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The Earth Observer

Editor's Corner

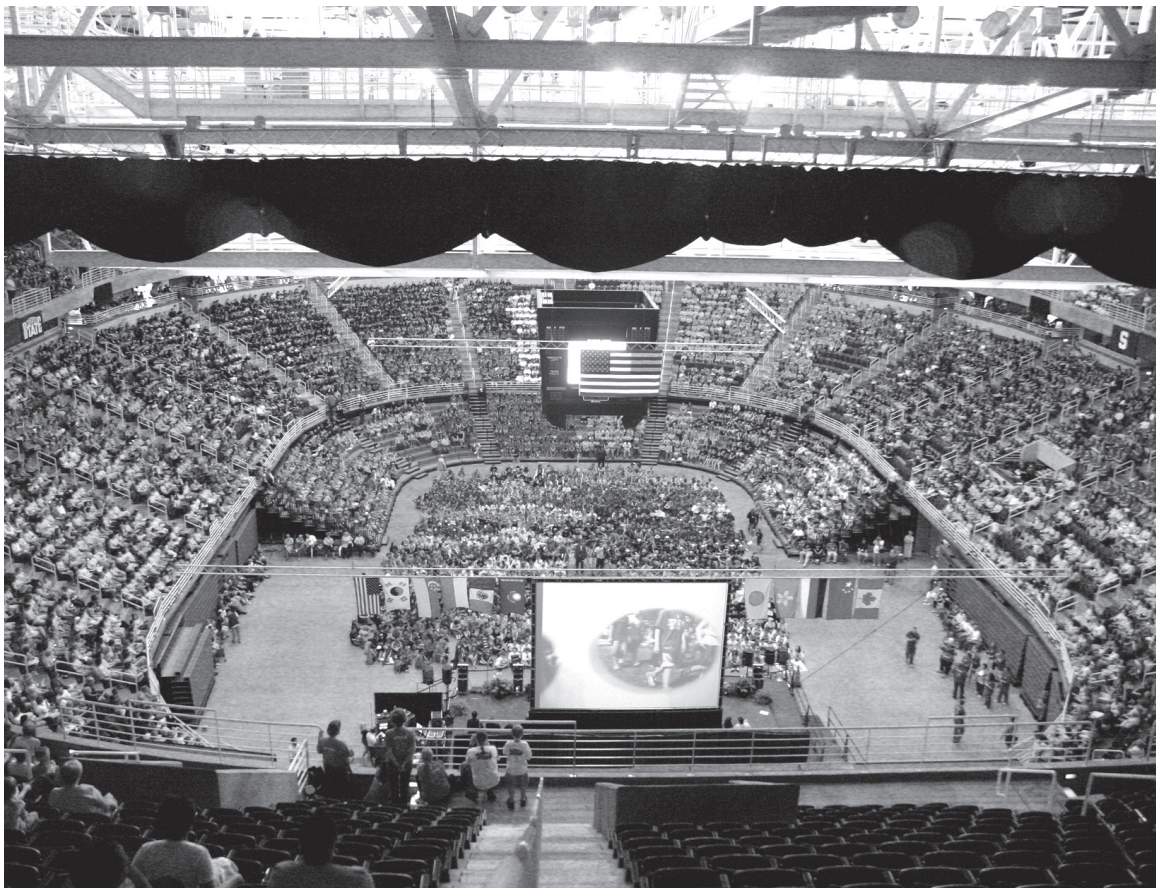
Michael King
EOS Senior Project Scientist

During the last week of May, I was honored to be one of the session chairs at the *Yoram J. Kaufman Symposium on Aerosols, Clouds, and Climate*. A group of scientists from around the world—including the Principal Investigators (PIs) of CloudSat, Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO), and Polarization and Anisotropy of Reflectances for Atmospheric Sciences Coupled with Observations from Lidar (PARASOL)—gathered at Goddard Space Flight Center for three days, May 30-June 1. The symposium was organized by **Lorraine Remer** [Goddard], **Didier Tanré** [University of Lille—*France*], and **Teruyuki Nakajima** [Center for Climate System Research, University of Tokyo—*Japan*], and included a series of presentations by invited speakers covering topics such as:

- Passive remote sensing of aerosols, clouds and the Earth's surface
- Active remote sensing of clouds and aerosols
- Aerosols and climate
- Aerosol field campaigns
- Future satellite missions

continued on page 2

Opening ceremony activities for the *Odyssey of the Mind's* 28th World Finals problem-solving competition, held at the Michigan State University in East Lansing, MI, May 23-26.



In This Issue

After the symposium concluded on Friday morning, participants were invited to attend an unveiling ceremony at the Judean Memorial Garden (the cemetery where Kaufman is buried) and an afternoon tea at the home of Kaufman's wife, Jean.

Following the symposium, all invited speakers as well as audience participants were invited to submit a journal article to a forthcoming special issue of the *Journal of Geophysical Research-Atmospheres* dedicated to Kaufman. The deadline for submissions is **August 1**.

I would like to congratulate **Angie Kelly** of the Earth Science Mission Operations office who received two awards from Goddard on May 14 for her work on the Afternoon Constellation (A-Train) missions. Kelly received *the NASA Exceptional Achievement Medal* for outstanding leadership in ensuring the safe conduct of the international Earth Science constellations, thus enabling unprecedented coincident science observations. The A-Train Mission Operations Working Group, of which Kelly is a member, received a *NASA Group Achievement Award* for exceptional teamwork and technical excellence in defining creative processes and cost-effective systems for safely operating an international constellation.

In other news related to Earth science missions, the Committee on Earth Observation Satellites (CEOS) has solicited NASA contributions for the Group on Earth Observations (GEO) Ministerial Summit on November 30 in Cape Town, South Africa. NASA's contribution would highlight the multiple benefits of a coordinated and integrated approach in the observation of the Earth's environment and climate, based on initial A-Train scientific results. CEOS said it would be extremely useful and beneficial to take the opportunity of the GEO Ministerial Summit to advertise early results from the A-Train as a perfect example of what can be accomplished flying satellites in a constellation.

Also, the Rapid Spacecraft Development Office (RSDO) has issued contracts to four groups for Landsat Data Continuity Mission (LDCM) spacecraft studies. A Request for Offer (RFO) for the actual spacecraft is expected by late summer with a selection anticipated in late fall. Meanwhile, the LDCM team continues to evaluate proposals for the primary LDCM sensor, the Operational Land Imager (OLI), and expects to select a bidder in July. Monitor the LDCM and Landsat websites for latest news: *ldcm.gsfc.nasa.gov/* and *landsat.gsfc.nasa.gov/*.

I would also like to draw your attention to an important land cover and land use change (LCLUC) activity. The Mid-Decadal Global Land Survey (MDGLS) is a partnership between the U.S. Geological Survey (USGS) and NASA, in support of the U.S. Climate Change Science Program (CCSP) and the NASA LCLUC Program.

Characterizing trends in land cover and land use remains a key goal for Earth science. The MDGLS is assembling a global dataset of 30-meter resolution satellite imagery to support measurement of Earth's land cover and rates of land cover change during the first decade of the 21st Century.

The MDGLS builds on the existing *Geocover* data sets developed for the 1970s, 1990, and 2000. Some 9500 Landsat images from the period 2004-2007 will be acquired, processed, and made available to the public via FTP download. Given the failure of the Landsat 7 Enhanced Thematic Mapper Plus (ETM+) Scan Line Corrector in 2003, a combination of Landsat 7 *gap-filled* data and Landsat 5 data from U.S. and international ground stations will be used in the project. Additional imagery from the Advanced Spaceborne Thermal Emission and Reflectance Radiometer (ASTER) on Terra and the Advanced Land Imager (ALI) on Earth Observing-1 (EO-1) will be used to fill in gaps. ALI images will be included to augment the Landsat coverage. Processing began in early 2007 and orthorectified products will be made available for download throughout the project. The complete dataset should be completed in late 2008.

I am also pleased 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 Michigan State University in East Lansing, MI in late May to staff a large exhibit and give live electronic theatre presentations to the roughly 18,000 students, coaches, parents, officials, and spectators in attendance at the World Finals. For more information please see the article, *NASA Takes Kids "Around the World in 8 Minutes" in problem-solving competition* on page 14 of this issue, and to read a student's perspective on the competition, please see *Scott's Odyssey: A Student Shares His Odyssey of the Mind Experience* on page 16.

Lastly, though not specifically related to Earth science, I'd like to point out that NASA Deputy Administrator **Shana Dale** has set up a *blog*—referenced at *www.spaceref.com/news/viewsr.html?pid=24641.* Dale says that she plans to try and update her *blog* weekly and explains her purpose as follows:

I am looking for a more direct way to communicate with people inside the agency. There is so much that goes on at Headquarters and I want to be able to pull the curtain back on at least some of it and also explain what is going on with new initiatives. ■

NASA exhibit staffers **Chikia Barnes**, **Sarah Brown**, and **Mark Malanoski** distribute a multitude of outreach materials to the *Odyssey of the Mind* participants. **Credit:** Steve Graham

Using ASTER Data to Study the Urban Heat-Island Effect

Yasushi Yamaguchi, Nagoya University, Japan, yasushi@nagoya-u.jp
Soushi Kato, National Cheng Kung University, Taiwan, katoso@mail.ncku.edu.tw

Introduction

Human beings have a tremendous impact on their environment. This impact is particularly significant in and around cities where concentrated human activity results in significant alterations to the original land surface, and leads to increased local and atmospheric surface temperature as compared to surrounding rural areas. Scientists refer to this as the *urban heat island effect*.

Two major factors contribute to the *urban heat island effect*. First, human beings tend to require a great deal of energy to sustain their activities. The generation of that energy releases additional heat into the atmosphere. In addition, humans tend to alter the land surface when they move into a region. They replace the natural landscape—vegetation and soil—with structures made of asphalt, bricks, concrete, and other artificial materials. The urban landscape tends not to absorb water nearly as well as the natural landscape, and water plays an important role in lowering the temperature of the surface. (As water changes from liquid to gas, energy is required and the temperature stays lower than it would if no water is present.) The artificial materials that make up the urban landscape also tend to be much more efficient at holding on to the energy they absorb than the natural landscape, so once they warm up, they tend to stay warm. At night these structures release some of that stored energy to help elevate the temperature in the urban area as compared to the surrounding rural areas.

Scientists are interested in figuring out exactly how much each of these factors listed above contribute to the urban heat-island effect, but the answer isn't simplistic. It is not sufficient to simply compare temperatures in urban areas to those of the surrounding rural areas. The factors that cause the heat-island are complex and interrelated, so scientists have to conduct a detailed analysis of all of the energy coming in and all of the energy going out in both urban and rural areas to begin to understand what is causing the increase in temperatures in urban areas.

Scientists have been conducting heat-balance studies for decades over rural areas particularly in the disciplines of agriculture and forestry, and in recent years they've begun to use data from satellites to help them—e.g., *Schmugge et. al.,* 1998. Now, a pair of scientists have come up with a practical way to estimate regional *heat-fluxes—heat flux* simply means the amount of heat going in or out of a specified area—in urban areas using remotely sensed satellite data. What follows is a summary of two papers that they have written that have been published in *Remote Sensing of Environments (RSE)—Kato and Yamaguchi*, 2005; 2007. The reader is referred to the two *RSE* papers for more detailed discussion of this research.

Region Studied

Kato and Yamaguchi chose a 1700 km^2 region in Japan that includes the city of Nagoya. Nagoya is a large city that is located on the Nobi Plain, facing the Ise Bay. Nagoya covers an area of 326.45 km^2, and in 2004, had a population of 2,122,977. The topography of Nagoya is hilly in the eastern part of the city and a plateau is located in the central part of the city. Commercial and business districts are located in the central area of the city, and characterized by high-rise buildings.

Satellite Data Used

Kato and Yamaguchi used data from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) on Terra for their research. ASTER has three spectral bands in the visible and near-infrared (VNIR), six bands in the shortwave-infrared (SWIR), and five bands in the thermal infrared (TIR) regions, with 15-, 30-, and 90-m spatial resolution, respectively (*Yamaguchi et al.*, 1998). The scientists used the atmospherically corrected ASTER data products of surface spectral reflectance (*2B05*), spectral emissivity (*2B04*), and surface temperature (*2B03*)—see **Figure 1**. These data were converted to surface albedo, broadband emissivity, and the Normalized Difference Vegetation Index (NDVI). The VNIR data and NDVI were used

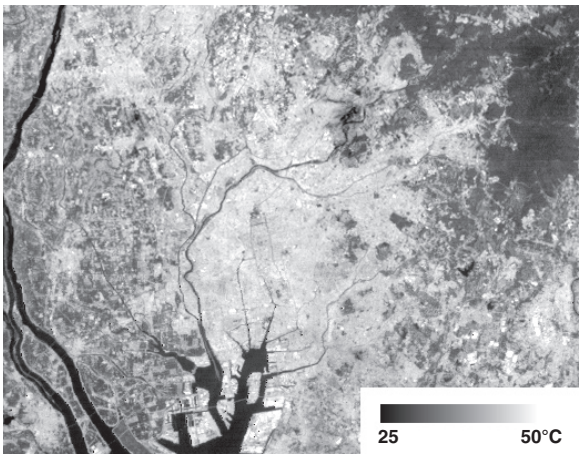


Figure 1. Daytime surface temperature distribution for Nagoya, Japan derived from ASTER data on July 10, 2000.

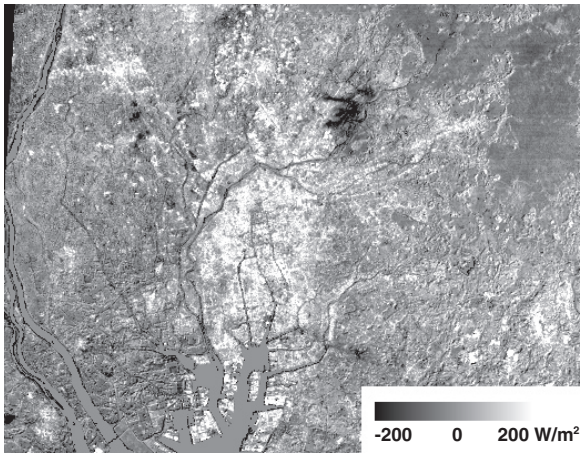


Figure 2. Artificial increase in daytime sensible heat flux (H_{as}) on July 10, 2000.

to classify the land surface types with spatial resolutions of 15 m. In addition, the ASTER relative Digital Elevation Model (DEM) data product (*4A01*) acquired on July 10, 2000, was used to correct the ground-based meteorological data for the affects of altitude.

Estimation of Sensible Heat Flux Due to Anthropogenic Heat

For a natural land surface, absorbed net radiation should balance outgoing ground heat, sensible heat, and latent heat fluxes. To study the urban heat island also requires taking into consideration the *anthropogenic heat discharge*—the "extra" heat that human activities create. So for the urban surface, the absorbed net radiation and the anthropogenic heat discharge should balance the outgoing fluxes of sensible heat, latent heat, and ground heat when advection (e.g., wind) is negligible,

$$R_n + A = H + LE + G \qquad (1)$$

where R_n is the net radiation, A is the anthropogenic heat discharge, H is the sensible heat flux, LE is the latent heat flux, and G is the ground heat flux. The energy consumption related to human activities generates anthropogenic heat discharge in the form of sensible heat, latent heat, and ground heat.

Anthropogenic sensible heat heats the atmosphere directly, but also contributes to increased surface temperature. Surface temperatures measured using satellite remote sensing are obviously influenced by this anthropogenic heating, which means that any estimates of heat fluxes made using these surface temperature measurements from satellites are also impacted. Scientists therefore need to determine how much effect anthropogenic heating has on satellite measurements.

Kato and Yamaguchi (2005) showed that the influence of temperature rise on latent heat and ground heat is negligible. Thus, the main impact of anthropogenic heating is felt through sensible heat. The scientists use the concept of surface heat balance described above, to determine the impact of anthropogenic heat discharge on sensible heat. As input to the heat balance equation, the net radiation, sensible heat, latent heat, and ground heat fluxes can be estimated using the ASTER data along with meteorological data.

The sensible heat flux due to radiant heat balance, expressed as H_n in the following, can be calculated as the residue of the heat balance equation:

$$H_n + R_n - G - LE. \qquad (2)$$

Finally, the sensible heat flux due to the artificial effects can be calculated as the difference between the total sensible heat flux and H_n as

$$H_{as} = H - H_n \qquad (3)$$

where H_{as} is the net increase in sensible heat flux given by surface heat balance and is not equivalent to A in Equation (1), because A includes the impact of latent heating and ground heating as well.

Patterns of Artificial Increase in Sensible Heat Flux

The artificial increases in sensible heat flux (H_{as}) on July 10, 2000, is shown in **Figure 2**. **In developed areas, H_{as} was high, and in areas having natural surfaces, H_{as} was low.** In Nagoya, the central commercial, governmental and business areas had lower H_{as} than the surrounding urban areas in daytime. One of the reasons for this phenomenon is that the uneven landscape presented by systematically arranged high-rise buildings causes shadows to block the solar radiation on the northwestern side of obstacles in the central part of the city. As a result, the surface temperature of the shaded roads and building roofs is low, and the satellite sensor observes them as thermal infrared radiation almost directly above the land surface. Another reason is the high *heat capacity* and *thermal inertia* of tall building areas—i.e., these large concrete structures have the capacity to store a great deal of heat, and once they warm up, they have a tendency to retain the heat and only slowly cool down. This also affects the surface temperature change. As a result of these effects, at the time of satellite overpass at 10:55 AM, the surface temperature of the central area did not increase compared to the surrounding areas.

At night, surface temperatures of urban areas should generally be higher than those of natural surfaces, because artificial surface materials store heat during the day and discharge heat at night. As shown in **Figure 3**, on the night of September 17, sensible heat (H) was discharged only from the central part of the urban area (center of the image) and the industrial areas (bottom

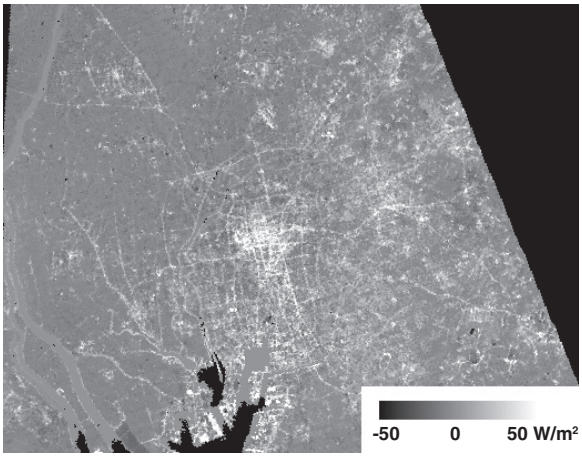


Figure 3. Nighttime sensible heat flux *(H)* on September 17, 2000.

center). On the other hand, relatively low, or even negative values of *H* were observed in the residential areas. The surface temperature in the residential areas cooled relatively quickly after dusk because many Japanese houses have wooden walls and thin tile roofs (approximately 10 to 20 mm thick)—these thinner materials have a substantially lower *heat capacity* than concrete. Based on these results, Kato and Yamaguchi concluded that, at night, changes in *H* are due primarily to anthropogenic heat discharge in industrial areas. On the other hand, the above-mentioned occurrence of low H_{as} in the daytime and high *H* at night in the central urban area implies that these results are largely affected by the *heat capacity* of the urban surface. The industrial area, which is situated in the southern part of the study area, for instance, had high H_{as} values regardless of temporal differences, which implies that the influence of anthropogenic heat discharge can be detected by using H_{as}.

Contributions of H_{as} and H_n as Causes of the Heat-island Effect

The heat-island effect results from increased sensible heat flux—i.e. increases in both H_{as} and H_n. In order to examine the individual contributions of H_{as} and H_n to the heat-island effect, the calculated fluxes were compared. On July 10, 2000, H_n of 320 W/m² was much higher than the H_{as} of 99 W/m² in the city, and H_n in the city was much larger than the 97 W/m² value measured in the agricultural area. (Transpiration of vegetation stomata keeps H_n low in the agricultural area.) **These results imply that the decrease in latent heat flux due to a decrease in vegetation has a more significant impact on temperature rise than the artificial increase in sensible heat flux in the summer.**

Estimation of Storage Heat Flux

Accurate estimation of ground heat flux *G* requires knowledge of the heat conductivity of the land surface material and the vertical temperature profile and its temporal change under the ground for soil and inside walls, roofs and floors for buildings. Since obtaining such data throughout the study area is difficult, *Kato and Yamaguchi* (2005) estimated *G* from the net radiation by using the empirical coefficient fixed according to surface type and season by referring to actual measurements.

On the other hand, since the anthropogenic heat discharge is generally much smaller than the solar radiation as a heat balance input, it is often difficult to obtain the anthropogenic heat discharge with sufficient accuracy, and thus to calculate the ground heat flux and the anthropogenic heat discharge separately. Therefore, *Kato and Yamaguchi* (2007) estimated the storage heat flux (ΔG) by merging the ground heat flux (*G*) and anthropogenic heat discharge (*A*) based on the heat balance equation, which is used in tower measurements in urban areas (e.g., *Oke et al.*, 1999):

$$\Delta G = G - A = R_n - H - LE \quad (5)$$

For the cases in which the storage heat flux exceeds 0 W/m², i.e., downward heat flux can be interpreted as heat storage in the urban canopy. In contrast, when the storage heat flux is negative, the upward heat flux is caused by stored heat in the urban canopy or anthropogenic heat discharge.

Patterns of Storage Heat Flux

The storage heat flux in daytime on July 10, 2000, is shown in **Figure 4**. A number of high storage heat lines appeared in the central part of Nagoya on July 10,

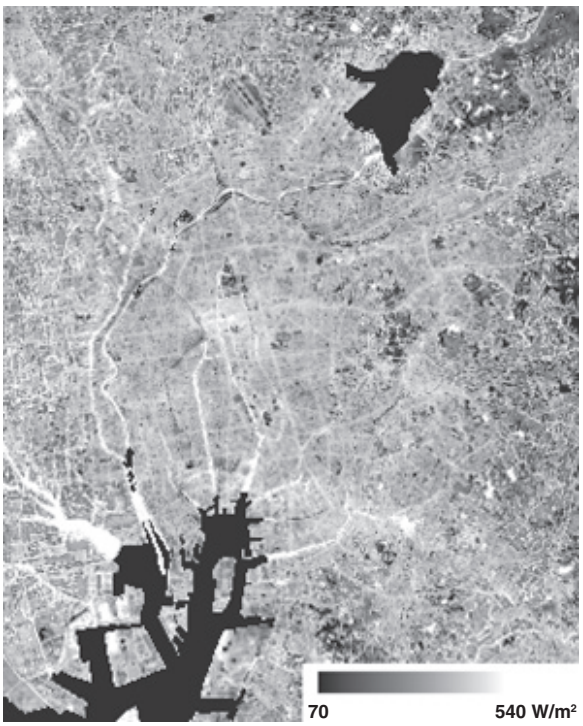


Figure 4. Daytime storage heat flux ΔG on July 10, 2000.

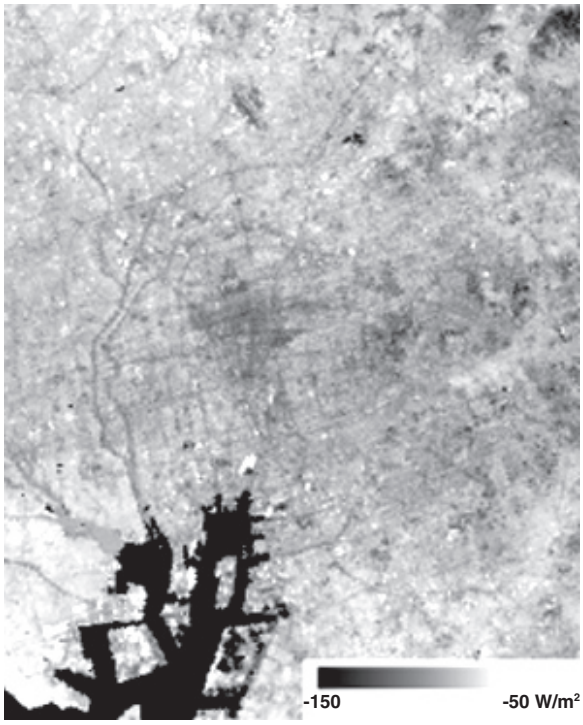


Figure 5. Nighttime storage heat flux ΔG on September 26, 2003.

2000, most of which correspond to rivers and main roads. High-rise buildings are concentrated along the main roads and form urban canyons, where the interruption of solar radiation by buildings suppresses the temperature increase and thus enhances the storage heat flux.

The storage heat flux on the night of September 26, 2003, is shown in **Figure 5**. The pronounced characteristic of the nighttime heat balance is huge upward heat fluxes, namely positive sensible heat and negative storage heat fluxes, on some roads including elevated expressways and overhead railways. In urban areas, the urban canyons mentioned above make the sky view factor small. As a result, radiation cooling from the surface of general roads is weakened. On the other hand, although the sky view factor on the elevated expressways and overhead railways is relatively large, the sensible heat from vehicles in heavy traffic should keep the temperature high, and massive elevated structures constructed of asphalt and concrete should have thermal properties that are similar to those of concrete buildings.

Water bodies such as rivers show high storage heat flux in the daytime and large negative heat storage at night. A similar pattern appears in the central urban area, where the high thermal inertia of the urban fabric causes a time lag in the surface temperature change compared to the other surface materials. The storage heat flux is very high during the day and highly negative at night on main roads. As in the case of the central urban area, heat stored during the daytime is released at night. The existence of negative or relatively low storage heat flux in the daytime and large negative storage heat flux at night is typical of some industrial areas, because these areas generate heat both during the daytime and at night.

Conclusion

Kato and Yamaguchi visualized spatial patterns of surface heat fluxes in an urban area (Nagoya, Japan) using remote sensing and ground meteorological data based on the energy balance assumption. The increase in sensible heat flux (H_{as}) due to anthropogenic heat discharge, is useful as an index for assessing the urban heat-island effect. H_{as} was high in developed areas and low in rural areas, as one would expect. The industrial areas, in which huge amounts of energy are consumed, had extremely high H_{as}. During the night in autumn (September), the spatial distribution of H implied that H is due primarily to anthropogenic heat discharge in industrial areas and heat storage in buildings during the daytime in the central urban area. In the urban area, in July, H_{as} was much lower than H_n. Therefore, the decrease in vegetation and resulting reduction in latent heat is thought to be the most significant contributor to the heat-island effect on summer days.

The storage heat flux in the central urban area was higher than those in the surrounding residential areas. Moreover, the negative storage heat flux in the central urban area was greater at night. These results suggest that urban surfaces store heat during the daytime and discharge heat at night. The difference in the storage heat flux between the central urban and residential areas is magnified by the large *heat capacity* of the high-rise buildings in the central urban area. On the other hand, extremely large negative storage heat flux occurred primarily in the industrial areas for both daytime and nighttime as a result of the enormous energy consumption by factories.

Kato and Yamaguchi used ASTER data not only as the auxiliary data for corrections but also for measuring the physical quantities such as surface temperature and reflectance. ASTER has a relatively high spatial resolution, a wide spectral range, and a high spectral resolution. The five TIR bands are especially useful for determining surface emissivity and temperature with high accuracy and spatial resolution. ASTER data are well suited to obtain such detailed information on the local scale, and are thus very useful for heat flux estimation in urban areas where both surface temperature and construction materials can vary significantly over short distances.

continued on page 12

The Sun Approaches Its 11-Year Minimum and Activity Cycle 24

Tom Woods, Laboratory for Atmospheric and Space Physics, University of Colorado, woods@lasp.colorado.edu
Judith Lean, Naval Research Laboratory, Washington, DC, judith.lean@nrl.navy.mil

Observations reveal that magnetic activity on the Sun varies dramatically over time, with a near periodic 11-year cycle. Large dark s*unspots* are frequently observed on the Sun during *solar maximum* and few, if any, sunspots are seen during *solar minimum*. **Figure 1** compares images of the Sun's visible disk during high (*left*) and low (*right*) solar activity. Sunspot occurrence is an indicator of a change in the Sun's energy output. In addition to the sunspots, large bright prominences called *faculae—faculae* is a Latin word that means small torches—are more commonly observed during *solar maximum*. The occurrence of sunspots and faculae changes the total energy output from the Sun—*total solar irradiance*.

As **Figure 2** shows, the Sun's brightness is higher during *solar maxima*; in recent cycles it increased by about 0.1% relative to *solar minima*. **Observations suggest that faculae increase radiance considerably more than sunspots decrease radiance from the Sun.** Scientists continue to work to more precisely quantify how much each factor contributes to the observed changes in solar irradiance. Since, as **Figure 2** shows, the magnitude of sunspot dimming and facular brightening both increase with solar activity, predicting their specific balance, which determines total solar irradiance, is difficult.

Since 2003, scientists have had a powerful tool to help them observe variations in the Sun's energy output. NASA's Solar Radiation and Climate Experiment (SORCE) [*Rottman et al.*, 2005] has been making precise measurements of the Sun's total and spectral irradiance, which are being combined with prior measurements [e.g., *Fröhlich and Lean*, 2004] to provide new insights in the long-term solar variations. Onboard SORCE, the Total Irradiance Monitor (TIM) measures the total solar irradiance (TSI), denoted by the top image in **Figure 2**. Because solar activity influences the Sun's output differently at every wavelength, SORCE also includes three other instruments, which measure the Sun's energy at individual wavelengths: XUV Photometer System (XPS) for soft-X-ray irradiance; Solar Stellar Irradiance Comparison Experiment (SOLSTICE) for solar ultraviolet irradiance; and Spectral Irradiance Monitor (SIM) for visible/near infrared irradiance. This unique and unprecedented combination of instruments monitors simultaneously both the total solar energy reaching our planet (the single most important contributor to natural climate variability) and how the Sun's energy output changes at different wavelengths. These latter measurements are used to determine the atmosphere's response to the Sun's changes. Changes occurring in the ultraviolet portion of the spectrum alter the amount of ozone in the atmosphere, which can impact large-scale atmospheric motions that couple the stratosphere and troposphere. Changes occurring at longer wavelengths, in the visible and near-infrared part of the spectrum, impact climate more directly by

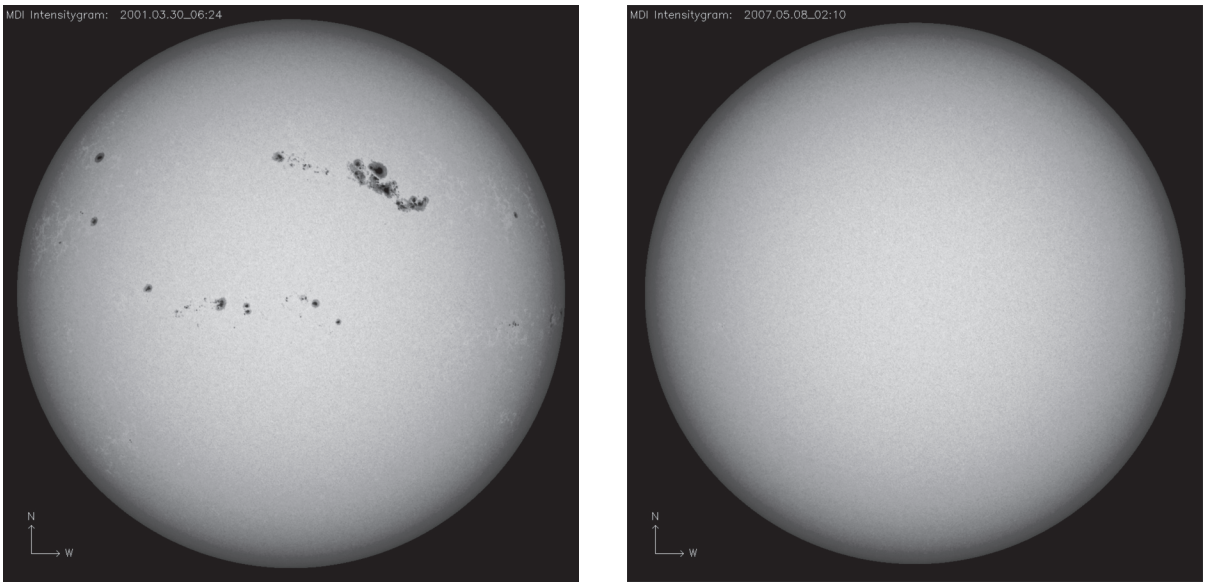


Figure 1. Near the peak of the solar activity cycle many sunspots appear regularly on the Sun, as seen in the left image on March 30, 2001, in *Cycle 23*. Currently, solar activity is near the minimum of the 11-year cycle and sunspots may be absent entirely, as seen on May 8, 2007, in the right image. The images are of the intensity of a narrow band of visible light, made by the Michelson Doppler Imager (MDI) instrument on the Solar and Heliospheric Observatory (SOHO).

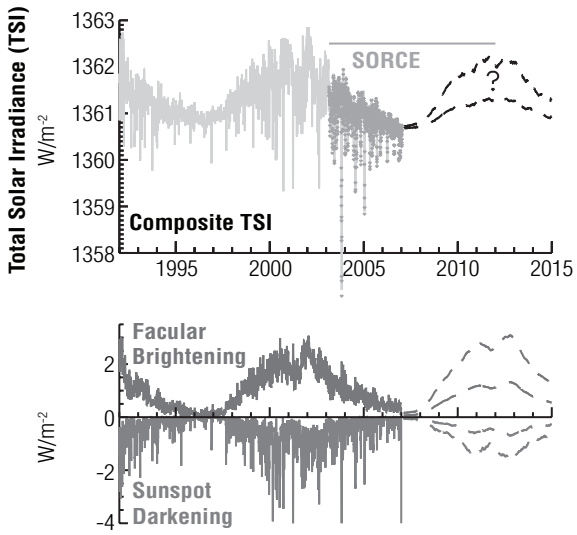


Figure 2. The *top panel* shows that solar activity is currently waning and approaching its 11-year solar cycle minimum. The dashed curves represent the next solar cycle estimates that correspond to solar activity 40% higher and lower than in the past cycle. The *lower panel* shows the two primary components for variability of the total solar irradiance (TSI) that is shown in the upper panel.

changing the heating at the Earth's land and ocean surface, and lower atmosphere.

The solar irradiance measurements from SORCE confirm earlier results and show similar variability for *Cycle 23* to that which has been observed in previous solar cycles. The increase in total irradiance reflects not just the effects of sunspots, whose presence on the solar disk actually decreases total irradiance, but the additional effects of bright faculae as well. **Facular brightening more than compensates (by about a factor of two) for sunspot dimming during the solar cycle, with the result that total irradiance varies in phase with solar activity.**

Currently, solar activity is entering a new minimum, and a new cycle known as *Cycle 24* will soon begin. During the previous cycle (*Cycle 23*) the *solar minimum* occurred in 1996, followed by the *solar maximum* in 2000-2002. Solar activity has waned during 2007, as has the total irradiance, signaling the impending onset of the next *solar minimum*—expected to occur in 2008. According to a recent NOAA-NASA panel report [*D. Biesecker and D. Pesnell*, private communication, 2007] peak activity in *Cycle 24* is forecast for late 2011 or mid-2012. That much is fairly certain, but there is still considerable debate over the strength of the next activity maximum. Some computer simulations of solar activity using a model suggest that solar activity will be 40% stronger in *Cycle 24* than in *Cycle 23* [e.g., *Dikpati and Gilman*, 2006], while others suggest much weaker activity in *Cycle 24*—e.g., *Schatten* [2005]. **Either way, the upcoming *Cycle 24* affords a unique opportunity to observe the cycle from start to finish and better understand and quantify sources of irradiance variability, especially the separate relationships of sunspot dimming and facular brightening with solar activity and the sunspot number.** Improved understanding of solar variability sources and their evolution on time scales longer than the 11-year cycle are needed to improve reconstructions of past irradiance changes that are used to assess natural climate change in both pre-industrial and present eras.

Elucidating and quantifying the role of solar irradiance variations in climate change continues to be a challenging task. Empirical evidence abounds for associations of solar variability with climate, especially the tropical hydrological cycle [e.g., *Shindell et al.*, 2006], but also in temperature and winds [e.g., *Crooks and Gray*, 2005]. The high fidelity global databases acquired since the 1980's (i.e., in the space era) reveal unmistakable Sun-climate associations in the contemporary epoch, on decadal time scales [e.g., *Douglass and Clader*, 2002; Lean *et al.*, 2005]. **Figure 3** shows empirical estimates of the primary factors that drive the Earth's global temperature anomalies near 2-km altitude over the past 25 years. A global temperature anomaly of 0.1 K is associated with solar activity, approximately in phase

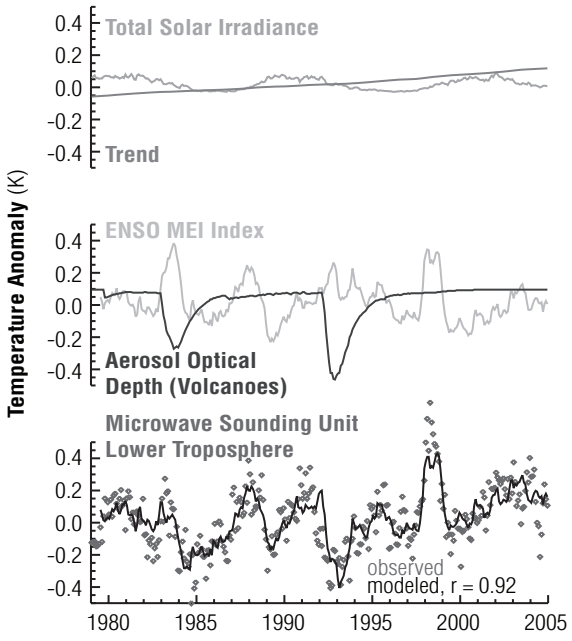


Figure 3. The *top panel* shows monthly mean global temperature anomalies in the lower troposphere (~ 2-km) associated with the solar activity cycle and also shows a trend line attributed to increasing greenhouse gases. The *middle panel* shows the temperature anomalies at 2-km caused by the El Niño Southern Oscillation (ENSO) and volcanic aerosols. The associations are extracted from multiple regressions analysis of the global microwave sounding unit (MSU) lower troposphere temperatures (with ENSO and volcanic influences, lagged by 7 and 9 months, respectively), following the approach of *Douglass and Clader* [2002]. The *bottom panel* shows results from a model that combines the effects of the four factors shown in the panels above (i.e., solar, greenhouse trend, ENSO, and volcanoes)—dark line— and accounts for 80% of the observed temperature variation—symbols.

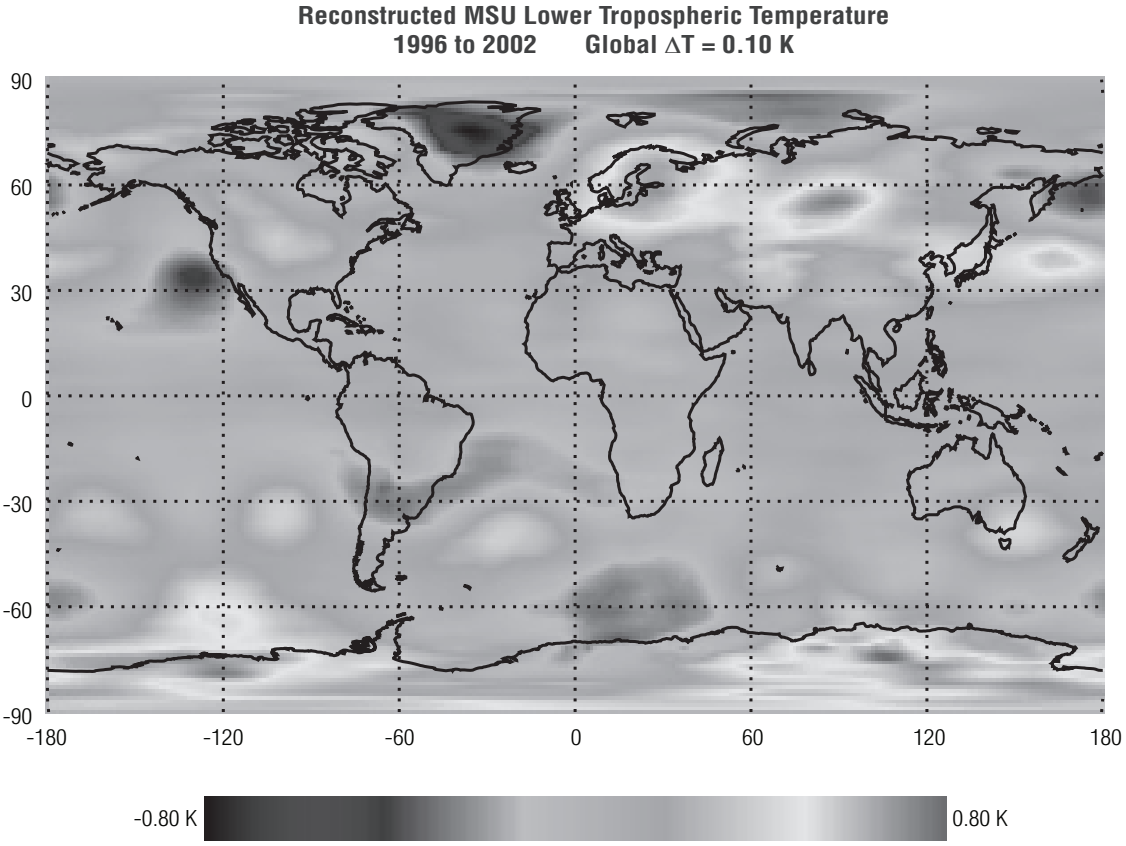


Figure 4. Shown is the spatial distribution of monthly mean 2-km temperature anomalies, extracted from multiple regression analysis of the 2.5°×2.5° latitude-longitude arrays of MSU temperature anomalies (including ENSO, volcanic activity and a trend, in addition to solar irradiance) that together comprise the global variations in **Figure 3**. The global average is +0.1K.

with the irradiance cycle. Analysis of the surface temperature datasets yield analogous results with a solar-driven temperature anomaly cycle of slightly smaller amplitude [*Lean et al.,* 2005]. As **Figure 4** shows, the 2-km (and surface) temperature increase is actually the net change from a complex pattern of regional solar-driven warming and cooling, with amplitudes even reaching ±0.7K in some locations.

Climate response to decadal solar forcing has previously been expected to be too small to be detected. (Scientists reasoned that the amount of change caused by solar forcing would be too small to change the ocean temperatures significantly—i.e., any change would be dampened by the ocean's *thermal inertia*.) However, recent empirical results associating decadal solar variability and climate, such as those shown in **Figures 3 and 4**, contradict this expectation, and recent studies are beginning to shed light on how this may take place. The National Center for Environmental Prediction (NCEP) reanalysis database [*van Loon et al.*, 2007] and fossil coral records during the past 1000 years [*Mann et al.*, 2005] reveal a cooling of the tropical Pacific not unlike the pattern observed during a La Niña. This cooling may be caused by differential solar heating in the east and west tropical Pacific Ocean, as a result of their different mixed layer depths. Positive solar forcing may increase the trade winds and induce upwelling of cooler waters that produce a La Niña-like pattern. More generally, solar activity appears to alter the interactions between the surface and atmosphere that drive the fundamental circulation cells (especially the north-south Hadley and Ferrell cells and the east-west Walker circulation) and generate atmospheric centers of action [e.g., *Christorofou and Hameed*, 1997]. Other mechanisms may involve the cloudy lower atmosphere, which absorbs more visible and near infrared radiation than previously thought (25% rather than 20%) [e.g., *Zastawny*, 2006]. This impacts convection, clouds, and latent heat in water vapor. Over relatively cloud-free regions, increased evaporation from enhanced solar forcing produces moisture that intensifies the regional monsoon and the Hadley and Walker circulations [*Meehl et al.*, 2003; *van Loon et al.*, 2007]. Also, the solar ultraviolet radiation, which varies far more than the total solar irradiance, influences stratospheric chemistry and dynamics, which in turn appears to couple to the troposphere and provide an indirect forcing of surface temperatures [e.g., *White*, 2006] and climate [e.g., *Geller*, 2006].

Crucial for assessing the influence of solar variability and other natural processes—i.e., volcanic eruptions and El Niño and Southern Oscillation (ENSO)—and

human activity—i.e., greenhouse gas production from fossil fuel combustion—on climate change are precise, long-term records of solar irradiance that extend over a much longer period than the observational databases—which commenced only in 1978. Depending on amplitude and spectral composition, long-term solar irradiance changes may alter climate in different ways than during the recent activity cycles. Model simulations of the transport of magnetic flux in the Sun (by differential rotation, diffusion and meridional flow) [*Wang et al.*, 2005], shown in **Figure 5**, suggest that long-term irradiance changes may accrue from the accumulation of magnetic flux during times of overall increasing solar activity, as witnessed during the past century. Solar irradiance measurements during cycle minimum periods, such as the present, are uniquely important because connecting levels during adjoining minima provides knowledge and quantification of possible longer-term irradiance changes that may underlie the 11-year irradiance cycle.

The measurements made by SORCE are the most fundamental of data needed to understand Earth's climate because the Sun provides virtually all the energy that warms the atmosphere and surface, evaporates water, and drives the general circulation of the atmosphere, oceans, and water cycle. Even relatively small changes in the Sun's output could impact the Earth because of potential amplifying effects in how the atmosphere responds to those changes. The unexpectedly large (by current understanding) solar-driven global decadal cycle of 0.1 K in 2-km temperatures exemplifies this. As models for simulating climate processes improve, sensors with exceptional accuracy and precision, such as those on SORCE, will be critical to resolve the smallest of solar irradiance changes. These data are needed to understand the state of climate now and why climate varied in the past, and to predict how climate may change in the future. Before we can truly interpret the role that human's are having in changing Earth's climate we must first more accurately assess the role that natural "forcings" have on the climate system, and the Sun is by far the most significant of those natural "forcings."

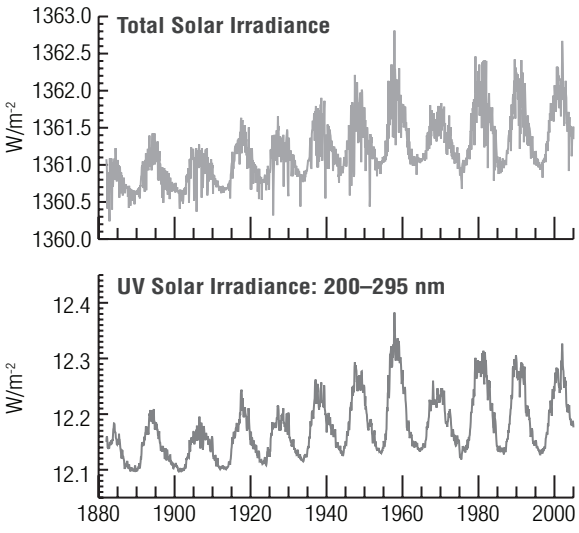


Figure 5. Shown in the *top panel* are monthly mean values of total solar irradiance, based on the magnetic flux transport calculations of *Wang et al.* [2005] that predict a small but significant accumulation of magnetic flux during the first half of the 20th Century, associated with the steadily increasing solar activity cycle amplitudes. In the *bottom panel* are the changes in UV irradiance at wavelengths from 200 to 295 nm (absorbed in the atmosphere), also based on the flux transport model simulations.

Acknowledgements: NASA contract NAS5-97045 funded this work. The data are available at *lasp.colorado.edu/sorce/*.

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continued from page 11

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continued from page 7

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High School Course Helps to Inspire the Next Generation of Earth Scientists

Scott Zuke, Washington College, Chestertown, MD

One of NASA's stated objectives has been to *inspire the next generation of explorers*. In pursuit of this goal, over the last five years, the National Aeronautics and Space Administration, and particularly the Science Mission Directorate, has embarked on new efforts to seek out skilled and driven youth to fill some of the world's most important science and engineering jobs. One example of this effort is a high school science course called Earth Systems Science Research (ESSR). The program recently completed its fifth year and has already led some former students of the class to internships and jobs at NASA, and rekindled interest in science for many others.

The idea for the course originated at NASA, and led to a collaboration between school systems in Carroll and Frederick County, MD to develop the course. A group of teachers worked with NASA representatives to create a unique curriculum involving nine weeks of Earth system science instruction and nine weeks of independent student research. The research culminates in a symposium at Goddard Space Flight Center, where students present their findings to some of the world's leading scientists.

Catoctin High School in northern Frederick County has led the way in developing the ESSR course.

"Students get to interact with scientists, with engineers, computer visualization experts, and get to see the people that are doing it," said **Lisa Bruck**, Catoctin's ESSR teacher, discussing the field trip to Goddard. "I think that's a great experience for them."

Year after year, the visits to Goddard have proven to be a life-altering experience for some students. After the first symposium, one student was offered an internship involving the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra and Aqua satellites. Because of a statistical discovery she made during that time, she was even listed as a contributor on a research paper. In subsequent years, three students have received internships at Goddard, and several others have requested information about other employment opportunities.

One of the students who did not take an internship with NASA still benefited from his research background in the ESSR course. As a freshman in college, a professor heard about his experience in the class and offered him a job during winter break. That background helped him get his foot in the door and work in Montana for the National Science Foundation.

In general, ESSR has had a positive impact on most of the students who have taken it. "Some have rethought what they may want to do because of the experience of the class," Bruck said. "Something sparked; something they didn't even know existed before going through the course was now something they were very interested in."

What makes the course so effective is its unique curriculum. In the first nine weeks the students receive a broad classroom introduction to the Earth's systems, or spheres, including the atmosphere, geosphere, hydrosphere, biosphere, cryosphere, and the Sun-Earth connection. In the second nine weeks, each student chooses a research project, usually involving an investigation between phenomena occurring in two different spheres, such as hurricanes and disease outbreaks, and then seek possible correlations between the two by searching online databases, sharing information, and occasionally even contacting scientists. Through this process, students not only learn about the connections between Earth's spheres, but also how to analyze data, conduct research, and how to ask the right questions and refine searches to find that data. Many students who have taken the Earth Systems Science Research course cite it as one of their favorite experiences in high school.

Through continued support from NASA and the school systems involved this program shows great promise to educate and inspire students of all backgrounds and interests, including the next generation of NASA scientists and engineers. ■

NASA Takes Kids "Around the World in 8 Minutes" in Problem-solving Competition

Steve Graham, NASA Goddard Space Flight Center, steven.m.graham.2@gsfc.nasa.gov

Students from around the world gathered to participate in Odyssey of the Mind's 28th World Finals, a creative problem-solving competition held at the Michigan State University in East Lansing, MI, May 23-26. These students had advanced from competitions held earlier in the year at the local, regional, state or country levels and were in East Lansing to compete for the title of World Champion.

The 2007 World Finals marked the seventh year NASA's Earth Observing System Project Science Office sponsored a long-term problem. This year's problem, *Around the World in 8 Minutes*, required teams to create and present a performance that included a "Traveler" character on a trip around the world. During the trip, the Traveler had to stop at three locations on Planet Earth that had different geographic characteristics. Two settings—one polar, the other different—had to be actual places, and the third one had to be an undiscovered location created by the team. The performance included an explanation about why the character took the trip and the reason it stopped at each location. (To read about one teams performance, see *Scott's Odyssey* on page 16.)

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—*earthobservatory.nasa.gov*. 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 191 teams participating in *Around the World in 8 Minutes* at World Finals, the following won top honors in their division:

Division 1

1st Place: Lewis Greenview Elementary School Team A, Columbia, SC

2nd Place: Valley View Elementary School Team D, Rockford, MI

The *Division 1* Champion team from Lewis Greenview Elementary School in Columbia, South Carolina. **Photo Credit:** Charlotte Griner

The *Division 1* team from W. W. Estes Elementary School in Asheville, North Carolina. **Photo Credit:** Charlotte Griner

3rd Place: Indian River Elementary School, Selbyville, DE
4th Place: St. John Neumann Elementary School, Williamsport, PA
5th Place: River Oaks Elementary School Team A, Houston, TX
6th Place: Happy Valley School, Lafayette, CA
6th Place: Crestview Elementary School, Greer, SC

Division 2
1st Place: Osrodek Psychoedukacji Damb, Gdansk, Poland
1st Place: Alexander Graham Middle School, Charlotte, NC
2nd Place: Oak Knoll Middle School, Mechanicsville, PA
3rd Place: Magnolia School Team A, Grass Valley, CA
4th Place: Anglo Chinese School, Singapore
5th Place: Harris Road Middle School Team C, Concord, NC
6th Place: Potosi Public School, Potosi, WI
6th Place: Saint Michael Lutheran School, Fort Meyers, FL

Division 3
1st Place: Anglo Chinese School, Singapore
2nd Place: Wellsville High School, Wellsville, NY
3rd Place: Minisink Valley High School, Slate Hill, NY
4th Place: Myers Park High School Platinum, Charlotte, NC
4th Place: Raffles Girls Secondary School, Singapore
5th Place: San Ramon Valley High School Team A, Alamo, CA
6th Place: Mount Pleasant High School, Mount Pleasant, NC

Division 4
1st Place: University of Wisconsin, Madison, WI
2nd Place: Ithaca College, Ithaca, NY

NASA reaches about 2.5 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. Over 800 teams from the U.S. and other countries including South Korea, China, Hong Kong, Singapore, Mexico, Canada, Kazakhstan, Poland, and Germany participated in World Finals. This includes teams from the Department of Defense Dependent Schools (DoDDS), many of which traveled from Europe to attend the competition.

NASA's Earth Science Division conducts and sponsors research, collects new observations from space, develops technologies and extends science and technology education to learners of all ages. Through a better understanding of our home planet, NASA 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 2008, NASA will sponsor Problem 5: *The Eccentrics!*

World Finals participants interact with NASA's Magic Planet and exhibit at the annual Creativity Festival.

Scott's Odyssey: A Student Shares His Odyssey of the Mind Experience

Scott King, Seaford Elementary School, Seaford, VA
Introduction: Charlotte Griner, NASA's EOS Project Science Office, clgriner@earthlink.net

As a volunteer staging judge for the NASA-sponsored problem, "Around the World in 8 Minutes," at the Odyssey of the Mind World Finals in East Lansing, MI, I had the distinct pleasure of coming face-to-face with many interesting students from around the world. It was a perfect position to talk with them about what they had learned in the process of doing research to solve the NASA problem. As one might imagine, they had many interesting stories to tell about their research and how they arrived at their own unique solution to the problem.

One student that really stood out was ***Scott King*** *from Seaford Elementary School in Seaford, VA. When asked what he had learned, he related so many facts that I was amazed. I could not imagine that a fifth grader would retain so much of what he had learned and be able to recite it with such clarity, so I decided to look Scott up and have him tell what solving the NASA problem meant to him. Scott graciously agreed to provide a short summary of his experience for* ***The Earth Observer****. Following is Scott's story in his own words:*

Picture yourself in a room full of 30 kids, all wanting to be on their school's Odyssey of the Mind Team (OotM). Only seven kids will make it. That's how my journey on the 2006-2007 Seaford Elementary Odyssey of the Mind team began. Before I moved to Seaford, VA, I had no idea what OotM was. Heck, I didn't even know it existed. Then the two coaches sent a letter to all the kids in the fourth and fifth grades to advertise that team try-outs were in a week. I signed up for try-outs just because I thought it was just some sort of club that met after school. Little did I know that I was signing up for the adventure of a lifetime.

After try-outs, the coaches gave each [student] a letter with the news of whether they made the team or not. I was one of the seven [students] on the team. The team —shown right—member's names were: **Kyle Abbott, Jordan Bronstein, Layne Callis, Josh Law, Alex Liang, Kaitlyn Manglicmot**, and myself. At the beginning of the first few practices the coaches, **Coach Wicher** and **Coach Rasmussen**, helped us get to know OotM better.

After about two weeks of bonding and getting to know OotM we finally chose our problem, *Around the World in Eight Minutes*. In this problem my team had to create a traveler who travels to three different locations, one Artic location, one imaginary location, and one other location, and show how he travels in a creative skit lasting eight minutes. We decided our traveler would be a *water molecule*, who would travel to the Grand Canyon, Disco Island—located off the coast of Greenland—and Mother Nature's Sanctuary. We spent many practices researching every aspect of our three locations: their environment, terrain, and so on. We also had to research our means of transportation from place to place (we used the water cycle), what the Northern Lights were made out of, the Ozone Layer, global warming's effects on the Polar Ice Cap, and why the Colorado River doesn't reach the Pacific Ocean anymore? Needless to say we learned a lot.

Then in January about four months after try-outs we had a dilemma, our script wasn't going anywhere! So we took a risky move and trashed our whole script. Usually by this time a team has finished their script and already assigned parts. Now we only had two months to finish our script, make our set, and rehearse our skit before Regionals! We started to tack on an extra hour to our regular practices and added four-hour practices on Saturday to try and finish our skit on time.

All that hard work paid off though! We finally completed [our set] with two weeks to spare. After a performance in front of the whole school on the Friday before Regionals we packed up and then went to dinner with the whole team. The next day we went to a local High School and performed our skit in front of about 40 people. After that we changed and watched other team's performances for the rest of the day. That afternoon we went to the Awards Ceremony where OotM Officials would announce the winners for each problem. After about 15 minutes of high tension the Officials announced that we had come in first place in *Division I* in our problem! We were going to States!

On April 21, we packed up and went to another local High School to perform our skit once more. We then watched other team's skits until about 3:00 P.M, and then we all went out to the soccer field and played football, soccer, and giant frisbee until 6:30 P.M. which was when the Awards Ceremony was held. We had come in first place at States and were going to *World Finals* at Michigan State!

About a month later the entire team packed up and flew together to Detroit with a fun pack on our backs and a towel full of Virginia State Pins in our suitcase. When we got there we then drove an hour to Michigan State

University! The next day we got ready and went out to go explore campus and trade pins. (You see, at Worlds every country or state has their own set of pins to trade.) We went swimming later in the day. The routine was the same the next day, except for one little thing, we were performing that afternoon! The performance was great. We had a load of fun doing it. We spent the rest of the day doing whatever we wanted—either trading pins or watching other teams perform. The next day we went and did our *spontaneous* competition. That also went great and the officials were a blast. After the competition, the coaches had to get plaid tails taped onto their shirt.

The rest of the week we spent most of our time trading pins, watching performances, going to events that NASA was holding, or just hanging out at the dorms. **NASA sponsored our problem and while at NASA-held activities we learned that our research was right on target. We also learned a lot of new things that we didn't know about planet Earth and NASA's satellite program. Thank's NASA!**

On the final day of world competition we all got together and went to a restaurant and had a mini-celebration for whatever place we received. Then we went to the awards ceremony where we found out that we placed 16th out of 67 teams in the world. To congratulate all the teams, the OotM Officials held a wild all night long party after the ceremony.

We flew home the next day with happy faces because we did so well. Over the next few days I felt sadder and sadder because OotM, something I had put hundreds of hours into, had ended just like that. **Even though it is tough to say good-bye to OotM, solving the problem, and using our skit as an educational tool, means a lot to me.** A couple years from now I may forget the names of some of my 5th grade classmates, but one thing's for certain, I'll never forget what my journey through OotM was like during my 5th grade year. ■

The Odyssey of the Mind team from Seaford Elementary in Seaford, VA at the World Finals at Michigan State University in East Lansing, MI. Scott King (author of the article) is in the foreground. Second row (left to right) - Josh Law, Alex Liang, Kaitlyn Manglicmot, Layne Callis, Jordan Bronstein, and Kyle Abbott. Back row (left to right) Coaches, Kelsey Rasmussen and Diane Wicher **Credit:** Charlotte Griner.

2007 AGU Joint Session—Special Session on Urban Remote Sensing

Dale A. Quattrochi, NASA Marshall Space Flight Center, dale.quattrochi@nasa.gov

One of the sessions that took place at the recent Spring meeting of the American Geophysical Union (AGU) in Acapulco, Mexico—May 22–25— focused on the topic of "Urban Remote Sensing." The Earth Observer staff asked one of the session co-convenors to give us a brief report, which follows below.

Session Co-convenors

- **Dale A. Quattrochi** [NASA Marshall Space Flight Center] *dale.quattrochi@nasa.gov.*
- **William Kustas** [U.S. Department of Agriculture-Agricultural Research Service-Hydrology and Remote Sensing Laboratory] *Bill.Kustas@ARS.USDA.GOV.*
- **Qihao Weng** [Indiana State University—*Department of Geography, Geology, and Anthropology*] ***geweng@isugw.indstate.edu.***

Session Overview

According to the United Nations Development Program, the 21st Century is the first "urban century." The focus on cities reflects awareness of the growing percentage of the world's population that lives in urban areas. In environmental terms, cities are the source of many of the global problems related to waste disposal, air and water pollution, and associated environmental and ecological challenges. The need for technologies that will enable monitoring the world's natural resources and urban assets and managing exposure to natural and man-made risks is growing rapidly. Expansion of cities, both in population and areal extent, is a relentless process. In 2000, approximately 3 billion people, representing about 40% of the global population, resided in urban areas. Urban population will continue to rise substantially over the next several decades according to UN estimates, and most of this growth will occur in developing countries. The UN estimates that by 2025, 60% of the world's population will live in urban areas. As a consequence, the number of *megacities*—cities with populations of 10 million inhabitants or more—will increase by 100 by 2025. Thus, there is a critical need to understand urban areas and what their impacts are on environmental, ecological, and hydrologic resources, as well as on the local, regional, and even global climate. This session sought to explore what the state-of-the-art is in using remote sensing data to understand urban growth and development, and the subsequent impact of cities on the environment. Additionally, because the overall urban milieu is so complex, we wish to explore how improved sensors and remote sensing analysis techniques can be employed to better define, characterize, and quantify the city environment.

Information on Presentations

The session was comprised of six oral sessions with all the presentations relating the uses of Earth science data for analysis of urban areas. Presenters and titles of the papers in this session are listed below. A complete listing of the abstracts for papers presented in the session can be found at *www.agu.org/cgi-bin/sessions5?meeting=sm07&part=H22B&maxhits=400.*

A. Melesse [Florida International University—*Department of Environmental Studies*] Landsat-Based Impervious Surface Mapping And Storm Runoff Response Modeling.

A. Omojola [University of Lagos, Lagos, Nigeria—*Department of Environmental Studies*] City Expansion And The Tragedy Of The Commons: The Case Of Lagos, Nigeria.

Dale A. Quattrochi [NASA Marshall Space Flight Center] Effects of Global Change On U.S. Urban Areas: Vulnerabilities, Impacts, and Adaptation.

Chistina Milesi [NASA Ames Research Center—*Foundation of California State University Monterey Bay*] Remote Sensing And Ecosystem Modeling For Monitoring Urban Ecosystems.

Anne-Marie Schneider [University of California Santa Barbara—*Department of Geography and Institute for Computational Earth System Science*] Mapping Global Urban Extent And Intensity For Environmental Monitoring and Modeling.

Eric Brown de Colstoun [Science Systems and Applications, Inc./NASA Goddard Space Flight Center] Using Time-Series of Impervious Cover And Tree Cover To Study Urban Dynamics In The Upper Delaware River Basin.

30th ASTER Science Team Meeting

Elsa Abbott, Jet Propulsion Lab, elsa.a.abbott@jpl.nasa.gov

The 30th U.S./Japan Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Science Team meeting was held in Pasadena, CA, December 4-7, 2006. **M. Abrams** [Jet Propulsion Lab (JPL)—*U.S. ASTER Science Team Leader*] and **H. Tsu** [Earth Remote Sensing Data Analysis Center (ERSDAC)—*Japan ASTER Science Team Leader*] welcomed sixty-some U.S., Japanese, and other team members and allied guests.

Plenary Session

Abrams and **W. Turner** [NASA Headquarters] discussed the current funding situation for both Terra as a whole and ASTER in particular. Currently, per the 2003 Earth Observing System (EOS) proposal, the team leader budget decreases 5% per year, plus decreases due to salary increases. A senior review at NASA for Terra and the instruments on it will occur in early 2007.[1] This will determine the future of the U.S. ASTER team funding. In the previous senior review held in 2005, Terra was ranked second of 18 missions. The selection of new U.S. ASTER Science Team members will be announced starting in Spring 2007. It seems the available funds for the science team will be between one-half to two-thirds of the previous funding levels.

Abrams gave a report on the recent test of the ASTER direct downlink which was designed as a fallback in case of failure of the solid state recorder on Terra, and secondarily to allow for acquisition of more ASTER data over the U.S. with minimal impact in case Landsat 5 and Landsat 7 should fail. The receiving station is at Earth Resources Observations and Science (EROS) Data Center in Sioux Falls, SD, near the center of the continental U.S. The acquisitions took place July 17, and August 2, 4, and 9 during which some decoding problems were encountered. The test will be re-scheduled when the software is working. Abrams also discussed the Mid-Decadal Global Land Survey. This project is a partnership between the U.S. Geological Survey (USGS) and NASA to characterize trends in land cover and land use, in particular changes that have taken place since the publicly available GEOCOVER-2000 30-m-orthorectified Landsat dataset. Landsat 7, which has global coverage, now has data gaps and Landsat 5 is not global and is now 20 years old, so backup plans are needed and a plan to use ASTER to augment the Landsat coverage has been submitted. Landsat 5 coverage excludes parts of central and northern South America, northwest and central Africa, and parts of central Asia to Siberia, all of which might be covered by foreign stations. However, there is no possibility of coverage over parts of the Middle East, Iran, Iraq, Pakistan, and Kamchatka, making ASTER an attractive instrument for this task.

T. Sato [Japan Resources Observation System and Space Utilization Organization (JAROS)] gave a presentation on the instrument's health, particularly on the rise in temperature of ASTER's shortwave infrared (SWIR) detector. He began with a synopsis of the history of the temperature rise and measures that have been taken to understand and attempt to solve the problem to date. As the temperature of the detector rises the SWIR offset digital numbers (DNs) increase and are corrected by the radiometric calibration, but the dynamic range decreases, meaning the detectable maximum radiance decreases and more pixels will be saturated. There are two possible ways to fix this problem. The *set point* of the heat transport system can be lowered, which will decrease the dewar temperature and then the detector temperature. This is a safe operation but only a short-term solution as it will only buy about a month. The cooler capability can also be enhanced by increasing the *piston stroke,* which may work for as much as half-a-year, after which the detector temperature will again rise. Risks to this second approach are: 1) a small increase in the power consumption, which may not be acceptable to the Terra Project; 2) the possibility of cooler failure; and/or 3) the possibility of complete SWIR subsystem failure. The project could do nothing and continue to use Band 4 (which is not very affected by the temperature problem) for cloud assessment. Sato requests that the ASTER Team make a decision as to what to do before the detector reaches 83 K, which will happen soon.[2]

B. Bailey [U.S. Geological Survey Land Processes Distributed Active Archive Center (USGS LPDAAC)] gave an update on current activities and concerns at the DAAC. Since the decision was made to make all Level-1B and higher products on demand and not archived (implemented in May 2006) an average of more than 3300 Level-1B and 1000 digital elevation models (DEMs) per month have been produced. The production of DEMs continues to be monitored and improved upon based on user comments and findings at the DAAC. An orthorectified image product was made available in early March 2007. The number of ASTER products distributed by the DAAC continues to be impressive with more than 140,000 granules

[1] The Senior Review of Terra took place April 26 at NASA HQ; results were still pending when this issue went to press.

[2] The piston stroke was in fact increased in May 2007. While the temperature reduction was not as great as hoped, the rate of increase has slowed and the SWIR is now collecting good science data. At present, it appears that the procedure gained about 6 months of operating time.

distributed last year. The distribution by data type and by recipient type was shown in addition to trends in requesters and data type. *GloVis* and the Data Pool are two popular ways for users to select ASTER products. *GloVis* is now fully populated with up-to-date Level-1A browse images and higher level products. The Data Pool, which is a free dataset covering the U.S., is populated with a 2-year "rolling archive" of Level-1B data. Cross talk within the SWIR continues to pose a problem for users, but two new products, *AST_07XT* and *AST_09XT*, are now available through the DAAC to help mitigate the problem, while uncorrected products are still available to users who prefer them. The DAAC will begin to offer media distribution for ASTER products in 2007, available both via EROS Data Center and *GloVis*. For users requesting ASTER data takes, there is a new data acquisition request (DAR) tool available. The old tool will remain available until May of 2007.

M. Hato [ERSDAC] reported that the Japanese Ground Data System (GDS) is running smoothly with very few problems. At the end of November 2006, more than 1.26 million scenes had been acquired and Hato presented a breakdown of types of higher level products produced and demographics of their customers. The ASTER Level-1B on demand processing has gone so well that they will no longer be sending that product to the U.S. after the end of January 2007. The one item of concern to all is the rise in temperature of the SWIR detector (as mentioned above); the problem has been addressed in the last GDS Interface Meeting. Hato followed with a discussion of the status of the late change operation, which is an opportunity to make changes in the scheduler primarily to include weather updates. There was a five-month hiatus in this operation whereby updates had to be done in a very labor-intensive manner starting May 3, 2006, due to a security breach at several NASA centers including Goddard. This operation was re-started October 5, 2006, and is now in place, with updates made during ordinary weekday hours. Network access from GDS to the EOS Operation Center (EOC) is one hour per day for the normal one-day schedule and for late changes. GDS also is re-engineering the scheduling tool to improve its functionality.

K. Okada [ERSDAC] showed graphically the locations of all ASTER scenes, and showed them broken down by year of acquisition, cloud cover and time of acquisition—i.e., day or night. He then showed priority areas for the third round of global mapping, and scenes acquired with these priorities. Of the high priority scenes, observations of Japan and North and South America are being achieved but the Middle East, India, and Australia are not well represented. By the end of November 2006, 33% of the high priority scenes had been acquired. For the medium priority scenes, the same trend is found with the additional trend that North Africa is not well represented. Antarctica should be covered starting December 2006. By the end of November, 2006, 36% of the medium priority sites and 29% of the low priority sites were achieved, with only Siberia poorly represented. Okada also showed a map of the nighttime thermal scenes acquired over prioritized areas. It seems that a band through central Europe and Africa is difficult to acquire partially due to problems in the daily scheduler. Areas of high daytime priority adversely affect acquisition of nighttime scenes on the same orbit. Okada then showed an assessment of the causes of failure to collect data for urgent and ground campaign requests. Causes included product generation failure, conflict with other data sets, and late submission. Some of these situations can be fairly easily solved but others are intrinsically more difficult to correct. There is some concern that since ASTER has now well-exceeded its nominal lifetime, the resources for pointing the telescopes are being used up. Okada asks that the working groups consider whether and how to restrict the number of pointings. The system may be robust enough to outlast the nominal lifetime expectation but perhaps the team may suggest restricting the number of pointings.

Y. Yamaguchi [Nagoya University] put forth some questions that should be discussed in the splinter working groups for recommendation to the whole ASTER team. They include:

- how to proceed with the third round of global mapping and nighttime TIR mapping;
- what to do about the consumption of pointing resources;
- what to advise as guidelines for the Landsat mid-decadal Geocover gap filler; and
- what to do about the rise in temperature of the SWIR detector.

Additional items on the agenda are timely updates of the coefficients for each telescope [Visible-Near Infrared (VNIR), Shortwave Infrared (SWIR) and Thermal Infrared (TIR)] and plans for vicarious calibration exercises. Yamaguchi also provided more details on the effects of the SWIR detector temperature rise discussed previously and potential effects of the proposed measures to alleviate the problem. Each working group was asked to decide how to advise the project on this matter since if the *piston stroke* is to be increased it should take place soon.

Working Group Reports

Atmospheric Calibration Working Group

K. Thome [University of Arizona] gave a summary of the historical background of atmospheric correction and reviewed the decisions and reasons for the approach used by ASTER. He also summarized the effects of atmosphere on Band 3B and mentioned that radiative transfer calculations are accurately handling these effects.

Surface Bidirectional Reflection Distribution Function (BRDF)/roughness effects are dominant in this backward looking band.

B. Eng [JPL] gave a status report on the atmospheric correction software. The current version, running on a Linux platform, is *Version 3.1-3* and it includes crosstalk correction. *Version 3.2* is to be delivered to the DAAC in the spring of 2007 and will include a new ozone source from the Total Ozone Mapping Spectrometer (TOMS) satellite and will also be able to do interpolation to smooth artifacts in VNIR and SWIR corrected products. There is also a plan to implement Moderate Resolution Imaging Spectroradiometer (MODIS) aerosol information.

H. Yamamoto [National Institute of Advanced Industrial Science and Technology (AIST)] reported on the Global Earth Observation (GEO) Grid, which is an ambitious infrastructure for archiving and processing satellite imagery and geographic information system (GIS) geographical datasets using ASTER data are at its core. Its atmospherically corrected products are based on ASTER Level-3A01 data with the ability to use ASTER DEMs for atmospheric correction and orthorectified ASTER radiance data. It has the capacity to be easily compared with MODIS products and to be used to conduct quality checks using ground measurement data. It is a sophisticated and complicated system integrating many types of data with which they aim to address many global problems.

Ecosystem/Oceanography Working Group

G. Geller [JPL] and **T. Matsunaga** [National Institute for Environmental Studies] reviewed the action items and reported that the Ecosystems and Oceanography Working Group has decided as a whole that all of the SWIR bands are important and that the *piston stroke* of the detector should be increased when the detector temperature reaches 83 K.

Geller and **Abrams** requested that someone from the United Nations Educational, Scientific and Cultural Organization (UNESCO) be invited to future ASTER meetings, and that they be requested to provide a report on the experience that World Heritage Site Park Managers have in using ASTER images.

The group also heard a number of reports on research done by team members and their affiliates:

- **Matsunaga** reported on the threat of sea level rise.
- Matsunaga gave a report on behalf of **T. Ishiyama** [Chiba University] discussing efforts to assess the degradation of oases surrounding the Taklimakan Desert by studying land cover change.
- **S. Scheidt** [University of Pittsburgh] discussed data fusion of ASTER VNIR, SWIR and TIR measurements to aid classification of desert coastal ecosystems and assessment of damage from the 1991 oil spill in the Persian Gulf.
- **Scheidt** also reported on the research to study the composition of potential dust sources in the Sahara Desert using ASTER TIR.
- **Yamaguchi** introduced a method to estimate carbon and heat fluxes by a combination of models and satellite data and showed validation results.
- Matsunaga presented on behalf of **Y. Sakuno** [Hiroshima University] about using satellite thermal imagery to study anoxic water distribution in Hiroshima Bay.
- Matsunaga presented on behalf of **H. Yamano** [National Institute for Environmental Studies] about a waterline method of extraction of satellite data over coral reefs using a case study in Australia.
- **A. French** [U.S. Department of Agriculture] discussed monitoring landcover change with ASTER emissivities over the Jornada New Mexico test site, and observing small but consistent decreases in emissivity.
- **Geller** gave an update on *TerraLook*, which was to have gone operational at EROS in January at which time Version 1.0 of the free viewer/toolkit should have been available.

Operations and Mission Planning Working Group/Science Scheduling Support Group

Abrams and **Yamaguchi** reviewed the action items from the last team meeting. **Okada** and **L. Maldonado** [JPL] gave a report on the operation status including the status of global mapping third round, SWIR pointing resource status and the search for causes of data acquisition failures. **K. Duda** [EROS Data Center], Abrams, and Okada discussed direct downlink issues. Okada also reported on his activities at the Ground Data System (GDS) during scheduling testing. There was some discussion on how to process data if SWIR ceases to function. Japan Resources Observation System Organization (JAROS) will investigate what happens to signal if the SWIR power is turned off and GDS will look into processing data without SWIR. The team recommends that the *piston stroke* be increased at 83 K. Okada also reported that some ecology users of ASTER data are not happy with the frequency that they can get ASTER data. He said that he would look at the Global Land Ice Monitoring from Space (GLIMS) project, the coral reef project, and the Amazon (LBA) project to assess success of data acquisitions in these areas. He also reported on a survey that found 97 published ASTER articles in just five journals.

Radiometric Calibration Working Group

Representatives of the companies that designed each of the four telescopes on ASTER (**Mitsubishi** for SWIR, **Fujitsu** for TIR, and **NEC/Toshiba** for VNIR) gave presentations on onboard calibration trends.

- *SWIR.* The Mitsubishi representative showed the latest onboard calibration datasets for SWIR that show the same tendencies as the previous set. Based on these findings, the Radiometric Calibration Coefficients (RCCs) will not be revised. The offset levels have been rising since September 2004, but the offset can be eliminated by the RCC offset correction using the detector temperature as a parameter.

- *TIR.* The Fujitsu representative showed the TIR onboard calibration trends including calculated temperature change by date for each band at four different DNs followed by a chart showing the fitting function description, date and version of each implementation. The representative also compared two fitting functions, one developed by Fujitsu and one developed by **F. Sakuma** [AIST], and showed that the one by Sakuma produced better results. Sakuma then reported on an action item to find the cause of the difference in the TIR error estimation between the two methods. He described both methods and showed why the Sakuma method will be adopted. In *Version 3.03* the error is within the threshold.

- *VNIR.* The NEC/Toshiba representative showed VNIR onboard calibration trends including optical calibration and dark pixel output by date for each band and dark pixel by gain state, as well as a series of other plots showing calibration trends with particular emphasis on the last two years.

The group also heard several other presentations about various calibration efforts related to ASTER.

S. Hook [JPL] discussed the inflight validation of ASTER and Terra MODIS TIR bands using the Lake Tahoe California/Nevada automated validation site. He described the site and the data reduction methods. The site was established in 1999 and since then many scenes have been validated with a broad range (3–18 C) of temperature. Ninety nine total clear ASTER scenes have been validated, 22 in 2005 and 16 in 2006. Hook then showed results for both Terra MODIS and ASTER. Corrected MODIS scenes show no evidence of bias throughout the mission. Validation of ASTER indicated a problem with the application of the radiation calibration coefficients that has been resolved. There remains a small bias which is under investigation.

K. Thome [University of Arizona] reported on continued ground-reference calibration results for Landsat data. He compared the similar Terra and Aqua sensors of ASTER, MODIS, Multiangle Imaging Spectro-Radiometer (MISR), and Enhanced Thematic Mapper Plus (ETM+) by computing the reflectance-based results using the same area of Railroad Valley Playa, NV. Thome showed graphs of the average percent differences of sensor bands versus wavelength in various combinations of common date, VNIR only, and morning versus afternoon sensors.

H. Tonooka [Ibariki University] reported on field campaign activities for the thermal infrared. He showed pictures of the field sites and experiments in progress and the vicarious calibration results.

J. Buchanan [University of Arizona] described vicarious calibrations over the lifetime of ASTER, showing the methodology and the test sites. Seventy-seven clear ASTER scenes at five different test sites were used, Level-1A imagery, one person evaluation, and MODTRAN radiative transfer code. The MODTRAN results were shown and were compared with results using the Gauss-Siedel radiative transfer code with very similar results. ASTER and Landsat 7 calibration using two sets of similar bands (Landsat 7 being ~30 minutes later) were then compared using MODTRAN code for both. Results were consistent with the standard deviation for all bands between 0.03 and 0.04, showing the reliability of the vicarious calibration method.

A. Kamei [AIST] described the field campaigns for vicarious calibration of the VNIR for the Japanese team using Railroad Valley, NV and Ivanpah Playa, NV. This team evaluated many radiative transfer codes for adoption in *GEOGrid* : G6, MODTRAN, Gauss-Seidel, Doubling/Adding and others, and decided on G6. Future work includes doing aerosol characterization trends for each site, collecting BRDF data and vicarious calibration with the National Space Organization's FORMOSAT-2 satellite data to be obtained in summer of 2007.

S. Tsuchida [AIST] presented information on a scheme to be offered in *GEOGrid* to determine the radiometric calibration coefficient of ASTER's VNIR 3B band, which has no onboard calibrator. The theoretical scheme for cross-calibration is quite complex with a need to assume many parameters and the currently used cross-calibration using the Earth and lunar surfaces as targets has uncertainties. They propose to estimate the degradation curve using the ratio of Band 3B to Band 3N, which has almost the same spectral characteristics.

Eng gratefully accepted the Japanese Level-1B SWIR crosstalk correction software on behalf of the U.S. It

was implemented as two new products in the ordering system (*AST_09XT* and *AST_07XT*) that use default parameters to be consistent with Japan.

Temperature/Emissivity Working Group

A. Gillespie [University of Washington] reviewed the action items from the previous meeting and gave a report on the Recent Advances in Quantitative Remote Sensing II (RAQRS II) Meeting held at the University of Valencia, Spain in September 2006. There was a strong emphasis on the Thermal Infrared (TIR) and the performance of ASTER Temperature/Emissivity Separation (TES) at the meeting. There were seven TES presentations made at RAQRS II. Gillespie felt that it was useful to present discussions on the problems and solutions since European users were beginning to notice problems with TES. He feels RAQRS III in 2010 will be a good venue for TIR presentations.

Okada reviewed the TIR nighttime data acquisition and he and **Matsunaga** both discussed the nighttime acquisition of TIR data, noting that acquisition of the Sahara and South Africa data, may impinge on daytime collections in Japan and Australia. Collections in South America should not impinge on any other collection sites but there seem to be several scheduling problems causing the lack of data. They suggest requests be submitted for South America and Africa and the effect on other regions watched, and then followed up with other nighttime requests.

Tonooka reported on the nighttime cloud assessment problem and offered a cloud mask based on a MODIS product that can be applied to Level-1A scenes and is available through the web. He also reported on a study on the impact of band-to-band misregistration on emissivity products. Emissivity scenes, especially those resampled by the nearest neighbor, have stripe noise due to resampling in the Level-1 processing, equivalent to 5–10% in emissivity and most likely caused by slope effects where one side is in shadow and one side warmed by the sun. If, in the processing, a single Ground Control Point (GCP) table is used for all bands rather than the standard one GCP table for each band, the results are better although some cross-track adjustment is still necessary for better quality. Tonooka also evaluated 102 emissivity scenes, nearly evenly divided in day and night, for temporal stability using vegetation free surfaces from three differenet sites: Big Island, HI; Death Valley, CA; and the Sahara Desert in Chad. The results indicated that the standard products are generally stable for dry areas but not so for humid areas due to errors in the atmospheric correction. The deviation of retrieved emissivity is roughly 0.01 per 1 cm of precipitable water vapor (PWV). The study continues.

B. Gustafson [University of Washington] made a presentation suggesting some changes to the Temperature/Emissivity Separation (TES) algorithm to address local unpredictable step discontinuities in emissivity and temperature images. They are visually disruptive and the temperature errors are particularly troubling because many users are interested in water and canopy temperatures. Local variability of water in the atmosphere is probably the cause of most of the error. Gustafsan tested the atmospheric compensation with a series of cloud free images looking at water at five different elevations from -69 m at the Salton Sea to 3193 m at Koko Nur, and checked the number of pixels in error in the downwelling radiance in Band 10. This test lead to a recommendation to change the Minimum/Maximum Difference (MMD) threshold from 0.03 to 0 and to eliminate the irradiance correction. He also suggests that temperature users check the emissivity values of their scenes. He suggests that the MODIS assist for atmospheric correction will be helpful, but also plans to do an in-scene atmospheric correction and use a classification of VNIR bands to assist daytime temperature/emissivity separation.

A. Mushkin [University of Washington] described a method of using subpixel roughness estimates from ASTER stereo images to compensate for roughness effects in the thermal infrared. He used lidar measurements and a two-look approach using an ASTER Band 3B / Band 3N ratio as a proxy for relative surface roughness. This approach has the advantage of being independent of albedo and most atmospheric conditions.

Geology Working Group

F. Kruse [Horizon GeoImaging, LLC] and **M. Urai** [Geological Survey of Japan] lead the discussion as the Geology Working Group discussed what to recommend about the SWIR detector temperature rise. The group agreed that in this group mineral mapping efforts and volcano temperature change detection and mapping will be most affected by loss or degredation of SWIR. The group unanimously recommended first to increase the *piston stroke*, followed by adjustment of the gains at a later date as required. The group also heard 17 presentations on a variety of geologic problems: three on geothermal topics and earthquake applications; three on glaciers; four on geological and mineral mapping; six on volcanoes; and one on DEM generation.

Level-1/DEM Working Group

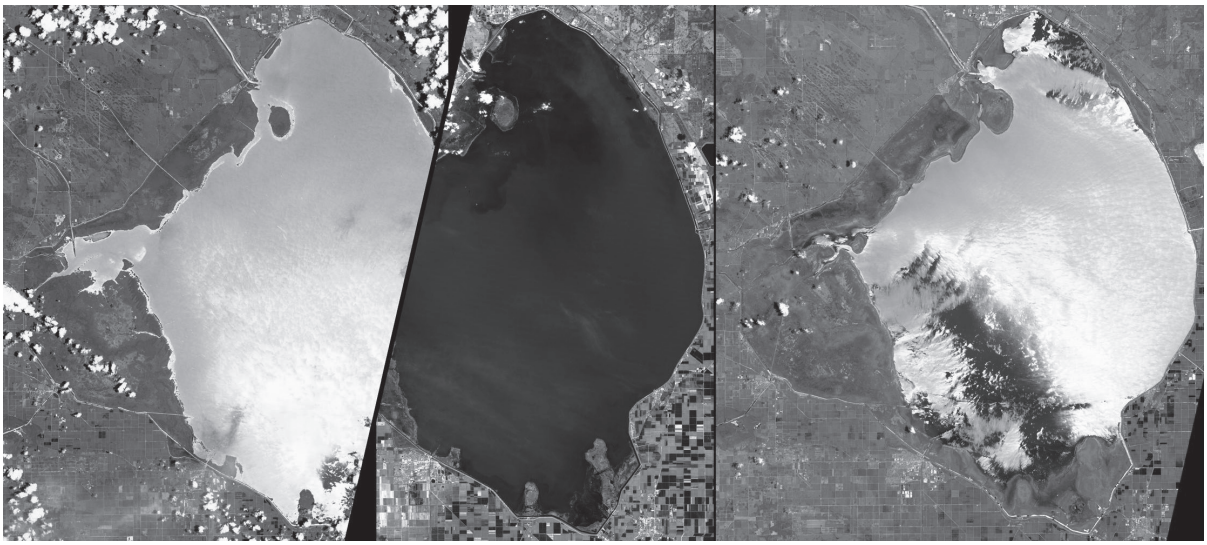
B. Bailey [USGS LPDAAC] reported on the status of the LPDAAC DEM and orthorectified image products. They began routine batch-mode production of the new ASTER DEM product on May 24, 2006. They pro-

duce relative DEMs only, at 30-m postings referenced to the Earth's geoid delivered in *GeoTIFF* format via *FtpPull* from the EOS Data Gateway. Production is running smoothly and they continue to monitor the data quality. Problems have been reported for several scenes at high altitude especially where there is abundant shadowing. The problem seems to be traced to *"water detection=on"* so the DAAC is adding an option for *"water detection=on or off"*. He showed a number of examples. Unlike Japan's ASTER Ground Data Center (GDC), the LPDAAC had not previously offered an orthorectified product, due to development complications and lack of approval from NASA HQ. Production was approved in July 2006 and should be running in January 2007. The new orthorectified product will be available to users via EROS Data Gateway and *GloVis* early in 2007 as zip files via *FtpPull* separately or with a DEM for $80 without or $160 with DEM, the same as other products. He then gave the status of several other items. The new billing and accounting product codes had been provided, the new Linux hardware had been delivered but not installed, which will take additional time after instillation for system integration, testing and product validation, and product documentation was in review.

H. Fujisada [Sensor Information Laboratory Corp. (SILC)] talked about ASTER Level-1, DEMs, and orthorectified products produced in Japan. Fujisada first discussed the Level-1 algorithms and software improvements (Fujitsu Ltd.). All the radiometric coefficients were updated to *Version 3.03* and were working well. The Level-1 geometric performance has no appreciable problems. Tests were done with band-to-band registration and geolocation accuracy day and night. He then discussed the SWIR parallax correction status (Mitsubishi Space Software Co., Ltd.). They measured cloud free scenes scattered over the world, Band 6 vs. Band 7, matching images in the along track and across track directions and found no problems in either direction and no problems in the error distributions, meaning the parallax correction is working properly. The inter-telescope registration correction tests (Hitachi, Ltd.) done both across track and along track showed that the registration had not changed since June 2006, and the relationship between inter-telescope offsets and pointing angles had not changed since November 2003. The DEM ortho-validation results (Central Computer Services, Co., Ltd.) using several validation sites in Japan and Australia show no problems. Fujusada also gave the values for the calculated offsets for SWIR at 83 K for the Level-1A data.

R. Nakamura [AIST] presented a paper describing the accuracy estimate of ASTER DEMs from the GEOGrid and described the methods used. Data transmission from ERSDAC to AIST started November 1, 2006, and data transfer from tape archive should be finished in 5-6 months. The GEOGrid portal is open to special users at *www.geogrid.org* and currently users can order DEMs and orthorectified products. The geometric accuracy is validated using the ERSDAC Level-3A data, Ground Control Points (GCPs), and lidar from the west coast of California, including the San Andreas fault zone. In summary, the GEOGrid product has similar geolocation accuracy as the ERSDAC product and the elevation accuracy may be better. Nakamura welcomed the ASTER team as *beta* testers.

Abrams and **Tsu** closed the meeting and declared it a success, with a promise to meet again in late spring in Japan. ■



Lake Okeechobee is located in south-central Florida and is the second-largest freshwater lake wholly within the continental United States, second only to Lake Michigan. The massive lake is 1913 km^2 (730 mi^2), with an average depth of 2.7 m (9 ft). Due to drought and usage of water for agriculture and residential purposes, the current water level is about 1 m (3 ft) below its historical average for this time of year. The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) on the Terra satellite acquired the left image on June 19, 2000, the middle image, January 19, 2003, and the right image, June 23, 2007. Shrinking is particularly evident on the west and the southeast parts of the lake. **Credit:** NASA/GSFC/METI/ERSDAC/JAROS, and U.S./Japan ASTER Science Team.

Seventh CERES-II Science Team Meeting

Shashi K. Gupta, NASA Langley Research Center, S.K.Gupta@larc.nasa.gov

The seventh meeting of the Clouds and the Earth's Radiant Energy System (CERES-II) Science Team was held April 24-26, 2007, at the Marriott City Center in Newport News, VA. **Norman Loeb** [NASA Langley Research Center (LaRC)] hosted the meeting. The next CERES meeting will be held jointly with the Canadian Cloud-Aerosol Feedbacks and Climate (CAFC) Network on November 12-16, 2007, in Victoria, British Columbia, Canada.

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

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

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

Climate Program Overview

Bruce Wielicki [LaRC—*CERES Principal Investigator*] 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 NPOESS Preparatory Project (NPP), the A-Train, and the National Research Council (NRC) Decadal Study. According to IPCC Assessment Report 4 (AR4), cloud feedback remains the largest uncertainty in climate sensitivity. Aerosol indirect effect remains the largest uncertainty in anthropogenic radiative forcing. Both of these factors affect planetary albedo. The report of the NRC Decadal Survey for Earth Science was released in January 2007. Among its first recommendations is the Climate Absolute Radiance and Refractivity Observatory (CLARREO) mission under which to continue the radiation budget time series, and launch an in-orbit observatory for calibrating solar and infrared instruments to climate quality.

At NASA Headquarters, Mike Freilich is the new Director of the Earth Science Division and Bryant Kramer is his Deputy. Don Anderson and Hal Maring are Modeling and Radiation Science leads respectively. The NASA/NOAA white paper dealing with consequences of dropping climate instruments from NPOESS and the resulting gap-risk in climate data record (CDR) has been submitted to the U.S. Office of Science and Technology Programs (OSTP) and the Office of Management and Budget (OMB) but has not yet been made public. It recommends moving Flight Model Five (FM-5) to the NPP mission in 2010 and building copies of the CERES instrument for NPOESS flights in 2014 and 2019.

A congressional bill requires annual reports on progress in converting NASA research developments into NOAA operations and utilizing NOAA operational data into NASA research. A Joint Agency Working Group constituted for the purpose submitted its first report in February 2007. Wielicki observed that U.S. public awareness of climate issues is increasing but is not yet enough to steer the Government to commit adequate resources to climate research.

Terra/Aqua Instruments and Calibrations

Kory Priestley [LaRC] presented the operational and calibration/validation status of the four CERES instruments on Terra and Aqua. Both instruments on Terra and one (FM-3) on Aqua continue to function nominally. The SW channel of FM-4 on Aqua suffered an anomaly on March 30, 2005 and stopped taking radiometric measurements. He discussed the modifications of calibration/validation methodology for *Edition-3* processing and the progress being made toward those objectives, and also sought science team approval for their implementation.

Grant Matthews [Analytical Services and Materials, Inc. (AS&M)] discussed the improvements made to the spectral darkening model and how they are applied for adjusting the total channel spectral responses. Results were shown from an *Edition-3* test run utilizing spectral darkening model and Single Scanner Footprint (SSF) inversion. This showed how the metrics of Deep Convective Cloud (DCC) albedo and unfiltered nadir direct comparison have been successfully adjusted to remove trends and dispersion for red and blue scene types.

CERES Cloud Properties

Patrick Minnis [LaRC] presented the status of CERES cloud algorithms and products. He outlined plans to complete Terra *Edition-2* and Aqua *Edition-1* process-

ing through the end of 2007, to examine the impact of Modern Era Retrospective-analysis for Research and Applications (MERRA) inputs on CERES cloud products, and to refine and validate *Edition-3* cloud algorithms. Comparisons of GEOS-4 and GEOS-5 surface skin temperature showed GEOS-5 to be colder over the Arctic, warmer over Antarctica, colder over daytime land, and warmer over nighttime land. Minnis indicated that the CERES Cloud Group is participating in the GEWEX Cloud Assessment activity.

Sunny Sun-Mack [Science Systems and Applications, Inc. (SSAI)] presented results of the work on co-location of Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) 333-meter lidar footprints with Moderate Resolution Imaging Spectroradiometer (MODIS) 1-km pixels for the month of January 2007. She showed comparisons between CERES-MODIS cloud amount and height retrievals with corresponding CALIPSO lidar retrievals. Sun-Mack also showed examples of integrated CALIPSO/CloudSat/CERES-MODIS datasets and retrievals.

Simple Surface Fluxes

Shashi Gupta [SSAI] presented early results from the validation of Aqua *Edition-2B* SSF SW Model-B fluxes. Comparison of SW Model-B footprint fluxes from 29 sites for a 12-month period (July 2002-June 2003) showed that the large biases that appeared in corresponding Aqua *Edition-2A* fluxes related to the change of aerosol properties in the model have been corrected. Gupta noted that results of all other simple surface flux models remain unchanged.

Terra and Aqua SARB Products

Thomas Charlock [LaRC] presented an overview of SARB results and comparison of current Aqua products with surface observations. Surface downward and upward LW fluxes were shown to be lower than surface observations due to biases in near-surface air temperature in the input data. Interpolation of MODIS daily average aerosol optical depth (AOD) was shown to result in 50% higher values over certain periods and caused large biases in clear-sky surface insolation. Charlock also presented a study of the effects of cloud phase and cloud optical depths on surface SW and LW fluxes.

CERES TISA Activities and Comparisons

David Doelling [SSAI] discussed activities of the Time Interpolation and Spatial Averaging (TISA) Working Group and announced public release of 3-hourly Synoptic Radiative Fluxes and Clouds (SYN), Monthly Regional Radiative Fluxes and Clouds (AVG), and Monthly Zonal and Global Radiative Fluxes and Clouds (ZAVG) archival SARB products. These products are directly comparable with global climate model (GCM) output. He also presented Aqua *beta-6* Monthly Surface and TOA Fluxes and Clouds (SRBAVG) data for the July 2002-October 2005 period and compared them with corresponding Terra results to ensure consistency. Aqua products are expected to be released by the end of Summer 2007.

Fred Rose [SSAI] presented the algorithms and validation of the instantaneous synoptic SARB product known as SYNI and the monthly regional AVG product. Comparisons were made with CERES Geostationary (GEO) and non-GEO fluxes and surface observations from 40 sites of the CERES/Atmospheric Radiation Measurement (ARM) Validation Experiment (CAVE) database. Diurnal-cycle comparisons were made only at the ARM Southern Great Plains (SGP) central facility.

Wenying Su [SSAI] presented validation of photosynthetically active radiation (PAR) and erythemal ultraviolet (UV) radiation derived from CERES SYNI products using surface-based measurements from the Surface Radiation (SURFRAD) network. Comparisons with 2002 data from six SURFRAD sites showed a bias of about 6 W/m^2 and random error of about 40 W/m^2 for PAR results. For erythemal UV results, bias and random error were found to be about 2.4 and 18 W/m^2 respectively.

Paul Stackhouse [LaRC] presented comparisons of monthly average surface SW and LW fluxes from several sources including SARB ZAVG, CERES SRBAVG, Global Energy and Water-cycle Experiment/Surface Radiation Budget (GEWEX/SRB) project, International Satellite Cloud Climatology Project (ISCCP) FD dataset, and reanalysis products. Input aerosol distribution and properties were apparently causing some of the larger SW differences. Surface skin and air temperature differences were identified as the cause of larger LW flux differences.

GERB Status

Grant Matthews [AS&M] representing **Jacqui Russell** [Imperial College, London] reported on the operational status of the GERB experiment. Effective April 10, 2007, GERB-1 flying onboard Meteosat-9 becomes the prime GERB instrument replacing GERB-2 that was flying on Meteosat-8. GERB *Edition-1* data products (from the GERB-2 instrument) will be available up to May 10, 2007. Data products from GERB-1 will be released after validation and are not expected before 2008.

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 60,000 observations from more than 2250 participants in all 50 states in the U.S. and 70 other countries. More than 25,000 observations are matched with a Terra or Aqua overpass with about 500 of those matched with both Terra and Aqua at the same time. Chambers urged attendees to participate in S'COOL activities in their own communities.

Data Management Status

Erika Geier [LaRC] presented an overview of the status of CERES data processing. CERES *Edition-2* products will be extended through December 2007. Terra products up to July 2006 are already available. Processing starting with May 2006 is making use of MODIS *Collection-5* inputs. Planning is underway for *Edition-3* processing where MERRA data are expected to be used along with MODIS *Collection-5*. Completion of *Edition-3* processing will take 2-3 years.

Mike Little and **Michelle Ferebee** [both from LaRC] presented a coordinated overview of the transformation underway at the Scientific Computing Facility (SCF) and the Atmospheric Sciences Data Center (ASDC). The SCF provides support to scientists and programmers during development of algorithms and codes. The ASDC performs production, archival, delivery, and user service functions. Both facilities are constantly evolving to deal with increasing lengths of data records, pressures to hold down cost, and changing computing hardware and environment. Both are effectively meeting the challenges while maintaining integrity of scientific data products.

Invited Presentations

Steve Warren [University of Washington] presented an overview of radiative properties of snow, clouds, and sea-ice from surface-based measurements made over Antarctic and Arctic regions. He showed numerous fascinating photographs of Antarctic snow and ice at the South Pole, the *Dome C* location, over the plateau, and over surrounding coastal regions. Properties of Arctic ice-sheets, sea-ice, and snow are substantially different than those over the Antarctic. Arctic snow is contaminated with black carbon and Arctic sea-ice is thicker and melts from top down forming puddles. Warren announced that cloud atlases published by his group in the 1980s as hard copies have been updated and are now available on-line at: *www.atmos.washington.edu/CloudMap/*.

John Fasullo [National Center for Atmospheric Research (NCAR)] presented results from a comprehensive study of annual cycle of energy flows through the climate system including its storage, release, and transport through the atmosphere, ocean, and land surface. The TOA energy budget was constrained by Earth Radiation Budget Experiment (ERBE) and CERES observations. Atmospheric energy budget parameters came from the National Centers for Environmental Prediction (NCEP)/NCAR and other reanalysis products. Fasullo presented estimates of mean and seasonal cycle of ocean energy divergence, and atmospheric and oceanic poleward energy transport.

Dave Winker [LaRC] reported on status and results of the CALIPSO mission and the progress made toward useable data products. Energy output of the laser was reported to be stable after 280 days of operation. Winker showed numerous records of CALIPSO data showing Arctic clouds, Saharan dust, smoke-dust discrimination, cloud-aerosol discrimination, and depolarization by Antarctic clouds. Validation of CALIPSO data was shown against Cloud Physics Lidar (CPL) data. Winker also showed some examples of merged CALIPSO-CloudSat profiles where CALIPSO observed thin cirrus and marine stratus clouds while CloudSat penetrated the deep convective clouds.

Co-Investigator Presentations

Robert Burgman [University of Miami] presented results of a study showing evidence of atmospheric radiative feedbacks on Subtropical Pacific sea surface temperature (SST) signals on decadal time scales. Outgoing longwave radiation (OLR), TOA reflected SW, and atmospheric water vapor (AWV) datasets from satellite databases were used in this study. Burgman showed several examples of feedbacks between SST signal and atmospheric circulation and attendant radiative effects.

Bing Lin [LaRC] presented a case study of the effects of a Saharan dust storm on convection and precipitation on an Atlantic storm of March 8, 2004. Using observations from multiple satellite sensors, Lin showed that the dust transported in the convective updraft provides additional ice nuclei. This resulted in an increase of precipitation in convective regions, decrease in stratiform regions, change of precipitation from heavy to light, and longer lifetime for clouds.

Shi-Keng Yang [Climate Prediction Center (CPC)/NCEP] presented early results from the incorporation of rapid radiative transfer model (RRTM) for LW computations in the Global Forecast System (GFS) model and planned incorporation of the same in the Climate Forecast System (CFS) model. The two main components of the CFS plan are: (1) a reanalysis for the 1979-2007 period; and (2) retrospective forecasts for the 1981-2007 period, and is expected to be completed by 2010.

Zhonghai Jin [SSAI] presented a study aimed at improving optical properties of snow surfaces for use

in the next version of SARB processing. A new set of optical properties for non-spherical ice particles were developed and implemented in a radiative transfer model. Model simulated radiances were validated with surface-based measurements and also with CERES/MODIS observations.

Ping Yang [Texas A&M University] presented results of a study of radiative effects of sub-visible cirrus clouds using CERES, MODIS, and Atmospheric Infrared Sounder (AIRS) data. Sub-visible cirrus clouds (optical depth <0.2) are known to contaminate a large fraction of MODIS pixels identified as clear but can be detected from the MODIS 1.38 μm channel. Yang showed that clear CERES footprints are also potentially contaminated by sub-visible cirrus.

Wenying Su [SSAI] presented a comparison of SW flux profiles derived from CERES data on the Tropical Rainfall Measuring Mission (TRMM) and Hadley Center's Global Environmental Model (GEM) for both clear-sky and cloudy conditions. He applied a correction to remedy TRMM diurnal sampling effects. For clear conditions, differences at 70 and 200 hPa were small but larger at 500 hPa and surface, especially over northern Africa. For cloudy conditions, agreement was good at 70 hPa but not at other levels.

Michel Viollier [Laboratoire de Meteorologie Dynamique (LMD)—*France*] presented comparisons of CERES/SSF TOA SW fluxes (albedos) from Terra with corresponding values derived from Polarization and Directionality of Earth's Reflectances (POLDER-2) narrowband radiances using a narrowband-broadband (NB-BB) conversion procedure. POLDER-2 fluxes were found to be about 2 W/m^2 higher than corresponding CERES values.

Laura Hinkelman [National Institute of Aerospace (NIA)] presented an overview of the GEWEX RFA activities. Most of the datasets received from the participants have now been uploaded into the web archive at: *eosweb.larc.nasa.gov/GEWEX-RFA/*. Efforts are now focused on data analysis, intercomparison of datasets, and error assessment. The Third RFA Workshop will be held at the end of June 2007. Hinkelman also presented results looking for trends in the GEWEX SRB *Release-2.8* dataset.

Seiji Kato [SSAI] presented a validation of global angular distribution models (ADMs) used in CERES over regions of permanent snow, fresh snow, and sea-ice. Global processing is done with ADMs for two types (bright and dark) of snow only, while snow ADMs can differ from region to region. SW fluxes over Antarctica derived using the above global ADMs were compared with corresponding fluxes derived with ADMs derived independently for every snow-covered region. Mean difference between the two flux datasets were found to be negligible.

Xiquan Dong [University of North Dakota] presented comparisons of the vertical distribution of stratus cloud properties, namely, liquid water content (LWC), droplet radius (r_e), and optical depth, over the SGP site derived from ARM radar-lidar measurements with those from CERES-MODIS observations at 2.1 and 3.7 μm. CERES-MODIS results at 3.7 μm showed better agreement with radar/lidar data than retrievals at 2.1 μm.

Alessandro Ipe [Royal Meteorological Institute of Belgium (RMIB)] presented several comparisons between GERB-1 and GERB-2 reflected SW radiances as well as between those and corresponding CERES *Edition-1* and *Edition-2* ES-8 products. GERB-2 radiances were mostly higher than GERB-1 as well as CERES radiances. GERB-2 to CERES differences were generally scene dependent and were attributable to deficiencies in GERB spectral response.

Lou Smith [NIA] discussed operations of the CERES FM-2 instrument in support of a special observing period of the African Monsoon Multidisciplinary Analysis (AMMA) project. An ARM program trailer was set up for making radiation and meteorological measurements during 2006 at the airport in Niamey, Nigeria. Coincident measurements were obtained from ground instruments while Terra FM-2 flew over that area. Ground data will be used for validation of corresponding SARB products.

James Coakley [Oregon State University] presented comparisons of optical depth and droplet radius for single layer marine stratocumulus over the North Atlantic derived from MODIS 1-km and 250-m pixels using overcast pixel assumption with those from his partly cloudy pixel retrieval (PCPR) technique. He showed that agreement between the two techniques was good when overcast pixels were used but not good for partly cloudy pixels. Comparisons with CERES products provided similar results.

Wenbo Sun [Hampton University (HU)] presented an investigation of possible causes of the apparent correlation between retrieved cloud amount and aerosol optical depth in most satellite products, especially in the *twilight zone*. Several potential causes, including 3-D cloud radiation effect and swelling of aerosols due to increased humidity in the vicinity of clouds were considered. Sun suggested that airborne High Spectral Resolution Lidar (HSRL) could be used for measuring twilight zone aerosols.

Greg Schuster [LaRC] presented results from a study of the effect of humidity on Angstrom exponent (AE) and fine mode fraction (FMF) for accumulation

mode aerosols. This study was designed to examine if aerosol swelling affected the above properties. Schuster concluded that aerosol swelling could be responsible for changes in the above properties and evidence of that can be seen in satellite datasets. He also suggested that relationships between AE, MODIS FMF, and aerosol fine mode volume fraction were not rigorous.

Istvan Laszlo [National Environmental Satellite Data and Information Service (NESDIS)] discussed the studies underway at NESDIS for transitioning of aerosol retrievals from MODIS measurements to those from the Visible Infrared Imaging Radiometer Suite (VIIRS) during the NPP/NPOESS era. Current MODIS algorithms and proposed VIIRS algorithms are sufficiently different to potentially produce different aerosol properties that will affect the continuity of the aerosol property record and radiation budget parameters.

Alexander Ignatov [NESDIS] presented aerosol properties retrieved from radiances from Spinning Enhanced Visible and Infrared Imager (SEVIRI) which is flying aboard the Meteosat-8 platform along with GERB-2. The Advanced Very High Resolution Radiometer (AVHRR)-like aerosol algorithm developed for CERES was used to derive these products. High spatial and temporal resolution afforded by the geostationary platform helps resolve the fine structure of aerosol distribution.

Marty Mlynczak [LaRC] presented a brief overview of the Far Infrared Spectroscopy of the Troposphere (FIRST) project, currently in the initial stages at LaRC. The FIRST instrument is a Michelson interferometer designed for measuring high-resolution spectra of the Earth in the 6-100 μm region. Mlynczak presented many spectra obtained during balloon flights of June 2005 and September 2006 and their comparisons with coincident AIRS spectra. He also showed spectra from ground-based measurements obtained in March 2007.

Takmeng Wong [LaRC] presented a methodology for bridging the gap between the record of SW fluxes developed from ERBE/Earth Radiation Budget Satellite (ERBS) data (up to September 1999) and that from CERES Terra data for March 2000 onward. This gap needs to be filled to complete the SW climate data record from 1985-to-present. Wong developed a method for filling this gap using deseasonalized anomaly time series of Sea-viewing Wide Field-of-view Sensor (SeaWiFS) PAR flux.

ADM/Inversion Working Group

Norman Loeb [LaRC] led the ADM Working Group discussions. **Nitchie Manalo-Smith** [SSAI] presented comparisons of CERES LW and window (WN) radiances with corresponding MODIS radiances to assess relative stability of CERES radiances over five years of the Terra mission. Manalo-Smith also presented deseasonalized monthly anomalies of LW and WN fluxes. **Cedric Bertrand** [RMIB] presented comparisons of GERB and CERES/Terra SW fluxes over the Sahel regions. GERB fluxes were shown to exceed CERES values by about 10%. Bertrand attributed this discrepancy to the use of CERES/TRMM ADMs in GERB processing that are inadequate for dealing with the temporal variability. **Wenbo Sun** [HU] presented work validating the diffusivity approximation using CERES WN channel data. Sun demonstrated that infrared fluxes could be estimated with sufficient accuracy by multiplying radiance at about 53° with π.

SARB/SOFA Working Group

Thomas Charlock [LaRC] led the SARB/SOFA Working Group discussions. **David Rutan** [SSAI] presented a study of ocean surface albedo at polar latitudes where sea-ice was likely to exist. He compared surface albedo retrieved under clear-sky and all-sky conditions for several CERES validation regions and showed that all-sky albedo is frequently underestimated. **Anand Inamdar** [U.S. Department of Agriculture] discussed a methodology for deriving land surface temperature (LST) and its diurnal cycle on a 1-km scale using MODIS and GOES data citing the importance of LST for a number of weather, climate, hydrology, and agriculture related applications.

Cloud Working Group

Patrick Minnis [LaRC] led the Cloud Working Group discussions. **Qing Trepte** [SSAI] presented comparisons between cloud amounts and brightness temperatures derived from MODIS *Collection-4* and *Collection-5* radiances. The largest differences were observed over polar regions at night. **Ping Yang** [Texas A&M] presented a study of the effect of ice-crystal surface roughness on cirrus cloud properties. Yang concluded that ice-crystal size is underestimated and cloud optical depth is overestimated if particle roughness is not taken into account.

Fu-Lung Chang [NIA] presented comparisons of water cloud droplet radii (r_e) and ice-cloud particle diameters (D_e) obtained from MODIS retrievals at 3.7, 2.1, and 1.6 μm with independent retrievals. He showed that MODIS r_e values at 3.7 μm were smaller than at other wavelengths. **Alessandro Ipe** [RMIB] presented comparisons between cloud properties retrieved from SEVIRI data using GERB and CERES-type algorithms. He showed comparisons of optical depths from the two retrievals for both water and ice clouds. ■

NASA LCLUC Spring Science Team Meeting

Garik Gutman, NASA HQ, garik.gutman@nasa.gov
Chris Justice, UMCP, justice@hermes.geog.umd.edu and Kelley O'Neal, UMCP, kellyo@herems.geog.umd.edu

The NASA Land-Cover and Land-Use Change (LCLUC) Program Science Team Meeting was held April 4-6, 2007, at the University of Maryland. Approximately 150 participants joined the meeting which was focused on land-use and climate interactions. The agenda from this meeting as well as past Science Team meetings can be found on the LCLUC website at ***ftp://ftp.iluci.org/LCLUC_APR2007/1_agenda_lcluc_apr2007.pdf.***

Opening Remarks

Garik Gutman [NASA Headquarters (HQ)—*LCLUC Program Manager*] opened the meeting with a status report describing the LCLUC Program vision, linkages with the other NASA programs and the Climate Change Science Program (CCSP), external international linkages and the current make-up of the LCLUC Program. He also reviewed the meeting format (structured as scientific overview presentations, programmatic presentations, and poster presentations) and detailed expectations. In addition, Gutman also discussed program activities, public relations, reporting, education opportunities, and data issues. He also noted some current and forthcoming events and shared news concerning ongoing projects and research announcements, including an update on the current status of Landsats 5 and 7 and the Mid-Decadal Global Land Survey (MDGLS). Gutman also mentioned the contributions of LCLUC to the Northern Eurasia Earth Science Partnership Initiative (NEESPI) and the Monsoon Asia Integrated Regional Study (MAIRS) programs.

Chris Justice [University of Maryland, College Park (UMCP)—*LCLUC Program Scientist*] followed with a presentation on how land use-climate interactions could be developed within the LCLUC Program. LCLUC and related NASA programs continue to fund research on the role of land use and biogeochemical cycles. The 'land use' term in the global carbon cycle is well recognized and a topic of continued research in the Carbon Cycle Program. Land use also provides a means by which we can reduce greenhouse gas emissions by sequestering carbon. (This particular application requires a strong science underpinning.) The impacts of land-use change in altering regional climate is an area currently receiving more attention, and a few projects were selected in the last funding cycle. The impacts of future climate change on land use in the context of sustainability and land use as a means to adapt to climate change and reduce human vulnerability have received less attention, and are areas that warrant development by the program and partner agencies in the U.S. CCSP. There is also an increasing recognition of the importance of models addressing multiple stressors. This includes the simultaneous impacts and feedbacks of land-use change (caused largely by socio-economic changes), and climate change (caused by regional land-use change and global warming).

LCLUC Science Team Meeting attendees.

Example Presentations

A total of 18 overview presentations were given during the meeting, including *State of the LCLUC Science* presentations and *Programmatic* presentations. Examples of the state of the science reviews, which provide a compilation of research from science team members are as follows.

Roger Pielke [University of Colorado] gave an overview of land use-climate interactions studies. He showed that land use, through its the role in the water, energy, and carbon cycles and trace gas and aerosol effects, has a first-order role in human and natural climate forcing and feedbacks. Pielke identified global atmospheric teleconnections due to land-use/land-cover change, which appear to alter weather and other aspects of the climate system as much or more than would occur due to the radiative effect of doubling carbon dioxide.

Hank Shugart [University of Virginia] gave an overview of carbon dynamics in boreal forests, showing the interaction between plant and soil processes, disturbances and climate change. He showed the synergy between LCLUC projects providing satellite observations and process studies from the leaf and plant level (e.g. photosynthesis, growth and mortality), through the stand level (e.g. regeneration, competition) to landscape and regional scales (e.g. dispersal, fire and logging disturbances). These projects provide the foundation for a system for monitoring and validating the distribution and change in land cover across Northern Eurasia. The fusion of data from different sensors with different resolutions and capabilities provides an increased capability to represent land cover dynamics as an essential part of the Earth's systems.

Irina Sokolik [Georgia Institute of Technology] gave an overview of aerosols and land-use interactions. She made the case for new approaches to develop dynamic emission algorithms based on a process-oriented description of land use- and ecosystems-dynamics and climate change. Sokolik explained the state of the art in aerosol modeling and outlined the key aerosol- and air pollution-induced processes and feedbacks that have been affecting the energy, water, and carbon fluxes over Northern Eurasia. She identified distinct trends in aerosol sources and spatial and temporal variability, due to region-specific climatic, economical, and political changes**.** She explained the role of aerosols within an integrated regional study under the International Geosphere-Biosphere Program (IGBP).

Andy Hansen [Montana State University] gave an overview of biodiversity, land-use, and climate interactions. He gave examples of studies at three scales, showing how local case studies can lead to a better understanding of processes and an understanding of global trends. Local scale predictive land-use studies allow society to visualize change and enable the development of policy that can improve local sustainability. At the regional scale, studies enable the development of theory and testing of continental-to-global scale models. These studies can help revise conservation strategies and improve monitoring to inform management and assess the impact of management policies. Future directions for land-use and biodiversity research include providing a spatial dimension for conservation biology, quantifying the impacts of population growth and consumption, evaluating possible unpredicted thresholds of land use change, and possible future land use options. Hansen suggested that in the context of biodiversity, land-use change needs to be elevated along with climate change to inform public and policy debates.

Jon Foley [University of Wisconsin] gave an overview of agriculture as a major force in the Earth System. He explained that agriculture has already altered the biosphere as much as projected climate change. Foley stated that 40% of the Earth surface has been converted to agriculture and that agricultural water use has tripled in the last 50 years, resulting in a massive release of excess nutrients into aquatic systems. He pointed out that land-use change and climate change are happening together, and that although satellite data are useful for identifying and monitoring land cover, fusion with socioeconomic data are needed to better understand land use. In the past 40 years, agriculture has expanded but that intensification has been greater. Current global data products are inadequate for capturing land use or quantifying the processes and increased attention is needed on land-use practices and agricultural management. Land-use practices are changing quickly and major changes can be foreseen in the coming years with increasing use of biofuels, increasing demand for animal feed, and increasing participation in global markets. Foley concluded by saying that the current focus on the carbon dioxide-climate change connection is shortsighted and that a more comprehensive framework is needed to explore changes in the Earth System.

Billie L. Turner II [Clark University] presented an overview of research on landscape vulnerability and resilience. He started by outlining the sustainable land architecture emerging from the International Geosphere-Biosphere Programme/International Human Dimensions Programme on Global Environmental Change (IGBP/IHDP) Global Land Project in the broader framework of sustainability science. Turner suggested that the latter will be the context for the next multi-decade climate and global change and development research agenda. He showed how LCLUC is poised to be a foundation for sustainability science, particularly in the area of human vulnerability.

Five others gave *state of the science* presentations including:

- **Amber Soja** [NASA Langley Research Center] who spoke on fires and climate interactions in the boreal zone;
- **Matt Hansen** [South Dakota State University] who spoke on multi-resolution forest monitoring;
- **Skip Walker** [University of Alaska, Fairbanks] who spoke on climate, sea ice, land cover, and human interactions in the Arctic Zone;
- **Walter Chomentowski** [Michigan State University] who spoke on tropical deforestation and carbon interactions, and
- **Marc Simard** [NASA/Jet Propulsion Laboratory] who spoke on advances in microwave data for land-use studies.

Three of NASA's major regional research programs place an emphasis on LCLUC research. The group heard from:

- **Daniel Nepstad** [Woods Hole Research Center] who represents the Large-Scale Biosphere-Atmosphere experiment in Amazonia (LBA) program;
- **Pavel Groisman** [NOAA] who represents the NEESPI programs; and
- **Sasan Saatchi** [NASA/JPL] who represents the North American Carbon Program.

In addition to the overview presentations, 48 posters were presented at the meeting during an invited poster session, which included results from both the New Investigator Program and the Graduate Fellowship Program.

Programmatic Presentations

Programmatic presentations were given to brief the team on recent developments**.**

Ed Sheffner [NASA HQ] summarized the agricultural component of the NASA Applications Program and described the recent changes in the Applications Program.

Jeff Masek [NASA Goddard Space Flight Center (GSFC)] presented the status of the USGS/NASA Mid-Decadal Global Land Survey which is aimed at providing a global Landsat data set from Landsat 5 and Landsat 7 for the 2004-2007 period. He described the progress that has been made with scene acquisition for that period, including data from selected international ground stations, the complexity associated with using composited data from the malfunctioning Landsat 7, and options for product generation from the baseline data set.

Jim Irons [NASA GSFC] presented the Landsat Data Continuity Mission status and on the first meeting of the U.S.Geological Survey (USGS) Landsat Science Team in Sioux Falls and the status of the NASA Landsat Data Gap Study.

Martin Herold [Friedrich Schiller University] presented the international Global Observations of Forest and Land Cover Dynamics (GOFC/GOLD) Deforestation Initiative and the FAO Land-Cover Classification System (LCCS).

Sasan Saatchi [NASA JPL] gave an overview of LCLUC projects in the North American Carbon Program.

Breakout Discussion Groups

Two breakout discussion groups were held: one group to discuss research priorities for land-use and climate interactions and another to discuss program priorities for land-cover and land-use change data. In addition to discussing priorities, the groups were tasked with identifying steps to improve data availability and access, obstacles impeding progress, near-term opportunities, and future recommendations. Findings from the two breakout discussion groups are outlined below.

Land-use and Climate Interactions

Co-Chairs: Robert Dickinson [Georgia Institute of Technology] and **Pavel Groisman** [NOAA]

Global changes are driven by events happening at the local and regional scales, but from a climate modeling perspective, we tend to think about them at the global scale because the atmosphere serves as a mixing bowl. The accumulation of events at the local scale, particularly the human impacts, are what matter most. There is a well-recognized need for a better understanding of the processes underlying the responses seen and for a better characterization of observed variability in land-change dynamics.

Before we can predict, we have to be able to describe the processes shaping what is happening now and what happened in the past. We need to know the sources of the finer scale variability of the processes of interest, spatial variability of land use, vegetative cover, cryosphere dynamics, hydrologic variability, and aerosol production. We also need to develop the ability to reliably reproduce and predict extreme events in regional analyses. We need to move beyond the biophysical component and develop the biogeochemical connections to the atmosphere and hydrosphere from land-use change processes with an ultimate goal of incorporating them into the coupled global Earth models.

For land-use impact studies, LCLUC researchers should not use a single model output of future predictions but rather an ensemble of global climate model (GCM) outputs, relying on converging lines of evidence. Our models and resulting products need to be able to com-

municate with each other using similar remote sensing products and generating the outputs that can be assimilated (adopted) by other models. A vision concerning the integration of various types of models at different scales into the whole should be developed. Multi-model comparison should be undertaken to estimate models' uncertainty and to facilitate use of their results. We need fully integrated human-environment models at all scales and a continuous supply of accurate data to support model development and validation.

The group's recommendations to the LCLUC program management were as follows:

- We want to maintain a balanced program and seek to do this by focusing on enhancing LCLUC data acquisition, studying projections, processes, feed backs between processes, and securing links with the global change modeling community.
- We need to encourage and strengthen international and interagency program collaboration.
- We should focus on regional climate prediction on a shorter time scale (10-50 years) with fully coupled aerosols and biogeochemistry because this currently seems to be the most promising strategy.
- We need a better understanding of the ways in which societal processes and feedback loops (e.g., population movements, agricultural practices, road development, etc) will be accounted for in coupled land-use and climate models.
- We need a better understanding of how regional scale feedbacks and impacts interact with global scale changes.

Land-cover and Land-use Change Data Priorities

Co-chairs: Curtis Woodcock [Boston University] and **Matt Hansen** [South Dakota State University].

Landsat class observations are essential to the success of the LCLUC Program. The approach by the science community is to use a time series of Landsat class data at the regional scale. Although there are large volumes of data in the archives, the current costs of Landsat 7 data are an obstacle for this approach. The generation of global datasets (surveys) by NASA and more recently in cooperation with USGS, which are available free of charge, has proven to be extremely helpful to the science community. Continuity of a Landsat class of measurements between now and the launch of the Landsat Data Continuity Mission is not assured, and NASA should seek to fill this data gap through a virtual constellation that includes international assets. In particular, NASA should be prepared to provide observations in support of a 2010 global decadal survey.

The group endorsed the transition of the Landsat Program to operational status and advocated improved security of measurement scenarios through use of a constellation of low-cost satellites. It was noted that a single Landsat-style satellite, although an important contribution, is a mission concept developed for the 1970's and will be insufficient to meet the current needs of the LCLUC research and applications community. The single greatest improvement to our ability to monitor change at the Earth's surface would be an improvement in temporal resolution of the Landsat class data. The four-to-five acquisitions per month demonstrated by the Advanced Wide Field Sensor (AWiFS) instrument is considered a major improvement.

The success of the LCLUC Program also remains dependent on continued production of science quality products from the Moderate Resolution Imaging Spectroradiometer (MODIS) and eventually the Visible Infrared Imaging Radiometer Suite (VIIRS), including sufficient overlap between the two missions to facilitate inter-calibration and product intercomparison. Given the current plans for Environmental Data Records from VIIRS, it will be necessary for NASA to support the generation of science-quality land-cover related products from VIIRS. As land observations migrate to operational status, we encourage NASA to ensure coordination across scales and wavelengths in support of land science. We endorse the recommendations of the National Research Council's *Decadal Survey* with respect to the need for a future mission which would include a lidar and a radar.

Closing Remarks

Garik Gutman [NASA/HQ] concluded by summarizing the meeting and adding some observations. The LCLUC Program supports research at the interface between remote sensing, physical science, and the human dimension of global change. The distinction between the Terrestrial Ecology and LCLUC programs is that while both programs address aspects of ecological problems, the LCLUC is unique in that it pays attention to managed ecosystems involving the human dimensions—i.e. with explicit inclusion of social science. In the next phase of funding, the program is moving toward larger projects addressing regional-scale and more integrative problems. While fewer total projects will be funded, there still remains room for smaller projects to be included in the program and develop links to established teams.

The Science Team Meeting agendas are built around geographic and topical breakdowns. The meeting format is currently a series of overview presentations with team member contributions listed. Spring meetings are held in the Washington, DC area, while fall meetings will be held abroad to facilitate greater participation of regional experts and international collaborators and managers.

Future areas for the development of the program are as follows:

- integration of LCLUC processes in regional and global climate models;
- International Polar Year research;
- involvement in new interdisciplinary areas including land use-human health relationship;
- improved predictive land-use modeling—regional focus on northern and southern Eurasia; and
- increased involvement of social science.

Chris Justice [UMCP] followed Gutman and emphasized the need for continued and active participation by LCLUC scientists in the U.S. CCSP and the need to initiate research on the adaptation of humans and land-use systems to climate change, sustainability and human livelihoods.

Future Meetings

The upcoming Joint NEESPI/LCLUC Science Team Meeting will be held September 16-20, 2007, in Urumqi, located in the western drylands of China. The focus of the meeting will be on dryland land-use systems. The meeting will provide an international forum for the exchange of scientific findings and discussion of research priorities and data coordination and exchange. More information concerning logistics, agenda, and registration, along with presentations and posters from the above meeting can be found on the LCLUC website at *lcluc.hq.nasa.gov*. We plan to hold the Spring 2008 LCLUC Science Team Meeting in conjunction with the Carbon Cycle and Ecosystems Focus Area Meeting in the Washington, DC area. ■

Although forest clearing for pasture is the primary driver of Amazon deforestation in the state of Mato Grosso, Brazil, a new study led by scientists at the University of Maryland showed that large-scale mechanized agriculture, mostly for soybeans, is rapidly becoming a major force behind forest loss in the region. A related study led by scientists at NASA's Goddard Space Flight Center indicates that what people do with the land—whether they leave it bare, plant crops, or convert it to pasture—influences the climate in different ways. Scientists fed satellite data on the area and type of forest conversion in Mato Grosso into computer models to predict the effect on climate. Leaving the ground bare has the most significant influence, raising temperatures up to 3° F. Croplands have the second most significant impact, followed by pastures.

This pair of images shows large clearings made in the Amazon Rainforest in the state of Mato Grosso, Brazil, between 2001 and 2006. A river meanders along the bottom right corner of the images, surrounded by forest, which appears medium-gray. In 2001, a few large clearings (light-gray rectangles) appeared. By 2006, the area cleared in the scene appears to have roughly tripled. Satellite observations such as these, which are from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) on NASA's Terra satellite, combined with on-the-ground surveys, help scientists monitor forest changes over time.

Credit: NASA images by Robert Simmon, based on data provided by the NASA/GSFC/METI/ERSDAC/JAROS, and U.S./Japan ASTER Science Team

AIRS Science Team Meeting Summary

Hartmut H. Aumann, AIRS Project Scientist, hha@airs1.jpl.nasa.gov

Program Overview

The Atmospheric Infrared Sounder (AIRS) Science Team Meeting was held in Pasadena, CA on March 27-30, 2007, at the California Institute of Technology's Beckman Auditorium. The number of attendees and presentations topped the March 2006 record breaking totals with over 103 participants and 71 presentations. The science presentations were grouped in topical sessions on Climate, Hydrology and Clouds, Data Assimilation for Weather Forecasting, Trace Gas Retrievals, and Validation.

Climate

Satellite measurements of the spectrally resolved upwelling infrared radiances have a unique role in the observation of climate and climate change: they give direct insight into the way the Earth Climate System responds to periodic and long-term changes in forcing, with changes in surface and atmospheric temperatures, and with changes in large-scale atmospheric circulation patterns. The exceptional radiometric accuracy and stability of the AIRS data, now available since 2002, are starting to provide new insights into climate models: there are large differences between models and observations in the diurnal patterns, amplitudes, and seasonal phases for the two major components of climate feedback: upper tropospheric water vapor and clouds.

Andy Dessler [Texas A&M University], found that outgoing longwave radiative flux (OLR) computed directly from AIRS Level-2 (L2) temperature profiles agrees with collocated measurements of OLR from Clouds and the Earth's Radiant Energy System (CERES) within 4.7 W/m^2.

Tim Barnett [Scripps Institute of Oceaography] compared tropospheric water vapor in coupled climate models with observations from AIRS and found that the models systematically differ from AIRS by as much as 50-100% at 500 hPa, and the discrepancies increase with height.

Joao Teixeira [North Atlantic Treaty Organization (NATO)/NARC] pointed out that liquid water and water vapor amounts simulated by different global climate models (GCMs) are highly variable for identical spatial and temporal domains. Comparisons with AIRS shows the models are drier above stratocumulus. It is possible this could be related to sampling of AIRS data, but it is likely an issue with the models.

Yi Huang [Princeton University] reached similar conclusions to those of Teixeira above in his examination of the Geophysical Fluid Dynamics Laboratory (GFDL) GCM model using the AIRS spectrally resolved radiances. January/April/July/October 2003 from ocean data. The persistent cold bias between the AIRS observations and the model in the water vapor band indicates a wet/cold upper tropospheric bias in the model. The twice daily AIRS observations provide a reference to check the model simulated diurnal variation. In equatorial oceans the model simulated total-sky radiances have a strong diurnal contrast at the two AIRS observation times (1:30 P.M. and 1:30 A.M.), which does NOT exist in the observation. This points to errors in the model simulated diurnal cycle of convection and cloudiness.

Mike Iacono [Atmospheric and Environmental Research, Inc. (AER)] arrived at similar conclusions to those of the previous two speakers using the comparison of the National Center for Atmospheric Research's (NCAR) Community Atmosphere Model (CAM3) water with AIRS cloud-cleared radiances: while the model and AIRS generally agree on the temperature structure, the associated radiances suggest the climate model is too moist by 50-100% in the middle troposphere.

Thomas Hearty [NASA/Jet Propulsion Laboratory (JPL)] compared seasonal variability of water vapor from AIRS with 17 different climate models and found significant differences in the amount of water (H_2O) at a given level. Discrepancies between climate models are also found in other data sets.

Dave Gregorich [JPL] compared four years of the seasonal variation of the solar reflected flux (SWR) and OLR—both from CERES—and the surface temperature for the tropical oceans (AVN SST)—from the GISS and the Coupled Model, *version 2* (CM2) models from GFDL. Sea surface temperatures from both models compared favorably with the AVN, but significant differences between the CERES observations and model SWR and OLR in both amplitude and phase are consistent with the discrepancies between models and AIRS data in the cloud and water vapor distributions, which were pointed out in the preceding presentations. The intensity of convection and large-scale meridional transport in the stratosphere is expected to intensify with increasing levels of greenhouse gases.

Dan Feldman [California Institute of Technology (CalTech)] compared the seasonal heating/cooling rates derived from AIRS observations and European Center for Medium Range Weather Forecasting (ECMWF) *ERA-40* reanalysis data with those derived from several climate standard models running under present-day scenarios including GISS Model E and GFDL CM2.1.

AIRS and *ERA-40* demonstrate comparable seasonal cycles in 50 mb temperatures and cooling rates, while temperatures and cooling rates for the two climate models are higher and exhibit a phase that is lagging compared to measurement and reanalysis. This suggests that the models produce a stronger radiative control on the Brewer-Dobson circulation than is borne out by the measurements.

Hartmut H. Aumann [JPL—*AIRS Project Scientist*] used the correlation between the frequency of deep convective clouds deduced from AIRS data and the sea surface temperature to predict that global warming in the tropical oceans at the rate of 0.1 K per decade is expected to increase severe storms by about 3-5% per decade. No significant change in convective activity is measurable with 4 years of AIRS data, but a trend of 1.5% per decade or larger should be measurable with 12 years of AIRS data.

Hydrology and Clouds

Clouds and water vapor are the key components in climate feedback and the source of the largest uncertainty in climate models [Intergovernmental Panel on Climate Change (IPCC) 2002]. The infrared is uniquely sensitive to clouds and the confidence in the accuracy of AIRS water vapor profiles and cloud products is increasing.

Eric Fetzer [JPL] *Characterized the Hydrologic Cycle with AIRS and other A-Train Data Sets* by preserving the instantaneous relationships between observations along the orbit track on a common, nested grid and found that AIRS humidity fields are either wetter or drier than Advanced Microwave Scanning Radiometer–EOS (AMSR-E) on Aqua and Microwave Limb Sounder (MLS) on Aura because of cloud-induced sampling effects.

Evan Fishbein [JPL] reported on *Validation of Water Vapor Retrieved from Aqua AMSU/HSB* and showed the effect of the loss of the Humidity Sounder for Brazil (HSB) in May 2004 by comparing Advanced Microwave Sounding Unit (AMSU)/HSB microwave-only water vapor retrievals, AIRS/AMSU retrieval, radiosondes, and ECMWF. AMSU/HSB's ability to characterize the water vapor in the vicinity of cloud-covered frontal systems complements the higher vertical resolution achievable with AIRS/AMSU.

Tom Yunck [JPL] compared AIRS, ECMWF and Global Positioning System (GPS) profiles of temperature in the upper troposphere and stratosphere and found good agreement between AIRS and ECMWF.

Brian Kahn [JPL] compared AIRS cloud fields from CloudSat and Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) and showed good general agreement, consistent with the sensitivity of the different wavelengths used by the three instruments. The AIRS upper layer is most sensitive to CloudSat cloud classes altocumulus, altostratus, cumulonimbus, cirrus, and nimbostratus. The AIRS lower layer is most sensitive to cumulus and stratocumulus. The direct retrieval of clouds in terms of water droplet and ice particle mixing ratio profiles allows the direct comparison of AIRS cloudy data and models. This requires the availability of efficient Radiative Transfer Algorithms (RTA) in cloudy scattering atmospheres.

Larrabee Strow [University of Maryland, Baltimore County (UMBC)] used a new RTA to compare 12 months of AIRS cloudy data with ECMWF in terms of histograms of computed and observed brightness temperatures at 1231/cm and found that the ECMWF model parameterization consistently produces too many low clouds and too few high clouds.

Alan Lipton [AER] applied Optimal Spectral Sampling (OSS), a technique that is much faster than prior approaches, to the retrievals of cloud properties.

Yuk Yung [CalTech] used principal component (PC) analysis for the Central Pacific (120° W–180° W; 6 S°–6 N°) for Janary 1-9, 2005, and found striking differences between GISS and AIRS for the structure and height of clouds and humidity in the boundary layer.

Breno Imbiriba [UMBC] spoke on *Synergy of Studying Dust Storms Using AIRS Radiances, and CALIPSO/MODIS Retrievals* and showed that AIRS provides useful and unique information on coarse mode atmospheric dust, which does not suffer limitations due to sun glint or nighttime limitations.

Brian Kahn [JPL] showed that there is a high degree of uncertainty on how cirrus clouds form and are maintained, and that AIRS is providing new information on cirrus properties, including effective particle size (D_e) and optical depth (τ).

Hui Su [JPL] confirmed the *Iris* hypothesis in her talk on *Tropical Cirrus Variation with SST and the Cirrus Radiative Effect* and showed a negative correlation between precipitation-normalized cloud fraction and SST, implying a negative feedback between SST and cirrus cloud cover. Measurements of temperature and moisture in the *boundary layer*—the lowest 1 km in the atmosphere—are a key capability of hyperspectral sounders.

Joe Santanello [NASA Goddard Space Flight Center (GSFC)] spoke on *Estimation of Convective Planetary Boundary Layer Evolution and Land Atmosphere Interactions from MODIS and AIRS* and pointed out the potential for near-surface retrievals.

Data Assimilation for Weather Forecasting

The use of AIRS data in numerical weather prediction around the world continues to grow. Representatives from five operational forecasting agencies made presentations - two European, one Canadian, and two from the U.S. Several research-oriented efforts were also presented.

Tony McNally [ECMWF] discussed efforts to assimilate AIRS cloud-cleared radiances (rather than just filtered cloudy ones) as well as CO_2 products. (ECMWF has assimilated AIRS clear radiances for more than two years with excellent positive impact in the northern and southern hemisphere.)

James Cameron [United Kingdom Meteorological Office] discussed another effort to assimilate AIRS radiances over land as well as cloudy radiances (rather than just clear ones), but the approach differs significantly from ECMWF.

Gary Jedlovec [NASA Marshall Space Flight Center's Short-Term Prediction Research and Transition Center (MSFC/SPORT)] gave an overview of their regional forecasts, which are distributed to regional NWS centers.

Brad Zavodsky [MSFC/SPORT] provided further details on the use of AIRS data. The SPORT approach differs from most NWPs in that they use derived geophysical AIRS products (namely temperature and moisture profiles) obtained in near real time from the direct-broadcast station at the University of Wisconsin, rather than radiances.

Nancy Baker [Naval Research Laboratory (NRL)/ Monterey] gave an overview of the operational numerical weather prediction (NWP) system there, which provides forecasts to Fleet Numerical Meteorology and Oceanography Center (FNMOC) and the Navy.

B. Ruston [NRL/Monterey] provided further details on how AIRS data are used at NRL. NRL will start assimilating AIRS radiances operationally by Fall 2007 and will transition to a 3DVAR and later to a 4DVAR system.

Elana Fertig [University of Maryland, College Park (UMCP)] reported on progress in the development of ensemble Kalman filtering methods (3/4D-LETKF) by the group led by **Eugenia Kalnay** (UMCP). Kalnay's group has experimented with AIRS retrievals and cloud-cleared radiances and report good results with both—but best with profiles.

Jason Dunion [National Oceanic and Atmospheric Association (NOAA)/Hurricane Research Division] reported on a 2005 field campaign and subsequent analysis to investigate the Saharan air layer's (SAL) effect on the evolution of tropical cyclones. He used AIRS profiles in the analysis, and comparisons with drop sondes show that AIRS captures the SAL temperature anomalies well and that AIRS water vapor profiles are slightly biased in and below SAL layers.

Joan Alexander [NWRA] reported on gravity waves in the AIRS data. It is expected that the observations will enable parameterization of these phenomena in models.

Joshua Fu [International Pacific Research Center] reported on observations of intra-seasonal waves in AIRS data.

Trace Gas Products and Science

This session focused on AIRS retrieval of trace gases and their scientific applications.

Murty Divakarla [NOAA/National Environmental Satellite Data and Information Service] showed good agreement between ozone retrievals with ozone sondes, though with a latitude-dependent bias in *Version 4*. Those biases were reduced except at far southern latitudes.

Fredrick (Bill) Irion [JPL] and **Chris Barnet** [NOAA] discussed improvement in the ozone retrievals, which now uses a climatological first guess (rather than using regression), an expanded channel selection and a relaxed damping parameter. Barnet presented data that showed improved agreement between the high altitude ozone-carbon monoxide (CO) anti-correlation and *in situ* results.

David Whiteman [GSFC] described the characteristics of ozone sondes launched from the Howard University-run facility at the Beltsville Agricultural Research Center, adjacent to NASA Goddard. A number of other quantities are measured at this site, including aerosol, temperature, and water vapor. The Beltsville site is located in a polluted urban environment and is thus a good representative sample of the air quality in many areas of societal interest around the world.

Baijun Tian [JPL] used AIRS ozone columns in the tropics and subtropics to better map variations in the upper troposphere from the Madden-Julian Oscillation.

Xun Jiang [JPL] presented upper tropospheric CO_2 results using the Vanishing Partial Derivatives (VPD) method; these results agreed with model and aircraft *in situ* results from the mid-latitudes to the tropics.

Larrabee Strow [UMBC] retrieved CO_2 from AIRS spectra using ECMWF data for the temperature profiles. Growth rates agreed well with *in situ* results from Mauna Loa and the seasonal zonal variability agrees with models.

Chris Barnet [NOAA] reported on a new methane product from AIRS, with averaging kernels showing best sensitivity in the mid-troposphere. Seasonal variability was observed in the data as well as indication of wetland emissions.

Wallace McMillan [UMBC] showed CO results for the first four years of AIRS operation. Retrievals over Antarctica have improved significantly.

Juying Warner [UMBC] showed good agreement in carbon monoxide retrieved from AIRS, the Tropospheric Emission Spectrometer (TES) on Aura and Measurements of Pollution in the Troposphere (MOPITT) on Terra, particularly when the MOPITT *a priori* was used for all three instruments, and particularly at high CO levels.

Stuart MacCallum [University of Edinburgh] presented CO results from AIRS using an optimal estimation retrieval algorithm.

Vince Realmuto [JPL] compared volcanic plume observations from AIRS, MODIS and the Advanced Spaceborne Thermal Emission and Reflectance Radiometer (ASTER) on Terra, and showed how the high-resolution AIRS spectra can be used to distinguish between ash and sulfur dioxide.

Validation

A continuing strong effort to validate the AIRS radiances and geophysical retrievals with ground-truth are key in establishing the climate quality of the AIRS data.

David Tobin [University of Wisconsin, Madison (UW)] described plans to validate AIRS radiances using data from the aircraft-borne Scanning High-resolution Infrared Spectrometer. He also gave a comprehensive overview of AIRS temperature and humidity validation using sondes launched at the three Atmospheric Radiation Measurement Program sites. AIRS performance is comparable at the North Slope Alaska and Southern Great Plains sites, though neither is as good as at the Tropical Western Pacific site.

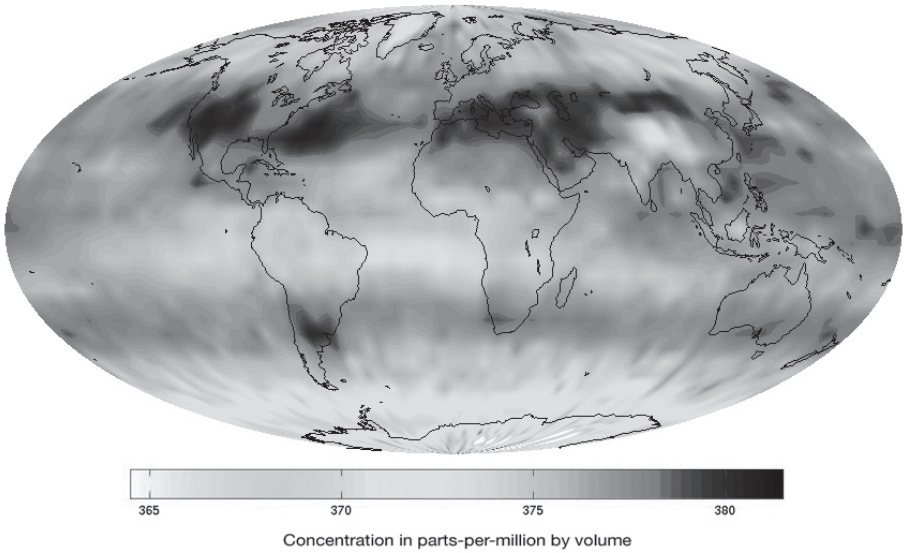
Shenfu Dong [University of Miami] compared AIRS near-surface parameters with NCEP reanalysis and *in situ* buoy observations in the tropics and the southern ocean. The AIRS measurements showed skill in temperature retrievals, but the near-surface relative humidity values were less representative of *in situ* observations.

Accurate measurements of surface emissivity are key to improving the accuracy of AIRS in the boundary layer (the lowest 2 km of the atmosphere).

Robert Knuteson [UW] showed that AIRS surface retrievals have become more accurate. AIRS and MODIS land surface temperature root-mean-squared differences are about 3 K globally. Comparisons of AIRS derived spectral emissivity with *in situ* data showed improvements at most wavelengths.

Jun Li [UW] presented a single field-of-view retrieval algorithm that has a regression-based first guess and a physical iterative solution. Surface emissivity is simultaneously retrieved along with temperature, water, ozone, and cloud-top pressure. Li's results compared well with MODIS and ECMWF above the clouds. ■

AIRS Mid-Tropospheric CO_2, Version 5, July 2003



Although originally designed to measure atmospheric water vapor and temperature for weather forecasting, scientists working with the Atmospheric Infrared Sounder (AIRS) instrument on the NASA Aqua spacecraft are now using AIRS to observe atmospheric carbon dioxide (CO_2). This global map of CO_2, produced by AIRS Team Leader, **Moustafa Chahine** at JPL, shows that despite the high degree of mixing that occurs with CO_2, the regional distribution can still be seen by the time the gases reach the mid-troposphere—about 4.97 mi (8 km) above the surface. Climate modelers are currently using the AIRS data to understand the global distribution and transport of CO_2 and improve their models.

A-Train Data Depot (ATDD): Giovanni Tool Enhanced to Explore and Visualize Four A-Train Instrument Coincident Datasets Simultaneously

The NASA GSFC Earth Sciences (GES) Data and Information Services Center (DISC) is pleased to announce *Version 2* of the A-Train Data Depot, now expanded to further process, archive, allow access to, visualize, analyze and correlate distributed atmospheric measurements from A-Train instruments. The ATDD portal provides easy on-line data access and services for science, applications, and educational use so that users get exactly the data they want, and not large files of data that would take much time and effort by individuals to co-register and refine.

Version 2 brings the following enhancements:

- Visualization of user selected data from the CloudSat, Cloud-Aerosol Lidar and Infrared Path finder Satellite Observation (CALIPSO), and Aqua—Moderate Resolution Imaging Spectroradi ometer (MODIS), and Atmospheric Infrared Sounder (AIRS) subsetted and co-registered.
- Co-registered vertical *curtain* plots for temperature, water vapor, cloud and aerosol products generated by the above instruments.
- Horizontal reference strips that show features +/-100 km from the CloudSat/CALIPSO vertical curtain (i.e., strip center line).
- Ability to download visualized co-registered data of interest, original input data, and plots.
- CloudSat/CALIPSO orbit segment selection map Geographical User Interface (GUI) that shows Earth's cloud coverage for selected day, using three separate map projections.
- Data temporal range is from June, 2006 to present, coincident with the CloudSat/CALIPSO missions.
- Ability to refine initial data plots by changing window size and data range, and zooming in on the horizontal and vertical axis.
- Access to archives containing A-Train data of interest.
- Access to A-Train missions and instruments documentation.

In addition, the popular, easy to use, *Giovanni* data visualization and exploration tool has been expanded to create the co-registered vertical profiles and horizontal strips without losing any of its simple usability appeal.

Please visit the ATDD at: *daac.gsfc.nasa.gov/atdd/*

The ATDD instance of *Giovanni* can be accessed directly at: *disc1.sci.gsfc.nasa.gov/daac-bin/G3/gui.cgi?instance_id=atrain_C*

NASA's Close-Up Look at a Hurricane's Eye Reveals a New 'Fuel' Source

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

In the eye of a furious hurricane, the weather is often quite calm and sunny. But new NASA research is providing clues about how the seemingly subtle movement of air within and around this region provides energy to keep this central "powerhouse" functioning.

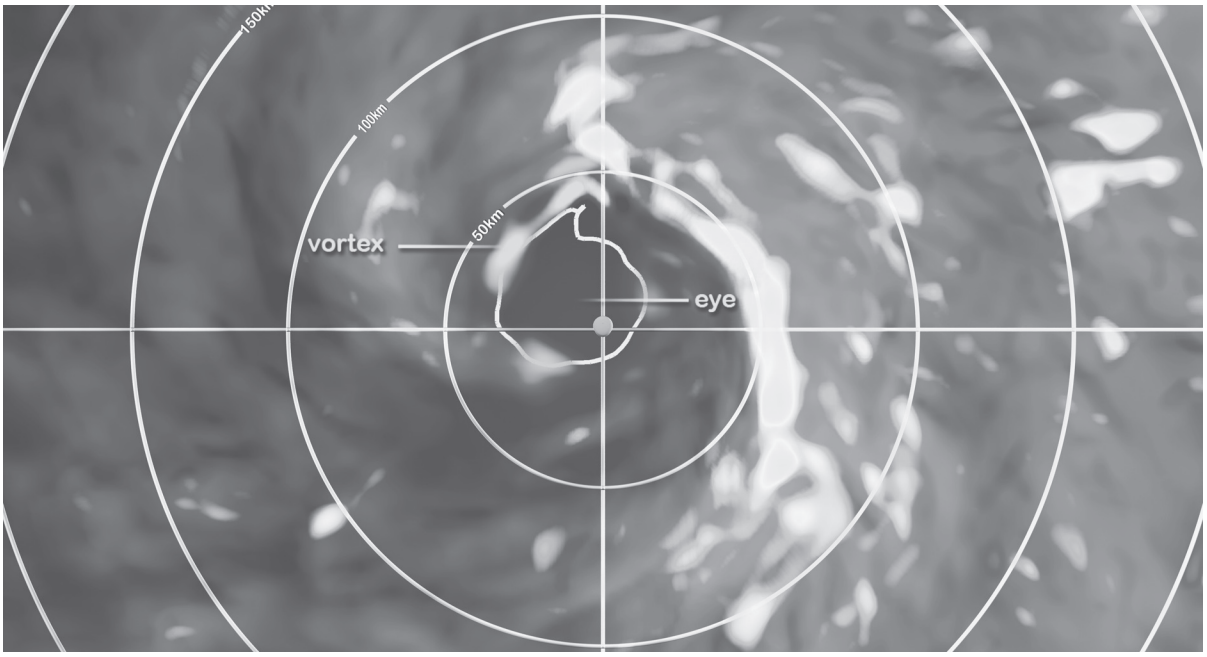
Using computer simulations and observations of 1998's Hurricane Bonnie, scientists were able to get a detailed view of pockets of swirling, warm humid air moving from the eye of the storm to the ring of strong thunderstorms in the eyewall that contributed to the intensification of the hurricane.

The findings suggest that the flow of air parcels between the eye and eye wall—largely believed trivial in the past—is a key element in hurricane intensity and that there's more to consider than just the classic "in-up-and-out" flow pattern. The classic pattern says as air parcels flow "in" to the hurricane's circulation, they rise "up," form precipitating clouds and transport warm air to the upper atmosphere before moving "out" into surrounding environmental air.

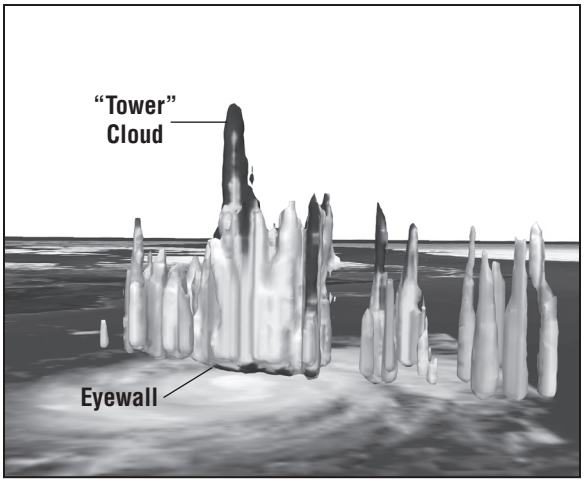
"Our results improve understanding of the mechanisms that play significant roles in hurricane intensity," said **Scott Braun**, research meteorologist at NASA's Goddard Space Flight Center. "The spinning flow of air parcels—or *vortices*—in the eye can carry very warm, moist eye air into the eyewall that acts as a turbocharger for the hurricane heat engine." The research appears in the June 2007 issue of the American Meteorological Society's *Journal of the Atmospheric Sciences*.

"While the 'in-up-and out' pattern has been the prevailing paradigm for the past five decades, when you closely examine intense hurricanes it's apparent that a second family of moist air parcels often travels from the border of the eyewall to the eye, where it picks up moisture from the ocean surface," said co-author **Michael Montgomery,** professor of meteorology at the U.S. Naval Postgraduate School, Monterey, CA. "These moisture-enriched air parcels then rather quickly return to the main eyewall and collectively raise the heat content of the lower eyewall cloud, similar to increasing the octane level in auto fuel."

The researchers analyzed thousands of virtual particles to track the movement of air between the eye and eyewall, and between the eyewall and its outside environment. To uncover the impact of these particles on storm intensity, they used a simulation of Hurricane Bonnie from a sophisticated computer model and data gathered during the NASA Convection and Moisture Experiment (CAMEX).



In the eye of a furious hurricane, the weather is often quite calm and sunny. But new NASA research is providing clues about how the seemingly subtle movement of air within and around this region provides energy to keep this central "powerhouse" functioning. For the first time, research meteorologists have run complex simulations of an intensifying hurricane using a very fine temporal resolution of three minutes. See: *www.nasa.gov/vision/earth/lookingatearth/eye_fuelsource.html* to view a movie that combines this simulation data with observational data from space and descriptive color illustrations to show how a hurricane intensifies. **Credit:** NASA GSFC Scientific Visualization Studio



Hurricane Bonnie's storm clouds towered 11 miles high. The height in this image is exaggerated for clarity and shades correspond to surface precipitation from light gray (light) to dark gray (heavy). For hi-res color image see: *www.nasa.gov/images/content/176426main_big_bonnie1.tif* . **Credit:** NASA GSFC Scientific Visualization Studio

The simulation has also helped to explain the formation of deep *hot towers* observed in Bonnie and many other hurricanes by NASA's Tropical Rainfall Measuring Mission (TRMM) satellite. TRMM carries the first and only space-based precipitation radar that allows researchers to peer through clouds and get a 3-D view of storm structure. It captured a particularly deep hot tower in Bonnie as the storm intensified several days before striking North Carolina.

Hot towers are deep, thick clouds that reach to the top of the troposphere, the lowest layer of the atmosphere, usually about ten miles high in the tropics. The updrafts within these "towers" act like express elevators, accelerating the movement of energy that boosts hurricane strength, and are called "hot" because of the large amount of latent heat they release as water vapor is condensed into cloud droplets. Deep hot towers in the eyewall are usually associated with a strengthening storm.

In previous research, **Braun**, **Montgomery**, and **Zhaoxia Pu** of the University of Utah, Salt Lake City, found a direct relationship between these deep hot towers and the intense vortices inside the eye. "The vortices were shown to be especially crucial in providing the focus and lift needed for *hot tower* formation and add insight into when and where hot towers will develop in storms," said Braun. The study was published in the January 2006 CAMEX special issue of the J*ournal of the Atmospheric Sciences.*

Vortices are created in response to the rapid change in wind speed from the fierce eyewall to the calm eye. Near the surface, air spiraling inward collides with these vortices to force air up, forming updrafts. Strong updrafts in the eyewall carry moisture much higher than normal and help create *hot towers.*

The current study suggests that in addition to providing lift, these vortices also feed high energy air from the low-level eye into the eyewall, boosting the strength of the updrafts. This transfer of energy allows the storm to remain stronger than expected, particularly when encountering weakening influences, including cooler ocean water temperatures and *wind shear*—the change in the direction and speed of winds with altitude.

"This discovery may help explain why strong storms can remain intense for several hours or longer after encountering conditions that usually bring weakening," said Montgomery. "Ongoing research will add to our understanding of the dynamics associated with storm intensity so that we can pinpoint the variables and processes that must be represented in numerical models to improve intensity forecasts."

When hurricane Bonnie finally began to lose strength a couple days before landfall, a significant amount of air in the eyewall was traced back—not to the eye—but to the middle levels of the atmosphere away from the storm. This inflow was caused by *wind shear* and brought much cooler, drier environmental air into Bonnie's circulation, acting like an anti-fuel to reduce energy in the storm and weaken its strong winds.

Despite these and other recent advances in understanding the internal workings of hurricanes, forecasting their intensity is still a significant challenge.

"Most of today's computer models that aid forecasters cannot sufficiently account for the extremely complex processes within hurricanes, and model performance is strongly dependent on the information they are given on the structure of a storm," said Braun. "We also typically only see small parts of a storm at a given time. That is why it is important to combine data from field experiments such as CAMEX with data from TRMM and other satellites. As observing technologies and models improve, so too will forecasts." ■

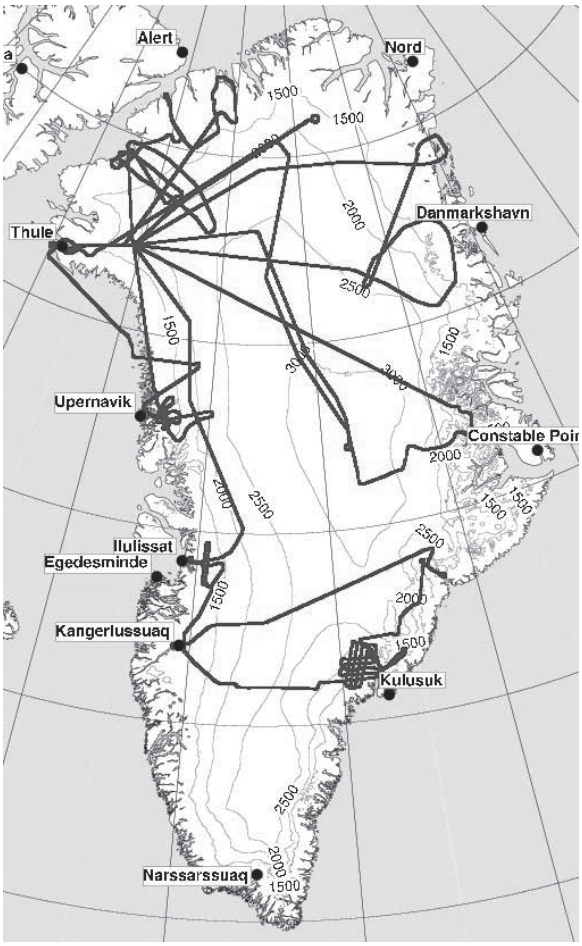
NASA Mission Checks Health of Greenland's Ice Sheet and Glaciers

Gretchen Cook-Anderson, NASA Goddard Space Flight Center, Gretchen.R.Cook-Anderson@nasa.gov

A NASA-led research team has returned from Greenland after an annual three-week mission to check the health of its glaciers and ice sheet. About 82% of Greenland is made up of a giant ice sheet. During the Arctic Ice Mapping Project, researchers measured critical areas of the island's ice sheet as well as its glaciers and monitored changes that may be connected to global climate change.

The science team, using laser and radar instruments aboard aircraft, has been closely monitoring the changes in the ice cover since 1991. Past measurements from the team have shown that areas of ice along the Greenland coast have been thinning while inland areas have thickened. However, when these changes are taken as a whole, Greenland has experienced a significant loss of ice.

The data from past mapping missions and from Earth-orbiting satellites such as NASA's Ice, Clouds, and Land Elevation Satellite (ICESat) spacecraft has shown that the ice sheet and glaciers have been melting at an increasing rate over the past several years.



Researchers will analyze results from this flight path accomplished during the recent Arctic Ice Mapping Project mission to Greenland. **Credit:** NASA

"Knowledge of how ice sheets and glaciers like those on Greenland are changing provide an indirect measure of sea-level changes and indicate trends in world climate," said **Bill Krabill**, lead investigator of the Greenland mission from the NASA Wallops Flight Facility, Wallops Island, VA. "Some of the island's major glaciers have sped up since the turn of the century, with documented thinning from 65 to nearly 100 ft/year. With this mission we measured what's happening to Greenland's ice with a low-flying state-of-the-art laser from just a third of a mile above the surface."

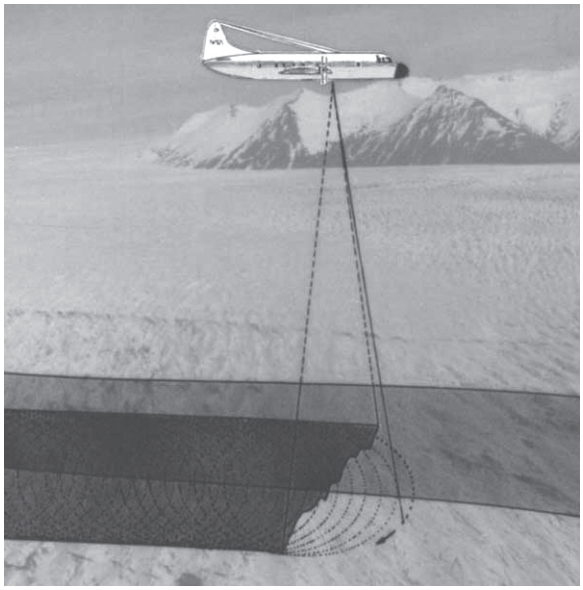
It has been estimated that a 9-in change in the average height of the central Greenland ice sheet would result in a .12-in change in the sea level of the world's oceans.

"This mission builds on our existing data from past flights and aids in correlating data from the ice-observing satellites," said Krabill. "The 16 years of very precise data we've gathered over the same flight paths gives us a very good look at the health of Greenland's ice cover."

The 19-person research team, which headed for Greenland on May 1, used a Wallops-built scanning laser system aboard a GPS-guided NASA P-3B aircraft to take detailed measurements of ice elevations, with accuracy within a few inches. Also onboard, an ice-penetrating radar system from the University of Kansas, Lawrence, provided elevation measurements of the bedrock as far as two miles below the ice sheet's surface. From the measurements of these two instruments, researchers determine the thickness of the ice.

"Each year, we refer to the views of glaciologists, NASA radar data, and information from other federal agencies to locate areas where thinning may be occurring, and fly out to those critical areas that may be changing more rapidly," said Krabill. In the end, weather conditions always dictate our data gathering success. We were terrain-hopping at just a third of a mile above the surface with a laser pulsing 5,000 times per second that cannot shoot through the clouds. So low-lying clouds could have prevented us from capturing any data."

This year, the aircraft also carried two new, high-altitude ice-measuring radars tested by their developers, Ohio State University, Columbus, and the Johns Hopkins University Applied Physics Laboratory, Laurel,



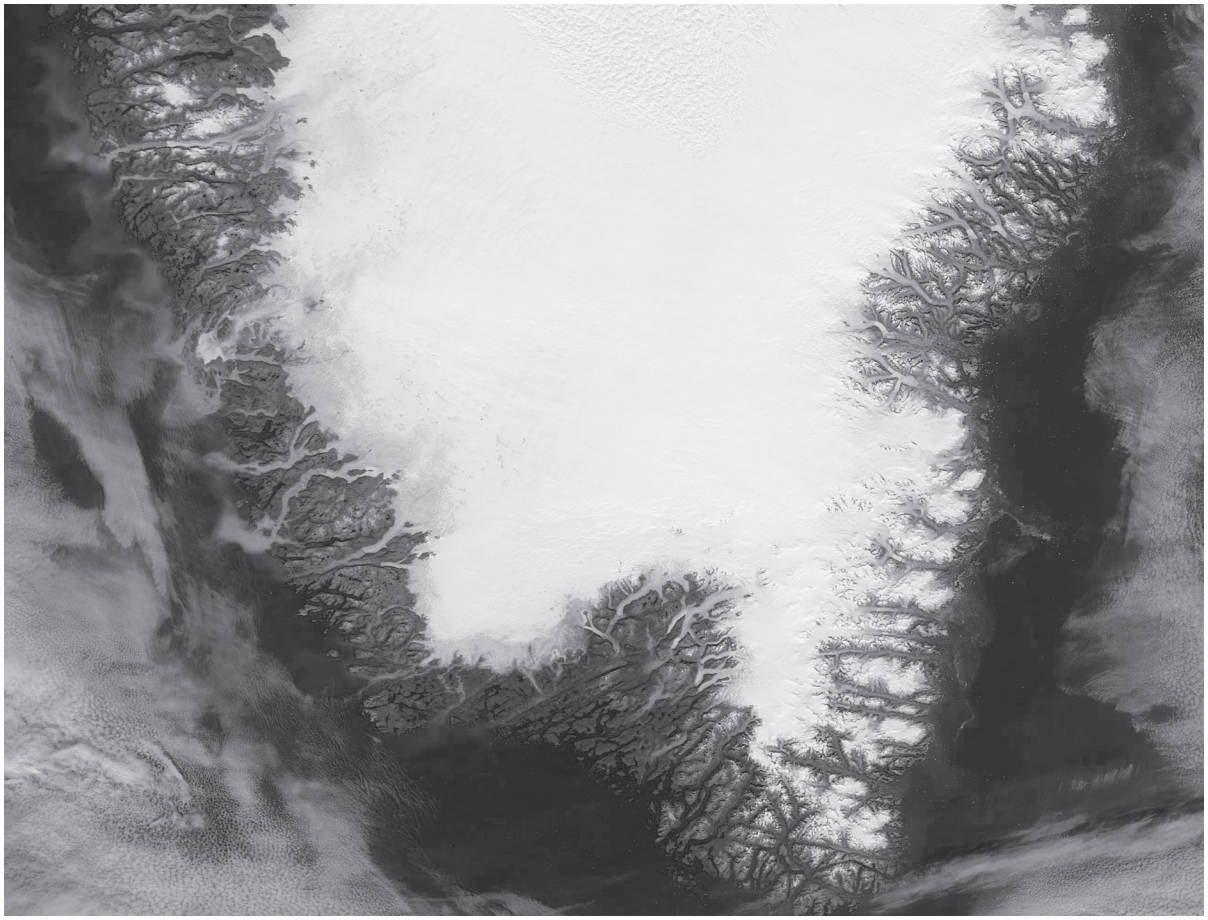
During the Arctic Ice Mapping Project flights over Greenland, a laser sensor scans and collects a series of overlapping elevation measurements that are combined into a "ribbon" or swath of data about 1,300 feet wide. Using Global Positioning System (GPS) technology, researchers obtain data that precisely overlaps data taken in the same location in previous years. **Credit:** NASA

MD. If effective, the new sensors could serve as precursors to instruments that could be used aboard a future satellite mission.

Multiple aircraft lifted off from the former U.S. air base Kangerlussauq and Thule Air Base, and primarily covered flight paths flown nearly every year since 1991.

"The aircraft performed in outstanding fashion this year, with no down time in the field, and the crew was outstanding on what were relatively long eight-hour missions," Krabill said. "All of our objectives for the sensors onboard were accomplished. In about two months, we'll finalize results that will offer researchers around the world a glimpse of what we expect will indicate a continuing trend of ice loss on the island." ■

This MODIS Terra image, acquired August 23, 2006, shows the southern portion of Greenland. About 81% of its surface is covered by ice—this is known as the Greenlandic ice cap. The weight of it has depressed the central land area to form a basin lying more than 984 ft (300 m) below sea level. Because of the ice coverage, nearly all Greenlanders live along the fjords in the south-west of the main island, which has a milder climate. As the season's white winter snow melts, the darker bare ice of Greenland's permanent ice cap is being exposed. **Credit:** MODIS Rapid Response Team



Research Finds That Earth's Climate is Approaching 'Dangerous' Point

Leslie McCarthy, Goddard Institute for Space Studies, Leslie.M.McCarthy@nasa.gov

NASA and Columbia University Earth Institute research finds that human-made greenhouse gases have brought the Earth's climate close to critical *tipping points*, with potentially dangerous consequences for the planet.

From a combination of climate models, satellite data, and paleoclimate records the scientists conclude that the West Antarctic ice sheet, Arctic ice cover, and regions providing fresh water sources and species habitat are under threat from continued global warming. The research appears in the current issue of *Atmospheric Chemistry and Physics.*

Tipping points can occur during climate change when the climate reaches a state such that strong amplifying feedbacks are activated by only moderate additional warming. This study finds that global warming of 0.6°C in the past 30 years has been driven mainly by increasing greenhouse gases, and only moderate additional climate forcing is likely to set in motion disintegration of the West Antarctic ice sheet and Arctic sea ice. Amplifying feedbacks include increased absorption of sunlight as melting exposes darker surfaces and speedup of iceberg discharge as the warming ocean melts ice shelves that otherwise inhibit ice flow.

The researchers used data on earlier warm periods in Earth's history to estimate climate impacts as a function of global temperature, climate models to simulate global warming, and satellite data to verify ongoing changes. Lead author **James Hansen**, NASA Goddard Institute for Space Studies, concludes: "If global emissions of carbon dioxide continue to rise at the rate of the past decade, this research shows that there will be disastrous effects, including increasingly rapid sea level rise, increased frequency of droughts and floods, and increased stress on wildlife and plants due to rapidly shifting climate zones."

The researchers also investigate what would be needed to avert large climate change, thus helping define practical implications of the United Nations Framework Convention on Climate Change. That treaty, signed in 1992 by the United States and almost all nations of the world, has the goal to stabilize atmospheric greenhouse gases "at a level that prevents dangerous human-made interference with the climate system."

Based on climate model studies and the history of the Earth the authors conclude that additional global warming of about 1°C (1.8°F) or more, above global temperature in 2000, is likely to be dangerous. In turn, the temperature limit has implications for atmospheric carbon dioxide (CO_2), which has already increased from the pre-industrial level of 280 parts per million (ppm) to 383 ppm today and is rising by about 2 ppm per year. According to study co-author **Makiko Sato** of Columbia's Earth Institute, "the temperature limit implies that CO_2 exceeding 450 ppm is almost surely dangerous, and the ceiling may be even lower."

The study also shows that the reduction of non-carbon dioxide forcings such as methane and black soot can offset some CO_2 increase, but only to a limited extent. Hansen notes that "we probably need a full court press on both CO_2 emission rates and non-CO_2 forcings, to avoid *tipping points* and save Arctic sea ice and the West Antarctic ice sheet."

A computer model developed by the Goddard Institute was used to simulate climate from 1880 through today. The model included a more comprehensive set of natural and human-made climate forcings than previous studies, including changes in solar radiation, volcanic particles, human-made greenhouse gases, fine particles such as soot, the effect of the particles on clouds and land use. Extensive evaluation of the model's ability to simulate climate change is contained in a companion paper to be published in *Climate Dynamics*.

The authors use the model for climate simulations of the 21st Century using both *business-as-usual* growth of greenhouse gas emissions and an *alternative scenario* in which emissions decrease slowly in the next few decades and then rapidly to achieve stabilization of atmospheric CO_2 amount by the end of the century. Climate changes are so large with *business-as-usual*, with additional global warming of 2-3°C (3.6-5.4°F) that Hansen concludes *business-as-usual* would be a guarantee of global and regional disasters."

However, the study finds much less severe climate change—one-quarter to one-third that of the *business-as-usual* scenario—when greenhouse gas emissions follow the alternative scenario. "Climate effects may still be substantial in the *alternative scenario*, but there is a better chance to adapt to the changes and find other ways to further reduce the climate change," said Sato.

While the researchers say it is still possible to achieve the *alternative scenario*, they note that significant actions will be required to do so. Emissions must begin to slow soon. "With another decade of *business-as-usual* it becomes impractical to achieve the *alternative scenario* because of the energy infrastructure that would be in place" says Hansen. ■

NASA Satellite Captures First View of 'Night-Shining Clouds'

Cynthia O'Carroll, NASA Goddard Space Flight Center, Cynthia.M.OCarroll@nasa.gov

A NASA satellite has captured the first occurrence this summer of mysterious shiny polar clouds that form 50 miles above Earth's surface.

The first observations of these "night-shining" clouds by a satellite named "AIM" which means Aeronomy of Ice in the Mesosphere, occurred above 70° north latitude on May 25. People on the ground began seeing the clouds on June 6 over Northern Europe. AIM is the first satellite mission dedicated to the study of these unusual clouds.

These mystifying clouds are called Polar Mesospheric Clouds, or PMCs, when they are viewed from space and referred to as "night-shining" clouds or Noctilucent Clouds, when viewed by observers on Earth. The clouds form in an upper layer of the Earth's atmosphere called the mesosphere during the Northern Hemisphere's summer season which began in mid-May and extends through the end of August and are being seen by AIM's instruments more frequently as the season progresses. They are also seen in the high latitudes during the summer months in the Southern Hemisphere.

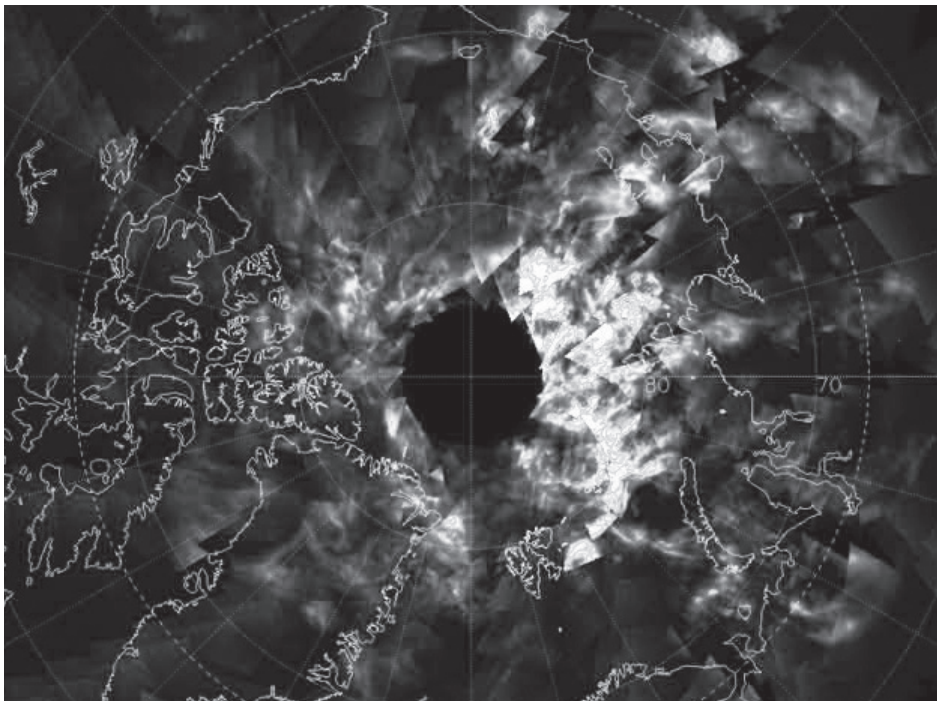
Very little is known about how these clouds form over the Poles, why they are being seen more frequently and at lower latitudes than ever before, or why they have been growing brighter. AIM will observe two complete cloud seasons over both poles, documenting an entire life cycle of the shiny clouds for the first time.

"It is clear that these clouds are changing, a sign that a part of our atmosphere is changing and we do not understand how, why or what it means," stated AIM principal investigator **James Russell III** of Hampton University, Hampton, VA. "These observations suggest a connection with global change in the lower atmosphere and could represent an early warning that our Earth environment is being changed."

AIM is providing scientists with information about how many of these clouds there are around the world and how different they are including the sizes and shapes of the tiny particles that make them up. Scientists believe that the shining clouds form at high latitudes early in the season and then move to lower latitudes as time progresses. The AIM Science Team is studying this new data to understand why these clouds form and vary, and if they may be related to global change.

Once the summer season ends in the Northern Hemisphere around mid- to late August, the Southern Hemisphere spring season starts about three months later in the period around mid- to late November. AIM will then be watching for shining clouds in the Southern Hemisphere from November through mid-March when that season ends.

AIM is managed at Goddard Space Flight Center, Greenbelt, MD and the AIM Project Data Center is located at Hampton University. ■



On June 11, 2007, the cameras on the AIM satellite returned some of the first data documenting noctilucent clouds over the Arctic regions of Europe and North America. This new data reveals the global extent and structure of these mysterious clouds, to a degree that was previously unattainable. In this image light areas represent noctilucent cloud structures. Black indicates areas where no data is available. **Credit:** Cloud Imaging and Particle Size Experiment data processing team at the University of Colorado Laboratory for Atmospheric and Space Physics.

EOS Scientists in the News

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

'Twilight Zone' Discovered Around Clouds, May 5; *United Press International, Fox News.* An extensive and previously unknown "twilight zone" of particles in the atmosphere could complicate scientists' efforts to determine how much the Earth's climate will warm, a new study co-authored by **Lorraine Remer** (NASA GSFC) and **Ilan Koren** (Weizmann Institute) has found.

NASA Warns of Scorching Summer Temps, May 10; *CBS Evening News, Associated Press.* A new study by **Barry Lynn** (NASA GISS), **Leonard Druyan** (NASA GISS), and their colleagues suggests that greenhouse-gas warming may raise average summer temperatures in the eastern United States nearly 10° F by the 2080s.

Analysis Finds Large Antarctic Area Has Melted, May 16; *New York Times.* A new satellite analysis shows that at least once in the last several years masses of unusually warm air pushed to within 310 miles of the South Pole and remained long enough to melt surface snow across a California-size expanse. Such melt zones are not common so far inland, says **Son Nghiem** (NASA JPL), who used QuikSCAT data to detect the melting.

NASA Finds New 'Fuel' Source in Hurricanes, May 16; *United Press International, Earth & Sky Radio.* New findings suggest that the flow of air parcels between the eye and eye wall of a hurricane -- largely believed trivial in the past -- is a key element in hurricane intensity, according to **Scott Braun** (NASA GSFC), co-author of the study.*

Southern California Wildfire Outlook 'Incendiary,' May 22, *CBS Early Show*. The region is bracing for what experts say could be its worst fire season in years. **Bill Patzert** (NASA JPL) says forest conditions are very dry for this early in the fire season.

NASA: Danger Point Closer Than Thought From Warming, May 29-31; *ABC News, MSNBC, Christian Science Monitor*. Dangerous climate change has not yet arrived, but the *tipping point* may not be far off and it may be reached with a smaller temperature rise than recent studies suggest, according to new research by **James Hansen** (NASA GISS) and colleagues. "If global emissions of carbon dioxide continue to rise at the rate of the past decade, this research shows that there will be disastrous effects," Hansen says.*

Study: Climate Change Models Overstate Droughts, June 1; *USA Today.* There will be more flooding and less drought than has been forecast in widely used projections of global warming, according to a new study by **Frank Wentz** (Remote Sensing Systems) using measurements from NASA weather satellites.

Greenland Ice Melt Speeds Up, June 2; *San Francisco Chronicle, United Press International (May 30), MSNBC*. Scientists reading signals from a satellite and flying aboard a low-flying plane over Greenland are finding fresh evidence of melting snows and thinning glaciers. **William Krabill** (NASA Wallops) reports on the speed-up of glaciers flowing into the sea, while new research by **Marco Tedesco** (NASA GSFC) shows that Greenland is experiencing more days of melting snow than average.*

Polar Research on Earth Assists with Mars Study, June 22; *PBS Online NewsHour.* As scientists continues to explore Earth's Poles as part of the International Polar Year, missions and technology like NASA's upcoming Phoenix lander may also spur planetary exploration, say **James Garvin** (NASA GSFC) and **Robert Bindschadler** (NASA GSFC).

China's Massive Dam Changing Weather, June 22; *Discovery Channel News*. Two years before its completion, China's Three Gorges Dam is reported to have changed local weather, says **Liguang Wu** (NASA GSFC). Using a time series of detailed Landsat images, **Jeff Masek** (NASA GSFC) notes that people can monitor the progress of the dam's construction and its influence on the Yangtze River.

Worrisome Drought in the West, June 25; *ABC World News*. Parched conditions in many parts of the western United States have led to an early start to this year's fire season, which may be a "non-stop" one in Southern California, says **Bill Patzert** (NASA JPL).

NASA Plans Earth Science Project, June 27; *United Press International*. NASA's largest field campaign of the year, the Tropical Composition, Cloud and Climate Coupling (TC4) mission, gets underway next month in Costa Rica. **Michael Kurylo** (NASA HQ) describes the campaign as an unprecedented opportunity to use NASA's suite of satellite and

airborne capabilities to investigate a largely unexplored region of the atmosphere.

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

**For more details on this topic see full "In the News" story in this issue.* ■

Upon completion in 2009, the Three Gorges Dam along China's Yangtze River will be the world's largest hydroelectric power generator and one of the few man-made structures so enormous that it's actually visible to the naked eye from space. NASA's Landsat satellites have provided detailed, vivid views of the dam since construction began in 1994. The *left image* is a 1987 bird's eye view of the Three Gorges region as seen with Landsat-5. By mid-2006, *[right image]* construction of the main wall was completed and a reservoir more than 2 mi (3 km) across had filled just upstream of the dam. While Landsat is a premier research tool for observing changes on the Earth's surface, other NASA satellites are also helpful in determining how changing land cover and use may influence climate and the environment. Just as transforming forested lands into cities can change the local climate, scientists have found evidence that Three Gorges Dam and its enormous reservoir might have a similar effect.

In a recent study, researchers used computer models and data from NASA's Tropical Rainfall Measuring Mission satellite to estimate how the dam's construction impacted area rainfall. Information from NASA's Terra and Aqua satellites also revealed the dam's effect on land surface temperatures.

"The satellite data and computer modeling clearly indicate that the land use change associated with the dam's construction has increased precipitation in the region between the Daba and Qinling mountains," said lead author **Liguang Wu** of NASA Goddard Space Flight Center, Greenbelt, MD, and the University of Maryland - Baltimore County. The land changes also reduced rainfall in the region immediately surrounding Three Gorges Dam after the dam's water level abruptly rose in June 2003.

The researchers were surprised to see that the dam affected rainfall over such a large area—a 62-square-mile region—rather than just 6 miles projected in previous studies. They speculate that by the time the construction is fully complete in 2009, the area impacted will be even greater. For full story see: *www.nasa.gov/vision/earth/lookingatearth/dam_construct.html* **Credit:** NASA/USGS

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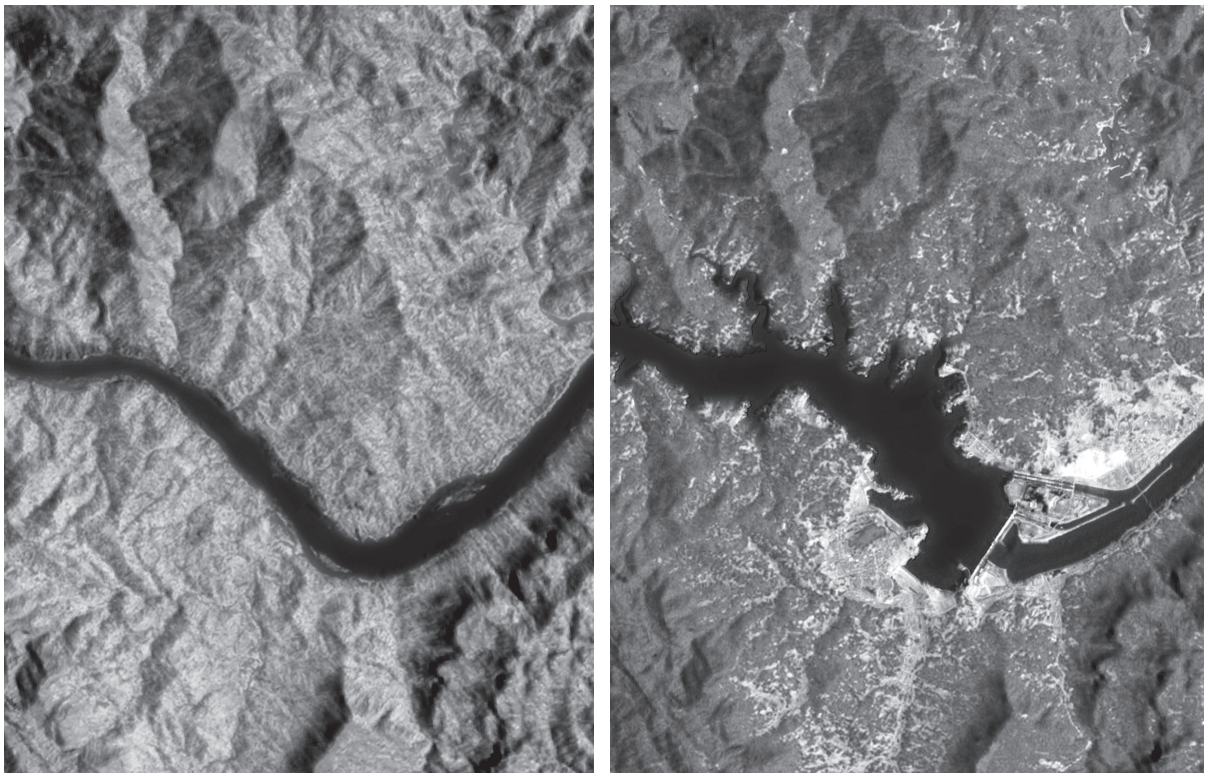


CERES Data Product Release

The Atmospheric Science Data Center (ASDC) at NASA Langley Research Center in collaboration with the CERES Science Team announces the release of the following data sets:

Clouds and Radiative Swath (CRS):
CER_CRS_Aqua-FM3-MODIS_Edition2A
CER_CRS_Aqua-FM4-MODIS_Edition2A

Monthly Gridded Radiative Fluxes and Clouds (FSW):
CER_FSW_Aqua-FM4-MODIS_Edition2A
CER_FSW_Aqua-FM4-MODIS_Edition2A

The CRS product is designed for studies which require fields of clouds, humidity, and aerosol that are consistent with radiative fluxes from the surface to the top of the atmosphere (TOA); for example, studies of cloud and aerosol forcing at both TOA and surface, or investigations of possible errors in retrievals of TOA fluxes, cloud properties, surface skin temperature, etc. Each CRS is an hourly file containing instantaneous data at the CERES field-of-view scale (20 km diameter at nadir) from a single CERES instrument mounted on one satellite.

The FSW archival data product contains hourly single-satellite flux and cloud parameters averaged over 1.0° regions. Input to the FSW Subsystem is the CRS archival data product. Each FSW covers a single month of data from a single CERES instrument mounted on one satellite. Individual Aqua FSW *Edition2A* files contain information for three consecutive latitude bands.

Data files are in the form:
CER_CRS_Aqua-FM3-MODIS_Edition2A_000000.yyyymmddhh
CER_CRS_Aqua-FM4-MODIS_Edition2A_000000.yyyymmddhh

CER_FSW_Aqua-FM3-MODIS_Edition2A_000000.yyyymmZzz
CER_FSW_Aqua-FM4-MODIS_Edition2A_000000.yyyymmZzz

where: 000000 is the configuration code
yyyy is the data year
mm is the data month
dd is the data day
hh is the data hour
zz is the latitude zone (Z01= 87N to 90N, Z60= 87S to 90S)

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

HOW TO CONTACT US

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

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

Announcement

NASA Science Mission Directorate – Science Education Update

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

After Katrina, a Story of Survival and Science

Lake Pontchartrain may be best known as the source of floodwaters that devastated much of New Orleans in the wake of Hurricane Katrina. However, for Lissa Lyncker, the lake is not only the culprit responsible for destroying the homes of many of her family and friends, but also the laboratory in which she conducts scientific research. Read more about Lyncker and the personal and academic challenges she has overcome in the latest Earth Explorers Series article at *science.hq.nasa.gov/education/earth_explorers/*.

Elementary GLOBE Books Now Available To Order Online

Elementary GLOBE is designed to introduce K-4 students to the study of Earth System Science. The complete unit is $39. Storybooks only, sold per set (not individually), are $25. The complete instructional unit includes:

- Science-based storybooks designed to introduce students to key concepts in water, soil, clouds, seasons and Earth System studies.
- Classroom learning activities complementing the science content covered in each storybook that are designed to further engage students in GLOBE's five investigation areas.
- A *Teacher's Implementation Guide* containing an overview of the resources and background necessary to implement Elementary GLOBE at various grade levels, K-4. The *Teacher's Implementation Guide* also includes a brief overview/discussion of connections to math and literacy, developing methods of inquiry, and other topics such as alignment with Educational Standards.

Elementary GLOBE books and teacher's guides can be purchased online from the National Center for Atmospheric Research (NCAR) Science Store: *www.ucar.edu/sciencestore/cat28_1.htm.*

NASA Partners with AGI on 2007 Earth Science Week

Earth Science Week is an initiative of the American Geological Institute (AGI). NASA is a partner in the tenth annual Earth Science Week, which will be celebrated October 14-20. The 2007 theme, "*The Pulse of Earth Science*," will promote public awareness of the status of Earth Science in education and society. The theme will also focus attention on geoscience research, such as that associated with the International Polar Year (IPY) and the International Year of Planet Earth (IYPE).

Earth Science Week Toolkits will be released starting in late July. The toolkits include educational resources from AGI, NASA, NOAA, USGS, National Park Service, Smithsonian Institution, and other organizations. To order toolkits, as well as learn about the latest plans for Earth Science Week, go to *www.earthsciweek.org/*.

NASA's Education Channel Wants Your Comments

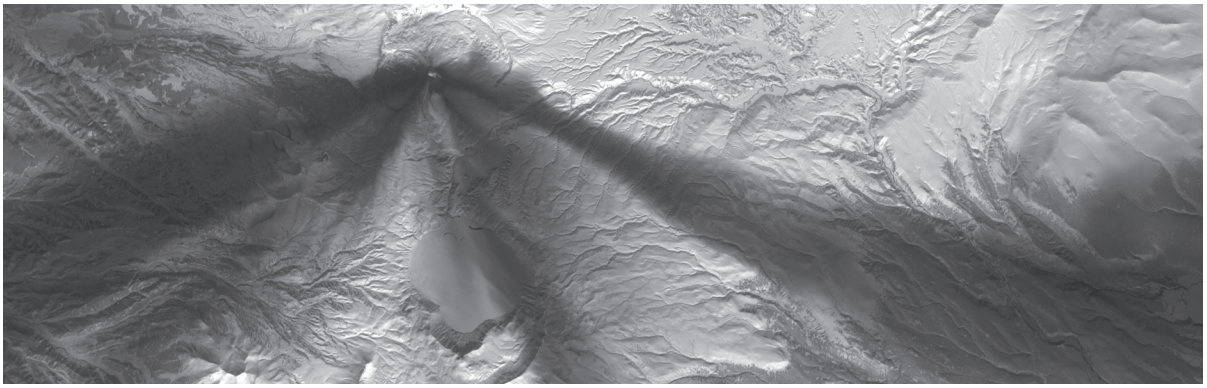
NASA Education wants your perspectives on NASA-TV and the Education Channel in particular. To obtain this information, NASA Education is conducting a short viewer survey that should take no more than five minutes to complete. Your answers will help NASA provide educational programming that supports your curriculum needs. To take the survey, visit *edtv.cotf.edu*

NASA International Polar Year (IPY) Web Site

Visit *ipy.nasa.gov* for the latest NASA images and videos on polar exploration, combined with a searchable storehouse of related information. This Web site is an essential resource for educators, news media and museums interested in the 2007-2009 IPY.

Earth and Space Science Explorers Poster

This poster highlights some of the people featured in the NASA Earth Explorers and NASA Space Science Explorers series of articles on the *NASA.gov* education pages. Some of the explorers highlighted on this poster are still in school, and some are adults who have chosen science as a career. The back of the poster includes suggestions for using the series in the classroom. Download the poster from *www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Earth_and_Space_Science_Explorers_Poster.html*



On March 25, 2007, the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) on NASA's Terra satellite captured this image of the area around the Karymsky Volcano on Siberia's Kamchatka Peninsula. Volcanic ash from earlier eruptions has settled onto the snowy landscape, leaving dark gray swaths fanning out toward the southwest, and toward the east of the volcano's summit. **Credit:** NASA image created by Jesse Allen, using data provided courtesy of the NASA/GSFC/MITI/ERSDAC/JAROS, and U.S./Japan ASTER Science Team.

Announcement

Aura-HIRDLS Level-2 Atmospheric Product Released

The Aura-High Resolution Dynamics Limb Sounder (HIRDLS) Level-2 Atmospheric Product *'HIRDLS2'* is now publicly available *disc.gsfc.nasa.gov/Aura/HIRDLS/hirdls2.shtml* from the NASA GSFC Earth Sciences (GES) Data and Information Services Center (DISC).

HIRDLS is a joint project between the U.K. and U.S. It was launched on the NASA Aura spacecraft on July 15, 2004. HIRDLS is a mid-infrared limb emission sounder (21 channels from 6.12 to 17.76 μm), designed to monitor the global distributions of temperature, clouds, aerosols, and 10 trace species O_3, H_2O, CH_4, N_2O, NO_2, HNO_3, N_2O_5, CFC-11, CFC-12, and $ClONO_2$ in the stratosphere and upper troposphere at high vertical and horizontal resolution in the Earth's atmosphere between about 8 and 100 km.

The instrument is performing extremely well, providing high vertical resolution information despite the fact that the optical beam is partially obstructed between the scan mirror and the aperture, probably by a piece of inner lining material that became detached during launch. HIRDLS Science Team members have been working hard and have come up with the correction algorithms that make use of the partial view of the atmosphere (vertical scans around azimuth angle of 47° line of sight to the orbital plane, on the side away from the sun). In spite of this anomaly, HIRDLS has retained most of its scientific capabilities to support the Aura Mission. Data are retrieved with 1-km vertical resolution.

The Principal Investigators for the HIRDLS mission are U.S. scientist **John Gille**, from the University of Colorado and the National Center for Atmospheric Research, and U.K. scientist **John Barnett** from the University of Oxford.

Each HIRDLS Level-2 data file contains one day's worth of data. At this time, in this first public release (*version 002*), the data file contains retrieved temperature, ozone, nitric acid, and cloud top pressure only. The HIRDLS team is in the process of refining the algorithms for other species, which will be available in later versions.

HIRDLS data are processed at the HIRDLS Science Investigator-led Processing System (SIPS) in Boulder, CO. The standard Aura derived products are made broadly available from the GES DISC Atmospheric Composition web site, *acdisc.gsfc.nasa.gov/*. A document describing the data quality is available at the DISC as well.

Aura Microwave Limb Sounder (MLS) and Ozone Monitoring Instrument (OMI) products have been released earlier. For the full set of Aura products available from the GES DISC, please see the link below. *disc.sci.gsfc.nasa.gov/Aura/data_products.shtml*

Congratulations to the HIRDLS Team for a job well done!

EOS Science Calendar

2007

September 16-20
Joint Northern Eurasia Earth Science Partnership Initiative (NEESPI) - NASA LandCover/Land-Use Change Science Team Meeting, Urumqi, China. URL: *lcluc.hq.nasa.gov.*

October 1-5
Aura Science Team Meeting, Pasadena, CA. URL: *aura.gsfc.nasa.gov*

October 22-25
A-Train Lille Symposium 2007, Lille Grand-Palais, France. URL: *www.a-train-lille2007.org*

November 6-8
HDF & HDF-EOS Workshop XI, "Connections: Bringing together data users, providers, developers and stewards," Landover, MD. Call for Topics. Contact: *Daniel.J.Marinelli@nasa.gov.*

2008

February 5-7
SORCE Science Team Meeting,"SORCE's Past, Present, and Future Role in Earth Science Research," Santa Fe, NM. URL: *lasp.colorado.edu/sorce/news/2008ScienceMeeting/*

Global Change Calendar

2007

August 20-24
First International Circumpolar Conference on Geospatial Sciences and Applications, Yellowknife, N.W.T., Canada. URL: *ess.nrcan.gc.ca/ipygeonorth/index_e.php*

August 22-24
Second International Conference on Access Networks, Ottawa, Ontario, Canada. URL: *www.accessnets.org/2007/*

August 26-30
Earth Observing Systems XII (OP400), San Diego, CA. URL: *spie.org/Conferences/Calls/07/op/oea/index.cfm?fuseaction=OP400*

August 27-29
2007 IEEE International Workshop on Machine Learning for Signal Processing (formerly IEEE Workshop on Neural Networks for Signal Processing), Thessaloniki, Greece. URL: *mlsp2007.conwiz.dk/*

August 29-31
The Third International Symposium on Information Assurance and Security (IAS'07), Manchester, UK. URL: *www.ias07.org/*

September 10-12
Workshop on "Tropospheric NO_2 measured by satellites," De Bilt, The Netherlands. URL: *www.knmi.nl/research/atmospheric_composition/observations/no2_workshop*.

September 11-13
The Second International Symposium on Arid Climate Change and Sustainable Development (ISACS), Lanzhou, China. URL: *www.gsma.gov.cn/reg/index1.asp*

October 10-11
Land and Vegetation Direct Readout Workshop, Unidad de seminarios of the Universidad Nacional Autonoma de México (UNAM), Mexico City. URL: *www.conabio.gob.mx/conocimiento/premota/doctos/location.html*

October 17-19
First International Conference on Networks for Grid Applications, Lyon, France. URL: *www.gridnets.org/2007*

October 28-30
First International Conference on Autonomic Computing and Communication Systems, Rome, Italy. URL: *www.autonomics-conference.eu/*

December 3-12
The Second International Joint Conferences on Computer, Information, and Systems Sciences, and Engineering. Will be held on-line. URL: *www.cisse2007online.org/*

December 10-14
American Geophysical Union (AGU) Fall Meeting, San Francisco. URL: *www.agu.org/meetings/fm07/*

2008

January 20-24
American Meteorological Society (AMS) Annual Meeting, New Orleans, LA. URL: *www.ametsoc.org/meet/annual/index.html*

March 11-13
Oceanology International Global Ocean Forum, London. URL: *www.oceanologyinternational.com*

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