NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

The Earth Observer. July - August 2006. Volume 18, Issue 4.

The Earth Observer

Editor's Corner

Michael King
EOS Senior Project Scientist

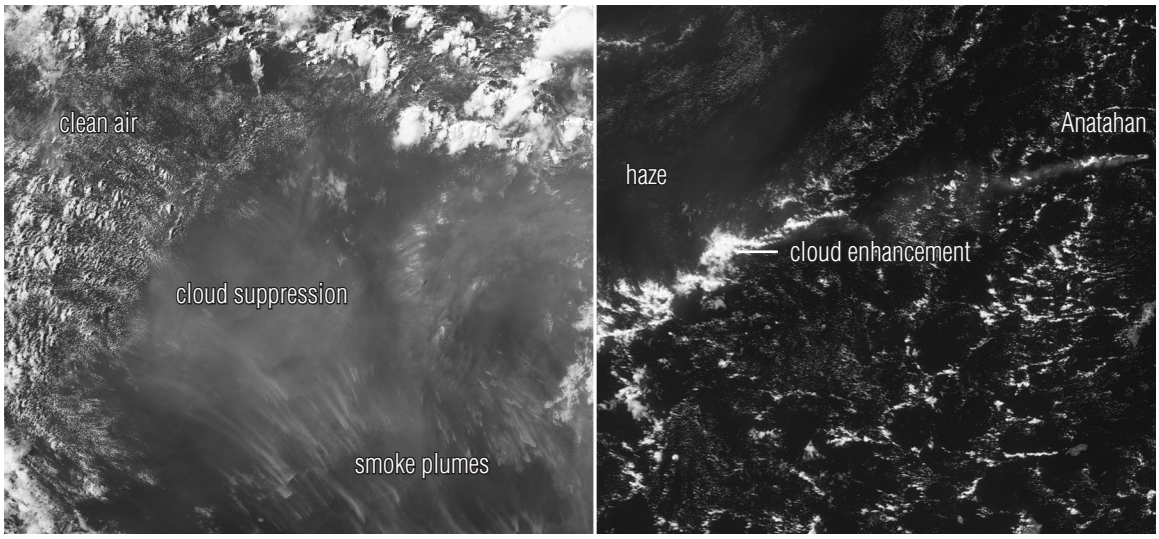
I am pleased to report that, after executing a series of extremely precise maneuvers, both the CloudSat and Cloud Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) satellites are in position in the Afternoon "A-Train" Constellation and *formation flying* has begun. CloudSat and CALIPSO now join Aqua, Aura, and PARASOL in the A-Train, and these missions will work together to provide new insights into the global distribution and evolution of clouds and aerosols to improve weather forecasting and climate prediction. CloudSat flies about a minute behind Aqua in the formation, and precedes CALIPSO by a mere 12.5 (+/- 2.5) seconds.

Even before the two satellites were in place in the A-Train, the first images from each mission were flowing back to Earth, revealing never-before-seen three-dimensional details about clouds and aerosols. Mission managers tested the flight- and ground-system performance of CloudSat's Cloud-Profiling Radar (CPR) in late May, and found it to be working perfectly. Thirty seconds after the radar was activated for the first time, the CPR obtained its first image of a warm front storm in the Norwegian Sea, and a few weeks later CloudSat observed Tropical Storm Alberto as it churned in the Gulf of Mexico.

Meanwhile, the CALIPSO team has been testing out the three instruments onboard the spacecraft—the Infrared Imaging Radiometer (IIR), Wide Field-of-view Camera (WFC), and Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP)—and all three are now active. CALIOP was activated on June 7, and captured a three-dimensional atmospheric profile of an area over eastern Asia, Indonesia, and Australia showing various layers of clouds and aerosols, including what is very likely the remnant of a volcanic plume caused by the eruption of the

continued on page 2

This issue of *The Earth Observer* is dedicated to the memory of Yoram Kaufman, who passed away on May 31 as a result of injuries sustained when his bike was struck by a car near the Goddard Space Flight Center. Kaufman's pioneering research focused primarily on the study of tiny atmospheric particles called aerosols, and how they impact Earth's climate. This pair of images from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensors on NASA's Terra (left) and Aqua (right) illustrates how the amount of sunlight that aerosols absorb affects cloud formation. The image on the left shows clouds and smoke from forest fires in the western Amazon Rainforest on September 17, 2005. Clouds were present in the clear (not smoky) air to the west and north, but the smoke choked off cloud formation across much of the center of the image. Smoke contains dark-colored soot particles that absorb a lot of sunlight. In the image on the right, a plume of aerosols emitted by the eruption of the Anatahan Volcano in the Pacific Ocean on April 5, 2006, has enhanced cloud formation in the middle of the image. Volcanic eruptions contain lots of sulfur dioxide gas, which chemical reactions turn into particles known as sulfates. Sulfates are reflective, absorbing less sunlight.



In This Issue

Soufrière Hills Volcano on the island of Montserrat in the Caribbean on May 20. To view these images as well as more-detailed descriptions, please see the article *First Images From NASA'S CloudSat and CALIPSO Have Scientists Sky-High* in this issue.

Researchers are excited about even more-detailed results that will be available in a few months. **Graeme Stephens**, CloudSat Principal Investigator at Colorado State University says, "We have now begun continuous radar operations, and we look forward to releasing our first validated data to the science community within nine months, hopefully sooner." **David Winker**, CALIPSO PI, added, "With CALIPSO and CloudSat finally in the A-Train, we're eager to begin using these new tools to improve our knowledge of how clouds and aerosols affect our climate." More information on CloudSat and CALIPSO, respectively—including additional images—can be found at: *cloudsat.atmos.colostate.edu* and *www-calipso.larc.nasa.gov.*

In other news, I would like to report that the U.S. Geological Survey's Landsat 5 Flight Operations Anomaly Team has been selected to receive the International Space Ops Award for Outstanding Achievement for 2006. The award is presented for outstanding efforts in overcoming space operations and/or support challenges, and recognizes those teams or individuals whose exceptional contributions were critical to the success of one or more space missions. The citation for the award reads as follows "For dedicated efforts in recovering Landsat 5 from two potentially mission-ending hardware anomalies and restoring the mission to full operations." The award consists of an engraved crystal trophy and certificates for all team members. **Ron Smilek**, the USGS MOC Team Leader, received the award at an AIAA banquet held in Rome, Italy on June 21, in conjunction with the Space Ops 2006 Conference. I tip my hat to the Landsat 5 Team for all of their tireless efforts to keep Landsat 5 operational for over 20 years!

In addition, I wish to congratulate several members of the Atmospheric Infrared Sounder (AIRS) Team who were selected as *NASA Honor Award* recipients for their outstanding achievements. **John Le Marshall** received the Exceptional Achievement Medal for "innovative use of AIRS hyperspectral data in numerical weather prediction models." **Annmarie Eldering** received the Exceptional Scientific Achievement Medal for "achievement in combining data from the Tropospheric Emission Spectrometer on Aura and the Atmospheric Infrared Sounder on Aqua to help in elucidating the physics and chemistry of clouds and aerosols in Earth's atmospheres." The **AIRS Team** (accepted by **Paul Morse,** Director of Engineering for BAE Systems) received the Public Service Group Achievement Award for "the successful design, development, calibration, and continued successful operation of the Atmospheric Infrared Sounder."

As mandated by the Nunn/McCurdy Law, the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Program has recently gone through a recertification process. The Department of Defense Undersecretary for Acquisitions, Technology, and Logistics presented his recommendations to Congress on June 5 with a briefing to Congressional staffers on June 6. The

NASA Administrator, the U.S. Air Force's Undersecretary for Space, and the NOAA Undersecretary for Oceans and Atmospheres testified on June 8 before the House Science Committee concerning the results of the Nunn/McCurdy process. The result of the Nunn/McCurdy-review is a certified but significantly restructured NPOESS program. Witness Testimony and other information is located at *www.house.gov/science/hearings/full06/June%208/*

I'd also like to report that the EOS Project Science Office once again sponsored an *Odyssey of the Mind* long-term problem related to Earth Science for team competitions during the past school year. Members of our outreach team traveled to the Odyssey of the Mind World Finals at Iowa State University in Ames, Iowa to staff a large exhibit and give live electronic theater presentations to the roughly 15,000 students, coaches, parents, officials, and spectators in attendance. For more information, please see the article *NASA Takes Kids on a Jungle Odyssey of the Mind* in this issue.

Finally, it is with deep sadness that I must announce the passing of **Yoram J. Kaufman.** A pioneering climate researcher, Kaufman died on May 31 from injuries he received in a collision with a car while biking near the NASA Goddard campus on May 26.
Kaufman was a highly regarded Senior Fellow in the Goddard Earth-Sun Exploration Division, where he worked from 1979 to 2006 on a number of high-profile NASA missions and research projects in the Earth sciences. From 1997 to 2001, Kaufman served as Project Scientist for the Terra mission, the first of three "flagship" satellites in NASA's Earth Observing System. Kaufman oversaw the scientific aspects of the mission in the critical days leading up to and following Terra's launch. Kaufman also served as Program Manager for NASA's Earth Observatory Website from its original publication date of April 29, 1999, through January 2006. It was his creative genius and leadership that led to the site's conception and establishment.

NASA, EOS, and the entire scientific community have lost an outstanding colleague and friend, and I want to express my deepest sympathy to his wife Jean and to his family. More details concerning his untimely death may be found elsewhere in this issue. ■

Announcement: NASA's *Earth Observatory* Wins Third Webby Award

NASA's *Earth Observatory* is the winner of the 2006 Webby People's Voice Award in Education. Nominations are made by, and winners selected by, the International Academy of the Digital Arts and Sciences. This award honors over a hundred Web sites with the prestigious title of the best on the Web. The winning Webby sites were selected from over 5,500 entries.

The 10th Annual Webby Awards Gala, hosted by **Rob Corddry** of *The Daily Show* with **Jon Stewart**, was held in New York City.

"It is an honor just to be nominated for a Webby Award, but to win our third People's Voice is a thrill," said **David Herring**, *Earth Observatory Program Manager* at NASA's Goddard Space Flight Center, in Greenbelt, MD. "The *Earth Observatory* is an agency-wide team effort. Receiving our third nomination over a 5-year period is a testament to the outstanding people across NASA's Earth Sciences Division—including scientists, data visualizers, science writers, and Web designers—all working together to share NASA's space-based perspective on Earth in ways that are easy to access and understand."

Thomas Friedeman, Pulitzer Prize-winning author and celebrated New York Times columnist; **Mark Cuban**, noted online entrepreneur and owner of the Dallas Mavericks; **the Gorillaz**, the platinum record selling and Grammy-performing music and animation pioneers; **Chris DeWolfe** and **Tom Anderson**, co-founders of MYSpace.com; and **Bill Simmons**, a.k.a. The Sports Guys, noted ESPN.com personality, all were present for the gala.

NASA's *Earth Observatory* is a free publication on the Internet where the public can obtain new satellite imagery and scientific information about our home planet. Topics include Earth's climate and environmental change as well as stories about innovative new ways in which scientists are using satellite data to benefit society.

For more information about NASA's Earth Observatory, visit:
earthobservatory.nasa.gov <http://earthobservatory.nasa.gov>

In Memoriam

Yoram J. Kaufman

1948-2006

With deep sorrow, we must report that our esteemed colleague, **Yoram J. Kaufman,** passed away May 31, from injuries he received in a collision with a car while biking near the NASA Goddard campus on May 26.

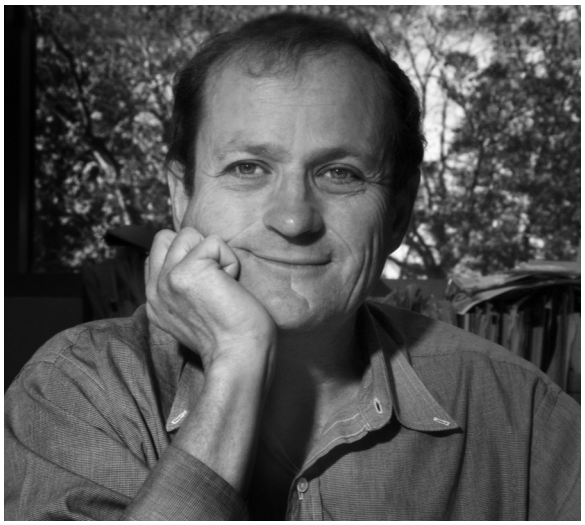


Photo Credit: Chris Gunn

Kaufman, a highly-regarded Senior Fellow in the Goddard Earth-Sun Exploration Division, worked from 1979 to 2006 on a number of high-profile NASA missions and research projects in the Earth sciences. He served as Project Scientist for the Terra mission from 1997 to 2001, and oversaw the science aspects of the mission in the critical days leading up to and following Terra's launch. He was Program Manager for NASA's *Earth Observatory* Website from its inception April 29, 1999, through January 2006. His creative genius and leadership led to the site's conception and award winning reputation.

Kaufman's professional passion was his research on atmospheric *aerosols*, tiny solid and liquid particles in the atmosphere. Aerosols occur naturally—due to wildfires, volcanic eruptions, dust storms, suspended salts from sea spray, and plant respiration—and they are produced by humans—including emissions from cars, factories, biomass burning, and agricultural dust. Aerosols are important because they represent an area of uncertainty within the Earth's climate system. Kaufman's research contributed greatly to scientists' understanding of the myriad roles of aerosols in the climate system. "Aerosols are a 'wild card'," Kaufman once explained. "They are hard to predict because they act like 'double' agents in the system."

Teams for the MISR, CERES, and MODIS instruments did not record data for a full minute on June 4, as NASA's Terra and Aqua satellites flew over Goddard Space Flight Center in Greenbelt, MD. Likewise, the Polarization and Directionality of the Earth's Reflectances (POLDER) instrument aboard the French Centre National d'Etudes Spatiale's (CNES) Polarization and Anisotropy of Reflectances for Atmospheric Sciences coupled with Observations from a Lidar (PARASOL) satellite, and a global network of upward-looking sensors (called sun photometers) within NASA's Aerosol Robotic Network (AERONET) remained inactive during that same span. Each of these instruments observed a moment of data "silence" in honor of Kaufman.

Kaufman will be remembered as a brilliant scientist, a charismatic leader, and a positive influence within NASA. He collaborated with many scientists around the world in helping to advance our understanding of Earth's climate system. In the days before his untimely death, Kaufman was not yet aware that he had been selected by the American Meteorological Society to receive its prestigious Verner E. Suomi Award, which is granted to one individual each year in recognition of highly significant technological achievement in the atmospheric (or related) sciences.

Perhaps our best tribute to Kaufman would be to continue the research he started. The CloudSat and Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) missions launched on April 28 will do just that, greatly expanding our understanding of clouds and aerosols, and how they impact Earth's climate.

There was a memorial service for Kaufman on June 4 at Goddard that was well attended and very moving. *The Earth Observatory's* Image of the Day on June 6 was a tribute to Kaufman and can be seen at earthobservatory.nasa.gov/Newsroom/NewImages/images.php3?img_id=17298.

The Earth Observer staff and the Earth-Sun Exploration Division at NASA Goddard Space Flight Center extends their condolences to his wife Jean, his son Nadav, and his daughter Daphne, and dedicates this issue to his memory. We are deeply saddened to lose a valued friend, mentor, and leader, and we are proud of Kaufman's considerable accomplishments. ■

First Images From NASA'S CloudSat and CALIPSO Have Scientists Sky-High

Alan Buis, NASA Jet Propulsion Laboratory, alan.buis@jpl.nasa.gov
Chris Rink, NASA Langley, c.p.rink@larc.nasa.gov
Katie Lorentz, NASA Langley, k.e.lorentz@larc.nasa.gov
Alan Ward, Goddard Space Flight Center, award@sesda2.com

Introduction

The CloudSat and the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) satellites were launched April 28 from Vandenberg Air Force Base, CA. Both satellites will orbit 705 km (438 mi) above Earth as part of NASA's "A-Train" constellation of five Earth observing satellites—four NASA missions plus a French mission. The A-Train satellites will work together to provide new insights into the global distribution and evolution of clouds to improve weather forecasting and climate prediction.

After a series of extremely precise maneuvers, as of June 15, CloudSat and CALIPSO are in position in the A-Train and *formation flying* has begun. CloudSat is in front of CALIPSO by a mere 12.5 (+/- 2.5) sec. Even before the two satellites were in place, the first images from each mission were flowing back to Earth, revealing never-before-seen three-dimensional details about clouds and aerosols. Researchers are excited about even more-detailed results that will be available in a few months.

*"We're seeing the atmosphere as we've never seen it before. We're no longer looking at clouds like images on a flat piece of paper, but instead we're peering into the clouds and seeing their layered complexity." —**Deborah Vane** [Jet Propulsion Laboratory—CloudSat Deputy Principal Investigator]*

*"The instruments are performing very well and are providing exciting views of aerosols and clouds around the globe, …" —**David Winker** [Langley Research Center, CALIPSO Principal Investigator]*

CloudSat's "First-Light" Image

On May 20, 2006, just 30 seconds after its radar was activated for the first time, CloudSat's Cloud Profiling Radar obtained its first image—see **Figure 1.** The image shows a three-dimensional profile of the atmosphere as a warm front over the Norwegian Sea in the North Atlantic approaches the coast of Greenland. Unlike other satellite

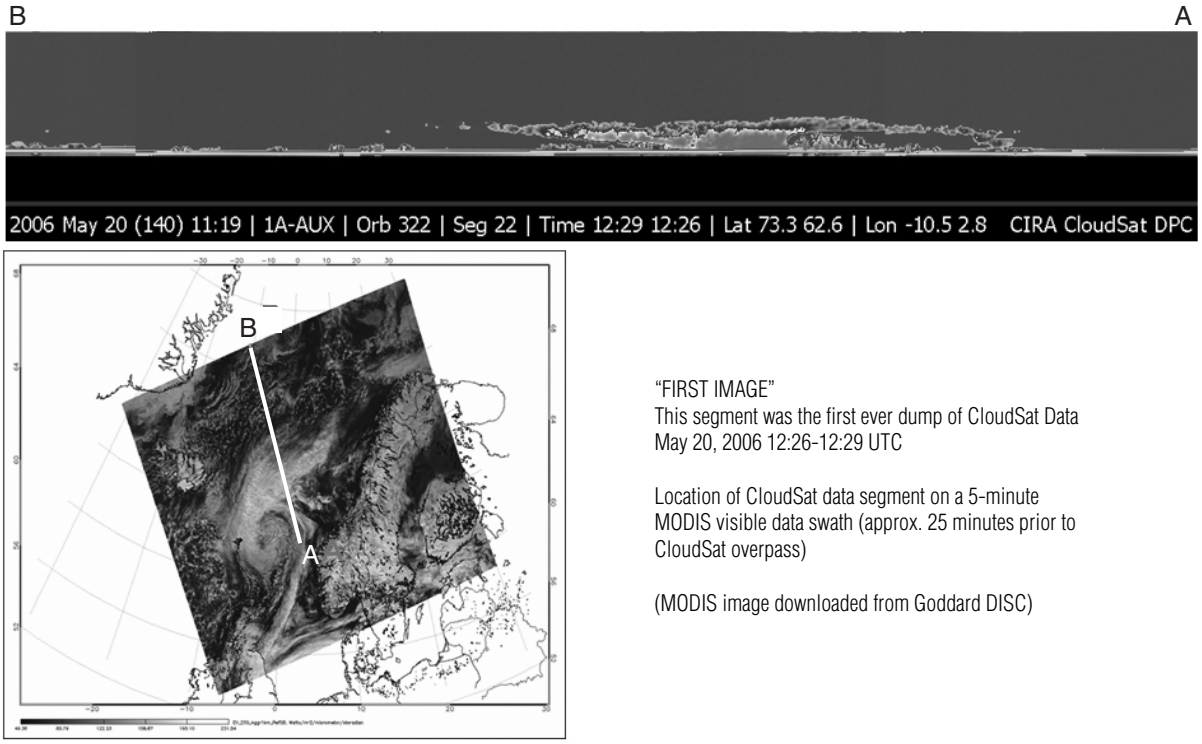


FIGURE 1: CloudSat observes a warm-front storm over the Norwegian Sea. MODIS (bottom) shows CloudSat's track from north to south across the scene. Image credit: NASA/JPL/The Cooperative Institute for Research in the Atmosphere (CIRA), Colorado State University]

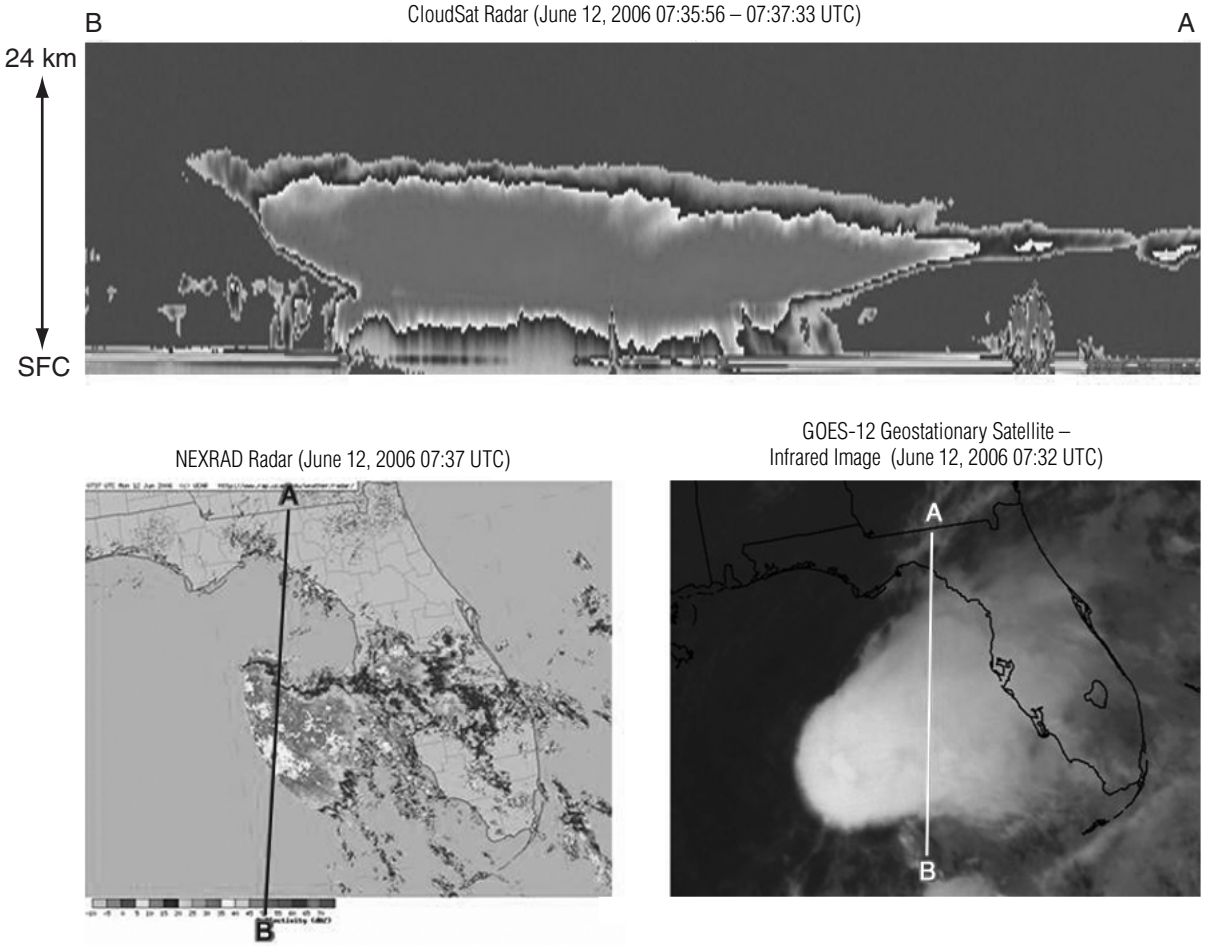


FIGURE 2: CloudSat (top) observes Tropical Storm Alberto. In order to highlight the enhanced cloud and precipitation observation capabilities of CloudSat, NEXRAD (lower left) and Geostationary Operational Environmental Satellite (GOES)-12 (lower right) images of Alberto are also shown with the CloudSat track superimposed on each image. Image credit: NASA/JPL/The Cooperative Institute for Research in the Atmosphere (CIRA), Colorado State University]

observations, the CloudSat radar image shows the storm's clouds and precipitation simultaneously.

In this horizontal cross-section of clouds, warm air is seen rising over colder air as the satellite travels from right to left. The light colors are indicative of highly reflective particles such as water droplets (or rain) or larger ice crystals (or snow), while the dark colors indicate thinner clouds (such as cirrus). The flat lines across the bottom represent the ground signal. The vertical scale on the CloudSat Cloud Profiling Radar image is approximately 30 km (19 mi). The flat line below the Cloud Profiling Radar image indicates that the data were taken over water. To give some perspective, the image below the radar data shows the CloudSat track relative to a Moderate Resolution Imaging Spectroradiometer (MODIS) infrared image taken at nearly the same time.

CloudSat Views Tropical Storm Alberto

On June 12, 2006, CloudSat captured its first tropical storm, Alberto, as it spun over the Gulf of Mexico. **Figure 2** illustrates how CloudSat "sees" such storms differently than conventional weather satellites. The CloudSat image is compared with images obtained at nearly the same time from two National Oceanic and Atmospheric Administration National Weather Service tools that are mainstays for monitoring the development and movement of tropical cyclones: the NEXRAD storm detection radar, which maps out precipitation patterns for that portion of the storm that comes into its range, and the Geostationary Operational Environmental Satellite (GOES-12) infrared imager, which is presented here to indicate the scale of the storm and the location where CloudSat overflies it. CloudSat sees the storm outside the range of NEXRAD and provides significantly greater vertical detail compared to the GOES satellite. NEXRAD, for example, can only see out to about 402 km (250 nautical mi), and so could not see the portion of the storm that CloudSat was flying over at the time. GOES-12 only sees the very top of the clouds, and cannot provide any detail about what is being seen beneath the cloud tops.

The CloudSat data show a storm that reaches about 16 km (10 mi) in height and extends perhaps 1,000 km (621 mi) in scale. The flat line at the bottom of the CloudSat image is the radar echo of the Earth's surface. Where this line starts to disappear under the storm is where the rainfall is

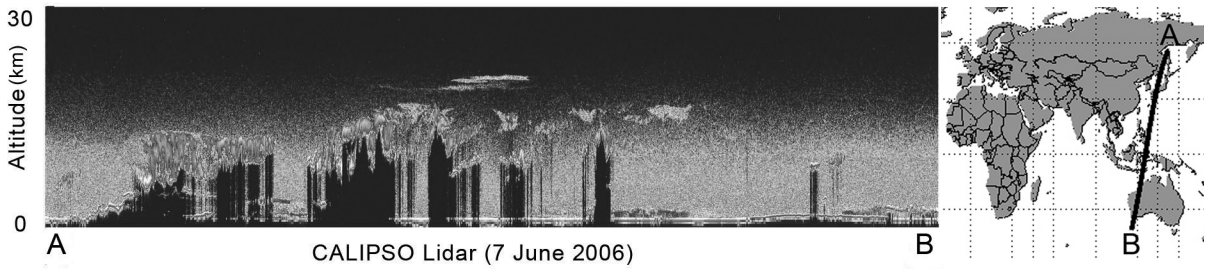


FIGURE 3: One of the first lidar profiles from the CALIPSO spacecraft, showing layers of clouds and aerosols over eastern Asia, Indonesia and Australia. The accompanying map shows CALIPSO's path over the area. Credit: NASA Langley Research Center.

heaviest. Very heavy rainfall can be seen over about 400 km (249 mi) of the satellite track. Cirrus clouds can also been seen out ahead of the storm (near letter A)—this is also evident in the GOES-12 image. A smaller thunderstorm is visible in the CloudSat image under that cirrus cloud anvil near the letter A. That storm is completely hidden from view in the GOES infrared image.

CALIPSO "First Light" Images Reveal the Remnant of a Volcanic Plume

The Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) spacecraft collected its first data recently—see **Figure 3**. On June 7, 2006, during its first day of lidar operations, CALIPSO observed the layers of clouds and aerosols shown here in an orbit over eastern Asia, Indonesia, and Australia. In the lower right-hand portion of the figure you can see the trace of the changing surface elevation of the Australian continent, a low horizontal line. Just above the surface, in a layer several kilometers deep, a layer of aerosol particles is shown. The signal from air molecules, or the background noise, is shown darker toward the top of the image and lighter toward the bottom. Clouds are especially easy to detect and are displayed as a mid-tone in the center horizon of the image. We can see that some of these clouds are quite dense because the region below them is shown as nearly black—the light from the lidar cannot penetrate the thick clouds. Also visible are thin tropical cirrus clouds at a height of 12 to 15 km (about 7 to 9 mi).

This image also illustrates an exciting feature of the CALIPSO satellite, the ability to detect and track volcanic plumes. On May 20, 2006, a major lava dome collapse took place at the Soufriere Hills Volcano on the island of Montserrat in the Caribbean. The dome collapse involved an explosion that sent ash clouds to 17 km (about 10.5 mi) high, probably entering the lower stratosphere. The sulfur dioxide column from this volcanic activity has been tracked by the Ozone Monitoring Instrument (OMI) on NASA's Aura spacecraft for several weeks. On June 6 and 8, OMI observed the sulfur dioxide plume over Indonesia, and in the lidar curtain profile above you can see a thin scattering layer at an altitude of about 20 km (about 12 mi)—see **Figure 4**. Because of the altitude and the correlation with the location of the plume, the very thin layer of clouds appears to be the aerosol component of the plume from Soufriére. The layer appears to be non-depolarizing, so it may be primarily composed of sulfuric acid droplets, rather than ash particles. Volcanic plumes such as this can be hazardous to air traffic if the plume crosses air traffic lanes at the altitude where commercial aircraft fly. CALIPSO can observe where aerosols occur around the globe, and their altitude, and such information improves our ability to assess and forecast episodes of poor air quality. ■

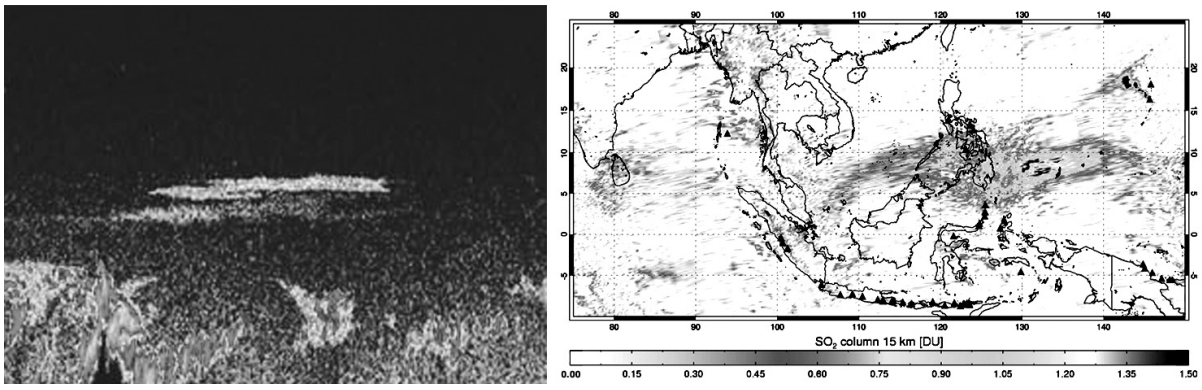


FIGURE 4: Data from the Ozone Monitoring Instrument (OMI) instrument on the Aura spacecraft, shown on the right, reveals a sulfur dioxide plume over Indonesia that originated from the volcanic activity of Soufriere on the island of Montserrat in the Caribbean on May 20, and has traversed around the globe. On the left is a close up image of the area shown in **Figure 3** as seen by CALIPSO. Scientists believe that the thin cloud at the center of this image is a remnant of the Soufriere sulfur dioxide plume which has been converted into aerosols (tiny droplets) of dilute sulfuric acid. The OMI image was produced by the volcanic emissions group at University of Maryland Baltimore County (S.A. Carn, N.A. Krotkov, A.J. Krueger, K. Yang) using data from the OMI on NASA's EOS Aura satellite. OMI is built by Dutch/Finnish collaboration and is managed by KNMI and NIVR in the Netherlands. The CALIPSO image was produced by Kathy Powell, SAIC and NASA Langley Research Center.

Solar Irradiance Variability During the SORCE Mission

Tom Woods, Laboratory for Atmospheric and Space Physics, University of Colorado, woods@lasp.colorado.edu
Jerald Harder, Laboratory for Atmospheric and Space Physics, University of Colorado, harder@lasp.colorado.edu
Greg Kopp, Laboratory for Atmospheric and Space Physics, University of Colorado, kopp@lasp.colorado.edu
Bill McClintock, Laboratory for Atmospheric and Space Physics, University of Colorado, mcclintock@lasp.colorado.edu
Peter Pilewskie, Laboratory for Atmospheric and Space Physics, University of Colorado, pilewskie@lasp.colorado.edu
Martin Snow, Laboratory for Atmospheric and Space Physics, University of Colorado, snow@lasp.colorado.edu,
Vanessa George, Laboratory for Atmospheric and Space Physics, University of Colorado, vanessa.george@lasp.colorado.edu,

Overview

High-accuracy measurements of total solar irradiance (TSI) and solar spectral irradiance (SSI) over periods of decades are crucial for establishing the solar influence on Earth's climate [*Intergovernmental Panel on Climate Change (IPCC) Report*, 2001]. For this reason, TSI and SSI measurements are two of the twenty-four key measurement parameters defined for the EOS program [*EOS Science Plan, King,* 2000]. The Solar Radiation and Climate Experiment (SORCE) mission has been providing these important solar-irradiance data since March 2003. SORCE measures TSI as well as ultraviolet, visible, and infrared spectral irradiance from 115–2700 nm with unprecedented precision and accuracy. It was launched on January 25, 2003, into a circular orbit with an altitude of 640 km and inclination of 40°. Routine solar-irradiance observations began approximately six weeks later and are scheduled to continue throughout a nominal 5-year mission life. An extended SORCE mission is required to overlap with NASA's Glory Mission (launch planned for 2008) in order to avoid gaps in these critical irradiance time series. An overlap with the Total Solar Irradiance Sensor (TSIS) was also anticipated. TSIS was scheduled to fly on the joint NASA/NOAA/Department of Defense (DOD) National Polar-orbiting Operational Environment Satellite System (NPOESS), but the recent restructuring of the NPOESS program has removed the climate instruments, including TSIS (TSI and SSI measurements), from the NPOESS missions. The specific launch plan for TSIS is currently uncertain, but NOAA and NASA will likely work together to find opportunities for TSIS to prevent a gap in the primary solar-irradiance data record.

The SORCE observations are both improving our understanding of and generating new inquiry into solar variability and its effects on Earth's energy balance, atmosphere, and long-term climate changes. TSI varies by a few tenths of a percent with decreases due to dark sunspots and with increases at solar maximum during the 11-year solar cycle. Although these changes are relatively small, they are a key climate-forcing component in the Earth's energy budget [*King, 2000; Pilewskie, Rottman, and Richard,* 2005]. Both the variation in solar spectral irradiance and its deposition into the Earth system are strongly dependent on wavelength. Measurement of the variability in the visible and infrared spectral ranges is required for radiation studies involving clouds and aerosols and their influence on climate changes [*King, 2000; Pilewskie, Rottman, and Richard,* 2005]. Observations of the ultraviolet irradiance and its variation are essential for atmospheric studies involving stratospheric chemistry, heating, and dynamics and possible dynamic coupling to the lower atmosphere [*King, 2000; Lean et al.,* 2005].

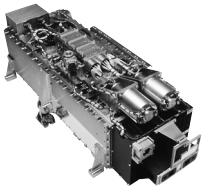
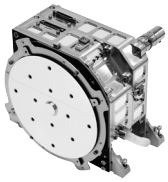
SORCE carries a complement of four different science instruments as listed in **Table 1**. The Total Irradiance Monitor (TIM) measures TSI [*Kopp and Lawrence,* 2005]. The Spectral Irradiance Monitor (SIM) measures SSI in the 200–2700 nm range. It has resolving power ($\lambda/\Delta\lambda$) that varies from 378 nm at 250 nm, to a minimum of 37 nm at 1260 nm, and increases slowly in the infrared to 142 nm at 2700 nm [*Harder et al.,* 2005a]. The ultraviolet irradiance is measured from 115–310 nm with 0.1-nm resolution by the SOLar STellar Irradiance Comparison Experiment (SOLSTICE) instrument [*McClintock et al.*, 2005]. The XUV Photometer System (XPS) is measuring the soft X-ray (XUV) range from

0.1–27 nm with bandpasses of 7–10 nm [*Woods, Rottman, and Vest,* 2005]. SORCE spectral observations cover the wavelengths that comprise more than 96% of the total irradiance. It is fortunate that the NASA Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED) Solar Enhanced-ultraviolet Experiment (SEE) [*Woods et al.,* 2005] that launched in 2001 fills the Enhanced Ultraviolet (EUV) wavelength gap between about 27–115 nm. The SORCE observations, supplemented by those of the TIMED SEE, are therefore providing the first time series of irradiance at all wavelengths between 0.1–2700 nm with a daily cadence. *Rottman* (2005) provides a more detailed overview of the SORCE mission, science objectives, and instruments.

The magnitude of the solar irradiance impinging on the Earth system varies for three reasons: (1) changes in the distance to the Sun; (2) changes in the radiation field directed from the Sun toward Earth; and (3) intrinsic variation in the output of the Sun. Changes in Earth-Sun orbital distance produce an annual irradiance variation of 6%, independent of wavelength. The second variation is caused by a "search-light" effect resulting from the non-uniform distribution of active regions on the solar disk that are modulated by the 27-day rotation period of the Sun. When the distribution of these features is non-uniform (the usual case), a 27-day rotational variation is quite apparent and also highly dependent on wavelength. This is true whether the solar disk has many active regions (solar maximum) or only a few (solar minimum). The third type of irradiance variation is caused by magnetic activity on the Sun. These variations have time scales ranging from minutes for eruptive phenomena, such as flares, to months for the evolution of active regions and the 27-day solar rotation, to years for the 11-year sunspot cycle (22-year magnetic cycle), and to even longer periods of centuries for secular trends, presumably related to the long-term changes of the internal solar dynamo.

The SORCE mission period has been an interesting epoch of solar activity. During the past 3 years, the solar activity declined from near the maximum of the 11-year solar cycle to near minimum. In addition, there have been several extremely large solar storm periods, including the Halloween Storm of 2003 when the TSI dropped by an unprecedented 0.34% and thanks to SORCE, for the first time ever,

Table I: The SORCE Instruments

SORCE Instruments	Spectral Range	Spectral Resolution	Instrument Scientist
Total Irradiance Monitor (TIM) 	Total Solar Irradiance (all)	N/A	 Greg Kopp
Spectral Irradiance Monitor (SIM) 	200-2700 nm	1-30 nm	 Jerry Harder
Solar Stellar Irradiance Comparison Experiment (SOLSTICE) 	115-320 nm	0.1 nm	 Bill McClintock
XUV Photometer System (XPS) 	0.1-27 nm, Lyman-alpha	7-10 nm	 Tom Woods

scientists could observe the impact of a solar flare on the TSI record. Other new results from SORCE involve the variability of the solar spectral irradiance, notably in the visible and infrared where very few previous, accurate measurements have been made. Furthermore, the high accuracy and precision of the SORCE TSI and SSI measurements have greatly improved upon previous results, such as for the widely used solar index from the Magnesium emission at 280 nm, and also raise new questions—e.g., *what is the absolute value for the TSI?* The following discussion highlights some of the ongoing research using the SORCE measurements.

Total Solar Irradiance (TSI) Variations

The TIM instrument measures the TSI, the spectrally-integrated total radiant output from the Sun incident at the top of the Earth's atmosphere. The TSI is the dominant driver of Earth's climate. Fortunately for climate stability, the TSI shows only small variations, with changes of 0.1% over the 11-year solar cycle and short-term variations of roughly 0.2%. TIM observed the largest short-term variation in TSI ever recorded, a decrease in solar radiant output of 0.34% due to the passage of two extremely large sunspot groups across the solar disk in October 2003. During this time of heightened solar activity, for the first time ever, using data from TIM, scientists were able to detect the impact of a solar flare on TSI. While flares are readily apparent in EUV and XUV spectral irradiances and in some high-energy spatial images, detecting a flare in TSI is significant because it directly measures the total radiant energy from the flare, a value that previously could only be approximated using models.

Figure 1: The SORCE/TIM TSI record currently exceeds 3 years in duration. The gradual decrease in the TSI is due to the declining phase of the current solar cycle, with solar minimum expected in 2007. The decrease in October 2003 is the largest measured short-term change in the 27-year TSI record.

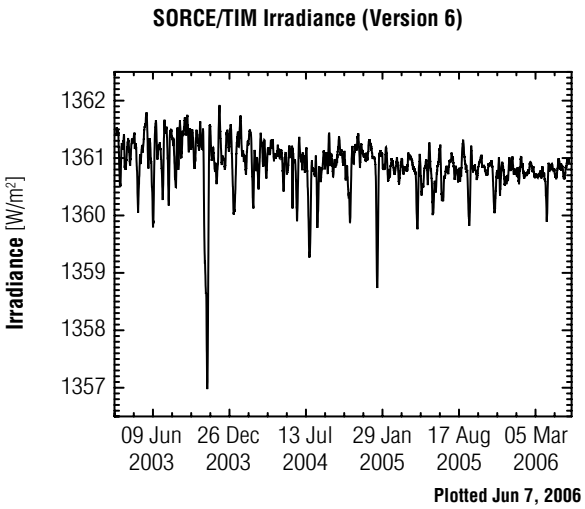


Figure 1 shows the TIM TSI record. These data have been corrected for instrument degradation, which is known to better than 0.001%/year, and background thermal emission, and are normalized to a distance of 1 Astronomical Unit [AU] from Sun center. Very simplistically, short-term decreases in the TSI can be largely attributed to dark sunspots, while values above normal are generally due to bright solar faculae. The current solar cycle is waning and is consistent with the gradual decrease in TSI observed over SORCE's three-year record.

SORCE's TIM continues the 27-year TSI record that is the result of ten space-borne instruments—see **Figure 2.** While each of these instruments is very precise and stable, they have offsets on an absolute scale. To detect possible long-term changes in the Sun's output despite these instrument offsets, it has been critical to have overlap between the instruments. TIM was designed for good absolute accuracy, necessary to maintain a link to the existing TSI record in the event of a potential gap in future measurements; yet this instrument reads lower than prior TSI instruments, calling into question both TIM's and the other instruments' accuracies. The TSI community, the National Institute of Standards and Technology (NIST), and NASA are involved in determining the possible causes of instrument offsets to improve the absolute accuracy of future instruments and to understand the radiative energy balance of the Earth.

Spectral Solar Irradiance (SSI) Variations

Variability in the visible and infrared

The SIM instrument on SORCE has given us the first-ever time series of high-precision visible and infrared spectral irradiance measurements. These data provide profound insight into the contributions of the spectral variability to the TSI and the wavelength-dependent solar influences on the Earth-climate systems. The new SIM results are expected to improve our understanding of the nature of solar variability and how it affects the Earth's climate. For example, the relative spectral variability between an active and quiet Sun—see **Figure 3**—is greatest in the ultraviolet and thus would have greatest influence in the middle atmosphere because ozone absorbs those wavelengths. Although *relative* variability is lower in the visible and near-infrared portion of the spectrum, the Sun's output is higher at these wavelengths so that the *absolute* variability (energy) in the visible and near-infrared is greatest. Radiation from the Sun at these wavelengths penetrates deep into the atmosphere and is absorbed at the surface and in the lower atmosphere by water vapor, clouds, and aerosol particles. Thus the spectral nature of solar variability

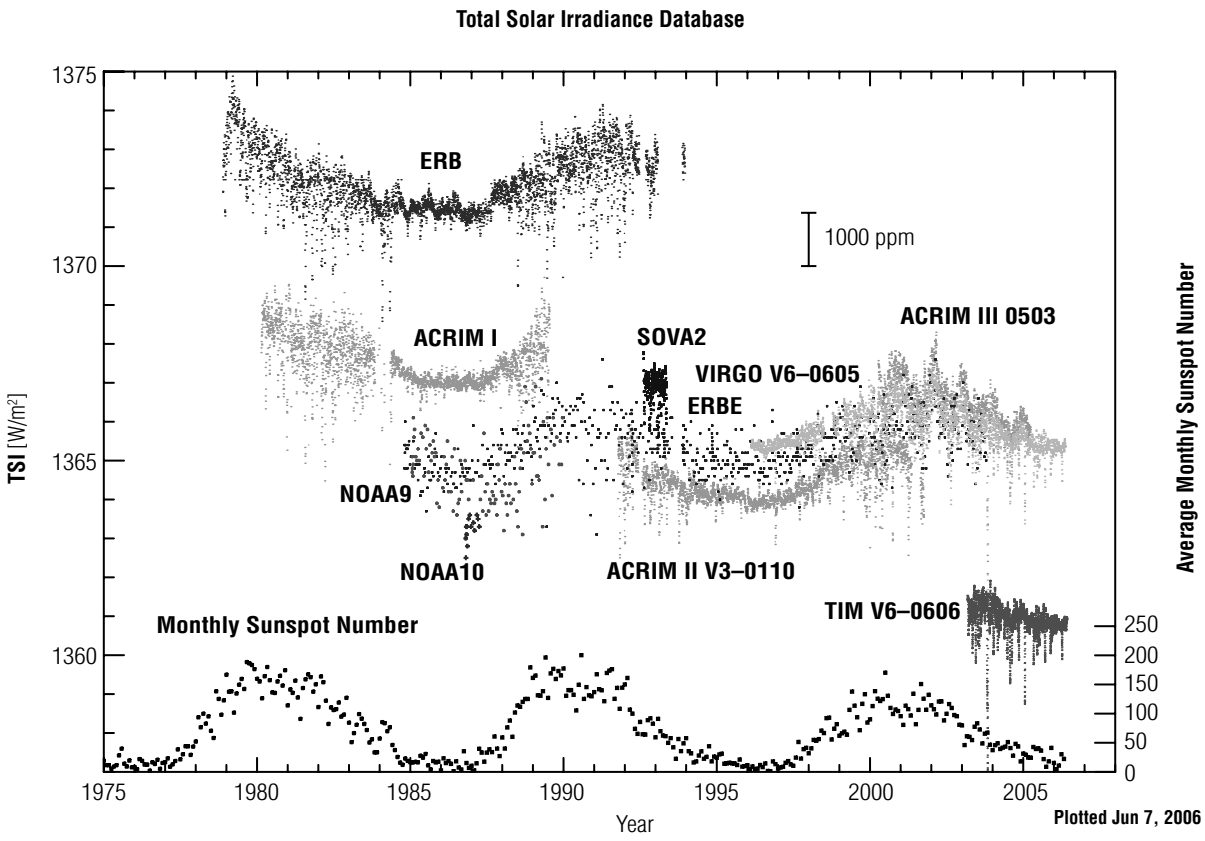


Figure 2: The current 27-year TSI record comes from 10 different space-borne instruments. Mission overlap allows creation of a composite TSI record despite the offsets between instruments. The TSI community—including NIST and NASA—is actively engaged in determining the causes of these offsets and resolving whether TIM is measuring too low a value or whether all other instruments are erroneously too high.

affects the vertical deposition of energy within the atmosphere with subsequent influences on weather and climate.

The SIM measurements of SSI are used to study the spectral composition of active regions and are thereby contributing to understanding the fundamental nature of solar activity. Similar to the well-known October 28, 2003 sunspot passage, the event on January 15, 2005 was particularly suitable for this approach because both the SIM instrument and the Precision Solar Photometric Telescope (PSPT) were routinely operational in this time frame, permitting both the SIM radiometric measurements and the concurrent analysis of the composition of the solar active regions using the Solar Radiation Physical Modeling (SRPM) [e.g., *Fontenla and Harder,* 2005; *Harder et al.*, 2005b].

Figure 3a shows the closest coincident PSPT images from two days corresponding to an active Sun scenario (January 15, 2005) and the quiet Sun (January 31, 2005) after the active region has rotated off of the observable disk. The *red continuum* (607.09 nm) image identifies the locations of several significant sunspot groups, while the Ca II image shows the bright plage and facular regions that accompany them. In addition, one can see faculae that are not associated with the sunspots and the active network, which appears over the entire disk. After the larger sunspot complexes rotate off of the solar disk (January 31), only small isolated sunspots and active network are seen suggesting a relatively quiet Sun scenario.

Figure 3b is the fractional disk integrated irradiance difference as a function of wavelength for these two time periods derived from SIM data, and the inset shows the time series of relative TSI. The two arrows in the inset show the times corresponding to the images and in the spectral fractional difference. In **Figure 3b**, the facular and plage regions produce a brightening relative to the quiet Sun in the UV portion of the spectrum ($\lambda < 260$ nm). The sunspots cause dimming for wavelengths greater than 260 nm but cause a significant brightening at 280 nm corresponding to the core of the Mg II emission lines. The sunspot umbra and penumbra remain fainter than the quiet Sun throughout the visible and infrared portions of the spectrum. SIM can measure the complicated, wavelength-dependent variability of the solar irradiance with more precision than has been possible previously, and these results are fundamental for understanding the subtle changes in

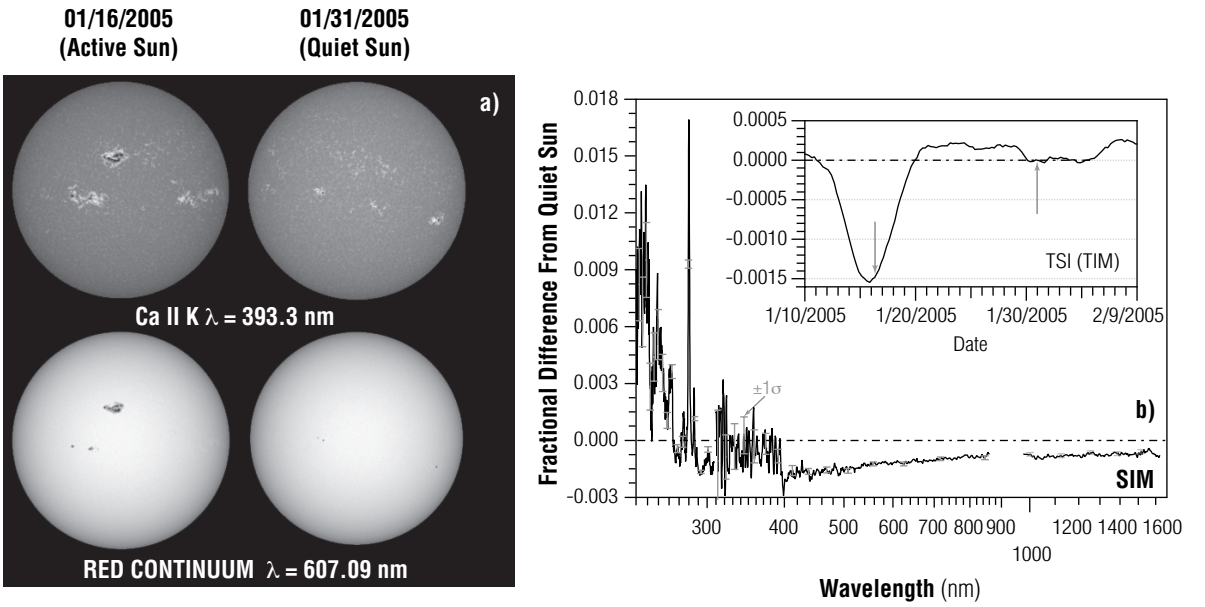


Figure 3: Figure 3a shows four images from the Mauna Loa Precision Solar Photometric Telescope (PSPT) observatory. The top two images are measured with a Ca II (393.3 nm) filter that emphasizes the presence of bright active regions such as plage, facula, and the active network. The bottom two images were taken with a *red continuum* (607.09 nm) filter that emphasizes the solar spectrum continuum and shows the locations of sunspot umbral and penumbral regions. Figure 3b shows a spectral ratio of these two days as measured by SIM. The +/-1σ error bars are shown to give an estimate of the precision of the ratio. The inset marks the dates of the images and the spectral ratio and shows the relative change in the TSI over this time period.

the TSI, solar forcing in the complex Earth-climate systems, and the differences between measurements and models, e.g., *Fontenla et al.,* 2004.

Variability in the ultraviolet – extending the Mg II index time series

The SOLSTICE instrument measures the solar irradiance from 115–320 nm at 0.1-nm spectral resolution. One significant measure of solar variability in the SOLSTICE wavelength range is the Magnesium II h & k doublet at 280 nm. These features are formed in the chromosphere and are much more variable than the photospheric spectral features in the absorption wings a few nanometers on either side of the central wavelength. A ratio of the "core" to the "wing" irradiance produces an index of chromospheric activity that is largely independent of instrumental effects [*Heath and Schlesinger,* 1986]. This Mg II index varies strongly on solar cycle (11 year) and rotational (27 day) timescales, and better predicts EUV emissions such as He II (30.4 nm) than the F10.7 index [described by *Viereck et al.,* 2001] and is therefore a better proxy for changes in the solar radiative input to the atmosphere.

Figure 4 shows the Mg II index measured by SORCE SOLSTICE [*Snow et al.,* 2005]. The general downward trend is due to the waning solar cycle (cf., **Figure 1**). The 27-day oscillations are due to the contribution from active regions that rotate in and out of view. An active region can have a lifetime of several months, so it can often be seen on more than one rotation. There were an unusually large number of very active regions in late 2003, as indicated by the large amplitude shown in the figure. The flares produced during this time interval are described in the next section.

Because the Mg II index is constructed in such a way as to eliminate most instrumental effects, producing a long-term composite record from an ensemble of instruments is much more straightfor-

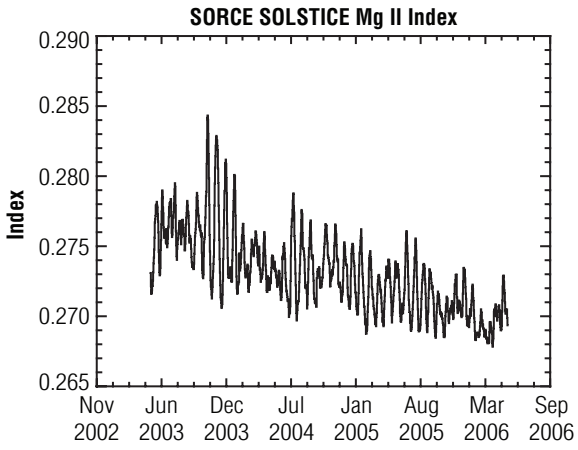


Figure 4: The SORCE SOLSTICE Mg II index daily measurement. The 27-day solar rotations can be clearly seen, as well as a gradual decline from the solar cycle.

ward than for a record such as TSI (cf., **Figure 2**). NOAA has produced a continuous time series of Mg II index daily measurements stretching back to 1978 [*Viereck et al.,* 2004]. The measurements from SORCE SOLSTICE are in good agreement with the NOAA composite , i.e., correlation coefficient greater than .99. The higher spectral resolution (0.1 nm) of SOLSTICE produces an index with greater precision than the typical 1.1-nm resolution of the NOAA measurement [*Snow et al.*, 2005]. This greater precision enables SORCE to measure changes in the Sun's chromospheric output on timescales as short as 10 minutes as compared to ~1 day with a 1.1 nm dataset [*Snow and McClintock,* 2005]. SORCE makes many more measurements per day than the operational NOAA satellites, which makes the data more useful for near real-time atmospheric models. Consequently, NOAA is considering adopting this observing cadence for future operational models.

Flare Variations

Solar flares are produced from eruptive events on the Sun that last for minutes to hours. They are not expected to have any effect on climate changes because of their short duration; however, the Earth's atmosphere does respond to flares on short timescales. The most widely known effects are associated with space weather. For example, a large flare instantly disturbs the ionosphere and can disrupt communications and affect navigation systems, e.g. by degrading GPS accuracy from its usual 3–10 feet to 50–100 feet. Flares also heat the thermosphere, which increases satellite drag. This effect degrades both satellite lifetime and tracking knowledge.

The SORCE instruments were not designed for or intended for flare observations. Nonetheless, interesting observations have been obtained of some extraordinary solar storms that have occurred during the SORCE mission. The activity during the infamous period in October–November 2003, which has been dubbed the 2003 Halloween Storm, included over 140 medium and large flares in a 2-week interval. This period was extraordinary because the average number of medium or large flares over any 2-week span is expected to be about 7 [*Garcia,* 2000]. SORCE observations of the extremely large flare on October 28, 2003 showed that its spectral variations were as large as solar cycle variations [*Woods et al.,* 2004]. On the other hand, since it only lasted for several hours the flare's integrated energy contribution to the atmosphere is much less significant compared to that of the longer-term 11-year solar cycle variation.

SORCE TIM also made the first detection of a flare in the TSI record. *Woods, Kopp, and Chamberlin* (2006) report that this event and some others have a total energy that is about 10 times larger than previously estimated, e.g., *Emslie et al.,* 2004. This result establishes more accurate bounds for understanding the solar physics of flares.

Future Studies of the Longer Term Variations

The SORCE mission has observed near solar maximum during the current 11-year solar cycle, but the solar minimum levels are not expected until 2007. Therefore, we continue to compile results from the SORCE mission in order to characterize the irradiance variability for the current 11-year cycle.

Long-term solar variations are of great interest to the climate and atmospheric communities, who are studying the solar influence on Earth's environment over periods of years to centuries. In addition to future solar-cycle studies using SORCE data, the SORCE team is also involved in estimating and modeling the solar-irradiance changes over extended time periods associated with solar-induced climate change, such as for the Maunder Minimum during the 17th century, a time of very low solar activity. For these studies, the solar irradiance results from SORCE provide validation and constraint for estimates of the longer-term solar variability. The climate models, along with improved estimates on the secular trends of solar irradiance, provide insight into the solar-forcing contribution to climate changes. This will shed light on the complicated processes that can have both positive and negative feedbacks into Earth's energy-budget as related to solar energy input, global and local temperature changes, atmospheric and oceanic circulations, and cloud formation and coverage. Continuing the long-term solar irradiance record started in the 1970's for the TSI, and at some ultraviolet wavelengths, is critical for these solar-climate studies and modeling. The SORCE mission is well established as a key part of this record, and the future solar irradiance measurements on NASA Glory and potentially on NOAA NPOESS are imperative for continuing this measurement record for the climate and atmospheric communities.

References

Emslie, A. G., and 14 other co-authors, 2004, Energy partition in two solar flare/CME events, *J. Geophys. Res.*, **109**, A10104, doi:10.1029/2004JA010571.

Fontenla, J. M., J. Harder, G. Rottman, T. N. Woods, G. M. Lawrence, and S. Davis, 2004, The Signature

of Solar Activity in the Infrared Spectral Irradiance, *Astrophys. J. Letters*, **605**, 1, L85-L88.

Fontenla J. and J. Harder, 2005, Physical Modeling of Spectral Irradiance Variation, *Memorie della Società Astronomica Italiana*, **76**, 826.

Garcia, H., 2000, Thermal-spatial analysis of medium and large solar flares, 1976 to 1996, *Astrophys. J. Suppl.*, **127**, 189.

Harder, Jerald, G. Lawrence, J. Fontenla, G. Rottman, and T. N. Woods, 2005a, The Spectral Irradiance Monitor: Scientific Requirements, Instrument Design, and Operation Modes, *Solar Phys.*, **230**, 141-167.

Harder, J., J. Fontenla, O. White, G. Rottman, and T. Woods, 2005b, Solar spectral irradiance variability comparisons of the SORCE SIM instrument with monitors of solar activity and spectral synthesis, *Memorie della Società Astronomica Italiana*, **76**, 735.

Heath, D. F. and B. M. Schlesinger, 1986, The Mg 280-nm doublet as a monitor of changes in solar ultraviolet irradiance, *J. Geophys. Res.*, **91**, 8672.

Intergovernmental Panel on Climate Change (IPCC), 2001, Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change, J. T. Houghton *et al*. (ed.), *Cambridge University Press*, Cambridge, MA.

King, M. D., editor: 2000, EOS Science Plan, NASA GSFC, Greenbelt, MD.

Kopp, Greg and G. Lawrence, 2005, The Total Irradiance Monitor (TIM): Instrument Design, *Solar Phys.*, **230**, 91-109.

Lean, Judith, G. Rottman, J. Harder, and G. Kopp, 2005, SORCE Contributions to New Understanding of Global Change and Solar Variability, *Solar Phys.*, **230**, 27-53.

McClintock, William E., G. J. Rottman, and T. N. Woods, 2005, Solar Stellar Irradiance Comparison Experiment II (SOLSTICE II): Instrument Concept and Design, *Solar Phys.*, **230**, 225-258.

Pilewskie, Peter, G. Rottman, and E. Richard, 2005, An Overview of the Disposition of Solar Radiation in the Lower Atmosphere: Connections to the SORCE Mission and Climate Change, *Solar Phys.*, **230**, 55-69.

Rottman, Gary, 2005, The SORCE Mission, *Solar Phys.*, **230**, 7-25.

Snow, Martin, W. E. McClintock, T. N. Woods, O. R. White, J. W. Harder, and G. Rottman, 2005, The MgII Index from SORCE, *Solar Phys*. **230**, 325-344.

Snow, M. and W. E. McClintock, 2005, High time cadence solar Magnesium II index monitor, *Proc. of the SPIE*, **5901**, 59011D, doi:10.1117/12.617044.

Viereck, R. A., L. Puga, D. McMullin, D. Judge, M. Weber, and W. K. Tobiska, The Mg II index: A proxy for solar EUV, 2001, *Geophys. Res. Lett.*, **28**, 1343.

Viereck, R. A., L. E. Floyd, P. C. Crane, T. N. Woods, B. G. Knapp, G. Rottman, M. Weber, L. Puga, and M. T. Deland, 2004, A composite Mg II index spanning from 1978 to 2003, *Space Weather*, **2**, doi:10.1029/2004SW000084, S10005.

Woods, T. N., F. G. Eparvier, J. Fontenla, J. Harder, G. Kopp, W. E. McClintock, G. Rottman, B. Smiley, and M. Snow, 2004, Solar irradiance variability during the October 2003 solar storm period, *Geophys. Res. Lett.*, **31**, L10802, doi:10.1029/2004GL019571.

Woods, Thomas N., G. Rottman, and R. Vest, 2005, XUV Photometer System (XPS): Overview and Calibrations, *Solar Phys*. **230**, 345-374.

Woods, T. N., F. G. Eparvier, S. M. Bailey, P. C. Chamberlin, J. Lean, G. J. Rottman, S. C. Solomon, W. K. Tobiska, and D. L. Woodraska, 2005, Solar EUV Experiment (SEE): Mission overview and first results, *J. Geophys. Res.*, **110**, A01312, doi:10.1029/2004JA010765.

Woods, T. N., G. Kopp, and P. C. Chamberlin, 2006, Contributions of the solar ultraviolet irradiance to the total solar irradiance during large flares, *J. Geophys. Res*., in press.

AIRS Tracks Transport of Dust from China Dust Storm of April 2006: A Preliminary Look at Data from the AIRS "Dust Flag"

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

Science content provided by:

- Sung-Yung Lee, *Jet Propulsion Laboratory*
- Sergio DeSouza-Machado, *University of Maryland Baltimore County*
- Eric Fetzer, *Jet Propulsion Laboratory*
- Bjorn Lambrigtsen, *Jet Propulsion Laboratory*

Large dust storms originating over northwestern China's Inner Mongolia region traveled eastward and caused the worst period of air pollution in six years in Beijing. As winds carried the storm along, other regions were also affected. An animation created from data taken by the Atmospheric Infrared Sounder (AIRS) shows how the dust from these storms travels around the globe.

Background on the Dust Storm

In April of 2006, a strong cold front swept across northern China ushering in cooler air from Siberia and stirring up strong winds as it passed. As these winds swept over the desert regions of China's Inner Mongolia region and Gansu province, they swept billions of tiny sand particles from the Gobi desert high into the atmosphere and they intermixed with chemical pollutants from China's industrial cities further downwind, to create a thick blanket of pollution over the region. A choking cloud of dust hovered over northern China for days, and led to the worst period of air pollution the area had seen in six years. Air quality in the capital city of Beijing reached hazardous levels, and elderly people and children were warned to stay indoors. At this latitude on the globe the air moves from west to east, so the dust storm next set its sights on the Korean peninsula and Japan. Though the storm weakened as it passed over the Bohai Sea and the East China Sea, South Korea was still greatly affected, and the storm was its second-worst this year.

The removal of forests and the overgrazing of grasslands in these regions of China, along with prolonged hot, dry weather, have led to *desertification*—more of the land surface is becoming a desert. Because the surface has less vegetation and trees than it used to, the dust storms occur more frequently, and are more severe than in the past. Also, since the desert surface is smoother than forests or grassland, the storms also move more rapidly than they did previously.

Large dust storms such as the one described here are not only a public health concern, but they can affect atmospheric chemistry and rainfall patterns, and transport micro-nutrients and micro-organisms. The deposited dust can kill coral, fertilize ocean photoplankton, or melt ice as dust makes that surface absorb rather than reflect sunlight.

AIRS Captures the Travels of Desert Dust

The Atmospheric Infrared Sounder (AIRS) on Aqua observed this dust storm from space and was able to track the dust as it traveled around the globe.

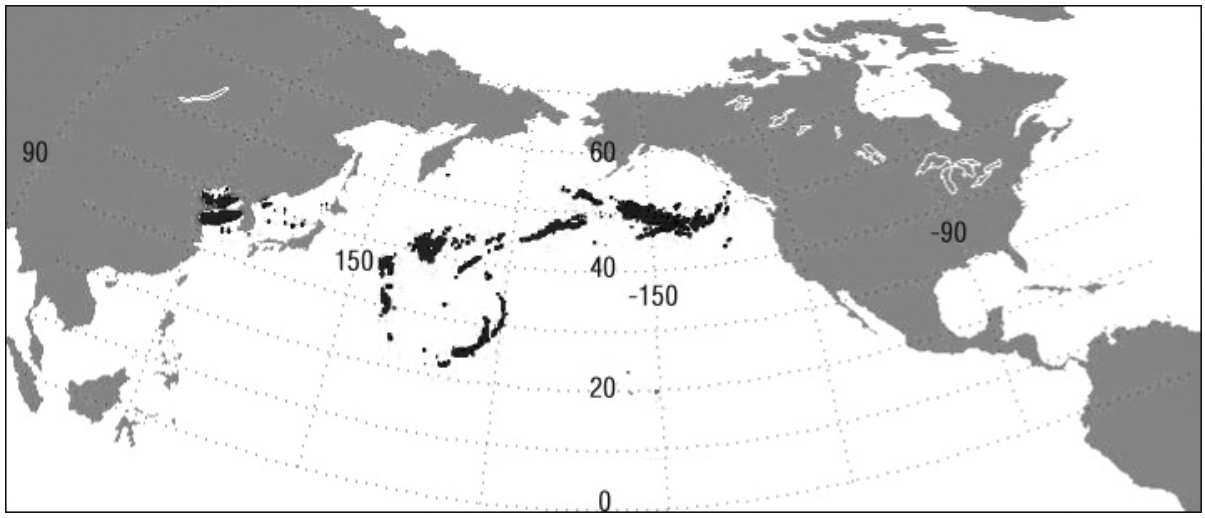


Figure 1: Dust map for April 13, 2006. Areas colored black are where AIRS detects dust in the atmosphere.

AIRS researcher **Sung-Yung Lee** [Jet Propulsion Laboratory] created an animation that shows a series of AIRS images that span 10 days beginning on April 7, 2006, and ending on April 16. **Figure 1** shows a single frame taken from the animation that shows data for April 13—please see *airs.jpl.nasa.gov/News/Features/FeaturesChinaDustStorm/* to view the full animation in color. These results are *preliminary* as scientists are just starting to cross-compare the results they've obtained from AIRS with what other sensors "see" to verify how accurately AIRS can detect dust. So far, however, the spatial consistency and temporal evolution in the AIRS data look plausible, even over land.

As one progresses through the animation, notice that on April 10, the large cloud seems to disappear, only to re-appear on April 11. The most likely explanation for the vanishing dust cloud is the presence of high-altitude clouds such as altocumulus, altostratus or cirrus, which prevent AIRS from detecting the dust cloud. Not only that, but AIRS has difficulty detecting dust when cirrus clouds are present. Cirrus clouds are thin wispy clouds that can look similar to dust when viewed in the infrared and this can "confuse" the computer programs used to detect dust.

Another possible reason the dust cloud appears to vanish and then reappear can be attributed to the way that AIRS collects data. As AIRS scans the atmosphere in its polar orbit around Earth it covers most of the globe, but it can't cover 100% of the globe in one day. This is because the AIRS *swaths*—the path covered by the instrument as it travels over Earth—don't butt up against each other perfectly in some areas, especially near the equator (Think of wrapping a ribbon around a ball from North Pole to South Pole, trying to cover the entire ball. There will be lots of overlap at the poles, but some gaps at the equator). These data gaps are referred to as *gores*, and could also cause it to appear that a cloud is present one day and gone the next.

As the animation progresses, the dust cloud continues to travel from west to east and moves across the Pacific Ocean. By April 14, it has traveled far enough eastward around the globe to reach the west coast of the U.S. and by the 16th another large dust cloud has taken form and can be seen off the coast of China. The images created from the 13th through the 16th appear to show another very interesting result. The AIRS dust flag gets triggered over the eastern U.S. and shows a cloud moving into the Atlantic Ocean. The series of images suggests that dust originating in Asia has traveled all the way around the Earth to reach the Atlantic Ocean, but this has not yet been confirmed.

About the AIRS Dust Flag

How does an infrared instrument detect dust? The AIRS instrument expects the atmosphere to have a typical *spectral signature*—a plot of the reflected and absorbed electromagnetic radiation at different wavelengths. The presence of dust in the atmosphere will change the spectral signature in a particular way and if AIRS detects such a signature, it assumes dust is present. Complicating the picture is the fact that the surface beneath the dust (e.g., sea or land or vegetation) also changes the spectral signature of the atmosphere. Therefore, it is not a trivial task to deduce dust from the data. Thus far, the AIRS dust flag has been tested mostly over ocean and found to be very effective (the AIRS dust flag was originally developed for ocean scenes). As of this writing, the effectiveness of the flag over land has not been evaluated. See the box below for more technical details on how the AIRS Dust Flag works. ■

Additional Details on the AIRS Dust Flag ...

According to **Sergio DeSouza-Machado** [University of Maryland Baltimore County] who created the dust flag for the AIRS data, the peak absorption of sandstorm dust in the infrared is at about 1000 cm^{-1}, and drops off rapidly on either side. This means that sand lifted into the air and blowing over ocean would lower the measurements at 1000 cm^{-1}, compared to measurements at 820 and 1231 cm^{-1} and other similar channels. By choosing a set of representative channels and scoring *brightness temperature* differences between pairs of channels in the set, AIRS can detect the presence of dust in the atmosphere day or night.

The Glory of the Story: A Summary of Kendall Haven's Presentation at the May EPO Colloquium

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

On Wednesday May 3, **Kendall Haven** was the featured speaker at the monthly Education and Public Outreach Colloquium. Haven's presentation was entitled *Voice of the Mind: The Amazing Power of Story … and What It Means to You*; the full presentation is available at the Committee for Education and Public Outreach website: *Esdepo.gsfc.nasa.gov.* Haven was formerly an oceanographer but has now become a professional storyteller—see *www.KendallHaven.com* for some of his materials. He has previously presented talks and workshops at Goddard Space Flight Center (GSFC) about the structure of stories and how to use them to convey scientific information. Haven maintains that story is the most effective means to convey scientific information, and some at Goddard wanted to know if he could prove what he was saying was true—i.e., does the literature back up what you claim??

The basic question Haven set out to answer was: *Do the form and structure used for narrative presentation affect the way the reader/viewer understands the material presented, creates meaning, and retains the information (memory and recall), based on scientific information, concepts, and research presented.* In short, the answer is a rather emphatic YES!

Haven gathered evidence from a wide range of sources including antecdotal evidence from 100 storytellers and 1800 practitioners (from a variety of fields), 300 qualitative studies, and 100 quantitative studies.

His research clearly shows that the use of story architecture provides superior retention and improved understanding, makes the reader pay more attention, and enhances creation of meaning.

Haven cited numerous examples of quotes from studies to back up his claims. Key words that keep coming up included meaning, understanding, relevance, and context. Some studies show that young children can understand more complex/abstract concepts when conveyed in context of story. (Haven argues the same is true for adults.) Many of the studies cited come from education, but others come from other fields. Interestingly, some directly address science writing.

Below is a sampling of some of the quotes that Haven shared. The full list is available at the EPO website listed above.

The literature clearly suggests that story is a very powerful tool for conveying information, including science. **Why, then, do we not see *stories* used more frequently?** Haven suggests two main reasons. First, there are a number of myths and misconceptions that persist concerning stories, and second, no one has thought to define story from any viewpoint more rational than personal preference.

Stories (structure of) are integral to the ability to have information and experience make sense to our lives. —Swatton (1999)

If you can't see the story; you won't learn the content and its meaning. —Spicer (1988)

Stories provide a way to make sense of experience. Stories provide particularly important ways of understanding uncertain experiences that challenge what had previously been taken for granted. —Babrow (2005).

Storytelling is increasingly seen as an important tool for communicating explicit and especially tacit knowledge—not just information, but know-how. —Kahn (2001).

Science is a form of storytelling. Science meaning is constructed and conveyed through storytelling and story structure. —Howard (1991).

The structural form of story carries power and appeal that is intentionally removed from what is commonly called scientific expository prose. —Tannen (1999).

People understand the world in terms of stories that they have already understood. New events or information are understood by reference to old, previously understood, stories and explained to others by the use of stories. —Schank (2000).

There are some common misconceptions concerning stories that need to be overcome, which include the following:

- Stories = fiction—i.e., *story* is really only useful for telling fiction.
- Stories = lies, made up, make believe; i.e., Parent to child: *"You better not be telling me a story!"*
- Stories are inappropriate for factual and scientific information, for nonfiction reporting.
- People won't believe you if you have to resort to telling stories, which goes back to story = lies above.
- Stories waste time by requiring needless details.
- Your arguments must be weak if you have to resort to stories.

With regard to the attempt to find a good definition for story, the dictionary defines a *story* as *a narrative account of a real or imagined event or events,* but that definition doesn't really help to clarify things. By that definition, "The boy went to the store," would be a story. Haven therefore asserts that **the dictionary is wrong,** or at the very least the dictionary definition doesn't lead us to a working definition of what a story is or how to effectively use this mighty architecture.

When one turns to the literature to search for a good definition of *story*, one doesn't find much more help. There seem to be almost as many definitions of *story* out there as there are studies on the subject. Haven showed some examples from the literature. To make it even more confusing, sometimes a single paper might have several different definitions for story. Haven classifies many of these definitions as *useless* since they do nothing to help us come up with a specific, concrete story architecture that will improve the reader's/viewer's attention to, development of meaning and understanding from, retention of, and memory and recall of the concepts, data, arguments, and conclusions presented.

So Haven has taken matters into his own hands. He has done research bringing together information from the fields of neural biology and linguistics, developmental psychology, computer neural-net modeling, information science and knowledge management, cognitive sciences, and education in order to attempt to construct a more-accurate and useful definition of *story.* Haven next briefly summarized some basic concepts of brain anatomy and brain-monitoring technology. His point in going through this information was to demonstrate that modern technology gives us unprecedented ability to track how the brain works—i.e., we no longer have to guess.

This research indicates that the **human brain is *hard-wired* for *story*.** That is to say, we're born with a predisposition towards making sense of our lives through story. The brain's *story predisposition* is reinforced and strengthened as the brain develops—mostly complete by age 12. In the words of *Kotulak* (1999), "Cells that fire together, wire together." By the time we reach adulthood, we are dependent on interpreting events and other human's behavior through a specific story architecture. So in essence, says Haven, "The mind is what the brain does." New technology has only helped us to confirm this.

Haven says that part of this pre-programming is that we tend to assume that sensory input makes sense and *fill in* missing information accordingly (using existing mental maps). Haven gave a couple of examples.

Example 1: "Where's John"… "Well… I didn't want to say anything. But I saw a green VW parked in front of Carol's"

Example 2: "Hi Ken" … "NO! I'm not Ken. I'm not here. I'm not here!"

Most of us probably filled in the blanks to make the conversations above make sense, almost without thinking about it. That is, we work with partial information so often that we have developed certain *mental structures* that allow us to create meaning when we are presented with partial information. According to *Pinker* (1997), our brain tends to create *rules of thumb* that help us process incomplete information. Among those *rules of thumb* are:

- events have causes in past events (temporal sequencing);
- actions are driven by beliefs and goals; and
- human behavior follows predictable patterns based on goal attainment.

Story structures are used to help us deal with partial information. We observe a situation and jump to a certain conclusion, i.e., help us make sense of the world. Haven gave a few examples.

- You see a woman slumped on a bench crying, dress smeared with grass and dirt… and assume there is a logical reason for it, that something happened to her (in the recent past) to make her cry.
- You see a man chasing a dog… and assume the man wants to catch the dog and that the dog has done something to deserve the man's pursuit.
- You see a black rock against white snow… and assume even lighting.
- You see black and white dots on a screen… and mentally assume it's a 3-dimensional reality

Mental maps such as these are how humans make sense of other human's behavior and *create meaning* from sensory input. Humans use *mental maps*, i.e., cheat sheets,

to process incomplete sensory input and to *combine our interpretation* of that input with existing banks of experience to make it *make sense*. If you can't *make sense* of the situation quickly, you get bored, you feel it's above your head, and you assume it's not worth your time to try and understand—i.e., you discount the value of the information that's before you because you couldn't connect with it. Since *story architecture* seems hardwired into us as human beings, it makes sense that we would turn to it as a means of creating these mental maps that help us make sense of our world.

Haven noted that human minds use a number of specific mechanisms to accomplish this including: metaphor/parable; correlation/prior knowledge/pattern matching; inference/elaboration; mapping/schema; cheat sheets/framing; language (grammar) ; and relevance/context/empathy. He elaborated on some of these mechanisms that were particularly relevant to the context of science writing.

Metaphor/Parable: Metaphors and parables allow us to understand one domain of experience in terms of another. Consider the difference the metaphor you choose to interpret something makes in the meaning you create. For example, is *argument a war* or is *argument a dance*? Your attitude going into an argument may be very different depending on how you choose to frame it.

Correlation/Prior Knowledge: Having prior knowledge greatly enhances our ability to understand. To demonstrate how *prior knowledge* helps us make *correlations*, Haven showed two examples from Bransford (1993).

For the first example, Haven put a bunch of sentences up on the screen, each connecting a seemingly random name to an action—e.g., Frank brings eggs; Joe built a boat. Then, he went on to the next screen and wanted to know how many the audience could remember? It was virtually impossible to remember any of the connections because we had no *prior knowledge* to give us context or relevance for who these people were that would help us remember. Next he showed the same list of actions, but this time the actions were associated with names that we would (from our *prior experience*) associate with those actions—e.g., the Easter Bunny brings eggs; Noah built a boat—and it was much easier to remember the list. The example is a good reminder to us that our audience may or may not have prior knowledge of what we are talking about when we write. This can be a particular struggle when doing science writing. It's one thing to write minutes for a science meeting and quite another to write articles/products geared to the general public.

For the second example, Haven asked the audience to compare how they understand these two paragraphs:

Paragraph 1: *A thirsty ant went to the river. He was carried away by the rush of the stream and was about to drown. A dove, sitting in a tree overhanging the water, plucked a leaf. The leaf fell into the stream close to the ant and the ant climbed onto it. The ant floated safely to the bank. Shortly after, a bird catcher came and laid a trap in the tree. The ant bit and stung him on the foot. In pain, the bird catcher threw down his trap. The noise made the dove fly away.*

Paragraph 2: *Pete argued that data gathered from a NASA voyage to Venus called into question current theories about the formation of our solar system. Part of his talk emphasized the importance of mass spec trometers. He then discussed the isotopes of argon 36 and argon 38 and noted that they were of higher density than expected. He also cited the high values of neon found in the atmosphere. He has a paper that is already written, but he was aware of the need for further investigation as well.*

The point here is that it's generally much easier to connect with **Paragraph 1** because you have *prior knowledge* and so your mind quickly fills in the blanks. **Paragraph 2** on the other hand is "NASA Speak," and though some in our audience may understand it perfectly well, the average person does not, because they have no *prior knowledge* to help them connect the dots.

Inference/Elaboration. According to *Bransford* (1998), "If you know a lot about a topic, it is much easier to elaborate on, and to create meaning from the information that is presented and remember what you have read or heard. However, when a topic is unfamiliar to readers/listeners, research shows that the natural tendency is to use familiar story structure with character goal, motive, and struggles to elaborate on available information and to provide mapping structures to bring *prior knowledge* and experience to bear on the interpretation of current input."

Haven gave an example here that illustrates this idea: *John was late to work because of the snow.* Haven pointed out that most people in the U.S. would connect with this statement, but what about someone living in Central America who has never seen snow in their life? The idea again is readers who connect with these details automatically elaborate—i.e, they *infer* the unwritten details and fill in the blanks easily—but unless you *elaborate* on why this matters, readers who don't connect with the details provided, will tend to discard your story and assume it doesn't have value to them.

Haven also pointed out that readers/listeners automatically make these types of inferences. Therefore, the story creator must anticipate and control this elaboration to

produce the desired understanding and interpretation of the information that is provided.

Mapping/Schema. A schema is a mental map produced in response to stimulus that becomes a framework or basis for analyzing or responding to other related stimuli. Readers tend to remember the mental map or schema rather than the text itself.

Next, Haven showed how understanding a character's goals and motives helps us make sense of information we read. He showed an example from Bransford (1993):

> *Sally let loose a team of gophers. The plan backfired when a dog chased them away. She then threw a party but the guests failed to bring their motorcycles. Furthermore, her stereo system was not loud enough. Sally spent the next day looking for a "Peeping Tom" but was unable to find one in the Yellow Pages. Obscene phone calls gave her some hope until the number was changed. It was the installation of a blinking neon light across the street that finally did the trick. Sally framed the ad from the classified section and now has it hanging on her wall.*

Upon first reading this paragraph, it is unclear how all these facts connect to one another. However, once we understand the character's (Sally's) goals and motives, our understanding increases. When we are aware that, *Sally hates the woman who moved in next door and wants to drive her out,* our mind can conjure images and sequences that help us form the connection between all of these different facts.

Human minds automatically seek key story elements. (If they aren't explicitly stated, people will tend to make them up themselves, perhaps jumping to erroneous conclusions.) People interpret objects and animate objects, assigning goal, motive, intent, conflicts, and values to all actions. Agents propel themselves in service of a goal. For example, a few dots on a screen are quickly given motive. We see each dot as seeking a goal, when in reality, they are just dots on a screen! According to *Pinker* (1997), "Beliefs and goals (wants) drive rational behavior. If we are to understand behavior, we must understand beliefs and *goals*." Remember, humans make decisions based on partial information, so we use cheat sheets (*mental maps*) to fill in the blanks, i.e., the most probable truth, and the *mental map* humans tend to use most to explain human behavior is story structure. So for example, we might read the sentence: *Sally smells smoke and leaves the building*, and our brain will quickly fill in the details. *Goal* and *motive* help to create context, meaning, relevance, and memory.

Haven suggests that **in science writing the prevailing attitude is that the facts should speak for themselves, but unfortunately, that often means the facts don't speak at all.** Facts, he suggests, are made more relevant in the context of a story. Science writing often implies (if not buries) most of key story elements, and that has the effect of losing the viewer/readers focus. The human mind basically goes through a series of questions when it receives new information:

1. Should I pay attention?
2. How can I interpret and understand what I received?
3. What of my experience and *prior knowledge* applies here?
4. So, what does this mean to me personally?
5. [If deemed worthwhile] File to memory.

So based on all of this combined research, Haven can now present a **new and improved definition of story**: A *character-based* narrative account of a character's *struggles* to overcome obstacles and reach a defined and *important goal* presented in sufficient *detail* to make the story real, vivid, and memorable. One could condense this down to: *Characters at war.* To effectively communicate using *story*, it's good to keep in mind and be able to answer the following questions:

1. Who is the *main character* in the story?
2. What *character traits* make them interesting and relevant?
3. What does the character need to do or get (*goal*)?
4. Why is that goal important (*motive*)?
5. What *conflicts/problems* block the character?
6. How do they create *risk* and *danger*?
7. What does the character do (*struggles*) to reach the goal?
8. What sensory *details* will make the story seem real?

Haven also spoke about **applying this new definition of story to the specific context of science writing**. The goal as stated earlier is to adapt story elements and architecture to increase attention, retention, memory, meaning, understanding, accuracy, and recall of the information presented. Haven suggests that often in science, we tell what he called *family stories*. The assumption made is *part of the family* and thus has prior knowledge of what we are discussing, so we can leave out extra details—e.g., defining acronyms, explaining details, etc. That assumption is often not correct, especially when trying to write for a more general audience. The solution, Haven suggests, is story architecture. Strive to put a face on science. Create context, empathy, and relevance through character development. Tell the story through the eyes of the scientist. There are many interesting characters in science and we should take advantage of that. Provide explicit goals and motive for characters (left implicit in family stories, because it's assumed we already know it), and help the reader create meaning and understanding.

continued on page 22

NASA Takes Kids on a Jungle "Odyssey of the Mind"

Steve Graham, NASA Goddard Space Flight Center, RSIS, steven.m.graham.2@gsfc.nasa.gov
Rob Gutro, NASA Goddard Space Flight Center, robert.j.gutro@nasa.gov

Students from around the world gathered to participate in *Odyssey of the Mind's* 27th World Finals, a creative problem-solving competition, at the Iowa State University in Ames, Iowa, May 24-27. These students had advanced from competitions held earlier in the year at the local, regional, state or country levels and were in Ames to compete for the title of World Champion.

The 2006 World Finals marked the sixth year NASA's Earth Observing System Project Science Office sponsored a long-term problem. This year's problem, *The Jungle Bloke*, required teams to create and present a performance about a *Bloke*—a person who has the ability to talk with and understand animals from a jungle. Part or all of the performance had to take place in a jungle selected from a list. The animals were required to tell the *Bloke* about a problem that existed *in the jungle* and then get the *Bloke* to help. In addition, the animals also had to help the Bloke in some way and the Bloke had to convince someone else that he had the ability to talk with the animals. Finally, the presentation had to include an original song and dance.

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

Out of the 174 teams participating in *The Jungle Bloke* at World Finals, the following won top honors in their division:

A team from Colorado visits the NASA exhibit to gather some educational materials from NASA Langley representative Dennis Diones. Photo Credit: Tim Suttles

Division 1

1st Place: Indian River Elementary School, Selbyville, DE
2nd Place: Afton Elementary School Team B, Yardley, PA
2nd Place: General Ricardo Sanchez Elementary School, Rio Grande City, TX
3rd Place: Holland Christian School, Holland, MI
4th Place: Millis Road Elementary School, Jamestown, NC
5th Place: Rural Point Elementary School Team A, Hanover County, VA
6th Place: Lewis Greenview Elementary School Team A, Columbia, SC

Division 2

1st Place: St. John's School, Houston, TX
2nd Place: Osrodek Psychoedukacji Damb, Gdansk, Poland
3rd Place: Hull Middle School Team A, Duluth, GA
4th Place: Liberty Middle School, Hanover County, VA
5th Place: John Read Middle School, Redding, CT
6th Place: William Penn Middle School, Yardley, PA

Division 3

1st Place: Savannah Arts Academy, Savannah, GA
2nd Place: Anglo Chinese School, Singapore
3rd Place: Dixie Heights High School, Edgewood, KY
4th Place: Spring Woods High School, Houston, TX
5th Place: Pine Bush High School, Pine Bush, NY
6th Place: Thomas Jefferson High School Team A, Alexandria, VA

Division 4

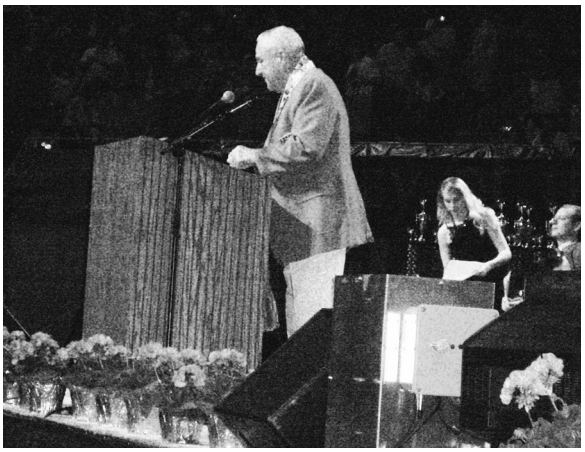
1st Place: York County Senior College, Sanford, ME
2nd Place: SWPS Filia Sopot, Sopot, Poland
3rd Place: School No. 30, Aktobe, Kazakhstan
4th Place: Kettering University, Flint, MI

NASA reaches nearly two million students, teachers, parents, and coaches around the world through its sponsorship of *Odyssey of the Mind* problems, stimulating interest in learning about Earth system science among all ages.

The *Odyssey of the Mind* program, founded in 1978, is an international educational program promoting team effort and creative problem solving for students from kindergarten through college. Thousands of teams from the U.S. and other countries including South Korea, China, Japan, Hong Kong, Singapore, Mexico, Canada, Kazakhstan, Poland, and Cameroon participated in World Finals. This includes teams from the Department of Defense Dependent Schools (DoDDS), many of which traveled from Europe.

NASA's Science Mission Directorate is dedicated to exploring, discovering, and better understanding the Earth and other planets. Through better understanding, the SMD hopes to improve prediction of climate, weather, and natural hazards using the unique vantage point of space. The goal of its participation in *Odyssey of the Mind* is to stimulate student's interest in pursuing an avenue of study that will be beneficial to future research in Earth science. To access the *Odyssey of the Mind* official web site, visit: *www.odysseyofthemind.com.*

In 2007, NASA will sponsor a problem called: *Classics… Around The World In 8 Minutes.*



Odyssey of the Mind founder "Dr. Sam" Micklus addresses the 15,000 attendees at the closing ceremonies. Photo Credit: Tim Suttles

The Glory of the Story

continued from page 20

There was a brief period for questions at the end of the talk. Someone asked how we should handle situations where the reader/viewer assumes they have *prior knowledge* of a topic that they actually don't understand at all. Haven suggests the best cure for that is to be as explicit as you can in your story telling, so they don't have to resort to *mental maps*, etc. It may also be appropriate to say, "*This may run counter to what you're used to …*"

To speak with Kendall about specific questions using story to communicate information, feel free to e-mail him at: *kendallhaven@spcglobal.net.*

CALIPSO-CloudSat Educator's Launch Conference

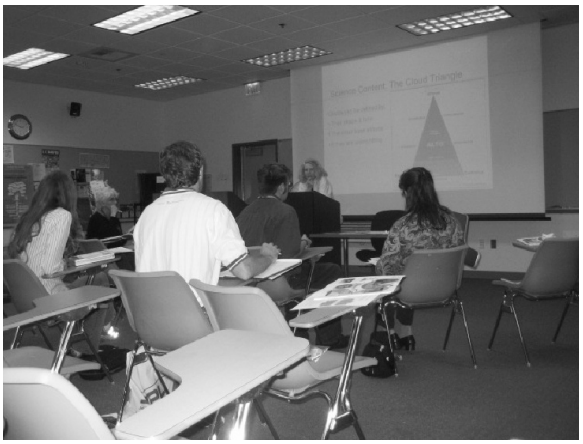
Debra K. Krumm, Colorado State University, Fort Collins, Colorado, dkrumm@atmos.colostate.edu

Summary: *NASA's CloudSat and Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) satellite missions successfully launched on April 28, 2006, at 3:02 AM PDT (1002 UTC) from Vandenberg Air Force Base (VAFB) in California. In honor of this exciting event, the VAFB-associated Space Endeavour Center hosted an educator conference. Twenty-six K-12 teachers from the state of California came together to learn how their students could participate in the two satellite missions and the NASA-sponsored GLOBE Program. Conference events included a series of six workshops held at Allan Hancock College's Lompoc Valley Center, a reception at the Space Endeavour Center, and a tour of VAFB. The highlight of the conference was a presentation and question and answer session by CloudSat Principal Investigator* ***Graeme Stephens*** *and CALIPSO Deputy PI* ***Chip Trepte.***

Background on the Space Endeavour Center

The Space Endeavour Center at Vandenberg, founded by Edmund Burke, (*www.endeavours.org/sec/index.htm*) is operated by Space Information Laboratories, Inc., a 501(C)(3) non-profit public benefit corporation, dedicated to educating and inspiring youth, and working with teachers to provide real-world science, technology, engineering, and math (STEM) education in the classroom. The *Endeavour Center* partners with government, industry, and the education system to support the public-benefit mission and vision. The mission is to implement Space Education Programs for the public in an interactive education facility that inspires youth to reach their highest potential and prepares them for math, science, and technology careers. The Center also works with teachers of grades K-12 and delivers real-world science and technology-based curricula and activities to their classrooms, and thereby seeks to improve the educational system across all levels. In addition to housing a NASA Educator Resource Center (ERC) for K-12 teacher conferences and workshops, the Center also disseminates educational materials to schools, and runs *Space Endeavour Camp* sessions.

CloudSat and CALIPSO aboard the Delta II rocket ready for launch.



Debra Krumm, CloudSat Director of Education and Public Outreach, describes cloud types to workshop participants.

The Educator's Conference

The CloudSat/CALIPSO Educator's Conference took place April 19-21, 2006, at the Space Endeavour Center. **Edmund Burke** [Space Information Labs—*President/CEO*] created, organized, and served as host for the workshop. Both **Burke** and **Roger Welt** [Allan Hancock College—*Executive Dean*] gave some opening remarks to all of the participants. Participants then spent the rest of the afternoon participating in three out of six possible workshops.

Three of the workshops stressed hands-on inquiry-based student research and the inter-connectedness of CloudSat, CALIPSO, and GLOBE. Among the activities teachers could participate in were cloud identification, use of a hand-held sun photometer to study aerosols, use of Global Positioning System (GPS), as well as other informative demonstrations and opportunities to gain experience using other scientific instruments.

Workshop Presentations

- **Debra Krumm** [Colorado State University (CSU)—*CloudSat Director of Education and Public*

Outreach] conducted a workshop entitled *NASA CloudSat Mission: Revealing the Inner Secrets of Clouds.*

- **Paul Adams** [Fort Hays State University], **Barbara Maggi** [Hampton University (HU)—*Outreach Director for the Center of Atmospheric Sciences*], and **Dianne Robinson** [HU—*Director of the Interdisciplinary Science Center and CALIPSO Outreach Director*] combined to present a workshop entitled *Aerosols and You: From the Ground to Space.*
- **Rebecca Boger** [University Center for Atmospheric Research (UCAR) GLOBE Program Office—*GLOBE Master Trainer and GLOBE Deputy Director of International Partnerships/Outreach*] conducted a workshop entitled *The GLOBE Program.*

The three other workshop choices for the afternoon highlighted additional NASA and other space-related programs that involve K-12 teachers and students.

- **Robert Coutts** [California State University, Northridge] presented *Solar Journey.*
- **Annie Richardson** [NASA Jet Propulsion Laboratory—*Education and Public Outreach Coordinator*] presented *Voyage on the High Seas: A NASA Oceanic Adventure.*
- **Carlo Ortega Cayetano** [Oklahoma State University—*Aerospace Education Specialist*] presented a workshop entitled *Rocketry: 3-2-1 Liftoff!*

Rebecca Boger, GLOBE Master Trainer, illustrates how to use a Global Positioning System (GPS).

During the CloudSat-, CALIPSO-, and GLOBE-related sessions, Educator's Conference participants learned about the CloudSat and CALIPSO satellite missions, their instruments, and educational opportunities for students. CloudSat flies a first-of-a-kind radar system that is much more sensitive than any weather radar. The Cloud Profiling Radar (CPR) provides a never-before-seen perspective on clouds because, for the first time, scientists can "see" inside the large cloud masses that make our weather. (Previous sensors have only viewed the tops of clouds.)

A cumulus cloud observed near conference locations.

This new three-dimensional perspective allows researchers to study the processes that convert the tiny cloud particles to precipitation with unprecedented detail and precision. CloudSat observations, will also allow scientists to predict the effects of clouds on our climate and improve predictions of climate change and help them gain a better understanding of how the water cycle works, where and how much it will rain, and if Earth's freshwater supplies might change in the future.

CALIPSO uses an innovative lidar and imaging system to "see" natural and human-produced aerosols and thin clouds that are invisible to radar, and sometimes even to the human eye. This provides a new and unique perspective on the amount, height, and type of aerosols and thin clouds. The lidar can even tell if a cloud is made of water or ice. CALIPSO helps scientists answer difficult questions about aerosols and make improved forecasts of air quality and predictions of climate change. From CALIPSO observations researchers will be able to observe the vertical layering of clouds and aerosols with a high level of detail; learn about the sources of aerosols, how they are transported, and how long they remain in the atmosphere; and determine where thin clouds occur and why, how they form, and how they affect the climate.

Smoke (aerosols) from a grass fire near the conference.

CloudSat Principal Investigator Graeme Stephens addresses the participants.

CloudSat and CALIPSO are both part of the *A-Train*, a nickname given to a group of satellites that fly close together and pass over the equator in the early afternoon. The *A-Train* provides coordinated science observations of the Earth and its atmosphere. Besides CloudSat and CALIPSO, other members of the *A-Train* include the NASA missions Aqua and Aura, a Centre National d'Etudes Spatiales (CNES) mission called Polarization and Anisotropy of Reflectances for Atmospheric Sciences coupled with Observations with a Lidar (PARASOL), and may eventually include NASA's Orbiting Carbon Observatory (OCO). Each satellite has a unique set of Earth-observing capabilities, but this is a case where t*he whole is greater than the sum of the parts.* Together, these diverse tools give scientists the most comprehensive set of observations of the Earth's atmosphere ever obtained. Combining data from the CloudSat and CALIPSO missions with observations from the other *A-Train* satellites will help improve the computer models used to simulate Earth's climate, answer significant questions about climate processes, and create a better understanding of global climate change.

Endeavour Educator's Conference participants were treated to a reception and dinner at the *Space Endeavour Center* followed by a series of keynote presentations. **Charles Matthew III** [Air Force Staff Sergeant at Vandenberg] explained procedures involving rocket launches from VAFB. **Michael Henderson** [The Boeing Company, ELS Division—*Program Manager, NASA Launch Services*] explained the Delta II rocket and gave the teachers a preview of the steps involved in the launch of CloudSat and CALIPSO. Both presentations generated a lot of discussion and questions. However, the highlight of the evening was a question and answer session facilitated by **Graeme Stephens** [CSU—*CloudSat PI*] and **Charles "Chip" Trepte** [Langley Research Center—*CALIPSO Deputy PI*]. Both scientists gave brief presentations on the satellite missions with an emphasis on how the missions will contribute to our understanding of the Earth's water cycle and help to improve our knowledge of global climate change. Stephens stated at the beginning of his presentation that he would rather hear from the teachers and answer their questions instead of giving a long talk. Stephens and Trepte answered questions for over an hour (until well past midnight) and the exceptionally high quality of the teachers' questions and their enthusiasm might have kept the scientists going longer, were it not for the fact that they had two satellites to launch—or so they thought!

Clouds over the launch guest operations hotel in Buellton where some of the visitors gathered to be taken to view the launch attempt at 1:00 am Pacific Daylight Time.

CALIPSO Deputy PI Chip Trepte explains CALIPSO and the A-Train to the audience.

The next day, April 20, conference participants got a special behind-the-scenes tour of VAFB. **Teresa Kennedy** [GLOBE—*Director of International/U.S. Partnerships and Outreach*] and **Nandini McClurg** [GLOBE—*US Regional Director*] gave a presentation about the various applications of GLOBE. At 3:00 a.m. the following morning, the participants attempted to view the launch but the launch was *scrubbed* with 48 seconds to go. A week later, the launch was successful, and CloudSat and CALIPSO continue to perform well and are now in position in the *A-Train* behind Aqua. Although disappointed about not getting to see the actual launch, the Educator's Conference participants were a dedicated and enthusiastic group who made the conference a big success. ■

Colorado State University Hosts CloudSat/CALIPSO Science Team Launch Dinner

Debra K. Krumm, Colorado State University, Fort Collins, Colorado, dkrumm@atmos.colostate.edu

On April 28 at 3:02 A.M. Pacific Daylight Time, a Delta-II Rocket roared off the launch pad at Vandenberg Air Force Base (VAFB) in California, carrying the CloudSat and the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) satellites into space. NASA selected both CloudSat and CALIPSO as Earth System Science Pathfinder (ESSP) missions. Prior to the launch, Colorado State University, home institution of the CloudSat Principal Investigator (PI) **Graeme Stevens**, hosted a special dinner for the CloudSat and CALIPSO science teams. The dinner was held not far from VAFB in the lovely town of Solvang, California, at the Royal Scandinavian Inn. Over a hundred science team members, their families, and other participants in the two satellite missions gathered together for special presentations and delicious food in anticipation of the launch. **Graeme Stephens** [CSU—*CloudSat PI*] and **David Winker** [NASA Langley Research Center—*CALIPSO PI*] welcomed the teams. **M. Patrick McCormick** [Hampton University—*CALIPSO Co-PI*] presented an overview of the CALIPSO mission, and **Donald Reinke** [Cooperative Institute for Research in the Atmosphere (CIRA)—*NASA-CloudSat Data Processing Center Manager*] gave an overview of CloudSat.

The highlight of the evening was a keynote address by **Pierre Morel** on the significance of the science of the two missions and the importance of understanding climate change. Initially a theoretical physicist (quantum statistical mechanics), Morel became engaged in space research from the very beginning and specialized in the study of the global atmospheric circulation and climate. In his capacity as Professor at the University of Paris, he created the Laboratory for Dynamic Meteorology (LMD) in 1968.

Morel was PI for the French-American EOLE satellite project—a.k.a., Cooperative Applications Satellite (CAS)—which tracked several hundred long-duration constant-altitude balloons around the Earth in 1971. The unique tracking system developed for EOLE was the forerunner of the French ARGOS data collection and location system used on NOAA operational satellites, as well as the global Search and Rescue Satellite (SARSAT) satellite-aided search and rescue system. He was also the originator of the European meteorological satellite program METEOSAT, first launched as a scientific initiative in 1977 and then continued operationally.

Morel served as Deputy Director-General of the French Space Agency in charge of science and technology (1975-82) and Director of the International World Climate Research Program (1982-1994). From 1995 until 2000, he was a Visiting Senior Scientist at NASA Headquarters and served for a year as Acting Director of Research in the NASA Office of Earth Science.

Both France and Canada play important technical and scientific roles in the CloudSat and CALIPSO missions, and a number of French and Canadian representatives came to the meeting, as did science team members from other partner countries.? Together, theseindividuals bring to the mission their expertise in a variety of disciplines ranging from general atmospheric science to the improvement of computer algorithms and data checking.

Meanwhile, space industry leaders CPI International Inc. (CPI) of Georgetown, Ontario, Canada and COM DEV of Cambridge Ontario, Canada developed a key element of CloudSat's cloud profiling radar, the *extended interaction klystrons* (EIKs)—a specialized electronic tube similar in concept to those used in microwave ovens that generate the radar waves that will enable CloudSat to probe the vertical structure of clouds. CPI and COM DEV also provided a central component of an electronic receiver: the radio frequency electronics subsystem (RFES).

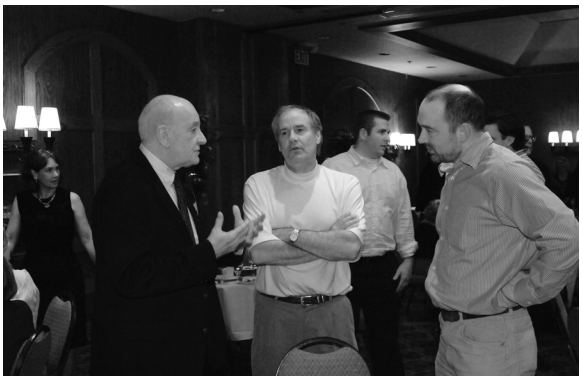
Other CloudSat partners include Ball Aerospace who constructed the satellite platform, the U.S. Air Force, the European Centre for Medium-Range Weather Forecasts (ECMWF), and Colorado State University. Most of these organizations had representatives at the dinner.

CALIPSO is a joint U.S. (NASA) and French [Centre National d'Etudes Spatiales (CNES)] satellite mission with an expected 3-year lifetime. CALIPSO is a collaboration between NASA Langley Research Center and CNES. Other members of the CALIPSO team are Ball Aerospace and Technologies Corporation, Hampton University, and the Institut Pierre Simon Laplace. ■

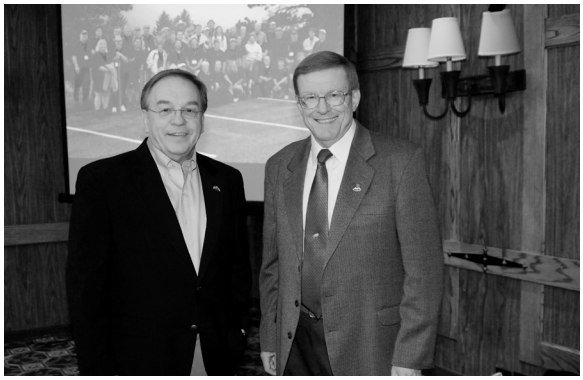
Roger Marchand (Pacific Northwest National Laboratory), and Gerald Mace (University of Utah), CloudSat Science Team members, inspect a painting by CloudSat Principal Investigator Graeme Stephens.

CloudSat's Principal Investigator Graeme Stephens (Colorado State University) welcomes the science teams and their families.

Thomas Vonder Haar, Director of Cooperative Institute for Research in the Atmosphere (CIRA), Pierre Morel, keynote speaker, and Adarsh Deepak, Science and Technology Corporation (STC).



Keynote speaker Pierre Morel, Graeme Stephens, CloudSat PI, and Gerald Mace of the University of Utah.



CALIPSO Co-Principal Investigator M. Patrick McCormick and Donald Reinke, NASA-CloudSat Data Processing Center (CIRA) Manager.

Fifth CERES-II Science Team Meeting

Shashi K. Gupta, Analytical Services and Materials, Inc., S.K.Gupta@larc.nasa.gov

The fifth meeting of the Clouds and the Earth's Radiant Energy System (CERES-II) Science Team was held May 2-4, 2006 at the Crowne Plaza Hotel in Williamsburg, Virginia. **Bruce Wielicki** [NASA Langley Research Center (LaRC) - *CERES Principal Investigator*] hosted the meeting. The next CERES Science Team meeting will be held jointly with the European Geostationary Earth Radiation Budget (GERB) Science Team during the week of October 23-27, 2006 at the Hadley Centre, U.K. Meteorological Office in Exeter, U.K.

Major objectives of the meeting included:

- a science team review of Terra and Aqua shortwave (SW) channel spectral throughput changes from 2000 to 2005;
- release of Aqua Edition-2A Single Scanner Footprint (SSF) and Surface Fluxes and Clouds (SFC) data derived with Aqua Angular Directional Models (ADMs); and
- release of Terra top-of-atmosphere (TOA) and surface averages (SRBAVG) monthly products and their validation results.

In addition to the main objectives, the science team also reviewed the plans for deriving SRBAVG daily products, gridded synoptic fluxes from the Surface and Atmospheric Radiation Budget (SARB) subsystem, proposed cloud subsystem improvements for *Edition-3* processing, and CERES participation in Global Energy and Water-cycle Experiment (GEWEX) Radiative Flux Assessment (RFA) activities. The data management group presented plans for converting CERES production codes from SGI platforms to commodity hardware clusters.

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, the National Polar-orbiting Operational Environmental Satellite System (NPOESS), the A-Train, the NASA Energy and Water-cycle Study (NEWS), and activities of the NASA/NOAA Research-to-Operations Panel. A multi-agency workshop on ways to achieve satellite climate calibration goals will be held May 16-18, 2006, in Washington, DC. A recent Global Climate Observing System (GCOS) draft document on satellite climate data record requirements is out for review and comments are due by June 12, 2006. The CCSP Observation Working Group (OWG) plans a retreat for June 14-15, 2006, to discuss climate observation requirements.

Recent leadership changes at NASA Headquarters have greatly increased the science/engineering experience within senior management ranks. **Mary Cleave** is now the Associate Administrator for Science and **Colleen Hartman** is her deputy. **Bryant Cramer** is the new Acting Director of the Earth Science Division. Earth Science budgets beyond FY2006 are expected to remain flat. Significant increases in manned space fight costs are putting a big squeeze on Earth and Space Science budgets.

The CERES FM-5 instrument may be launched on the first NPOESS spacecraft in a 1:30 p.m. orbit. Cost and schedule constraints have delayed that launch by up to 30 months (to mid-2014). NPOESS is currently under congressional review, and a report is due in June 2006. Major problems have come to light with two of the instruments, Visible Infrared Imager Radiometer Suite (VIIRS) and Conical scanning Microwave Imager Sounder (CMIS). The Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) and CloudSat were successfully launched together on April 28, 2006, and will join the A-Train.

A congressional bill requires annual reports on progress in converting NASA research developments into NOAA operations and utilizing NOAA operational data in NASA research. A Joint Agency Working Group held a planning meeting in January 2006, and a broader meeting later on April 24-26, 2006, to review challenges and opportunities in all Earth Science disciplines. The first report is due in February 2007.

Terra/Aqua Instruments and Calibrations

Kory Priestley [LaRC] presented operational and calibration/validation status of the four CERES instruments on Terra and Aqua. Both instruments on Terra and one (FM-3) on Aqua continue to function nominally. The SW channel of FM-4 on Aqua suffered an anomaly on March 30, 2005, and stopped taking radiometric measurements. Priestly explained how contaminant deposition was causing spectral darkening of the SW channel of instruments operating in the rotating azimuth plane (RAP) mode.

Grant Matthews [Analytical Services & Materials (AS&M)] discussed how the spectral darkening model was adapted for the use of filtered deep-convective cloud (DCC) albedo as a stability metric in place of onboard lamps. The use of DCC albedo resolved the differences between revision-1 factors for Terra and Aqua. He also reported that reanalysis of a 3-channel intercomparison suggested that *Edition-2* daytime longwave (LW) fluxes may be too low and need to be corrected for *Edition-3* processing.

CERES Cloud Properties

Patrick Minnis [LaRC] presented the status of CERES cloud algorithms and products. Minnis described the extensive ongoing effort to intercalibrate sensors on different satellites and instruments to achieve consistency. These efforts indicated that the progression from VIRS *Version 5a (v5a) to Version 6 (v6)* introduced a trend in the visible channel calibration. A DCC correction was developed and will be applied to *v6* data. The DCC correction aligns the Terra and Aqua Moderate Resolution Imaging Spectroradiometer (MODIS) instruments, with Aqua MODIS having near perfect agreement with theoretical calculations. Minnis discussed some of the improvements to be implemented in *Edition-3* processing including improved cloud detection, refined thin-cirrus detection, dust discrimination, high-resolution cloud detection for low clouds, and multilayer cloud detection and retrieval methods.

CERES ADM and Albedo Analyses

Norman Loeb [National Institute of Aerospace (NIA)] examined the response of CERES SW and LW TOA fluxes to cloud algorithm changes. One day of the modified Terra Single Scanner Footprint (SSF) dataset was produced using cloud properties from the MODIS *MOD06* cloud product in place of CERES clouds. Comparisons showed SW differences up to 20 W/m^2 over Antarctica and LW differences up to 35 W/m^2 at 60°S. Loeb also compared CERES broadband TOA albedos for overcast scenes with those derived over a 25-day period from Level-2 Multiangle Imaging SpectroRadiometer (MISR) albedos using a narrowband-to-broadband conversion algorithm. The two datasets showed excellent agreement both regionally and globally.

Simple Surface Fluxes

David Kratz [LaRC] presented validation of SW and LW surface fluxes from SSF data derived by the Surface-only Flux Algorithms (SOFA) group using simpler surface flux algorithms. The group obtained ground-based fluxes for validation from a number of sources such as the Atmospheric Radiation Measurement (ARM) sites, Baseline Surface Radiation Network (BSRN), and SURFace RADiation (SURFRAD) network. Substituting newer aerosol properties from the Model for Atmospheric Transport and Chemistry (MATCH) resulted in a slight improvement in SW *Model A* fluxes but gave rise to a large positive bias in SW *Model B* fluxes. The cause of this bias is under investigation. LW errors for both clear and cloudy conditions were within desired range.

Terra and Aqua SARB Products

Thomas Charlock [LaRC] presented comparisons of CERES SARB products over the ARM Central Facility with corresponding results produced by the ARM program. He also showed time series of biases of SARB TOA and surface fluxes relative to CERES TOA measurements (with and without *Revision-1* correction) and ground-based measurements respectively. These biases were examined in relation to the values of several input variables. The largest biases were found to occur in the presence of thin ice clouds. Charlock also discussed several changes planned for *Edition-3* processing.

CERES TISA Activities

David Doelling [AS&M] reported on the activities of the Time Interpolation and Spatial Averaging (TISA) Working Group and announced the public release of 3 years (March 2000 – February 2003) of Terra SRBAVG products that are available from the Atmospheric Science Data Center (ASDC) at LaRC. These products use geostationary (GEO) satellite data for improving diurnal sampling. Aqua FM4 SW and LW fluxes showed small calibration anomalies that will be corrected during *Edition-3* processing. SRBAVG SW and LW fluxes were found to be consistent with corresponding fluxes derived by the SOFA group. In order to verify that GEO-procedures did not introduce any spurious spatial patterns in the products, a prinicipal components analysis was performed. In an accompanying presentation, Doelling discussed the work underway to produce daily SRBAVG products and monthly SRBAVG products organized similarly to ISCCP-D2 products.

Fred Rose [AS&M] presented the methodology and preliminary results on a diurnally resolved synoptic SARB product known as SYNI resulting from a cooperative effort between the SARB and TISA groups. This product is computed on an hourly basis with the Fu-Liou radiative transfer code using gridded hourly meteorological data from CERES Meteorology, Ozone, and Aerosols (MOA), clouds obtained from the CERES Cloud Group, and TOA fluxes needed to constrain GEO processing. Rose discussed known deficiencies in all the inputs and their effects on the SYNI products.

CERES 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 51,000 observations from more than 2000 participants in 68 countries. More than 20,000 observations are matched with a Terra or Aqua overpass with about 350 of those matched with both Terra and Aqua at the same time. Chambers encouraged attendees to participate in S'COOL activities in their own communities.

Data Management Status

Mike Little [LaRC] presented an overview of the activities of the CERES Data Management Group, the changes already underway, and those coming in the near future.

These changes, which are driven mainly by considerations of costs and increasing data volume and complexity, will also improve coordination between the Science Computing Facility (SCF) and the Atmospheric Sciences Data Center (ASDC). The new setup will make use of the power of clusters of commodity-based computing hardware, Storage Area Networks, and new cluster management tools to reduce costs. Codes and scripts will be converted to run on multiple platforms. A cluster of Mac-G5 servers will replace the current SGI workstations.

Invited Presentations

Michelle Ferebee [ASDC] apprised the Science Team of the evolution in progress at the ASDC where operational production, archival, and distribution of CERES data take place. ASDC is a full-service data center for radiation budget, aerosols, clouds, and tropospheric chemistry. ASDC currently supports over 40 science projects, has over 1000 datasets archived, and distributes data to science communities worldwide. Budgetary pressures are the primary factor motivating this evolution. These changes will result in greater use of commodity-based hardware for processing, archival, and distribution. Ferebee emphasized that these changes will be implemented gradually and will be coordinated with the CERES Data Management Team.

Chip Trepte [LaRC] presented a brief overview of the CALIPSO mission that, along with CloudSat, was successfully launched the previous week. CALIPSO carries a dual-wavelength lidar, a 3-channel Imaging Infrared Radiometer, and a wide-field camera. These instruments will provide measurements of vertical profiles of aerosol and cloud properties at a very high resolution. These data will be valuable in enhancing our understanding of the role of clouds and aerosols in the processes that govern our climate. Both CALIPSO and CloudSat will fly in formation with several other satellites as part of the A-Train. Together, observations from these satellites will provide a comprehensive 3-dimensional look at the radiation, aerosol, and cloud parameters in the atmosphere.

Co-Investigator Presentations

Amy Clement [University of Miami] presented results of an analysis of spatial patterns of outgoing LW radiation (OLR) trends in Earth Radiation Budget Experiment (ERBE) and CERES data for 1985-1999 over tropical regions to determine if the observed trends were robust and meaningful. Clement also examined the effect of ENSO episodes on the observed trends. Clement performed similar analysis for corresponding SW fluxes and also for High-resolution Infrared Radiation Sounder (HIRS) OLR data. The primary objective of this study was to relate these observed trends in the ERBE/CERES record to patterns of some underlying atmospheric phenomena or circulation.

Bing Lin [LaRC] presented results from a study of the climate feedback of tropical deep convective systems (DCS) which are extremely important to the hydrological and energy cycles of the climate system. Recent analysis of Tropical Rainfall Measuring Mission (TRMM) data had shown that rainfall efficiency of DCS increased with increasing SST. This study shows that DCS area coverage and ice-water path of DCS also increase along with increased rainfall efficiency. This results from the greatly increased moisture supply from the boundary layer which is also transported to the upper troposphere.

Lou Smith [NIA] presented results from a study of the changes in the radiation budget of the Arctic region (north of 70°N) using ERBE scanner data for 1985-1988 and Terra/CERES data for 2000-2005. Smith showed that net radiation over the Arctic region increased significantly from the ERBE period to the CERES period and this increase was accompanied by a corresponding decrease in snow/ice cover. This hypothesis was corroborated by the observation that OLR over the region changed very little while absorbed SW radiation increased significantly.

Seiji Kato [Hampton University (HU)] presented a study of the variability of TOA radiation budget and cloud amount over polar regions. Kato showed that daytime cloud amount over the Arctic region derived by using the CERES cloud algorithm showed a modest increase during the period March 2000–February 2004. The TOA reflected SW flux for that period did not show a corresponding increase. These results suggest that the effect of decreasing Arctic snow/ice cover compensates for the increase in cloud amount.

Norman Loeb [NIA] presented results from a study of aerosol-cloud interactions using coincident CERES and MODIS observations. The study was restricted to single-layer low clouds off the African coast in regions where both aerosol and cloud retrievals were available. Each 5° x 5° region was subdivided into two populations: one with lower and the other with higher than average aerosol optical depth (AOD). The population with higher AOD showed larger cloud amounts, higher LWP, and higher TOA SW fluxes. The effective droplet radius showed no difference between the two populations.

William Collins [National Center for Atmospheric Research (NCAR)] presented an evaluation of Model for Atmospheric Transport and Chemistry (MATCH) aerosol properties relative to corresponding data from AEROCOM. MATCH data are one of the alternative sources of aerosol properties used in CERES/SARB processing. AEROCOM is an intercomparison project that has developed a database of ground-measured and satellite-derived aerosol properties for validation purposes. The present comparisons were restricted to using ground data from the Aerosol Robotic Network (AERONET).

Comparisons of 550 nm AOD over North America and Europe showed slight overestimation by MATCH.

Alexander Ignatov [National Environmental Satellite Data and Information Service (NESDIS)] presented an analysis of consistency between spectral AOD retrievals over ocean from MODIS data from Terra and Aqua. Ignatov presented AOD retrievals at 0.66 µm from global data for October 2002. AODs from both retrievals showed nearly log-normal distribution. Significantly higher AODs from Terra at all wavelengths were attributed to either more cloud contamination (less screening) or the occurrence of higher humidity during morning.

Xiquan Dong [University of North Dakota (UND)] presented comparisons of cloud properties derived from MODIS data with those derived by surface instrumentation at the ARM Central Facility. Terra retrievals for March 2000–December 2004 and Aqua retrievals for July 2002–December 2004 were used. Dong showed that satellite-derived cloud temperatures agreed well with ARM site measurements but the algorithm for deriving cloud heights needs some improvement. Daytime comparisons of microphysical properties showed better agreement than nighttime results.

Michel Viollier [Laboratoire de Meteorologie Dynamique (LMD)—*France*] presented an analysis of the modified CERES along-track radiances and fluxes. Viollier showed that obliquely viewed fore and aft CERES footprints identified with the location of a nadir footprint can be as far apart as 80 km because of the Earth's rotation, and have large differences in radiances. He presented a scheme that compensates for the effects of Earth's rotation. Comparisons of LW and SW radiances for matched fore and aft footprints before and after compensations showed significant improvement in bias and random error.

Istvan Laszlo [NESDIS] presented comparisons of satellite-retrieved surface insolation over two Tibetan sites with ground-based measurements during the GEWEX Asian Monsoon Experiment (GAME). Present satellite retrievals were made with *Version-3.0* of the Pinker-Laszlo SW algorithm. This version uses a full radiative transfer module in place of look-up tables used in the earlier *Version-2.2*. A surface elevation map, not used in the old version, is also used in this version. Laszlo showed that these improvements largely corrected the severe underestimation of surface insolation occurring with *Version-2.2.*

Lin Chambers [LaRC] presented an overview of the GEWEX RFA activity. The purpose of this activity is to assess our ability to estimate surface and TOA radiative fluxes from satellite observations and the uncertainties in those estimates. The overall goal is to acquire a sound understanding of the long-term variability of radiative fluxes so that it can be used to develop climate-system-observation requirements, assess GCM and reanalysis products, and be used in IPCC reports.

Betsy Weatherhead [University of Colorado] presented an examination of the internal structure of time series of satellite-derived and ground-measured *insolation* data looking for indications of a *trend*—a change that is large relative to the natural variability and instrument uncertainty. Weatherhead used time series of mean and deseasonalized surface *insolation* for global and selected-site averages to illustrate the method. She found that deseasonalized time series of global mean fluxes showed significant autocorrelation and a clear decadal time scale.

Laura Hinkelman [NIA] presented an analysis of surface *insolation* data looking for long-term trends in satellite-derived as well as ground-measured datasets. Satellite data came from the GEWEX/SRB project put on a 2.5° x 2.5° grid for GEWEX RFA while ground data came from the Global Energy Balance Archive (GEBA). Time series constructed for the July 1983–June 2002 period were used. Linear trends were estimated using the least mean square method. Detected trends in the time series did not reach 95% significance level but significance increased with decreasing variance in the signal.

Paul Stackhouse [LaRC] presented a report on the status of the GEWEX/SRB project and comparisons between recently released CERES SRBAVG data and GEWEX/SRB results. GEWEX/SRB fluxes are derived using satellite-derived cloud properties and ozone data, and reanalysis meteorology. The current GEWEX/SRB data, designated as *Release-2.5/2.6* were submitted recently to the GEWEX RFA. Problems related to filling data gaps in SW fields near twilight zones have now been resolved. Comparisons with SRBAVG results showed good agreement for global averages though larger differences exist over polar regions.

Steven Dewitte [Royal Meteorological Institute of Belgium (RMIB)] reported on the GERB *Edition-1* data scheduled for release in the near future. These data come from the GERB-2 instrument that was launched on Meteosat-8 satellite in August 2002. After several rounds of validation and improvement, the GERB-2 processing algorithm was frozen; this current version is designated as *V3.* Dewitte presented GERB-2/*V3* TOA reflected SW and emitted LW radiances and fluxes for one week each in June and December 2004, and compared them with corresponding CERES SSF results.

Pam Mlynczak [Science Applications International Corporation (SAIC)] presented results comparing the output of the 256 GERB detectors. The CERES instrument serves as a transfer radiometer between the GERB detectors. Unfiltered SW radiances from each of the GERB detectors were compared with corresponding CERES FM2 ES8 footprints that were matched in location and viewing geometry. Results showed that GERB detector output varies considerably across the array with GERB/CERES ratio varying between 1.03 and 1.08.

Wenying Su [HU] presented results of photosynthetically active radiation (PAR) reaching the surface derived within SARB processing. PAR is defined as solar irradiance in the 400–700 nm range. Until now, fluxes from Fu-Liou bands 7, 8, 9, and 10 have been summed to obtain PAR. Su developed *look-up tables* to scale the values in bands 7 and 10 to the exact bounds of the PAR wavelength range. The use of this scheme provided better PAR values. She showed numerous comparisons with surface PAR measurements available from SURFRAD sites.

Craig Long [NOAA NCEP] apprised the Science Team of a new ozone product soon to be available from NCEP Climate Prediction Center's Global Forecast System (GFS). CERES already uses an analysis ozone product from NCEP known as the Stratospheric Monitoring-group Ozone Blended Analysis (SMOBA) product. This new product can be used if there is an interruption in SMOBA availability. The GFS model currently assimilates NOAA-16 and NOAA-17 Solar Backscatter Ultraviolet (SBUV-2) total and profile ozone data. The GFS model has ozone chemistry but does not provide results for polar night regions.

Seiji Kato [HU] presented a study quantifying the uncertainties in estimating TOA reflected SW fluxes under twilight conditions when solar zenith angle (SZA) is greater than 85°. Kato used CERES/TRMM data for his study. Global mean all-sky irradiance was determined to be 0.22±0.07 W/m^2 when SZA was greater than 90°. The uncertainty in irradiance due to extrapolation of directional models in the 85–90° SZA range was estimated to be 0.57 W/m^2.

ADM/Inversion Working Group

Konstantin Loukachine [SAIC] presented a strategy for estimating TOA radiative fluxes for the upcoming Indo-French Megha-Tropiques mission under which a Scanner for Radiation Budget (ScaRaB) instrument will be launched in a 20° inclination, 886-km altitude orbit. In the absence of an imager, scene identification information on this mission will be scarce. He proposed a neural network (NN) approach to develop training sets using CERES ADMs.

Cedric Bertrand [RMIB] reported on the presence of diurnal asymmetry in GERB clear-sky SW fluxes. Computation of GERB broadband fluxes starts with average narrowband radiances over 3 x 3 arrays of Spinning Enhanced Visible and Infrared Imager (SEVIRI) pixels and subsequent narrowband-to-broadband and radiance to flux conversions. To correct the problem, Bertrand replaced the theoretical narrowband-to-broadband relation with an empirical approach.

Wenbo Sun [HU] presented comparisons of CERES TOA albedos with MISR Level-2 albedos derived using narrowband-to-broadband regression relations. Both datasets were put on a common 1° x 1° grid for the month of October 2001. Sun's results showed excellent agreement for overcast conditions, but differences for all-sky conditions was about 2.5%, and much larger for clear-sky conditions.

Cloud Working Group

Pat Minnis [LaRC] discussed the discontinuity in CERES cloud mask between polar and non-polar zones. The Aqua/MODIS nighttime cloud amount field for October 2002 showed the exact location of the discontinuity. Causes of this discontinuity are under investigation.

Fu-Lung Chang [NIA] spoke briefly about the multilayer cloud detection algorithm being tested for CERES *Edition-3* processing. New output parameters expected from this algorithm were also discussed.

Xiquan Dong [UND] presented comparisons between cloud physical and microphysical properties from the Goddard Institute for Space Studies (GISS) model, MODIS, and ARM Central Facility data. He showed that both surface and satellite cloud observations miss multilayer clouds when compared to ARM radar/lidar measurements.

SARB/SOFA Working Group

David Kratz [LaRC] presented the results of testing a new LW algorithm provided by Zhou and Cess for use in CERES for computing surface LW fluxes. This algorithm is designated as LW *Model-C*. Earlier tests of this algorithm showed large errors over cold and dry regions and also in the presence of ice clouds. The algorithm has been modified in consultation with the authors. Results of the modified algorithm show good agreement with ground-based measurements. It will now be used in CERES *Edition-3* processing.

David Rutan [AS&M] showed comparisons of SARB footprint level results with a value-added product from the ARM Central Facility known as the BroadBand Heating Rate Profiles (BBHRP). Comparisons of input data for the two sets, namely, surface temperature and albedo, showed large differences in surface albedos. Largest differences in both SW and LW fluxes occurred at the 500 hPa level.

Zhonghai Jin [AS&M] presented a parameterization for ocean surface albedo, developed as analytical fits to the look-up tables that were used in earlier work. Jin showed several good comparisons of broadband and spectral albedos between model results and measurements made at the CERES Ocean Validation Experiment (COVE) site. ■

NASA Study Finds Clock Ticking Slower On Ozone Hole Recovery

Gretchen Cook-Anderson, NASA Goddard Space Flight Center, gretchen.cookanderson@rsis.com

The Antarctic ozone hole's recovery is running late. According to a new NASA study, the full return of the protective ozone over the South Pole will take nearly 20 years longer than scientists previously expected.

Scientists from NASA, the National Oceanic and Atmospheric Administration and the National Center for Atmospheric Research in Boulder, CO, have developed a new tool, a math-based computer model, to better predict when the ozone hole will recover.

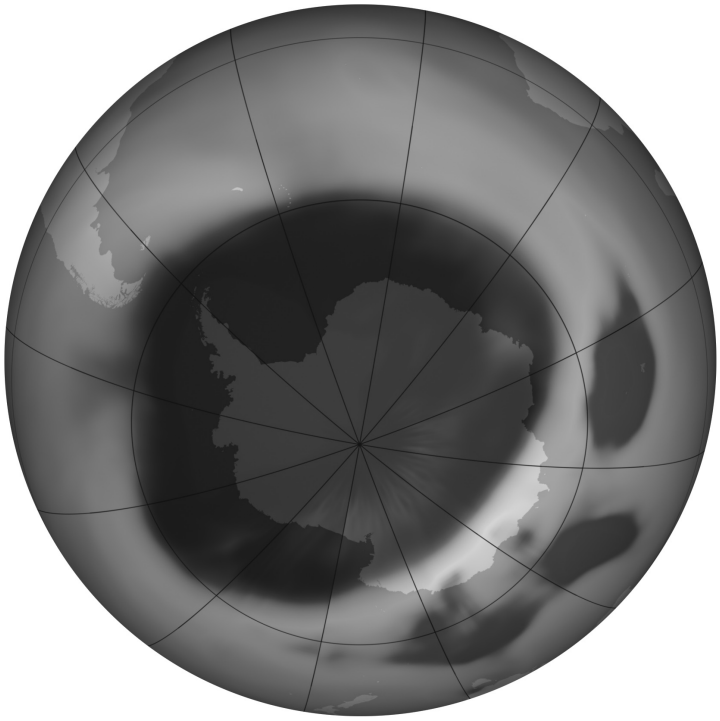
The Antarctic ozone hole is a massive loss of ozone high in the atmosphere (the stratosphere) that occurs each spring in the Southern Hemisphere. The ozone hole is caused by chlorine and bromine gases in the stratosphere that destroy ozone. These gases come from human-produced chemicals such as chlorofluorocarbons, (CFCs).

The ozone layer blocks 90-99% of the sun's ultraviolet radiation from making contact with Earth. That harmful radiation can cause skin cancer, genetic damage, and eye damage, and harm marine life.

For the first time, a model combines estimates of future Antarctic chlorine and bromine levels based on current amounts as captured from NASA satellite observations, NOAA ground-level observations, and NCAR airplane-based observations, with likely future emissions, the time it takes for the transport of those emissions into the Antarctic stratosphere, and assessments of future weather patterns over Antarctica. The model accurately reproduces the ozone hole area in the Antarctic stratosphere over the past 27 years. Using the model, the researchers predict that the ozone hole will recover in 2068, not in 2050 as currently believed.

"The Antarctic ozone hole is the poster child of ozone loss in our atmosphere," said author **Paul Newman**, a research scientist at NASA's Goddard Space Flight Center, Greenbelt, MD and lead author of the study. "Over areas that are farther from the poles like Africa or the U.S., the levels of ozone are only 3 to 6 % below natural levels. Over Antarctica, ozone levels are 70% lower in the spring. This new method allows us to more accurately estimate ozone-depleting gases over Antarctica, and how they will decrease over time, reducing the ozone hole area."

International agreements like the Montreal Protocol have banned the production of most chemicals that destroy ozone. But the researchers show that the ozone hole has not started to shrink a lot as a result. The scientists predict the ozone hole will not start shrinking a lot until 2018. By that year, the ozone hole's recovery will make better time. ■



This image shows the ozone hole on September 11, 2005. The ozone thinning over Antarctica reached its maximum extent for the year on this date. The darker regions represent areas with maximum ozone loss. Credit: NASA

What's Up with Sea Level?

Rosemary Sullivant, Jet Propulsion Laboratory, Rosemary.Sullivant@jpl.nasa.gov

Sea level isn't… well… level, nor is the rate by which sea level has been rising over the past few decades; but the trend is clearly up. Global sea level has risen an average of 3 mm (0.1 in) per year since 1993. Rising seas have the potential to affect billions of people around the globe, not just those living near coastlines. With the ocean soaking up more heat from a warming planet and glaciers melting at a record-breaking pace, is there any way to know where and when sea level rise may level off?

Measuring changing sea level is just the beginning. "One single number for sea level rise isn't all you need to know," says Jet Propulsion Laboratory's **Michael Watkins.** "You want to know what's happening in different locations. You also want to know if it is accelerating. You want to put the current decade under a microscope and see exactly what's going on."

Watkins is the Project Scientist for the Gravity Recovery and Climate Experiment (GRACE), one of several NASA missions and projects that are helping to dissect sea-level rise and understand the individual components that make up the whole complicated system. Scientists now have the tools to begin to understand the mechanisms that drive global sea level and make better predictions for the future.

"Global sea level can rise for one of two reasons," says **Josh Willis**, oceanographer at JPL. "One is when water gets hotter, it expands. The other is when water is added to the ocean, which changes its mass. That happens, for example, when glaciers melt."

Different tools for each part of the problem

No single ocean-observing system can pick out the exact source of rising seas, but by combining measurements made by different instruments, scientists can get very close. "For studying sea level, there are basically three global observing systems," says Willis.

One is made up of satellite altimeters, like the recently retired NASA/French TOPEX/Poseidon, and its follow-on Jason, which make precise measurements of ocean-surface height. Altimeters provided the first detailed picture of global sea level and now track its change. Altimeters measure total ocean height. The total height of the ocean is the result of changes in mass, thermal expansion, and, in some cases, salinity. Different observation systems are needed to isolate the contribution that each of these factors makes to the whole, explains Willis.

That's where the GRACE mission comes in. It measures the change in mass of water on Earth and its location. "GRACE contributes to sea-level measurements in two ways. It measures the mass of ice as well as the mass of the entire ocean," says Watkins. If the water is frozen, as on Antarctica, and then melts, GRACE can measure that change and how it evolves over time, he explains. For example, researchers using GRACE data found that the mass of ice in Antarctica had decreased significantly from 2002 to 2005, enough to raise global sea level by 1.5 mm (0.05 in) during that period.

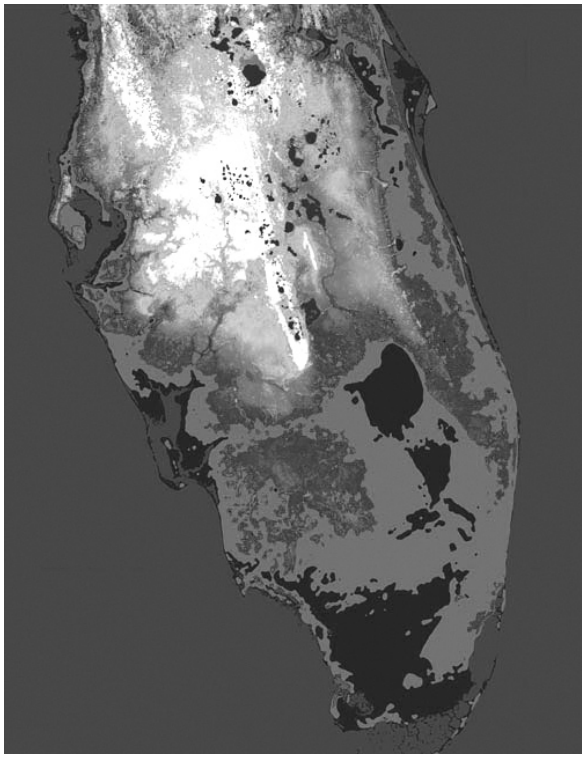
The third global observing system consists of thousands of ocean floats, *in situ* profilers, like those of the international Argo array. They measure temperature from the top of the ocean down to 2,000 m (about 6,600 ft) depth. "Ideally if you were to add up the thermal component that the *in situ* profilers see with the mass that GRACE measures, you should get the total sea level that Jason observes," says Willis. "That should work for the global average, but the patterns of sea level change are more complicated."

For example, fresh water isn't as dense as salty water. As a result, fresh water with the same amount of mass as salty water will take up more volume. "So if you're worried about sea level rise in a particular place, say a small island in the Pacific," says Willis, "you need to know how salty the nearby water is, too, and whether that may be changing." The Argo floats, he adds, also measure salinity, and now that the system is global, it will help us understand this component of sea level better in the future. In 2009, NASA will launch the Aquarius satellite to provide direct measurements of sea surface salinity from space, providing more information on this missing piece of the climate puzzle.

How high and how fast?

Researchers say that about half of the rise in global sea level since 1993 is due to thermal expansion of the ocean and about half to melting ice. As Earth warms, these proportions are likely to change with dramatic results.

"More heat is coming into Earth's atmosphere than is going out," says JPL Researcher and Jason Project Scientist **Lee-Lueng Fu**. "Over the past 40 years, the ocean has absorbed 84% of this excess heat—enough heat to warm the entire atmosphere by 27°C (49°F)." The ocean has been able to absorb this heat by mixing warm surface water with much colder water from its



Rising seas would have dramatic effects on regions with low topography like Florida. The darkest areas are less than 5 m (16 ft) above sea level.

depths, he explains. "The question is how long can it continue to do this."

Add more heat to the oceans, already Earth's largest storehouse of solar radiation, and not only does global sea level rise due to thermal expansion but circulation patterns could change and affect the ocean's ability to store more heat in the future.

Excess heat that doesn't go into the ocean has to go somewhere. If it's melting ice, the effect on sea level will be immense. Melting, not warming, has the biggest potential to raise sea level. "If you warm up the ocean, it will rise perhaps half a meter (1.6 feet)," says JPL researcher **Eric Rignot**. "If you melt land ice, you could raise sea level by 70 m (230 ft). The real concern over the long term is the ice sheets in Greenland and Antarctica. With thermal expansion, the coastlines erode; with the ice sheets melting completely, you are talking about cities and states under water."

Rignot and his colleagues have been using radar measurements from several different satellites to find out just how fast ice sheets are discharging into the ocean. He and his colleagues recently found that glacier ice losses in Greenland are accelerating in response to climate warming. The loss of ice doubled between 1996 and 2005.

"There are a lot of changes taking place in Greenland," says Rignot. "and we expect to see acceleration in ice loss continuing north in the next ten years." By tracking the flow of glaciers around the globe, researchers will have a much better idea about the rate of change.

Melting ice on Greenland raised global sea level by 3.5 m (about 11 ft) in the last interglacial," Rignot says, "this is where we are heading and it looks like we could get there much sooner than we thought."

Related links:
www.csr.utexas.edu/grace/
www.argo.ucsd.edu
aquarius.gsfc.nasa.gov/

Kudos

Dr. Joanne Simpson, Chief Scientist Emeritus for Meteorology at NASA's Goddard Space Flight Center is slated to become a Fellow of the American Academy of Arts and Sciences (AAAS) at their annual induction ceremony October 7 at the Academy's headquarters in Cambridge, MA. Fellows are selected by current members through a highly competitive process that recognizes individuals for their major contributions to society. Simpson, the first woman to earn a Ph.D in meteorology, made numerous contributions to atmospheric research at NASA including serving as Science Planning Team Lead for the Tropical Rainfall Measuring Mission (TRMM), a joint mission between NASA and Japan's Aerospace Exploration Agency (JAXA).

In the late 1950s, Simpson and her former professor **Herbert Riehl** came up with an explanation of how the atmosphere moved heat and moisture away from the tropics to higher latitudes. That explanation consisted of the "hot tower" hypothesis that later shed light on hurricanes. Simpson developed the first mathematical cloud model using a slide rule to do the calculations because computers weren't available. Her work sparked a brand new field of study in meteorology. In the early 1960s, she developed the first computer cloud model.

The Earth Observer staff and the entire scientific community would like to thank Dr. Simpson for her numerous contributions to the study of atmospheric science, and congratulate her on this outstanding achievement.

NASA Satellites Find Balance in South America's Water Cycle?

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

For the first time, NASA scientists using space-based measurements have directly monitored and measured the complete cycle of water movement for an entire continent.

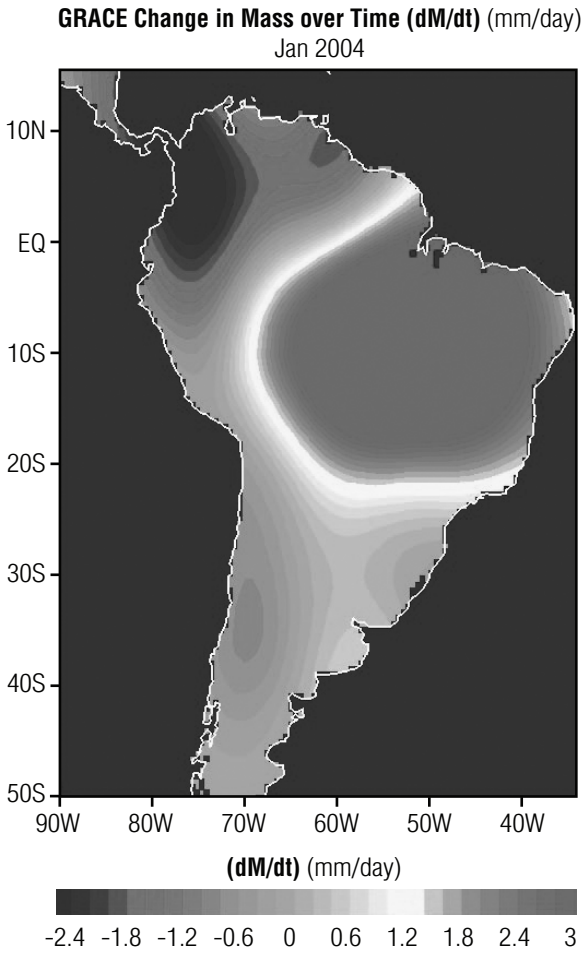
Using satellite data from three Earth-orbiting NASA missions—Quick Scatterometer (QuikScat), Gravity Recovery and Climate Experiment (GRACE), and Tropical Rainfall Measuring Mission (TRMM)—a science team at NASA's Jet Propulsion Laboratory (JPL), Pasadena, CA, directly observed the seasonal cycling of water into and out of South America. Their research confirmed that the amount of water as rain or snow flowing into the continent from the marine atmosphere is in balance with the estimated amount of water returned to the ocean by the continent's rivers.

The findings are significant because until now there had been no direct way to monitor continental water balance. Scientists had been estimating the balance through regional ground-based measurements and computer models. These new findings are published in *Geophysical Research Letters.*

"Having a better understanding of the processes in which water is transported from Earth's oceans to continental land masses is important to a variety of climate and ecology studies," said **Timothy Liu**, science team leader at JPL. "We'll have greater understanding of floods and drought, surface and ground water quality, and the availability of freshwater resources for agriculture and ecosystems."

To calculate the continent's overall water balance equation, Liu's team compared the amount of water coming into the continent with that going out. The scientists came up with a statistical method that allows them to estimate water transport using QuikScat's surface wind data and atmospheric water vapor data from microwave radiometers. Researchers used rainfall data from NASA's TRMM to measure the rainfall over the continent, and measured water going out from the continent by combining data from river flow gauges with projections from models that predict the amount of water discharged at the rivers' mouths.

The amount of river discharge rate data that was available varied depending on the river basin, ranging from as short as a few years to as long as a century, and were averaged to determine an annual cycle. Scientists compared that estimate with the monthly changes in South America's mass over two annual cycles, from August 2002 to July 2004, as measured by GRACE.



Data from NASA's Gravity Recovery and Climate Experiment (GRACE) show the distribution of water over South America in January 2004. By tracking the month-to-month changes in the distribution of water mass over time and comparing it with data from other NASA satellites, scientists were able to monitor and measure the complete cycle of water movement for the continent. Medium gray (right center) signifies higher water mass, dark gray (upper left) lower water mass. Image credit: NASA/JPL

They determined that the seasonal mass change is dominated by changes in the amount of surface and underground water.

Liu said the large-scale geographic patterns of rainfall and mass change rates follow an apparent counterclockwise annual march over the northern half of South America. With relatively small amounts of evaporation, and small or slow surface-water outflow, the mass change over a certain region is primarily driven by rainfall. The team found the annual variation of rainfall in the Amazon and La Plata basins —the two largest drainage basins in South America —correlates closely with the GRACE measurements of their mass change. In addition, measurements of

the flow of moisture across relevant segments of the continent's Pacific and Atlantic coasts were found to correspond with measurements of the annual cycle of rainfall in the two basins and the Andes Mountains.

Liu said the study strongly validates the credibility of space-based measurements to study continental water balance, but is only a beginning. "Planned reprocessing of QuikScat, GRACE, and TRMM data to improve the data quality and resolution, when combined with data from planned future missions, promises to further enhance our understanding of water balance on a global basis," he said. Those planned future missions include NASA's Global Precipitation Measurement Mission, the European Space Agency's Soil Moisture and Salinity Sensor and NASA's Aquarius satellite.

GRACE is a joint partnership between NASA and the Deutsches Zentrum für Luft- und Raumfahrt. The identical twin GRACE satellites are managed by JPL. GRACE tracks changes in Earth's gravity field, primarily caused by the movement of water. The University of Texas Center for Space Research has overall mission responsibility. GeoForschungsZentrum (GFZ) Potsdam [Potsdam, Germany] is responsible for German mission elements. Science data processing, distribution, archiving, and product verification are managed jointly by JPL, the University of Texas, and GFZ Potsdam.

QuikScat, managed by JPL, measures ocean-surface winds by transmitting high-frequency microwave pulses to Earth's ocean surface and measuring the strength of the radar pulses that bounce back to the instrument. These ocean-surface winds drive Earth's oceans and control the exchange of heat, moisture, and gases between the atmosphere and the sea.

TRMM is a joint mission between NASA and the Japan Aerospace Exploration Agency (JAXA) that monitors and studies tropical rainfall. NASA's Goddard Space Flight Center, Greenbelt, MD manages TRMM.

An animation illustrating the annual variation of South America's water balance as detected by Grace is available at: *airsea.jpl.nasa.gov/movie/sa.qt.*

For more information on Grace, QuikScat, and TRMM on the Web, visit: *www.csr.utexas.edu/grace ; winds.jpl.nasa.gov ; and trmm.gsfc.nasa.gov/.*

JPL is managed for NASA by the California Institute of Technology. ■

TRMM Data Access and Exploration Metrics

Steve Kempler, NASA Goddard Space Flight Center, Steven.J.Kempler@nasa.gov

Over the last few months the Goddard Earth Sciences (GES) Data and Information Services Center (DISC) has seen a huge increase in the usage of Tropical Rainfall Measuring Mission (TRMM) data. Currently, an average of 140 files or 7 GB of TRMM data are being archived per day—30 to 40 times this amount are being distributed.

In addition, *Giovanni*, the TRMM Online Visualization and Analysis System's (TOVAS) data analysis and visualization tool has attracted large usage thereby helping science data users to explore large datasets for specific precipitation events/patterns. During the first 4 months of 2006, TOVAS recorded over 62,000 user accesses that ranged from casual image browsing to exploring science phenomena. TRMM data can be explored at: *disc2.nascom.nasa.gov/Giovanni/tovas/*

TRMM near-real-time rainfall maps generated from TRMM and other data are now available from the GES DISC. These maps show global and regional rainfall for the past 3-hour, 24-hour, 10-day, 30-day, 60-day, and 90-day periods, as well as rainfall anomalies and rainfall percent of normal for all but the first 2 time periods. Just click and view at *disc.gsfc.nasa.gov/agriculture/ais_sup/anal_cur_cond.shtml.*

As part of the Earth Science REASoN Project, entitled *Integrating NASA Earth Science Enterprise Data into Global Agricultural Decision Support Systems,* TRMM data are available to the U.S. Department of Agriculture's Foreign Agricultural Service (USDA FAS) in two forms as featured on, and accessible through, the GES DISC Agriculture website at *disc.gsfc.nasa.gov/agriculture/index.shtml.*

1. Through the Agriculture *Giovanni* known as the Agriculture Online Visualization an Analysis System (AOVAS): *agdisc.gsfc.nasa.gov/Giovanni/aovas/*

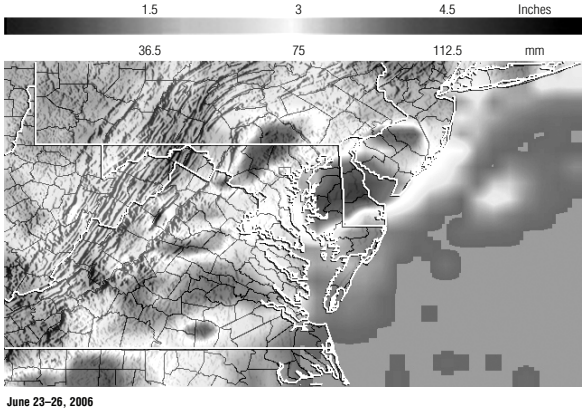
2. Through USDA FAS *Crop Explorer*, which now also includes access to the most 10-day period of TRMM data. Direct link: *www.pecad.fas.usda.gov/cropexplorer/mpa_maps.cfm* (just click on the map!) TRMM data for previous decades are also accessible from Crop Explorer's regional pages.

NASA's TRMM Satellite Captures Deluge in the U.S. Mid-Atlantic

Rob Gutro, NASA Goddard Space Flight Center, robert.j.gutro@nasa.gov

From June 23 through June 27, a stationary front draped itself up and down the Atlantic seaboard dropping as much as 10 in. of rain in isolated locations. The stalled-out front provided the focus for the abundant showers and thunderstorms as a steady stream of moist tropical air was channeled northward up the East Coast between a trough of low pressure over the eastern half of the country and the Bermuda High in the western Atlantic.

The Tropical Measuring Rainfall Mission (TRMM) was launched in November 1997 to measure rainfall over the global Tropics. The satellite uses a combination of passive microwave and active radar sensors.



NASA's Tropical Rainfall Measuring Mission (TRMM) satellite views rainfall from space. This TRMM image shows rainfall amounts for June 23-26 that fell in southern New Jersey, southern Pennsylvania, eastern West Virginia, Maryland, Delaware, Washington, DC, and Virginia. Credit: NASA

As of June 26, the heaviest rainfall totals for the period (in darker grey) are on the order of 6 in. over Maryland's eastern shore (east of the Chesapeake Bay) and central Delaware. Locally, 10–12 in. of rain were reported in Federalsburg, MD. Other areas of heavy rain are seen northwest of Baltimore between the city and eastern slopes of the Appalachians, north-central North Carolina, and parts of Virginia and southern New Jersey.

At one point, Washington's Capital Beltway, the highway that circles the Nation's capital, was closed due to a mudslide. Other roads in the region were closed as well as a result of widespread flash flooding.

On June 27, Reagan National Airport reported 0.93 in. of rain bringing the June total to 13.85 in., which is 11.05 in. above normal for the month of June. At the Thurgood Marshall Baltimore Washington International Airport, 1.17 in. of rain fell, bringing June's total to 6.73 in., which is 3.66 in. over the monthly average. At Dulles Airport in northern Virginia, 1.47 in. of rain fell on June 27, bringing the monthly total to 11.71 in., which is 8.02 in. greater than the average monthly total.

In Millersville, PA, located in the south central part of the state, flooding was reported near rivers, streams and creeks. In Harrisburg, PA, 6.5 in. of rain fell, bringing June's monthly total to 8.37 in. or 3.63 in. above normal. Many rivers were over their banks. The Susquehanna River overflowed its banks in many locations. The Conestoga River at Lancaster was reported at 14.7 ft., and flood stage was 11.0 ft. Many creeks and streams also overflowed. Major flooding was reported on June 28 for Swatara Creek near Hershey, PA, and it was also affecting Dauphin and Lebanon Counties.

Sunshine prevailed throughout the mid-Atlantic on June 28, giving a chance for the rain-soaked areas to dry out, as the low pressure system moved into New England. ■

Flooding in Millersville, Pennsylvania. Credit: Joel Farr

EOS Scientists in the News

Stephen Cole, scole@pop600.gsfc.nasa.gov, NASA Earth Science News Team
Mike Bettwy, mbettwy@sesda2.com, NASA Earth Science News Team

First Images from NASA's CloudSat Have Scientists Sky High, June 6; *Associated Press, Reuters, United Press International, MSNBC, Fox News, Rocky Mountain News.* **Graeme Stephens** (Colorado State) and **Deborah Vane** (NASA JPL) report that the first images from NASA's new CloudSat satellite are already revealing never-before-seen 3-D details about clouds.

NASA and U.S. Forest Service to Test New Aerial Wildfire Capabilities, June 6; *SpaceRef.com, Spaceflight.com.* Researchers including **Vince Ambrosia** (NASA ARC) are evaluating advanced unmanned aerial systems technologies to expand wildfire imaging and mapping capabilities.

NASA's Role in Hurricane Monitoring and Research, June 1; *CNN Headline News, Associated Press Television, CBS Newspath, WPIX Radio-New York.* **David Adamec** (NASA GSFC) and **Jeff Halverson** (University of Maryland-Baltimore County) discussed NASA's unique contributions to hurricane research and monitoring, including satellite data and educational efforts.

NASA Launches Next-Generation Satellite, May 24; *Associated Press, Reuters, ABC, CBS, MSNBC, CNN, USA Today, Washington Post, Los Angeles Times.* The GOES-N satellite will be the first to have enough battery power to continue data collection and transmission around the clock, even when the solar-powered craft is in Earth's shadow and, unlike its predecessors, will be able to analyze the moisture content of storms, say project managers including **Andre Dress** (NASA GSFC).

New Space Observations Poised To Save Lives From Floods, Landslides, May 24; *United Press International, National Geographic Online, Earth & Sky Radio.* Using NASA's advanced Earth-observing satellites, scientists **Robert Adler** (NASA GSFC), **Yang Hong** (NASA GSFC), **Robert Brakenridge** (Dartmouth College), and **Kwabena Asante** (U. S. Geological Survey) report a new opportunity to build early detection systems that might protect thousands from floods and landslides.

NASA Takes Kids on a Jungle "Odyssey of the Mind," May 18; *SpaceRef.com, SpaceWire.com.* **Michael King** (NASA GSFC) discusses the international "Odyssey of the Mind" event and how NASA is sponsoring a problem that requires teams to create and present a performance about a *Bloke*, a person who has the ability to talk with and understand animals from a jungle.

NASA Looks at Hurricane Cloud Tops for Windy Clues, May 16; *United Press International, MSNBC, Fox News, Discovery.com, Earth & Sky Radio.* **Owen Kelley** (NASA GSFC) and **Jeff Halverson** (University of Maryland-Baltimore County) say data from NASA's Tropical Rainfall Measuring Mission satellite allows scientists to look at how high up rain is forming within clouds to help estimate whether a hurricane's surface winds will strengthen or weaken.

Climate Scientist: "I Was the Kid Who Loved Storms," May 12; *Earth & Sky Radio.* **Chip Trepte** (NASA LaRC) discusses the CALIPSO satellite and how it will aid in determining the roles of aerosol pollution in global warming.

Cloud Scientists Plumb Some Cirrus Mysteries, May 8; *Christian Science Monitor, Earth & Sky Radio.* **Graeme Stephens** (Colorado State University) discusses the launch of the CloudSat and CALIPSO satellites that will study the structure and processes that govern the rise and fall of various cloud types.

La Niña Not Expected to Affect 2006 Atlantic Hurricanes, May 4; *Reuters, MSNBC, CNN, National Public Radio, Earth & Sky Radio, Discovery.com.* NASA scientists **Bill Patzert** (NASA JPL) and **David Adamec** (NASA GSFC) say the recent La Niña in the eastern Pacific Ocean is not expected to have an effect on the Atlantic hurricane season this year.

Experiment on Monsoon Season Rainfall Lives Up To Its "NAME", May 2; *Science Daily, PhysOrg.com, Terra Daily.* **Siegfried Schubert** (NASA GSFC) and **Myong-In Lee** (NASA GSFC) discuss results from a recent field mission involving intensive observations of the North American monsoon by using sensitive instruments from 20 different vantage locations, including NASA satellites and aircraft.

NASA Launches Satellites for Weather, Climate, Air Quality Studies, April 28; *Associated Press, Reuters, AFP, Knight-Ridder, United Press International.* NASA

launches two new satellites, CALIPSO and CloudSat, that include instruments to distinguish between cloud particles and precipitation and to detect aerosol particles, information vital to climate prediction, say **Graeme Stephens** (Colorado State) and **David Winker** (NASA LaRC).

In Spite of Progress, Climate Questions Remain, April 28; *Earth & Sky Radio.* Answers to questions regarding changes in the distribution of rainfall and magnitude of severe weather events remain largely elusive to climate scientists, says **Berrien Moore** (University of New Hampshire), but new technology and computing power will offer new clues over the next decade.

NASA Disassembles and Reassembles Tropical Storm Gert, April 26; *United Press International, Scripps Howard, Science Daily.* After summer 2005, a research team including **Scott Braun** (NASA GSFC) and **Michael Montgomery** (Colorado State) used data from tropical storm Gert as a test case to make sure new computer models were accurately "re-assembling" the storm as it appeared.

NASA Data Combined to Improve Hurricane Landfall Forecasts, April 24; *United Press International, Science Daily, SpaceRef.com.* By combining ocean surface wind data from NASA's QuikSCAT satellite and NOAA's GOES-11 with observations from aircraft sensors and new computer models, scientists including **Zhaoxia Pu** (University of Utah) were able to improve tropical cyclone track and intensity forecasts.

Will Deserts Grow in a Warming World?, April 22; *Earth & Sky Radio.* Despite recent reports that a warmer world will be a drier one, **Christopher Potter** (NASA ARC) says satellite data over the past 25 years show that the southern margins of the Sahara Desert look greener now than two decades ago.

Dimming the Sun, April 18; PBS (NOVA). Climate researcher **James Hansen** (NASA GISS) was interviewed for a series examining the role of air pollution on our climate. Hansen reports that "global dimming" is cooling our planet and as we cut back on the pollution that contributes to dimming, global warming may escalate. ■

I**nterested 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.*

A Boeing Delta IV rocket roars off the launch pad to lift the GOES-N satellite into space. Liftoff from Launch Complex 37 at Cape Canaveral Air Force Station was on time at 6:11 p.m. EDT. GOES-N is the latest in the Earth-monitoring series of Geostationary Operational Environmental Satellites developed by NASA and the National Oceanic and Atmospheric Administration. By maintaining a stationary orbit, hovering over one position on the Earth's surface, GOES will be able to provide a constant vigil for the atmospheric "triggers" for severe weather conditions such as tornadoes, flash floods, hail storms and hurricanes. Image credit: Carleton Bailie for Boeing

NASA Science Mission Directorate – Science Education Update

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

NASA-FUNDED PROJECT 3D-VIEW INVITES BETA-SCHOOLS TO SEPTEMBER TRAINING

Project 3D-VIEW [Virtual Interactive Environmental Worlds], designed and developed by U.S. Satellite Laboratory, Inc., is a new, NASA-funded, comprehensive, curriculum-based program for Grades 5 and 6. Students engage in simple-to-use, immersive technologies with 3D imagery and animations, learn standards-based concepts, and practice inquiry in lithosphere, biosphere, hydrosphere, atmosphere, and Earth systems. Being a *beta*-school includes online professional development in six one-hour, live sessions in September 2006 including Comprehensive Curriculum Materials, Formal Literacy and Mathematics Components, and Assessments and Rubrics. Visit: *www.3dview.org* for more information, or contact **Glen Schuster**, Project Director, at *gschuster@us-satellite.net*

NASA PORTAL FEATURE: OCEANWORLD

OceanWorld, a Web site developed at Texas A&M University, explores connections among the ocean, atmosphere, economy, and other aspects of everyday life. Read more about this online resource for students in middle school through college in a story recently featured on the NASA portal: *www.nasa.gov/audience/foreducators/5-8/features/F_Ocean_World.html*

EARTH SCIENCE WEEK 2006: "BE A CITIZEN SCIENTIST!" OCTOBER 8-14, 2006

Since October 1998, the American Geological Institute (AGI) has organized Earth Science Week, a national and international event to help the public gain a better understanding and appreciation for the Earth Sciences, and to encourage stewardship of the Earth. AGI has announced "Be A Citizen Scientist!" as the theme for this year's Earth Science Week. Being a Citizen Scientist means getting involved with real people collecting data, observing, and testing. Neither a Ph.D nor formal education in Earth Science is necessary to be a Citizen Scientist, only an interest and desire to learn. To get involved in ESW 2006 visit *www.earthsciweek.org/*.

NEW "FUN FACTS ABOUT LASERS" ON THE NASA SPACE PLACE WEB SITE

Many highly useful devices are based on lasers. Lasers can be used to play music or movies, read inventory codes on objects, cut through everything from fabric to solid steel, and perform exquisitely delicate surgery. Laser energy is a form of light, but what makes it different from ordinary light? The latest "Amazing Fact" on *The Space Place* website for elementary-aged children describes step by step the basic properties of natural light and the special properties of laser light. Interactive animations demonstrate the concepts in a simple and fun way. Visit *spaceplace.nasa.gov/en/kids/laser* to get a laser-sharp understanding of this form of energy and find out how lasers can help find life on other planets.

21ST CENTURY EXPLORER NOW AVAILABLE ON NASA'S EDUCATIONAL PRODUCTS PAGE

The cornerstone of the NASA-designed 21st Century Explorer is a series of newsbreaks and educational materials featuring student actors. These videos address space-related questions and offer engaging responses. NASA KSNN™ Newsbreaks and Noticiencias NASA™ materials are available online for classroom teachers, informal educators, and community members. Students and educators in grades three through five will find a wide selection of hands-on projects, stories, and videos presented in both Spanish and English. Go to *Into the 21st Century!* at *www.nasa.gov/audience/foreducators/k-4/features/F_21_Century_Explorer_Videos.html*

NASA PORTAL FEATURE - EARTH AND SKY RADIO SERIES

The *Earth & Sky* radio series provides a daily dose of 90-second educational science shows, including an "Observing Earth" series that often features NASA scientists and research. The programs can be heard on more than 1,000 affiliate stations across the country, on satellite radio, and on dozens of international stations and networks. The *Earth and Sky* radio series was recently featured in an article on the NASA portal: *www.nasa.gov/audience/foreducators/5-8/features/F_Sound_of_Science.html.*

CESE MEETING PLANNED FOR NOVEMBER 17-18, BOULDER, CO

The 2006 Coalition for Earth Science Education meeting will be held November 17-18, 2006, at UCAR in Boulder, Colorado. The preliminary meeting theme is "Earth System Science for All Ages." The goal of this meeting is to share information, ideas, models, projects, and resources related to best practices in the teaching and learning of Earth system science at all grade levels, e.g., K-20, and in informal settings. Participation from the academic,

government, not-for-profit, philanthropic, and business communities is invited. Interested parties should contact **Ed Geary** for further details: *egeary@globe.gov*

TWO NEW COLLECTIONS IN DLESE

The Digital Library for Earth System Education (DLESE) is a distributed community effort involving educators, students, and scientists working together to improve the quality, quantity, and efficiency of teaching and learning about the Earth system at all levels. DLESE resources include electronic materials for both teachers and learners, such as lesson plans, maps, images, data sets, visualizations, assessment activities, curriculum, online courses, and much more. Funding for DLESE comes in part from the National Science Foundation. The two new collections are: MY NASA DATA and REALTIME ATMOSPHERIC DATA.

MY NASA DATA
www.dlese.org/dds/query.do?q=&ky=01e&s=0

The MY NASA DATA collection showcases NASA Earth science data through lesson plans, data microsets, computer tools, data information pages, and a science glossary. Resources are geared toward K-16 educators, students, and citizen scientists. Resources generally cover clouds, aerosols, the radiation budget, and tropospheric chemistry. The collection emphasizes data and analysis tools. When developing these materials, National Science Education Standards and the Virginia State Standards were taken into consideration.

REALTIME ATMOSPHERIC DATA
www.dlese.org/dds/query.do?q=&ky=01n&s=0

The Realtime Atmospheric Data collection provides access to various atmospheric model data, i.e., NAM, GFS, RUC, for North America at several different spatial resolutions. The collection is geared to the needs of users who understand atmospheric model data, primarily students at the undergraduate and graduate levels or atmospheric science professionals. These needs may be atmospheric research, environmental studies, enhancing educational resources, or developing new resources, that is, any projects that would benefit from realtime data use. ■

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/*.

NOTICE:

The White House Office of Science and Technology Policy (OSTP) has enlisted the support of American Society for Photogrammetry and Remote Sensing (ASPRS) and its members to play a major role in helping to determine the future of the U.S. moderate-resolution land imaging program. In an effort to assist OSTP in documenting the value and nature of societal benefits derived from moderate-resolution-land imaging, ASPRS has developed a survey so that the professional community can provide useful input into the deliberative process. This survey asks for information about past applications of Landsat and other moderate-resolution sources, as well as solicits opinions on future systems and policies.

Your response to this questionnaire will provide valuable information to ASPRS as it supports the White House effort to "operationalize" moderate resolution satellite land imaging by the U.S. Please go to *www.surveymonkey.com/s.asp?u=99782258161* to access the survey. If you know of colleagues who have not yet completed the survey, please feel free to forward this link. Survey results will be published in a future issue of *Photogrammetric Engineering & Remote Sensing*.

Thank you for your continuing interest in remote sensing and land imaging.

Kimberly A. Tilley
Associate Executive Director/Communications Director
ASPRS: The Imaging and Geospatial Information Society
Phone 301-493-0290 ext. 103, Fax 301-493-0208
www.asprs.org

EOS Science Calendar

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

September 18
Workshop on Exploring and Using MISR Data, University of Maryland, Adelphi. URL: *eosweb.larc.nasa.gov/PRODOCS/misr/workshop/current_workshop.html*

September 20-22
SORCE Science Team Meeting: *Earth's Radiative Energy Balance Related to SORCE*, Orcas Island, San Juan Islands, Washington. Contact: Vanessa George, *Vanessa.George@lasp.colorado.edu;* URL: *http://lasp.colorado.edu/sorce/2006ScienceMeeting/*

October 23-27
CERES Science Team Meeting, Hadley Centre, U.K. Meteorological Office, Exeter, UK. Contact: Shashi Gupta, *S.K.Gupta@larc.nasa.gov.*

March 3-10, 2007
IEEE/AIAA Aerospace Conference: Global Earth Observation System of Systems (GEOSS), Big Sky, Montana. Call for Papers. Contact Kathy Fontaine, *Kathy.Fontaine@nasa.gov. URL: www.aeroconf.org.*

April 17-20, 2007
IEEE Radar Conference 2007, Boston, MA. Call for papers deadline August 18, 2006. URL: *www.radar2007.org/*

Global Change Calendar

September 13-15
Commercial Remote Sensing Satellite Symposium: Key Trends and Challenges in the Global Marketplace, Ronald Reagan Building, Washington, DC. URL: *www.CRSSymposium.com*

September 17-23
Joint CACGP/IGAC/WMO Symposium: Atmospheric Chemistry at the Interfaces 2006, Cape Town, South Africa. Call for Papers. Contact: *brian@globalconf.co.za*. URL: *www.atmosphericinterfaces2006.co.za/*

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

October 13-15
American Association for Artificial Intelligence Fall Symposium, Arlington, VA. URL: *www.aaai.org/Symposia/Fall/fss06symposia.php*

November 2-4
Pan Oceanic Remote Sensing Conference, Busan, Korea. URLs: *porsec.nwra.com* and *www.isrs2006 porsec.com*

November 7-8
2nd International Young Scientists' Global Change Conference, Beijing, China. URL: *www.start.org/links/announce_oppo/YSC_2006_Announce7.pdf*

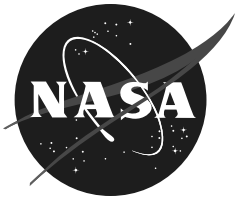
November 9-12
Global Environmental Change: Regional Challenges–An Earth System Science Partnership, Global Environmental Change Open Science Conference, (IGBP, WCRP, IHDP, Diversitas), Beijing, China. URL: *www.essp.org/essp/ESSP2006/*

December 11-15
American Geophysical Union (AGU) Fall Meeting, San Francisco, CA. URL: *www.agu.org/meetings/fm06/*

January 14-18, 2007
2007 American Meteorological Society (AMS) Annual Conference, San Antonio, Texas, URL: *www.ametsoc.org/meet/annual/index.html.*

Erattum

The images of the **AMIGOSberg**, *The Earth Observer, Vol. 18, Issue 2*, pp 1, appeared with incorrect labeling. The images with correct labels can be viewed at *earthobservatory.nasa.gov/Newsroom/NewImages/images.php3?img_id=17209*. *The Earth Observer* staff regrets this error.



Code 610
National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Md 20771

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

Official Business
Pentalty for Private Use: $300

(affix mailing label here)

The Earth Observer

The Earth Observer is published by the EOS Project Science Office, Code 610, NASA Goddard Space Flight Center, Greenbelt, Maryland 20771, telephone (301) 614-5561, FAX (301) 614-6530, and is available on the World Wide Web at *eos.nasa.gov/earth_observer.php* or by writing to the above address. Articles, contributions to the meeting calendar, and suggestions are welcomed. Contributions to the calendars should contain location, person to contact, telephone number, and e-mail address. To subscribe to *The Earth Observer*, or to change your mailing address, please call Steve Graham at (301) 614-5561, or send a message to *steven.m.graham.2@gsfc.nasa.gov*, or write to the address above.

Printed on Recycled Paper