maps will be generated and a database for the watershed will be developed using ASTER data to generate the maps.

J. Masek [Goddard Space Flight Center (GSFC)**]** gave an update on the Recent North America Forest Dynamics Project (NAFD), which is a project to map forest disturbance from 2000–2005 using ASTER and Landsat data. Initial work indicates discrepancies between ASTER calibration for the visible bands with MODIS and Landsat.

T. Gubbels [Science Systems and Applications, Inc.] reported on a study focused on comparison of ASTER and MODIS cloud cover estimates as part of the next Landsat Ecosystem Disturbance Adaptive Processing System (LEDAPS) survey. Significant differences were found with the ASTER cloud cover estimate showing errors of omission (missed clouds) more than 10% of the time.

T. Ishiyama [Chiba University] used multi-temporal MODIS and ASTER images to investigate changes of vegetation in the Tarim River basin from 2001–2005. MODIS NDVI data showed that maximum vegetation coverage occurred earlier in the west than in the east and ASTER images showed changes in vegetation near farmlands in the western part of the basin.

L. Prashad [Arizona State University] gave an update on the *100 cities project*, which will use a set of analytical tools based on tools developed for Mars image analysis for viewing and processing images from a variety of sensors.

T. Matsunaga [National Institute for Environmental Studies] presented a paper for **Y. Sakuno** [Hiroshima University] and **K. Kawasaki** validating ASTER Sea Surface Temperature (SST) maps using SST data from buoys in Mikawa Bay, Japan.

M. Ramsey showed an ASTER–MODIS comparison of albedo and thermal inertia of the White Sands, NM aeolian system. He used day/night pairs of ASTER data from 2002–2008 and found that the average values compared fairly well.

T. Matsunaga prepared a talk with **Y. Sakuno** and **T. Kozu** on image characteristics off the San-in District coast under a red tide condition in 2007 using the Panchromatic Remote-sensing Instrument of Stereo Mapping (PRISM) and Advanced Visible and Near Infrared Radiometer type-2 (AVNIR-2) sensors on the Japanese Advanced Land Observing Satellite (ALOS) and ASTER data.

J. Kargel [University of Arizona] reported on field validation efforts and science assessment of ASTER classification and time series of glaciers and postglacial vegetation change in the Copper River Basin, AK.

G. Geller gave an update on *TerraLook*, which makes ASTER and historical Landsat data available as georeferenced *jpegs*, for free, to novice users.

Radiometric Calibration/Atmospheric Correction Working Group

B. Eng [JPL] gave an update on software status.

F. Sakuma [National Institute of Advanced Industrial Science and Technology] reported on instrument calibration issues. The VNIR radiometer outputs are slowly decreasing but manageable with everything else on the system stable. The SWIR system was restarted with an 83 K set point on August 27 and October 22, 2008, but the temperature was not controlled so the cooler has been kept off. New coefficients were applied to TIR on July 5, 2008.

T. Tachikawa reported on SWIR product issues and gave several scenarios for recovery of cloud assessment capability in the event that SWIR capability is lost.

H. Tonooka reported on TIR field campaigns in 2008 at Alkali Lake, CA; Railroad Valley, NV; Coyote Lake, NV; and Lake Kasumigaura, Japan.

K. Thome [University of Arizona] reported on VNIR field campaigns in 2008 at Railroad Valley, NV;

Ivanpah Playa, NV; and Alkali Lake, CA. He also announced that he will be leaving University of Arizona for GSFC in December 2008 and announced the changes taking place at Arizona.

K. Arai [Saga University] reported on his team's 2008 field campaigns. Sites included Ivanpah Playa, NV; Alkali Lake, NV; Railroad Valley, NV; and Roach Lake and Coyote Lake, CA. He included comparisons with different calibration teams.

S. Biggar [University of Arizona] announced a request by M. Abrams to include a choice of solar spectrum in reflectance processing and request for a comparison of ASTER with MODIS and Landsat by J. Masek.

Geology Working Group

R. Wessels [USGS] reported on satellite imaging of the summer 2008 eruptions at Okmok, Cleveland, and Kasatochi volcanoes in Alaska with a total of 17 ASTER images.

A. Carter [University of Pittsburgh] gave a talk on ASTER-derived and field-based thermal studies in the North Pacific using Bezymianny as an example. The ASTER Emergency Scheduling Interface and Control System (AESICS) automatically schedules ASTER acquisitions.

M. Ramsey showed some unique thermal infrared observations of active dome and pyroclastic flow deposits of Sheveluch volcano, Kamchatka, fusing Forward-looking Infrared (FLIR) imaging and ASTER data to allow validation of observations of small-scale flow feature morphology.

J. Mars [USGS] demonstrated mapping hydrothermal silica using ASTER SWIR and TIR data with examples from Cuprite and Goldfield, NV and Balqash, Kazakhstan, where he has successfully separated hydrothermal from non-hydrothermal quartz.

M. Urai [Geological Survey of Japan] showed a statistical analysis of 964 active volcanic *hotspots* using night-time ASTER SWIR. ASTER is able to detect more *hotspots* than MODIS because it has a smaller spot size.

D. Pieri [JPL] gave an update on the ASTER Volcano Archive and reported on planned improvements to the website. A bilateral stretch will be implemented to improve the quality of the *jpgw* files and a low temperature hotspot detection algorithm is also being tested.

T. Gubbels reported on his study of volcano change detection using ASTER DEMs: methodology and validation at Mt. St. Helens. Differencing ASTER DEMs documents the 2004–2005 dome growth with a precision of at least 10 m.

T. Rhodes [University of California, Santa Cruz] is using ASTER DEMs to assess mass-loss from Greenland's perimeter. The goal is to compare ASTER DEMs from February 2001–July 2006 and assess glacial mass balance by calculating ice-volume flux from the elevations derived from the DEMs.

J. Kargel reported on a classification of glaciers, lakes, rocks, and vegetation in the Copper River Basin, AK with a goal to document the movement of glacial fronts since 1010. They documented the spectral signatures of affected vegetation and a variety of sediment types and used a fuzzy *c-mean unsupervised clustering technique* to discriminate spectral domains.

D. Pieri showed the extent of paleo ice-cap surfaces in Siberia by studying river network patterns and drainage basin slope characteristics, ridge morphologies and dimensions, and large scale glacial scour to delineate the extent and nature of the glaciated area.

A. Gillespie talked about the loss of spectral contrast in rocks due to microscale (less than 1 mm) roughness, which may be hard to quantify remotely and may limit the use of TIR for compositional mapping.

Closing Plenary Session

Each working group chairperson presented a summary of the discussions and talks that were given during the working group sessions. They each gave reports on suggestions made by the group for further actions by the whole team, particularly how to address the possible loss of SWIR and how to allocate resources to complete the various global map data acquisitions.

At the close of the meeting, **H. Tsu** invited the ASTER Science Team to attend the 35th team meeting in Japan. ■

ASDC at NASA Langley Releases Several New CERES Products

The Atmospheric Science Data Center (ASDC) in collaboration with the Clouds and the Earth's Radiant Energy System (CERES) Science Team announces the release of the following data sets:

Synoptic Radiative Fluxes and Clouds (SYN)
- CER_SYN_Terra-FM1-MODIS_Edition2C
- CER_SYN_Terra-FM2-MODIS_Edition2C
- CER_SYN_Aqua-FM3-MODIS_Edition2B
- CER_SYN_Aqua-FM4-MODIS_Edition2B

Monthly Regional Radiative Fluxes and Clouds (AVG)
- CER_AVG_Terra-FM1-MODIS_Edition2C
- CER_AVG_Terra-FM2-MODIS_Edition2C
- CER_AVG_Aqua-FM3-MODIS_Edition2B
- CER_AVG_Aqua-FM4-MODIS_Edition2B

Monthly Zonal and Global Radiative Fluxes and Clouds (ZAVG)
- CER_ZAVG_Terra-FM1-MODIS_Edition2C
- CER_ZAVG_Terra-FM2-MODIS_Edition2C
- CER_ZAVG_Aqua-FM3-MODIS_Edition2B
- CER_ZAVG_Aqua-FM4-MODIS_Edition2B

The SYN/AVG/ZAVG products provide 1.0° gridded surface and atmospheric *Fu-Liou* radiative transfer fluxes consistent with observed CERES Top-Of-the-Atmosphere (TOA) fluxes.

These are a *Level 3* version of the Clouds and Radiative Swath (CRS) and Monthly Gridded Radiative Fluxes and Clouds (FSW) *Level 2* CERES data products and they add diurnal cycle improvements based on 3-hourly geostationary satellite data.

These are the only CERES products with a package of surface ultraviolet (UV) fluxes. Like the ungridded CERES CRS data product, constrained fluxes are available for clear-sky and all-sky conditions at 70 hPa, 200 hPa, and 500 hPa. Likewise, constrained and untuned fluxes at surface and TOA for clear-sky, all-sky, pristine (no aerosols or clouds), and all-sky-no-aerosol conditions are also available. These fluxes allow the user to infer various cloud and aerosol forcings. Unlike the CERES Surface Averages (SRBAVG) data product (1.0° monthly averages), these new products add:

a) *2-stream shortwave* (SW) (*2/4 stream longwave* (LW)) radiative transfer for surface fluxes and constraints to TOA CERES fluxes, as well as aerosols and clouds derived from the Moderate Resolution Imaging Spectroradiometer (MODIS), and 3-hourly clouds derived from geostationary satellite data intercalibrated with MODIS.
b) *3-hourly synoptic fluxes* (SYN), with fluxes averaged over 3-hour periods (not instantaneous fluxes as in FSW); 3-hourly averaged fluxes were requested by climate and weather modeling groups for model validation studies.
c) The *3-hourly average fluxes* (SYN) can be easily composited to daily, or any other time period by simple averaging.
d) *Monthly* (AVG) and *zonal monthly* (ZAVG) products are also provided for smaller data volumes.

Temporal coverage for the Terra *Edition2* products will run from March 2000–October 2005. Temporal coverage for the Aqua *Edition2* products will run from July 2002–October 2005.

Information about the CERES products including products available, documentation, relevant links, sample software, tools for working with the data, etc., can be found at the CERES data table: *eosweb.larc.nasa.gov/PRODOCS/ceres/table_ceres.html.*

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

Atmospheric Science Data Center
NASA Langley Research Center
User and Data Services
Mail Stop 157D, 2 S. Wright Street
Hampton, VA 23681-2199
Phone: 757-864-8656
E-mail: *larc@eos.nasa.gov*
URL: *eosweb.larc.nasa.gov*

The End of an Era: NOAA-N Prime is the Last POES Satellite

Adam Voiland, NASA Goddard Space Flight Center, avoiland@sesda2.com

On February 6, 2009, NASA launched NOAA-N Prime, the forty-first and last in a productive series of polar-operational environmental satellites (POES) that dates back to 1960—and encompasses the K, L, M, N and N Prime series of satellites. As it has for other satellites in the series, NASA's Goddard Space Flight Center has managed the development and launch of the mission, and transfered operational control to the National Oceanic and Atmospheric Administration (NOAA) 21 days after launch. (**Editor's Note**: After the transfer to NOAA on February 27, the name of the satellite changed to NOAA-19. A "first light" image from NOAA-19 appears on page 3 of this issue.)

The NOAA-N Prime satellite roars into orbit aboard a Delta II rocket launched from Vandenberg Air Force Base in California on the morning of February 6.

N Prime's main objective is to gather critical meteorological data to aid weather forecasting. As it orbits Earth once every 102 minutes, the satellite will collect global images of cloud cover and surface features, as well as temperature and humidity profiles over sea and land. Meteorologists use such data to make short-term weather forecasts and to monitor longer-term meteorological trends such as the cycles associated with El Niño and La Niña. In addition, climatologists can use the data to better understand and quantify Earth's changing climate patterns.

To carry out its objective, the bus-sized spacecraft carries a suite of eight instruments, including: an Advanced Very High Resolution Radiometer (AVHRR) that will image surface features, such as vegetation and bodies of water; a High Resolution Infrared Radiation Sounder (HIRS) that will generate temperature and moisture profiles; two Advanced Microwave Sounding Units (AMSU) primarily for atmospheric and temperature profiles; and a Microwave Humidity Sounder (MHS) that will measure atmospheric moisture and precipitation rates.

Beyond its core meteorological and climate missions, N Prime carries instruments to collect other useful data. A space weather instrument called the Space Environment Monitor (SEM-2), for example, allows scientists to monitor potentially damaging electrons and protons in solar wind streams that can harm satellites.

N Prime also carries components of the international Search and Rescue Satellite-Aided Tracking system (SARSAT). The system relays distress signals from aviators, mariners, and individuals in remote locations through satellite-to-ground stations capable of dispatching rescue teams. Since SARSAT's creation in 1982, the system is credited with saving the lives of more than 24,500 people. Enhancements in the SARSAT system will improve locating accuracy to within 330 ft (100 m), as opposed to two to three miles with previous systems.

Although nearly identical to NOAA N, its immediate predecessor, N Prime has some notable new technologies. Engineers have added a deployable antenna that enhances the spacecraft's Data Collection System (DCS) designed to collect environmental data from unmanned buoys, instrument platforms, and balloons—as well as tagged animals—and relay it to scientists on the ground. The new Advanced DCS can send signals to individual beacons on the ground, allowing mission controllers to remotely modify beacon performance or turn them off to conserve power during idle times.

N Prime also highlights the increasing role of international collaboration in weather and environmental monitoring. In an agreement with the European

Organization for the Exploitation of Meteorological Satellites (EUMETSAT), NOAA agreed to carry EUMETSAT's Microwave Humidity Sounder (MHS) on N Prime, while EUMETSAT has agreed to carry NOAA instruments aboard a series of European-built MetOp satellites.

Built by Lockheed Martin Space Systems, N Prime was launched from the Western Range at Vandenberg Air Force Base by a United Launch Alliance two-stage Delta II rocket. The launch was managed by NASA's Launch Service Program at the Kennedy Space Center. The satellite will send back data to NOAA's command and data acquisition centers in Fairbanks, AK and Wallops Island, VA.

"It's a bit sad to see this extremely successful program come to an end," said **Mary Walker**, deputy project manager of the POES program. "For nearly 50 years, NOAA and NASA have worked extremely well together on weather satellites."

Related Links:
NOAA-N Prime Website—*www.nasa.gov/mission_pages/NOAA-N-Prime/main/index.html*

What Comes After NOAA-N Prime?

A new generation of satellites is poised to pick up where the POES satellites will leave off. The new program, called the National Polar-Orbiting Operational Environmental Satellites System (NPOESS), was created as a cost-saving measure in the 1990s. NPOESS will merge the nation's civilian weather satellite programs with the Department of Defense's (DoD) Defense Meteorological Satellite Program (DMSP). An Integrated Program Office (IPO), located within NOAA, is charged with acquiring, managing, and operating this new series of weather satellites.

After the launch of N Prime, NOAA will remain responsible for operating NPOESS satellites through 2026. The DoD will build and launch the series. NASA will be responsible for injecting cost-effective new technology into NPOESS satellites. NPOESS aims to launch its first satellite in 2013.

NASA engineers are preparing to launch a demonstration mission in 2010—the NPOESS Preparatory Project (NPP)—which will test critical sensors slated to fly on the NPOESS satellites. The NPP mission will also ensure that there are no gaps in key data sets started by NASA's Terra and Aqua satellites.

"It's a busy time for environmental monitoring satellites," said NPP Project Manager **Kenneth Schwer**. "We're working very hard to ensure a smooth transition between the two programs."

Former Vice-President Al Gore Shows AIRS CO_2 Images in Testimony to U.S. Senate Foreign Relations Committee and at AAAS Annual Meeting

Sharon Ray, NASA Jet Propulsion Laboratory, sharon.r.ray@nasa.gov

Former Vice-President **Al Gore** appeared before the Senate Foreign Relations Committee on January 28, 2009 to urge lawmakers to adopt a binding carbon cap and push for a new global climate pact by the end of the year. As part of a slide show presented to the committee, Gore displayed two global maps of carbon dioxide from July 2003 and July 2008 (see below), created with data from the Atmospheric Infrared Sounder (AIRS) that flies aboard NASA's Aqua satellite. Gore used the images to demonstrate the increase in carbon dioxide in Earth's atmosphere in this 5-year time span.

In addition to the Senate testimony, Gore also displayed the AIRS CO_2 images at the recent American Association for the Advancement of Science (AAAS) meeting in Chicago, IL, on February 12–16. As Gore addressed attendees at the AAAS Annual Meeting (the world's largest general science conference) he called on scientists to communicate the urgent nature of climate change to the political leaders and the public.

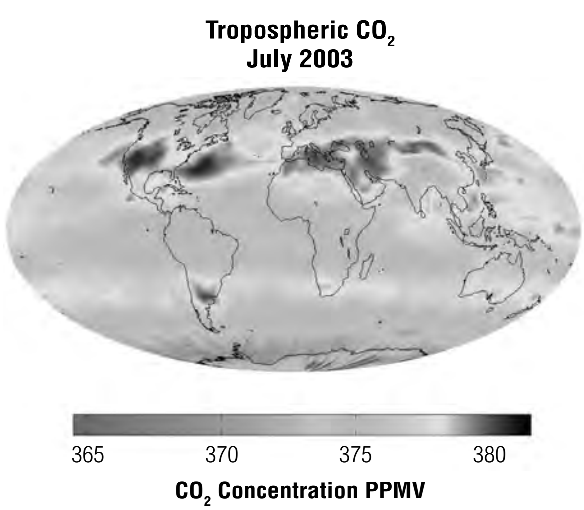
Speaking to an overflow audience at the AAAS Annual Meeting, the 2007 Nobel Peace Prize winner welcomed the signs that long years of political and policy gridlock in the U.S. are ending. But, he said, scientists must use their knowledge and their respected status in the community to press for broad, swift changes in energy and environmental policies.

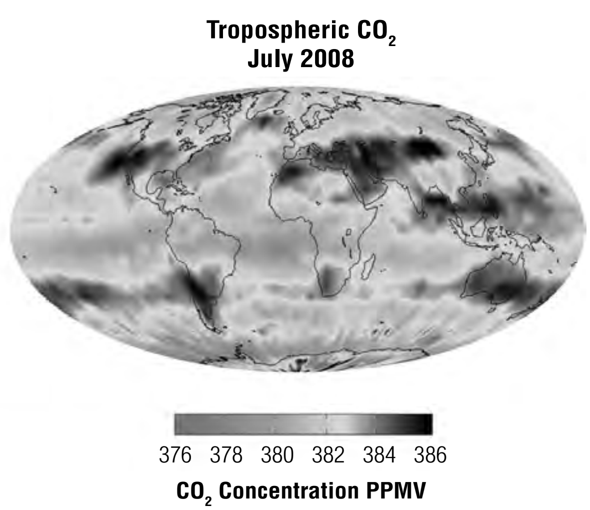
Gore spoke for about 50 minutes; with charts and images, he described the immediate nature of the threat: record-high global temperatures; the shrinking Arctic ice cap; diminishing ice in the high Himalayas; droughts in China and California; an "extraordinary" die-off of trees in the American West; and a 500-year flood that has wrecked Cedar Rapids, IA. Wildfires in Greece have nearly toppled a government, and wildfires this month in Australia have left scores of people dead and sparked a new national debate about climate change.

But today, Gore said, the climate problem is interwoven with a national security crisis and the world financial meltdown. According to Gore, the common thread is, "Our absurd over-dependence on carbon-based fuels." An extended excerpt from his speech is printed below.

"We have a full-blown political struggle to communicate the truth," he said. "...This is a task for all of us. And those of you who have not been engaged in trying to communicate effectively in your communities—to those who respect you and who understand that you have worked hard to obtain the knowledge and wisdom that you have—this is no time to sit back. This is an historic struggle.

"We as a species must make a decision. How absurd that sounds—it sounds absurd because **we've never made a decision as a species, and it seems implausible to think that we could**. But we've now reached a stage where continuing on our present course would threaten the entirety of human civilization."





"Many of the most distinguished members of your professions, in scientific fields, have been saying now, for a few years, that in their estimation, we could have around a decade within which to make major changes in our direction lest we lose the opportunity to retrieve a climate balance that is favorable for human life and human civilization...

"And the only way that's going to happen is if those of you who are in a position to exercise influence and communicate your understanding of what this is all about make a decision to get involved....

"I'm asking you for help. I believe in my heart that we do have the capacity to make this generation one of those generations that changes the course of humankind. The stakes have never been higher. We have the knowledge, we have the emerging technology, we have new leadership, we have cabinet members and science advisers and NOAA heads and policymakers in all of the important positions who are of you, who are your colleagues...

"If I could," Gore concluded, "I would motivate you to leave this city after this meeting and start getting involved in politics. Keep your day job, but start getting involved in this historic debate. We need you."

The audience responded with a standing ovation that lasted over a minute, until Gore had left the room.

Moustafa Chahine at NASA/Jet Propulsion Laboratory produced the AIRS global maps of CO_2 that Gore displayed. The maps show that despite the high degree of mixing that occurs with carbon dioxide in the atmosphere, the regional patterns of atmospheric sources and sinks are still apparent in mid-troposphere CO_2 concentrations.

Said Chahine, "This pattern of high CO_2 in the Northern Hemisphere (i.e., North America, the Atlantic Ocean, and Central Asia) is consistent with model predictions."

Climate modelers, such as **Qinbin Li** at the University of California, Los Angeles (UCLA), **Yuk Yung** at Caltech and **Eugenia Kalnay** at University of Maryland, College Park, are currently using the AIRS data to study the global distribution and transport of CO_2 and to improve their models.

Related Links

The JPL AIRS website: *airs.jpl.nasa.gov/story_archive/AIRS_CO2_in_Gore_Testimony_Jan_2009/.* This site has some of the graphics that Gore showed as well as a link to a video of his testimony before the Senate.

The AAAS Annual Meeting Blog: *news.aaas.org/2009/0214gore-a-call-to-action-on-climate.shtml.* This site has more information on Gore's speech. ■

Erratum

The staff here at *The Earth Observer* would like to acknowledge an error in our January-February 2009 issue [**Volume 21**, **Issue 1**, pp. 21-22]. In the feature article, "Progress Update on NASA's Earth Science Decadal Survey Missions", the SMAP mission was incorrectly referred to as the Soil Moisture and Precipitation mission. Its correct name is the Soil Moisture Active Passive mission. We apologize for this error and thank our diligent readers for pointing it out.

in the news

CALIPSO Finds Smoke at High Altitudes Down Under

Jennifer Collings, NASA Langley Research Center, Jennifer.D.Collings@nasa.gov

As smoke plumes from powerful bushfires clouded the Australian skies in early February, satellites orbiting the Earth captured the rapid dispersal of smoke in real-time. One particular satellite, however, saw the occurrence from a different perspective than the rest and uncovered a rare phenomenon.

The NASA Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO), using its active lidar system, traced vertically through the layers of the atmosphere to find that the Australian bushfire smoke was lofting, or rising, to an astonishing 12 mi, an unusually high altitude that penetrates the lower part of the stratosphere.

"Typically, the altitude of the smoke from wildfires is emitted to the lower troposphere, and occasionally, the smoke can get as high as tropopause heights," explains **Chieko Kittaka**, a research scientist at NASA Langley Research Center in Hampton, VA, who is working on analyzing the satellite data.

CALIPSO has the ability to see the vertical distribution of smoke particles in the atmosphere. While most other satellites saw the smoke as a flat image that portrayed the horizontal direction of the distribution, CALIPSO was able to see the altitude of the lofting smoke. The satellite is not only unique for its ability to make vertical measurements of the atmosphere, but it can also see aerosol layers and plumes that are often invisible to most other instruments. At first glance, another satellite may have thought that the smoke was a low-level cloud, but CALIPSO is able to look deeper.

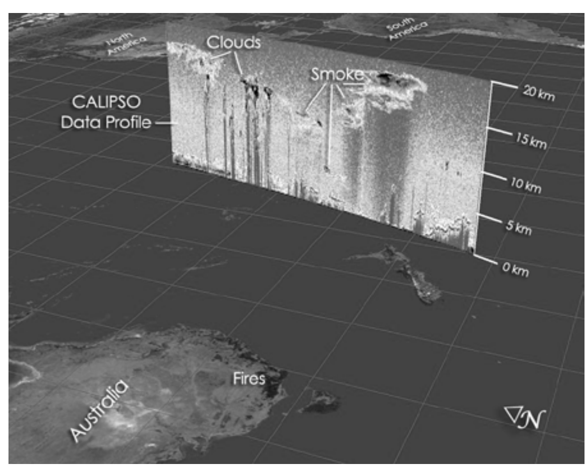
"For the most part, smoke particles are smaller than cloud particles, and they have a shape that differs from ice crystals and water droplets. CALIPSO recognizes this and is able to distinguish smoke from clouds," explains **Mike Fromm**, a researcher from the U.S. Naval Research Laboratory in Washington, who has been investigating these fires with CALIPSO scientists at NASA Langley.

Determining where smoke layers are found and their location is important to better understand how tiny ash particles can possibly effect climate. "If smoke particles reach the upper troposphere or lower stratosphere, they can persist for weeks and travel long distances," explains **Chip Trepte**, the project scientist for CALIPSO. And at these altitudes they can also influence the formation and lifetime of clouds as well as their brightness. All of these effects can alter the way sunlight is reflected and absorbed in the atmosphere.

Because so many different aspects of the atmosphere are affected by the smoke particles, it is important to understand what caused their abnormal presence in the stratosphere. Fromm explains that as the heat from the fire rises, a convective weather system is created. Within this, a severe thunderstorm, known as the pyrocumulonimbus (pyroCb), develops. As the fire increases in strength, it acts like a chimney as it sucks the smoke from the flames up into the convective column. The smoke is then injected into the atmosphere at abnormally high altitudes—a side effect similar to volcanic eruptions. The abundant smoke fuels the storm's updrafts by serving as the nuclei for cloud particles, seeding so many that little-to-no precipitation forms, and taking away a storm-killing drag force.

While the elements of the fires in Australia are becoming clearer, there is still quite a bit of uncertainty surrounding the pyro-convection process. Satellite missions like CALIPSO have been supporting field campaigns to get a better handle on the meteorological, chemical, physical anomalies that forest fires create. This support in turn helps scientists learn more about other pyroCbs that have occurred.

"PyroCbs, such as the ones in Victoria, are historically rare," explains Fromm, who has been studying pyroconvection for over a decade. "Preliminary data from CALIPSO show that the smoke from these storms has gotten to altitudes never observed before."



As CALIPSO passed over the smoke plumes accumulating over Australia on February 10, 2009, its lidar technology took a vertical "slice" of the atmosphere to see the distribution of clouds and aerosols. In this photo, the CALIPSO data reveals that the smoke reached an altitude of 20 km—unusually high—a detail that planar images are not able to detect. To view image in color please visit: *www.nasa.gov/topics/earth/features/calipso-australia.html*. **Credit:** Chieko Kittaka, NASA's Langley Research Center.

NASA Study Finds 'Pre-Existing Condition' Fueled Killer Cyclone

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

A "pre-existing condition" in the North Indian Ocean stoked the sudden intensification of last year's Tropical Cyclone Nargis just before its devastating landfall in Burma (Myanmar), according to a new NASA/university study. The cyclone became Burma's worst natural disaster ever and one of the deadliest cyclones of all time.

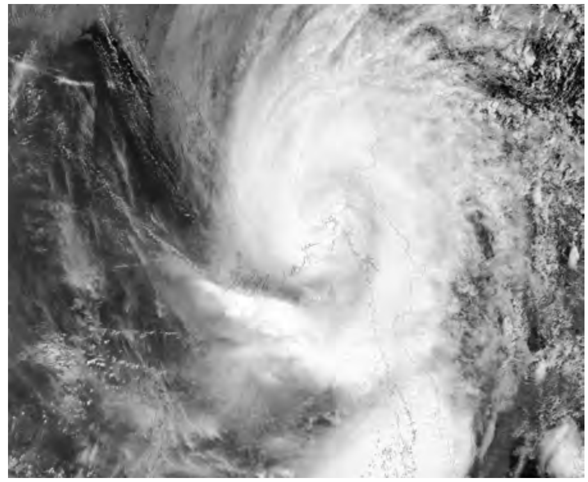
Scientists at the National Taiwan University, Taipei; and NASA's Jet Propulsion Laboratory, used data from satellite altimeters, measurements of ocean depth and temperature, and an ocean model to analyze the ocean conditions present at the time of the catastrophic storm. Nargis intensified from a relatively weak Category 1 storm to a Category 4 monster during its final 24 hours before making landfall on May 2, 2008.

Lead author **I-I Lin** of National Taiwan University and her team found the ocean conditions Nargis encountered created the perfect recipe for disaster. Cyclones thrive on warm layers of ocean water that are at least 79°F (26°C). As they traverse the ocean, they typically draw deep, cold water up to the ocean surface, a process that limits their ability to strengthen, and even weakens them as they evolve. However, Nargis passed over a pre-existing warm ocean feature in the Bay of Bengal where upper ocean warm waters extended deeper than normal, from 240–331 ft (73–101 m).

"This abnormally thick, warm water layer, which formed about a month earlier, kept deeper, colder waters from being drawn to the surface, increasing the energy available to fuel Nargis' growth by 300%," said Lin. "Combined with other atmospheric conditions conducive to strengthening, this warm ocean feature allowed Nargis to reach speeds of 115 knots [132 mph (213 kph)] at landfall. Had Nargis not encountered this warm ocean feature, it would likely not have had sufficient energy to intensify rapidly."

Nargis' rapid intensification occurred predominantly over warm ocean regions where sea surface temperatures were about 86°F (30°C) and sea surface heights ranged from 2.4–7.9 in (6–20 cm) above normal. Between May 1–2, 2008, the storm intensified from Category 1 to Category 4. When Nargis briefly passed outside the warm ocean region on May 2, it weakened somewhat, only to strengthen once again as it returned to the warm ocean feature. (Similar warm ocean features in the Gulf of Mexico contributed to the rapid intensification of hurricanes Katrina and Rita in 2005.)

Lin said the research will contribute to improving our understanding of and ability to forecast catastrophic events like Cyclone Nargis in the future, reducing loss of life and property. "Such a capability is particularly needed in developing countries, where less advanced cyclone monitoring and warning systems can leave people with little time to escape from disaster," she said.



In early May 2008, Cyclone Nargis passed over Burma (Myanmar) after forming in the Bay of Bengal. This image was acquired by the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite. For additional information and to view this image is color please visit: *earthobservatory.nasa.gov/NaturalHazards/view.php?id=19860.* **Image Credit:** NASA MODIS Rapid Response Team.

The scientists compared the thermal structure of the upper ocean waters within the warm ocean feature during the storm with its thermal structure under normal climatological conditions. Study data came from the international Argo float program, NASA's Jason-1 satellite, the European Space Agency's Environmental Satellite, the U.S. Navy's GEOdetic SATellite (GEOSAT) Follow-On satellite and NOAA's Global Temperature and Salinity Profile Program data base. The satellite data were used to derive the upper ocean thermal structure for regions where no suitable direct measurements were available.

"This research demonstrates a significant potential benefit of using altimeter data for operational weather forecasting and tropical cyclone intensity predictions," said study co-author **Tim Liu** of NASA/Jet Propulsion Laboratory. "Current hurricane analyses include variations in ocean heat, which can be revealed by ocean altimeters. Satellites like NASA's Jason-1 and Ocean Surface Topography Mission/Jason-2 make important contributions to the operational monitoring and prediction of tropical cyclones, as have other NASA satellites."

Results of the study were published in the February, 2009 *Geophysical Research Letters*.

EOS Scientists in the News

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

The Warming Earth Blows Hot, Cold and Chaotic, January 2; *The Wall Street Journal*. "I wouldn't run for the hills … but it might be time to start walking," said glacier analyst **Eric Rignot** (NASA JPL), commenting on the amount of recent ice loss from Greenland's glaciers.

NASA to fly Unmanned Drone for Science Research, January 16; *Associated Press*. Researchers including project scientist **Paul Newman** (NASA GSFC) will use *Global Hawk*, an unmanned spy plane that will be outfitted with science instruments, to sample greenhouse gases responsible for ozone depletion and to verify measurements by NASA's Aura atmospheric research satellite—see picture of *Global Hawk* and description on page 41.

Los Angeles' Toasty Streak Sets a Record, January 19; *Los Angeles Times*. After nine straight days of temperatures above 80°F (27°C) in Los Angeles, CA, the record-breaking January trend was expected to come to an end, but **William Patzert** (NASA JPL) said that the dry January, which is normally one of the year's wettest months, is a bad sign.

We're in a CO_2 Danger Zone, Says Scientist, January 21; *Earth & Sky Radio*. **James Hansen** (NASA GISS) and colleagues describe a number of different criteria showing that a safe level of carbon dioxide is no more than 350 parts per million, and probably less, which requires significant changes in current energy use.

Study Finds New Evidence of Warming in Antarctica, January 21; *The New York Times*. University of Washington researcher Eric Steig and colleagues including **Drew Shindell** (NASA GISS) described in the January issue of *Nature* how they used satellite data to interpolate 50 years of ground-based temperature trends, showing that the area of warming in Antarctica is more extensive than previously thought.

Carbon Dioxide May Be the Least of Our Warming Worries, January 25; *Discover*. Atmospheric levels of climate-affecting gases such as nitrogen trifluoride and methane are on the rise, and **Ralph Kahn** (NASA GSFC) believes that although the extent of the impact on global temperatures is unknown, it's more than just carbon dioxide that plays a role.

Prescription for Arctic Melting: Clear the Air Down South, January 29; *Scientific American*. The quickest way to curb Arctic melting may be to turn off the tap of short-lived pollutants swirling from cities and industry to the south. In contrast, explains **Drew Shindell** (NASA GISS), we have little leverage to affect carbon dioxide's effects.

Earth's Upper Atmosphere 'Breathes' Sun's Energy, February 3; *Earth & Sky Radio*. Astrophysicist **Marty Mlynczak** (NASA LaRC) has discovered that our planet's upper atmosphere expands and contracts, describing it as "breathing" the sun's energy in and out.

JPL: La Niña Still a Factor, February 9; *Pasadena Star-News*. Early February storms in Southern California dropped a month's worth of rain in some places, but **William Patzert** (NASA JPL) believes that, overall, the region will have a relatively dry winter thanks to the cold and dry influences of La Niña.

Report Predicts 'Significant Risks' to City's Climate, February 17; *The New York Times*. **Cynthia Rosenzweig** (NASA GISS) participated in a panel that outlined potential changes to New York City's local climate, including rising average annual temperatures and rainfall. The report can help identify risks and mitigation plans for climate change.

New NASA Probe to Help Track Climate Change, February 18; *MSNBC*. **Ralph Oscillo** (NASA JPL) and **David Crisp** (NASA JPL) described the Orbiting Carbon Observatory, and how the science measurements collected from the mission would have contributed to a better understanding of climate change.

Carbon Dioxide Emissions Map Released on ***Google Earth***, February 19; *Imperial Valley News*. U.S. carbon dioxide emissions can now be viewed on Google Earth thanks to the NASA-funded Vulcan system, which quantifies carbon dioxide emissions. **Peter Griffith** (NASA GSFC) describes its utility for public policy.

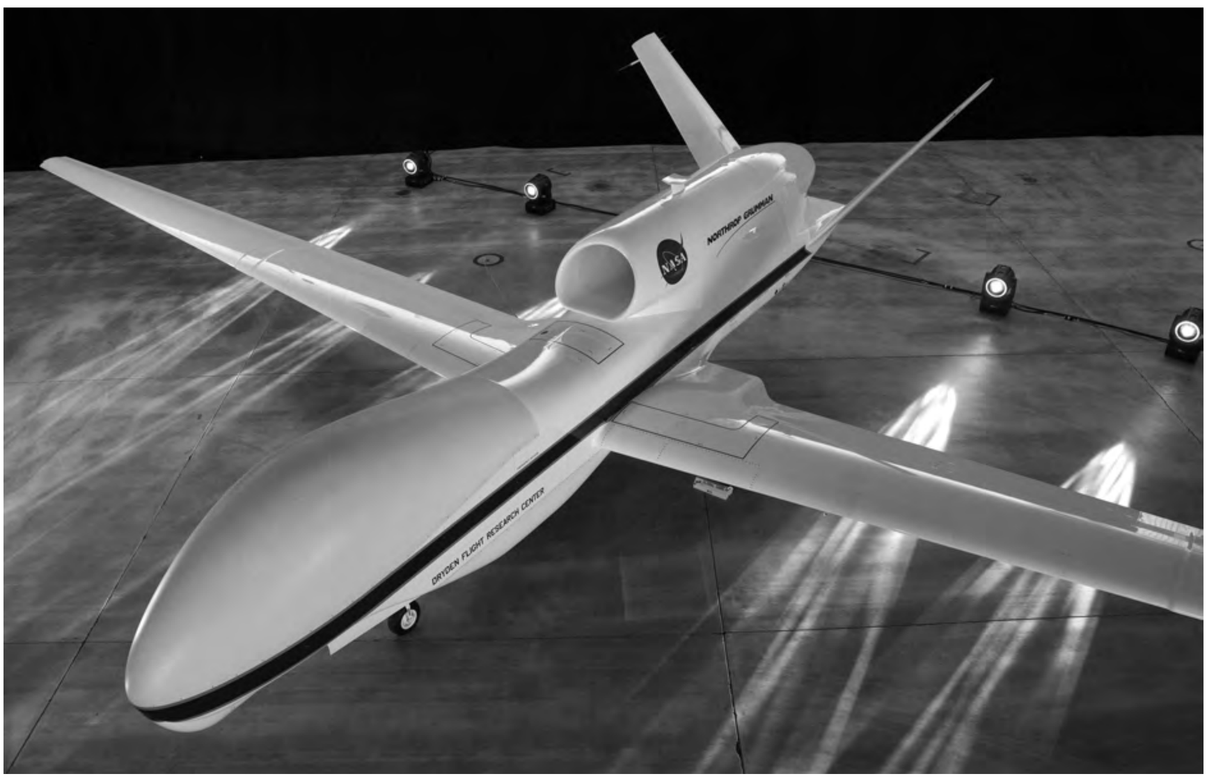
Ministers Get Close Look at Antarctic Ice Threat, February 23; *Associated Press*. Representatives from more than a dozen nations observed the last leg of a 1,400-mi (2,300-km), two-month trek to learn more about how a melting Antarctica may endanger the planet. The dangers, according to **James Hansen** (NASA GISS), include the potential for a several-meter rise of sea level.

NASA: 2008 Coolest Year of the Decade, February 23; *United Press International*. NASA climatologists say 2008 was the coolest year since 2000, but the ninth warmest since continuous records were started in 1880. **James Hansen** (NASA GISS) speculates how the next El Niño, beginning this year or 2010, could result in a new global surface air temperature record.

NASA's Global Warming Satellite Falls to Earth, February 24; *MSNBC/Space.com*. NASA's Orbiting Carbon Observatory (OCO), a new satellite dedicated to mapping Earth's carbon dioxide levels, crashed into the ocean near Antarctica just after launch. **Michael Freilich** (NASA HQ) explains the importance of the measurements OCO would have made and notes that NASA will take a good look at how to advance Earth and carbon cycle science observations using available assets.

Why Global Warming Can Mean Harsher Winter Weather, February 25; *Scientific American*. Most scientists say there should be a distinction between weather—the short-term events that make up our recently cold and stormy winter—and climate, which **Gavin Schmidt** (NASA GISS) describes as the long-term trends.

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



NASA and the Northrop Grumman Corporation of Los Angeles have unveiled the first *Global Hawk* aircraft system to be used for environmental science research, heralding a new application for the world's first fully autonomous high-altitude, long-endurance aircraft. The debut took place in January at NASA's Dryden Flight Research Center in Edwards, CA.

NASA's initial use of the aircraft to support Earth science will be the *Global Hawk* "Pacific 2009" program. This campaign will consist of six long-duration missions over the Pacific and Arctic regions in the late spring and early summer of 2009. Twelve scientific instruments integrated into one of the NASA Global Hawk aircraft will collect atmospheric data while flying high through Earth's atmosphere in the upper troposphere and lower stratosphere.

Global Hawk has many potential applications for the advancement of science, improvement of hurricane monitoring techniques, development of disaster support capabilities, and development of advanced autonomous aircraft system technologies. For example, *Global Hawks* were used to help monitor wildfires in Southern California in 2007 and 2008.

Related Links:
www.nasa.gov/home/hqnews/2009/jan/HQ_09-008_Global_Hawk.html
www.nasa.gov/centers/dryden/multimedia/imagegallery/Global_Hawk/

NASA Science Mission Directorate – Science Education Update

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New on the *Sea Level From Space* Web Site

NASA's *Ocean Surface Topography from Space* Web site has added new features, including the Sea Level Viewer, a new interactive tool illustrating sea level, and a discussion on the terms *global warming* versus *climate change*. To check out the site, visit *sealevel.jpl.nasa.gov.*

Toolkit for Developing Interactive, Scientific, Web-based Learning Activities

The NASA-funded Satellite Observations in Science Education (SOSE) web site promotes the teaching and learning of the Earth system through quality educational resources that make use of satellite observations. SOSE has made available a library of Reusable Content Objects (RCOs)—a free toolkit that allows educators to quickly develop their own scientific e-learning activities. For more information, visit *www.ssec.wisc.edu/sose/.*

NASA Students on Facebook

NASA has a *Facebook* page designed for students in grades 9-12 and higher education. The page is updated daily, excluding weekends and holidays. It features information for students regarding competitions, feature articles, podcasts, videos, and more. Information is also posted to update students on opportunities that have an upcoming deadline, when the Space Shuttle is preparing for a launch or a landing, and other significant NASA events. *Facebook* members can join. Just search for "NASA Students" at *www.nasa.gov* or visit *www.facebook.com/home.php?#/group.php?gid=34760681199.*

Ocean Motion, NASA Web Site For Students, Grades 9-12

What explains the hundreds of sneakers that washed ashore along the Pacific Northwest during the winter of 1990-1991? Or the bath toys that have periodically appeared on Alaskan beaches since 1992? The answer is ocean surface currents, which are the focus of *Ocean Motion*, a NASA Web site for students at grade levels 9-12. For more information, visit *www.ocean-motion.org/.*

No Boundaries National Competition for High School Students

NASA has teamed with *USA TODAY* Education to create the *No Boundaries* project and national student competition. This project is designed to help students explore careers in science, technology, engineering, and mathematics (STEM). The *No Boundaries* Web site has a Teacher Toolkit and step-by-step instructions for teachers to implement the project in their classrooms. Students research and develop projects (podcast, Web site, newspaper, songs, artwork, etc.) marketing NASA STEM careers to teens and are encouraged to enter their projects in the No Boundaries National Competition. The contest deadline is May 15, 2009. For more information, visit *www.noboundaries-stemcareers.com/.*

Windows to the Universe Features *Poles In Space*

The NASA-funded *Windows to the Universe* Web site provides students, educators, and the public with more than 7,000 pages of content on a wide range of Earth and space science topics (in English and Spanish). A new *Poles in Space* section highlights information and stunning images from NASA missions of polar regions around the solar system, including: Saturn's northern polar hexagon and southern polar vortex, methane lakes around Titan's North Pole, auroral lights at the poles of Jupiter and Saturn, various sublime terrain features near the polar ice caps of Mars, the ice geysers at the South Pole of Enceladus, and more. Visit the *Poles in Space* section at: *www.windows.ucar.edu/poles_in_space.html.*

Weather Puzzle Game on *Space Place* Web Site

Weather can be puzzling. What's it going to do next? The new weather picture "Slyder" puzzles on *The Space Place* Web site are easier to solve. Users can pick easy, medium, or hard levels of difficulty to challenge logical- and spatial-reasoning muscles and to reveal dramatic ground- and space-based images of Earth and space weather phenomena. Each image is identified and credited. Whether you solve the chosen puzzle or not, you will no doubt find abundant weather enlightenment. Visit the "Slyder" puzzles at: *spaceplace.nasa.gov/en/kids/goes/slyder.* ■

EOS Science Calendar

2009

March 31–April 2
LCLUC Science Team Meeting, Bethesda North Marriott, Bethesda, MD, URL: *lcluc.umd.edu/Program_Information/meeting-registration_spring09.asp*

April 28–30
CERES Science Team Meeting, Newport News, VA. URL: *science.larc.nasa.gov/ceres/meetings.html*

May 4–7
AIRS Science Team Meeting, Pasadena, CA. URL: *airs.jpl.nasa.gov/*

July 19–29
SORCE Science Team Meeting, Montreal, Canada. URL: *iamas-iapso-iacs-2009-montreal.ca/e/99-home_e.shtml.* (NOTE: This meeting is being held in conjunction with the IAMAS Meeting described in the *Global Change Calendar*)

September 14–17
Aura Science Team Meeting, Netherlands. URL: *aura.gsfc.nasa.gov/*

Global Change Calendar

2009

April 26–30
7th International Science Conference on the Human Dimensions of Global Environmental Change (Open Meeting), Bonn, Germany. Contact: *openmeeting@ihdp.unu.edu*; URL: *www.ihdp.org/*

May 4–8
41st International Liege Colloquium on Ocean Dynamics, Liege, Belgium. URL: *modb.oce.ulg.ac.be/colloquium/*

May 4–8
33rd International Symposium on Remote Sensing of Environment, Stresa, Lake Maggiore, Italy. URL: *isrse-33.jrc.ec.europa.eu/index.php?page=home*

May 18–20
International Conference on Land Surface Radiation and Energy Budgets, Yingdong Hall, Beijing Normal University, China. URL: *www.landenergybudget.org/LED/default.htm*

July 19–29
International Association of Meteorology and Atmospheric Sciences 2009, Montreal, Canada. URL: *iamas-iapso-iacs-2009-montreal.ca/e/99-home_e.shtml*

August 16–19, 2009
Wilhelm and Else Heraeus Seminar on Determination of Atmospheric Aerosol Properties Using Satellite Measurements, Bad Honnef, Germany
URL: *http://www.iup.uni-bremen.de/eng/events/*

November 3–5
6th GOES Users' Conference, Monona Terrace Convention Center, Madison, Wisconsin. Contact: *Dick.Reynolds@noaa.gov* or *james.gurka@noaa.gov*
URL: *http://cimss.ssec.wisc.edu/goes_r/meetings/guc2009*

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

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