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The Earth Observer

Editor's Corner

Michael King
EOS Senior Project Scientist

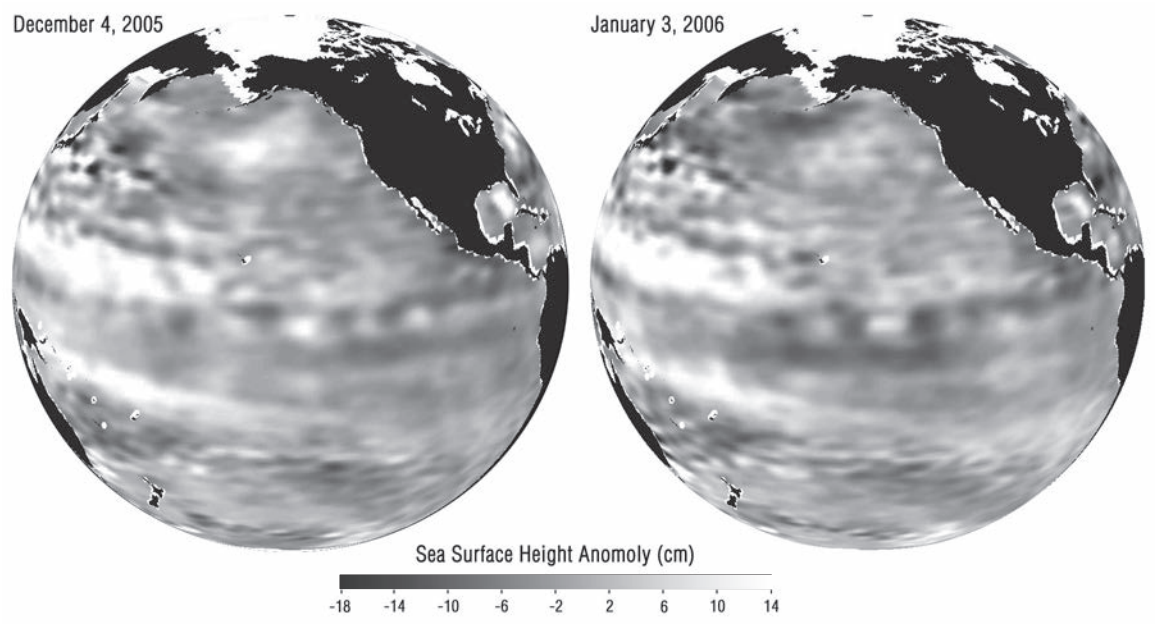
On behalf of the *The Earth Observer* staff, I would like to wish all of our readers a happy, healthy, and prosperous new year. I hope 2006 will be a good year for Earth Science at NASA.

It is with regret that I announce the departure of Ghassem Asrar, former Deputy Associate Administrator of Science at NASA Headquarters. Asrar left NASA effective January 6 to take a position at the U.S. Department of Agriculture as Deputy Administrator of the Agricultural Research Service. Prior to the reorganization of NASA that took effect in August 2004, Asrar served as Associate Administrator of the Office of Earth Science since February 1998.

Asrar's career at NASA began in 1987, and he was a key player in the Earth Science program from its beginnings, playing an important role in leading an international science team promoting the Earth Observing System (EOS). While serving as the Associate Administrator, the Office of Earth Science successfully launched the first EOS satellites and developed a comprehensive data and information system for managing the wealth of information resulting from these missions. These new measurements from Earth Science satellites have provided new insights into the connections between Earth's land, oceans, atmosphere, ice, and life, and have fundamentally changed the way we study and monitor our home planet. Most importantly, the information obtained from these satellites has been available to scientists, governments, commercial firms, educators, and the public worldwide.

continued on page 2

Between December 2005 (left image) and January 2006 (right image), sea-surface height of the Pacific Ocean near the equator rose approximately 5 centimeters on average, as illustrated by these two images taken by the U.S.-French Jason satellite. Jason, launched in 2001, is continuing TOPEX/Poseiden's study of of ocean circulation effects on the Earth's climate. TOPEX/Poseidon lost its ability to maneuver on October 9, 2005, which ended the project's 13-year operation. Image courtesy Akiki Hayashi, NASA Jet Propulsion Laboratory.



In This Issue

On behalf of the entire Earth Science community, I would like to thank Ghassem for his leadership during a critical period in the history of Earth Science at NASA, and wish him the best in his new endeavors at the U.S. Department of Agriculture.

I would also like to announce that Carl "Skip" Reber retired from NASA effective January 3. Skip served as Project Scientist for the Earth Sciences Data and Information System (ESDIS) since 2002. Prior to that he was Acting ESDIS Project Scientist, Deputy Senior EOS Project Scientist, and Senior Earth Scientist in the Mission to Planet Earth Office.

Reber came to Goddard in late 1959 while still a physics graduate student at the University of Maryland. In his first ten years at Goddard, he was a Principal Investigator on three satellite mass spectrometer experiments and a high altitude rocket payload, and Co-Investigator on half a dozen other atmospheric experiments. Aided by a NASA fellowship, he earned a PhD from the University of Michigan in 1973. From 1977 to 2003 he worked on the Upper Atmosphere Research Satellite (UARS), first as Study Scientist, then as the Project Scientist and Theoretical Investigator. I would like to convey my sincere appreciation to Skip for his untiring efforts toward the success of Earth Science at NASA.

In other news, the twin satellites of the Gravity Recovery and Climate Experiment (GRACE) successfully completed a swap of positions during the month of December with GRACE-2 now becoming the leading satellite. The maneuver was initiated on December 3, and GRACE-2 passed to within 420 m of GRACE-1 on December 10th—quite remarkable. The swap was done to reduce the risk of loss of thermal control of GRACE-2's K-Band horn (and subsequent spurious K-Band range signal) that can be caused by excessive exposure to atomic oxygen. GRACE continues to measure the Earth's gravity field with unprecedented detail and is leading to exciting new discoveries about gravity and Earth's climate system. Additional information on the maneuver is available at *www.csr.utexas.edu/grace/operations*.

With regard to upcoming missions, at the Fall Meeting of the American Geophysical Union (AGU), Mary Cleave, Associate Administrator for Science, announced that NASA is canceling the Hydrospheric State Mission (Hydros). NASA remains committed to studying soil moisture and will reassess its plans and priorities after the results of the National Academies' Decadal Survey of Earth Science are released toward the end of 2006.

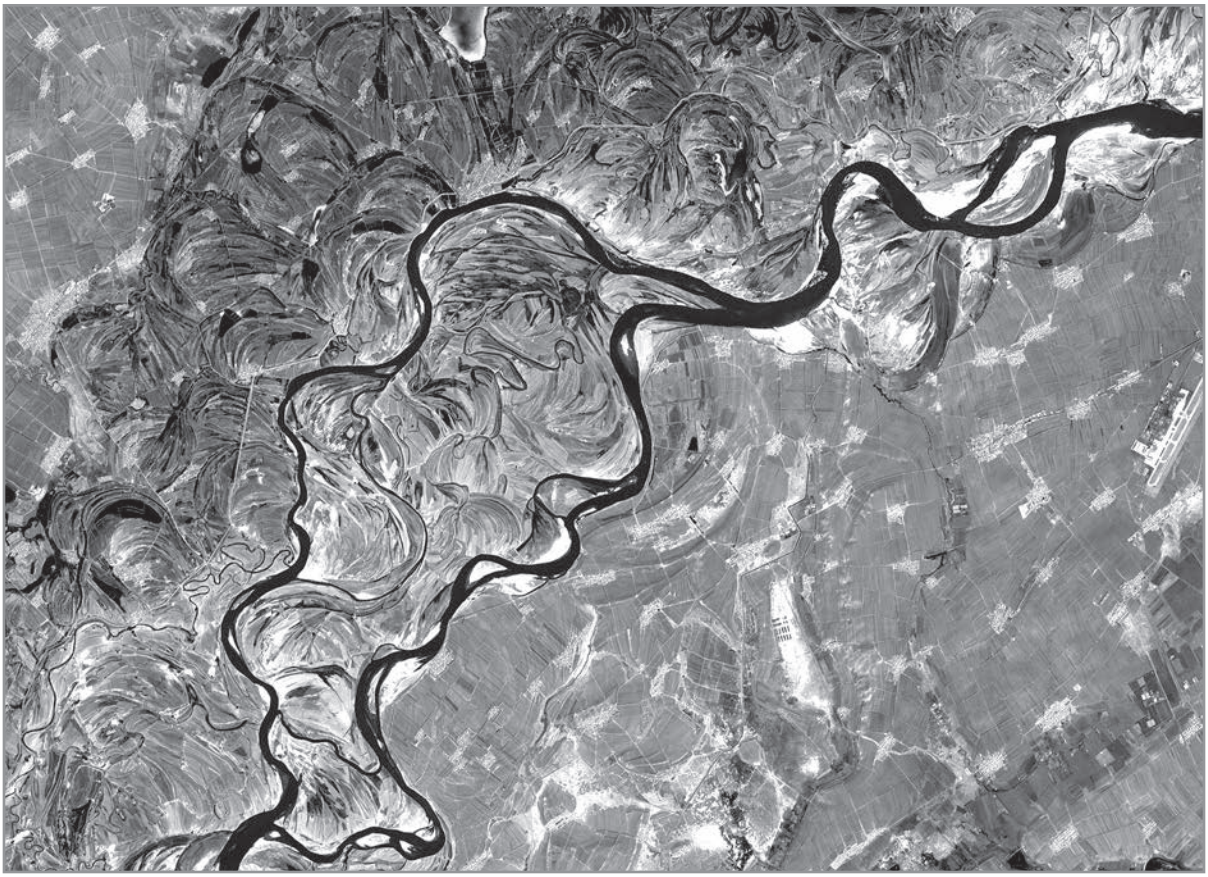
Meanwhile, the Orbiting Carbon Observatory (OCO), Aquarius, and Glory missions are proceeding with development. Glory will enable scientists to draw conclusions about the effects of aerosols on the Earth's atmosphere and climate system, and measure the effects of solar irradiance on Earth. OCO will make space-based measurements of atmospheric carbon dioxide (CO_2), an important greenhouse gas, and help scientists better understand how increasing CO_2 concentrations will drive climate change around the globe. Aquarius is a focused satellite mission to measure global sea surface salinity (SSS) and provide global maps of salt concentration on the ocean surface, a key area of scientific uncertainty in the oceans' capacity to store and transport heat, which in turn affects Earth's energy and water cycle.
Plans are also underway to have Glory become part of the Afternoon or A-Train constellation of satellites. The A-Train currently consists of the NASA missions Aqua and Aura and a French Centre National d'Etudes Spatiale (CNES) mission known as Polarization and Anisotropy of Reflectances of the Atmosphere coupled with Satellite Observations from a Lidar (PARASOL), and will eventually include CloudSat and Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO)

satellites, scheduled to launch in 2006, and may eventually include OCO. The addition of Glory to the A-Train will allow for even more comprehensive characterization of clouds and aerosols in the Earth's atmosphere and the impact they are having on weather and climate.

Lastly, I would like to recognize the end of the joint NASA/CNES TOPEX/Poseidon oceanography mission. The TOPEX/Poseidon satellite ceased operations after 13 years—nearly 62,000 orbits of Earth. The spacecraft lost its ability to maneuver, bringing to a close what Project Scientist Lee-Lueng Fu of NASA's Jet Propulsion Laboratory described as *"history's longest Earth orbiting radar mission."* TOPEX/Poseidon data have helped in hurricane and El Niño/La Niña forecasting, ocean and climate research, ship routing, offshore industries, fisheries management, marine mammals' research, modernizing global tide models, and ocean debris tracking. Congratulations to Lee Fu and all those who have been involved in this long-lived and highly successful mission.

Jason, a follow-on oceanography mission launched in December 2001, is continuing TOPEX/Poseidon's study of ocean circulation effects on the Earth's climate. Jason precisely maps the ocean surface height, wind speed and wave height of 95% of the Earth's ice-free oceans every 10 days. The data provide invaluable input for short-term weather forecasting, long-term climate forecasting, and prediction models. ■

This image from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) on NASA's Terra satellite shows the Songhua River just downstream (east) of the city of Harbin on April 1, 2002. It flows northward out of the Changbai Mountains and cuts across the Manchurian Plain before emptying into the Amur River, which separates northeastern China from Russia's Far East. As China's northernmost river system, the Songhua is an important artery for transporting agricultural products grown on the plain. On its way, the river flows past Harbin, the capital of China's Heilongjiang Province, where it is the source of drinking water for several million people. The main stem of the river and its myriad channels wind from bottom left toward center right. The extreme flatness of the Manchurian Plain has caused the river to meander widely over time. The result of the meandering is that the river is surrounded by a wide plain that is filled with swirls and curves, showing paths the river once took. Image courtesy NASA/GSFC/METI/ERSDAC/JAROS, and the U.S./Japan ASTER Science Team.



New Landsat Data Continuity Mission (LDCM) Memorandum from OSTP

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The Director of the Office of Science and Technology Policy (OSTP), **John Marburger, III**, signed a memorandum on December 23, 2005, with a subject line reading "Landsat Data Continuity Strategy Adjustment." This memorandum revises guidance provided by Marburger in a previous memorandum dated August 4, 2004. The earlier memorandum directed Federal agencies to place Landsat-type sensors on National Polar-orbiting Operational Environmental Satellite System (NPOESS) platforms. Following evaluation of the technical complexity of integrating Landsat-type sensors on the NPOESS platforms, the new memorandum directs the Departments of Commerce, Defense, the Interior, and NASA to "Proceed with the NPOESS program without incorporating a Landsat-type instrument." The memorandum further directs NASA to acquire a single *free-flyer* spacecraft for LDCM and assigns the Department of Interior / United States Geological Survey (DOI/USGS) responsibility for operating the spacecraft. The memorandum also states that the transition of the Landsat program from a series of independently planned missions to a sustained operational program remains a goal of the U.S. Government.

Following the release of the 2004 memorandum, the LDCM Project Office at NASA Goddard Space Flight Center (GSFC) and the DOI/USGS worked with the NPOESS Integrated Program Office (IPO) and with their prime contractor, Northrop Grumman Space Technology (NGST) to specify requirements for Landsat-type sensors for flights aboard two *2130* NPOESS satellites. Mid-morning equatorial crossing times are planned for these two satellites and with the addition of a Landsat-type sensor, the IPO planned its first satellite launch for a *2130* platform and gave it the designation *C1*. The second *2130* satellite would ultimately replace *C1* and was given the designation *C4*. NASA and the IPO began to refer to the Landsat sensor concept as the Operational Land Imager (OLI) and posted draft OLI specifications on an open web site for industry comment. NASA posted a Synopsis for an OLI Request For Proposals (RFP) on June 27, 2005, and followed up with briefings to potential bidders in July. The concurrent evaluation of the technical complexities delayed the release of the OLI RFP and led ultimately to the adjusted strategy guidance in the more-recent OSTP memorandum.

The technical complexities included constraints on the location of an OLI on the NPOESS platforms. The OLI sensors were latecomers to the NPOESS sensor manifest. Plans called for each *2130* satellite to carry at least six other Earth-observing sensors. These instruments are under development and interfaces to the satellite have been defined for each of the instruments. The late addition left limited space and location for the incorporation of OLI sensors and restricted the fields-of-view available for Earth observation and, in particular, for solar-based calibration.

NPOESS spacecraft vibrations, also known as *jitter*, presented the most challenging technical issue. An OLI would not be able to meet specifications for performance and image quality without isolation from the jitter predicted for the *2130* platforms. Any isolation mechanism would have decoupled the sensor from the attitude knowledge provided by the spacecraft. An isolated OLI would have required its own attitude sensors to provide the line-of-site knowledge required for accurate image geolocation and geometric correction. The adjusted LDCM implementation strategy reflects recognition of the cost, schedule, and risk ramifications of these complexities.

Attention now turns to the acquisition of a free-flyer spacecraft for the LDCM in accordance with the most recent OSTP memorandum. The mandate to collect and archive data consistent with data from the previous Landsat satellites remains intact and the mission specifications for a free-flyer spacecraft can be expected to satisfy data-continuity requirements. Expeditious progress towards the acquisition, launch, and operation of the LDCM spacecraft can also be anticipated given the condition of Landsat 5 and Landsat 7.

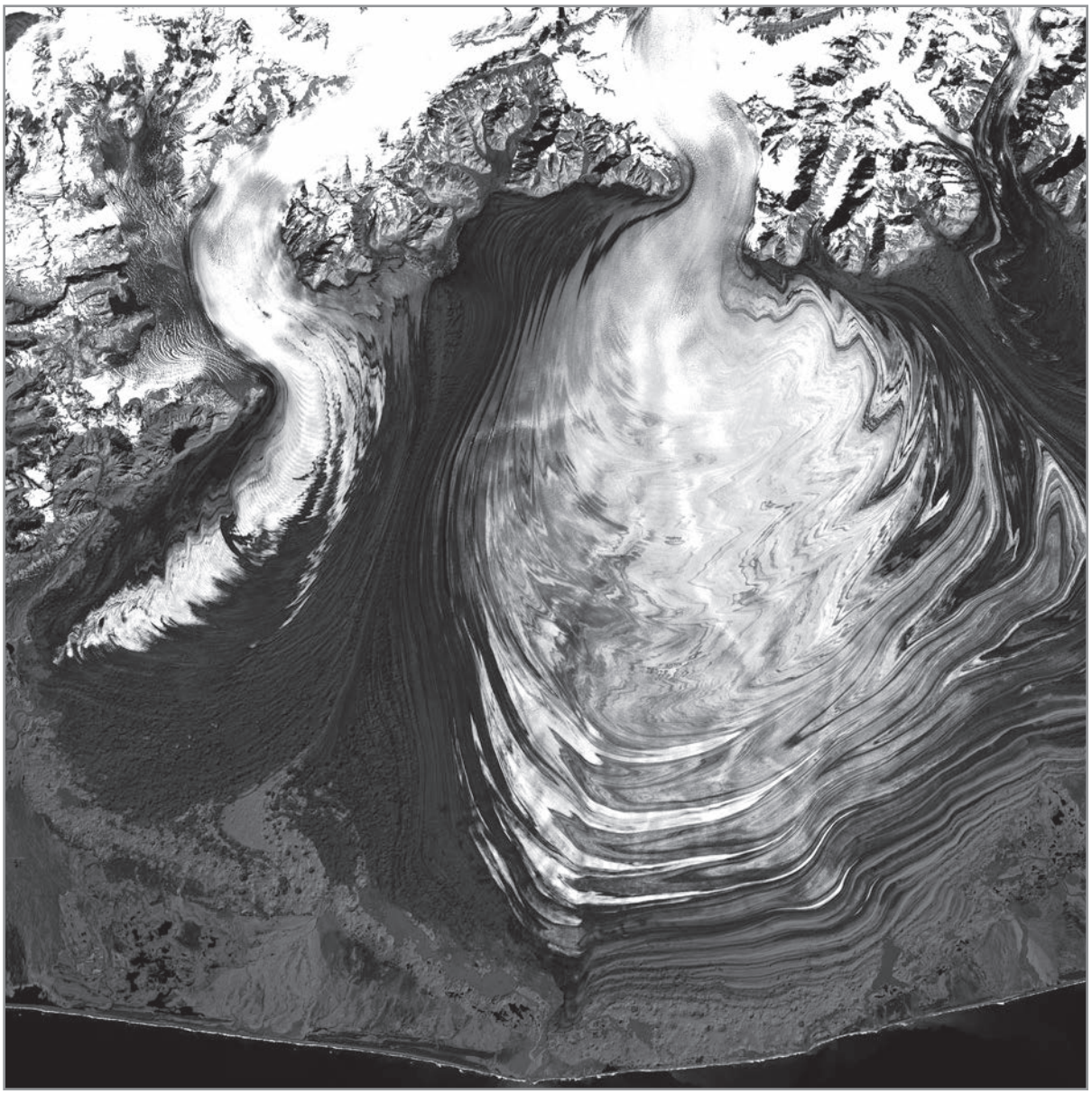
Landsat 5 and Landsat 7 remain in operation but the two satellites may not last until the launch of an LDCM spacecraft. Landsat 5 is over 21-years old, and collection of Thematic Mapper (TM) data was suspended on November 26, 2005 due to an anomaly in the performance of the spacecraft's solar-array drive. Efforts are underway to restore some solar drive functionality and resume TM operations. Initial results are promising, but the aged system cannot be counted on to carry us into the LDCM era. Similarly, Landsat 7 is almost two years past its five-year design life and has lost the services of one of its three attitude control gyroscopes. The spacecraft is able to maintain attitude control with the remaining two gyroscopes, but the Enhanced Thematic Mapper-Plus (ETM+) aboard Landsat 7 has collected degraded image data since the failure of its scan-line corrector, a component of the optical scanning mechanism, in May 2003. These

conditions create the distinct possibility of a multi-year gap in the collection of data from a fully functional Landsat satellite. NASA and DOI/USGS are exploring strategies for mitigating the impact of a Landsat data gap, but the Landsat mission requirements will only be met completely by the implementation of an LDCM. Those investigators and resource managers requiring Landsat data should, therefore, welcome the clear strategic direction provided by the latest OSTP memorandum.

The full text of the OSTP memo can be found on the internet at : *landsat.gsfc.nasa.gov/main/ldcm-memo05.html* or at *ldcm.nasa.gov/docs/OSTP_Landsat_memo_12-1AF496.pdf* ■

Malaspina Glacier in southeastern Alaska is considered the classic example of a piedmont glacier. Piedmont glaciers occur where valley glaciers exit a mountain range onto broad lowlands, are no longer laterally confined, and spread to become wide lobes. The Malaspina Glacier is actually a compound glacier, formed by the merger of several valley glaciers, the most prominent of which seen here are Agassiz Glacier (left) and Seward Glacier (right). In total, Malaspina Glacier is up to 65 kilometers (40 miles) wide and extends up to 45 kilometers (28 miles) from the mountain front nearly to the sea. The tongue of the Malaspina Glacier, the largest glacier in Alaska, fills most of this image, which was acquired by Landsat 7's Enhanced Thematic Mapper Plus (ETM+) instrument on August 31, 2000. The Malaspina lies west of Yakutat Bay and covers 1,500 sq mi (3,880 sq km).

Glaciers erode rocks, carry them down slope, and deposit them at the edge of the melting ice, typically in elongated piles called moraines. The moraine patterns at Malaspina Glacier are quite spectacular in that they have huge contortions that result from the glacier crinkling as it gets pushed from behind by the faster-moving valley glaciers.



Feature Articles

Earth Observing 1: A Pathfinder to Future Sensor Webs

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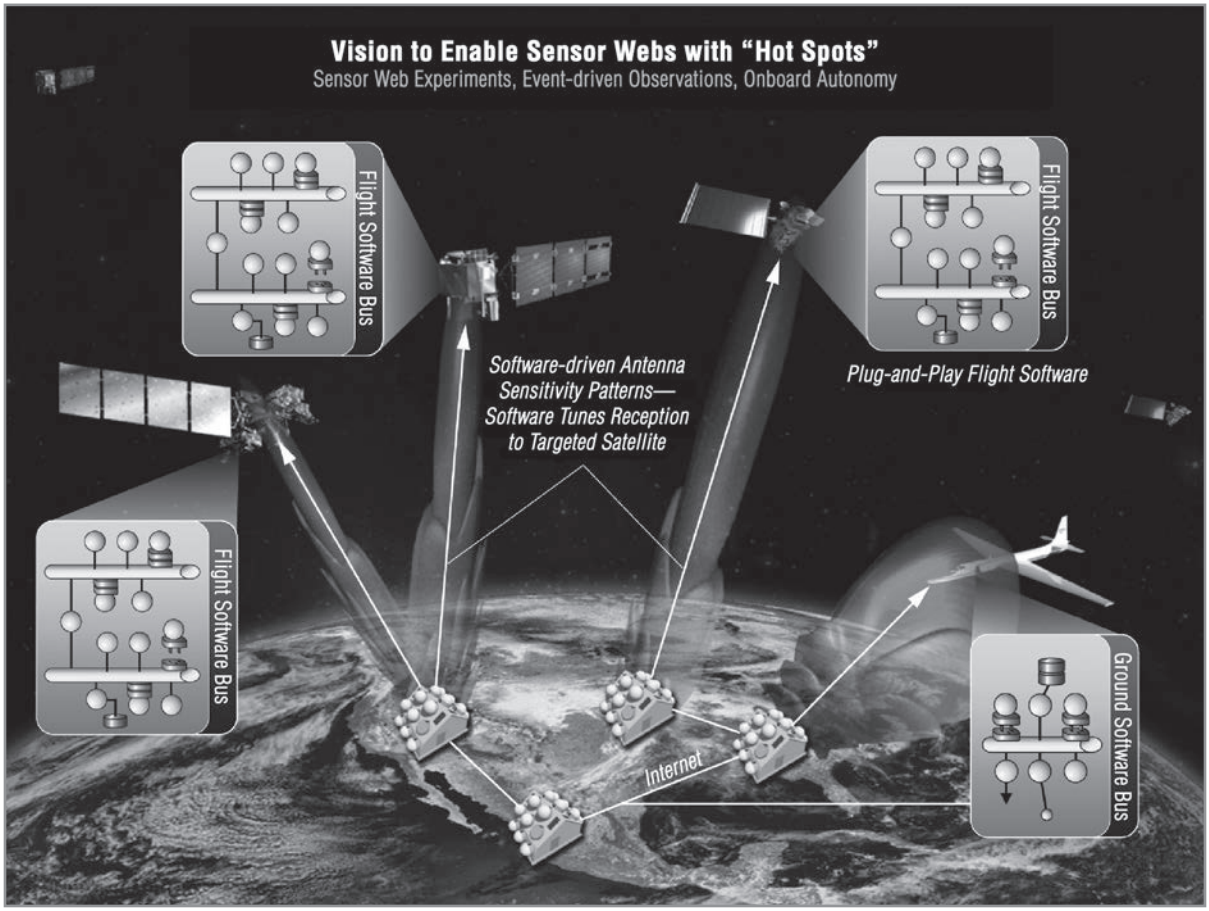
Overview

The Earth Observing 1 (EO-1) satellite was launched on November 21, 2001 as a one-year technology validation mission under the NASA New Millennium Program. The EO-1 mission is managed and operated by the Goddard Space Flight Center (GSFC). After a flawless and successful first year of operations, in which all of the onboard technologies were validated, the mission was extended and reformulated to utilize the three onboard imagers for continued science research into hyperspectral imaging, and to be a pathfinder for new sensor web operations concepts. **Figure 1** depicts the vision used in designing the EO-1 sensor web experiments, which includes integration of sets of heterogeneous sensors to collaborate autonomously triggered by real-world events. Middleware, software radio and *plug and play* software environments for both the ground and flight software further facilitate this vision (a software radio is a radio that uses software to define channel waveform modulations).

Since the end of the first year of operation, EO-1 has been flying in an on-orbit testbed mode and will continue operating in this mode for at least another two years, barring onboard component failure. During this extended-mission phase, EO-1 has been re-outfitted with new flight software in order to take steps towards the vision depicted in **Figure 1**. Specifically, we installed new software onboard EO-1 to: 1) perform onboard Level 0 and Level 1 data processing; 2) perform onboard pixel classification to detect features such as clouds, thermal events, water, and ice; 3) enable autonomous onboard decision-making based on triggers from the classification software; and 4) autonomously schedule and task EO-1 imaging events. These capabilities were linked to other satellites and ground instruments to form various *ad hoc* sensor webs enabling various operations concepts that would be useful for future NASA missions. The sensor web and autonomy capabilities developed thus far have been retained and used operationally on EO-1 and have served

Figure 1: Vision for future sensor webs using inter-sensor connectivity via software radio antennas and *plug-and-play* ground and flight software.



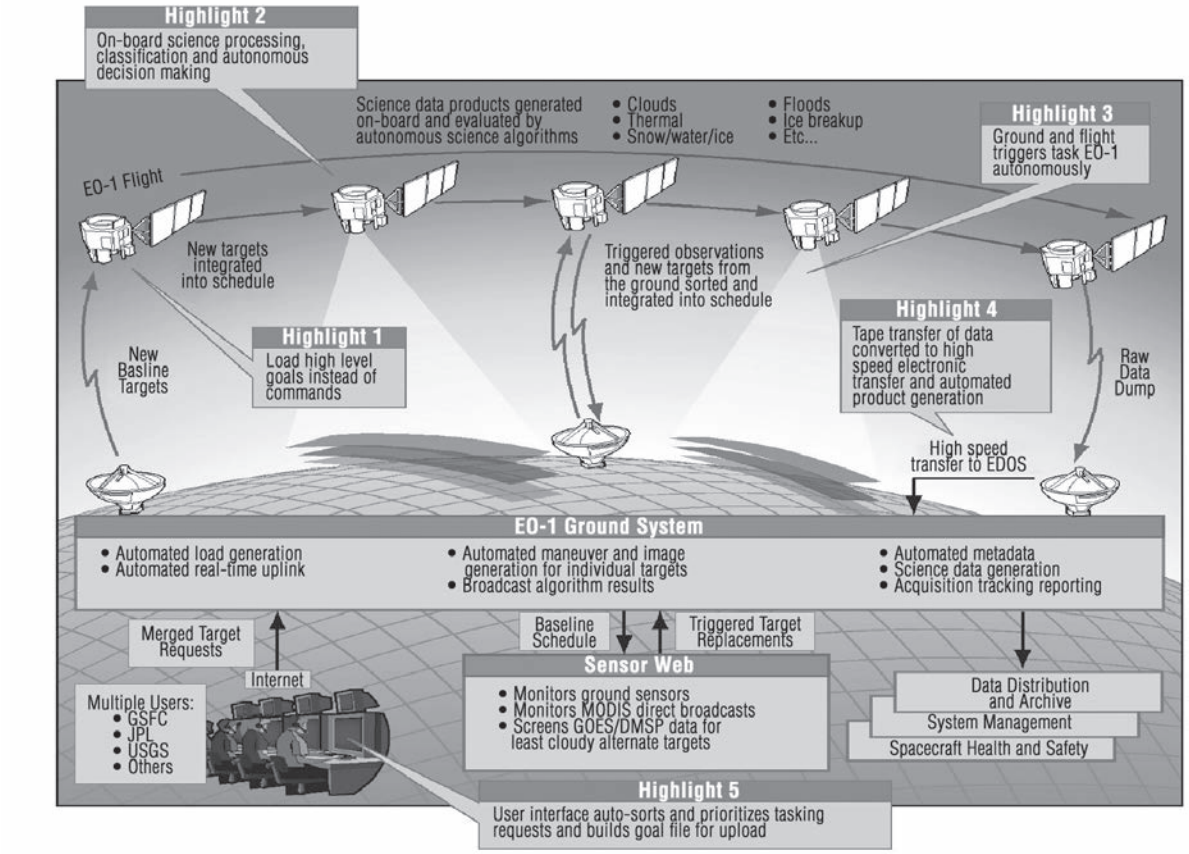


Figure 2: Overview of autonomy and automation software installed on EO-1 to date.

to reduce the cost of operations by over 50%. **Figure 2** shows a summary of the software installed on EO-1 for this experiment.

Sensor Web Definition

A *sensor web* is a coherent collection of space-based and/or ground-based sensors and computation nodes linked by a communication fabric that collectively act as a single, dynamically adaptive, observing system. An example sensor web might be one satellite observing a target event and triggering another satellite autonomously. Another example might be a ground instrument triggering a satellite image. A more unusual twist might be a modeling software package requiring a key observation in real-time to make a prediction and thus autonomously triggering a desired satellite image.

EO-1 Background

The EO-1 mission was originally designed to be a one-year mission to validate revolutionary space technologies. It hosts three land remote sensing instruments: the Advanced Land Imager (ALI), a multispectral imager, and Hyperion and an Atmospheric Corrector, both hyperspectral imagers. Furthermore, it hosted eight new spacecraft technologies. **Figure 3** depicts the EO-1 satellite.

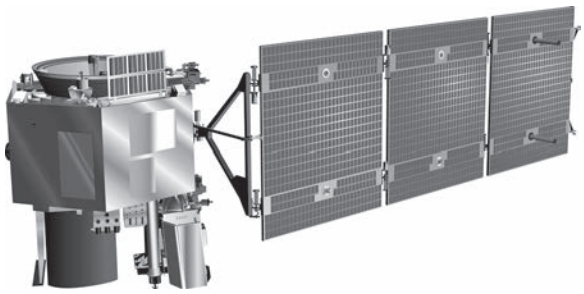
Key Features of EO-1 Autonomy and Automation:

The highlights are as follows:

- tasking of the EO-1 satellite with high-level goals instead of specific commands;
- onboard science processing, classification, and autonomous decision-making;
- ability to accept autonomous triggers from both space- and ground-based assets; and
- automated user interface to sort, prioritize, and build tasking files for EO-1

The Jet Propulsion Laboratory (JPL) led the autonomy software development in collaboration with Goddard and it was called the Autonomous Science Experi-

Figure 3: The EO-1 Satellite



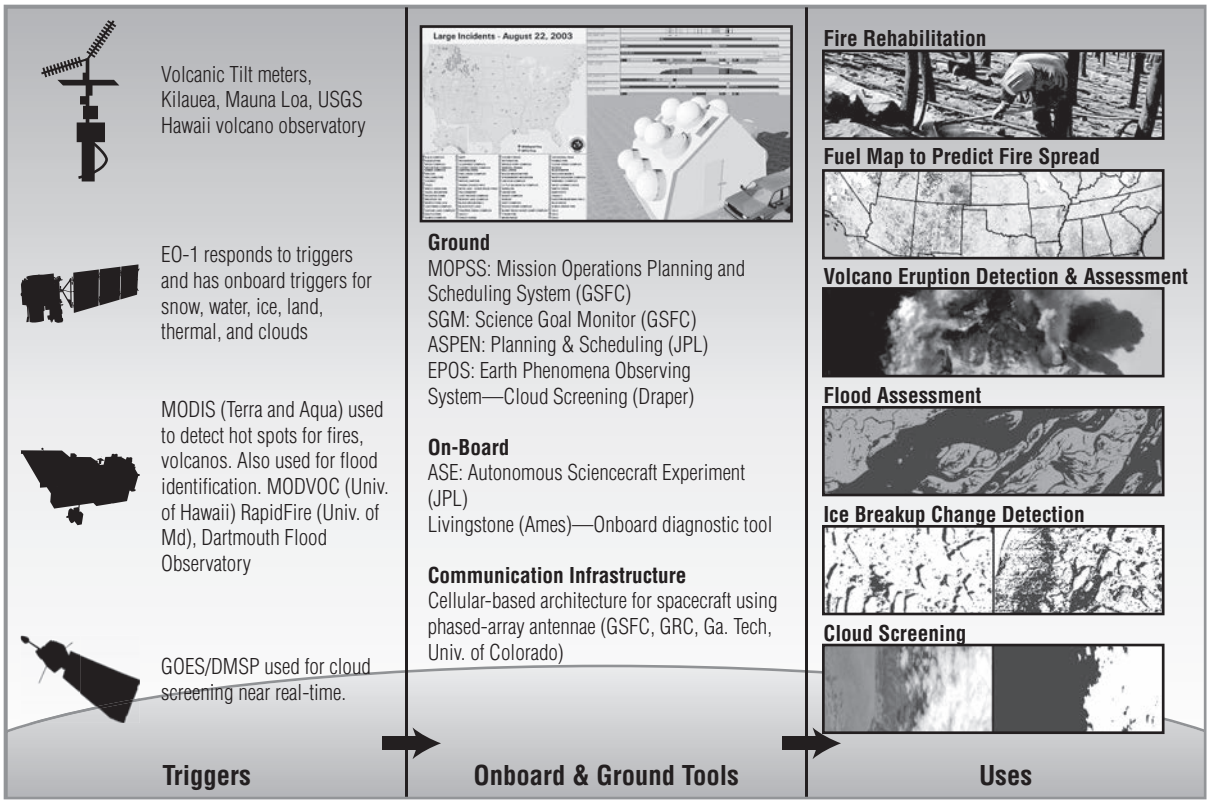


Figure 4: Overview of various EO-1 sensor web experiments conducted.

ment (ASE). ASE is composed of three components, Continuous Activity Scheduling and Planning, Execution and Replanning (CASPER), which is an onboard planner and scheduler, Spacecraft Command Language (SCL), which acts as a middleware execution engine and finally the science processing software to perform Level 0, Level 1 and additional science classification and processing. There is also a complementary ground piece of software called Automated Scheduling and Planning Environment (ASPEN), which works collaboratively with CASPER to process triggers and imaging requests for use by CASPER. In particular, triggers and requests are automatically sorted and prioritized and then converted into a list of high-level goals that can be worked on by CASPER. Prior to the development of ASPEN, we used Science Goal Monitor (SGM) which was software developed at Goddard, to act as a pathfinder for this functionality. The ASE software won the NASA 2005 Software of the Year Award.

Experiments with EO-1

A variety of experiments were conducted with EO-1 using the autonomy and automation that was integrated. **Figure 4** depicts the variety of scenarios that were exercised. Note that a variety of triggers were received from the Terra and Aqua spacecraft to detect thermal activity, such as volcanoes and wildfires, and subsequently triggers were sent to the Geostationary Operational Environmental Satellite (GOES) and the Defense Meteorological Satellite Program (DMSP) to detect clouds and perform cloud screening. A tiltmeter in Kilueha, Hawaii which triggers an EO-1 image whenever the ground moves as a result of a volcano. The experiments with Terra and Aqua involved using the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument to detect hot spots and have EO-1 automatically take a high-resolution image of the area. Meanwhile we were able to use other satellite data to perform real-time cloud screening to allow EO-1 to autonomously choose the least cloudy of conflicting image choices that were available. Thus we were able to demonstrate increased efficiency for utilization of EO-1 by demonstrating reduction of lag time from event detection to imaging and reduction of cloud-obscured imagery.

Other experiments included setting up a demonstration communication link to EO-1 via experimental software radio antennas, the future target being the transformation of ground antennas to act more like wireless routers for satellites with no moving parts. Also, during the Fall of 2005, we collaborated with a University of Maryland at Baltimore County (UMBC) sensor network class in which the students built projects which linked a sensor network, a mini-rover, and EO-1 (**Figure 5**). Demonstrations were held at UMBC and at Goddard and were attended by UMBC faculty, Goddard personnel and a *Baltimore Sun* reporter. In one of the class experiments, one of six ground sensor *motes*

Figure 6: Mini-rover in action during one of the demonstrations (insets). UMBC Sensor Network class taught by Dr. Younis (main picture).

was turned off to simulate failure, which then autonomously directed the mini-rover to find the broken mote and then to take a picture of the area. Furthermore, a message was sent to a website that autonomously tasked EO-1 to image the UMBC campus. **Figure 6** depicts experiment day in an atrium at UMBC.

Future Efforts

The sensor web experiments conducted thus far with EO-1 have acted as a springboard to more-complex future experiments. In particular, we will address interoperability issues by making use of emerging standards. In particular, we will be using Goddard Mission Services Evolution Center (GMSEC) 6, Core Flight Executive (CFS)6 and Sensor Modeling Language (SensorML). GMSEC together with CFS, both efforts managed at GSFC, to provide a ground and flight message bus. SensorML is a widely accepted interoperability standard for sensors sponsored by the Open Geospatial Consortium (OGC). We have begun to use the Cosmic Hot Interstellar Plasma Spectrometer (CHIPS) satellite together with these standards in similar experiments to extend the sensor web experiments. CHIPS features a ground-to-space Internet Protocol (IP) interface along with a more-advanced onboard CPU, and thus is better suited to perform these type of experiments. Thus we will be able to more closely replicate the vision outlined in **Figure 1**.

References

1. "UMBC students will do work of NASA Engineers Today" in *Baltimore Sun* Dec 15, 2005

2. "NASA's Earth Observing-1 To Play Key Role in Sensor Web Demo" May 15, 2003, in *Space News: www.space.com/spacenews/archive03/demo-arch_051503.html*

3. Information on ASE, CASPER and ASPEN: *ase.jpl.nasa.gov*

4. 45 papers and 41 more articles on EO-1 sensor web work at: *eo1.gsfc.nasa.gov/new/general/resources/papers.html*

5. Information on EO-1 in general: *eo1.gsfc.nasa.gov*

6. Information on GMSEC and CFS: *gmsec.gsfc.nasa.gov*

Students Examining the Mysteries of the Red Planet with the JASON Project and NASA

Jennifer Walsh, jennifer@tricomassociates.com, The JASON Project

Middle-grade students across the country this year are learning Life, Space, Earth, and Physical Sciences by comparing the planetary environments of Earth and Mars through The JASON Project's Mysteries of Earth and Mars standards-based, multimedia curriculum. Working with NASA scientists and the latest Mars rover research, JASON students are investigating Mars analogs: locations on Earth where environmental conditions, geologic features, or biologic attributes resemble in some way those thought to exist on Mars, now or at some point in the past. In addition, JASON students are examining how engineers designed and built the Mars' rovers, *Spirit* and *Opportunity*, to explore the Red Planet.

Geared to help educators meet today's educational challenges, *JASON Expedition: Mysteries of Earth and Mars* brings cutting-edge NASA research scientists and engineers into classrooms through interactive computer-based simulations, video-on-demand, inquiry-based experiments and activities, expedition broadcasts, and print materials for students and teachers.

A NASA Science Education Product Review "overwhelmingly-rated Mysteries of Earth and Mars outstanding, with several reviewers noting that it is one of the best NASA education products that they have ever reviewed, and one reviewer noting it as the 'best product I have seen in 15 years of teaching.' "

A nonprofit subsidiary of the National Geographic Society, The JASON Project provides multimedia science curriculum and professional development to one million middle-grade students and 20,000 teachers in 41 states and around the world. Its mission is to improve the way science is taught by allowing students to learn directly from leading scientists and engineers.

Named for the mythological Greek adventurer, JASON was founded in 1989 by Robert Ballard, best known for his discovery of the *RMS Titanic shipwreck*. Its use of telepresence technology to connect students with real scientists is unique in education. JASON is widely recognized for its power to teach difficult concepts and to excite and engage students of diverse learning styles.

"The JASON Project is thrilled to partner with NASA to bring groundbreaking research and distinguished scientists directly into classrooms nationwide," said **Caleb M. Schutz**, president of The JASON Project. "We harness the excitement of exploration and discovery to excite students about learning science and have them think like scientists. Through generous support, we can equip students with the skills they'll need for the 21st Century marketplace and inspire the next generation of scientists and explorers."

The *JASON Expedition: Mysteries of Earth and Mars* curriculum aligns to textbooks and engages students of different levels of learning. Independent evaluations confirm that JASON's multimedia science curriculum positively influences their perceptions of scientists and helps them grasp a deeper understanding of complex science concepts.

The JASON Project works collaboratively with institutions. Such institutions are: NASA, National Park Service, National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Education, National Geographic Society, EDS, Jet Propulsion Laboratory, Arizona State University, the University of Hawaii, George Washington University and numerous educational institutions around the world that provide access to leading scientists, ground-breaking research, and top-notch technology and tools.

The *JASON Expedition: Mysteries of Earth and Mars* provides teachers with a standards-based, multimedia program that transforms classrooms into research-rich environments. Each curriculum contains:

- Student Activity Book
- Teacher's Edition
- Introductory video
- Hands-on activities that utilize technology
- Access to JASON's online community, which includes: live chats with scientists, game-like simulations, assessment tools, and links to additional resources
- Expedition broadcast and Webcast with researchers
- Opportunity for face-to-face or online professional-development curriculum training

As a highlight to the year's curriculum, JASON hosted expedition broadcasts and webcasts January 30 through February 4, 2006, where students across the country interacted with the scientists featured in the Mysteries of Earth and Mars curriculum. The scientists and their expedition teams of students and teachers explored Hawaii Volcanoes National Park, NASA Jet Propulsion Laboratory, Meteor Crater in Arizona, and Mono Lake in California. To learn more about this JASON expedition, visit *www.jason.org*. In addition to providing award-winning curricula, The

JASON Project offers professional development in the form of online courses, face-to-face workshops, and an annual National Educators' Conference. To learn how to best implement the JASON Expedition curriculum and technologies in the classroom, teachers can participate in community training or online courses. The workshops introduce teachers to hands-on, practical and inexpensive classroom activities that mirror the work of researchers in the field. Continuing education units are also available.

For teachers who want to receive anytime, anywhere professional development, The JASON Project has five-week online, standards-based graduate-level courses. Presented by science professors around the country, the courses increase teachers' content and pedagogical knowledge. Teachers can choose from over 20 courses that cover Physical Science, Life Science, Earth Science, and Pedagogy. Additional professional development components include ongoing mentoring sessions delivered via Web conferencing.

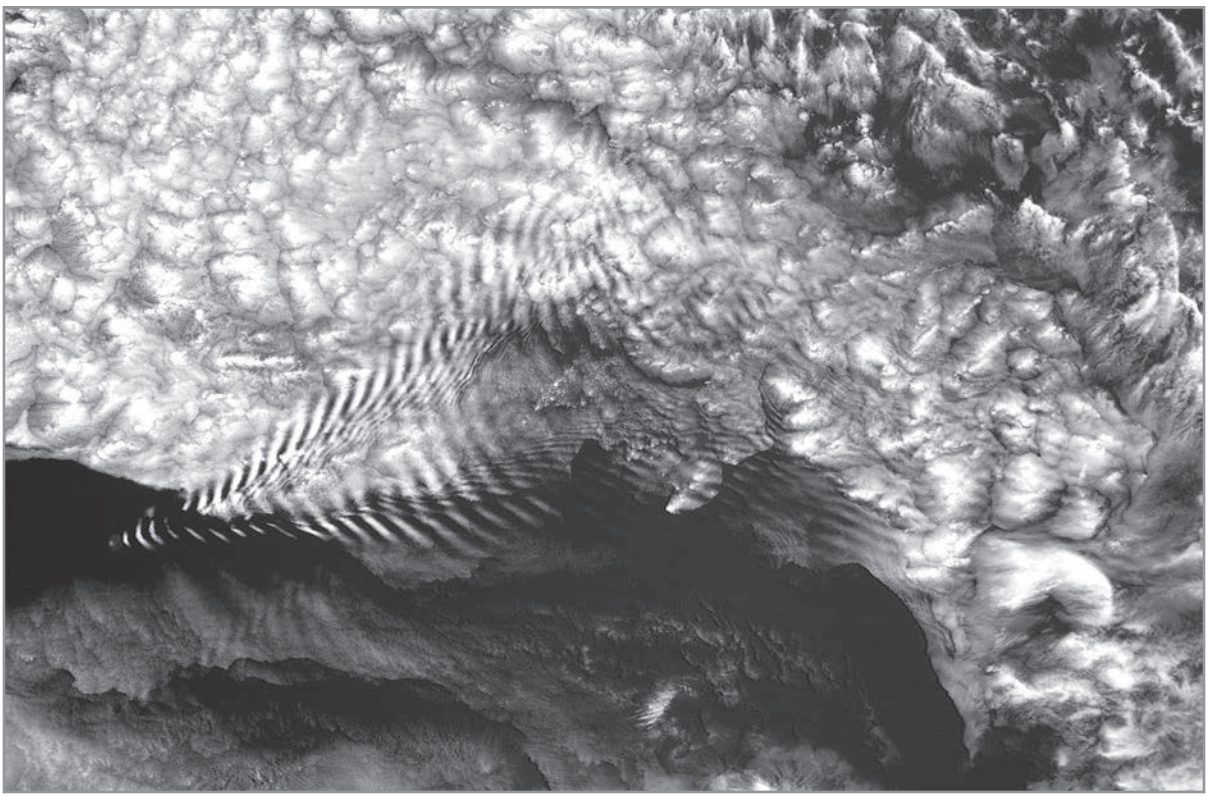
Long associated with innovative *early adopters*, JASON is redesigning its curriculum and delivery systems to better serve mainstream classrooms. Beginning in 2006, JASON will offer multiple expeditionary curricula every year, with more telepresence and more interactivity. All content will be immediately recognizable as standards-based to ensure its widespread use.

Other new features:

- Affordable annual subscriptions for all classroom materials, including *evergreen* segments from previous expeditions.
- A prototype search engine and digital archive giving students and teachers easy, intuitive access to the educational resources of JASON and its key partners.
- A measurement and assessment system, fully integrated within the gated online community to permit JASON—and our partners and customers—to measure, track, survey, and assess students and teacher offerings.
- Local Student Argonaut clubs that provide thousands of middle-grade students the opportunity to connect with researchers and engage directly in scientific field work.

To learn more about The JASON Project's standards-based science curricula and professional development, visit *www.jason.org* or call 1-888-527-6600. ■

In mid-December 2005, the diminutive Amsterdam Island made waves—not in the Indian Ocean where it resides, but in the clouds overhead. Described casually as wave clouds, these features took on the shape of a giant ship before blending in with a larger cloud formation to the north and east. The Moderate Resolution Imaging Spectroradiometer (MODIS) flying onboard the Terra satellite captured this image on December 19, 2005. The island itself is almost too small to see in this image, but it serves as the starting point for the clouds that flow toward the northeast in a giant V shape. NASA image courtesy Jeff Schmaltz, MODIS Land Rapid Response Team at NASA GSFC.



AIRS Science Team Meeting

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In his opening remarks **Mous Chahine** [Jet Propulsion Laboratory (JPL)—Atmospheric Infrared Sounder (AIRS) Facility Team Leader] expressed his pleasure with the progress that has been made since the launch of AIRS in May 2002, particularly the August 24, 2005 NASA-NOAA Press Release on the positive forecast impact achieved from the assimilation of AIRS data.

Jack Kaye [NASA Headquarters] quoted Mary Cleave, who succeeded Ghassem Asrar as associate administrator for NASA's Science Mission Directorate, "The forecast improvement accomplishment alone makes the AIRS project well worth the American taxpayers' investment." NASA is assisting the world's weather prediction agencies by providing very detailed, accurate observations of key atmospheric variables that interact to shape our weather and climate. Currently AIRS is funded through the end of FY2006. There is the option for a fourth year extension. All other funding for FY2007 will have to be competed through Research Opportunities in Space and Earth Sciences (ROSES). In 2006, six years after launch, there will be a senior review of the Aqua program.

Claire Parkinson [Goddard Space Flight Center (GSFC)—Aqua Project Scientist] complimented the AIRS Team on the progress and showed results from the other instruments on the Aqua spacecraft: the Moderate Resolution Imaging Spectroradiometer (MODIS), Clouds and the Earth's Radiant Energy System (CERES), and the Advanced Microwave Scanning Radiometer for EOS (AMSR-E). The major emphasis is validation of the data for climate applications and increased inter-instrument data utilization. The Aqua spacecraft is in excellent shape. The only consumable is the propulsion gas, which is used for the orbit maintenance and ultimately for the de-orbit maneuver. At the current rate of consumption there is more than enough fuel to last for seven years.

George Aumann [JPL—AIRS Project Scientist] made a presentation of lessons learned and provided an overview of products being produced by AIRS and research products currently under development. Five teams within the science team (called *focus teams*) focus on specific issues where further development and algorithm refinements are desired for the next delivery of the Product Generation Executive (PGE) to the NASA/Goddard Space Flight Center (GSFC) Distributed Active Archive (DAAC). The major part of the team meeting deals with reports from the focus teams.

Steve Friedman [JPL—Acting AIRS Project Manager] provided more details on the status of AIRS and the Advanced Microwave Sounding Unit (AMSU). The AIRS PGE version 4.0 is currently running at the DAAC. The next upgrade is Version 5.0 (v5.0). Friedman discussed the v5.0 Schedule and the key roles and responsibilities for the v5.0 focus teams.

The following summary is divided into the reports from the five Focus Teams, reports from the data assimilation teams and, finally, reports on potential new capabilities from AIRS.

Focus Team Reports

Focus Team 1: AIRS/AMSU Bias and RTA (L. Strow, Moderator)

The purpose of this Team is to provide data and develop appropriate software for v5.0 to either eliminate bias tuning (as used in v4.0) or to minimize the need for it, and to bias tune the microwave relative to the infrared (IR). Five members of the AIRS/ASMU Bias and Radiative Transfer Algorithm (RTA) Focus Team gave presentations.

Bias as used in the context of sounding refers to the fact that the observed spectrum cannot be fully reconciled with the spectrum calculated for those conditions where the true state of the atmosphere is known, referred to in shorthand as *obs-calc*. This bias has to be eliminated to produce accurate retrievals. The IR and microwave bias used in v4.0 is based on Susskind's *obs-calc* for nighttime clear moderate and tropical ocean assuming that the European Center for Medium-range Weather Forecasting (ECMWF) state of the atmosphere is correct. IR water channels and surface channels are never tuned. The microwave bias includes a scan-angle dependence. The ECMWF temperature profiles in the troposphere have been shown to be statistically very good, but there is a significant bias for stratospheric temperature profiles.

Joel Susskind [NASA/GSFC] showed the results of a number of experiments using tuning and showed that the AIRS retrieval system is becoming less sensitive to bias tuning, which is the goal. Susskind's work indicates that we are approaching a system that does not need empirical bias tuning from ECMWF.

Eric Maddy [NOAA/NESDIS] presented the results of *obs-calc* for the AIRS validation RS-90 sondes and the NOAA operational daily radiosonde product. Maddy's results build on work done by L. Strow; Maddy improved upon Strow's work by using AIRS data to determine the upper atmospheric profiles instead of relying

on sonde data, which is notoriously inaccurate at higher altitudes. Maddy found some significant discrepancies between the retrieved stratospheric temperatures using the 4.2- versus the 15-µm carbon dioxide (CO_2) channels, which needs to be resolved for v5.0.

The main reason why the bias in *obs-calc* is changing in the IR channels is because the radiative transfer algorithm (RTA) is using 370 parts-per-million by volume (ppmv), which may have been reasonable in 2002, but the shift in some of the CO_2 sensitive channels results in a bias shift of as much as 100-mK per year.

Larabee Strow [University of Maryland Baltimore County (UMBC)] discussed his retrievals of variable atmospheric CO_2 (ocean only) derived from radiances biases relative to ECMWF. Monthly and zonally averaged CO_2 retrievals compared well with the NOAA/Climate Monitoring and Diagnostics Laboratory (CMDL) model, although the higher latitudes exhibited a phase lag relative to CMDL, probably because AIRS is sensitive to mid-tropospheric CO_2 while the CMDL model is for the marine boundary layer. The seasonal modulation over the ocean is about 5 ppmv. Annual increases in CO_2 of ~1.5 ppm/year were also observed. Discussion ensued as to whether the AIRS v5.0 software should use a CO_2 model that only varied with time, or one that varies both in time and with latitude. Strow indicated that the relative accuracy of his results for ±50° latitude is ~1-2 ppm.

The RTA used in v4.0 produces a large bias during daytime in the upper tropospheric 4.3-µm CO_2 channels due to non-local thermodynamic equilibrium (non-LTE).

Sergio De Souza-Machado [UMBC] showed progress in developing an AIRS RTA with non-LTE effects included so the 4.3-µm CO_2 band can be used during daytime in the upper-troposphere and stratosphere. The new model was tested on two different days of AIRS data, and gives bias standard deviations relative to ECMWF that are essentially identical for day and night, down to 2300 cm^{-1}. From 2300 cm^{-1} to 2230 cm^{-1} not enough CO_2 bands are included in the calculations yet to fully simulate non-LTE behavior. Mean biases for daytime non-LTE channels are similar to those for nighttime data down to about 2350 cm^{-1}. This model has been implemented in the AIRS fast RTA (Stand Alone RTA [SARTA]), and Barnet (NOAA/NESDIS) plans to test the non-LTE RTA in retrievals in the future, although it is not certain there will be time for this to be put into v5.0.

The proper handling of the bias observed in the microwave channels is essential for obtaining optimum cloud clearing. The microwave bias correction used in v4.0 is a simple additive, scan-angle-dependent value added to each channel, based on Susskind's *obs-calc* for nighttime clear moderate and tropical ocean, assuming that the ECMWF state of the atmosphere is correct.The ECMWF temperature profiles in the troposphere have been shown to be statistically very good, but there is a significant bias for stratospheric temperature. If the IR channels are not tuned, then the microwave channels must be empirically aligned (tuned) to the IR. There also are indications that the microwave bias is land/ocean/day/night/latitude dependent.

Phil Rosenkranz [Massachusetts Institute of Technology (MIT)] briefly outlined his plan for AMSU tuning, which will be based on AIRS-only retrievals of temperature and moisture for clear fields of view (FOVS).

Focus Team 2: Emissivity IR and Microwave (C. Barnet, Moderator)

The task of this Team is to recommend solutions and provide software for the v5.0 PGE to improve the way emissivity is handled. Accurate representation of emissivity is key to getting accurate retrievals, particularly if the emissivity differs significantly from unity, as in the case of the IR over land, and the microwave over ocean and land. Failure to account for a 1% change in emissivity shifts the IR surface-channel brightness temperatures by 0.5 K. Over land there are conditions where the emissivity is as low at 0.8, corresponding to a 10 K decrease in the brightness temperature. An error in the emissivity produces errors in the cloud-cleared radiances, which result in errors in the retrievals.

Joel Susskind, NASA/GSFC, showed that the NOAA surface regression discussed in the May 2005 science team meeting has minor impact on the core products, i.e., achieving 1K/1 km accuracy retrievals over ocean. There was a slight improvement on the moisture profiles over land. However, the derivation of incorrect emissivities has a significant impact on the interpretation of the cloud products and retrievals of minor gases.

Phil Rosenkranz [MIT] discussed the changes made to microwave surface retrieval over land and ocean in v4.0. A possible direction for future research is to include an update to the microwave surface and liquid water parameters in the final algorithm state (after AIRS channels are used to derive water). This algorithm package has been delivered for consideration. Additional ideas are to evaluate more-physically adapted adjustment functions and to combine specular and diffuse components, e.g., unified model for all surface types.

Nick Nalli [NOAA/NESDIS] presented his work on an improved ocean emissivity model, currently being validated with the Marine Atmospheric Emitted Radiance Interferometer (M-AERI). The emissivity of the ocean is scan-angle and wind-speed dependent. Al-

though it is typically 0.99, it can drop as low as 0.96. Nalli expects that the Wu/Masuda model, currently employed by the AIRS PGE, may have measurable biases at the edge of scan (Wu/Masuda under-estimates surface-leaving radiances). He has an improved model based on deriving an average facet angle instead of the traditional method that computes an average reflectance. The new method improves comparisons to M-AERI observations at 55° viewing angle by 0.15%-0.3%. At nadir the traditional and Nalli models agree.

The AIRS v4.0 PGE includes a module which solves for the surface emissivity using a statistical regression.

Lihang Zhou [NOAA/NESDIS] showed some new work with the NOAA emissivity regression. A desert emissivity type was added as an additional class (currently non-frozen land, ice/snow, and ocean) and regressions are trained on the University of California Santa Barbara (UCSB) MODIS emissivity library. This improves the regression emissivity over bare-soil and desert regions, especially in the 980 cm^{-1} region.

Chris Barnet [NOAA/NESDIS] discussed a number of upgrades that are desired and attempted to summarize what could/should be tackled for v5.0. The list at this time is:

- Continue exploring new surface classifications for the regression and, if these perform better, recommend for installation to v5.0.
- Explore the use of more channels in the surface regression.
- Explore the use of shortwave channels in the surface regression.
- Explore the use of on/off line channels in the physical algorithm.
- Fix the emissivity limit test so that the physical retrieval does not remove spectral structure derived from the regression.
- Explore using <= 5 functions, possibly a dynamic set of functions to allow fewer functions when the atmosphere transmittance is low, e.g., when total precipitable water (TPW) is large.
- Evaluate the impact of specular thermal reflectance versus Lambertian reflectance (PGE currently assumes Lambertian).
- Evaluate ocean biases with respect to wind speed to see if we may need improvements to the ocean wind estimate (PGE currently uses a fixed 5 m/s).

Participants also discussed the idea of using a land-emissivity database to improve the AIRS initial cloud-clearing and cloud-product retrievals. The current first guess over land is fixed at 0.96 for the longwave (LW) and 0.94 for the shortwave (SW) channels. Obviously, this could be improved; however, previous experiments to improve the start-up infrared emissivity had little impact. John Blaisdell recommended that we demonstrate the impact of an improved emissivity first guess before making a large investment in installing an emissivity climatology.

At a previous AIRS science team meeting, Bob Knuteson suggested using a database built by Suzanne Seeman and Eva Borbas at the University of Wisconsin (UW), and delivered to the Joint Center for Data Assimilation (John LeMarshal) in the assimilation of AIRS radiances. This database is derived from the Aqua MODIS *MOD11* products and laboratory spectra on a 0.05° grid (3600x7200 spatial points) and a software package unfolds the low spectral-resolution functions (8 inflection points) onto the entire AIRS frequency set. The database has 12 files, each file is 1.6 GB. An operational algorithm for AIRS will require averaging onto the AIRS spatial footprint; however, code is provided to provide this product on grids with lower spatial resolution.

Another idea is to use the NOAA gridded re-processing product to derive AIRS products on a coarse grid (3° x 3°). The advantage of this product is higher spectral resolution and emissivities that are typical for a 50-km footprint. The low spatial resolution nature of the product is an artifact of using the re-processing grids for quick turnaround. This product could be available quickly and could be used to assess the impact of improving the emissivity first guess in time for ingestion of this database in v5.0. If this product does improve the initial cloud clearing then it might be possible to use the same methodology with a higher spatial resolution dataset for AIRS or for ingesting the Seeman/Borbas model.

Some have suggested, e.g., Evan Fishbein, Simon Hook, Lihang Zhou, that using surface parameters (such as the normalized difference vegetation index [NDVI] and/or the MODIS surface classification) to select a spectral emissivity curve from a library might be useful. However, at this time little effort has been spent on this idea. Also, the idea of using AIRS NDVI in the algorithm met with some criticism, because the NDVI has meaning only for strictly cloud-free spectra (obviously) during the day. For the typically cloudy AIRS footprints it has no meaning.

Finally, NOAA/NESDIS is exploring the use of MODIS radiances from clear parts of the AIRS pixel, spatially convolved to the AIRS footprint, as a way to derive emissivity products directly from the footprint. This avoids having to use static emissivity climatologies (the so-called *representation issue*) or products derived from other instruments (the so-called *latency issue*).

Focus Team 3: AIRS Retrievals Without AMSU (S. Y. Lee, Moderator)

The current v4.0 PGE uses the combination of AMSU and AIRS data to generate cloud-cleared radiances and temperature and moisture profiles. The desire to generate high-quality retrievals from AIRS data alone, without AMSU, is motivated by three considerations:

1) The nominal lifetime of AMSU is three years, while the AIRS nominal lifetime is seven years. The PGE has to be able to function in the absence of AMSU data.
2) There are indications that the use of the AMSU temperature profiles over land, where the microwave emissivity is highly uncertain, produces spurious results in the cloud-clearing step. The AMSU *microwave only* temperature profile is used to calculate the clear-column radiance needed for cloud-clearing. The object of the *AIRS only* focus team is to replace the *microwave only* retrieval.
3) The use of *AIRS only* Level 2 products should make the Level 2 products more acceptable to the Numerical Weather Center (NWC), who are already assimilating the Aqua AMSU radiances.

Sung-Yung Lee made a presentation on the status of the *AIRS Only* Retrieval Team. The simplest approach, doing retrieval in truly cloud-free areas only (referred to as *hole hunting*) is not acceptable because of the extremely low (1%) yield. The second simplest approach, using the National Centers for Environmental Prediction (NCEP) temperature profile, was rejected because it prevents the retrievals from being used to improve the forecast in near real time. The PGE version 4.1.7 is the first version that can do *AIRS only* retrieval. It has the option of applying the cloudy regression algorithm from NOAA/NESDIS and using the regression as first guess to the initial cloud clearing. Then it proceeds with the rest of the team algorithm without using any microwave data. First results shown by Chris Barnet at the May 2005 AIRS team meeting show that the cloudy regression produces a better temperature profile than the microwave, but with only about half the yield. The initial analyses of Level 2 and Level 3 data products also indicate several outlier issues, especially for the cloud and outgoing longwave radiation (OLR) products. Algorithm and QC updates will be necessary for v5.0 delivery.

A Stochastic Cloud Clearing (SCC) algorithm from Cho and Staelin of MIT, can be trained to work with and without AMSU. The software, written in *Matlab*, was tested on ocean granule 50 from September 6, 2002. Steve Licata [JPL] has ported the software to the Team Leader Science Computing Facility (TLSCF) computer and tested other granules. The software is currently limited to ±70° latitude ocean and land (less than 500-m elevation). Only 314 temperature sounding channels (all with weighting function more than 15 K, corresponding to the heights of 8000 ft above the surface and no water channels) are currently implemented. The SCC radiances were compared to initial cloud cleared (ICC) radiances. The QC of SCC seems to have better skill, although SCC rejects many more than ICC does. The approach has potential, but appears to need much more work to be considered for v5.0 delivery, since the hardest work (identification and elimination of clouds below 8000 ft) has not been demonstrated.

The current plan calls for focusing on the cloudy regression for the v5.0 delivery.

1) Possible cloudy regression coefficient update to improve angle dependency and hot surface anomaly.
2) Algorithm and QC update.

Both items should be finished before the end of the calendar year. However, it may take until January or February 2006 to update coefficients and make minor upgrades to the code.

Focus Team 4: Error Estimation (J. Susskind, Moderator)

The assignment of accurate uncertainty estimates to every AIRS Level 2 product is key to the optimal utilization of the AIRS data. The v4.0 PGE uses unrealistically small uncertainties, but assigns to each retrieval a number of coarsely quantized quality flags. The task of the Error Estimation Focus Team is to provide improved algorithms for the v5.0 PGE.

Joel Susskind [NASA/GSFC] presented the approach to error estimation and quality control, the current status, and plans for v5.0. Some results were shown for ocean-surface skin temperature, temperature profile, clear-column radiances, and water-vapor profile. The new methodology for generating case-by-case, and layer-by-layer, error estimates was shown to work well for both sea-surface temperatures and temperature profile. Sea-surface temperature quality control based solely on the error estimate was shown to produce both a higher yield of accepted cases and a better accuracy than the previous *ad hoc* quality-control methodology used in v4.0. In addition, use of these error estimates as the sole means of generating layer-by-layer quality control for temperature profile was shown to work reasonably well with regard to temperature-profile accuracy. Continued improvements to the methodology used to generate temperature-profile-error estimates and quality control have led to higher yield and comparable temperature-profile accuracy to what was done previously using the v4.0 *ad hoc* quality-control methodology. Susskind subsequently also developed and tested a methodology for using the layer-by-layer temperature profile error estimates to generate Level 3 products.

Some modifications will have to be made to the final product-retrieval portion of the PGE to accommodate the new methodology. Susskind anticipates that there will be no change to the number or meaning of the error estimates or quality flags. Currently, the quality flags are set subsequent to the completion of the actual physical-retrieval process, based on use of a number of internal convergence parameters. In the new methodology, we use similar parameters to generate the error estimates and quality-control flags by a more-sophisticated algorithm. As before, this is done after the completion of the physical-retrieval process. The error estimates are computed in a matrix multiplication step using the product of coefficients and the convergence parameters. The need for, and existence of, these coefficient tables is new and must be accommodated. Details of the size and number of such matrices must be worked out. There will be roughly four 101x15 matrices that accommodate sea-surface temperature and temperature profile—fifteen coefficients for each quantity. Separate matrices are generated for non-frozen ocean and *land* cases—*land* is defined as anything that is not non-frozen ocean. In addition, we may use first- and second-pass coefficients as described at the AIRS Science Team meeting.

Empirical error estimates will also be generated on a case-by-case basis, using analogous methodology, for each clear-column radiance. Preliminary results were shown at the AIRS Team meeting for two mid-lower tropospheric temperature-sounding channels over ocean, and indicated very good skill. The methodology to generate empirical error estimates requires knowledge of *truth*. Complications exist for channels sensitive to the surface over land, and sensitive to water vapor or ozone absorption over all surfaces. Susskind is currently developing a methodology to determine reasonable case-by-case error estimates for those channels. The infrastructure will be similar to that for temperature-profile and sea-surface temperature. He anticipates the need for two 2386x15 matrices to generate clear-column-radiance-error estimates. Details of the generation of empirical case-by-case, layer-by-layer, water-vapor-column-density percentage-error estimates are being worked out. Two possible approaches were discussed at the AIRS Team meeting. One approach is completely analogous to what was done for temperature profile. This would require four 100x15 matrices. A second, promising approach, gives the water-vapor-column-density percent-error estimate in a given layer (of the 100) as a simple function of the temperature-profile error estimate for that layer. This would require a smaller matrix (perhaps 100x2) and be more stable if it is adequate. He has shown that using the temperature error estimate works as excellent quality control for water vapor, and also performs well with regard to the generation of water vapor Level 3 products. He is also starting to test the feasibility of an analogous methodology for quality control and error estimates for Carbon Monoxide (CO) and Methane (CH_4) profiles.

Focus Team 5: Minor Constituents (W. McMillan, Moderator)

The primary objective of AIRS was to obtain radiosonde quality temperature and moisture retrievals. It is by now apparent that the AIRS spectra contain useful information about many minor atmospheric constituents and aerosols. The task of this Minor Constituents Focus Team is the development of software for the retrieval of these constituents, including error estimation, and the validation of the results before the software is used for routine production at the DAAC.

Wallace McMillan [UMBC—Focus Group Leader] presented a status update on the work of the AIRS Minor Constituent Focus Group and then an update on the CO retrieval algorithm. After the summary, a series of presentations followed, including **Eric Maddy** on Verticality Issues; **Chris Barnet** on CH_4, Ozone (O_3), and Nitric Acid (HNO_3) retrievals and RTA changes; **Sung-Yung Lee** on the new Sulfur Dioxide (SO_2) flag; and **Sergio DeSouza Machado** on the new dust score.

Table 1 summarizes the status of AIRS minor constituents and presents the projected delivery time for inclusion in v5.0 PGEs.

Major outstanding issues to be resolved by February 2006:

- Resolving retrieval verticality issues (not just for trace gases, but temperature and H_2O).
- Deciding on output formats for standard and supplemental products.
- Is HNO_3 required for best CH_4 retrievals?
- Building and assessing new O_3 regression.

Focus Team 6: Infrared and Microwave Level 1b (S. Gaiser, Moderator)

The charter of the Calibration Focus Team is to refine the existing Infrared and Microwave Level 1b software for the v5.0 PGE.

AIRS-IR

Steve Gaiser [JPL] provided the IR calibration overview. The expected changes for v5.0 do not affect the radiances. Gaiser's presentation dealt with the Channel Properties Files, results from Strow/Hannon for the statistical trending of the SRF positions and the potential utility of the Parylene spectra for spectral calibration updates. Names and dates in brackets are action items.

Constituent	Status	Delivery time
SO_2 flag	Ready to implement	Now: v5.0 L1b
Dust score	Version 1 ready, final version being optimized	12/05: v5.0 L1b
O_3	The current column-O_3 retrieval is good, but the profile is too low in the stratosphere and too high in the troposphere. Bill Irion will provide Chris Barnet a new training set for an improved regression. Bill Irion will assess revised regression with v4.5/4.6 algorithm (model error term removed) for improvements to upper tropospheric O_3. Barnet and Jennifer Wei will work with upcoming NCAR experiment for *in-situ* validation of AIRS upper trop O_3.	2/06: v5.0 L2
CO	Preliminary validation with INTEX-A data looks good even for v4.2 algorithm. Will be reoptimized with v4.5/4.6 algorithm (model error term removed) considering different damping, trapezoidal functions, and first-guess profiles. Verticality and output formats remain as unresolved issues. McMillan's group will participate in INTEX-B experiment for *in situ* validation of AIRS CO, CH_4, CO_2, and O_3.	2/06: v5.0 L2
CH_4	Chris Barnet is implementing the latest RTA upgrades from L. Strow which include HNO_3 to assess whether HNO_3 must be included in covariances for CH4 retrievals. Reoptimization of CH_4 retrievals continues with v4.5/4.6 algorithms (model error term removed). Assessing CH_4 retrievals from NOAA grids vs. models with new webpage interface.	2/06: v5.0 L2
HNO_3	Barnet is assessing whether latest RTA with HNO_3 is required for best CH_4 retrievals. If yes, then major changes required at JPL.	TBD
CO_2	Barnet assesses this product as not ready for primetime.	No

Table 1: status of AIRS minor constituents and presents the projected delivery time for inclusion in v5.0 PGEs

1) Channel Properties File

Status: We have a file that people are using and depending on, but some of the fields, like RTA error, are AIRS Level 2 centric. Some fields are obsolete.
Plan: Determine which fields are currently being used, and what pain there would be in making changes (subgroup meeting, October 18, 2005) Provide new sample file, November 18, 2005 [Gaiser]. Modify software as needed to process new file (TBD, Dec-Jan). Provide new files for all epochs. February 2, 2006 [Gaiser].
Fallback: Retain current meanings, correct contents only [February 2, 2006, Gaiser].

2) Spectral Calibration

Status: We have two fields for spectral frequencies every granule. One contains static values from the Channel Properties File, the other contains a noisy estimate of the per-granule frequencies estimate based on the comparison between observed clear spectra and the U.S. standard spectrum.
Plan: Replace static frequencies with time-dependent frequency model based on *ex post facto* analysis, e.g., the trends observed by Strow in the analysis of *obs-calc*. The trends are very small, about 1 ppm of the frequency, and can be ignored for Level 2 retrievals, but not for climate analysis. Model to be determined by December 20, 2005. Analysis of three datasets required. Long-term component, seasonal component, and orbital component, with uncertainty estimates PGE upwelling, current and multiple climatologies: [November 22, 2005 Gaiser], clear field analysis: [November 22, 2005, Hannon] and Q-branch channel pair analysis: November 22, 2005, Aumann]
Fallback: Model as long-term exponential decay, with 0.75-μm p-p (8 ppm of frequency) orbital signal superimposed. Ignore seasonal component.

AMSU-L1B

Lambrigtsen and **Aumann** presented details of their proposals for what to put into the AMSU scene brightness temperature and temperature-uncertainty fields. The consensus emerged to fill the AMSU scene brightness-temperature fields with the empirically bias-corrected (*tuned*) values, and to put a more-realistic value into the uncertainty field.

1) Brightness Temperature (brightness_temp)

Status: Field already present, have algorithm. Needs implementation.
Plan: Change algorithm to apply current Level 2 PGE bias corrections (Susskind, developed over mid-latitude ocean). Schedule TBD, based on availability of implementer (Manning). CR submitted.

Hope: An AIRS-consistent bias correction by Rosenkranz will become available prior to 2006. If so, they should be implemented in the AMSU Level 1B PGE immediately after implementation in the Level 2 PGE.

2) Brightness Temperature Error (brightness_temp_err)

Status: Field already present, has bad algorithm.
Plan: Understand uncertainties assigned to AMSU BTs in Level 2 PGE. [October 25, 2005 Gaiser] If suitable, apply them to AMSU Level 1B PGE. (TBD), Manning.
Fallback: If Level 2 estimates are unsuitable, then calculate uncertainties from the spread (standard deviation) of alternatives. Alternatives gathered by December 1, 2005 [Lambrigtsen]. Spread versus standard deviation characterized December 15, 2005 [Licata].

3) AMSU Tb/Ta Noise estimate

Status: Have unlimited engineering fields QA_NeDT and QA_NeDT2NomRatio. They provide incorrect (and noisy) estimates.
Plan: Replace with fields NeDT and NeDT2NomRatio, calculated similar to the AIRS method. Use NeDT = gain * (stddev(SV1) + stddev(SV2) + stddev(WL1) + stddev(Wlevel 2))/4. Add space_signal and BB_signal limited engineering structures as per AIRS, and use their stddev fields. Schedule: TBD, depending on availability of Manning. CR submitted.

Implementation of these changes based on global comparisons with rawinsonde observations (RAOBs) and ECMWF warrant upgrading the status of the AMSU Level 1B calibration from provisional to beta validated. The next upgrades require validation under land, subarctic, and arctic conditions.

Humidity Sounder for Brazil (HSB)—Level 1B

Rosenkranz presented details of the HSB validation. Since there is no indication of a significant bias or scan-angle-dependent bias in *obs-calc*, the HSB Level 1b fields are considered validated at the beta level. No change is required. The next upgrade requires validation under subarctic and arctic conditions.

Data Assimilation for Weather Forecasting

The AIRS Level 1 requirement to obtain RAOB quality retrievals globally under clear and cloudy conditions was established by the NWC as a requirement to achieve forecast impact. A positive forecast impact has by now been achieved by John Le Marshall at the Joint Center for Satellite Data Assimilation (JCSDA), using direct assimilation of radiances.

James Cameron [United Kingdom Meteorological Office (UKMeto)—*call in*) discussed the status of AIRS data assimilation for the operational runs at UKMeto. They are having trouble demonstrating continuing positive impact with the AIRS assimilation system. Ozone is a possible cause of the problems, so retrieving total column ozone in the *1D-Var* is under investigation as a possible solution. If positive impact is demonstrated then AIRS should be part of the next parallel suite, scheduled for operations in February 2006.

John Le Marshall [JCSDA] attributed the positive impact achieved with AIRS data assimilation to using the full AIRS data stream (rather than the center of the 3x3 AIRS footprints) in every second AMSU and the conservative detection of IR cloudy radiances. Wavenumbers > 2000 cm^{-1} are downweighted, wavenumbers > 2400cm^{-1} are removed.

Joanna Joiner [GSFC] reported on the effort to assimilate AIRS Level 2 data (profiles) rather than radiances. Assimilation of AIRS team retrievals yielded positive impact with temperature data only. Assimilation of cloud-filtered radiances yielded positive results in the Northern Hemisphere. Assimilation of cloud-cleared radiances (first as far as we know) showed that fvSSI system accepts many as clear.

Junjie Liu [University of Maryland College Park (UMCP)] from Kalnay's Weather and Chaos Group gave a progress report on the assimilation of AIRS with Local Ensemble Transform Kalman Filter applied on the fvGCM. Assimilation of AIRS radiances is expected to start in May 2006.

Gary Jedlovec [Marshall Space Flight Center] reported on the application of AIRS T(p) and q(p) profiles to short-term weather forecasts. Using several case studies in the continental U.S., he showed that inclusion of the AIRS data improved the short-term forecast (0-24 hours) at most levels except near the surface. The assimilation was hampered by the coarse quality indicators included with the AIRS retrievals, particularly the moisture retrievals.

Liguang Qu [GSFC—Laboratory for Atmospheres] discussed the potential capability of AIRS data to improving the prediction of the tracks of hurricanes and showed a case study from Hurricane Isabel (2003). The retrieved AIRS temperature and humidity profiles provided useful information for the evolution and structure of the Sahara Air Layer (SAL). When the AIRS profiles are used through the nudging technique, the Mesoscale Meteorological Model, Version 5 (MM5) model well simulates the formation of Hurricane Isabel in terms of the timing and location of formation and the subsequent track.

New Capabilities and Science

George Aumann [JPL] presented details of AIRIES, an instrument which uses the AIRS grating-array concept, which has AIRS spectral resolution and sensitivity, but with 1-km footprints, rather than the 15-km footprints. This design builds on the proven success of AIRS as a hyperspectral sounder, its ability to retrieve minor gases and the unexpected application of the data for inter-satellite calibration. It satisfies NOAA's requirement for satellite inter-calibration and near-real-time hyper-spectral follow-up for targets identified by the polar and geostationary satellites. The AIRIES design also satisfies NASA's requirement for the identification of sources and sinks of minor gases.

Joel Susskind [GSFC] made a presentation on *Temperature and moisture retrievals with 3.7- to 9-μm channels only*. He showed that the retrieval accuracy is only slightly degraded from what is achieved with AIRS, if channels longward of 9 μm are simply deleted from the current AIRS retrieval, and the stratosphere is tagged on from climatology. This is a very important result for the definition of requirements for the hyperspectral sounder on the advanced GOES.

Xavier Calbet [EUMETSAT] presented an *Analytical Estimation of the Optimal Parameters for EOF and Variational AIRS Retrievals: Comparison with Radiosondes*. He used 1990 of the 2378 AIRS channel for the evaluation. The background was taken from the ECMWF climatology.

Joel Susskind made a proposal for the *Continuation of TOVS climate parameters for the AIRS v5.0. PGE*. The TOVS Pathfinder Path A dataset covers 1979-present. Tying the AIRS data into a long time series is an important step in the validation as climate data record.

Chris Barnet presented work he is doing with **Joan Alexander** [Colorado Research Associates] on *Observing Gravity Waves From Space* using AIRS data.

Mitch Goldberg [NOAA/NESDIS] presented *The Limb Adjustment of AIRS Observations for Climate Applications*. The AIRS radiances are of climate quality, and monthly maps of AIRS radiances would be valuable to the climate community. For this the AIRS radiances have to refer to nadir, i.e. they need to be limb adjusted. This is accomplished with Principle Component Scores (PCS).

Marty Mlynczak [Langley Research Center] made a presentation on *Far-Infrared Spectroscopy of the Troposphere (FIRST): Flight Results & Preliminary Comparisons with AIRS*. FIRST was successfully demonstrated June 7, 2005, on a high altitude balloon from Ft. Sumner, NM, which included an overpass of the Aqua spacecraft under near perfectly clear conditions. Agreement in window with CERES and AIRS is excellent.

Gregory Leptoukh [GSFC] made a presentation on *AIRS in Giovanni* (GES-DISC Interactive Online Visualization and Analysis Infrastructure). Giovanni makes gridded remote sensing and model data available in a format that anyone can learn to use within minutes and put to work productively for research or applications.

Shahram Tehranian [NOAA/NESDIS] presented a *Distributed Processing and Archival of AIRS Science Data on Linux Clusters*. This is one approach to cost-effectively handle large amounts of data. One day of AIRS Level 1b data can be processed using one master and 30 work stations in 2 hours. The current limitation is input/output.

The next AIRS Science Team meeting will be a Netmeeting on November 22, 2005. The next physical meeting will be March 7-9, 2006 in Pasadena, CA. ■

Kudos

NASA and the U.S. Department of the Interior (DOI) recently presented the 2005 William T. Pecora Award, a prestigious federal award given to recognize career achievements in remote sensing, to **Jeff Dozier**, University of California Santa Barbara, a preeminent researcher in snow hydrology and the remote sensing of snow properties, and to **John R. G. Townshend**, University of Maryland, who has had a profound influence on the advancement of remote sensing for the study of global land characteristics. Dozier was the Senior Project Scientist for NASA's Earth Observing System in its formative stages when the configuration of the system was established. Townshend is a member of the MODIS Science Team.

The Earth Observer staff and the entire science community would like to congratulate them on this outstanding achievement.

Aura Science Team Meeting

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An Aura Science Team Meeting was held November 8-10, 2005, in The Hague, Netherlands. The meeting included representatives from the European Space Agency's (ESA) Environment Satellite (ENVISAT)—which includes the Michelson Interferometer for Passive Remote Sensing (MIPAS), Scanning Imaging Absorption Spectrometer for Atmospheric Cartography (SCIAMACHY), and Global Ozone Measurement by Occultation of Stars (GOMOS) among its instruments—and the Canadian Space Agency's Atmospheric Chemistry Experiment (ACE) also known as SCISAT, which includes the ACE Fourier Transform Spectrometer among its instruments.

Ben Droste [Netherlands Agency for Aerospace Programmes (NIVR)], **Hernie Kelder** [Royal Netherlands Agency for Aerospace Programmes (NIVR)—speaking on behalf of the director], **Anne Douglass** [Goddard Space Flight Center (GSFC)], and **Jack Kaye** [NASA Headquarters] all gave short welcome messages.

Pieternel Levelt [Koninklijk Nederlands Meteorologisch Instituut (KNMI)—Principal Investigator (PI) of the Ozone Monitoring Instrument (OMI)] reported on efforts to improve the situation with striping seen in maps of minor constituents caused by a Charge-Coupled Device (CCD) dark current. The Sodankyla campaign coming in Spring 2006 will address differences between the Differential Optical Absorption Spectrometer (DOAS) and Total Ozone Mapping Spectrometer (TOMS) retrievals. The OMI maps of pollutant nitrogen dioxide (NO_2) on Saturday and Monday show high levels associated with volume of traffic, and much lower levels on Sunday when many people enjoy a day of rest.

John Gille [National Center for Atmospheric Research (NCAR)—PI of the High Resolution Dynamics Limb Sounder (HIRDLS)] outlined the procedures for accounting for the Kapton that is blocking the scan mirror and retrieving high-vertical-resolution profiles of temperature, ozone, water, and other constituents. Wave motions of a few kilometers vertical scale are apparent in HIRDLS temperature profiles.

Joe Waters [Jet Propulsion Laboratory (JPL)—PI of the Microwave Limb Sounder (MLS)] reported that MLS has been in stable operations since December 2004 with nearly 100% observations since then. The MLS team will provide alerts concerning changes in retrievals or artifacts that have been identified in the dataset year to registered MLS users four times per year.

Reinhard Beer [JPL—PI of the Tropospheric Emission Spectrometer (TES)] explained the present scan pattern for TES, which eliminates limb observations, to extend the TES lifetime, and surveyed recent scientific results from TES observations.

Status reports had been requested for SCIAMACHY, MIPAS and GOMOS (all on ENVISAT) and for ACE (on Canada's SCISAT). **Stefan Noël** [Institute of Environmental Physics (IUP) University of Bremen] reported on SCIAMACHY, both an acronym and a Greek word that means *chasing shadows*. SCIAMACHY tropospheric observations of carbon monoxide (CO), sulfur dioxide (SO_2) and nitric oxide (NO_2) are being used to distinguish sources of pollution. For example, high CO and SO_2 accompanied by low NO_2 are associated with coal burning. Limb measurements of ozone (O_3), NO_2 and bromine monoxide (BrO) are also available.

Thorsten Fehr [Deutsches Zentrum für Luft und Raumfahrt (DLR)] reported that MIPAS operations were normal at full resolution of 0.035 cm^{-1} until 2004. Since then MIPAS has made observations with a reduced resolution of 0.065 cm^{-1} and a 35% duty cycle. All MIPAS data are now available on line via FTP following registration at the ESA web site, drastically improving data availability. Access to non-standard products requires a proposal.

Erkki Kyrölä [Finnish Meteorological Institute (FMI)] reported that GOMOS observes the entire globe except at summer poles because then it is not possible to see stars. Polar night observations have been used to develop a climatology of NO_2 and nitrate (NO_3).

Peter Bernath [University of Waterloo] reported that SCISAT ACE presently provides 30 high-quality profiles of many constituents per day. ACE measures the "complete" chlorine budget [hydrochloric acid (HCl), chlorine nitrate ($ClONO_2$), HOCl, chlorine monoxide (ClO)] and observes other important constituents including O_3, hydrogen fluoride (HF), sulfur hexafluoride (SF_6). An improved retrieval of ACE constituents (v2.2) has been released recently.

Anne Douglass [GSFC] summarized the September 2005 Aura validation workshop. Comparisons of Aura measurements with observations from other satellites, ground-based sources, and aircraft were invaluable in needed retrieval improvements. TES comparisons for ozone, temperature, and water revealed a calibration problem that will be corrected in Version 2 (to be implemented early in 2006). Areas for which more validation data are necessary were identified. For example, insufficient ozonesonde launches to meet the

stringent coincident requirements for validation of TES tropospheric ozone. The Project Science Office seeks to obtain more coincidences by providing sonde stations with 15-day forecasts of TES overpasses. The first six months of 2006 are action packed, with a WB-57 experiment during January [Costa Rica Aura Validation Experiment (CRAVE)], a high-latitude balloon launch, participation [Intercontinental Chemical Transport Experiment (INTEX)], a DC-8 field mission in spring [Megacity Iniative: Local and Global Research Observations (MILAGRO)], and the Texas Air Quality Study.

Bojan Bojkov [GSFC] presented an overview of the Aura Validation Data Center (AVDC), a central archive established for the validation of Aura's four instruments. The AVDC contains tools to determine Aura data collocation, to determine instrument field of view and to subset Aura data. Validation datasets available through AVDC include those from NASA-supported projects and campaigns, from ground-based measurement networks, and from other satellite missions.

Pepijn Veefkind [KNMI] showed that 3% of all OMI observations of NO_2 above a threshold of 2 x 10^{16} molecules/cm^{-2} are clustered, indicating a source region. The region of elevated aerosol index is not collocated with the sources, suggesting that aerosols must be lofted before they can be observed by OMI. OMI's high resolution made it possible to detect a signature in NO_2 of the Portuguese forest fires, an interpretation that is supported by Moderate Resolution Imaging Spectroradiometer (MODIS) fire counts.

Ronald van der A [KNMI] combined observations from 1996 – 2005 for GOME and SCIAMACHY and used temporal characteristics of this dataset to distinguish anthropogenic, soil, biomass burning, and lightning sources of NO_2.

Gregory Osterman [JPL] reported on the status of validation of TES data. The TES O_3 column above 100 hPa and the MLS column above 100 hPa are in good agreement, attesting to the absolute calibration of both instruments. The TES total column is somewhat higher than observed by OMI; this may be resolved when a known TES calibration problem is resolved in the next retrieval version of TES.

Mark Filipiak [University of Edinburgh] showed comparisons of CO and O_3 with the Goddard Earth Observing System (GEOS) CHEM at 147 hPa (the lowermost stratosphere at middle and high latitudes, the upper troposphere in the tropics). MLS observations and GEOS CHEM show many of the same features, but with much different magnitudes.

Kevin Bowman [JPL] showed results of assimilation of TES CO, seeking to establish consistency among TES CO, Measurements of Pollution in the Troposphere (MOPITT) CO, and the simulated fields of GEOS CHEM. There is a remaining source of inquiry involving the TES and MOPITT *a priori* profiles. In the case of MOPITT, a single *a priori* profile is used for all retrievals. The TES *a priori* profile depends on latitude. In a poster **M. Luo** showed the differences in *a priori* profiles of TES and MOPITT in the low and high troposphere.

Jack Fishman [Langley Research Center (LaRC)] described a means to determine the tropospheric ozone residual using OMI total-column measurements and the assimilated fields from the Global Forecast System to determine the stratospheric contribution.

Ken Pickering [University of Maryland College Park (UMCP)] showed that ultraviolet (UV) surface measurements tend to correlate with the OMI tropospheric ozone residual for episodes when OMI is elevated for several days, even though OMI is insensitive to the boundary layer ozone. He discussed other contributions of OMI to air quality forecasts.

Ellen Brinksma [KNMI] reported on the Dutch Aerosol and Nitrogen Dioxide Experiment for the Validation of OMI and SCIAMACHY data (DANDILIONS). This field experiment intercompared observations from several ground-based instruments that had been brought to the same location and provided observations for comparison with OMI measurements. The OMI pixels vary in size depending on the daily location of the nadir point in the OMI swath.

Helen Worden [JPL] reported on comparisons of TES observations and ozonesonde profiles. She used a coincidence criterion of 600 km and 18 hours to obtain 55 coincidences for Fall 2004. She used back trajectories to evaluate the likelihood that the time coincidence is realistic, and noted that more coincidences are likely in the present TES nadir-only mode because observation points are closer together.

Folkert Boersma [KNMI] discussed the KNMI near-real-time retrievals of NO_2 that are being provided by OMI. The main difference between this system and the operational system is that they use a forecast from the chemistry transport model (CTM) to obtain a profile shape for the retrieval, rather than waiting for a CTM profile calculated using assimilated meteorological fields.

Marcel Bobber [KNMI] discussed OMI in-flight calibration. The spectral long-term stability of OMI is excellent. Signal-to-noise ratio for solar measurements is 2 to 3 x 10^3.

Nickolay Krotov [GSFC] showed OMI observations

of SO_2. The residual used to derive SO_2 depends on the height of the SO_2 layer, as OMI is more sensitive to SO_2 in the mid and upper troposphere than in the boundary layer. A one-year composite from OMI reveals very small sources such as copper plants. OMI can see smaller features than TOMS, GOME, or SCIAMACHY because of improved spatial resolution.

Jochen Langraf [KNMI] presented an idea to retrieve ozone in the lower troposphere with improved sensitivity by combining information for TES and OMI. These instruments make near-simultaneous measurements when viewing the nadir. He showed that the UV is reliably more sensitive to ozone in the troposphere than the infrared, which lacks sensitivity whenever the boundary-layer temperature is close to the surface temperature. An actual retrieval using combined information could be an important *proof-of-concept* for a future sensor.

Hennie Kelder [KNMI] discussed the results of the European plan for future measurements—known as CAPACITY. This study specifies measurements of O_3, CO, CH_4, CO_2, NO_2 and aerosols that can be used in inverse modeling to obtain emissions. To obtain these measurements, a revisit time of 0.5 to 2 hours and 5- to 20-km spatial resolution is required. These requirements can be met with two satellites, one geostationary and one low-Earth orbit, or with a constellation of three satellites in inclined low-Earth orbits.

Chiara Piccolo [Oxford University] showed preliminary results of application of the MIPAS retrieval algorithm to TES radiances. Even though both instruments are Fourier Transform Spectrometers and both provide resolved spectra, there are significant differences in their operating modes that made this exercise complicated.

Ann-Marie Eldering [JPL] gave a phenomenological explanation of TES measurements of O_3 and CO for about their first year's observations. The fact that these constituents are measured simultaneously and the height resolved information make this dataset unique.

Kevin Bowman [JPL], speaking for Quinbin Lee, presented preliminary results from an assimilation of TES tropospheric CO and comparisons of assimilated fields and an analysis of tropospheric ozone measurements and simulations using the GEOS CHEM. The effort is directed towards a better understanding of sources of tropospheric ozone.

Stephanie Stockman [GSFC] reported on the Education and Public Outreach (E&PO) activities associated with Aura. In addition to a recent issue of *ChemMatters*, EPO is working with the American Chemical Society (ACS) to provide materials appropriate for after-school chemistry clubs (high school level). An exhibit *Change is in the Air* will open in January at the Smithsonian Institution. After two years at the Smithsonian, it will become a traveling exhibit. There are tentative plans for a brochure and video describing Aura results, but work on these projects is not likely to begin before next fall.

Paul Palmer [Harvard University] presented results for the Formaldehyde (HCHO) column derived from GOME 1996-2001. During the growing season isoprene is produced by leaves and enters the atmosphere where it has a short lifetime and a high yield of HCHO. The areas of elevated HCHO are close to their source region. Surface-temperature variation explains 30% of the variability in HCHO. The effort relies on OMI's horizontal resolution.

Andreas Richter [IUP University of Bremen] presented NO_2 trends from the GOME/SCIAMACHY NO_2 multi-annual dataset. Some areas of the globe (Europe) have seen a decrease in this pollutant, while some parts of the globe (China) continue to experience large increases. He also presented observations of BrO (polar BrO increases are associated with frost flowers), and chlorine dioxide (OClO) (elevated at the poles during winter as part of the polar processes leading to ozone destruction).

Kevin Bowman [JPL], speaking for John Wordon, presented TES observations of Deuterium (HDO) and H_2O. These are discussed by considering the ratio HDO/H_2O and its relationship to that ratio in sea water. The quantity δD is about -80 just above the ocean surface and -800 in the upper troposphere, where removal of water and ice during condensation processes has preferentially removed HDO from air parcels. These two quantities are retrieved jointly; their ratio is calculated. The retrieval is most sensitive at 750 hPa. TES is most sensitive in the tropics, and the sensitivity decreases poleward. Most values of the ratio fall between curves that describe evaporation and condensation.

Jan Fokke Meirink [KNMI] presented methods to derive CH_4 emissions from SCIAMACHY observations of the CH_4 and carbon dioxide (CO_2) columns. The ratio of CH_4/CO_2 is nearly independent of variations due to aerosol loading and clouds that confound the effort to determine CH_4 sources. Some regions of very high emission of CH_4 accompany observations of high SO_2, suggesting regions of coal mining. Inverse modeling is used to estimate the monthly mean surface fluxes. The *a posteriori* fluxes (results of inverse modeling) are interpreted through comparison with the *a priori* fluxes. There are both decreases and enhancements depending on location.

Thomas Kurosu [KNMI] showed results of BrO, HCHO and OClO retrievals from OMI data (1:30 p.m crossing time). OClO is only enhanced in the winter

polar vortices and shows a seasonal dependence. BrO is mostly stratospheric, but also can be enhanced by frost flowers at high latitudes, emissions from salt lakes, and volcanoes. The small pixel size of OMI made it possible to isolate a region of high values downwind of the dead sea, and also to identify volcanic eruptions. The OMI data show evidence of CHO-CHO in Hong Kong, consistent with ground-based observations in various urban centers. This is not seen in SCIAMACHY (crossing time is about 10:30 a.m.) consistent with ground-based observations showing a midday CHO-CHO peak that is double its value at 10:30 a.m.

Gabriele Stiller showed results from MIPAS in the upper troposphere and lower stratosphere. Although the vertical resolution is only 3 km they provide a comprehensive dataset, including good retrievals of SF_6 and δD (related to the HDO/H_2O ratio and discussed above). Horizontal maps at 275 hPa show ethane (C_2H_6) associated with biomass burning.

Ugo Cortesi [Italian National Research Council's Electromagnetic Wave Research Institute (IROE-CNR)] discussed operational retrievals of MIPAS ozone and comparisons with correlative observations from the Network for the Detection of Stratospheric Change (NDSC) ground-based stations and from other satellites. Differences are attributed to geolocation differences and vertical and horizontal smoothing.

Kaley Walker [University of Waterloo] reported on validation of ACE O_3 profiles produced with a new retrieval version. This version was developed because differences between Stratospheric Aerosol and Gas Experiment III (SAGE-III) and ACE profiles persisted when the current (Version 2.2) algorithm was implemented. Issues were found with the retrieval microwindows, and the difference between ACE and SAGE III profiles is less than 5% when these issues are resolved.

Cathy Clerbaux [Service d'Aéronomie, Université de Paris] discussed CO profiles from 5 to 100 km obtained from ACE. The wide altitude range is obtained by using different spectral bands for the retrieval in different parts of the atmosphere. The strong band used for the high-altitude part of the profile saturates, and a weaker band is used for the lower atmosphere. The ACE observations show a signature of an Alaskan fire, corroborated by the Multiangle Imaging Spectroradiometer (MISR).

Klemens Hocke [Max-Planck-Institut für Aeronomie] showed comparisons of ground based microwave measurements of ozone and water with MLS measurements. Signal-to-noise issues limit the utility of these comparisons.

Ken Jucks [Harvard-Smithsonian Center for Astrophysics] gave a summary of the results of the September 2005 balloon flight of the Far-Infrared Spectrometer (FIRS-2), MkIV, SLS, and BOH. This successful flight provided profiles of many species that are being used for validation of Aura measurements.

Scott Lewicki [JPL], chair of the Data Systems Working Group, gave a summary of their meeting. They are investigating the use of file-format guidelines developed for Aura as a NASA standard or as *best practices*.

Angie Kelly [GSFC] reported on the Mission Operations. Aura has not been placed in *safe* or *survival* mode during the first 16 months since launch. The single anomaly since launch involves a solar-array cable connector. The impact of this is to decrease the margin for available power at the end of the mission. MLS, HIRDLS and OMI are operating well. TES has presented some challenges, particularly to accommodate the optical bench warm-up that will improve TES CO retrievals.

Doug Kinnison [University Center for Atmospheric Research (UCAR)] reported on the status of the nitric acid (HNO_3) retrieval from HIRDLS. The profiles make geophysical sense and are reasonable compared with correlative measurements. There are still obvious challenges to this retrieval, but HIRDLS HNO_3 for January 2005 does provide a signature of denitrification.

Kai-Uwe Eichmann [IUP University of Bremen] presented results for SCIAMACHY Limb Observations for stratospheric and mesospheric constituents. There is a pointing error of 500 m that must be accounted for in the retrieval. Observations are available from an archive at University of Breman.

Bruno Nardi [UCAR] showed comparisons of HIRDLS ozone with observations from other satellite instruments [Aura MLS, Halogen Occultation Experiment (HALOE), Polar Ozone and Aerosol Measurement 3 (POAM3), Stratospheric Aerosol and Gas Experiment 2 and 3 (SAGE2 and SAGE3)], from ozonesondes and from ground-based lidar. HIRDLS profiles agree within ±10% between 20 and 55 km, with the expectation that the lower bound for scientifically valid profiles will be decreased in the next retrieval version.

Claire Waymark [Oxford University] made direct radiance comparisons between HIRDLS channels and MIPAS radiance for the 10 HIRDLS channels that completely overlap MIPAS. She plans to use the Oxford Forward Reference Model to enable further radiance comparisons for channels that do not overlap fully. These comparisons test the HIRDLS strategies that account for the scan-mirror blockage.

Dorien Lolkema [RIVM] showed comparisons of

SCIAMACHY limb ozone profiles with coincident profiles measured by lidar. Such comparisons show how well the retrievals account for the pointing problem discussed in the Eichmann presentation mentioned above.

Matthey Toohey [JPL] focused on stratospheric variability in northen middle latitudes as represented in the Canadian Middle Atmosphere Model and observations from Aura MLS and ACE. Such variability is important as it impacts detection of trends.

Lucien Froidevaux [JPL] discussed continuity in the time series of HCl observed by the Upper Atmosphere Research Satellite (UARS) HALOE (an occultation instrument measuring about 15 profiles at two latitudes each day) from 1991 – 2005. The HALOE time series overlaps ACE (also an occultation instrument) and also Aura MLS (daily global fields). MLS and ACE are both systematically higher than HALOE in the upper atmosphere where almost all inorganic chlorine is HCl. A decrease in HCl is expected (and observed) due to the decreases in source gases with an appropriate lag due to stratospheric transport.

Ross Salawitch [JPL] presented more results on HCl amounts and their expected decline. Chlorine source gas scenarios from the World Meteorological Association produce a stratospheric peak of 3.58 ppbv, consistent with HALOE HCl; MLS HCl suggests a peak of 3.7 ppbv. It is possible that very short-lived halocarbons contribute an additional 120 ppt of inorganic chlorine to the stratospheric burden.

Nathaniel Livesey [JPL] showed observations of MLS N_2O. During Northern Hemisphere late spring low-latitude (high N_2O) air was pulled into the anticyclone. This high anomaly in N_2O persisted most of the summer; this places an upper limit on the role of horizontal mixing.

Herb Pickett [JPL] presented an overview of the first year's measurements of hydroxyl (OH) and hydroperoxyl (HO_2) by MLS; these are the first global measurements of these radicals for such a long period. The mesospheric distributions of these radicals explain features in the night glow.

Jean-Baptiste Renard [Laboratoire de Physique et Chimie de l'Environnement—Centre National de la Recherche Scientifique (LPCE-CNRS)] used measurements from MIPAS and GOMOS to argue that the NO_2 enhancement during January 2004 was a result of auroral electrons.

Michelle Santee [JPL] used measurements of ClO and HCl from MLS along with measurements of $ClONO_2$ from ACE to examine the decrease in ClO and formation of chlorine reservoirs during the polar spring. In the Northern Hemisphere initial recovery is always to $ClONO_2$ followed by slow repartitioning to HCl.

Steven Massie [UCAR] presented HALOE extinction measurements for January 27, 2005. HIRDLS observed regions of extinction that are associated with polar stratospheric clouds, stratospheric aerosols, and tropical cirrus clouds. Size distributions were determined using information from multiple wavelengths.

Anne Douglass [GSFC], speaking for Mark Schoeberl, presented analysis of an inward breaking wave that was observed by lidar on the DC-8 during the Polar Aura Validation Experiment (PAVE) experiment. Taken together, MLS data and the lidar profiles of ozone and aerosols provide a complete picture of the processes that took place during this unusual event.

Arjo Segers [KNMI], speaking for Hank Eskes, showed total ozone measurements from SCIAMACHY and results of assimilation of SCIAMACHY total ozone by ECMWF for the 2005 southern-hemisphere ozone hole. These assimilated fields compare well with TOMS observations.

Mike Coffey [UCAR] showed column measurements made during the PAVE mission and comparisons with Aura observations.

Ninad Sheode [IUP University of Bremen] presented SCIAMACHY measurements for stratospheric BrO. BrO is generally less than 20 ppt, and is on the low side compared with some other estimates.

On Wednesday afternoon there was a poster session with more than 56 presentations. A listing of posters, oral presentations, and copies of many of the posters can be obtained from the Aura validation data center *avdc.gsfc.nasa.gov/Overview/news.html*. The next Aura validation working group meeting and science team meeting will be in September 2006. The data-release schedule for all Aura measurements is found on the Aura web site *aura.gsfc.nasa.gov* ■

Fourth CERES-II Science Team Meeting

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The fourth meeting of the Clouds and the Earth's Radiant Energy System (CERES-II) Science Team was held November 1-3, 2005 at the Radisson Hotel in Hampton, VA. Bruce Wielicki [NASA Langley Research Center (LaRC)—CERES Principal Investigator] hosted the meeting. The next Science Team meeting will be held in Williamsburg, VA in early May 2006.

The objectives of this meeting included a science-team review of the calibration of instruments on Terra and Aqua, development of Revision-1 adjustment factors to correct for the in-flight degradation of shortwave (SW) channels, and the investigation of the SW channel anomaly on the Aqua Flight Model (FM)-4 instrument. The Science Team also reviewed Terra and Aqua cloud properties, Surface and Atmospheric Radiation Budget (SARB) products, Aqua Angular Distribution Models (ADMs), CERES error budget for global net radiation, comparisons between CERES and Geostationary Earth Radiation Budget (GERB) results, and a strawman plan for *Edition-3* processing of all Terra and Aqua data.

The National Polar Orbiting Environmental Satellite System (NPOESS) Earth Radiation Budget Sensor (ERBS) Operational Algorithms Team (OAT) met on the afternoon of November 3. Immediately following the CERES II meeting, **James Coakley** [Oregon State University (OSU)] chaired the meeting and discussions centered on the status of the project, the launch schedule, and preliminary results from a trade-off study for an arrangement under which ERBS data from NPOESS will be processed at the LaRC Atmospheric Science Data Center (ASDC). **Kory Priestley** [LaRC] outlined the modifications needed if the CERES FM-5 instrument is to be flown as ERBS on the first 1:30 p.m. NPOESS. **Bruce Wielicki** [LaRC] outlined accuracy and stability requirements for the NPOESS/ERBS system for its products to be useful for detection of climate trends.

Climate Program Overview

Bruce Wielicki [LaRC] presented an overview of a broad range of topics including the state of the U.S. Climate Change Science Program (CCSP), the Intergovernmental Panel on Climate Change (IPCC), NASA Earth Science, CERES, NPOESS, and the NPOESS Preparatory Project (NPP). The CCSP Observations Working Group is planning a Workshop on Climate Observation Requirements for March 2006. A multi-agency report of the Workshop on Satellite Calibration Requirements for Climate Data Records was published in the September 2005 issue of the *Bulletin of the American Meteorological Society* (*BAMS*; Ohring *et al.*). The IPCC Assessment Report 4 (AR4) includes a discussion of decadal changes of clouds and radiation in one of the chapters.

Recent leadership changes at NASA Headquarters have greatly increased the science/engineering experience within senior management ranks. Hal Maring is the now the Radiation Sciences lead; Don Anderson has moved to lead Modeling. The FY2006 budget for Earth science is expected to remain flat but further cuts are not expected. The Terra Senior Review went very well. CERES funding is expected to moderately decrease over next few years as algorithms and data processing mature.

The CERES FM-5 instrument may be launched on the first NPOESS in a 1:30 p.m. orbit. Cost and schedule constraints may delay that launch by up to 30 months (to mid-2014). CERES has examined the effect of this delay on climate record gap risk and has communicated to NPOESS the new gap assessment and minimum improvements needed for FM-5, and is cooperating on estimating the costs of transitioning data-product software to the NPOESS system. The Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) launch has been delayed by equipment and personnel issues.

Terra/Aqua Instruments and Calibrations

Kory Priestley [LaRC] presented the operational and calibration/validation status of the four CERES instruments on Terra and Aqua. Both instruments on Terra and one (FM-3) on Aqua continue to function nominally. The SW channel of FM-4 on Aqua suffered an anomaly on March 30, 2005 and stopped taking radiometric measurements. Total and window channels on FM-4 continue to function nominally. Near-term impact of the anomaly seems minimal, but long-term, the climate data gap risk increases significantly. Also, future activities planned in concert with other *A-Train* instruments and the GERB satellite may be adversely affected.

Grant Matthews [Analytical Services and Materials (AS&M)] presented the work underway to quantify spectral darkening of SW channels on all CERES instruments due to contamination of the optics. Results from a physical model that estimates spectral transmission of optical contaminants were shown. A procedure for making use of these results to modify spectral response of the instrument was presented.

SW Trend Comparisons

Norman Loeb [Hampton University (HU)] presented results of a study in which several months of CERES (Terra and Aqua), Moderate Resolution Imaging Spectroradiometer (MODIS/Terra), Multi-angle Imaging SpectroRadiometer (MISR/Terra), and Sea-viewing Wide Field-of-view Sensor (SeaWiFS) data were used to examine the relative stability of these instruments in the visible and shortwave regions. Comparisons of 64 months of CERES and MODIS data showed that CERES and MODIS calibration were stable to 1% over 5 years. Comparisons of MODIS and MISR radiances taken from the merged CERES-MODIS-MISR product showed them to be stable to 1%. Loeb also presented comparisons between CERES Terra SW flux and SeaWiFS Photosynthetically Active Radiation (PAR), and a few other pairs of parameters. None of the instruments studied exhibited the dramatic 6 W/m^{-2} increase in top-of-atmosphere (TOA) SW flux between 2000 and 2003 as reported in the Earthshine study.

CERES Cloud Properties

Patrick Minnis [LaRC] presented the status of CERES cloud algorithms and products. Terra *Edition-2B* cloud processing is complete through June 2005 while Aqua *Edition-1A* processing is done through March 2005. Minnis described the ongoing effort to intercalibrate sensors on different satellites and instruments to accomplish consistency. Aqua retrievals yielded slightly more ice clouds, lower heights for water clouds, and greater heights for ice clouds. Extensive validations of CERES cloud properties were shown using ground-based and aircraft measurements, and retrievals from other satellite instruments, most showing good agreement. Minnis also outlined the improvements to be implemented in *Edition-3* processing that include high-resolution cloud detection and multilayer cloud retrievals.

CERES Aqua ADMs

Norman Loeb [AU] presented new Aqua Angular Distribution Models (ADMs) recently developed using the same approach as used for Terra ADMs. Significant differences between Terra and Aqua were found to occur in polar regions. Daytime changes in CERES cloud mask resulted in significant improvements in Aqua SW Top of the Atmosphere (TOA) fluxes over Arctic sea-ice compared to Terra. The ADM group recommended using Aqua sea-ice SW ADMs in Terra *Edition-3* processing and Terra nighttime longwave (LW) and window-channel (WN) permanent snow ADMs in Aqua *Edition-2A* processing. The ADM group will examine the possibility of improving CERES Terra and Aqua clear ocean ADMs to account for aerosol fine-mode fraction variations in *Edition-3* processing.

Simple Surface Fluxes

David Kratz [LaRC] presented validation of SW and LW surface fluxes from single-scanner footprint (SSF) data derived with simpler surface flux algorithms. Ground-based fluxes for validation were obtained from a number of sources such as the Atmospheric Radiation Measurement (ARM) sites, Baseline Surface Radiation Network (BSRN), and SURFace RADiation (SURFRAD) network. Clear-sky SW errors were small and cloudy sky SW errors were within the desirable range everywhere except at high-latitude coastal sites. LW errors for both clear and cloudy conditions were within the desired range and results from Terra and Aqua were very similar.

Terra and Aqua SARB Products

Thomas Charlock [LaRC] presented an accuracy analysis of CERES SARB instantaneous-footprint (CRS) and hourly-gridded (FSW) products. These products are validated using ground-based measurements from several global networks assembled within the CERES/ARM Validation Experiment (CAVE) database. Charlock showed that flaws in the International Geosphere-Biosphere Program (IGBP) surface-type map make validation at the CERES Ocean Validation Experiment (COVE) site very difficult. Comparisons at the ARM Southern Great Plains (SGP) sites showed good agreement and those at the Fort Peck (SURFRAD) site showed SARB retrievals accurately capturing annual and interannual variability of surface albedo.

CERES TISA Activities

David Doelling [AS&M] presented three years of gridded monthly average TOA and surface SW fluxes (SRBAVG *Edition-2D* products) and their validation. With Science Team approval, these data will be released by the ASDC in December 2005. Doelling presented the methodology wherein geostationary (GEO) satellite data were used to remedy the effects of sparse temporal sampling of polar satellites and improve diurnal averages. SRBAVG surface fluxes were validated against ground-based measurements from 36 ground stations. A principal components analysis was performed to ensure that GEO procedures did not introduce any spurious spatial patterns in the data.

Bruce Wielicki [LaRC] discussed the absolute accuracy of global net radiation achievable with CERES results. He showed a list of known error sources and assigned an achievable accuracy to each. Cumulative absolute bias fell in the 0.3 to 6.5 W/m^2 range. Wielicki emphasized that decadal variability of ocean heat storage is determined by stability and not by absolute accuracy of global net radiation, and absolute accuracy needs to be kept within a factor of 5-10 of the stability requirement.

FLASHFlux Activities

Paul Stackhouse [LaRC] reported on the status of the Fast Longwave and Shortwave Fluxes (FLASHFlux) project, a new project starting at LaRC aiming to produce surface and TOA radiative fluxes on a global scale from CERES measurements within about a week of the observations. Radiative fluxes on such a short turn around are desirable to many in the modeling community. FLASHFlux processing uses most of the components of the CERES processing system, including the surface-flux algorithms. Stackhouse showed validation of instantaneous surface fluxes over several ground sites and fields of gridded surface fluxes. FLASHFlux results were used recently in support of a field experiment.

Data Management

Erika Geier [LaRC] apprised the team of the Revision-1 correction that needs to be applied to all CERES *Edition-2* SW products. This correction is required to account for the spectral darkening of the transmissive optics on CERES SW channels. CERES will soon start a reprocessing of all data that will be designated as *Edition-3*. Geier advised participants to subscribe to the *CERES News* e-mail bulletin to stay informed of the latest developments. Edward Kizer (ASDC) discussed the issues related to processing, archiving, and distribution of Earth-science data at the ASDC and described recent enhancements of data visualization and ordering tools.

Outreach

Lin Chambers [LaRC] reported on the status of the Students' Cloud Observations On-Line (S'COOL) project. The S'COOL database now has more than 45,000 observations from about 2000 participants in 66 countries. More than 20,000 of those observations are matched with a Terra or Aqua overpass. Chambers encouraged attendees to participate in S'COOL activities in their own communities.

Invited Presentations

Chuck Long [Pacific Northwest National Laboratory (PNNL)] presented results of studies on how surface-based radiometric and meteorological measurements from high-quality ground sites may be utilized to retrieve accurate radiative and microphysical cloud properties. Long discussed the SW flux analysis method for estimating fractional sky cover and cloud optical depth. This methodology was extended for deriving clear-sky downward LW flux and LW cloud effect from all-sky LW measurements. He demonstrated a method for retrieving cloud height and temperature and showed a comparison with Raman Lidar measurements. Long emphasized that these retrievals do not make use of any ancillary, model, or satellite data and thus are a completely independent source of validation data.

Rich Ferrare [LaRC] presented results of studies underway on the next generation spaceborne multi-wavelength aerosol lidar known as the High Spectral Resolution Lidar (HSRL). This instrument operating at 3 wavelengths (355, 532, and 1064 nm), represents a major advance over backscatter lidars currently flying, such as the Geoscience Laser Altimeter System (GLAS), or soon to be launched CALIPSO, and is being recommended for post-2010 satellite missions. This system will be capable of providing profiles of many more aerosol microphysical properties without having to make assumptions about extinction-to-backscatter ratios that are known to be highly variable.

Co-Investigator Presentations

Tom Zhao [National Environmental Satellite Data and Information Service (NESDIS/NOAA)] presented results of a study in which CERES observations in conjunction with Global Ozone Chemistry Aerosol Radiation Transport (GOCART) model simulations were used to derive direct radiative effect (DRE) of individual aerosol components for clear-sky conditions over global oceans. Total aerosol was divided into natural and anthropogenic components. Total DRE over clear oceans was -6.47 W/m^2. Values for individual components were provided.

Alexander Ignatov [NESDIS/NOAA] presented results of Advanced Very High-Resolution Radiometer (AVHRR)-like retrievals of aerosol properties derived from the Spinning Enhanced Visible Infrared Imager (SEVIRI). The AVHRR-like algorithm was delivered to Imperial College, London to be used in the analysis of GERB satellite observations. Ignatov presented results of a case study focused on retrieving dust aerosol properties that showed good agreement with MODIS retrievals but not with Aerosol Robotic Network (AERONET) measurements.

William Collins [National Center for Atmospheric Research (NCAR)] presented results of a study of radiative forcing by well-mixed greenhouse gases exhibited by a large number of Atmosphere/Ocean General Circulation Models (GCMs), which are participating in the Radiative Transfer Model Intercomparison Project for the IPCC AR4. Results provided by these models were compared with benchmark line-by-line results. Most models were designed to show better agreement at the top of the troposphere, but agreement at the surface also needs to be improved.

James Coakley [OSU] presented results of a study of MODIS cloud mask and an analysis of pixels that are partly cloudy or have clouds in multiple layers. Coakley presented a comparison of cloud properties

from operational MODIS and partly cloudy pixel retrievals and a method for isolating layered clouds in multi-layered systems. He also showed observations of surface radiative fluxes made aboard an OSU ship and compared them with model computations and CERES observations.

Zachary Eitzen [Science Applications International Corp. (SAIC)] presented results of a study of cloud objects using joint probability density functions (PDFs). Three objects—a deep convective system, a boundary-layer stratus, and a boundary-layer stratocumulus—were analyzed for this study. For the deep convective system, SW and LW cloud radiative forcing (CRF) showed a correlation between them but neither showed any correlation with sea-surface temperature (SST). For stratus and stratocumulus systems, the cloud liquid water path showed some correlation with SST.

David Rutan [AS&M] described the development of a global dataset of gridded clear-sky surface-albedo maps on a 1°x1° grid using archived CERES/SARB products. These albedos were derived for clear-sky conditions and spatially averaged into 1°x1° grid boxes. ASCII files of monthly mean maps for a 58-month period were made available to the science community through the web site: *www-cave.larc.nasa.gov/cave/sfc_albedo.html*

Martin Mlynczak [LaRC] presented results from an instrument flown under the Far Infrared Spectroscopy of the Troposphere (FIRST) program. This program was designed for developing and demonstrating capability for measurement of the far-infrared spectrum (15-100 μm) from space. The instrument is a Michelson interferometer (Fourier Transform Spectrometer; 0.625 cm^{-1} resolution) and was flown on a high-altitude balloon from Fort Sumner, NM, on June 7, 2005. It recorded 15000 interferograms during 5.5 hours of flight. Mlynczak showed several spectra recorded by the instrument and compared them with reference line-by-line computations.

Ferenc Miskolczi [AS&M] presented a methodology for converting Atmospheric InfraRed Sounder (AIRS) measurements into CERES window-channel radiances.

Steven DeWitte [Royal Meteorological Institute of Belgium (RMIB)] presented comparisons between GERB and CERES radiances and fluxes in both reflected SW and emitted LW regions working toward a release of GERB data. GERB Version-999 data reprocessed with new spectral response function and empirical ADM corrections, and CERES data from FM-2 (Terra) and FM-3 (Aqua) for June-July 2004 were used in the comparisons. Reflected solar fluxes for GERB were found to be 6% higher than CERES values, while net GERB fluxes were about 2 W/m^2 higher. Larger differences were found over deserts and sunglint affected areas.

Pamela Mlynczak [SAIC] showed comparisons between CERES *Edition-2* Revision-1 ES8 and GERB Version-001 unfiltered SW and LW radiances matched in space, time, and angles. CERES data were compared to each GERB detector so that CERES served as transfer radiometer to compare GERB detectors to one another. Those detectors showed a variability of ±2% among them. For Version-001 data, the GERB/CERES ratio for SW radiances was 0.95 ±0.02 while that for LW radiances was 1.00±0.01.

Almudena Velazquez [University of Valencia, Spain] presented results of a study in which clear-sky SW and LW radiances and fluxes computed with radiative transfer models were compared with CERES observations over Valencia Anchor Station in Spain. Meteorological and other inputs to the models were taken mostly from surface-based measurements. Models and procedures validated in this study will eventually be used for validating GERB products at high spatial resolution.

Xiquan Dong [University of North Dakota] presented a comparative study of the radiation budget of deep convective systems (DCS) over ARM SGP and Tropical Western Pacific (TWP) Manus and Nauru sites. Both Terra and Aqua data were analyzed to observe diurnal effects. A total of 229 cases over the TWP sites and 182 cases over the SGP site were examined. Dong also compared Terra and Aqua results with a number of simulations with the Fu-Liou code. Comparison of Terra and Aqua results showed no significant diurnal effects. Atmospheric-column absorption was found to be slightly higher in the tropics than in the mid-latitudes.

Christos Mitas [University of Miami] presented a study of the decadal variability of the tropical TOA radiation budget, based on 15 years of Earth Radiation Budget Experiment (ERBE) data from the Earth Radiation Budget Satellite. Trends and spatial patterns in satellite data were compared with several sets of simulations from the Geophysical Fluid Dynamics Laboratory (GFDL) GCM. These include the Atmospheric Model Intercomparison Project (AMIP) simulations, the 20th Century simulation (20C3M), and the SRES simulation for 21st Century. Results showed that AMIP and 20C3M did not reproduce the observed trends of 1985-1999 but long-term trends were observable in GCM results forced by greenhouse gases only.

Moguo Sun [State University of New York, Stony Brook] presented a study of changes in the two-dimensional cloud structure and associated radiative effects over the western and eastern tropical Pacific Ocean during the 1998 El Niño based on CERES Tropical Rainfall Measuring Mission (TRMM) SSF data for

January-August 1998. Results showed that high clouds played a dominant role throughout the region. During the intense El Niño period, high clouds decreased in the western Pacific and increased in the eastern Pacific. Their radiative effects changed accordingly. The situation was reversed as El Niño subsided.

Hai-Tien Lee [University of Maryland, College Park] presented a 25-year (1979-2003) dataset of outgoing longwave radiation (OLR) recently reconstructed from High-Resolution Infrared Sounder (HIRS) channel radiances from the long series of NOAA polar orbiting satellites. Lee compared the HIRS time series to available ERBE scanner and non-scanner records, and CERES scanner records from TRMM, Terra, and Aqua. He showed good agreement of HIRS data with ERBE and CERES data over the tropics and stability comparable to ERBE non-scanners.

Laura Hinkelman [National Institute of Aerospace (NIA)] presented an overview of the Global Energy and Water-cycle Experiment (GEWEX) Radiative Flux Assessment (RFA) Project initiated for evaluating and validating multiple datasets of surface and TOA radiative fluxes that have become available over the past decades. The RFA project is in the process of collecting radiative flux datasets, assessing their accuracy, and making them available to the science community through a web portal. Surface-based measurements used for validating these products are also being made available. A website for disseminating these datasets is already operational at: *eosweb.larc.nasa.gov/GEWEX-RFA.*

Proposals for *Edition-3* Processing

Working Group chairs proposed improvements and changes to their respective processing systems based on the experience gained to date and the newly available databases and algorithms.

- **Kory Priestley** [LaRC] proposed to account for the temporally varying spectral darkening of the SW channel among other things.
- **Patrick Minnis** [LaRC] proposed several improvements to the cloud algorithm including detection and retrieval at high spatial resolution and for multiple layers. He suggested that *Edition-3* transition coincide with the start of MODIS *Collection-5* data use.
- **Norman Loeb** [AU] proposed to explore the use of fine-mode fraction in the development of new clear oceans ADMs.
- **David Kratz** [LaRC] proposed to make use of newer climatological ancillary databases in the computation of surface fluxes and add the Zhou-Cess LW algorithm to SSF processing.
- **Tom Charlock** [LaRC] proposed to make modifications to the IGBP surface-type map to remedy known deficiencies, enhance the Fu-Liou code by splitting up the 0.7- to 1.3-μm region into several bands, and account for the small variation of solar constant over an 11-year solar cycle.
- **David Doelling** [AS&M] proposed to produce SRBAVG daily averages on both universal and local time bases, provide SRBAVG cloud products in ISCCP-D2-type format, and provide specialized datasets for outside users.

Bruce Wielicki presented a schedule for the proposed changes and time estimates of when the various new products may become available.

SARB Working Group

Zhonghai Jin [AS&M] presented results on the effects of ocean-surface roughness on radiative transfer in the ocean and the atmosphere derived from a coupled ocean-atmosphere radiative-transfer model. Ocean-surface roughness showed a significant effect on radiation fields in the atmosphere and the ocean. Sunglint-pattern broadens and ocean surface albedo decreases with increasing wind speed or roughness. These effects depend on wavelength and solar elevation.

Ellsworth Dutton [Climate Monitoring and Diagnostic Laboratory (CMDL)/NOAA] presented a 30-year record of surface solar irradiance data from five ground-based radiometric sites operated by the CMDL looking for evidence of global dimming. These sites cover very diverse climate regimes and were shown to be representative of about 25% of the globe on an interannual basis. Dutton showed that these 30-year datasets show a dimming before 1990 followed by a brightening during the 1990s, but no further brightening after 2000.

Wenying Su [HU] discussed a method for deriving PAR, solar radiation in the 400-700 nm range, as part of SARB processing. She defined FPAR (the Fraction of PAR absorbed by vegetation) and reviewed available sources of both Photosynthetically Active Radiation (PAR) and FPAR. In SARB processing, PAR will be computed by summing fluxes over four Fu-Liou bands and spectrally adjusting those near the boundaries of the range. PAR may become a part of SARB output in *Edition-3* processing.

Cloud Working Group

Bing Lin (LaRC) presented results from a study on scale dependence of the relationship between tropical thin cirrus and SST. Lin showed that area coverage of thin cirrus had a negative correlation with DCS over small spatial and temporal scales and a positive correlation over large scales. The variation of thin cirrus with SST was small except over DCS. Lin concluded that climate-feedback mechanisms for thin cirrus and DCS are very different.

Patrick Minnis [LaRC] discussed the biases in cloud optical depth, droplet radius, and ice particle diameter found in both GOES-10 and GOES-12 (GOES is the Geostationary Operational Environmental Satellite) retrievals, possibly related to scattering angle. Similar biases are present also in CERES-MODIS cloud retrievals and get worse with increasing solar zenith angle. Further investigations to verify these biases are underway and, if confirmed, warnings will be added to the Data Quality Summaries.

Inversion/ADM Working Group

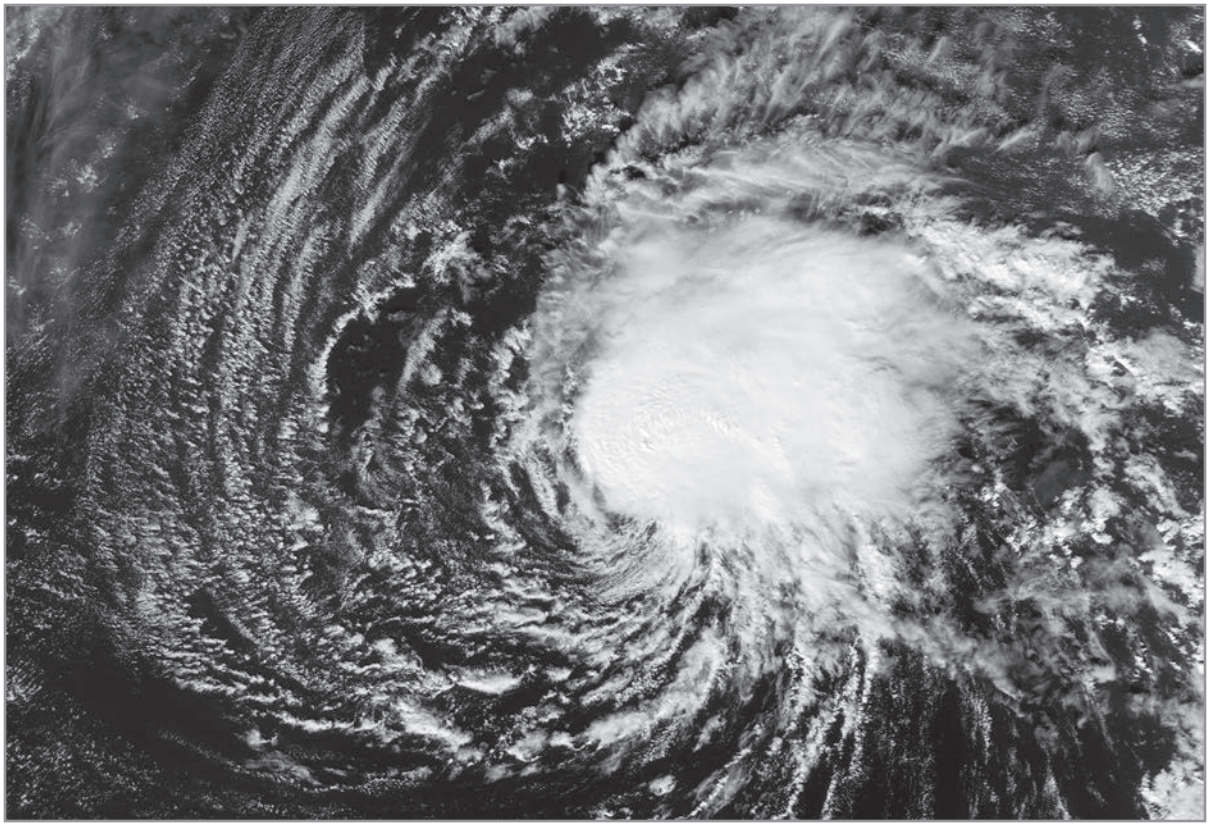
Wenbo Sun [HU] introduced a new merged dataset of CERES, MISR, and MODIS data for studying the relative calibration stability of these instruments and for CERES-MISR anisotropy studies. Sun plans to compare CERES and MISR broadband albedos and utilize the multiangle CERES-MISR-MODIS dataset to diagnose any differences between the two products.

Nitchie Manalo-Smith [AS&M] presented results from a study comparing Terra and Aqua crosstrack and rotating azimuth plane (RAP) LW TOA fluxes. She showed that Terra daytime flux differences were generally positive over land and negative over ocean and nighttime differences were positive everywhere. Aqua daytime flux differences were negative in January and positive in October, and nighttime differences were small for both months.

Seiji Kato [HU] used CERES SSF data to compare near-simultaneous CERES Terra and Aqua TOA radiances and fluxes for fresh snow, permanent snow, and sea-ice between 60°N-75°N. He showed that FM-1 SW radiances are 1.4% higher than FM-4, and FM-1 LW radiances are 0.8% lower during daytime, and 0.3% lower during nighttime than FM-4. Kato corrected for these differences and showed comparisons of FM-1 and FM-4 mean daily instantaneous TOA fluxes.

Konstantin Loukachine [SAIC] presented results of CERES Terra and Aqua instantaneous TOA flux consistency tests. The relative consistency of near-nadir and oblique view SW TOA fluxes over ocean is between 4% and 6% for land, and between 7% and 8% for polar regions. In the LW, the TOA flux consistency is generally between 2% and 4%. Overall, the uncertainty in CERES Terra and Aqua TOA fluxes is consistent: 10-15 W/m^2 for SW; 5-10 W/m^2 for LW. ■

December 30, 2005, saw an unexpected addition to the year's weather events: Tropical Storm Zeta. The Moderate Resolution Imaging Spectroradiometer (MODIS) flying onboard the Aqua satellite captured this image several days later on January 2, 2006, at 16:05 UTC (roughly 11:05 a.m. EST). At that time, Zeta had sustained winds of around 82 kilometers per hour (52 miles per hour), a steady strength the storm had maintained for several days without relenting. NASA image created by Jesse Allen, Earth Observatory, using data obtained courtesy of the MODIS Rapid Response T eam.



EOSDIS In The News

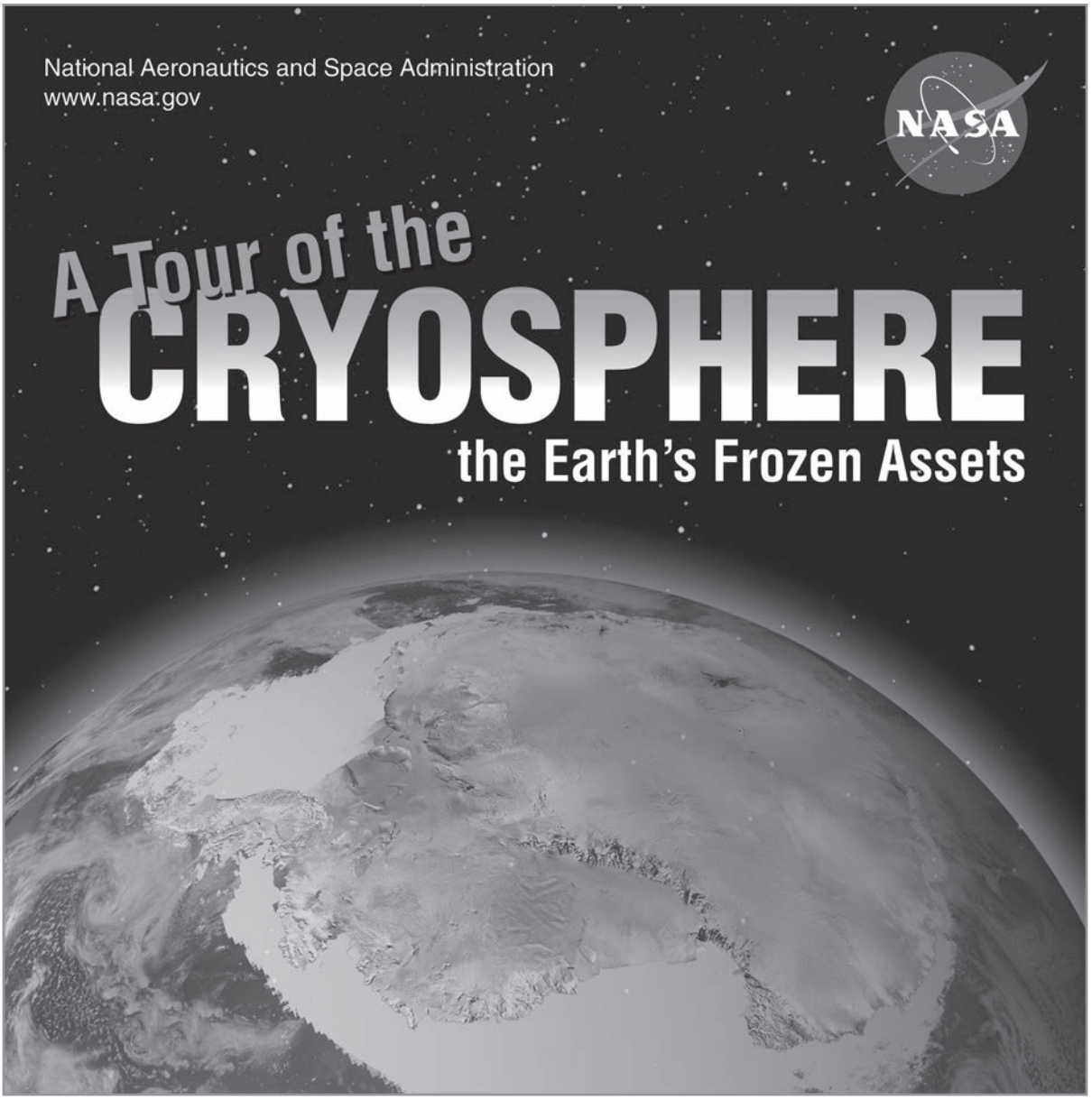
Jennifer Brennan, jennifer.brennan@gst.com, NASA Goddard Space Flight Center, ESDIS

Tour of the Cryosphere DVD Released

NASA Earth Observing System Data and Information System (EOSDIS) is pleased to announce the release of the *Tour of the Cryosphere* DVD. This high-resolution multi-media outreach product was unveiled during this year's Fall American Geophysical Union (AGU) meeting, held in San Franciso, CA December 5-9, 2005. The 8-minute feature animation takes the viewer on a tour of the cryosphere as it exists around the world. From shrinking Arctic sea ice to retreating glaciers and collapsing Antarctic ice shelves, this unique global view of cryospheric research is shown with state-of-the-art Earth-observing-satellite data animations. The animation also highlights the scientific importance of continued collection of this kind of data and how NASA Earth observing satellites are providing scientists with unparalleled insight into how the cryosphere behaves, how it is changing, and what implications these changes have for the Earth's interrelated systems.

Three separate press/media special events were planned around this product: a special media briefing on Tuesday, December 6, a private Geophysical Information for Teachers (GIFT) workshop viewing on Wednesday, December 7, and a screening made open to all Fall

A Tour of the Cryosphere takes viewers on a tour of the cryosphere as it exists around the world, from shrinking Arctic sea ice to retreating glaciers and collapsing Antarctic ice shelves.



AGU conference participants on Thursday, December 8, 2005. The NASA home page featured this product as the "Top Story" during the week of December 5-9. Many local media outlets picked up the story with Discovery Channel Online featuring a video and news brief on December 20, 2005.

This multimedia product was sponsored by the NASA Goddard Space Flight Center (GSFC) Earth Science Data and Information System (ESDIS) Science Operations Office (SOO), and represents a collaborative effort between the NASA EOSDIS Outreach Team at GSFC, The National Snow and Ice Data Center, NASA GSFC's Cryospheric Sciences Branch, and the Scientific Visualization Studio (SVS), located at NASA GSFC. The animation is available in multiple resolution formats at *svs.gsfc.nasa.gov*. For animation or DVD inquiries, please contact *outreach@eos.nasa.gov*

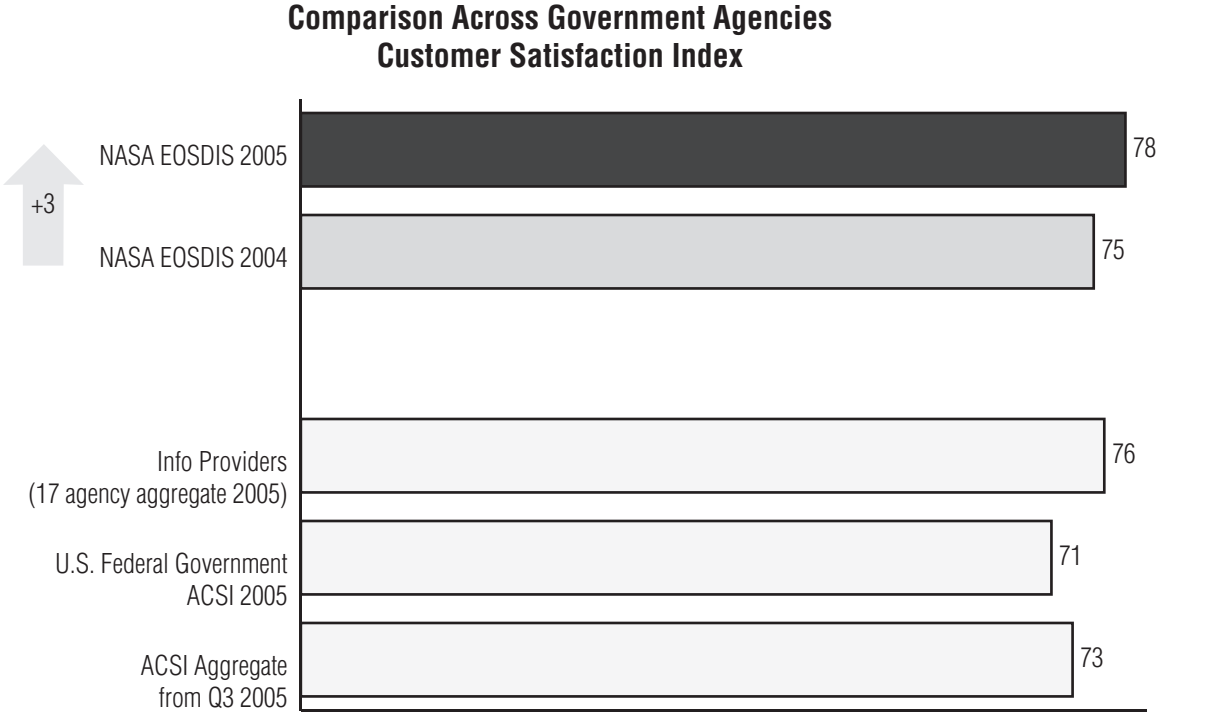
American Customer Satisfaction Index for Earth Observing System Data and Information System Released

On December 15, the 2005 Federal Government American Customer Satisfaction Index (ACSI) scores were released. The ACSI is the top-ranked national economic indicator of customer satisfaction. Claes Fornell International (CFI) under contract with the Department of Treasury's Federal Consulting Group has conducted surveys for over 70 Federal agencies. EOSDIS is among the 136 Federal programs and services rated for 2005.

The EOSDIS score is based on the completed responses from 1,263 users of EOSDIS data centers. Although both private sector and the Federal aggregate scores for 2005 were lower than in 2004, the overall satisfaction score for EOSDIS significantly increased from 75 in 2004 to 78 in 2005. There was a significant score increase in both respondents' likelihood to recommend the specific data center and to use services provided by the data center in the future. The scores for ESDIS for both 2004 and 2005 are significantly higher than the aggregated Federal scores (72.1 for 2004 and 71.3 for 2005).

The ESDIS Project, Code 423, manages the EOSDIS through data centers at Goddard Space Flight Center, Jet Propulsion Laboratory, Langley Research Center, Marshall Space Flight Center, Department of Energy, U.S. Geological Survey, Columbia University, University of Alaska, and University of Colorado. EOSDIS systems manage over four petabytes of data. There were more than 2.7 million accesses by almost 200,000 distinct users during 2005.

The purpose of conducting the ACSI survey is to help EOSDIS and its data centers assess current status, analyze customer needs, and improve future services. Results of the ACSI are among the reports satisfying the requirement set by the President's Management Agenda and the Government Performance and Results Act. ESDIS thanks the user community for taking the time to respond to and include comments in the surveys. ■



NASA Satellites Yield Best-Ever Antarctic Maps

Rob Gutro, rgutro@pop900.gsfc.nasa.gov, NASA Goddard Space Flight Center

Scientists using satellite data have now created the most detailed maps ever produced of the vast snow-covered Antarctic continent. The maps reveal unprecedented views of surface features that provide clues to how and why the continent's massive ice sheets and glaciers are changing.

Researchers can now decipher the intricate history of ice movements in the just-released *Mosaic of Antarctica*, which uses images from the Moderate Resolution Imaging Spectrometer onboard NASA's Terra and Aqua satellites. The map is the result of a partnership between NASA's Goddard Space Flight Center, Greenbelt, Md.; the University of Colorado's National Snow and Ice Data Center (NSIDC), Boulder; and the University of New Hampshire, Durham.

A second map to be released early next year will provide the most complete and accurate topographical survey of the continent ever undertaken, with more than 65 million points surveyed from space by the Geoscience Laser Altimeter System orbiting on NASA's Ice, Cloud and Land Elevation Satellite (ICESat). This *digital elevation model* produced at Goddard will be distributed by NSIDC in a format compatible with the Mosaic map.

"The Antarctic Mosaic shows a lot of very subtle changes in the slope of the terrain that you cannot see from the ground," says **Robert Bindschadler**, chief scientist of Goddard's Hydrospheric and Biospheric Sciences Laboratory. "These subtle variations are important because they tell us the direction the ice is flowing now and they indicate where it has gone in the past. The surface roughness also tells us about the bed underneath the ice and whether the ice is sliding over the bed or frozen to it."

"The map will very likely reveal unseen features and new opportunities for exploration," Bindschadler said. "Antarctica is a big place, and there is still an awful lot of the ice sheet that hasn't been explored." The new map will be used by researchers to identify interesting areas and plan expeditions to investigate them.

The Mosaic removes the terrain distortion and produces a more-accurate and natural-looking view of the continent and its very subtle surface features. "Using the Mosaic map together with the Canadian satellite, RADARSAT, is a real breakthrough," says **Ted Scambos**, one of the creators of the Mosaic at NSIDC. "The Mosaic shows the snow and rock surface almost perfectly, and RADARSAT reveals some of the features below the snow. It's very informative."

The ICESat topographic map complements the Mosaic's detailed views of the surface with elevation measurements over more of the continent than has ever been surveyed before. Although the very center of Antarctica remains unmapped because the satellite does not fly directly over the pole, more of the interior of the continent was mapped and in unprecedented detail.

"This is the most accurate elevation map of the ice sheet ever produced," says **Jay Zwally**, ICESat Project Scientist at Goddard. "And it will get even better as ICESat continues to acquire more elevation data for studying changes in the ice-sheet volume."

The precision of the ICESat map is more than 10 times better than previous satellite surveys due to the very narrow beam of the laser altimeter instrument compared to the broader beam of radar instruments flown before. The improved mapping of the height of the ice sheet, particularly in the interior of the continent, yields new information about how the topography of this remote area drives the flow of interior ice streams. Key areas such as the major ice streams feeding the Ross Ice Shelf are seen in detail for the first time.

Both maps will be distributed by NSIDC, which serves as one of eight Distributed Active Archive Centers funded by NASA to archive and distribute data from NASA's past and current satellite and field measurement programs. The Mosaic map is available through a user-friendly zoom-in Web interface that brings together previous maps, such as those from RADARSAT, with new data in different contrast settings that draw out hard-to-see features. The NASA-funded interface was developed at the University of New Hampshire by Mark Fahnestock and Norman Vine. ■

Erratum

The article titled **Global Land Ice Measurements from Space**, *The Earth Observer, Vol. 17, Issue 6*, pp 5-6, was written by Jeffrey S. Kargel, University of Arizona, *kargel@hwr.arizona.edu*, rather than Mike Abrams. *The Earth Observer* staff regrets this error.

NASA's Aura Satellite Peers Into Earth's Ozone Hole

Rob Gutro, rgutro@pop900.gsfc.nasa.gov, NASA Goddard Space Flight Center

NASA researchers, using data from the agency's Aura satellite, determined that the seasonal ozone hole that developed over Antarctica this year is smaller than in previous years.

NASA's 2005 assessment of the size and thickness of the ozone layer was the first based on observations from the Ozone Monitoring Instrument (OMI) on the agency's Aura spacecraft. Aura was launched in 2004.

This year's ozone hole measured 9.4-million square miles at its peak between September and mid-October, which was slightly larger than last year's peak. The largest ozone hole ever recorded occurred in 1998, averaging 10.1 million square miles. For 10 of the past 12 years, the Antarctic ozone hole has been larger than 7.7-million square miles. Before 1985, it measured less than 4-million square miles.

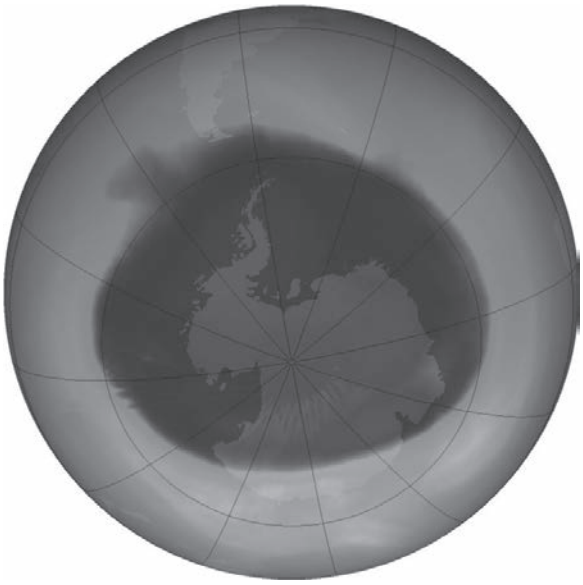
The protective ozone layer over Antarctica annually undergoes a seasonal change, but since the first satellite measurements in 1979, the ozone hole has gotten larger. Human-produced chlorine and bromine chemicals can lead to the destruction of ozone in the stratosphere. By international agreement, these damaging chemicals were banned in 1995, and their levels in the atmosphere are decreasing.

Another important factor in how much ozone is destroyed each year is the temperature of the air high in the atmosphere. As with temperatures on the ground, some years are colder than others. When it's colder in the stratosphere, more ozone is destroyed. The 2005 ozone hole was approximately 386,000 square miles larger than it would have been in a year with normal temperatures, because it was colder than average. Only twice in the last decade has the ozone hole shrunk to the size it typically was in the late 1980s. Those years, 2002 and 2004, were the warmest of the period.

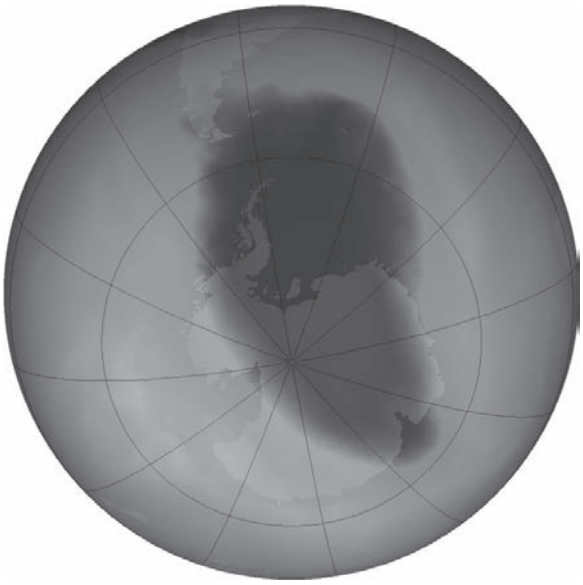
Scientists also monitor how much ozone there is in the atmosphere from the ground to space. The thickness of the Antarctic ozone layer was the third highest of the last decade, as measured by the lowest reading recorded during the year. The level was 102 Dobson Units (the system of measurement designated to gauge ozone thickness). That is approximately one-half as thick as the layer before 1980 during the same time of year.

OMI is the latest in a series of ozone-observing instruments flown by NASA over the last two decades. This instrument provides a more-detailed view of ozone and is also able to monitor chemicals involved in ozone destruction. The instrument is a contribution to the mission from the Netherlands' Agency for Aerospace Programs in collaboration with the Finnish Meteorological Institute. The Royal Netherlands Meteorological Institute is the principal investigator on the instrument. ■

The annual "ozone hole" over Antarctica this year reached its largest area on September 11. Observations are from the Ozone Monitoring Instrument on NASA's Aura satellite, launched in 2004.



The 2005 Antarctic ozone hole was breaking up and shrinking on November 8 when these observations were made by NASA's Aura satellite. The region of low ozone moved over the tip of South America.



EOS Scientists in the News

Rob Gutro, rgutro@pop900.gsfc.nasa.gov, NASA Earth Science News Team
Stephen Cole, scole@pop600.gsfc.nasa.gov, NASA Earth Science News Team

NASA's GRACE Finds Greenland Melting Faster, 'Sees' Sumatra Quake, December 20; *Oakland Tribune, Tri-Valley Herald* (CA), *SpaceWire.com*, *Universe Today*. Scientists including **Victor Zlotinicki** (NASA JPL) use data from the Gravity Recovery and Climate Experiment (GRACE) satellite to measure a significant decrease in the mass of the Greenland ice cap and study how the 2004 Sumatra earthquake affected Earth's gravity field.

NASA Responds to Coral Bleaching In Caribbean, December 19; *Yahoo News*, *SpaceRef.com*, *Kansas City InfoZine*. Responding to a recent coral bleaching event in the Caribbean, a team of scientists led by **Liane Guild** (NASA ARC) seeks to better understand and be able to predict the future health of the reef using AVIRIS data and field measurements.

Video Technique Enhances Public Safety, December 15; *CNN Headline News (The Nancy Grace Show)*. **David Hathaway** (NASA MSFC) discusses how MSFC video enhancement and the VISAR team assisted local, state and federal law enforcement agencies by enhancing video from past crime scenes.

Temperature Trends Data, December 14; *ABC News*, The Wall Street Journal. Recent research including that conducted by **Reto Ruedy** (NASA GISS) show that 2005 is likely to be the warmest on record.

Seeing Into the Past, December 13; *Space Daily*, *Science Daily*. With new technology and digital imaging, scientists including **Gregory Bearman** (NASA JPL) are gaining more clues about the Dead Sea Scrolls.

The Psychology of Global Warming: Alarmist versus Alarming, December 8; *ABC News*, *Los Angeles Times*. In a talk at the American Geophysical Union meeting, **James Hansen** (NASA GISS) discusses the need to reduce growth in greenhouse warming over the next 10 years.

NASA Satellite Eyes Atmosphere to Improve Pollution and Climate Forecasting, December 8; *BBC*, *New Scientist*. Scientists including **Mark Schoeberl** (NASA GSFC) and **Duane Waliser** (NASA JPL) are now measuring local and regional air pollution thanks to the latest sophisticated, satellite-based instruments onboard Aura.

A Tour of the Cryosphere: Earth's Frozen Assets, December 6; *Terra Daily*, *Space Daily*, *ZDNet*. In an online visual tour, NASA scientists, including **Waleed Abdalati** (NASA GSFC) present dramatic images on the icy reaches of Antarctica, the drifting expanse of polar sea ice, the shrinking cap around the North Pole and more.

NASA's Aura Satellite Peers into Earth's Ozone Hole, December 6; *Science Daily*, *PhysOrg.com*, *BBS News*, *Innovations Report* (Germany). NASA researchers, including **Paul Newman** (NASA GSFC) used data from the Aura satellite and found that the seasonal ozone hole that developed over Antarctica this year is smaller than in previous years.

NASA, NSF Create Unprecedented View of Upper Atmosphere, December 5; *USA Today*, *KeralaNex* (India), *PhysOrg.com*. Scientists from NASA and the National Science Foundation, including **Barbara Giles** (NASA HQ) and **Tony Mannuci** (NASA JPL) discover a way to combine ground and space observations to create an unprecedented view of upper atmosphere disturbances during space storms.

Ozone Hole: Prospects for Recovery, December 5; *Associated Press*, *ABC News*, *The New York Times*, *BBC*, *Nature*. At the American Geophysical Union meeting, **Paul Newman** (NASA GSFC) discusses the chemical and atmospheric processes affecting the size and structure of the ozone hole.

NASA: Best Maps for that Antarctic Vacation? December 5; *Anchorage Daily News*, *CNN*, *SpaceRef.com*. Thanks to satellites, NASA has the best maps to help researchers, including **Robert Bindschadler** (NASA GSFC) and **Jay Zwally** (NASA GSFC), get a detailed look at surface features on the continent.

Scientists Say Slower Atlantic Currents Could Mean a Colder Europe, December 1; *The New York Times*. **Gavin Schmidt** (NASA GISS) comments on how changing currents in the Atlantic Ocean might cool parts of western Europe, including the United Kingdom, over the next 50 years.

Science in the Web Age: Joint Efforts, December 1; *Nature* magazine. An article on the growth of the Web and technology in the science arena quotes **Gavin**

Schmidt (NASA GISS) about blogs and other tools to keep up with developments.

Unusual Weather and Relation to Climate, November 27; *CBS Evening News*. **Drew Shindell** (NASA GISS) appeared for a story on the topic of unusual weather and its potential relation to climate.

Warriors and Heroes, November 3; *Rolling Stone* magazine, *Fox News*. **James Hansen** (NASA GISS) is the focus of a story called "The Paul Revere" of climate warming.

NASA to Fly Into Portal to the Stratosphere, January 19; *Associated Press, United Press International*. **Paul Newman** (NASA GSFC) and **Eric Jensen** (NASA ARC) are leading an airborne field experiment to a tropical locale to take a close look at a largely unexplored region of the chilly upper atmosphere that is critical to the recovery of the ozone layer and predicting future climate change.

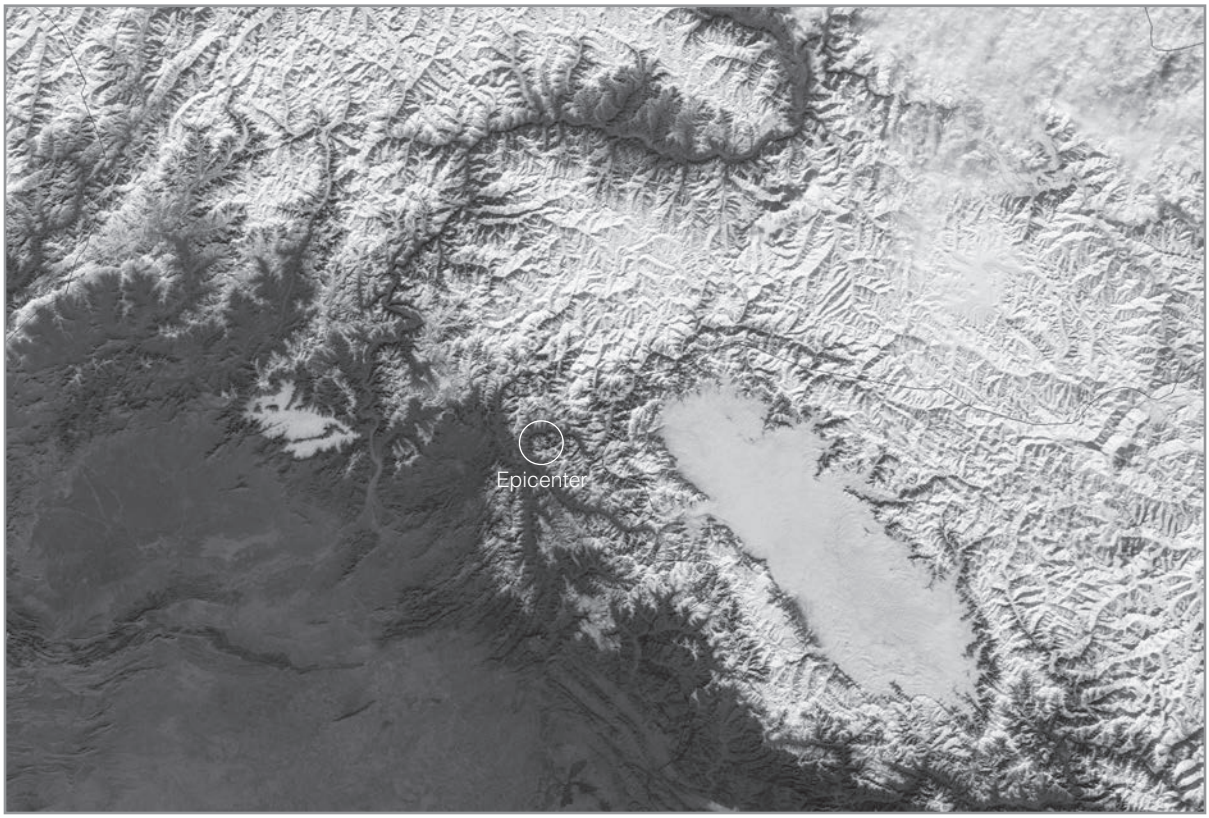
Space Probes Detect Enormous Natural Particle Accelerator, January 11; *Science Daily, SpaceRef.com, PhysOrg.com*. A fleet of NASA and European Space Agency space-weather probes developed by a team of scientists including **Ronald Lepping** (NASA GSFC) has observed an immense jet of electrically charged particles in the solar wind between the Sun and Earth.

NASA's TOPEX/Poseidon Oceanography Mission Ends, January 5; **Science Daily, Terra Daily**. The TOPEX/Poseidon oceanography satellite ceased operations after nearly 62,000 orbits of Earth, reported project scientist **Lee-Lueng Fu** (NASA JPL).

Health of the Chesapeake Bay, November 15; *WTOP-AM Newsradio* (Washington DC). **Ron Vogel** (NASA GSFC) discusses how NASA satellite data is used to monitor the bay.

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

On October 8, 2005, a large earthquake shook the mountainous Kashmir region near the border of Pakistan and India. Tens of thousands of people died, and many more were isolated in the mountains by damage to roads and bridges as well as by landslides. This image from the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Aqua satellite shows snow highlighting the ridges and ravines in the mountains northeast of the city of Islamabad on January 6. NASA image created by Jesse Allen, Earth Observatory, using data obtained courtesy of the MODIS Rapid Response Team.



NASA Science Mission Directorate – Science Education Update

Ming-Ying Wei, mwei@hq.nasa.gov, NASA Headquarters
Theresa Schwerin, theresa_schwerin@strategies.org, IGES

NASA Earth Science Education Roadmap

NASA's draft Earth Science Education Roadmap will be released in January 2006 for community comment. The roadmap is a 10-year plan that will guide the NASA Earth science education program and ensure that future generations of Earth explorers have the knowledge and ability required to understand and protect our home planet and contribute to NASA's Vision for Space Exploration. The document will be available on the Community Roadmap Website at *eo.ucar.edu/roadmap*.

Graduate Student Summer Program in Earth System Science
Application Deadline: February 28, 2006

NASA Goddard Space Flight Center in collaboration with the Goddard Earth Sciences and Technology (GEST) Center of the University of Maryland Baltimore County, offers a limited number of graduate student research opportunities during the summer. The 2006 program will be held June 5 to August 11, and is designed to stimulate interest in interdisciplinary Earth science studies by enabling selected students to carry out an intensive research project at GSFC, which can be applied to the student's graduate thesis.

The ten-week program is designed for students interested in any Earth system science conducive to the research of NASA GSFC in Greenbelt, MD, as well as oceanography and instrumentation research on coastal-zone processes at NASA's Wallops Flight Facility (WFF) on the Eastern Shore of Virginia. Each student is teamed with a NASA scientist mentor.

The program begins with an introductory lecture series. Students will be expected to participate in the introductory lecture series, and produce final oral and written reports on their summer research activities at the end of the program. For more information, go to *gest.umbc.edu/student_opp/2006_gssp.html*.

Educator Workshop—NASA Satellites Study Earth's Atmosphere: CALIPSO, CloudSat and Aura Partner with the GLOBE Program
Applications due March 10, 2006

CALIPSO, CloudSat, and Aura are three satellite missions that will provide students worldwide with a link to NASA research through their Education and Outreach programs. These satellites will be part of a formation of satellites called the Afternoon Constellation (because they cross the equator within minutes of each other at 1:30 p.m. local time), and are also known as the *A-Train*. The *A-Train* satellites will fly in close proximity, providing combined, detailed observations about the condition of Earth and assisting scientists with making predictions related to climate change.

This educator workshop will be held July 9-15, 2006, in Hampton, Virginia. It will primarily target middle-school educators, who will work with the missions by involving their students in collecting and reporting cloud observations and sun-photometer data at the GLOBE Program website. Participants will receive both a stipend and travel expenses. Support will also be provided for participants to present at regional workshops. Applications are due March 10, 2006 and are available at: *calipsooutreach.hamptonu.edu/va2006.html*.

Vertical Mentoring Workshop for the Blind in Science, Technology, Engineering, and Mathematics
July 26-28, 2006, University of Washington, Seattle

The National Federation of the Blind (NFB)/Jernigan Institute, through the National Center for Blind Youth in Science, is supporting a Vertical Mentoring Workshop for the Blind (VMWB) in Science, Technology, Engineering, and Mathematics (STEM). This workshop will enhance the career development of high school, undergraduate, and graduate students who are blind and are interested in STEM careers. In addition, blind professionals in STEM careers are encouraged to participate as mentors. The workshop will feature a technology fair highlighting emerging technologies that enhance the participation of the blind in STEM fields. In conjunction with the workshop, the NFB Jernigan Institute will be hosting a one-day workshop for employers to raise awareness and encourage the recruitment and hiring of blind people in STEM careers.

For more information about the workshop and employer's seminar, please visit: *www.cs.washington.edu/vmwb*

NSF Invites Proposal Submissions Related to the GLOBE Program
Proposal Deadline: March 8, 2006

Global Learning and Observations to Benefit the Environment (GLOBE) is a hands-on international education and science program that joins students, educators,

and scientists from around the world in studying Earth systems science. The goals of the GLOBE Program are to improve science education, enhance environmental awareness, and increase understanding of the Earth as a System. GLOBE is an interagency program funded by NASA and NSF, supported by the U.S. Department of State, and implemented through a cooperative agreement between NASA, and the University Corporation for Atmospheric Research in Boulder, Colorado. Since its inception in 1994, GLOBE has grown to include tens of thousands of schools and teachers and over one million students. The new ten-year GLOBE plan, *The Next Generation GLOBE* (NGG; 2005), has identified strengthening connections between the existing GLOBE community and scientists engaged in cutting-edge Earth Systems Science research as a high priority.

In support of this vision, NSF seeks to establish new partnerships between GLOBE program participants and scientists associated with Integrated Earth Systems Science Programs (IESSP), defined as major NSF- or NASA-funded research programs related to Earth systems science. NSF 06-515 solicitation replaces NSF 02-013.

The new GLOBE NSF request for proposals can be accessed at *www.nsf.gov/funding/pgm_summ.jsp?pims_id=5466&org=GEO&from=home*

Education Resources

The following education resources are on topics related to NASA's Earth science program.

Earth & Sky: Observing Earth Radio Shows

Earth & Sky's 90-second radio shows include an Earth science series, with many of the shows featuring NASA research. Listen to the shows online, download to a computer, or subscribe to the Observing Earth Podcast at *www.earthsky.org/shows/observingearth.php*. Following are just a few of the recent NASA-related shows:

Big weather changes from shrinking sea ice?
www.earthsky.org/shows/observingearth.php?date=20051201

Amazon River exhales carbon dioxide
www.earthsky.org/shows/observingearth.php?date=20051103

Are hurricanes becoming more powerful?
www.earthsky.org/shows/observingearth.php?date=20051021

Satellite data aids volcano prediction
www.earthsky.org/shows/observingearth.php?date=20051013

What's New on the NASA Earth Observatory

Mosaic of Antarctica
earthobservatory.nasa.gov/Study/MOA/
Thanks to NASA satellite data, scientists visiting or studying Antarctica after October 2005 have a significantly better map of the continent's surface than they had before. *See the article on page 33 of this issue for more details.*

Amazing Space
amazing-space.stsci.edu
Learn more about our universe by exploring its planets, galaxies, comets, black holes, and more. This site is rich with science content, teaching tools, interactive pages and games for teachers and students of all ages. Be sure to check out the *Myths vs. Reality* section, which addresses misconceptions relating to black holes, comets, stars, and more.

Science and Application News

For the latest NASA Earth science news, visit the NASA Earth Observatory, *earthobservatory.nasa.gov* or Science@NASA, *science.nasa.gov*. Science@NASA stories are also available as podcasts, as well as translated into Spanish at their sister site, Ciencia@NASA, *ciencia.nasa.gov*.

New Models of Weather Pattern
earthobservatory.nasa.gov/Newsroom/MediaAlerts/2005/2005120921159.html
A researcher is using mathematical theory to build a model of the Madden-Julian Oscillation, a tropical weather pattern that influences drought and rainfall in the western United States.

Glacial Pace of Erosion Was Not So Slow, New Technique Shows
earthobservatory.nasa.gov/Newsroom/MediaAlerts/2005/2005120921147.html
Glaciers, rivers, and shifting tectonic plates have shaped mountains over millions of years, but Earth scientists have struggled to understand the relative roles of these forces and the rates at which they work—until now. ■

EOS Science Calendar

February 21-23
Community Workshop on Air Quality Remote Sensing from Space: Defining an Optimum Observing Strategy, Boulder, CO. URL: *www.acd.ucar.edu/Meetings/Air_Quality_Remote_Sensing*. Contact: David Edwards, *edwards@ucar.edu*.

March 7-9
AIRS Science Team Meeting, Pasadena, CA. Contact: George Aumann, *Hartmut.H.Aumann@jpl.nasa.gov.*

March 20
Workshop on Exploring and Using Multi-angle Imaging SpectroRadiometer (MISR) Data (part of the Fourth International Workshop on Multi-angular Measurements and Models [IWMMM-4]), Sydney, Australia. Contact: Nancy Ritchey, *n.a.ritchey@larc.nasa.gov*. URL: *eosweb.larc.nasa.gov/PRODOCS/misr/workshop/*.

May 2-4
5th CERES Science Team Meeting, Williamsburg, VA. Contact Shashi Gupta, *s.k.gupta@larc.nasa.gov*

September 18
Aura Science Team Meeting and Validation Working Group Meeting. Contact: Anne Douglass, *Anne.R.Douglass@nasa.gov*.

Global Change Calendar

February 20-24
2006 AGU Ocean Sciences Meeting, Honolulu, Hawaii. URL: *www.agu.org/meetings/os06/*

March 9-10
Asia GIS 2006 International Conference, Universiti Teknologi Malaysia (UTM) Skudai, Johor, Malaysia.

March 20-24
4th International Workshop on Multiangular Measurements and Models (IWMMM-4), Sydney, Australia.

April 2-7
The European Geosciences Union (EGU) General Assembly, Vienna, Italy. URL: *meetings.copernicus.org/egu2006/.*

May 23-26
2006 AGU Joint Assembly, Baltimore, MD. URL: *www.agu.org/meetings/ja06/*

July 3-6
ISPRS Commission I Symposium, Paris, France. Call for Papers. Email: *isprs2006@colloquium.fr* URL: *www.colloquium.fr/sfpt2006*.

July 12-14
4th IEEE Workshop on Sensor Array and Multi-Channel Processing (SAM), Westin Hotel, Waltham, MA. URL: *www.sam2006.org*.

August 13-17
SPIE's Optics and Photonics 2006: Earth Observing Systems XI (OEI101) Conference, San Diego, CA. URL: *spie.org/conferences/calls/06/op/conferences/index.cfm?fuseaction=OEI101.*

September 25-29
2nd International Symposium on the Recent Advances in Quantitative Remote Sensing, Torrent, Spain. URL: *www.uv.es/raqrs/index.htm*.

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