Earth Observing System

# THE EARTH OBSERVER

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## In this issue ...



## EDITOR'S CORNER

**Michael King**
*EOS Senior Project Scientist*

The agenda has been set for the upcoming EOS Investigators Working Group (IWG), scheduled for November 18-20 at the Turf Valley Resort and Conference Center in Ellicott City, MD. The IWG is the primary forum for sharing information on the latest EOS program and science activities, typically attracting around 150 attendees.

The science portion of the agenda deviates slightly from the last meeting, where the meeting was divided into sessions following the ESE science research strategy (variability, forcing, response, consequence, prediction) rather than science themes (e.g., atmosphere, ocean, etc.). This year, we are focusing on new science results from Aqua and other recently launched missions, including Jason-1, GRACE, and SAGE III. Aqua Project Scientist Claire Parkinson will chair a session on new science results from Aqua, and Terra Project Scientist Jon Ranson will chair a similar session on Terra. Both sessions will emphasize integrated data sources from multiple missions.

We will also have a special session on Earth science applications, chaired by Ron Birk, Director of the NASA Headquarters Applications Division. The National Applications Initiative has identified eleven specific themes involving human health and the environment, including community growth management, public health, homeland security and others. Many of these themes, along with other applications-oriented topics, will be presented during the meeting.

More information on the meeting is available on the EOS Project Science Office web site at *eos.nasa.gov*. I hope you will plan to participate in this important opportunity to share the latest EOS program and science activities.

**Continued on page 2**

At the time this newsletter was printed, three new EOS missions were scheduled to launch in early December. The Solar Radiation and Climate Experiment (SORCE), the Ice Cloud and Land Elevation Satellite (ICESat), and the Advanced Earth Observing Satellite II (ADEOS II) continue important studies of solar radiation, ice sheet mass balance, and weather studies respectively. SORCE provides the scientific community with long-term, accurate measurements of the solar ultraviolet (UV), far ultraviolet (FUV), solar spectral irradiance from the UV to the shortwave infrared, and total irradiance from the sun. In addition to ice sheet studies, ICESat monitors cloud and aerosol heights and optical densities, height of vegetation, and land topography. ADEOS II will expand research of global climate changes and their effect on weather phenomena. A brochure and fact sheet have been prepared to describe the SORCE mission and, similarly, a brochure for ICESat. These publications will be augmented by an educational CD-ROM containing selected data. These and many other types of reference literature describing EOS missions and instruments are available from the EOS Project Science Office.

I congratulate the teams of scientists and engineers who have contributed to the success of these missions, and look forward to the exciting new science results that will emerge from them.

Finally, I'm pleased to share with you the successful launch of STS-112 on October 7, which marked the debut of Piers Sellers as a Mission Specialist with the shuttle program. Many of you will remember the tremendous contributions that Piers made to EOS during his tenure at Goddard Space Flight Center before entering the astronaut training program at Johnson Space Center. Among other accomplishments, he served as Terra Project Scientist (then known as AM-1) from 1993-1996. It is indeed a pleasure to be both professionally and personally associated with Piers as he pursues his lifelong dream of manned space flight.

## *Kudos: SeaWiFS Team wins Pecora Award*

The **Sea-viewing Wide Field-of-View Sensor (SeaWiFS)** Team received the 2000 William T. Pecora Award during ceremonies on October 3, 2002 at the National Space Club's 21st Annual Fall Reception at NASA's Goddard Space Flight Center, Greenbelt, Md.

The award, sponsored jointly by the U.S. Geological Survey and NASA, recognizes the SeaWiFS Team for outstanding contributions towards understanding the Earth's biology.

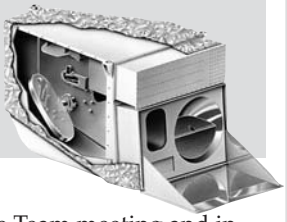
The Pecora Award has been presented annually since 1974 to honor the memory of Dr. William T. Pecora, who was a motivating force in the establishment of Earth resource sensing from space. The award recognizes outstanding contributions by individuals or groups toward the understanding of the Earth by means of remote sensing.

The 2000 award recognizes the team responsible for the Sea-viewing Wide Field-of-View Sensor which has been providing global views of oceanic biological activity with no interruption in service since data reception began on September 18, 1997.

The award was presented to the NASA/ORBIMAGE team by **Dr. Ghassem Asrar**, NASA's Associate Administrator for Earth Science and Barbara Ryan, Associate Director for Geography for the U.S. Geological Survey.

# MODIS Science Team Meeting Overview and Summary of Data Access Panel Discussion

— *Vincent V. Salomonson, vsalomon@pop900.gsfc.nasa.gov, Goddard Space Flight Center, MODIS Science Team Leader*



## OVERVIEW

The Moderate Resolution Imaging Spectroradiomter (MODIS) Science Team Meeting convened at the Greenbelt Marriott, July 22-24, 2002. Overall, this was a very productive and exciting meeting. The Terra MODIS data products are increasingly showing outstanding results that are described in companion articles by the MODIS Discipline Groups in this issue of the *Earth Observer*. The presentations made during the plenary sessions of this meeting can be accessed at: *modis.gsfc.nasa.gov/sci_team/meetings/200207/index.html*. Highlighted examples (among many) include the provision of wind measurements over the poles by MODIS that are enhancing the prediction performance of general circulation models; the provision of ocean color and sea surface temperature data sets that are meeting or exceeding goals; and the real-time application of MODIS fire observations by various agencies.

Of course, one facet that added to the upbeat tone of the meeting was the successful launch on May 4, 2002, of the Aqua satellite and the attendant early, positive results from the Aqua MODIS instrument. The Aqua MODIS became operational by the time of the MODIS Science Team meeting and in the intervening weeks has continued to produce results demonstrating improved performance to that of the Terra MODIS in several respects. Both **Jon Ranson**, Project Scientist for the Terra Mission, and **Claire Parkinson**, Project Scientist for the Aqua mission, were able to provide good updated overviews of the status and results coming from those missions that were quite encouraging.

The Terra MODIS is experiencing a growing number of data formatter resets each day. However, at the time of the Science Team meeting these resets, due to software overrides of these occurrences, were not affecting the MODIS science data. It did seem clear, however, that eventually a switch from the MODIS A-side formatter to the B-side equivalent would have to be made. Both Jon Ranson and Claire Parkinson are articulating and presenting to NASA management the case for a Deep Space Maneuver (DSM). The DSM is important to MODIS because it, in particular, will refine the radiance-versus-scan angle characteristics of the MODIS mirror. From this improved knowledge the possibility then opens up to improve MODIS Sea Surface Temperature (SST) observations beyond what can be achieved by algorithms that rely on correlations with sea-truth (e.g., buoys and shipboard radiometers).

In addition to the instrument results described above, a great deal of progress has been made in processing and reprocessing MODIS data into time series spanning a year or more. This has led to MODIS products reaching a considerable degree of maturity and scientific utility. The sense of the meeting, as noted above, was that several instances indicate products are not only well characterized in terms of known uncertainty and performance compared to results from predecessor instruments and ground-truth/validation campaigns, but also are being incorporated productively into scientific studies and journal articles. Aligned with the general status on data processing is the production of an "Introductory MODIS Multidisciplinary Data Set" that is available at an ftp site (*ftp://modis.gsfc.nasa.gov/pub/Data_Sets/*) and on a CD that will be distributed at upcoming scientific conferences and workshops so as to introduce MODIS products to the broader community. It is also encouraging that the Direct Broadcast (DB) capability of MODIS data is spreading across the world (well over 50 DB stations) allowing quick, regional access to MODIS data. Particular acknowledgement goes to James Dodge at NASA Headquarters for his leadership and vision in encouraging and nurturing this successful program.

Reaching the potential for utilization of MODIS products by the scientific and applications communities depends on four factors: (1) having a well-performing, well-characterized instrument leading to carefully calibrated radiance

(Level 1) data; (2) developing scientifically valid, geophysical (Level 2 and above) products derived from carefully constructed and validated algorithms developed by the MODIS Science Team; (3) developing and operating adequate data processing capability, leading to careful processing and reprocessing of the MODIS products, allowing for optimized observations and development of time series to identify geophysical trends; and (4) providing capabilities that allow the broad Earth science and applications community to readily and efficiently access the MODIS products.

Given the above discussion regarding successful use of the MODIS capabilities, the MODIS Science Team feels that factors 1-3 have largely been, and are continuing to be, accomplished. The major challenge at this time is to improve the access to MODIS products. This is a particular challenge for the MODIS situation because of the breadth of capability (i.e., number of bands, 3 different spatial resolutions, 12-bit quantization) and the attendant volume and complexity of the MODIS data products. While considerable progress has been and is being made on these issues, more needs to be done.

## PANEL DISCUSSION ON MODIS DATA ACCESS

With the background just described, a Data Access Panel was formed and an afternoon was set aside on the second day (July 24) of MODIS Science Team plenary meetings to discuss the general issue of MODIS data access as seen by representatives of four elements involved in the issue, namely: data access tools, user services, user experiences, and system development and provision. The following panelists participated. Sara Graves (Director of the Information Technology and Systems Center at the University of Alabama, Huntsville) described developments in data access and analysis tools. Jim Koziana (GSFC DAAC User Services), John Dwyer (EROS Data Center DAAC User Services), and Marilyn Kaminski (National Snow and Ice Data Center MODIS Product Team) described the experiences and activities of the DAACs involved in providing MODIS products to the user community. Dorothy Hall (NASA/Goddard) representing land science, William Ridgway (Science Systems and Applications, Inc [SSAI]) representing atmospheric science, and Tim Moore (University of New Hampshire) representing Oceans science, provided user experiences and suggestions. Mike Moore (Goddard/ ESDIS Project) described the activities designed to develop and implement capabilities that will enable the access of MODIS products by the user community. Each of the panelists provided a short presentation and then engaged in discussion with the audience attending the panel discussion. Summaries of the of the panel presentations follow.

### Data Processing Tools

**Sara Graves** started the panel presentations by describing developments in subsetting, data mining, and Earth Science Markup Language (ESML) tools for scientists (*modis.gsfc.nasa.gov/sci_team/meetings/200207/presentations/graves.pdf*). She first presented an overview of the ESDIS system with highlights on recent developments and noted that a demonstration was ongoing of newly developed software tools. These developments fall into four categories:

1 **Data Usability**: The big problem within the science community is how to use the new remote sensing data. ESDIS developed ESML, an adaptation of HTML, to enhance the data's usability.
2 **Science Data Preprocessing**: Tools for subsetting and browsing.
3 **Science Data Analysis**: Including data mining and algorithm development.
4 **Mission/Project/Field Campaign Coordination**: Including electronic collaboration.

Regarding ESML, Graves said that the concept is to define something once and use it many times. The heterogeneity of data formats has created a huge usability problem, but with the development of ESML, the ESDIS can create an ESML file for each data set that serves as a description/metadata file and provides a structural description as well as semantic and syntactic data files. ESML is a machine-readable and interpretable representation of the structure and content of any data file, regardless of format.

Graves listed the tools currently available (*esml.itsc.uah*) and cited examples of comparative studies using MODIS and Multi-Angle Imaging Spectro-Radiometer (MISR) data for correlation with Clouds and the Earth's Radiant Energy System (CERES) short wave flux data. Regarding subsetting, Graves said that there are many tools (*subset.org*), including an available toolbox of subsetters. She noted that her organization has also developed and made available a number of subsetting tools.

Graves announced that the HDF-EOS Web-based (HEW) subsetter is now complete and available, and noted that

it is possible to customize a front end and set up subset centers. They are developing tools for stitching data granules, and the integration of HEW with ECS is in progress. They are also planning on making subsetting into a web service. Vince Salomonson asked whether it is possible to specify according to band and geographic locations, and Graves said yes, it is possible. Concerning data mining, Graves said that the task is to discover interesting patterns and anomalies and to extract novel information. Data mining is only as useful as the scientist using it makes it. Scientists must be able to know when they've found something of value. She concluded that it is an iterative process.

**User Services Experiences and Activities.**

*Goddard Space Flight Center DAAC (GDAAC)*

*modis.gsfc.nasa.gov/sci_team/meetings/200207/presentations/koziana.pdf*

**Jim Koziana** began by saying that the MODIS mission is unknown to potential users at a surprisingly large level. In the area of data discovery, access, and delivery, Koziana said that current issues include data maturity, enhanced data previews, the look and feel of the web interface, unknown order status, multiple product ordering, and the quality of archived data (duplicates and missing data). As for data usability, he identified an issue with getting MODIS data into a GIS (i.e., GEOTIFF) or other simple format. There are too many parameters in a single file, and file sizes are too big. There are also no simple tools available for using data. Koziana identified the most popular MODIS data products, emphasizing their use in regional and global studies. One person in the audience suggested it would be interesting to see how orders from team members compare to orders from all other users.

Koziana reported on the response of remote sensing data users from IGARSS 2002. Twenty-four percent of respondents said that they didn't know anything about MODIS data. Thirty-two percent said they haven't used it, but see its improvement over older remote sensing data and plan to use it in the future. Eighteen percent said that they work with higher resolution data than MODIS provides and require real-time data. Twenty-two percent said that they are very satisfied with their acquisition of MODIS data, and four percent expressed general dissatisfaction. Koziana said that conclusions from IGARSS show that small data volume users are accessing MODIS data at a healthy pace, and that MODIS data is relatively unknown outside the IWG community. Koziana explained that there is a natural lag between the availability of new data sets and end users, so the growth should occur as more information about MODIS products becomes available and concomitant research and applications needs or opportunities develop. He mentioned that TRMM data distribution did not see a marked increase until about 20 months after the TRMM launch. In conclusion, Koziana listed the GDAAC's future directions.

*Land Processes DAAC (LP DAAC)*

*modis.gsfc.nasa.gov/sci_team/meetings/200207/presentations/dwyer.pdf*

**John Dwyer** reported that the Land Processes DAAC has a user support model that includes the use of a web-based system to log customer contacts and responses, uses a "consultation tree," publishes FAQs, and is capable of generating summary reports. He reported that the user community recognizes that the turnaround time from data acquisition to product availability is getting better, and highlighted positive user community response to the increasing availability of MODIS 250-m products. The LP DAAC provides "1-page" fact sheets on its web site that provide general descriptions of the products, format and data type specifications, valid data ranges, scale factors, and explanations of the QC-bits. The more common inquiries received from users regarding data set characteristics include product formats, metadata, questions about data and information from other sites, and projection and grid characteristics. Dwyer noted that most ASTER data are requested on media (CD and DVDs), whereas MODIS data are mostly distributed via ftp. Regarding software tools, Dwyer said that current issues include file formats that are incompatible with **commercial, off the shelf products (**COTS) and showed deficiencies in using COTS geolocation and quality control bits.

In summary, Dwyer said that he is seeing an overall positive response from the community of MODIS land data users. The user community is alive and growing. The LP DAAC is pursuing a CPU upgrade to the local EOS Data Gateway (EDG) client as well as the implementation of data pools. They are also working to improve links to additional information and alternative data sources. Dwyer noted that the workshops conducted by the MODIS Land Science Team have been providing excellent feedback.

*National Snow and Ice Data Center (NSIDC) DAAC*

*modis.gsfc.nasa.gov/sci_team/meetings/200207/presentations/kaminski.pdf*

**Marilyn Kaminski** reported that the NSIDC currently has eight snow and ice data products, and distribution numbers are going up rapidly. She said that this is a good sign of maturity of the products and that tools are becoming available. However, there are still problems. Kaminski said that the EDG is slow, cumbersome, and difficult to use. She said that a solution could include data pools to allow many users to avoid the EDG. The NSIDC is developing scripts to enter queries directly that include Earth Science Data Type (ESDT), location, start time, and stop time information. Another solution could be an improved EDG tutorial.

Kaminski also reported that the Integrated Sinusoidal (ISIN) projection is difficult to use. Suggested solutions included the NSIDC providing the Eros Data Center (EDC) with code fixes for the MODIS Reprojection Tool (MRT), offering workshops, offering an improved MODIS image gallery, improving the HDF-EOS support pages, and better advertisement of NSIDC-developed tools for data manipulation. Kaminski acknowledged that the EDG is problematic for casual users, but people do get better at using it over time.

### User Community Experieces and Suggestions

*A MODIS Oceans User Experience*

*modis.gsfc.nasa.gov/sci_team/meetings/200207/presentations/timmoore.pdf*

**Tim Moore** reported that he has been working with remotely sensed (RS) data for the past 10 years. He's also been using SeaWiFS data from the DAACs, and most recently he has started using MODIS data. Moore said that, given his experience with it so far, he would give it a "B" grade. Moore grouped users into three levels based on experience:

- **Novice**. No HDF, MODIS, or SeaWiFS experience;
- **Average**. Some HDF, some SeaWiFS, no MODIS; and
- **Expert**. HDF and MODIS experience.

He said that most users fall into the novice and average levels. Moore indicated that the overall MODIS web structure is complicated, disjointed, and tangled, resulting in an overall "C+" grade. There are many duplicate pages across different groups (e.g., MODIS, GDAAC and MODAPS pages) and FAQs are needed up front on the MODIS home page. Some good pages are buried too deep, e.g., *daac.gsfc.nasa.gov/MODIS/software.shtml*. Moore noted that most of the Oceans community is already familiar with the GDAAC from SeaWiFS experience and will prefer the GDAAC over the EDG for data access, but many others are lacking that frame of reference. Given this, he offered no specific comments on the EDG, but said that overall, it is clumsy, confusing, and discouraging to use.

Moore did however make some specific recommendations for the GDAAC. Overall, Moore said that the GDAAC got a "B+," and could improve a few issues. They should allow for temporal searches greater than 8 days; they should build in links to all ocean products and geo files; they should provide a true-color browse for Level 2 granules; and he recommended removing the disclaimer from its prominent level on the final page before submitting an order.

*A MODIS Land User Experience*

*modis.gsfc.nasa.gov/sci_team/meetings/200207/presentations/hall_afternoon.pdf*

**Dorothy Hall** began by noting some good points about the DAAC. She said that data center unplanned downtime has been much less than it was six months ago; data are available just a few days after acquisition; and the data center personnel are very helpful. She noted that she often gets notifications that her requested MODIS products have been staged for ftp within a few minutes after ordering them. She also noted that the NSIDC will put daily Climate Modeling Grid (CMG) maps up on their site as jpg files for easy browsing prior to order, and browse products will be implemented this fall. Hall reports that the EDG has a steep learning curve, but once mastered, it's easy to use. She noted a number of excellent features, including showing where the study area is located. Hall said that the browse problem is currently being addressed.

Hall then turned to some of the negatives. She said that there is a general lack of browse products for most of the products she searches for, and the system is very slow every time she "turns" a page. Hall said that the granules should be numbered when they are listed, which is very important for large orders (more than 10 granules). She feels there is too much wasted space on the granule listing page that requires a lot of extra scrolling and mouse clicking. She feels this should be avoided. It is also awkward at times, especially when selecting a data set from among the hundreds of choices and when granules are displayed.

Hall said that in regards to Hierarchical Data Format (HDF), ENVI (a software package by Research Systems, Inc.) makes it easy to read HDF files, but it is expensive and a lot of people, espe-

cially students, don't have access to it. Many people prefer flat binary files. As for the MODIS reprojection tool, users must register for it. Hall said that it took her a day to register, but it took a week for a student with whom she spoke, and she wasn't certain why.

In conclusion, Hall said that the data centers have made good progress in data distribution and reducing unplanned downtime. The EDG is slow and awkward, but becomes easy with experience. Free tools should be available right away, and browses should be produced for each product when possible.

*A MODIS Atmospheres User Experience*

*modis.gsfc.nasa.gov/sci_team/meetings/200207/presentations/ridgway.pdf*

**Bill Ridgway** focused on the process of getting the desired files from the archive to the desktop, highlighting the complexity of choices that the user must make in the process. In the area of selection, Ridgway said that the EDG and "no-frills" tools have perhaps 50% of the desired functionality. The search and wait interface is not adequate for serious research. Geographic searches include excessive near misses, and the MODIS product packaging remains a big issue. As for staging, Ridgway said that it can take anywhere from five minutes to 48 hours. He acknowledged that the number of failures has come down a lot in the past year, and also noted that the demand on system resources limits orders. In the area of delivery, Ridgway said that the ftp pulls are most reliable, and product volume is probably the greatest obstacle. As for help, Ridgway said that better tools, better examples, and better images are still needed.

Ridgway then turned to selection roadblocks. For the novice, Ridgway pointed out the maze of navigating ESDT and collection numbers. The products are packaged with too many parameters; there are no useful browse images; and selecting data with the right time and/or location is problematic. For the repeated/experienced user, Ridgway highlighted order size limits; the "no-frills" GDAAC interface can't always do what is needed; the EDG interface is torturous (though has useful functionality); and both are painful for repetitive ordering (both should allow for profile repeat orders).

Ridgway suggested streamlining the EDG and "no-frills" interface for repeat customers, pointing out that they already know what they want and just need an easy way to get it. He also suggested a data pool with an ftp interface for machine data acquisition, a geographical search tool that really works, and easy ordering of many products for a five-minute granule.

## ESDIS System Developments and Plans

*modis.gsfc.nasa.gov/sci_team/meetings/200207/presentations/mikemoore.pdf*

**Mike Moore** agreed that there are significant issues on the front end and from the user's perspective that must be immediately addressed and resolved. He said that he will work to form a team of MODIS, MISR, and Advanced Space Thermal Emission and Relflection (ASTER) users to identify, prioritize, and decide how to implement solutions to those issues.

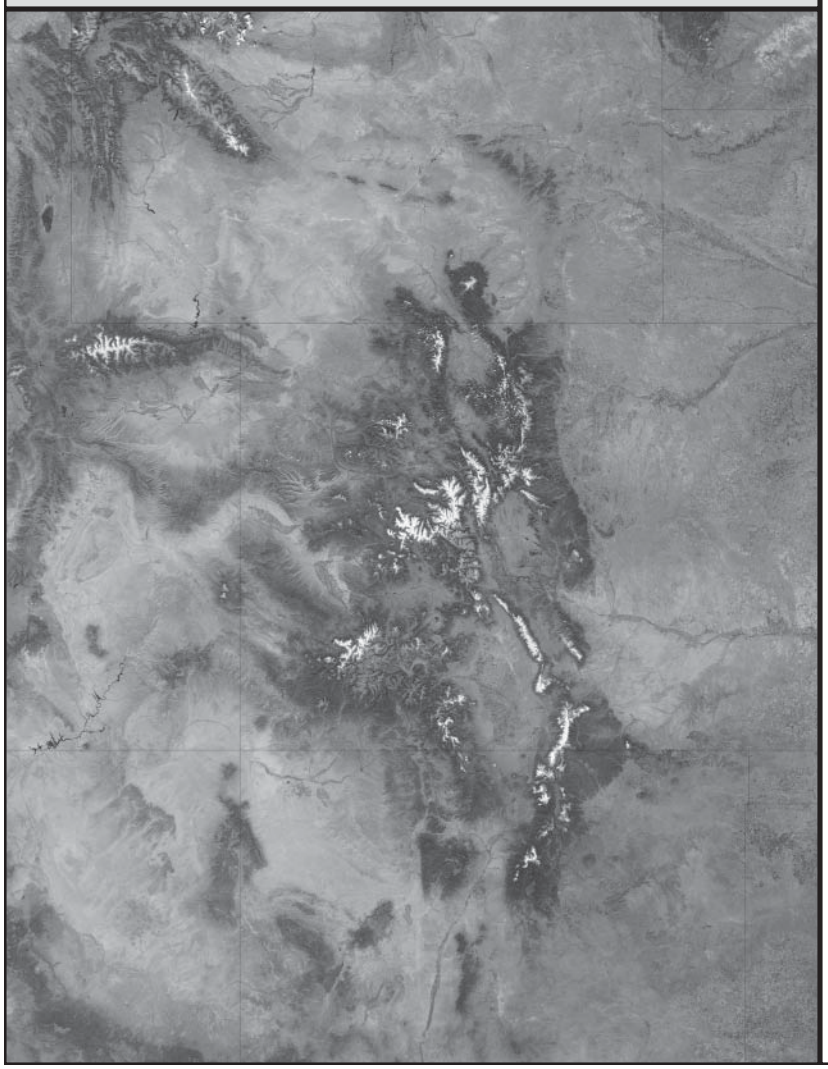
Moore said that the EOSDIS has been working with the Data Access Working Group (DAWG) to identify and prioritize needed changes as well as addressing many items through a Synergy Program. They expect to receive Science Working Group for Data (SWGD) distribution recommendations soon, and will address them as funds become available based on SWGD priorities. They are implementing SWGD ingest and archive recommendations based on currently available funds with special emphasis on archiving Level 1A subsets. Moore said that they are enhancing the Data Pools to provide more on-line data and data services, and noted that an initial Data Pool is operational at the GSFC DAAC. They are enhancing the HDF toolset (HDF EOS to GeoTiff or "HEG") to aid in the use of retrieved data, and are integrating the University of Alabama's (UAH) HDF EOS Web-based (HEW) subsetter into the ECS. Moore also listed the DAWG results to date.

Moore listed the Data Pool CY '02 enhancements/capabilities to be delivered by December 2002. They will deliver: population via search and script-based ingest; interfaces to external ECHO and EDG search engines; personalized data views, bookmarks, and data themes; and access via OpenGIS interfaces. They will also deliver data access services via an HDF toolset (HEG); compression of data on distribution; and expanded capacity and throughput (due in August 2002). The capacity and throughput will include 2 tb for the NSIDC; 44 tb for the EDC with on-line ASTER Level 1B in GEOTIFF; 25 tb for LaRC; and 63 tb for GSFC, including on-line MODIS Level 1B data to smooth flow to MODAPS. Lastly, EOSDIS will provide management of NEPSTER direct broadcast and Rapid Response data for MODIS as well as consistency checking tools.

**Summary of Discussion**

Overall, this panel discussion appeared to be quite productive and illuminating. Certainly much progress has been made in improving the access for the user community to MODIS products. However, much remains to be done. In the course of implementing improvements such as browse images and simplified ordering, subsetting tools, etc., it will be important due to certainly finite and generally limiting resources to make use of existing capabilities and the MODIS Science Team, et al., the ESDIS Project, and the user community working together to accomplish these ends. Specific steps that hold high potential for success are now underway as a result of this panel discussion. Given the exciting performance of the MODIS instrument, the success achieved in the development, validation, and processing of the data products, and the clear potential for advancing Earth science and applications through the use of these capabilities, the motivation to work together toward these ends is clear.

# MODIS Captures Season's First Snowfall in Colorado



Snowfall returned to the mountain ranges of western and central Colorado on September 18—the first significant accumulation of the 2002-03 snow season. Ski resorts in the region reported several inches of accumulation.

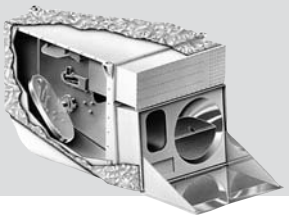
The image shown was acquired on Sept. 20 by the Moderate Resolution Imaging Spectoradiometer (MODIS) sensor onboard the Terra spacecraft. It is a grayscale version of a false color image. Even in grayscale, however, the bright snow-capped peaks contrast sharply with the darker surrounding landscape. This contrast makes it easier to spot specific mountain ranges. Running north-south near the top of this scene are the Medicine Bow Mountains, roughly in the center of the state and extending northward into Wyoming. To their west, the Rocky Mountain ranges have names like the Elkhead Mountains and the Steamboat Range.

The Medicine Bow range terminates in a long line of north-south tending ranges called Colorado's Front Range, at the foothills of which lie the state's biggest cities: Fort Collins, Denver, and Colorado Springs. Farther to the south, near the center of the state, are the Gore and Sawatch Mountain Ranges (left center). In southern Colorado, both the San Juan Mountains (west) and the Sangre de Cristo Range (east) stretch over the state line into New Mexico. Between the two flows the northern reaches of the Rio Grande.

Other landmarks are visible in this scene. Wyoming's and Utah's Flaming Gorge Reservoir can be seen in the upper left hand corner of this image. This image was provided by **Jacques Descloitres** of the MODIS Land Rapid Response Team at NASA GSFC.

# MODIS Science Team Meeting Atmospheres Discipline Summary

— *Paul Menzel, paul.menzel@ssec.wisc.edu, University of Wisconsin – Madison, MODIS Atmospheres Science Team Member*



## Overview

The Atmospheres Group reviewed each of the MODIS atmospheres data products that are being produced by the Terra mission and characterized differences, where they occur, with comparable products produced by Aqua. MODIS data are being processed from Level 1 (radiances and brightness temperatures that have been geolocated), to Level 2 (derived geophysical data products at the Level 1 resolution) to Level 3 (variables mapped onto daily, eight-day, and monthly time intervals and at a 1° x 1° latitude-longitude grid globally). It was reported that an algorithm for cloud shadow detection was recently successfully tested. The essential elements of all Level 2 'pixel-based' MODIS atmosphere data products are working well; the algorithms are stable (the Total Precipitable Water Vapor derived from infrared radiances has overcome early difficulties with retrievals over desert regions); the products have been validated (with the exception of the cloud phase and particle size, which will be confirmed using data collected during the recent Cirrus Regional Study of Tropical Anvils and Cirrus Layers - Florida Area Cirrus Experiment (CRYSTAL-FACE) field experiment; and one-year global data sets are being studied to infer seasonal patterns. In addition, there have been exciting developments regarding the MODIS polar winds and model impact studies. Several publications will be released soon that announce the MODIS capabilities and detail the new discoveries with many examples; five atmospheres papers are in the special Aqua issue, there is a special section in Geophysical Research Letters (GRL) that will have an atmospheres paper, and an aerosol review paper has been accepted by Nature.

The Atmospheres Group noted that overall Aqua MODIS performance is excellent: striping is much reduced from that of Terra, cross talk into the longwave $CO_2$ channels has been eliminated, scan-mirror reflectance issues have been ameliorated, and signal-to-noise ratios are improved for most channels. Software updates have been made to accommodate Aqua data, and the initial product flow looks good. However, there is some concern about Aqua's near-real-time geo-location for polar winds, an offset between warm-cold focal planes total precipitable water derived from near infrared radiances and the non-functional 1.6 μm (Band 6) channels. It was reported that in the near term, the Atmospheres Group plans to move forward on global IR radiance bias adjustments for sequencing 8-day clear sky composites in the forward and reprocessing streams. In addition, Level 3 products will be animated for easier quality control. Algorithm Theoretical Basis Documents (ATBDs) will be updated by the end of September 2002 to include algorithm evolutions, product validation results, Aqua adjustments, and quality indicators. The group concluded that having two MODIS instruments will result in better polar winds; improved diurnal process studies of aerosols, moisture, and clouds; and improved AIRS + MODIS observations of cloud properties and surroundings.

## Plenary Summaries

**Paul Menzel** reported on seasonal changes in semi-transparent or cirrus global cloud cover that have been monitored with multi-spectral observations from a series of eleven polar orbiting High resolution Infrared Radiation Sounder (HIRS) instruments launched since December 1978. Trends are beginning to emerge in the path-finder reprocessing, but orbit drift and volcanic and El Niño events must be accommodated. Comparison of HIRS and MODIS cloud detection reveals similar total cloud detection but more attribution to high-levels and opaque clouds by MODIS. Menzel also reported that early indications are promising that MODIS will be a more than worthy successor to the venerable HIRS.

**Jeff Key** reported on the derivation of tropospheric wind information at high latitudes from sequences of MODIS water vapor images. The methodology

employed is based on the algorithms currently used with geostationary satellites, with modifications to overcome the irregularity of temporal sampling, different viewing geometries in successive orbits, uncertainties in wind vector height assignment as a result of low atmospheric water vapor amounts and thin clouds typical of the Arctic and Antarctic, and the complexity of surface features. A 30-day case study data set has been produced and is being used in model impact studies. Preliminary results are extremely encouraging when the MODIS winds are assimilated in the European Centre for Medium Range Weather Forecast (ECMWF) system and the NASA Data Assimilation Office system. Forecasts of the geopotential height for the Arctic, Northern Hemisphere extra-tropics, and Antarctica are improved significantly (forecast skill improved by half a day at 4 to 5 days). Real time production of these winds has started with the help of NOAA and the National Environmental, Satellite, Data and Information Service (NESDIS).

**Bryan Baum** reported on recent progress in the detection of cloud shadows over land. Comparison of MODIS measured reflectances with those from a clear-sky reflectance map indicate possible cloud shadow when the reflectance from the field of view is considerably lower than that suggested by the 8-day composite clear sky map. Baum also reported on progress in the detection of multilayered clouds in daytime data. Much of the uncertainty in the cloud phase product, specifically pixels assigned to the "uncertain" or "mixed-phase" categories, can be traced to the presence of multilayered clouds, specifically optically thin cirrus overlying lower-level water clouds. Both the daytime multi-layered cloud detection method and the cloud shadow detection method will soon be implemented on the MODIS direct broadcast data routinely collected at the University of Wisconsin and the results will be made available to the land and cloud communities for discussion. When the algorithms become more mature, they will be implemented operationally at the NASA Goddard Space Flight Center.

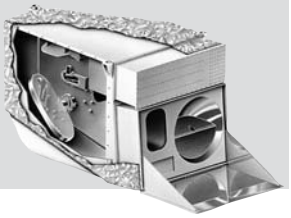
**Bo-Cai Gao** presented results from the Near-IR Water Vapor Algorithm that uses the ratios of Near Infrared (NIR) water vapor absorbing channels. He reported that MODIS NIR Water Vapor agrees quite well with ground based microwave radiometer (MWR) measurements, especially in clear conditions. He showed numerous examples of global water vapor changes with the seasons. In addition, he noted that the Cirrus Reflectance Algorithm is working quite well, and can be used to improve aerosol optical depth retrievals as well as high cloud optical depth over both land and ocean surfaces.

**Yoram Kaufman** and **Lorraine Remer** reported on Aerosol Algorithm validation for the 2001 data set. The primary aerosol products have been found to be valid within pre-launch error estimates, and the team has made the first-ever operational retrieval of aerosols over land. Remer reported that they have made a significant step forward by making a fine-versus coarse-aerosol division, and are working to "re-call" retrievals for dust in glint or extensions over land. Remer reported that non-spherical phase functions will be a major innovation, but they will not be ready for Collection 4. Kaufman showed global aerosols maps for the year 2001; anthropogenic and natural aerosol and their seasonal variations were dramatically evident.

Overall, the MODIS Atmospheres work is going well. Following the completion of field work analyses such as that with the CRYSTAL field experiment, most if not all atmospheres products will have entered into validated status with further improvements to be expected as reprocessing occurs, such as those associated with Collection 4 beginning in October and finishing next summer. It is exciting to see the atmospheres products being increasingly applied to gaining improvements in models and understanding of conditions and processes occurring in the Earth's atmosphere.

# MODIS Science Team Meeting Oceans Discipline Summary

— *Wayne Esaias, wayne.esaias@gsfc.nasa.gov, NASA Goddard Space Flight Center, MODIS Oceans Discipline Leader*



The first of three very positive and exciting aspects of the meeting for the Oceans group was that Terra reprocessing (Ocean Collection 4) is proceeding very well. We expect that two years of data will be produced by October 1, 2002. Second, the majority of the resulting products will be declared "validated" based on work reported at the meeting. Third, a full suite of global Aqua ocean products was produced within 24 hours of first light and shows that the data quality is truly excellent. Further work is required for vicarious calibration, and validation will take time to accumulate match-up in situ data.

At the time of the meeting, the reprocessing effort had completed 11 months of data that were used by team members for comparisons with in situ data, SeaWiFS, and AVHRR. (**NOTE**: As of September 14 the first two years of the mission have been processed.) The Sensor Intercomparison and Merger for Bilogical and Interdisciplinary Oceanic Studies (SIMBIOS) Project is assisting in this effort by performing the visible matchups based on "cookies" produced by the MODIS Adaptive Processing System(MODAPS) and the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) Bio-optical Archive and Storage System (SeaBASS) in situ data. Additionally, the SIMBIOS project is merging MODIS chlorophyll with similar data from SeaWiFS to produce a better-sampled global daily product. Several MODIS ocean members showed mpeg movies of weekly composites for their products that illustrated the dynamic nature of the oceanic biosphere and Sea Surface Temperatue (SST) fields.

**Bob Evans**, who has led this effort, discussed vicarious calibration of MODIS Ocean Bands. Evans demonstrated that the Terra SST data have the lowest root mean square (rms) error when compared with the Marine-Atmosphere Emitted Radiance Inteferometer (M-AERI) than other satellite data sets. In the visible region, the water-leaving radiances for the first two years show rms differences from Marine Optical Buoys (MOBY), which are comparable to values obtained with SeaWiFS. Remaining issues with time dependencies in the across-track direction, improved polarization formulation, in-water Bi-directional Reflectance Factors (BRF), and sun glint corrections will be addressed in the future.

**Mark Abbott** illustrated the high sensitivity of the fluorescence line height (FLH) measurement, and concentrated on validation using coastal data off Oregon. **Frank Hoge** showed several spectacular comparisons of aircraft laser stimulated fluorescence with the MODIS FLH. Despite the cosmetic striping, Hoge found that differences were very minor, and he further showed that the FLH is not affected by the presence of dissolved organic matter.

**Janet Campbell** found that the MODIS chlorophyll products compare favorably with similar SeaWiFS products, especially the SeaWiFS analog product. Root mean square differences between the satellite products are equivalent to, or less than, comparisons of the satellite to in-situ data.

**Ken Carder** showed that the semi-analytic algorithm for chlorophyll and optical properties successfully accounts for the effect of pigment packaging in the Southern Ocean and upwelling regions. The Level 3 chlorophyll-a product agrees better with in-situ data in these regions because it accommodates the presence of different function groups of phytoplankton. **Dennis Clark** discussed validation status of the MOBY data, and the case 1 algorithms for Chlor-MODIS, total pigments, K490 – diffuse attenuation coefficient at 490 nm, and Total Suspended Sediments.

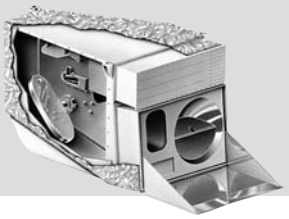
**Howard Gordon** discussed a new spectral optimization algorithm being developed for case 2 coastal waters. It appears to work well for Chesapeake Bay using SeaWiFS data, but results with MODIS need improvement, possibly in the NIR calibration.

**Wayne Esaias** showed the Ocean Primary Productivity (OPP) results from Collection 4 and compared

**Continued on page 13**

# MODIS Science Team Meeting Land Discipline Summary

— *Chris Justice, justice@hermes.geog.umd.edu, University of Maryland, College Park, Land Discipline Group Leader*



The MODIS Land products are now widely available and are being used by the science and applications communities. The Science Team is making efforts to provide summary products to the community and make it easier for scientists to obtain and use the data. Recent product developments by the Land Team include the contributions to the Introductory MODIS Multidisciplinary Data Set (special credit to Eric Vermote and Nazmi Saleous) (*ftp://modis.gsfc.nasa.gov/pub/Data_Sets/*); an LAI/FPAR CD (R. Myneni et al.) which includes a monthly summary of the standard 8-day products at 1-km and 4-km resolutions (*ftp://crsa.bu.edu/pub/rmyneni/myneniproducts/*); a Vegetation Index CD (A. Huete et al.); the MODIS 500-m Global Percent Forest Cover Product using year 2000 data (J. Townshend et al.); and a consistent year land cover product (A. Strahler et al.). The MODLAND Rapid Response System (J. Descloitres et al.) continues to provide excellent near-real-time images (*rapidfire.sci.gsfc.nasa.gov/gallery/*) that are used for educational purposes by the Earth Observatory. The rapid response imagery and fire locations (*firemaps.geog.umd.edu*) continue to be used by the U.S. Forest Service and a large number of fire management agencies around the world. The Rapid Response System also provides product code for Direct Broadcast users (*directreadout.gsfc.nasa.gov*). Currently, the Rapid Response Team is also exploring how advances made with MODIS and the data delivery system can be transitioned to the operational domain of NOAA/NESDIS and eventually to the National Polar-orbiting Operation Environmental Satellite System (NPOESS) Preparatory Project (NPP) Visible Infrared Imager/Radiometer Suite (VIIRS) instrument.

The current areas of emphasis for the MODIS Land Group are Aqua Calibration and Product Quality Assurance, Land Product Outreach and User Community Feedback, Product Validation, and Preparation for Collection 4 reprocessing. In the area of outreach, the early Land product validation results have been submitted to *Remote Sensing of Environment Special Edition* and are expected to be published by the end of the year. The first three in the sequence of Land Product Outreach Workshops (Land Cover, Vegetation Parameters, Fire) have been held and were well received by the attendees, and the team is receiving much useful feedback. The last in the current series of outreach workshops, Radiation Products, is planned for late October. Part of this outreach activity is aimed at helping established AVHRR users become aware of the new MODIS capabilities and products. The Science Team is planning additional outreach workshops in the future.

Based on user feedback, the Land group is proposing a modification of the current Integerized Sinusoidal (ISIN) Projection to make it more compatible with re-projection software found in most image processing systems. This change to a simple Sinusoidal (SIN) Projection will not significantly impact the data production schedule and will take effect in Collection 4. The Land group continues to advocate that work is needed on providing improved tools and user service that will enable science users to better manage and analyze MODIS data. The group encouraged ESDIS to redouble its efforts to work with image processing vendors to include MODIS processing capabilities. MODIS data usage continues to be evaluated by the DAACs. It has been proposed that a voluntary list of MODIS Land data users be compiled by the EDC DAAC so that a closer connection can be made between the science team and the user community and so that user needs and problems can be better understood.

The current Land/Water Mask needs to be improved and it was also suggested that the Shuttle Radar Topography Mission (SRTM) may be one important source of data. It was suggested that the NASA Digital Elevation Model (DEM) Working Group might be resurrected now that SRTM data are starting to be made available. The next step for the Multidisciplinary Data Set is being discussed and the relationship to the Climate Modeling Grid products

is being evaluated. The development of MODIS time series studies is awaiting the first major Land reprocessing starting October of 2002 providing a consistent data set.

Land product validation is in progress and includes efforts to internationalize the validation efforts through the Committee on Earth Observation Satellites (CEOS) Land Product Validation Working Group (*modarch.gsfc.nasa.gov/MODIS/LAND/VAL/CEOS_WGCV/index.html*) (special credit to Jeff Morisette and Jeff Privette) and the Global Observation of Forest Cover/Global Observation of Landcover Dynamics (GOFC/GOLD) regional networks. There is an effort underway to expand the EOS Land Validation Test Sites to become the CEOS Validation Test Sites with involvement of other space agencies that are providing similar land products to MODIS.

Currently EOS identifies three types of products:

- **Beta**: The code is running with known issues;
- **Provisional:** Known problems are identified, product intercomparison and validation are underway; and
- **Validated**: Product accuracy has been determined.

The Land group has proposed a breakdown of the different stages of Validation. As part of the process of validation, estimates of accuracy and product uncertainty are obtained through comparisons with independent data. The extent of validation and attendant confidence in the products are described below. For a product to be determined as validated, the results of the product validation need to be published or be in the process of being published in the peer-reviewed literature. It is also important that the associated validation data are openly available for others to check or improve the validation. Scientific use of the product is recommended and encouraged commensurate with the stages of validation achieved. The proposed stages of validation are listed below.

- **Stage 1 Validation**: Product accuracy has been estimated using a small number of independent measurements obtained from selected locations and time periods and ground-truth/field program efforts.
- **Stage 2 Validation**: Product accuracy has been assessed over a widely distributed set of locations and time periods via several ground-truth and validation efforts.
- **Stage 3 Validation**: Product accuracy has been assessed and the uncertainties in the product well established via independent measurements in a systematic and statistically robust way representing global conditions.

These clarifications on the validation process and stages of validation are now being implemented for MODIS products by the MODIS Science Team. The Land Group believes that validation needs to become a mainstream activity for NASA and those agencies providing derived satellite data products. It is also important that validation data be made available to the broader community. The Land Group hopes that the validation approaches developed for MODIS will be adopted for products to be generated from NPP VIIRS. The Land Team is very much concerned that the planned NPP VIIRS instrument retains significant advances achieved by MODIS for Land monitoring in terms of the instruments, improved products, and data system.

Overall, the Land Discipline Group believes that MODIS is an outstanding instrument with excellent data products available for land science. The data from Aqua MODIS, though still new, look extremely promising. Data production overall has stabilized, however, the team is keeping an eye on how much of an impact the ramp-up of Aqua data processing will have. Although this was not originally envisioned as a major focus role for the Science Team, attention is shifting to critical issues of data distribution and data use. And while user awareness of the products is increasing, it needs to be broadened through continued outreach efforts and facilitated by the provision of data analysis tools.

## MODIS Oceans Team Summary

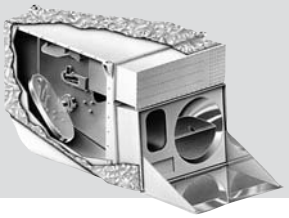
*continued from page 11*

outputs when using various chlorophyll input products. Extrapolated annual OPP varied by 20% depending on input chosen. This will be updated using the new SeaWiFS Repro 4.

**Chris Brown** reported that NOAA Coastwatch is now providing MODIS chlorophyll and SST images and data with a several hour delay for the full U.S. coastal region, using the basic , MODAPS Product Generation Executive (PGE) software. This provides a good basis upon which to build for the next generation Visible Infrared Imager/Radiometer Suite to fly on National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project which is a precursor to NPOESS.

# MODIS Vegetation Workshop Report

— *Steven W. Running, swr@ntsg.umt.edu, University of Montana*



The Land Science Team for the NASA Earth Observing System Moderate Resolution Imaging Spectroradiometer (MODIS) sensor [*modis-land.gsfc.nasa.gov/*] held a special workshop to present analysis of the first year (2001) of MODIS satellite data.

Although the Terra satellite was launched on December 18, 1999, platform initiation and sensor calibration activities precluded science quality data from being delivered for much of 2000. The year 2001 is the first complete year of data collection for the MODIS sensor, allowing a first look at the entire growing season sequence for the terrestrial vegetation variables. A recent MODIS Land Workshop was convened July 16-18, 2002, at the University of Montana in Missoula to present first results and progress with measurements of these vegetation variables. The workshop was attended by 140 scientists from 13 countries and 30 states. The focus of the workshop was on Vegetation Indices, (VI), Leaf Area Index (LAI), Fraction-absorbed Photosynthetically Active Radiation (FPAR) and Net Primary Production (NPP). The MODIS Land Science team and relevant EOS Data Centers covered step-by-step details of the processing, distribution, analysis, and interpretation of the MODIS vegetation variables. The workshop also included hands-on computer labs to take a user through details of data ordering, reprojection, reformatting, and other technical tools. Proceedings of the workshop are also available on line at *www.forestry.umt.edu/ntsg/MODISCon/*. The site contains all Powerpoint talks presented, and video clips of each of the authors introducing their presentations.

Complete processing of the MODIS Land variables is now occurring within 5 days of acquisition. Details of the Level 1 and 2 processing are important to the final quality and utility of the Level 3 and 4 vegetation algorithms, so **Robert Wolfe** (NASA Goddard Space Flight Center) covered sensor calibration, geolocation, land/water masking, cloud screening, aerosol corrections, and gridding details. The MODIS Vegetation variables are archived and distributed by the EROS Data Center (EDC). Full details on ordering MODIS data, reformatting and reprojection issues, and initial data analysis were covered by **John Dwyer** (EDC).

The Vegetation Indices, presented by **Alfredo Huete** (Univ. of Arizona) are the heritage of the widely used Advanced Very High Resolution Radiometer (AVHRR) Normalized Difference Vegetation Index (NDVI). MODIS radiometric sensitivity and spectral wavelength locations are both superior to AVHRR, so an identical NDVI cannot be computed simply. However, the time series of AVHRR NDVI from 1981 to the present is essential to global-change science, so MODIS must produce an equivalent for continuity. Huete explained the MODIS continuity Vegetation Index and the efforts his team is making to merge the AVHRR and MODIS data records. MODIS land spectral channels were chosen specifically to avoid atmospheric absorption features, and target known regions of leaf pigment absorption and reflectance. So, a MODIS enhanced vegetation index has also been derived to optimize use of these features. The continuity NDVI and Enhanced VI were compared against the AVHRR NDVI for an array of intensive study sites in the U.S.

LAI and FPAR are advanced biophysical variables used to define vegetation in climate, hydrologic, and biogeochemistry models. LAI and FPAR quantify the vegetation energy exchange and mass transfer characteristics important to weather forecasting and carbon cycle models. LAI is a measure of leaf biomass, while FPAR is a radiometric measure of light absorption. In canopy radiative transfer modeling, these variables are solved together, as explained by **Ranga Myneni** (Boston University). LAI ranges from near zero in deserts to a maximum of 10 in large tropical and temperate forests. In annual croplands and grasslands, LAI can begin in the spring at zero and grow to LAI of 5-6 within three months at the peak of the growing season. Algorithm assumptions and details were covered, and

field validation for 2001 from sites in South Africa, Finland, Massachusetts, and Wisconsin were presented.

NPP is the biomass growth of vegetation measured over a specific time period. NPP is effectively the beginning of the carbon cycle, quantifying the mass of carbon fixed into living plant tissue. NPP also provides a practical measure of the food, fiber, and fuel of vegetation consumed by humans. The MODIS NPP algorithm uses a commonly used production efficiency logic, where the photosynthetically active radiation absorbed by the vegetation canopy, (computed from the FPAR variable above) is transformed by a conversion efficiency term to give vegetation biomass. Climatic constraints based on known physiological responses by plants to low air temperature and desiccating humidities are derived from a daily surface meteorology datastream from the NASA Goddard Data Assimilation Office. A daily photosynthesis is computed, and summed to an 8-day NPP output product. **Steve Running** (University of Montana) presented the MODIS NPP algorithm and the array of validation activities underway, predominantly using the global FLUXNET network of eddy-covariance $CO_2$ flux towers,

A number of other MODIS land variables are relevant to vegetation sciences but were not the focus of this workshop. Summary presentations were given for Landcover by **Alan Strahler** (Boston University), Vegetation Continuous Fields and Fire Products by **John Townshend** (University of Maryland), Evaporation Index by **Rama Nemani** (University of Montana), and Snow Products by **Steven Running**.

The MODIS Land Team participates in a range of validation activities for these vegetation variables. The overall validation strategy for the team, presented by **Jeff Morisette** (NASA Goddard Space Flight Center) includes a global array of core validation sites where selected measurements are regularly made. The Oak Ridge Data Center hosts a wide array of terrestrial validation data sets for the MODIS vegetation variables, summarized by **Dick Olson**. The Bigfoot Project attempts to quantify the scaling problems that arise when comparing field vegetation measurements of LAI and NPP, often collected on 0.1 ha plots, to MODIS data at 1-km-pixel resolution. The Bigfoot logic, presented by **Warren Cohen** (Oregon State University) entails statistically sampling the landscape based on preclassified high-resolution imagery such as Landsat at 30 m, then aggregating the field samples proportionally to reach a 1-km effective measurement. The Bigfoot Team has so far sampled boreal forest, deciduous forest in Massachusetts, Midwest cropland, and a Wisconsin mixed evergreen forest, with future sites planned in the New Mexico desert, Amazon rainforest, and Barrow tundra.

The FLUXNET project is an organized network of over 180 eddy-covariance $CO_2/H_2O$ flux towers located around the world. This network, initiated by the International Geosphere-Biosphere Program, measures atmospheric eddies and $CO_2$ concentrations every few seconds to estimate the net $CO_2$ balance of the land surface. The flux measurements operate continuously, all year-around, and quantify photosynthetic uptake of $CO_2$ during the day, and respiratory losses at night. **Bev Law** (Oregon State University) is Chair of Ameriflux, the North American flux network, and presented the technical details of eddy covariance measurements, and annual carbon flux comparisons for a variety of sites in North America.

The presentations of every speaker identified here are on the electronic proceedings website at *www.forestry.umt.edu/ntsg/MODISCon/index.html*. The workshop also featured over 40 posters by workshop attendees using the recent MODIS data and vegetation variables. These posters are also on the workshop website.

# Summary of the Third International Workshop on Multiangular Measurements and Models (IWMMM-3)

— *Anne Nolin, nolin@spectra.colorado.edu, University of Colorado – Boulder*
— *David Diner, David.J.Diner@jpl.nasa.gov, NASA Jet Propulstion Laboratory*

## Introduction

The Third International Workshop on Multiangular Measurements and Models (IWMMM-3), cosponsored by NASA and the Department of Energy (DOE), was held in Steamboat Springs, Colorado, June 10-12, 2002. Attended by 85 Earth System scientists from over a dozen countries, this workshop served as an international forum for discussion among the growing community of those benefitting from multiangular research. The overall goal of the IWMMM-3 was to present and promote the advantages of multiangular observations and modeling in addressing key questions in Earth System Science. The primary focus of this workshop was to assess the impacts and uniqueness of multiangular contributions to improving our understanding of the variability, forcings, responses, and consequences of changes in the Earth system. Towards this end, the workshop had the following specific themes:

- The unique and innovative contributions of multiangular data to Earth System Science.
- Evaluation of radiative transfer models and inversion methods.
- Where do we go from here? Assessment of accomplishments and a view to the future.

These themes were designed to appeal to the broader community of Earth System scientists, not just those who are already involved in the multiangular community. The emphasis was on synergy and fusion of observations and models to address questions relating to changes in the Earth system. With the acquisition of satellite-based multiangular measurements in recent years, we are now in a position to evaluate the contributions of multiangular measurements and models to key questions in Earth System Science. This workshop's themes represent a shift in priorities from previous workshops that emphasized more the methodological aspects.

## Day 1: Keynote Presentations, Poster Session, and RAMI-2 Talk

After introductory remarks by conveners **Anne Nolin** (University of Colorado) and **Dave Diner** (NASA Jet Propulsion Laboratory [JPL]), Diner led off the keynote presentations by describing the Muli-angle Imaging SpectroRadiometer's (MISR) abilities to map and characterize aerosols, to discriminate between snow and clouds, and to relate bidirectional reflectance signatures to vegetation structure, ice texture, post-earthquake surface liquefaction features, and wetlands vegetation.

**Marc Leroy** (Centre Nationale d'Etudes Spatiale [CNES]/MEDIAS - France) next described "lessons learned" from the Polarization and Directionality of the Earth's Reflectances (POLDER) instrument and covered POLDER accomplishments such as distinguishing cloud water phase and measurements of the hot spot over vegetation and soil.

**Peter North** (University of Wales) presented an overview of the 11+ year time series of data from the Along Track Scanning Radiometer (ATSR). He described various geophysical parameter retrievals such as sea-surface temperature (SST) to within about 0.2 K, aerosol optical thickness retrievals to about 0.02 (at 550 nm), and land surface reflectance. North also discussed cloud stereo mapping and parameter retrievals. Future efforts will add retrievals of land surface temperature biophysical parameters such as Leaf Area Index (LAI).

**Roger Davies** (NASA JPL) demonstrated how MISR angular data can be used to derive cloud-top heights and height-resolved cloud-motion wind vectors, to detect thin cirrus over snow and ice, to characterize cloud texture for classifications, and to identify cloud heterogeneity. This last point represents a paradigm shift in that the multiangular data can be used to indicate when one-dimensional (1-D) radiative transfer (RT) theory is applicable and when three-dimensional (3-D) theory must be used.

**Steve Warren** (University of Washington) wrapped up the morning session with a presentation on bidirectional reflectances over snow surfaces. He described the problems of correcting albedo retrievals for surface roughness effects such as over sastrugi (wind erosion features on snow). He also

showed how homogeneous snow surfaces that don't melt in summer (such as the high portions of Antarctica and Greenland) are excellent satellite calibration targets.

The afternoon was spent in an extensive poster session with presentations covering a wide range of innovative applications including: mapping coastal wetlands vegetation; surface roughness and albedo of snow, glaciers and ice sheets; parameterization of vegetation structure; hot spot measurements; mapping and characterization of clouds and aerosols; new instrumentation; and model inversion approaches.

Day 1 concluded with an evening session led by **Bernard Pinty** (European Union Joint Research Centre [EU-JRC]) that focused on the results of the second phase of RAdiation Model Intercomparison (RAMI-2). The RAMI-2 exercise involved both 1-D and 3-D radiative transfer models for simulating the spectral bidirectional reflectance of carefully specified vegetation scenes, including spectrally and structurally heterogeneous scenes. Model results were carefully compared and their variability quantified. While model deviations with respect to an ensemble average provide information on overall variability, these are difficult to interpret in the presence of outliers. In addition, the results strongly depend on the models that are participating in the RAMI exercise. Results from RAMI-2 will be published in the coming year.

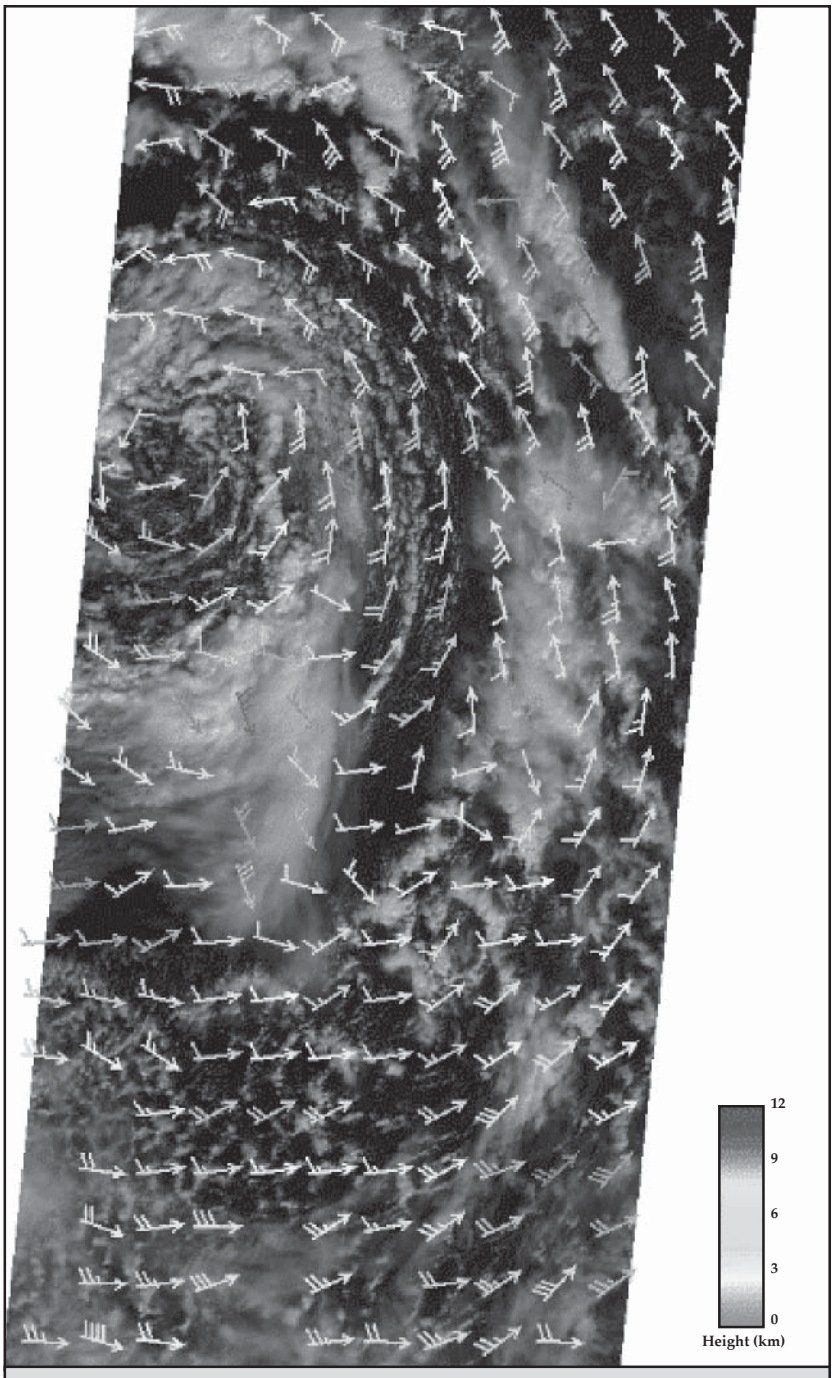



**FIGURE 1**. MISR cloud motion winds are derived from MISR's multiangular cloud stereo capabilities and displacement measurements. This figure shows an Arctic cyclone with height resolved wind speeds and an enhanced spatial resolution of 35.2 km. **Image Credit**: A. Horvath and R. Davies, original in color.

### Day 2: Keynote Presentations and Breakout Group Discussions

**Robert Cahalan** (NASA Goddard Space Flight Center [GSFC]) opened the Day 2 keynote talks with a presentation that covered albedo bias in the plane-parallel model representation of clouds, the scaling properties of clouds, and sources of atmospheric absorption that are neglected in models. He also gave an overview of results from the Intercomparison of 3-D Radiation Codes (I3RC). The study finds that exact RT models, such as Monte Carlo and Spherical Harmonic Discrete Ordinate Method (SHDOM) simulations, agree very well while other inexact models do not.

**Alan Strahler** (Boston University) described various Moderate Resolution Imaging Spectroadiometer Bidirectional Reflectance Distribution Functions (MODIS BRDF) and albedo products that are currently available. In general, the MODIS albedo values agree closely with in situ albedo data from the surface radiation monitoring (SURFRAD) sites (rms error of 0.02), except over snow-covered land. He announced upcoming MODIS albedo workshops to be held October 21-24, 2002 at Boston University.

**Bernard Pinty** followed with a presentation on using multiangular data to characterize surface heterogeneity in vegetation. In this case, he was able to identify metrics that correspond to rough vs. smooth and sparse vs. dense vegetation and went on to relate these metrics to ground-based and MISR measurements.

**Rob Braswell** (University of New Hampshire) spoke on his innovative use of MISR data for detailed land surface assessments in Amazonia and biophysical characterization in the White Mountains of New Hampshire. Multivariate analyses showed that the textural information provided by MISR was required to reduce classification errors and to derive ecological information.

**Alexander Marshak** (NASA GSFC) showed that multiple reflections between a vegetated surface and broken clouds can be exploited to retrieve cloud optical depth from ground-based radiance measurements. This promising method is highly sensitive to surface albedo variations, and thus, MISR and MODIS surface albedo data are very helpful.

**Yuri Knyazikhin** (Boston University) concluded the keynote presentations and described a missing solution to the radiative transfer equation and its effect on estimating the reflection/absorption properties of vegetation canopies and clouds.

The afternoon sessions consisted of two breakout discussion groups. Participants divided themselves into Atmosphere (led by **Yves Govaerts**, European Organization for the Exploitation of Meteorological Satellites [EuMetSat]) and Land Surface (led by **Crystal Schaaf**, Boston University) and worked to address the following topics:

- Unique and innovative contributions of multiangular data to improving our understanding of variability, forcings, response, and consequences of change in the Earth system.
- Scaling issues in multiangular modeling and measurements of the Earth system including 3-D structure.
- Synergies with other methods of observation including multi-instrument approaches, and synergies between measurements and models.

Results of these breakout sessions were presented on Day 3.

## Day 3: Visualization Tools, Breakout Summaries, and Panel Discussion

The morning of the final day began with demonstrations of tools for visualizing multiangular data and model output. **Jean-Luc Widlowski** (EU-JRC) showed an Interactive Data Languate (IDL)-based tool for visualizing land surface BRDF. **François-Marie Bréon** (Centre National de la Recherche Scientifique [CNRS]) demonstrated another IDL-based tool for visualizing POLDER products including hot-spot measurements and polarized images. **Roger Davies** showed his IDL-based tool for visualizing cloud heights and motions from MISR. **Peter White** (Canada Centre for Remote Sensing) demonstrated an Excel-based modeling tool that is targeted for farmers, foresters, and other practical users interested in transforming measurements of surface bidirectional reflectance into physical parameters such as LAI, etc. **Dave Diner** finished the session with three-dimensional and multiangular visualizations of MISR data showing cloud heights in stereo, hurricane and vortex winds, smoke plumes from wildfires, and motions of Antarctic glaciers.

The remainder of the morning was spent with presentations of the breakout group summaries by the breakout group leaders and open discussion between the two groups.

The **Atmospheres breakout group** identified a number of unique applications of multiangular data for improved mapping and characterization of clouds and aerosols. One area where MISR data have succeeded extremely well is in cloud discrimination over polar snow/ice surfaces. This is important for polar climate (radiative forcing and surface-atmosphere interactions), where even the natural variability of polar cloud coverage is poorly known. Cloud-height-resolved winds, derived from the MISR cloud stereo product, provide a proof-of-concept for potential assimilation of such data into numerical weather prediction models for improved forecasting. Cloud structural parameters (e.g. aspect ratio, internal cloud variability), needed for large-scale

albedo and energy balance studies, can be determined from multiangular measurements. MISR can identify regions and times when traditional 1-D cloud property retrievals may be trustworthy and can help provide corrections for 3-D effects. A multiangular approach can discriminate between spherical droplets (sulfate, sea salt, etc.) vs non-spherical mineral dusts. This has the potential to distinguish anthropogenic vs. natural sources, and determine the direct radiative impact of mineral dust. Multiangular data also provide a unique means of discriminating between aerosols and sub-visible cirrus. This has major implications for mapping heretofore unknown global and seasonal distributions of sub-visible cirrus clouds and their impact on large-scale energy budget and climate. Lastly, multiangular approaches allow aerosol retrievals over bright, non-vegetated surfaces such as deserts, urban areas, and possibly snow/ice. This has applications for monitoring urban pollution and Arctic haze, as well as for improving atmospheric characterization over desert regions for military purposes.

The **Land Surface breakout group** identified a number of significant achievements from multiangular remote sensing and modeling. First and foremost, multiangular data and products are flowing from MISR, POLDER, ATSR, and MODIS with new applications being identified and promising leads being followed. Examples of these new applications include mapping surface roughness on ice sheets for improved characterization of glacier facies and discrimination of vegetation community types within biomes (e.g., wetlands vegetation mapping). Currently, large-scale vegetation maps do not resolve widespread but fine-scale features such as wetlands and human-induced land changes (e.g., logging). Vegetation and ecosystem structural parameters are extremely important for understanding biosphere-atmosphere interactions and multiangular data can potentially resolve these. Vegetation structure can be derived using angular signatures from sensors such as MISR. However, appropriate parameterizations of structure need to be developed. For instance, carbon flux models need a structural parameter that relates openings in canopies to canopy height. Such models also would also benefit from potential multiangular capability to separate measured reflectance into its understory/overstory components.

The workshop wrapped up with a panel discussion that was tasked to address several questions. Panelists included **Yves Govaerts**, **François-Marie Bréon**, **Michel Verstraete** (EU-JRC), **Alan Strahler**, **Dave Diner**, and **Ian Grant** (Commonwealth Scientific and Industrial Research Organization [CSIRO]) and was moderated by **Anne Nolin**. The first question asked the panelists to *examine past accomplishments and how we could build on them*. The main accomplishments were a plethora of new spaceborne data and increased model sophistication (3-D, multiangular). Building on these will require key case studies in which we identify the consequences of having multiangular data. There is a continuing need to focus on Earth System Science questions and to further engage the climate, ecology, and air quality communities. In addition, the multiangular community needs a better understanding of synergies between measurements made with different instruments (POLDER, MISR, ATSR, MODIS, and Synthetic Aperture Radar [SAR]).

The second question addressed by the panelists was *"What do we need to ensure that the multiangular community has the necessary resources to accomplish the recommendations described above?"* The consensus was that outreach to the broader science community is key. An important part of this is demonstrations of the value of a multiangular approach. Case study applications are needed and will help increase visibility and understanding of the relevance of the multiangular approach. The broader Earth System Science questions require large-scale studies while local/regional scales are important for agriculture, watershed hydrology, and other smaller scale applications. Outreach would also be facilitated by developing a website to act as a clearinghouse for multiangular information.

Lastly, the panel and workshop participants listed *recommendations for IWMMM-4*, tentatively scheduled for Australia in 2005. Along with general and technical sessions, the next workshop will include tutorials and workshops for new users, presentations from a wide range of investigators, especially those from the climate and ecological modeling communities, and structured comparisons of multiangular products with the aim of quantifying the benefits of multiangular data.

For more information on the conference including themes, abstracts, and a list of participants, please see the website at *cires.colorado.edu/iwmmm-3*.

# Report from a Workshop on Regional-to-Global Pollution

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*In May 2002, NASA Goddard Space Flight Center's (GSFC) Laboratory for Atmospheres sponsored a Workshop on the topic "Interactions of Urban Pollution with the Regional and Global Environment." The Workshop, attended by 80 researchers in atmospheric chemistry, air quality, and remote sensing, was held at the NASA Goddard Visitor's Center in Greenbelt, Maryland. The Organizing Committee consisted of Anne Thompson, Paul Newman, and James Gleason (all at GSFC), and William Brune (Penn State) and Russell Dickerson (University of Maryland-College Park).*

Atmospheric chemistry and the study of pollution are at a crossroads. Traditionally, communities have investigated distinct issues, e.g., regional air quality, intercontinental transport, microscale and molecular processes, global remote sensing, and gas-particle-climate connections. At the same time, the links between climate change and atmospheric chemistry have become clearer. Changing climate—perturbed temperatures, cloud properties, aerosol distributions, precipitation patterns—will affect the Earth's chemical composition, just as changes in trace gases (e.g., ozone) and aerosol distributions are among the major forcings on the Earth's radiation budget [**Hansen et al., 2000**]. Thus, integrated strategies bridging local, regional, and global scales and observing and modeling capabilities are required (see **Figure 1**). The purpose of the Goddard Workshop was for the atmospheric community to survey progress in measurement and modeling capabilities and to identify the most pressing uncertainties and research needs (National Research Council, 2001).

Progress in a number of areas was noted in four plenary talks with shorter presentations on related topics. The first two plenary talks and associated presentations were "regional" and the focus was on multi-disciplinary experiments conducted in the U.S. **Spyros Pandis** (Carnegie-Mellon University) described measurements and models—primarily for aerosol composition, source evaluation and transformation—as they were used in a regional air quality experiment, the Pittsburgh Air Quality Study (PAQS). Experimental foci on Atlanta (**Ted Russell**, Georgia Tech) and the mid-Atlantic (**Russ Dickerson** and **Ray Hoff**) presented similar issues to the PAQS study but with greater emphasis on the role of biogenic chemicals and region-to-region tracking of pollution transport. A plenary talk by **James Meagher** (NOAA/Aeronomy Laboratory) included an overview of the 1999 Nashville Southern Oxidants Study and the massive TexAQS2000 experiment, with measurements from the ground, from balloons, and from

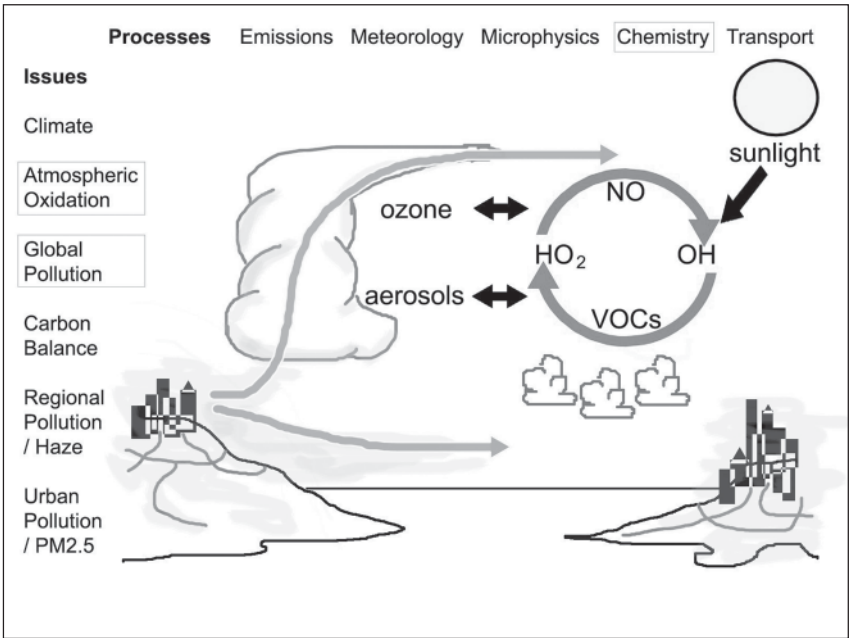


**FIGURE 1**: A number of fundamental processes (listed across the top) must be considered in understanding interactions in regional-to-global pollution. These processes cut across a wide range of important issues (listed down the left side).

aircraft. TexAQS2000 showed that Houston's prominence in the petrochemical industry helps make it the current "ozone capital" of the US. Highly reactive Volatile Organic Carbons (VOCs) in Houston appear to be underestimated [**Kleinman et al., 2002**].

Recent advances in aerosol composition and sizing have enabled observations of particle formation and particle-growth events and of chemically speciated size distributions (**Manjula Canagaratna**, Aerodyne). **William Stockwell** (Desert Research Institute) reported on models and measurements of ozone, nitrogen oxides, and nitrate aerosols from western U.S. experiments. **Danny McKenna** (National Center for Atmospheric Research) described the airborne Canadian TOPSE (Tropospheric Ozone Production about the Spring Equinox, 2000) experiment and emphasized the role that stratospheric-tropospheric interactions play over North America during the March-April period [**Browell et al., 2002**].

At larger scales, international campaigns with multiple platforms, state-of-the art measurements and models have confirmed the role of country-to-country and intercontinental transport [**Thompson et al., 2001**]. Examples were shown from last year's Transport and Atmospheric Chemical Evolution-Pacific (TRACE-P) and Aerosol Characterization Experiment (ACE) - Asia by **Gregory Carmichael** (University of Iowa), **James Crawford** (NASA/Langley Research Center) and **Mian Chin** (Georgia Tech/NASA-Goddard). Strong regional impacts from India were observed in the 1999 Indian Ocean Experiment (INDOEX) campaign, described by **Russell Dickerson** (University of Maryland). Very long-range transport of pollution vented out of the boundary layer leads to near-global pollution in the tropics (**Robert Chatfield**, NASA/Ames). The large database from ozone-instrumented commercial aircraft showed that ozone profiles at Johannesburg, South Africa, can be classified into populations that correlate with distinctive synoptic conditions (**Roseanne Diab**, University of Natal-Durban). Satellite data displaying source regions (as from the Global Ozone Monitoring Experiment (GOME)[**Randall Martin**, Harvard]) and transport of CO (as from Measurements Of Pollution In The Troposphere (MOPITT) [**David Edwards**, NCAR]) point to the future when, it is hoped, a geostationary satellite with pollution detection can track megacity and large-scale pollution minute by minute. **A step toward the reality is NASA's Aura satelite, scheduled to launch in 2004. Annmarie Eldering** of JPL described Aura's capabilities.

Although it has become easier to distinguish sources, sinks, transport, and ozone precursor-production relationships with better instrumentation and models, it is still a challenge to capture urban- and regional-scale transport and chemical transformations in global models. **Kenneth Pickering** (University of Maryland) showed a stretched-grid model in which a meso-scale mesh can be embedded in a global coupled-chemical-transport model. Another challenge is adequate knowledge of emissions. **Prasad Kasibhatla** (Duke University) showed that inverse modeling is one approach to identifying potential inaccuracies in emissions.

In a summary presentation, **William Brune** used OH and $HO_2$ data and models to emphasize the fact that uncertainties affect the full matrix of issues (urban-regional-global-period of climate change projections) and the processes shown in the Figure. The nonlinearity of oxidant formation (OH, $HO_2$, ozone) has long been a challenge in predictive models. Instruments to measure the OH and $HO_2$ radicals are a breakthrough but the agreement between observations and models varies greatly, depending on numerous factors. These differences suggest that the interactions among atmospheric chemistry, microphysics, gaseous pollutants, and aerosols deserve much more attention for a wide variety of spatial and temporal scales.

**Acknowledgments**. The Workshop Organizers thank Goddard Space Flight Center, its Laboratory for Atmospheres, and the Goddard Visitor Center Staff for facilities and financial support. Thanks also to: all attendees for enthusiastic participation; to **Jacquelyn Witte** (SSAI at NASA/Goddard) and **Vickie Connors** (NASA/Langley) for assistance with this article; and to **Mary Floyd** of Westover Consultants for Workshop logistics.

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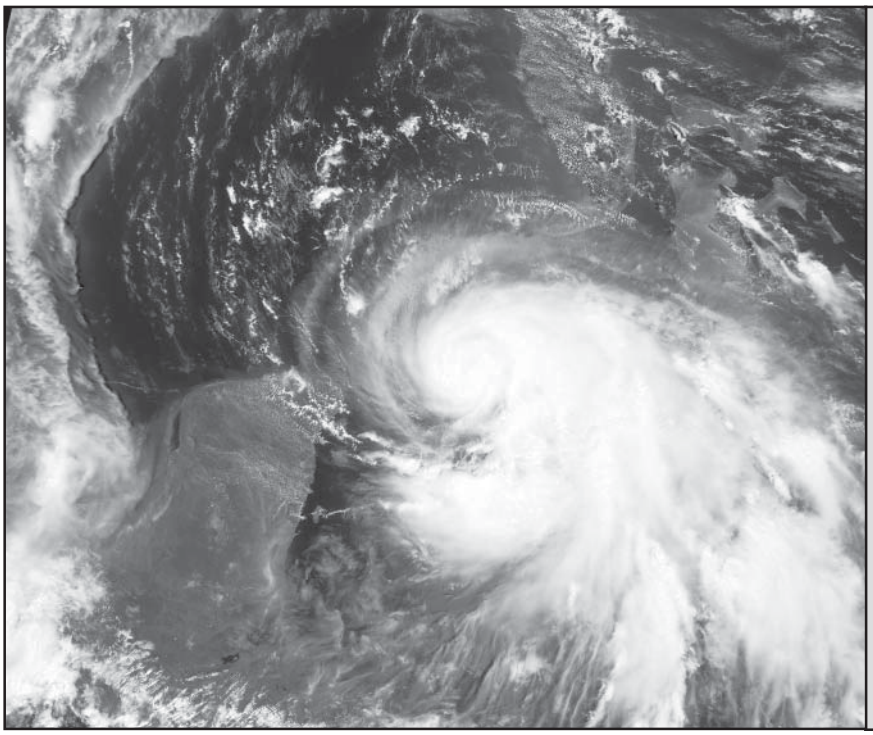
## *Kudos: EOS Colleagues Named Senior Fellows*

The following EOS colleagues were selected as Goddard Senior Fellows and joined the ranks of "senior Goddard employees who have demonstrated the highest level of achievement for scientists and engineers. They are involved in space related research and development with a distinguished record and strong potential for continuing contributions to the nation's space program."

- **Dr. Yoram Kaufman**, former Senior Project Scientist for Terra
- **Dr. Vincent Salomonson**, Team Leader for the MODIS instrument

The Earth Observer staff and the entire EOS community would like to congratulate these colleagues on their outstanding achievements.



**MODIS views Hurricane Isidore**. The Moderate Resolution Imaging Spectroradiometer (MODIS) aboard NASA's Terra satellite acquired this image of Hurricane Isidore at roughly 11:30 AM local time, September 20, 2002. At this time, Isidore was a weak Category 3 storm. It raked into western Cuba with sustained winds of 105 mph. Isidore later crossed the Yucatan peninsula of Mexico and weakened to a Tropical Storm as it passed over the rugged mountains in that area. It eventually reemerged into the Gulf of Mexico and struck the Louisiana coast as a strong Tropical Storm - just below hurricane status. The remnants of Isidore continued northeast and brought flooding rains to parts of the southeastern United States already saturated by abundant rainfall this summer, but welcome rains for the Ohio Valley and Mid-Atlantic states that have been experiencing severe drought. **Image Credit**: Terra MODIS data captured by direct broadcast at Louisiana State University and processed at the University of Wisconsin-Madison by Liam Gumley, Space Science and Engineering Center.

# Summary of Earth Science Enterprise Outreach Workshop

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— *Jim Closs, jim_closs@seada.com, NASA Goddard Space Flight Center, SSAI*

*On August 29, 2002 a group gathered in Seabrook, MD, to discuss education and public outreach activities in the Earth Science Enterprise (ESE). The meeting was intended to provide a broad overview of the outreach activities that are ongoing in ESE and bring together a representative group of those activities. The meeting was an extremely successful first step and it is intended that future workshops will be held to discuss some of the issues that arose during the course of the meeting in greater detail. These minutes present summaries of all presentations given at the workshop.*

## Introduction

**Jim Closs** chaired the meeting and provided opening remarks. The one-day format is too short to go into a great deal of detail about any one program. Each presenter gave a brief synopsis of their activities and further discussion is possible on line or in subsequent meetings. (Closs anticipates follow-on meetings that will go into greater detail on specific aspects of outreach.)

## The Big Picture

**Greg Williams** (NASA Headquarters, Code Y) was the first speaker. Williams presented an overview of the ESE outreach strategy and goals. His view is that NASA ESE has a very important story to tell, but that as of yet, very few people know it. He reviewed the NASA mission and vision statement. The key phrase to emphasize in the mission, *"As only NASA can."* The idea is that NASA is uniquely prepared to fulfill the mission it has. No other agency can fulfill the role that NASA fulfills. Earth Science has the "pole position" in NASA's new mission statement, which presents a tremendous opportunity for us. NASA's overall mission and goals flow very nicely into the mission and goals of the ESE. The research plan, with its five overarching science questions, is designed to help ESE meet its goals and fulfill its mission. Our outreach and education activities need to reflect this idea.

The new NASA Administrator, Sean O'Keefe, is emphasizing that the agency should present a unified image. This idea of *"one NASA"* needs to be reflected in the outreach and education activities that ESE designs. Williams continued to talk about the subject of outreach and discussed the various areas, listed what group is leading each area, and listed some activities in each category. His diagram illustrates that many of these target audiences have overlapping needs, and there needs to be coordination between activities to develop outreach products with these various uses in mind. One of the most important needs is strategic communications. Strategic communication involves communicating to people who ultimately either decide if NASA receives continued funding or who advise the people that will make these decisions on why it is vitally important for NASA to continue to do what it is doing.

The agency and enterprise mission and goals should be reflected in ESE publications. More generally, all ESE communications need to reflect a unified purpose, namely, pointing to the value of what the enterprise is doing. They should present a simple, coherent, and appealing message about Earth System Science. Williams commented that there is much negative publicity surrounding Earth science studies and that ESE publications need to counteract these ideas with the truth about the value of ESE programs. In contrast to all the bad news people hear about the environment, they need to hear from us the positive contributions NASA is making through scientific observation of the Earth. They need to show how scientific data leads to societal impact and back again. NASA/ESE does not do a mission just to do a mission—as highlighted by the Earth Observatory website (see page 25 of this issue.) There are specific goals that will be obtained and socioeconomic benefits that will be derived.

With the remainder of his presentation, Williams briefly presented some ideas on an investment strategy and proposed some guidelines to follow when creating publications. For example, all of our products ought to include the NASA logo and the name "Earth Science Enterprise." He reminded all the attendees that he holds a weekly

telecon on outreach at 11 AM on Wednesdays and invited everyone to participate.

Williams closed by showing a diagram (not included) conveying C.S. Lewis' ideas on how we effectively influence people to make decisions on matters we care about. Lewis's experiences taught him that the first step to getting people to seriously consider your ideas is to capture their imagination, then use this stimulus to engage their minds and reason with them, and finally penetrate their will. Lewis felt it unreasonable to expect peoople to instantly listen to what you have to say without first working with them to engage their imagination and minds. The process takes time and effort. Williams feels our goal with outreach and education is very similar. ESE outreach is intended to change (or perhaps create for the first time) people's perceptions about the importance of Earth System science. To do this, there is a need to first capture their imagination and engage their minds about what is possible in this area. Then, people will be much more receptive to the message ESE is trying to convey and better understand how vitally important these issues are to society.

**Anita Davis** (ESE Lead for Informal Education, NASA Goddard Space Flight Center) spoke about the ESE Informal Education Strategy and also reviewed the role of the ESE Informal Education Office. ESE defines informal education as lifelong learning outside of formal education, characterized by a methodology known as Interpretation. To date, there is no structured plan for informal education in NASA as there is for formal education; however, a plan is being formulated. A draft strategy has been prepared which defines criteria for selection for all education efforts of the Enterprise Education Office. In the plan, informal education is sub-divided into five categories: informal learning centers (museums and zoos for example); natural and cultural history sites; libraries; multiple media (the web and newscasts for example); and community/youth groups. The ESE education plan emphasizes a theme-based approach to learning. For example, the science questions that form the basis of the NASA Research Plan can serve as themes for development of education efforts, projects, and products.

## ESE Data/Service Provider Reviews

**Jennifer Farnham** (EOSDIS Outreach Coordinator) presented information regarding EOSDIS and DAAC Alliance Outreach and the respective roles of both EOSDIS and the User Services Working Group (USWG) within this collaborative effort. Farnham reviewed EOSDIS's outreach goals and mission, and further discussed both current and future outreach plans—including a new "Road-Show Series" plan for outreach to universities. This venue represents more of a grass-roots outreach effort, bringing valuable EOSDIS and DAAC Alliance resources to the audience. This newly proposed venue is designed to engage a targeted audience of both undergraduate and graduate students pursuing their studies in various Earth science disciplines. Other topics included discussion of target audience, primary products and services, and metrics for evaluating performance.

**Betsy Sheffield** (NSIDC, USWG Outreach Lead) was a co-presenter with Farnham and provided information concerning the collaborative efforts between EOSDIS, the DAAC Alliance, and other NASA ESE entities. Sheffield also highlighted DAAC-specific outreach, showcasing several of the Data Center specific venues and outreach materials or products that have been well received by both the general public and the smaller group of people who actually use this information on a regular basis.

**Dave Jones** (Stormcenter Communications, Inc., President of the Federation of Earth Science Information Partners [ESIP]) gave the workshop participants an idea of where the Federation has been, but more importantly, where it is headed. Jones was elected ESIP Federation President in May of this year and feels the Federation has been doing good things among its partners up to this point and is ready to show significant growth for the broader Earth-Science community beginning now. The goal of the ESIP Federation is to establish and continuously improve science-based end-to-end processes that increase the quality and value of Earth science products and services throughout their life-cycle for the benefit of the ESIP Federation's stakeholder communities. Jones explained that to understand an issue, one must first collect data and information about the issue, then produce results and ideas about the issue, and finally deliver the information and data in a timely fashion to a broad audience. In the case of the Federation, the issue is the condition of our home planet. Thus, the Federation works to collect, produce, and deliver information about the condition of planet Earth.

Jones briefly reviewed the list of partners involved in the Federation. Originally, 24 organizations were involved and that number has grown

considerably to 42 organizations. The partners in the Federation are divided into three categories. The divisions are somewhat arbitrary but they attempt to divide the participants according to what aspect of understanding (collecting, producing or delivering) is their main focus.

Jones next discussed outreach goals for the Federation. The Federation seeks to have the broadest possible impact on society with its products. The Federation has a Standing Committee for Community Engagement whose purpose is to focus on these sorts of activities. They seek to increase the use of Earth Science data in our daily lives, expand the scope and range of uses and applications of such data, and communicate its value to stakeholders. The Federation also seeks to foster opportunities for collaborative efforts between partners and to develop educational materials that are appropriate for all ages.

Jones also talked about the newly formed ESIP Foundation and its executive director, Dick Wertz, who will be helping the Federation develop a five-year strategic plan to help the Federation establish priorities. Jones is very excited about the future of the ESIP Federation and the impact it will have in helping to collect, produce and deliver quality science information to a broad range of users for the betterment of society.

**Heather Weir** (SSAI, Global Change Master Directory[GCMD]) spoke about outreach efforts at GCMD. Weir quickly reviewed the features of the GCMD. She then touched on the primary outreach products and services. The user audience for the GCMD includes researchers and scientists, educators, students, and the general public. Weir also discussed outreach activities. GCMD participates in conferences and collaborates with a multitude of other groups from within and from outside NASA. Finally, she touched on how GCMD evaluates success. Their main determinant is statistics compiled at their website. They also produce reports on the conferences they attend. More information on the services provided by GCMD is available at: *gcmd.nasa.gov/services/*. At the moment, Weir reported that 355 services (SERFs) are registered in the database.

**Rob Simmon** (SSAI, NASA Earth Observatory [EOb] Staff) presented a review of the EOb, and also included a discussion on outreach for Terra. Simmon began by discussing results from the first meeting of the Goddard Education and Outreach Committee, led by Franco Einaudi. It was an effort to bring together scientists, outreach specialists, and media professionals to talk about ESE outreach and education activities. The group agrees that there is a need to define the audience for products, the message intended to be conveyed, the best method to convey that message, and an effective means of evaluating the effectiveness of the communication. It seemed that this group shared Greg Williams' earlier view that one of the most important groups to convince that ESE is doing worthwhile work is stakeholders—those who will ultimately decide if funding for ESE programs continues. Future meetings of this group will continue to discuss these important issues.

Simmon next talked about how the EOb came into being. When Terra outreach was being planned, Dave Herring and the others involved came to the conclusion that the general public doesn't really care too much about the specifics of each mission. What they want to know is the big picture—they will appreciate details about a mission more if they appreciate how it fits into the overall science issues being studied. So while there are mission specific outreach products (such as a web site, video, brochures) for Terra, much more emphasis is placed on promoting the science that is being studied and introducing people to the various instruments on Terra in the context of stories that talk about the science questions be studied using data from Terra. EOb is one of the primary tools for pursuing this "big picture" approach and, now, this same philosophy is carrying over to outreach for other missions on the EOb. One can find information on individual missions (such as Aqua, Aura, SORCE, GRACE, IceSat, etc.) but one will find many more articles about the science being studied by these missions and images being returned by them that help us better understand the condition of our planet.

Simmon continued to talk more specifically about EOb, discussing overall strategy for the site and also the objectives for the site. EOb's strategy falls in line with the overall strategy for ESE outreach as outlined earlier by Greg Williams. Simmon then touched on some of the problems that still exist and possible remedies. This sparked some discussion among participants. Simmon ended by showing some of the new features on EOb, including the Natural Hazards section, new data sets such as the blue marble, an image composite editor (ICE), and, coming soon, a tool to allow students to learn about aerosols and the role they play in regulating climate. To learn more check out: *earthobservatory.nasa.gov*.

### ESE Mission Outreach Reviews

**Steve Graham**, (SSAI, Aqua Outreach Coordinator) presented an overview of the Aqua outreach efforts. Aqua was successfully launched on May 4, and all six Earth-observing instruments have been turned on and have returned high-quality data. A full-color Aqua brochure has been published detailing the Aqua mission as a whole, and four separate brochures have been published detailing the individual Aqua instruments: one brochure each for MODIS, CERES, and AMSR-E, and a combined brochure for AIRS, AMSU, and HSB, the three Aqua sounders. Three fact sheets have been created. One focuses on the Aqua mission and the other two focus on specific science topics that Aqua will study – the water cycle and weather forecasting. Other publications include a lithograph and an Aqua Science Writers' Guide. In addition to the print materials, there have been seven Aqua webcasts, the first focusing on the spacecraft, the next four on the science, and the last two on the launch. The webcasts are each between one and three hours long and are archived at the *aqua.nasa.gov* website. Another section of the website is dedicated to "cool science" and provides a series of short but informative clips of Aqua scientists and engineers describing concepts that fit into the National Academy of Sciences Science Content Standards for grades 9-12. Graham played one such clip, showing the AMSR-E U.S. Science Team Leader, Roy Spencer of the University of Alabama at Huntsville, describing the concept of latent heat. The webcasts and "cool science" web page are produced by the Special Project Initiatives Office at GSFC. Additional Aqua resources are available at the Aqua website, including images of the spacecraft, summaries of science, science teams and instruments, animations, and visualizations. Graham showed animations of the Aqua launch and the Aqua orbit, and explained that the times of data collection vary considerably from the 1:30 p.m. and 1:30 a.m. equatorial crossing times. His last animation was of the A-train. It depicts all the satellites involved, with Aura lagging behind Aqua by about fifteen minutes.

**Stephanie Stockman** (SSAI, Aura Outreach Coordinator/Landsat Outreach Coordinator) gave an overview of outreach activities for the Aura mission. Aura should launch some time in 2004 and focuses on studying the chemistry of the atmosphere. It will seek to answer three questions: (1) Is the earth's ozone layer changing as expected; (2) is the air quality of the lower atmosphere changing; and (3) is the Earth's climate changing? Each of the three main questions can be further subdivided into subquestions that help reduce the broader questions to more specific inquiries that are easier to answer. Aura outreach is divided into three components. The first is to educate the public about why EOS missions are necessary, and the Aura mission in particular. A second component is also dedicated to educating the Federal Government about what NASA is doing—the Environmental Protection Agency (EPA) for example. The third and final component is outreach to grades K-12. NASA has several partners working with it on Aura. These include the American Chemical Society, the Smithsonian, and Global Learning and Observations to Benefit the Environment (GLOBE). The American Chemical Society is doing a series of special issues that focus on Aura, the first two of which have been released. This publication is sent to every high school chemistry teacher in the nation, over 30,000. The Smithsonian has set up an exhibit in its Natural History museum called "Forces of Change." Next year, "Forces of Change" will focus on atmospheric chemistry with a display called "More than Meets the Eye" (tentative title). The formal education plan for Aura will include supporting the GLOBE aerosols and surface ozone protocols as well as the GLOBE special UVA measurement. Aura outreach efforts also extend to the web. Jeannie Allen is a science Education/Public Outreach specialist who works as a liaison to the Earth Observatory website for Aura and focuses on atmospheric chemistry-related topics. An Aura brochure will be developed, but, more so than some current brochures, it will be material more specifically geared to science peers.

**Stockman** then continued on and spoke about Landsat 7 outreach. She talked about the educational products that have been developed relating to Landsat 7. The most well known is "Echo the Bat." Another program is "Grow Smart," where students in Prince Georges County use remote sensing to understand land cover and land use change over time. The students role play scenarios and have to research what they would need to know to be in the position they are assigned. They also have a lithograph and a poster with educational activities. Another classroom activity, "Finding Impact Craters with Landsat," will go online this fall, as it has been strongly recommended by ESE Product Review. In 2002, a number of education workshops have been held. This includes some NASA Education workshops, which are new this year. Stockman also mentioned

improved generation and dissemination of enhanced graphic products. They make use of such resources as: e-theater; science visualization studio; public affairs office; NASA Headquarters; and "Our Earth as Art"—a series of Landsat images usable as art (see page 34 of this issue for an example). Stockman closed by briefly reviewing a number of collaborative projects. They are working with the Jason project, Echo the Bat, Landsat.org, and GLOBE. They will also be helping to develop the outreach plan for the Landsat Data Continuity Mission. Outreach products developed for this follow-on mission to Landsat 7 will likely borrow heavily from outreach products that have already been developed for the current mission.

**Alan Ward** (SSAI, Earth System Science Pathfinder (ESSP) Outreach Scientist) reviewed ESSP outreach. He works for the Earth Observing System Project Science Office (EOSPSO), under the ESSP Project Scientist, Marc Imhoff, and coordinates outreach for the ESSP missions at Goddard. Ward briefly reviewed the ESSP Program and how it fits into ESE. Each mission has a Principal Investigator (PI) and an outreach coordinator; each mission also has numerous partners involved from government, academia, and private industry. Furthermore, many missions are also collaborations with foreign countries, adding yet another level of coordination. Ward's role is to be a central point of contact to help create a cohesive outreach plan for each individual ESSP mission and a consistent message for the overall program. He works closely with each mission's PI and outreach coordinator(s) to develop material appropriate to the mission and assure that all partners are given input. The hope is to prevent needless duplication of efforts and get the most for limited outreach dollars.

Ward proceeded to describe the specific plan that has been implemented for the Gravity Recovery and Climate Experiment (GRACE), the only ESSP mission that is in orbit to date. EOSPSO developed a brochure, fact sheet, and lithograph for this mission. Other products created by other partners include: a mission website maintained by the University of Texas Center for Space Research (UTCSR), a full educational curriculum developed by UTCSR, a CD ROM developed by the Earth Explorer's Office (EEO) at Goddard, and a video on the mission developed by EEO. UTCSR also is training "master teachers" who can teach other teachers to, in turn, teach their students about the science of the GRACE mission. The public affairs offices at NASA Headquarters, Goddard Space Flight Center, Jet Propulsion Laboratory, and the German Space Agency were all involved in promoting this mission.

Ward also reviewed the plans that are in the works for CloudSat and the Cloud Aerosol Lidar Infrared Pathfinder Satellite Observations (CALIPSO) missions, two more ESSP missions that will launch on the same vehicle in 2004. Each mission is distinct and has developed its own plan for outreach, but since the missions are co-manifested, it is logical for the two missions to work together for outreach and education activities where possible. CloudSat and CALIPSO will fly in formation with Aqua, Aura, and PARASOL (French mission) in what is referred to as the "A-Train" constellation. Some joint outreach will be planned to promote this important concept. CloudSat and CALIPSO also plan to leverage the resources of EOSPSO to help them with outreach. In addition, teacher workshops are planned beginning next summer to give teachers a curriculum that they can teach to their students. Teachers will be trained to use a handheld sun photometer (developed as part of the GLOBE program) so that their students can help with validating data collected by CALIPSO.

Ward closed by mentioning that two additional ESSP missions have been chosen. The Orbiting Carbon Observatory (OCO) and Aquarius were chosen with a third mission, Hydros, selected as a backup. EOSPSO will likely be involved in outreach activities for these missions as well.

### ESE Education Program Reviews

**Theresa Schwerin** (IGES) spoke about the ESE education products review. This independent peer panel review happens twice a year; products are due the first week in May for the spring review and the first week in December for the fall review. Review panels include a combination of scientists (mostly non-NASA) and educators who are selected based upon the products that are submitted to the review.

Schwerin encouraged product developers to talk to her and the IGES staff during the processes of product development and submission, and, if products require revision, to make the revisions and resubmit for approval

She also identified ESE education contacts who are available to product developers and strongly recommended, that from the beginning, people discuss their products/ideas with NASA ESE education contacts. These are: John Entwistle, ESE Lead for Formal Educa-

tion, and Anita Davis, ESE Lead for Informal Education. She also strongly suggested that you contact the education office at your NASA Center. For example, Michael Hubenthal works in the GSFC Education Office and is an excellent contact to discuss your ideas for ESE education products before you begin developing them.

Schwerin gave the group a few pointers on developing excellent ESE education materials that will help increase the likelihood of their being approved by the education product review:

- **Audience, Audience, Audience**: Schwerin stressed the need to know one's audience and design products according to their needs. One size will not fit all; sometimes the intended audience for a product is broad and other times it is very specific. Schwerin suggests that the target audience be given input into the design of the product from the beginning. She also recommends considering the most effective means of distributing and disseminating the product to the intended audience and also recommends letting the intended audience evaluate the product and give feedback, which may include suggestions for improvement.
- **Provides Scientifically and Technically Correct Information**: The content needs to be reviewed by experts in whatever subject is being dealt with. When teachers see the NASA logo, they trust that what they are getting is accurate and so, it is important that they not be disappointed.
- **Education Friendly**: Every product needs to support its intended audience's requirements (e.g., formal education materials need to support National education standards — science, math, geography, and technology). The product should also incorporate effective teaching/learning styles: Inquiry-based, Learner Centered. The material should, again, be appropriate to the audience it is intended for and the presentation of the information needs to be effective.
- **Technology-Based Products**: Products need to be 508 Compliant and platform independent, able to run on a Mac or PC—there is no standard computer in this country. The product needs to be designed so that it is appropriate to the computer resources available to its intended users. Schwerin encourages the use of the web to enhance products but beware of "cobwebs." That is, keep all links current and keep current the content of all sites referenced. Overall, make use of technology but use it in a cost-effective manner.
- **Production/Design Quality is High**: Again, as stated earlier, have an effective, visually stimulating and appealing design for products that are submitted. Make sure the visuals and images that are used are crisp and clear high-resolution images. Also, make sure that the quality of the audio/video (if applicable) is good and that the publication is free of production errors—such as typos.
- **Includes Resources/References for Further Information**: An important objective of NASA ESE education materials is to capture your audience's interest and to provide direction on where they can go to learn more on the topic.

For more information on the review, go to: *earth.nasa.gov/education/* and click on the link for "Product Review" or contact: *theresa_schwerin@strategies.org*. This site includes the review criteria that are used to evaluate ESE education products. Developers are encouraged to use these criteria to assess their products before submitting them to the review. **In a side discussion that followed this talk, Anita Davis** pointed out that the standards for informal education will be changing in the near future. So, it is a good idea to stay current with what the standards are. Don't assume that because you checked once, they will always be the same. **Blanche Meeson** also reported that they are working on means to filter out older products during the review process.

**Michael Hubenthal** (Educational Specialist, NASA/GSFC Educational Programs) spoke about Earth Science education activities at Goddard. Hubenthal touched on educational priorities. The major concern here is to make good use of taxpayers' money. He also talked about educational planning. The advice here is simple: plan for education and public outreach from the beginning. The latest missions that have been approved by NASA require that a plan be developed for outreach and education right along with the plan for science—**Examples**: LDCM, GPM, new ESSP selections. This helps assure that missions align well with NASA's priorities and allow for both financial and implementation planning . Hubenthal next touched on the subject of systemic reforms in education products at NASA. The idea is to infuse products into school curriculums and a program for the public schools in Anne Arundel county

Maryland is doing just that. All tenth graders in Anne Arundel county learn about Earth System science. Carroll and Frederick counties, also in Maryland, are also developing similar programs and, on a larger scale, the U.S. state of Vermont is working on a program called "Mission Geography." Hubenthal finished by talking a bit about educator professional development opportunities. Teachers are working on the research teams to study data gathered by a NASA science team going to Bolivia to study a meteorite impact crater. There is also a teacher internship program for school teachers from Anne Arundel county.

**Nora Normandy** (NASA HQ, Office of Public Affairs, Informal Education/ Outreach Officer) spoke about informal education/outreach from the perspective of HQ and the Office of Public Affairs. She reiterated the idea that publications, programs, and other education/outreach activities need to adhere to the *"one NASA"* philosophy. Nora encouraged the participants to be aware of existing resources in order to take advantage of work already done and to avoid duplication of efforts. A good way to do this is to talk to the ESE education team leads (Anita Davis, Blanche Meeson, John Entwistle) or Center public affairs or education offices, at the beginning of the development process. She made available a list of the resources available through NASA HQ PAO and also provided information about the NASA Speakers Bureau. She also reminded the participants to work with Public Affairs. They can provide advice and assistance in getting the word out about education and outreach activities. Lynne Chandler at Goddard and David Stietz and Elvia Thompson at Headquarters are the PAO leads for Earth Science. There was a question raised about formal partnerships with the Department of Education. Such links do not exist formally at this time. However, NASA has, and continues to, work with Department of Education and other Federal Agencies on education initiatives. There is a reorganization of NASA's Education program in progress in which Education is being raised to Enterprise status. There will be an Assistant Administrator who will focus on the Agency's Education program. It is expected that one result of this will be a closer working relationship with the Department of Education. NASA has a Formal Education framework in place and is in the process of developing an Informal Education framework, which should help as it establishes ties to the Department of Education.

## ESE Cross-Enterprise Group Reviews

**Jim Closs** (SSAI, EOSPSO) presented a talk that described the role of the EOSPSO and described its outreach activities. He reviewed the goals and objectives of the program. Essentially, EOSPSO strives to increase the public's awareness of NASA's contibution to Earth Science and the understanding of the Earth as a system and is a resource for programmatic information. Closs reviewed the plethora of publications that EOSPSO has available. The EOSPSO staff is dedicated to assisting ESE programs with developing products to promote their mission. These products are distributed at conferences that EOSPSO representatives attend throughout the year and are also made available at the EOSPSO website [*www.eospso.nasa.gov*]. Some of the products do overlap with one another but there are few gaps in coverage. EOSPSO helps to work toward the idea of *"one NASA"* by attempting to collocate exhibits at conferences. They work with NASA Headquarters, with public affairs offices at the various NASA centers and at Headquarters, and with the Goddard News Team. Closs reported that, as is often the case, metrics for success are hard to quantify. One metric used is activity at previous conferences. EOSPSO does keep accurate material inventories and detailed records of the type and amounts of materials distributed at conferences.

**M.K. Richardson** (Goddard Laboratory for Terrestrial Physics [LTP]) gave a review of outreach activities at LTP. She reviewed the mission and objectives of the LTP and reviewed their target audience. She then talked about how collaborations and partnerships ensure successful product development in supporting the Lab's sciences. Richardson also touched on the subject of evaluating success. To end her presentation, Richardson reviewed some of the highlights of the LTP website: *ltpwww.gsfc.nasa.gov* or *imagers.gsfc.nasa.gov/Arizona*. One of the most notable sections is "Echo the Bat Goes to Arizona." Much of the LTP site is still under development but is accessible to the public.

## Closing Discussion

The meeting was a very successful first step toward planning a strategy for outreach and education activities throughout ESE. This was probably the largest gathering of outreach/education representatives in one place to date. Jim Closs was excited about possible follow-on meetings and wanted to get a sense from the participants about what topics they thought

needed further discussion in the future. The meeting concluded with an open discussion on this question.

One recurring topic in today's talks was the issue of effectively evaluating the success of education and outreach products. This raises the tricky question, *"What does it mean to succeed?"* Participants observed that often, success is judged by how many hits a website received. But does this really tell the whole story? Clearly, it does not. Perhaps the real criterion for success needs to be, how much did the students learn? Or perhaps it should be, do they have a desire to learn more? While these are much more difficult to quantify, they may ultimately be the types of questions that matter most when one attempts to judge the success of a particular product or program.

The group seemed to agree that a big step toward effectively evaluating "success" is to have a plan in place from the beginning that states what the objectives are for the project. In other words, if this is an educational product or program, what is it that students should know after they complete this program. Then, success or failure can be judged on whether the students achieve the objectives or not. **Stephanie Stockman** pointed out that the GLOBE program has done quite a bit with this sort of assessment already. Perhaps ESE can learn from their experience as they attempt to develop metrics for their programs.

Other topics that were raised as worthy of further discussion included:

- Considering the possibility of commercializing NASA products.
- Developing more effective peer-to-peer communications—the sense was that the majority of existing products are not designed for this audience.
- Developing improved means to evaluate effectiveness of products, for example, developing on-line metrics recording tools.
- Leveraging the resources of the Federation of ESIPs to help develop products.
- Improving data access for "non-traditional" users. (Perhaps follow the model used by Tropical Rainforest Informatioin Center (TRFIC) at Michigan State University or the Global Land Cover Facility (GLCF) at University of Maryland, College Park—both are ESIPs.)
- Developing an on-line survey to find out about more people who are doing outreach and education activities.

Participants were advised to expect further discussion of some of these issues via e-mail and to expect another workshop, possibly in the Spring of 2003.

# EOS Clearinghouse (ECHO) is Open for Limited Release

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## Introduction

The Earth Observing System ClearingHOuse (ECHO) is open for business on a limited basis for scientists and developers who want to build their own tailored user or machine-to-machine interfaces for accessing Earth Science data. ECHO is an enabling framework that allows different data systems and services to work together. It enables more efficient access to more data. As an open system, ECHO's application program interfaces (APIs) are published for use by the science community to exchange data, information, and services. It is based on concepts intended to extend available Earth Science resources among the science community. It accomplishes this through its metadata clearinghouse and service broker application program interfaces, which are based on Extensible Markup Language (XML) and Web Service technologies. It is being developed and released in increments to allow for insight and feedback during the development process. ECHO is being built by NASA's Earth Science Data and Information System (ESDIS) Project.

This article is intended to encourage the community to develop alternative clients for access to EOS and related data via ECHO. As an enabling system, ECHO is focused on supporting the needs of a number of different and ever-changing client applications. ECHO will support the variety of client types as described here.

## Client Types

ECHO provides an API-based interface to the holdings of the clearinghouse. This frees clients to present the holdings in a variety of ways that are independent of ECHO and of the data provider. ECHO offers a search and retrieval mechanism that is fast enough (for well-bounded searches) to allow for different types of client interaction than the traditional: create a query, send it, and wait for the response. A client can choose to harvest some key metadata ahead of time, present a navigation or category browsing style of interface, or present the browse imagery first and still use ECHO as its supporting framework. As new ideas are generated for clever clients, ECHO's iterative development process allows for their inclusion in the API.

It is also important to point out that clients have the liberty of addressing their particular community. It is possible to construct a client that will limit what is viewed out of the clearinghouse to only those data sets of interest to a community, and the user interface (UI) allows the freedom to use the exact terms that are familiar to their customers, performing any necessary translation when communicating with ECHO.

Two basic data-discovery paradigms are supported—the traditional Search/Retrieval and the newer Navigation/Discovery. Within these two major paradigms a variety of client types can be supported. Search/Retrieval clients include machine-to-machine interfaces, partially automated interfaces such as simple scripts that a user initiates, and user-interaction interfaces. The EOS Data Gateway (EDG) is primarily a search and retrieval type system.

Navigation/Discovery-based clients include those based on dynamic queries, fixed links, and content summary. Dynamic query clients are those that allow the user to interact with the metadata represented on the screen in real time and see results immediately. Users have dynamic, continuous, reversible control of the query and both the query and results are represented visually at all times throughout the session. The Data Validation User Interface (DVUI) being prototyped for the MODIS Land data validation community is an example of this type of interface. Fixed-link clients allow users to select a link to follow, narrowing choices based on the last link selected. Subsequent links can either be pre-generated or dynamically created, based on previously selected options. The Mercury interface at Oak Ridge Distributed Active Archive Center (DAAC) is an example of a fixed-link interface (*mercury.ornl.gov/ornldaac/wbt.asp?database=landval*).

Content Summary clients allow a user to select a starting point in the data summary; a preview of actual data is then displayed organized by a few attributes. Upon viewing the preview, the user can navigate through the data using these and potentially other attributes. Browse-first interfaces such as the USGS Global Visualization Viewer (*glovis.usgs.gov/L7Img Viewer.shtml*) are included in this Content Summary category of clients. These are clients that allow the user to start by viewing a display of browse images that represent the data. The user can navigate the browse images in space and time, then, once an image of interest is identified, the user can order it. Most Navigation/Discovery clients require pre-processed, cached metadata. The access to ECHO's metadata by a pre-processing and staging system is often a machine-to-machine-based Search/Retrieval client but the end user is never aware of this interaction.

Hybrid clients combine Navigation/Discovery and Search/Retrieval, where part of the user interface starts out with one paradigm and the final stage is the other. The Web-based Hierarchical Ordering Mechanism (WHOM) system developed by the Goddard DAAC is a hybrid interface (*acdisx.gsfc.nasa.gov/data/dataset/MODIS/index.html*).

Clients can interact with ECHO in a variety of ways. Some clients harvest metadata to populate their local systems so they can support a navigation-discovery user-interface paradigm (such as the aforementioned GDAAC WHOM, and the Data Validation User Interface [DVUI] also used at Goddard—Code 586). Clients may be tailored to a user's needs so that data access is optimized for a particular user or community (DVUI). Other clients may be machine based to retrieve metadata or data on a regular basis or as initiated by an end user (DVUI backend, WHOM). This latter type of client is more for a user who regularly queries for large volumes of data—a power user. Due to resource constraints, power usage must be limited to client providers. A few alternative clients are being (or have already been) prototyped to illustrate ECHO's potential for supporting new data-access methods. These are listed in **Table 1**.

### The Benefits of Using ECHO.

*Querying is Independent of Data Provider Downtime.*

In the current distributed search architecture, searches are sent out over the network to participating archives and the search is executed at the archive site. Results are returned to the user interface for display. If a network connection goes down, or an archive is unavailable, the result set is incomplete. The onus is on the user to search again at a later time. With ECHO, the search is done inside ECHO. The user gets a complete result set. If there are any connectivity problems between the client and ECHO, the user's context is retained with ECHO's session management services. When the user places the order to the data provider, if the data provider is unavailable, ECHO holds the order and continues to attempt to place the order on behalf of the user until the order goes through. In this fashion, ECHO provides a supporting framework for clients, allowing them to focus on their customers, rather than on the details of completing an order or dealing with a largely incomplete result set.

*Enables Navigation and Discovery Paradigm.*

In addition to the existing search and retrieval (aka 'search and wait') data-access paradigm, ECHO supports a navigation-discovery paradigm that can serve to eliminate zero- and mega-

**TABLE 1**: Upcoming User Infterfaces on ECHO (As of September 25, 2002).

| Organization | Client Name | Data Access Paradigm |
|---|---|---|
| GSFC Code 586 | Data Validation UI (Proof of Concept) | Navigation/Discovery (Dynamic Queries) |
| ESDIS | EOS Data Gateway | Search/Retrieval |
| GDAAC | WHOM | Navigation/Discovery (Fixed Links) |
| LPDAAC | ASTER Global Vis | Navigation/Discovery (Browse Image Based) |
| MODIS | MODIS Websites | Search/Retrieval |
| GSFC Code 935 | NEpster | Search/Retrieval (var.) |
| NSIDC DAAC | GISMO-E/PSQ | Search/Retrieval |
| ORNL | Mercury– EOS | Search/Retrieval |

**TABLE 2**: ECHO Metadata Population (As of September 25, 2002)

| Archive Name | Number of Datasets | Number of Granules | Degree of Population |
|---|---|---|---|
| Goddard DAAC | 12 | 3126146 | BMGT in place |
| Land Processes DAAC | 57 | 201290 | BMGT in place |
| LaRC DAAC | 2 | 0 | BMGT in place |
| NSIDC DAAC | 2 | 5287 | BMGT in place |
| ORNL Version 0 DAAC | 560 | 104835 | 100% |

hit results sets. Additionally, a client that takes ECHO metadata and hosts it as part of the user interface can provide dynamic interaction with the metadata, maximizing end-user performance for data access.

*Access/Visibility Control.*

Data Providers can establish policies by which their data and service can be accessed. This includes metadata and data visibility control through Access Control Lists (ACLs). Although visibility control tends to reduce the search performance, it's often a small price to pay when control is necessary.

*Flexible Spatial Searching.*

ECHO allows providers of data to represent their metadata in either Geodetic or Cartesian coordinate systems. Queries will search both types of providers. Geodetic providers can have data that crosses the poles or the international date line, while Cartesian cannot. ECHO supports polygons for both data representation and search areas. It will also allow a spatial query region to return any region that intersects it, is contained within it, or is contained by it as the client chooses. Additionally ECHO will support an optional orbit-based search mechanism based on the Backtrack method developed by the National Snow and Ice Data Center.

*Standards Compliance.*

ECHO, as a clearinghouse of Earth Science metadata, provides the opportunity for meeting standards with one system augmentation rather than many. For instance, ECHO will have an ISO standard view of the metadata contained within it. As long as a provider puts sufficient information into ECHO to meet ISO minimum requirements, it will be represented to ISO clients according to the standard.

## Data Population

For ECS archives, a Bulk Metadata Generation Tool (BMGT) has been deployed so that metadata can be generated automatically and sent to ECHO. This tool detects insertions, updates, and deletions of metadata in an ECS archive and creates an ECHO compliant XML version of the metadata. The ECS subscription mechanism is then used to push this information to ECHO.

For non-ECS archives, there are a number of choices. For example, the Oak Ridge DAAC has chosen to write custom code to export their metadata directly into the ECHO ingest format. There are also tools for exporting database content in ASCII or in XML. Once in XML, a mapping can be performed using various tools. The correct mapping requires an understanding of the original data model and the ECHO data model. The data providers can then configure their systems to export any changes to their holdings on a regular basis (daily, hourly, monthly, or whatever makes sense), have the mapping conversion performed automatically, and then ftp the result to ECHO for ingest. ECHO will respond with a report of the success of ingest via email. **Table 2** shows the current population status by participating archives as of September 25, 2002.

## Services

The next step in the mission to enable more efficient access to Earth Science data is to offer mechanisms for making external services available to ECHO users. In that vein, ECHO is working to provide the platform for a marketplace of services that are relevant to Earth Science. ECHO is leveraging contemporary web services technologies to build a service registry, allowing third parties to publish their Services. This registry will allow ECHO clients to either navigate through available services (in multiple taxonomies) or to determine which services might be appropriate for the given granules. ECHO has developed four different schemes to facilitate binding the user to a requested service. These schemes span from simply advertising services to full service brokering. Eventually ECHO services will include search

services, data services, and administrative services. Currently, prototyping of data services is underway. Data services are those that collect data, or manipulate data products (subsetting, reprojection, processing) and output a product that can be delivered to the end user.

### Current Limitations.

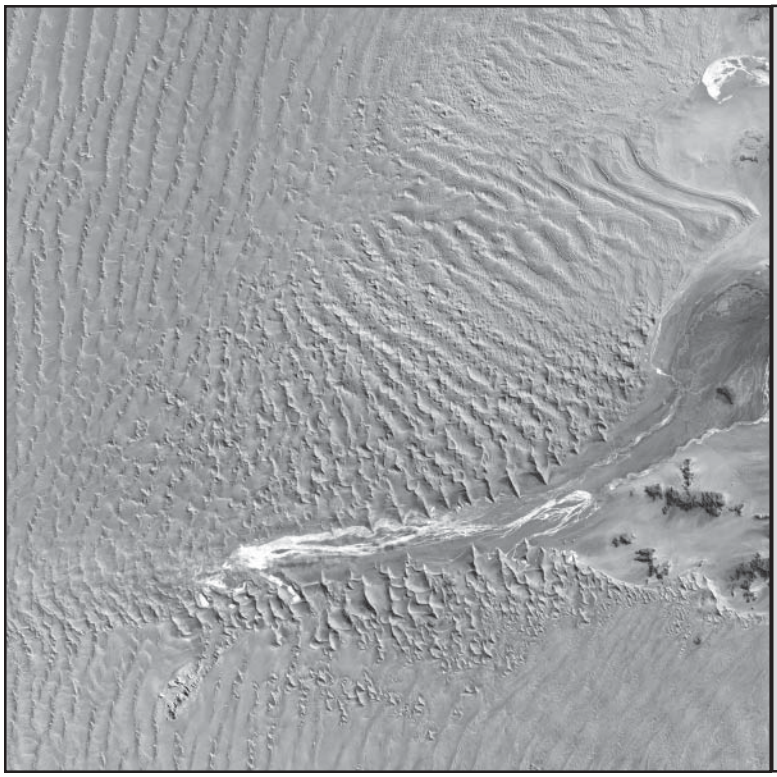
The EOS archives are still in the process of populating the metadata clearinghouse, so data availability is limited. As the DAACs test their metadata generation systems they will be turning on more data sets for routine metadata export to ECHO. The ECHO team is also working on loading the backlog of metadata for already existing data from the DAACs.

Work to improve the ECHO provider website that assists developers in participating as a data provider or in creating a new user interface is still in progress. Part of the purpose of this article is to put out a call for partners to exercise the ECHO APIs and give us feedback to help us improve the provider interface and developer guides.

Currently data service support is being prototyped. Early prototyping identifies the services associated with a specified granule.

### Summary

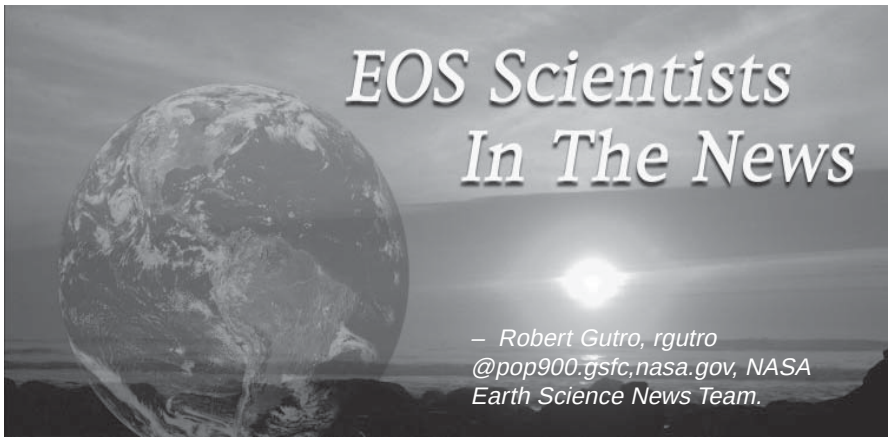
ECHO provides an enabling framework that allows diverse communities to share tools, services, and metadata. As a metadata clearinghouse, it supports both the old iterative query data access and a new navigation/discovery data access. The latter serves to eliminate zero-hit and mega-hit results sets. As a service broker, ECHO decentralizes tools for manipulating data and supports interoperability of distributed functions. A well-documented, message-based interface enabling the flexibility for anyone to hook in their own user interface is provided, as opposed to a single, integrated user interface that forces a one-size-fits-all solution. This approach allows various providers to build their own user interfaces and not be limited by any single integrated data search and order system. This new approach is consistent with the trend toward a federated community. To register as a client provider, data provider, and in the future, service provider, or to just find out about ECHO, visit *eos.nasa.gov/echo*.



**Is it Landsat or is it Art?** How about both? This image is part of the ongoing "Landsat as Art" series. Namib-Naukluft National Park is an ecological preserve in Namibia's vast Namib Desert. Coastal winds create the tallest sand dunes in the world here, with some dunes reaching 980 feet (300 meters) in height.

This image was acquired by Landsat 7's Enhanced Thematic Mapper plus (ETM+) sensor on August 12, 2000.

**Image Credit**: USGS EROS Data Center Satellite Systems Branch.




**Black Carbon Contributes to Droughts and Floods in China,** Sept. 26; *ABC News, Annanova, AP, CNN*. Surabi Menon and Jim Hansen (both of NASA/GISS) found that large amounts of black carbon particles and other pollutants are causing changes in precipitation and temperatures over China.

**Ocean Water May Show Drought's not Over**, Sept. 21; *Pasadena Star-News*. William Patzert (NASA/JPL) discusses current drought conditions in Southern California, the outlook for El Niño and the effects of the Pacific Decadal Oscillation.

**Satellites Predict Killer Waves for Surfers**, Sept. 20; Tech TV. William Patzert (NASA/JPL) discusses how data from NASA's Quick Scatterometer is being used by surfers to forecast surfing conditions.

**Study Finds Thicker Storm Clouds Over Warmer Tropical Waters**, Sept. 20; *ScienceDaily*. Using TRMM data, Tony DelGenio (NASA/GISS) found over warmer waters in the tropics, clouds become thicker and more extensive overthan cooler waters, countering the Iris Theory.

**Study: Earth to Warm Even if Greenhouse Gas Cut**, Sept. 20; *Reuters, ABC News, Ananova*. Research from Jim Hansen (NASA/GISS) found that the Earth's climate will warm up over the next 50 years whether or not greenhouse gases are curbed soon.

**Space Sensor Stretches the Weather-Forecast Envelope**, Sept. 18; *San Diego Union-Tribune*. Moustafa Chahine (NASA/JPL) discusses the outlook for improved weather forecasting as a result of the Atmospheric Infrared Sounder Experiment (AIRS) on the Aqua spacecraft.

**Scientists Map Global Air Pollution**, Sept. 18; *Spacedaily, ENS*. Yoram Kaufman (NASA/GSFC) and others are now routinely producing the first global maps of fine aerosols that distinguish plumes of human-produced pollution from natural aerosols.

**Physical Effect of Sept. 11 Scrutinized From on High**, Sept. 17; *NY Times*. Luis Nguyen and Patrick Minnis (NASA/LaRC and others used airborne spectrometers and charted the toxic dust from the disintegrating twin towers of Sept. 11th. Robert O. Green (NASA/JPL) was also quoted.

**Polar Ice Sheets Changing Rapidly**, Sept. 16; *Space News*. Eric Rignot (NASA/JPL) discusses the results of his research into the mass balance of the polar ice sheets.

**EO Birds Confirm Rapid Changes in Earth's Polar Ice Sheets**, Sept. 10; *Spacedaily.com*. Eric Rignot (NASA/JPL) and Robert Thomas (EG&G/NASA Wallops) were featured in this article that said Earth's polar ice sheets are changing much more rapidly than previously believed.

**Satellites Map Earth's Gravity**, Sept. 7; *Associated Press, Space.com, New Jersey Star-Ledger*. Michael Watkins (NASA/JPL) discusses the early scientific results of the GRACE mission.

**Satellite Unveils Clues To Water's Changes**, Sept. 6; *UPI Science News*. Richard Miller, chief scientist for NASA's Earth Science Applications Directorate, is leading research to develop a procedure to identify and monitor sediment re-suspension in shallow waters.

**Team Determined to Unearth Origin of Iturralde Crater**, Sept. 5; *Spaceflightnow.com, Space.com, Baltimore Sun*. Compton Tucker (NASA/GSFC) and others are trying to determine if a meteor created a 5-mile-diameter crater in the Amazon.

**JPL Studying Glaciers' 'Lives'**, Sept. 4; *Pasadena Star-News*. Eric Rignot (NASA/JPL) and Robert Thomas (NASA/Wallops) discuss the results of their reseach into the mass balance of the polar ice sheets.

**Put on a Sweater for the Cold Facts**, Sept. 4; *San Diego Union-Tribune*. William Patzert (NASA/JPL) discusses current weather conditions, the outlook for an El Niño and effects of the Pacific Decadal Oscillation.

**Atmospheric Wave Linked to Sea Ice Flow Near Greenland** Sept. 3; *Cosmiverse.com., Wissenschaft Berichte(Germany)*. Don Cavalieri (NASA/GSFC) has discovered the link between a wave of atmospheric

pressure at sea level and the amount of sea ice exported near Greenland.

**Satellites Show Overall Increases In Antarctic Sea Ice Cover**, Aug. 30; *ScienceDaily, UPI*. Claire Parkinson's (NASA/GSFC) research indicates that since the 1970s the amount of sea ice in the Antarctic has increased.

**Satellite Trio Helps Track Hurricanes**, Aug. 26; *United Press International, Cosmiverse*. Since Hurricane Andrew in 1992, NASA has launched 3 missions to help improve forecasting of tropical cyclones: TRMM, QuikSCAT and Aqua. Bob Adler and Claire Parkinson were featured (both NASA/GSFC).

**Robot Plane to Probe Storms**, Aug. 26; *Nature Magazine*. Featuring research related to NASA's Altus Cumulus Electrification Study (ACES), the article quotes, mission principal investigator (PI), Richard Blakeslee (NASA/MSFC – NSSTC) of the National Space Science and Technology Center (NSSTC).

**Pacesetter: Robbie Hood**, Aug. 25; *Huntsville Times in Huntsville, Ala*. Hurricane hunter, Robbie Hood (NASA/MSFC), based at the NSSTC, was one of 12 women honored at the 2nd Women of Color Government and Technology Awards conference.

**NASA Scientists Here for the Weather**, Aug. 23; *The Citizen in Key West, Fla*. Featuring science and aviation research related to NASA's ACES, the article quotes PI, Richard Blakeslee (NASA/MSFC) and project manager (PM), Tony Kim of the NSSTC.

**Satellite Data Informs Wildfire Recovery**, Aug. 20; *ENN, Silicon Valley.com*. University of Maryland, NASA and the Forest Service are using data from NASA's Terra satellite to provide faster, broader assessments of burn damage after wildfires according to Rob Sohlberg (UMD-College Park).

**Soil Study May Yield Harvest of Water Cycle Data**, Aug. 19; *Spacedaily.com*. Eric Njoku (NASA/JPL) took part in a 3 week field experiment using remote sensing techniques over the nation's heartland to better understand soil moisture.

**Days of Thunder**, Aug. 19; *Electronic Engineering Times*. This photo and caption features ACES PI, Richard Blakeslee and PM, Tony Kim, both of the NSSTC.

**JPL Marks Exploration Milestones**, Aug. 18; *Pasadena Star-News*. William Patzert (NASA/JPL) discusses the TOPEX/Poseidon satellite on its 10th anniversary.

**Dry Ideas**, Aug. 16; *South Coast California Beacon*. William Patzert (NASA/JPL) discusses the current drought conditions in Southern California and the effects of the Pacific Decadal Oscillation.

**Oceans May Help Clean the Air**, Aug. 15; *Associated Press*. Daniel Rosenfeld (Hebrew University) claims that salty sea spray encourages rain, which washes out dust and other pollutants.

**Terra Satellite Refines Map of Global Land Cover**, Aug. 15; *Cosmiverse*. Mark Friedl (Boston University) and Steve Running (University of Montana) were quoted in this article about new NASA land cover studies.

**Cosmic Rays/Global Warming Linked**, Aug. 12; *Discovery Channel*. Fangqun Yu (SUNY-Albany) said that cosmic rays may explain why the lower atmosphere is cooling while thermometers on Earth's surface show a warming trend. Drew Shindell (NASA/GISS) was quoted about the research.

**Study May Give Boost to Space-Based Lightning Sensors**, Aug. 12; *Space News*. Featuring NASA's ACES, the article quotes the study's PI, Richard Blakeslee and mentions Hugh Christian (NASA/MSFC)—both based at the Global Hydrology and Climate Center (GHCC).

**Plankton Loss Potential Threat to Seas and Climate**, Aug. 9; *Toronto Star, Atlanta Journal Sentinel, CNN, MSNBC*. Watson Gregg (NASA/GSFC) and Margarita Conkright (NOAA) used satellite surveys to detect a sharp decline in plankton in several oceans around the world.

**Heat Forecast Sparks Fire Alert**, Aug. 9; *Orange County Register*. William Patzert (NASA/JPL) discusses the cool summer conditions being experienced in Southern California this year.

**JPL Scientists Celebrate Successful Data Transmission**, Aug. 8; *La Canada Valley Sun*. Moustafa Chahine (NASA/JPL) discusses the success of the first-light images obtained from AIRS on the Aqua satellite.

**Eastern U.S. Smokeout in Early July Set Record**, Aug. 8; Space.com, *The Quebec Tribune.* Smoke from the Canadian forest fires in July brought a record amount of air pollutants to the U.S. mid-Atlantic area, according to Norm O'Neill (Université de Sherbrooke) and Brent Holben (NASA/GSFC).

**NASA UAV Grabs Lightning Data**, Aug. 8; *Aero-News*. Featuring science related to NASA's ACES campaign the article quotes the study's PM NASA Marshall's Tony Kim of the NSSTC in Huntsville, Ala.

**Aqua Opens New Window on Weather**, Aug. 8; *New Scientist News*. Moustafa Chahine (NASA/JPL) discusses the advances in weather forecasting anticipated as a result of the AIRS instrument on the Aqua satellite.

**Continued on page 38**

# Earth Science Education Program Update

— *Blanche Meeson, bmeeson@see.gsfc.nasa.gov, NASA Goddard Space Flight Center*
— *Theresa Schwerin, Theresa_schwerin@strategies.org, IGES*

### Journey Through the Universe – An Opportunity for Scientists and Engineers to Make a Difference in Under-Served Communities

In 1999, the Challenger Center for Space Science Education launched Journey Through the Universe, an initiative to establish a national network of under-served communities committed to sustainable community-wide science, mathematics, and technology education.

Funded by NASA, Journey Through the Universe uses research disciplines across all NASA Enterprises (Earth Science, Space Science, Human Exploration and Development of Space, Aerospace Technology, and Biological and Physical Research) to engage entire communities. The program also provides remarkable outreach opportunities for NASA scientists and engineers.

The Challenger Center provides diverse national resources to the communities, including local programming for students and families, K-12 curriculum-support materials and teacher training, and ongoing support. The resulting programming reflects the strengths and capabilities of the community and provides access to resources that would otherwise be unavailable.

Programming includes a week-long celebration of learning conducted by a national team of researchers and engineers reflecting organizations from across the NASA Research & Development communities. During the week, training is provided for up to 350 K-12 educators; 4,000-8,000 K-12 students are visited in classrooms; and 2-4 Family Science Nights are held, each for 300-1,000 parents and their children. Each community selects the dates for their Journey Through the Universe Week; Washington, DC is scheduled for October 21-24.

Nine communities are part of the initial network, with plans to add up to four new communities each year over the next three years. Current participants are: Nogales, AZ; Moscow, ID; Tuskegee, AL; Muncie, IN; Washington, DC; Marquette, MI; Labette County, KS; Broken Arrow, OK; and San Diego, CA.

NASA is also funding the creation of a K-12 Earth science module to be used by the entire Journey Through the Universe community network. The middle school version will be rolled out during October 2002 for DC Public Schools. To learn more, visit *www.challenger.org/jttu*, or write John Hamel, program coordinator, at jhamel@challenger.org.

### NSIP 2002-2003 Earth Science Competitions

**Deadlines**: January 15 and January 31, 2003

The NASA Student Involvement Program (NSIP) is a national program of six competitions that links K-12 students directly with NASA's diverse and exciting missions of research, exploration, and discovery. NSIP supports national education standards for science, mathematics, technology and geography. Entry opportunities are provided for entire classes, teams, and individual students. Earth-science related competitions in 2002-03 include:

- My Planet, Earth. Grades K-1 and 2-4
- Watching Earth Change. Grades 5-8 and 9-12.

The Thacher Scholarship is an independently-funded scholarship that is awarded annually to a grade 9-12 winner in the Watching Earth Change NSIP competition. The scholarship was founded in honor of Peter S. Thacher, an international leader in promoting the use of space-based remote sensing worldwide and former UN Assistant Secretary-General. Other 2002-2003 competitions are:

- Aerospace Technology Engineering Challenge. Grades 5-8
- Design a Mission to Mars. Grades 5-8 and 9-12
- Science and Technology Journalism. Grades K-1, 2-4, 5-8, and 9-12
- Space Flight Opportunities. Grades 9-12

The deadline for entering Space Flight Opportunities is January 15, 2003. The deadline for all other competitions is January 31, 2003. For complete details and to obtain an entry form, competition rules, checklist, judging rubric, and

resource guide, please visit *education.nasa.gov/nsip*, or e-mail info@nsip.net or call 1-800-848-8429.

### NOAA Satellite Direct Readout Users Conference

December 9-13, 2002, the National Oceanic and Atmospheric Administration (NOAA) will host the Satellite Direct Readout Users Conference for the Americas in Miami, Florida. The conference purpose is to bring together users of the NOAA geostationary and polar-orbiting satellites, potential users of the forthcoming METOP polar orbiting satellite, and the future NOAA/DoD NPOESS.

During the next several years the NOAA satellite system will undergo significant changes and technological improvements. These changes will affect all current and future users of these satellites, particularly those who receive data directly from the satellites. The Conference for the Americas will begin preparing all users for these upcoming changes.

This conference will be of particular interest to all national hydro-meteorological agencies in the Americas and Caribbean, any government agency or commercial interest using satellite direct readout data or GOES and Argos DCS, and any university or other organization that utilizes NOAA satellite data. Further details, including registration information, are available at noaasis.noaa.gov/miami02/.

**EOS Scientists in the News** (cont from p.36)

**First Images from NASA's Thermometer in the Sky**, Aug. 7; *Cosmiverse.com*. Moustafa Chahine (NASA/JPL) was featured in this article about the AIRS instrument aboard the Aqua satellite.

**NASA's Aqua Satellite Generates First 3-D Storm Data**, Aug. 6; *Space.com*. Moustafa Chahine (NASA/JPL) and Claire Parkinson (NASA/GSFC) discuss the first light images obtained by the AIRS instrument on the Aqua satellite

**Satellite Snapshots Bring Planners and Scientists Together**, Aug. 6; *Daily Camera*. Scientist Dale Quattrochi (NASA/MSFC – NSSTC) was featured in an article related to the Urban Heat Island effect and city planning.

**Forecasters Find Clues to How Storms Form**, Aug. 4; *Atlanta Journal Constitution*. Discussing thunderstorm research, the article quotes Hugh Christian (NASA/MSFC) of the GHCC.

**Scientists Find Lightning Acts As Storm Warning**, Aug. 4; *Sunday News in Lancaster, Pa*. Discussing the relationship between lightning and severe weather, the article quotes Hugh Christian (NASA/MSFC) of the Global Hydrology and Climate Center (GHCC).

**Satellites Reveal A Mystery Of A Large Change In Earth's Gravity Field**, Aug. 1; *CNN, BBC News, MSNBC, UPI, NPR, NY Times, Bloomberg News*. Satellite data since 1998 indicates that the bulge in the Earth's gravity field at the equator is growing, and Chris Cox and Ben Chao (both NASA/GSFC) think that the ocean may hold the answer.

**Scientists Scope Cirrus Clouds**, Aug. 1; *Florida Today*. Discussing several NASA storm-research efforts, this article mentions NASA's ACES's efforts to probe thunderstorms.

**In the Line of Fire: First Global Lightning Map Reveals High-Strike Zones**, Aug. 2002; *National Geographic*. Discussing global lightning distribution, the article quotes Hugh Christian (NASA/MSFC – GHCC – NSSTC).

**Satellites Observe the Mysteries of Lightning**, Aug. 2002; *Spaceflight*. Discussing global lightning distribution, the article features a map created by NASA/MSFC scientists from the GHCC.

**NASA Radar on the Rescue**, Aug. 2002; *NASA Tech Briefs*. JPL and GSFC are working to see if Synthetic Aperture Radar (SAR) can detect remote crash sites. Picture is NASA DC-8 pilot Edwin Lewis inspecting the AirSAR antenna mounted behind wing of DC-8.

**Epic Winter Ahead? El If We Know**, Aug. 2002; *Surfer Magazine*. Dr. William Patzert (NASA/JPL) discusses the prospects for an El Niño this year.

## *EOS Science Calendar*

**November 18-20**

EOS Investigators Working Group Meeting, Ellicott City, MD. Contact: Mary Floyd, email: mfloyd@wsestover-gb.com, URL: eospso.gsfc.nasa.gov.

**December 3-6**

ASTER Joint Science Team Meeting, Palm Springs, CA. Contact Leon Maldonado, email: leon.maldonado-jr@jpl.nasa.gov.

**December 4-5**

HDF/HDF-EOS Workship VI, San Francisco, CA. Contact: Richard Ullman, email: Richard.Ullman@gsfc.nasa.gov, URL: hdfeos.gsfc.nasa.gov.

### *2003*

**February 25-28**

2003 AVIRIS Earth Science and Applications Workshop, Pasadena, CA. Contact: Robert Green, email: rog@mail2.jpl.nasa.gov

## *Global Change Calendar*

**November 10-14**

30th International Symposium on Remote Sensing of Environment (ISRSE), Honolulu, Hawaii. E-mail: isrse@email.arizona.edu, URL: www.symposia.org.

**November 10-15**

PECORA 15/Land Satellite Information IV Conference, Denver, CO. Contact: Ron Beck, email: beck@usgs.gov, URL: www.asprs.org/Pecora-ISPRS-2002/program.html.

**November 18-22**

WOCE and Beyond: Achievements of the World Ocean Circulation Experiment, San Antonio, TX. Contact: Maureen Reap, email: woce2002@tamu.edu, URL: www.woce2002.tamu.edu.

**December 3-5**

US Climate Change Science Program: Planning Workshop for Scientists and Stakeholders, Washington, DC. Contact: Bob Hopkins, email:Robert.Hopkins@noaa.gov, tel: (202) 482 6090, URL: www.climatescience.gov.

**December 3-6**

International Symposium on Resource and Environmental Monitoring, Hyderabad, India, Contact R. Nagaraja, email: nagaraja_r@nrsa.gov.in, tel: 91-40-388-4239.

**December 6-10**

American Geophysical Union Fall Meeting, San Francisco, CA. Contact: E. Terry, email: eterry@agu.org, URL: www.agu.org/meetings/fm02top.html.

**December 9-13**

NOAA Satellite Direct Readout Conference for the Americas, Miami, Florida. Email: satinfo@noaa.gov, URL: noaasis.noaa.gov/miami02.

### *2003*

**February 9-13**

American Meteorological Society Annual Meeting, Long Beach, CA. Email:amsinfo@ametsoc.org, URL: ametsoc.org/AMS/.

**February 13-18**

AAAS Annual Meeting, Denver, CO. URL: www.aaas.org/meetings/.

**March 11-13**

Eleventh Annual Workshop on Adaptive Sensor Array Processing (ASAP 2003), Boston, MA. Contact: James Ward, email: jward@ll.mit.edu, URL: www.ll.mit.edu/asap.

**April 6-11**

AGU/European Geographical Society (EGS)/European Union of Geosciences (EUG) Joint Spring Meeting, Nice, France. Email:EGS@copernicus.org, URL: www.copernicus.org/EGS/egsga/nice03/.

**May 7-9**

American Society of Photgrammetry and Remote Sensing, Anchorage, AK. Contact: Thomas Eidel, email:teidel@gci.net, URL: www.asprs.org/alaska2003/.

**June 4-6**

Oceanology International (OI) Americas, New Orleans, LA. URL: www.oiamericas.com.

**June 30-July11**

International Union of Geodesy and Geophysics 2003, Saporo, Japan. Email: IUGG_service@jamstec.go.jp, URL: www.jamstec.go.jp/jamstec-e/iugg/index.html.

**July 21-25**

IGARSS 2003, Toulouse, France. Email: grss@ieee.org, URL: www.igarss03.com.

**August 30-September 6**

Second International Swiss NCCR Climate Summer School: "Climate Change – Impacts of Terrestrial Ecosystems." Grindelwald, Switzerland. Contact: Kaspar Meuli, email: nccr-climate@giub.unibe.edu, URL: www.nccr-climate.unibe.ch.

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