National Aeronautics and Space Administration
Earth Observer : May—June 2005 : Vol. 17 : No. 3

The Earth Observer

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In This Issue

Editor's Corner

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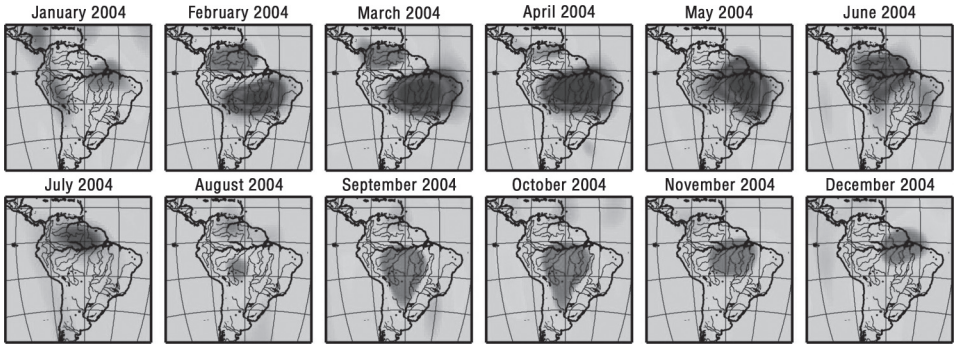
EOS Project Scientist

Responding to a recent report issued by the National Academy of Sciences, the House Appropriations Committee has held hearings and issued their own report expressing serious concern over the drastic reductions to Earth science programs that NASA has proposed. According to the Academy's report, "The aggressive pursuit of understanding Earth as a system—and the effective application of that knowledge for society's benefit—will increasingly distinguish those nations that achieve sustained prosperity from those that do not. At NASA, the vitality of Earth science and application programs has been placed at substantial risk by rapidly shrinking budgets that no longer support already-approved missions and programs of high scientific and societal relevance." To begin to address these budget shortcomings, the Committee provided $40 M in additional funding for science at NASA above the Administration's original budget request.

I'm happy to announce that included in that amount is $30 M in additional funding for the Glory mission. Glory is a critical mission for achieving the goals of the Climate Change Research Initiative (CCRI). This additional funding will allow for work to continue on the two instruments planned to fly on Glory—the Aerosol Polarimetry Sensor and the Total Irradiance Monitor—and also allow for work to begin on reintegration of the spacecraft bus. Work can also begin on the science data ground processing system and on education and outreach activities related to Glory. Critical design reviews for all aspects of the program—the instruments, the bus, and the ground system—will be held in 2006.

The Gravity Recovery and Climate Experiment (GRACE) continues to measure the Earth's gravity field with unprecedented accuracy and the data provided are leading to new scientific discoveries. Below is an example of how information from GRACE provides a valuable new tool that helps hydrologists study month-to-month variations in water storage over large land areas from space. The maps show the monthly fluctuation in water storage (relative to a three year average value) over South America's Amazon and Orinoco River basins during 2004. You can see the rainy and dry seasons very clearly in the Amazon basin and also see distinctly different characteristics in the smaller Orinoco basin to the north.

The Tropical Rainfall Measuring Mission (TRMM) has been given a new lease on life. Mike Griffin, NASA Administrator, announced at a public meeting on July 9 that he intends to extend the TRMM mission beyond this summer. TRMM is expected to reach the mini-

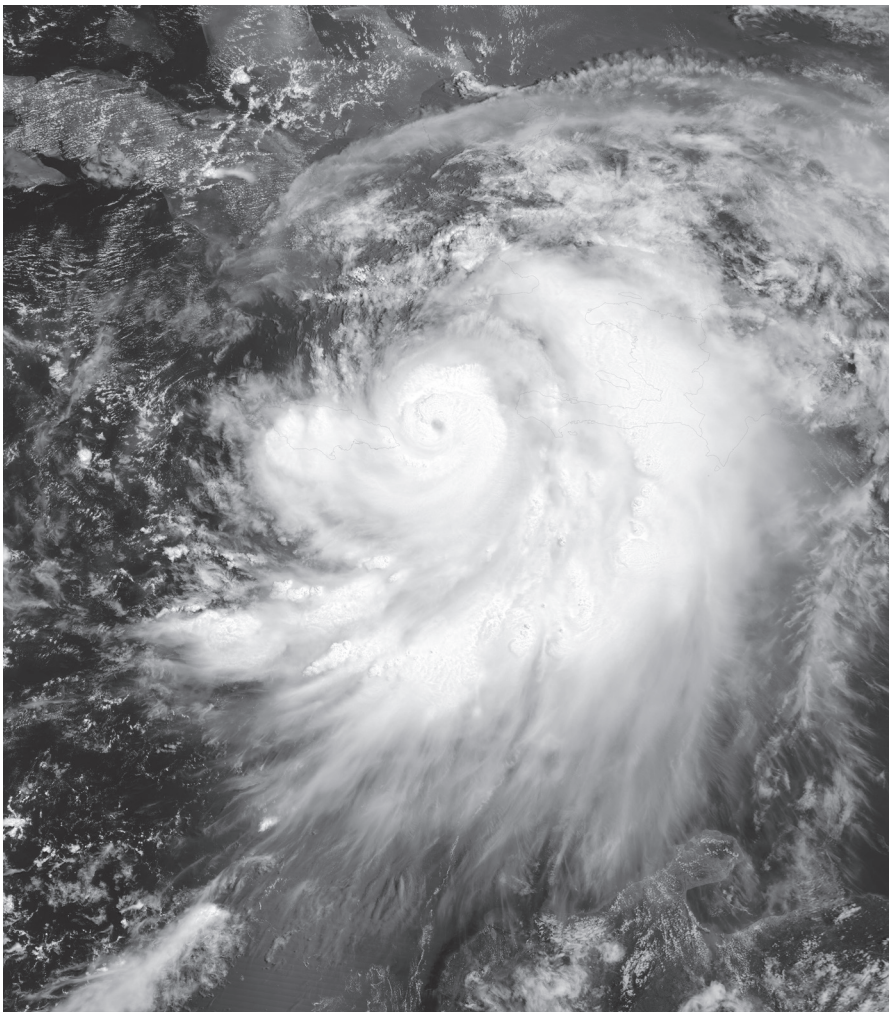


mum level of fuel for a controlled reentry in August of this year; however, Griffin believes the public safety benefits gained from its storm tracking capabilities far exceed any small risk of human injury resulting from an uncontrolled reentry. The TRMM spacecraft is expected to last until at least 2010, when the core spacecraft for the Global Precipitation Measurement Mission—a TRMM follow-on—is planned for launch.

In other news, bearings are starting to fail on the Tropospheric Emission Spectrometer (TES) on Aura. The TES team has eliminated limb scanning to lengthen the lifetime of the instrument. Nadir measurements are more important to the overall mission objectives for TES and taking nadir scans only will extend the lifetime of TES between 20-40 months. Other instruments on Aura should mostly compensate for the loss of limb scanning from TES. Despite this setback, TES continues to produce new science results, including maps of HDO, which is useful for understanding dehydration in the tropics as air enters the stratosphere, and for studying changes in the tropical troposphere that may result from climate change. Recent results have also demonstrated that TES can obtain data through clouds up to an optical depth of ~0.8.

As I reported in the previous issue, preparations continue for the launch of CloudSat/Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) from Vandenberg Air Force Base later this year. Both CloudSat and CALIPSO are now at Vandenberg being prepared for launch, which is now planned no earlier than September 11, 2005.

Lastly, our decision to discontinue printing the newsletter has been reversed due to feedback from the scientific community. With the continuation of printing, we will be completely redesigning and refocusing the newsletter to include more interesting research articles, images and pictures, along with reports from workshops and meetings. Look for a totally new *The Earth Observer* in the near future. As always, it will continue to be available at *eos.nasa.gov*.



Hurricane Dennis threaded its way between Jamaica and Haiti on a direct course for Cuba on July 7, 2005. The storm has the distinctive hurricane form, with a well-defined eye surrounded by bands of swirling clouds. At 10:50 a.m. local time (15:50 UTC), when the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite took this image, Dennis was just below a Category 3 hurricane, with winds of 175 kilometers per hour (110 miles per hour) and stronger gusts. Less than an hour before this image was taken, the storm's small dark eye was about 105 kilometers (65 miles) northeast of Kingston, Jamaica and 170 kilometers (105 miles) south-southeast of Guantanamo, Cuba. The National Hurricane Center reported that Dennis is traveling northwest at about 24 kilometers per hour (15 mph).

A storm of this size is a threat not just because of its powerful winds: Dennis produced heavy rain and coastal and inland flooding. Five to ten inches of rain fell over Haiti, the Dominican Republic, Jamaica, Cuba, and the Cayman Islands, with as much as 15 inches in parts of Jamaica. Heavy rainfall can trigger flash floods and mudslides in mountainous regions. The storm increased tide levels by five to seven feet and generated large and dangerous waves.

Dennis strengthened as it moved north towards the Gulf Coast of the United States.

The image is available in additional resolutions from the MODIS Rapid Response Team.

NASA image courtesy Jeff Schmaltz, MODIS Land Rapid Response Team at NASA GSFC.

March 2005 MODIS Science Team Meeting Overview

— Yolanda Harvey, yrharvey@yahoo.com, Goddard Space Flight Center
— Vince Salomonson, Vincent.V.Salomonson@nasa.gov, Goddard Space Flight Center

The twenty-fifth Moderate-Resolution Imaging Spectroradiometer (MODIS) Science Team Meeting was held on March 22, 23, and 24, 2005, at the BWI Marriott in Baltimore, Maryland, with nearly 300 persons in attendance. At the meeting Vince Salomonson, the MODIS Science Team Leader, indicated that the objective of the meeting was primarily to update all members of the Team and the community on progress since the previous meeting (held in July of 2004) on the implementation of MODIS products and their use for science and applications. The meeting had three major parts: plenary sessions, poster sessions, and breakout meetings for the three disciplines. This article covers the plenary sessions; details of the poster and breakout sessions can be found on the MODIS website at *modis.gsfc.nasa.gov/sci_team/meetings/200503/index.php*.

Plenary Day One

The first day of plenary focused on overviews and overarching activities affecting the MODIS project. **Vince Salomonson** opened the meeting and noted that the current Science Team is composed of 91 members actively working to improve MODIS products and apply them for science and applications purposes. Nearly 100 posters were presented at the meeting showing a wide range of results achieved by the team, which illustrated the considerable breadth and extent of the use of MODIS data.

Since 1990, MODIS has spawned over 1,400 published articles (the vast majority of which are available in the MODIS database). As other indicators of the pervasiveness of MODIS results, Salomonson noted that over 180 papers were presented at the Fall American Geophysical Union (AGU) with MODIS content. The Web of Science lists 722 refereed publications as of March 21, 2005. In addition, MODIS data are increasingly used across the world. A recent survey showed that there are more than 100 Earth Observing System (EOS) Direct Readout ingest sites that pull data from MODIS overpasses for more than 800 distinct users. A nearly complete list of ingest sites is listed on the Direct Readout Portal (*directreadout.gsfc.nasa.gov/links/eos-db_sites.cfm*).

Terra and Aqua MODIS are both performing well; after five years of operation Terra MODIS is still meeting or exceeding its calibration and geolocation specifications, as is Aqua MODIS after three years of operation. The data processing systems have continuously evolved, and the three DAACs have delivered, processed, and archived large MODIS data volumes including over a petabyte of MODIS data at the Goddard and EROS Data Center (EDC) Land Processes Distributed Active Archive Center (DAAC) each since data started to be acquired. Collection 4 reprocessing has finished, and Collection 5 is set to begin later this year.

Efforts to extend MODIS into the National Polar-Orbiting Operational Environmental Satellite System (NPOESS)/Preparatory Project (NPP) era continue. Jeff Privette, the Visible Infrared Radiometer Suite (VIIRS) Deputy Project Scientist, reported that the VIIRS instrument (based in large part on the MODIS instrument) should start flying on NPOESS in the 2009-2010 timeframe. Issues such as modifying and fixing the VIIRS cryoradiator are being addressed to keep the development on schedule.

The overarching thrusts set out by Salomonson at the July 2004 Science Team Meeting still apply. The team must continue to improve access to and the use of MODIS data products via supporting and collaborating with the EOS Data and Information System (EOSDIS) and other entities that provide data products to the various user communities, as well as interact with modeling communities to assimilate MODIS data into Earth system and Earth system component models. The team must pursue the goal of providing Climate-Data-Record (CDR) quality data sets, as well as increase interdisciplinary efforts to use MODIS products (for example, atmosphere products for use in land and oceans efforts). Finally, the team must continue its work educating and training students to use and appreciate remote-sensing data for Earth Science applications.

Paula Bontempi, MODIS Program Scientist and Manager of NASA HQ Ocean Biology and Biogeochemistry Programs, presented on a number of topics related to the MODIS project, including the NASA Headquarters reorganization, budget issues, the Terra Senior Review, and challenges facing the team. Overall, MODIS is doing very well, though the team needs to continue and increase its efforts toward interdisciplinary algorithm development, and also refine the products through their own efforts and an EOS Data Review. NASA is switching from a missions-based to a measurements-based focus, and MODIS needs to realign accordingly.

Jon Ranson, the Goddard Terra Project Scientist, updated the team on the status of the Terra satellite. As of February 24, 2005, the Terra satellite and its instruments have gathered five years of high-quality science data. The volume of validated data at the many DAACs is unprecedented, despite anomalies with a few of the instruments. Issues still facing the satellite are a Terra/Aqua follow-on (i.e., NPP), long-term archiving, the NASA reorganization, and the Senior Review (which will affect all missions at the end of their design life). Terra's review is planned for March 2005. (Editor's

Note: the review took place on April 27, 2005.) As of July 7, in a letter from Dr. Mary Cleave, Director of the Earth-Sun Division at NASA Headquarters, the Terra mission was given both positive science and education/public outreach reviews and the mission is to be extended for the period FY06-09.

Steve Platnick, the Goddard Aqua Deputy Project Scientist, updated the team on the status of the Aqua satellite. Every instrument on the satellite, with the exception of the Humidity Sounder for Brazil (HSB), is working well. There have been only minor spacecraft anomalies, and none have affected science data. Aqua has successfully performed a number of orbit maneuvers, and data downlinks and Direct Broadcast are working well. Orbital debris is a concern, however.

Martha Maiden, NASA Headquarters Program Executive, Data and Information Systems, Earth-Sun System Division, chaired the following session on Data Access and Delivery. Presenters in this session were Robin Pfister on the EOS-DIS Clearing House (ECHO) activities, Bill Ridgway on the Atmosphere Archive and Distribution System (ADDS), David Herring on NASA Earth Observations (NEO), and Myra Bambacus on Geospace Interoperability and the Earth-Sun Gateway.

Robin Pfister, the NASA Goddard Earth Science Data and Information System (ESDIS IMS) Lead Engineer, presented on ECHO activities. ECHO is an enabling framework that allows interoperability among diverse and distributed data, service, and client systems. It is a metadata clearinghouse and order broker, an open system, and in the near future will also be a granule-level service broker. ECHO is iteratively developed, and is currently on version 5.5.3 with more advanced versions in testing and development. As of March 1, 2005, ECHO lists 1409 public and restricted collections, over 41.6 million granules, and 7.3 million browse images. More information about ECHO and its progress can be found at *eos.nasa.gov/echo*.

Bill Ridgway, the MODIS Atmosphere Science Discipline Data Team (SSDT) Lead, presented on AADS. The goal of the AADS is to put a high percentage of L2 and L3 products in a readily-available archive, and to make those data available for those people with large/compacted orders. AADS was originally designed as a science testing utility for MODIS Science Team members, but it now houses Science Test Data for distribution to the Atmosphere Discipline Science Team (ADST), including test Level 2 and 3 data from Collections 4 and 5. AADS is also used extensively for distributing science test data. In the future, it will be expanded to offer an online inventory of all MODIS atmosphere products over the complete mission lifetime. AADS is available at: *aadsweb.nascom.nasa.gov/* and LADS (the Land discipline version) is available at *ladsweb.nascom.nasa.gov/*. Both archives are currently functioning and populated with Collection 4 and 5 science test data, and both are ready for production and public distribution (April for AADS, and September for LADS).

David Herring, Program Manager for Education & Outreach, NASA Earth-Sun Exploration Division, NASA/Goddard Space Flight Center, presented an update on the NEO Gateway. NEO is a web-based application and infrastructure designed to provide formal and informal educators with a simple interface for searching and retrieving NASA remote-sensing imagery data. The current focus is on MODIS data, but more data sets will be added as the project moves forward. NEO is currently in prototype stage, but the team is working with a number of data providers to continue developing and testing the system. The production server will soon be established, and soon thereafter begin ingesting data packets from participating MODIS data providers. It is expected to go live around June of 2005, but long-term hosting is still up in the air.

Myra Bambacus, NASA Geospatial Interoperability Program Manager, Applied Sciences Program, NASA Science Mission Directorate, presented on the Geospatial Interoperability and Earth Sun Gateway. The current challenges facing the program are transitioning from research to operations; characterizing uncertainty in model forecasts for weather, climate, and natural hazards; acquiring the computing capacity to handle the volume and range of data produced by NASA's Earth observatories; accessing those observations and model outputs throughout the Global Spatial Data Infrastructure; and establishing an Earth-Sun Gateway that can provide access to scientists, decision makers, educators, and citizens. Geospatial Standards and Interoperability are crosscutting functions needed in the current national and international initiatives. They build on existing catalogs and portals, and comments/requests are welcome via *esg.gsfc.nasa.gov*.

Frank Lindsay, Visiting Senior Scientist for Data and Information Systems, NASA HQ, followed Myra Bambacus, talking about ACCESS: Advancing Collaborative Connections for Earth-Sun System Science. ACCESS' premise is to enable Earth science and application through near term improvements in NASA's existing Earth science data systems infrastructure and related services, and also to take advantage of existing solutions developed from members of the science communities that have wider applicability. ACCESS' roles are to provide data and information tools and services to support emerging or existing community science processing systems (ComPS), and data and information tools and services to support the seven Science Focus Areas (SFAs). To improve ACCESS to data and services, each SFA contributes to three elements: REASoNs (Science), ComPS (Community Science Processing), and Decisions (Applied Sciences). Bambacus added that this hopefully will settle down to a reasonable number of mechanisms so that users don't have to keep reinventing the wheel. The metrics should be enriched by people working together, with people focused on output, and capable of measuring customer satisfaction.

Milt Halem, NASA Goddard Space Flight Center (Emeritus), chaired this plenary session focusing on the use of MODIS in modeling. He added that

he was pleased to see all the posters on display at the meeting, and gave a brief history of his involvement in the MODIS project. The presentations in this session were made by Arlindo da Silva on Cloud Studies, Watson Gregg on Ocean Biology Studies, and Rama Nemani on Land Processes Studies.

Arlindo da Silva, from the NASA Goddard Global Modeling and Assimilation Office (GMAO), presented on that office's efforts at assimilating MODIS data. The group there has been working with the International Satellite Cloud Climatology Project (ISCCP) and MODIS data for assimilating cloud observations, wind data, and aerosol data, as well as developing an aerosol model. The work done by the GMAO has shown that cloud observations have a very positive impact on the fvDAS cloud radiative forcing and land surface. MODIS winds complement other satellite observations in the high latitudes, and on-line aerosol data assimilation enables the production of long term analyzed data sets, aerosol forecasting in support of field campaigns, as well as the stimulation of future aerosol instruments.

Watson Gregg, GMAO, and a MODIS Oceans Science Team Member, presented on efforts to assimilate Aqua Ocean Chlorophyll Data into a global three-dimensional model called the NASA Ocean Biogeochemical EOS Assimilation Model (OBEAM). The motivations for this are to maximize data use, estimate parameters to improve models, estimate state and flux, and make predictions. The initial assimilation results are promising, but require further analysis of new methodologies. The team is awaiting new SeaWiFS data, and will proceed on the incorporation of the MODIS/GMAO products.

Rama Nemani, Research Scientist at NASA Ames Research Center, presented on terrestrial ecosystem analyses using MODIS data which have been very valuable for terrestrial ecosystems. Some examples were extrapolating fluxtower observations, mapping wildland fire risks, and detecting vegetation in the Amazon River Basin. He noted that MODIS use among modelers stresses a number of things, including the importance of quality analysis, producing high-quality monthly-average products, interdisciplinary studies, and uncertainty levels.

Plenary Day Two

Plenary continued on the morning of the second day of the meeting, starting off with a session on Climate-Quality Data Sets, chaired by **Paula Bontempi**. This session covered presentations made by Nazmi Saleous on the Research, Education, and Applications Solutions Network Cooperative Agreement Notice (REASoN CAN), Chuck McClain on ocean color data sets, Paul Menzel on Atmospheric Data Sets, and Lucia Tsaoussi on Climate-Quality Data Records.

Nazmi Saleous, SAIC Senior System Analyst, presented on REASoN CAN progress. REASoN CAN focuses on the status of the 0.05-degree global climate/interdisciplinary long-term data set from the Advanced Very High Reolution Radiometer (AVHRR), MODIS, and VIIRS. The five-year project is in the earliest stages. The first beta AVHRR/MODIS surface-reflectance data set will be released soon. The project is on target and working on first-year activities including acquiring input and ancillary data, evaluating existing data sets, and adapting calibration approaches. Upcoming work will focus on making AVHRR data set improvements, making data sets available online via web and ftp, and soliciting user-feedback via their project website. Their work so far has shown that the creation of a long-term Land Surface Data Record is feasible, and work on it will continue.

Chuck McClain, the MODIS Oceans Science Team Leader, presented on the progress/status of the ocean color data sets. The MODIS Oceans Team has been making progress putting together an ocean color time series, which can be used to track changes that will show how the ecosystems adjust to atmospheric changes. Climate Data Records (CDRs) have a number of requirements, including a long-term data series, the highest-possible quality satellite and *in-situ* data, and consistency between satellite data sets. Seasonal cycles are a challenge, but given good quality data this becomes less of a concern. Work continues, and a number of data set reprocessings will take place to meet quality goals.

Paul Menzel, MODIS Atmospheres Science Team Member from NOAA/NESDIS and the University of Wisconsin, presented on achieving climate-quality data sets. Menzel used clouds as an example. Clouds are an important factor in climate system energy, and an accurate determination of global cloud cover has been the goal for a long time. There is a need for consistent long-term observation records to enable better characterization of weather and climate variability. However, clouds are tough to measure for a number of reasons, but especially since cloud properties can vary by a factor of 1000 in a few hours. In addition, climate data sets are very challenging in and of themselves, requiring spectral consistency, accurate radiative transfer, orbit constancy, consistency with the Global Observing System, and reprocessing opportunities.

Lucia Tsaoussi, the Deputy Director Research & Analysis Program Earth-Sun System Division, NASA Headquarters, presented on the programmatic considerations of Earth System Data Records (ESDRs). An ESDR is defined as a unified and coherent set of observations of a parameter of the Earth system, which is optimized to meet specific requirements in addressing Earth science questions and/or provide for science applications. In principle, ESDRs will extend the value of NASA's existing data products, and the primary motivation for this plan is the need to develop and generate a unified and coherent data record for a given Earth System parameter by properly merging multi-sensor and multi-platform satellite observations. These data sets are critical to understanding Earth System processes, assessing variability, long-term trends and change in the Earth System. They also provide input and validation means to modeling efforts. There

are a number of plans in place to help reach the goal of creating ESDRs. The Division is inviting input on establishing high priority science products (including ESDRs and articulating their purpose), identifying scientific challenges for their development and implementation, and participating in any of the planning efforts, collectively and individually.

The final plenary session on the second day was chaired by **Vince Salomonson**. This session focused on the fusion of data and observations from multiple instruments. The purpose of the session was to highlight progress being made in data fusion and to emphasize the importance of making progress in this regard as the NASA Earth sciences efforts focus more in the future on the measurements needed for science and applications rather than individual missions. The presentations were made by David Diner on MISR/MODIS comparisons, Norman Loeb on analyses of CERES/MISR/MODIS data, Mitch Goldberg on the advantages of combining AIRS/AMSU with MODIS observations, and Simon Hook on the synergisms gained by combining ASTER and MODIS observations.

David Diner, the Terra Multiangle Imaging Spectroradiometer (MISR) Principle Investigator from JPL, presented on comparisons between MISR and MODIS data. For aerosols and cirrus, MISR/MODIS standard products are complementary: MODIS brings broad spectral coverage (which enhances sensitivity to size, particularly coarse mode), while MISR provides multiangle data that is sensitive to shape. Simultaneous broad spectral coverage from MODIS and wide angular coverage from MISR provides a uniquely valuable combination. Having independent retrievals of related parameters from each sensor using different methodologies is a key element of a robust observing system. Data fusion also capitalizes on complementary sensitivities to aerosol, cloud, and surface properties. MISR/MODIS data fusion is currently being done in research mode.

Norman Loeb, Senior Scientist, Langley Research Center and Research Professor from Hampton University, presented on the Cloud and the Earth's Radiant Energy System (CERES)/MODIS/MISR data analyses. Loeb provided examples of how data fusion from CERES, MODIS, and MISR are being used to tackle science problems, and showed how merged CERES and MODIS data are being used to quantify the global direct radiative effect of aerosols. Loeb also illustrated how combined CERES and MISR data can be useful for examining cloud and aerosol interactions, and pointed out that much more can be done with merged CERES, MODIS, and MISR measurements. The instruments are highly complementary providing broadband, spectral, and multiangle information from one spacecraft. Such capabilities can be used to improve the ability to infer aerosol and surface properties, cloud-radiation interactions, and cloud radiative forcing at both coarse and high spatial resolution.

Mitch Goldberg, the Chief of the Satellite Meteorology and Climate Division of the National Oceanic and Atmospheric Administration's (NOAA)/National Environmental Satellite Data and Information Service's (NESDIS) Office of Research and Applications, presented on integrating data from MODIS and the Atmospheric Infrared Sounder (AIRS) to improve AIRS radiance and retrieval products. The Advanced Microwave Sounding Unit (AMSU)-AIRS processing system is integrated by design, provides a sounding for every field of view, provides retrievals in overcast conditions, and derives cloud-clearing. Science improvements are continuing, including adding MODIS to improve the cloud-clearing and soundings algorithm; adding trace gas retrieval algorithms to derive CO_2, CO, and CH_4; and improving surface emissivity/bi-directional reflectance (non-ocean). The challenges for AIRS Numerical Weather Prediction (NWP) are to assimilate cloud-cleared radiances to improve the yield of observations in the lower troposphere and to provide very accurate cloud-cleared radiances. The strategy is to use MODIS data to improve accuracy, and results show that retrieval errors are significantly reduced after MODIS is used to quality control AIRS cloud-cleared radiances.

Simon Hook, JPL scientist and MODIS Calibration Science Team Member, presented on the synergistic use of data sets from multiple instruments for Earth Science research, specifically the Advanced Spaceborne Thermal Emission Reflection Radiometer (ASTER) and MODIS. His presentation covered examples of hazards (e.g., mapping volcanic plumes and validating the MODIS fire product), ecology, and hydrology research. Hook also discussed critical factors limiting the use of multi-instrument data, and ways to increase multi-instrument studies. He listed a number of factors that limit the use of multi-instrument data, including interoperability/protocols/standards, information assurance and security, hardware/software, infrastructure/bandwidth, and human and institutional capacity.

Plenary Day Three

The last day of the Science Team Meeting ended with summaries from the Science Team Discipline Leaders of discussions and major points covered during the meeting in discipline sessions.

Chuck McClain, the MODIS Oceans Science Team Leader, reported that for Aqua MODIS ocean color processing, Level 0 to Level 3 data processing is now fully supported in the Sea-viewing Wide Field of View Sensor (SeaWiFS) Data Analysis System (SeaDAS), the major differences between SeaWiFS and Aqua MODIS have been resolved, reprocessing was recently done after several months of algorithm testing and evaluation, and the OBPG is working with the MODIS Calibration Support Team (MCST) to reduce striping in Level 1 and Level 2 data. For calibration and validation, work by Jim Mueller and Carol Johnson to lead a cal/val working group on error budget and future measurement strategy is ongoing. Product suite and algorithm selections continue, with a comprehensive chlorophyll algorithm development set and quality control procedure being released very soon by the OBPG. The team is working on remedying inadequate validation sets for many products, and the products

themselves are being vetted with the community via team meetings and workshops. Atmospheric corrections are also ongoing via work with Menghua Wang and the Miami group. There has also been discussion of Terra ocean data processing, though this must first be approved by NASA HQ for it to move forward.

Michael King, the MODIS Atmospheres Science Team Leader, noted that he Atmospheres Team has grown significantly from 5 to 37, and the amount and quality of work being accomplished is very impressive. For Collection 5, there were a number of modifications and enhancements made, and processing is ready to commence in April 2005. The cloud product has had changes to ice crystal libraries, phase determination, atmospheres/land surface reflectance product, atmospheric correction, and many other parameters. The aerosol product uses new spatial variability tests to improve the screening of heavy aerosol and clouds, and does better regional characterization of aerosol optical properties. In addition, water vapor over high dry regions, like Tibet, has improved in the near-infrared algorithm. New software is planned for AIRS and MODIS data in 2005, and work on Collection 6 has already begun.

In addition, MODIS Direct Broadcast is exploding internationally. New software at Wisconsin will incorporate MODIS cloud, snow, reflectance, and Bidirectional Reflection Distribution Function (BRDF) products, Advanced Microwave Scanning Radiometer for EOS (AMSR-E) precipitation, and high resolution AIRS/MODIS analysis in 2005. For applications, the Infusing Satellite Data into the Environmental Air Quality Applications (IDEA) project (NOAA/NASA/Environmental Protection Agency, EPA) is using MODIS data and EPA's Particulate Matter 2.5 (PM2.5) data to input into air quality monitoring in the US. MODIS polar winds are being used by the European Center for Medium-Range Weather Forecasts (ECMWF), the Global Modeling and Assimilation Office (GMAO), the National Centers for Environmental Prediction (NCEP) (June), Japan, and Canada. There were also several data assimilation and modeling investigations described that are showing great progress, such as a new clear-sky radiance data set being developed for ingest at ECMWF.

Chris Justice, the MODIS Land (MODLAND) Science Team Leader, presented on the Land Discipline's progress. There are a number of current issues and priorities facing the Land group, including broadening MODLAND in the framework of the focus area measurement teams and land data processing following the Ocean Color model; Collection 5 testing; validation; continuing community outreach; MODIS Land Direct Broadcast; continuing to integrate Land products into NASA applications; distributing and archiving data; and ramping down MODIS' support services (MCST and the Science Data Support Team, SDST). A number of presentations showcased the Land group's work, including the tracking of snow-cover depletion curves used in famine early-warning in Afghanistan; improving 500-m white sky albedo; and Land Rapid Response, which continues to give high visibility to the applications community.

The Land Measurement Team has also been working on ESDRs, the priority of which is derived from the importance of end uses, and requirements derived from end user needs (e.g. science questions, applications, and decision support). These will engage the relevant agencies: NASA, NOAA, the U.S. Geological Survey (USGS), U.S. Department of Agriculture (USDA), etc. They will be compatible with other frameworks, e.g. the Global Terrestrial Observing System (GTOS), Ground Computer Operating Systems (GCOS), and will be consistent with records managed by other measurement teams. They will also be linked to historical measurements for continuity.

In general, the Land Discipline faces a number of considerations including error, uncertainty, and precision rates as required in product definitions and production. There is also the issue of consistency between Land subgroups and ESDRs, which are important for the modeling community. The team also needs to pay attention to the bigger picture, e.g. Terra extension, Landsat, and the Global Earth Observation System of Systems (GEOSS). They have to look for ways to do things better, faster, and cheaper, including utilizing the resources they have to the greatest effect.

Paula Bontempi, NASA Headquarters MODIS Program Scientist, then presented the NASA Headquarters response to the work and progress that has been reported. She noted that Justice's presentations in particular hit on many of the big-picture issues the team needs to think of, and she was pleased to see the ideas/uses for data and progress that has been made on research, proposals, and algorithms since the recompetition. The interest in Terra and Aqua MODIS ocean data is encouraging, and the work done there was impressive. The aerosol measurements need to be taken advantage of by the other disciplines, since a great deal of quality work is being done there. Algorithm Theoretical Basis Document (ATBD) reviews are very important, and the team needs to get moving in this direction with the involvement of NASA HQ. In the end, the impact this team is having on the real world is amazing, and shows a good bit of progress on the team's part.

Vince Salomonson closed the meeting by thanking the MODIS Administrative Support Team and all others that supported this Science Team meeting for their efforts, and the Science Team members for their participation along with excellent presentations, and posters.

A very rich set of results has been presented at this meeting. The Science Team members and colleagues need to continue publishing with emphasis on publishing in refereed journals. The use of MODIS products is growing and, concomitantly, work needs to continue on the user guides and ATBDs. It is good to see in this meeting and elsewhere that the access to MODIS products is improving and, in fact, does not seem to be a major issue as it has been in the past. The use of MODIS products

(continued on p.17)

Third CERES-II Science Team Meeting

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The third meeting of the Clouds and the Earth's Radiant Energy System (CERES-II) Science Team, held May 3-5, 2005, was hosted by Leo Donner at the Geophysical Fluid Dynamics Laboratory (GFDL) in Princeton, New Jersey. The choice of venue was guided by the CERES objective of fostering close cooperation with climate modeling groups around the U.S. and the world. The next Science Team meeting will be held November 1-3, 2005 at or near NASA Langley Research Center (LaRC) in Hampton, Virginia.

The objectives of this meeting included a review of the status of CERES data products, examination of the stability of Terra calibration over the last 5 years, assessment of the effect of the recent anomaly on the Aqua Flight Model (FM)-4 shortwave (SW) channel, and examination of interannual variability in cloud and radiation data. There was a discussion on how CERES products fit with the reprocessed Earth Radiation Budget Satellite (ERBS) Edition-3 data, new data on ocean heat storage, and Earthshine data. Status of the Global Energy and Water-cycle Experiment (GEWEX) Radiative Flux Assessment activity was also discussed.

Climate Program Overview

Bruce Wielicki (LaRC) reported on the state of the U.S. Climate Change Science Program (CCSP), the Intergovernmental Panel on Climate Change (IPCC), NASA Earth Science, CERES, National Polar Orbiting Environmental Satellite System (NPOESS), and NPOESS Preparatory Project (NPP). The Fall 2005 CCSP Workshop may include a session on climate observation requirements and/or climate prediction uncertainty. The IPCC Assessment Report 4 (AR4) is under development. The Working Group Report of the IPCC Meeting on Climate Sensitivity held in April 2004 at the U.K. Meteorological Office (UKMO) reported on new ways of using Perturbed Physics Ensembles to rigorously infer uncertainties in climate predictions. Wielicki is a contributing author to the AR4 chapter on changes in top-of-atmosphere (TOA) fluxes.

NASA's reorganization focusing on Lunar and Mars exploration initiatives is likely to lead to a 10-30% funding cut in Earth and Space Sciences activities in the coming years. The FY2005 budget resulted in a 10-20% cut for Earth Sciences overall. The Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO)/CloudSat launch is planned for August/September 2005. NASA's next Earth System Science Pathfinder (ESSP) competition, originally planned for FY2005, is now uncertain. (Editor's Note: The launch date for CloudSat/CALIPSO is now no earlier than September 11, 2005.)

The CERES Project is taking an additional 5% cuts for FY2005 and FY2006 on top of the 20% cut taken in FY2004. The CERES FM-5 instrument has been knocked off the NPP mission a second time. CERES has been working with NPOESS to estimate the cost of transitioning CERES data product codes to the NPOESS system. NPOESS has formally requested NASA to provide the stored CERES FM-5 instrument for use on the first NPOESS 1:30 local time satellite. CERES has re-examined the radiation budget data gap risk. It moderately exceeds climate goals if Terra and Aqua data continue to be taken as long as viable. Wielicki also presented an executive summary outlining the basic requirements of a climate program, listing key advances of the CERES project over the Earth Radiation Budget Experiment (ERBE) and other Earth radiation budget (ERB) projects.

Terra/Aqua Instruments and Calibrations

Kory Priestley (LaRC) presented the operational and calibration/validation status of the four CERES instruments on Terra and Aqua. Both instruments on Terra and one (FM-3) on Aqua continue to function nominally. The SW channel of FM-4 on Aqua suffered an anomaly on March 30, 2005, and stopped taking radiometric measurements. Total and window channels on FM-4 continue to function nominally. The FM-3 instrument was immediately put in cross-track mode to preserve the quality of the climate data record. Near-term impact of the anomaly seems minimal, but if it is not resolved soon, the climate data gap risk increases significantly. Also, future activities planned in concert with other A-train instruments and the Geostationary Earth Radiation Budget (GERB) satellite will be adversely affected.

Grant Matthews (Analytical Services and Materials, AS&M) presented an investigation of the slow, approximately 2% decrease observed in Terra TOA SW fluxes between March 2000 and December 2003. Darkening of instrument optics due to solar ultraviolet (UV) exposure while the instrument operated in the rotating azimuth plane (RAP) mode was identified as the cause of this decrease. Similar darkening was found to have occurred in SW instruments on both the Long Duration Exposure Facility (LDEF) and the Global Ozone Monitoring Experiment (GOME). Matthews developed correction factors for Terra SW fluxes based on LDEF data.

CERES Cloud Properties

Patrick Minnis (LaRC) presented the status of CERES cloud algorithms and products. The objective is to retrieve complete sets of cloud properties from Tropical Rainfall Measuring Mission (TRMM), Terra, and Aqua that are consistent with measured radiation budget parameters and can be used to initialize and validate climate and weather prediction models. He described the extensive ongoing effort to intercalibrate sensors on various satellites to accomplish consistency. Terra cloud products are now available for March 2000-December 2004 and Aqua products for July 2002-June 2004. CERES cloud properties are validated extensively using ground-based and aircraft measurements, and retrievals from other satellite instruments. Cloud amount comparisons with Geoscience Laser Altimeter System (GLAS) retrievals showed GLAS amounts to be much higher (mostly thin clouds). Comparisons were also shown with ground-based, International Satellite Cloud Climatology Project (ISCCP), and Moderate-resolution Imaging Spectroradiometer (MODIS) results. CERES MODIS retrievals and MODIS team results showed substantial differences.

Simple Surface Fluxes

David Kratz (LaRC) presented validation of SW and longwave (LW) surface fluxes from single scanner footprint (SSF) data derived with simpler surface flux algorithms which are based on TOA-to-surface transfer methods or fast radiation parameterizations. Ground-based fluxes for validation were obtained from a number of sources such as the Atmospheric Radiation Measurement (ARM) sites, Baseline Surface Radiation Network (BSRN), and SURFace RADiation (SURFRAD) network. Clear-sky SW errors were within an acceptable range for most cases, but cloudy-sky SW errors were larger and generally related to scene identification problems. LW errors for both clear and cloudy conditions were within the desired range.

ERBS Edition-3 Data Set

Takmeng Wong (LaRC) presented the ERBS nonscanner Edition-3 data set, its comparisons with other available long-term ERB data sets, and its effect on the decadal variability values published in *Wielicki et al.* (2002). Edition-3 data result from a reprocessing to correct for the downward drift of ERBS orbit from 611 km to 587 km over 15 years starting in 1988. Another correction applied to this data set accounts for a 1% degradation of the SW filter due to solar UV exposure over the same period. These corrections have resulted in a modification of the decadal change values from 3.1 Wm^2 to 0.6 Wm^2 for outgoing LW radiation and from –2.5 Wm^2 to –2.1 Wm^2 for reflected SW flux.

CERES TISA Activities

David Doelling (AS&M) presented the temporal interpolation and spatial averaging (TISA) methodology used to derive the next generation of climate quality, monthly average CERES flux and cloud products. The goal is to minimize errors in daily and monthly averages caused by inadequate diurnal sampling by using geostationary data without compromising the calibration achievable with CERES instruments. Significant differences were shown between monthly results derived with and without the use of geostationary data. The first 3 years of Terra results were presented. LW fluxes produced using geostationary data were validated against ground-based measurements and are already available from the LaRC Atmospheric Sciences Data Center (ASDC). Corresponding SW results are undergoing final tests and will be available shortly.

Terra SARB Products

Thomas Charlock (LaRC) presented an accuracy analysis of CERES Surface and Atmospheric Radiation Budget (SARB) products. SARB data are produced by constraining fluxes at the surface, TOA, and three levels in the atmosphere computed with the Fu-Liou radiative transfer code. CERES TOA measurements were used as the TOA flux constant. These products are validated using ground-based measurements from several global networks assembled within the CERES/ARM Validation Experiment (CAVE) database. Instantaneous biases in SARB downward SW fluxes over the ARM Southern Great Plains (SGP) central facility averaged for the year 2001 were about 13.1 Wm^2. The corresponding bias for downward LW flux was –6.1 Wm^2. Gridded SARB products are regarded as highly valuable for general circulation model (GCM) validation.

Fred Rose (AS&M) presented a brief description and a demonstration of the online version of Fu-Liou radiative transfer code. The online version can be used for quick forcing and sensitivity studies. It is accessible to the science community at *www-cave.larc.nasa.gov/rose/flp*.

Terra ADM Studies

Norman Loeb (Hampton University [HU]) presented a brief overview of CERES Terra Angular Distribution Model (ADM) development and validation. Using multi-angle CERES and MODIS data, he showed that the uncertainty in instantaneous TOA flux is approximately 4% in the SW and 2.5% in the LW. Global average all-sky SW TOA fluxes from the CERES ERBE-like product exceed SSF fluxes by 2 W/m^2. When ERBE-like and SSF SW TOA fluxes are compared using only cross-track data during four years, a spurious trend in SW TOA flux difference is observed due to biases in the ERBE ADMs with seasonal changes in relative azimuth angle.

Terra SW Trend Correction

Norman Loeb presented an investigation of the ~2% decrease in CERES SSF Edition-2B TOA SW fluxes observed for the 2000-2003 period. A separate investigation of this showed that part

of the decrease was caused by spectral darkening of the optics due to solar exposure when the instrument is operating in the RAP mode. Applying adjustment factors based on the above assumption, he showed that spectral darkening accounts for about 1% of the decrease and the remaining 1% may be real.

Terra Data and Earthshine

Norman Loeb presented an analysis of Earthshine data examining the results of *Palle et al.* (2004) who inferred a 6% increase in Earth reflected SW radiation between 2000 and 2003. CERES data for the same period show a 2% decrease in the reflected SW flux. Loeb's analysis of the same Earthshine data showed no change in reflectance during this period. Loeb suggested that the methodology used in the *Palle et al.* analysis is questionable because apparent albedo differences between negative and positive lunar phase angles and year-to-year differences in sampling of lunar phase angles were not considered.

Data Management

Mike Little (LaRC) made a brief presentation on the current state of CERES data products, issues facing the data management group, and plans for the near future. The data management staff is currently trying to improve production efficiency of analysis products by increasing automation. There is increased emphasis on computer security. Little presented a list of CERES products made available since the last meeting and those expected to be available by the next meeting.

Edward Kizer (Science Applications International Corporation [SAIC]) gave a brief report on the status of processing, archiving, and distribution of Earth Science data at the ASDC. Universities and other Government agencies were the biggest users of these products. Kizer also outlined the improvements already made and planned to the ASDC website.

Outreach

Bruce Wielicki presented an overview of the CERES education outreach effort, the Students' Cloud Observations On-Line (S'COOL) Project. S'COOL now has over 1900 registered participants in 65 countries and more that 42,000 ground observations of clouds, 15,500 of which are matched to a Terra or Aqua overpass to within 15 minutes.

In other presentations, Wielicki discussed the absolute accuracy requirements for observational climate data sets and how CERES is approaching those objectives by improving every step of the process. He discussed the many improvements made over ERBE and emphasized that absolute accuracy improvements are difficult to achieve beyond a certain point. He compared recent global ocean heat storage data with global net radiation records from ERBS and CERES and showed that they tracked each other well. Wielicki explained that this agreement was more a function of the stability of ERBS/CERES instruments than of their absolute accuracy. He also stressed the need to better quantify the uncertainties in model climate predictions, and gave an overview of innovative methods being developed around the world for comparing model predictions, with observations.

Invited Presentations

Leo Donner presented an overview of GFDL climate modeling activities. The atmospheric GCMs are evolving into coupled ocean-atmosphere models and then into Earth system models. The latter include tracer transport and chemistry in the atmospheric component, ecology and biogeochemistry in the oceans, and dynamic vegetation and land use over land. He discussed the current research on atmospheric dynamic cores and presented results from the coupled models CM-2.0 and CM-2.1 and the classical atmospheric model AM2. Donner showed numerous comparisons of mean fields between AM2, CM2, National Centers for Environmental Prediction (NCEP)/National Center for Atmospheric Research (NCAR) reanalyses, and other observational data sets. Model radiation budget fields were compared with ERBE observations. Interannual variability in model radiation budget fields was compared with ERBE/CERES results from *Wielicki et al.* (2002). Significant differences were found to result from changes to the dynamic core of the model.

Kuan-Man Xu (LaRC) presented a modeling study of satellite cloud objects conducted using the University of California Los Angeles (UCLA)/LaRC cloud resolving model (CRM). Analyses were presented for tropical deep convective cloud objects from March 1998 and March 2000 and for boundary-layer cloud objects from the TRMM period. CRM simulations of deep convective clouds were compared with European Center for Medium-range Weather Forecasts (ECMWF) analysis products and other observations. Boundary-layer cloud analysis focussed on solid stratus, stratocumulus, shallow cumulus objects. Histograms of CRM-simulated properties were found to be closer to observations than to ECMWF analyses.

Investigator Presentation Highlights

Amy Clement (Rosenstiel School of Marine and Atmospheric Sciences [RSMAS]) presented results of a study looking for trends in the strength of Hadley circulation during the last two decades and their relationship to the observed trends in SW and LW radiative fluxes. She examined reanalysis data sets, [NCEP-1, NCEP-2, and ECMWF Reanalysis (ERA)-40], and climate model products from IPCC 20th century simulations and the Atmospheric Model Intercomparison Project (AMIP)-II and found them to differ significantly. Clement concluded that model-to-model differences resulted from different responses of model vertical temperature to the changes in radiation fields.

Brian Soden (RSMAS) presented results of a study of radiative damping and

climate sensitivity of a number of climate models from the IPCC simulations, and AMIP runs and effects of various feedbacks in those models. He showed climate sensitivity for a large number of IPCC models to CO_2 increases through the Year 2200 and climate feedbacks for many climate models. Results for GDFL and NCAR models showed large differences in sensitivity and low cloud feedback in earlier simulations, but were greatly reduced after model improvements. Soden showed results of regional, seasonal, and interannual radiative damping from a large number of AMIP-II simulations.

Robert Cess (State University of New York at Stony Brook) presented an analysis of cloud vertical structure anomalies in the Eastern and Western Pacific Ocean during the 1997/98 El Niño episode using CERES data from the TRMM satellite. The changes from non-El Niño years to 1998 showed that cloud heights greatly decreased in the Western Pacific and increased in the Eastern Pacific during El Niño conditions. This indicates a collapse of the Walker circulation in the Pacific. Cess compared total cloud radiative forcing in AMIP-II runs with ERBE/CERES data and showed that models differ greatly and exhibit large biases with respect to satellite data.

Bing Lin (LaRC) presented a study of the effects of environmental conditions on tropical deep convective systems (DCS) using measurements from CERES, Visible Infrared Scanner (VIRS), and TRMM Microwave Imager (TMI) for the January-August 1998 period. He found that rainfall efficiency increases with increasing sea surface temperature (SST). Areal coverage of DCS continues to increase with increasing SST despite the increase in rainfall efficiency. It was found that moisture supply for DCS from the boundary layer increases greatly with SST. Lin found no evidence of upper tropospheric dehydration over high SST areas.

Lou Smith (National Institute of Aerospace) presented results of a principal component analysis of the diurnal variation of surface radiation budget (SRB) components derived from a 12-year SRB data set. Three-hourly fields of downward and net SW, and upward, downward, and net LW fluxes were interpolated to hourly fields. Monthly climatological averages for July over land regions were examined in detail. SW fluxes were generally symmetric about the local noon while LW fluxes showed slight asymmetry. The first eigenvalue explained 95% of the diurnal variability for each SRB component.

Norman Loeb presented results from a study of direct radiative effect of aerosols (DREA) using 46 months of CERES and MODIS measurements. SW DREA over clear oceans was estimated to be -5.5 Wm^2 based on cloud screening from the MODIS MOD04 aerosol product, and -3.8 Wm^2 using cloud screening from the NOAA-SSF aerosol product. He showed seasonal variations in DREA and found that it has a pronounced seasonal cycle in the Northern Hemisphere and large year-to-year fluctuations between 30°-60°N.

William Collins (NCAR) presented results from an aerosol simulation where satellite retrieved aerosol optical depths (AODs) are assimilated in the Model for Atmospheric Transport and Chemistry (MATCH), which in turn is driven by meteorological data from atmospheric analyses. The current version of MATCH assimilates MODIS data. Modifications of MATCH are underway that will allow assimilation of Multiangle Imaging Spectrometer (MISR) data as well. Five years' of MATCH products are currently available and have been provided to CERES for use in SARB processing.

Alexander Ignatov (NOAA National Environmental Satellite, Data, and Information Service) presented a comparison of spectral AODs derived from MODIS (MOD04) data from Terra and Aqua satellites. Global 1°x1° data for October 13-21, 2002, from Terra and Aqua were analyzed to check consistency of spectral AODs. Global mean spectral AODs and standard deviations between Terra and Aqua differed significantly. The Angstrom exponents for Terra and Aqua were estimated to be about 0.3 and 0.5, respectively.

Zachary Eitzen (SAIC) presented results of a sensitivity study of simulated cloud objects. The LaRC cloud resolving model was used to simulate many CERES-identified deep convective cloud objects. Atmospheric state and large-scale forcing corresponding to these objects were obtained from ECMWF analyses. Five simulations: a control run, runs for a ±2 K change in SST, and ±50% changes in large-scale forcing were made. Simulated clouds were more sensitive to changes in large-scale forcing than SST.

Jay Mace (University of Utah) presented results of a study in which ground-based measurements of cloud properties made at the ARM central facility are utilized to characterize vertical distribution of radiative energy in the atmospheric column. Mace presented a method for retrieving LWC profiles in super-cooled clouds using Millimeter Cloud Radar (MMCR) and Microwave Radiometer (MWR) measurements. He showed results and validation of the proposed methods.

Bruce Wielicki presented an outline of a concept mission called the Climate Calibration Observatory (CCO) that may be submitted in the near future for consideration by various government agencies. The CCO concept is being developed around a pair of highly calibrated/stable instruments in low inclination (about 67°) orbits with a precession cycle of about 3 months. These instruments can underfly numerous radiation budget instruments on other low-Earth and geostationary platforms. Coincident measurements between CCO and those other instruments may be used to calibrate the measurements from other instruments.

Xiquan Dong (University of North Dakota) presented a study of the effects of deep cumulus clouds on the radiation budget at the surface, in the atmosphere, and at the TOA performed using

ground-based measurements from the ARM SGP and Tropical Western Pacific (TWP) sites and CERES data from Terra. Thirty cases of deep cumulus from the SGP and 14 cases from the TWP were selected for this study. Matching between ground and CERES data was accomplished by averaging ground data over one hour, and averaging CERES data over a 1° x 1° box.

Sunny Sun-Mack (SAIC) presented comparisons of surface-measured and satellite-derived cloud properties in the Arctic. While comparisons in the past were focused mainly on cloud fraction, cloud optical depths are radiatively the most important. She compared monthly time series and monthly climatologies of cloud fraction and optical depths from the radar at Barrow, Alaska, CERES retrievals, and Extended Advanced Very High Resolution Radiometer (AVHRR) Polar Pathfinder (APP-X).

Seiji Kato (HU) presented estimation of the magnitude of errors in CERES SW fluxes potentially resulting from ignoring 3-D radiative effects. A comparison of CERES fluxes with corresponding fluxes derived from a gamma-weighted two-stream model and MODIS cloud properties showed CERES fluxes to be 3-5% lower. The CERES retrieval process was simulated using a 3-D radiative transfer model and cloud fields generated with a large-eddy simulation (LES) model. Kato concluded that a 3-5% error is unlikely to be caused by the neglect of 3-D effects.

Zhonghai Jin (AS&M) compared CERES SW radiances and fluxes with corresponding results derived from the coupled ocean-atmosphere radiative transfer (COART) model. The r.m.s. differences between CERES and model SW radiances were <5% except for clear oceans (where they were up to 9.9%). Differences between CERES and model SW fluxes were <4% over oceans but larger over snow. Jin concluded that these were due to differences in aerosol absorption over oceans and differences in aerosol absorption and snow albedos over snow.

James Coakley (Oregon State University, OSU) showed that cloud properties derived using threshold methods provide good results for completely cloud-filled pixels but not for partly cloudy pixels. He developed and implemented a partly cloudy pixel retrieval method on 1-km MODIS data and estimated errors incurred in MODIS products derived with the threshold method. Coakley also explored if shipboard measurements of surface fluxes available from OSU-operated vessels can be used for validating CERES-derived surface fluxes.

Shi-Keng Yang (NOAA Climate Prediction Center) presented results assessing recently indicated ozone recovery trends using cohesive ozone data from the Solar Backscattered Ultra Violet (SBUV/2) record. Even though the date of the onset of change in the trend may be uncertain, the recovery trend appears sound. However, the recovery seems limited to the Northern Hemisphere only. A definite inference of recovery onset is not possible at this time.

Cuba is the largest of the Caribbean islands, with a long, complex coastline and considerable chains of offshore islands. Coral reefs stretch along virtually the entire border of the Cuban shelf. The majority of these reefs lie offshore in long tracts which resemble barrier reefs, separated from the main island by broad lagoons. The longest runs for some 400 kilometers along the north coast from the Archipiélago de Sabana to the Archipiélago de Camaguey. On the south coast a similar reef tract stretches for over 350 kilometers from Trinidad to Cabo Cruz. This Landsat 7 image captures the western end of Cuba, showing both southern and northern reef communities. Unlike true barrier reefs, the lagoons behind these reef tracts are very shallow. Hurricanes are more frequent in the south and west where the reef communities are dominated by species resistant to sedimentation and water movement, especially in the Gulf of Batabanó. The Enhanced Thematic Mapper Plus (ETM+) instrument acquired this view of the island on April 3, 2001.

NASA image by Jesse Allen, Earth Observatory, using data obtained from the University of Maryland's Global Land Cover Facility.

Report on the Second International Workshop on Albedo Product Validation

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Introduction

The 2nd International Workshop on Albedo Product Validation, sponsored by the Land Product Validation (LPV) subgroup of the Committee on Earth Observing Satellites' (CEOS) Working Group on Calibration and Validation (WGCV), was held April 27-28, 2005 as a splinter meeting within the European Geosciences Union's General Assembly in Vienna, Austria. The goal of the workshop was to discuss, initiate, and organize community validation exercises for satellite-derived land surface albedo products from CEOS members. The workshop expanded upon discussions from the first LPV albedo workshop in Boston, USA in October 2002 (Privette et al., 2002). More than 25 people from several countries and research disciplines participated.

The main components of the meeting and the related activities included discussions on:

- the albedo products being produced by CEOS members
- albedo field measurement networks
- comparison of field measurements with moderate resolution satellite albedo products (direct validation)
- inter-comparison of albedo products derived from different sensors or algorithms.

The agenda and related presentations are posted at: *lpvs.gsfc.nasa.gov/LPV_Albedo_meeting05.html.*

Definitions and Products

Broadband surface albedo is generally defined as the instantaneous ratio of surface-reflected radiation flux to incident radiation flux over the shortwave spectral domain. Most current satellite albedo products are defined differently. Below we describe key characteristics that often vary among the products.

Surface irradiance conventions

To estimate albedo, most satellite algorithms rely on multiple cloud-free directional satellite observations to determine a bidirectional reflectance distribution function (BRDF) model of the surface. The model is angularly integrated to determine the reflected shortwave flux. Because most sensors do not collect multiple observations of a target in a single pass, data from multiple orbits may be used. Irradiance differences with observation time necessitate establishment of a product irradiance standard. The following albedo definitions reflect the different irradiance standards currently used in practice:

White-sky albedo. This corresponds to the angular integration of BRDF over both reflected and incident directions and is formally designated as the bihemispherical reflectance (BHR). It is an approximation of the albedo of the surface under diffuse (atmospherically scattered) irradiation only. The incoming radiation is often assumed isotropic, and may be designated as BHRiso. BHRiso is an intrinsic theoretical quantity that uniquely does not vary with sun angle or atmospheric state.

Alternately the apparent BHR is the bihemispherical reflectance measured under actual diffuse illumination, i.e. including the contribution of multiple reflections between the surface and the sky.

Black-sky albedo. This corresponds to the angular integration of BRDF over the reflected directions when illuminated only by direct (uncollided, i.e., assuming no scattering) irradiance. It is formally designated as the directional-hemispherical reflectance (DHR). It is generally computed for a specific sun position such as at the time of the satellite overpass or at local solar noon. Typically, black sky albedo increasingly exceeds white sky albedo as the solar zenith angle increases; however, this is not a firm rule and can vary with surface conditions.

Blue-sky albedo. This quantity is equivalent to the albedo measured in the field in that it assumes the surface is illuminated by both direct and diffuse irradiance. It depends on both the solar geometry and the atmospheric conditions, and therefore tends to change most rapidly in time. Remote sensing algorithms that estimate blue-sky albedo typically require knowledge of the surface BRDF as well as several atmospheric parameters, including aerosol amount and properties, water vapour and pressure. Alternatively, it can be approximated through the weighted combination of the black- and white-sky albedos (Lucht et al., 2000). In addition, the contribution of the possible multiple reflections between the surface and the sky can be also included.

Temporal Compositing

Currently, no daily global albedo products from moderate resolution sensors are operationally available. The same applies to the computation of the diurnal variation of the black(blue)-sky albedo, although it is possible to simulate such temporal variations from the retrieved BRDF models and adjusted coefficients. Satellite products are either instantaneous retrievals (from multi-angular instruments) or sequential retrievals from radiometers that collect a single observation per target per orbit (where BRDFs are established from directional data collected over a short period of time). In order to maximize global coverage, products are generally provided at 8 day, 10 day, 16 day or monthly time intervals. The temporal compositing window extends from 8 days to 30 days with either a fixed or a moving centre. Such compositing poses a problem when comparing albedo over transitions periods (snow falls/melt, rapid vegetation growth/disappearance). Such cases at least need to be flagged and properly and consistently processed and documented.

Spectral Domain

Most satellite products correspond to broad-band albedo computed over the whole shortwave radiation (SWR) spectral domain (0.3-3.0 µm). However, albedos for individual bands and for broad visible (VIS) (0.3-0.7µm), Photosynthetically Active Radiation (PAR) (0.4-0.7µm), Near Infrared (NIR) (0.7-3.0µm) bands are also available for some products.

Ground-based Albedo Networks

Workshop presentations mainly focused on existing BSRN sites (Baseline Surface Radiation Network) including ARM (Atmospheric Radiation Measurement) and SURFRAD (Surface Radiation) sites.

BSRN (Ohmura et al., 1998) started under World Climate Research Programme (WCRP) to "Provide continuous, long-term (15 years), frequently sampled (order of seconds), state-of-the-art measurements of surface radiation fluxes adhering to the highest achievable standards of measurement procedures, calibration and accuracy." It is used to calibrate and validate satellite-based estimates of the surface radiation budget (SRB) and radiation transfer through the atmosphere. It is also used to monitor regional trends in radiation fluxes at the surface. Several facts justify the use of BSRN as a main component of the LPV direct validation planning:

1. WMO Global Atmosphere Watch (GAW) recognizes "BSRN" as the best practice in observing irradiance.
2. Global Climate Observing System (GCOS) has designated BSRN its radiation network.
3. BSRN measurement uncertainties are well defined. BSRN allows individual scientists to determine how to meet desired uncertainties for their own stations or networks, and there is a protocol for how to establish their site's accuracy.
4. FTP file archive is available at *ftp://ezksun3.ethz.ch.*

There are currently 37 operational sites which are mainly concentrated over the U.S. and Europe, with 15 sites archiving measured (blue-sky) albedo (both incoming and reflected solar radiation). These include 8 sites with at least 10m towers such as at Boulder (USA) and Payerne (Switzerland). Additional BSRN sites measure albedo but do not necessarily archive (e.g., Lindenberg, Germany, and Bratt's Lake, Canada). The CERES ARM Validation Experiment (CAVE) provides a service to the community by hosting and reformatting a wealth of surface data, including these BSRN and ARM measurements (Rutan et al., 2001).

In addition to the BSRN sites, a large number of global flux tower sites, long-term ecological research sites, and other field sites collect albedo data. In these cases, the challenges for LPV validation will be to encourage "best practice" measurement protocols and error budgeting, as well as negotiate timely access to the data. To facilitate comparisons of field data with MODIS products, the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) has been providing 7 km x 7 km product

Sensors	Platform	Spacial Resolution[1]	Satellite Revisit Time[2]	Spectral Domain[3]	Temporal Restriction of Product
MODIS	Terra/Aqua	1 km	1 day	0.3-5.0	16 days
MISR	Terra	0.275-1 km	8 days	0.4-1.0	8 days
MERIS	ENVISAT	0.3-1.2 km	2-3 days	0.4-1.0	10 days
VEGETATION[4]	SPOT 4-5	1 km	1 day	0.4-2.4	10 days
POLDER	ADEOS 1-2	6 km	1 day	0.4-1.0	10 days
PARASOL	MYRIADE	6 km	1 day	0.4-1.0	10 days
SEVIRI	MSG	1-3 km	15 min	0.4-1.6	1-10 days
Meteosat	GOES	2.25 km	30 min	0.4-0.8	10 days
ISCCP	(climatology)	60 km	N/A	0.3-3.0	30 days
ECOCLIMAP	(climatology)	1km	N/A	0.3-3.0	30 days

Table 1. Sensors and products considered within the workshop. [1] spacial resolution at the equator; [2] revisit of the sensor at the equator; [3] wavelength (µm) of the shorter and longer spectral band used; [4] a Wide Field-of-View Sensor on the SPOT-4 satellite.

subsets over both BSRN sites and a large set of other tower sites.

Research challenges discussed in the field validation of albedo included adjusting for the spatial heterogeneity of some sites and possible albedo variability within compositing periods, and the up-scaling procedures required to allow comparison of point tower measurements with medium resolution satellite products.

Requirements for Albedo Products and Their Validation

Although relatively few albedo "end users" were represented during the workshop, the participants suggested the main user requirements as:

- Availability of long and consistent time series of albedo values over the globe. This point forces the need to address the necessary temporal consistency within sensors as well as between the several sensors used from the beginning (e.g., AVHRR in 1982). For this reason, inter-comparison between products is mandatory.
- Data gaps (spatial or temporal) pose a problem to some users. Methods of 'gap filling' should be also included as an important issue in the development of albedo products.
- The accuracy/uncertainties values should be associated to the albedo products. The validation activity could be extended to the evaluation of these vital quality assessment criterions.

Albedo Product Inter-comparison

Workshop participants agreed that the different satellite products should be systematically compared in an LPV community activity (hereafter called inter-comparison). The inter-comparison must encompass a range of areas (land cover and atmospheric characteristics). The presentations of inter-comparisons accomplished thus far were followed by discussions leading to a proposal for the organisation of this inter-comparison activity.

The inter-comparison of products has to be organized to be efficient. Similar to what was proposed for the LAI/fAPAR (Leaf Area Index/fraction of Absorbed PAR) validation exercise (Morisette et al., 2005), albedo products could be inter-compared over a consensus network of sites and periods. Each team in charge of a product should extract the albedo products over the selected sites and periods, and make them available to the community by posting a link through the LPV web site. Several more detailed aspects of this exercise were discussed, leading to the following proposition:

Product type. focus on current operational products as listed in Table 1. Priority was set on the white-sky albedo products (BHRiso) that are computed for all the products. However black-sky (and blue-sky when available) albedo products are also of interest although the definition may slightly vary from product to product. Comparison will be conducted for VIS (0.3-0.7), NIR (0.7-3.0µm) and SWR (0.3-3.0µm).

Spatial and temporal resolution. Studies should be conducted over a range of spatial resolutions currently used in practice, including 1/2°, 1/4° and 1/15°. The inter-comparison could not be achieved at a higher spatial resolution than 1/30° without accounting for possible perturbations by geometrical problems such as co-registration accuracy and point-spread-function effects. The temporal resolution will mainly depend on the products. Although daily to monthly products will be inter-compared, attention should be also paid to the diurnal variation (BRDFs) as simulated from the various sensors and algorithms.

Spatial and temporal domain. Researchers will focus on data from Year 2003 since most of the sensors from which albedo products are derived were flying (e.g., MODIS, MERIS, VEGETATION, POLDER, MISR, MSG, Meteosat). The spatial domain will be global within ±70° latitude, with special emphasis on the Meteosat/MSG field of view (i.e. Europe and Africa). This will be achieved by sampling the surface according to the proposed BELMANIP (Baret al., 2006) network of sites designed to represent the prevalent surface types and conditions. In North America, emphasis will be placed on the mid-continent and will utilize the ARM sites, the BSRN sites and any appropriate flux tower locations. The list of sites considered, with 1/2° extent and without overlap will be posted at the LPV site.

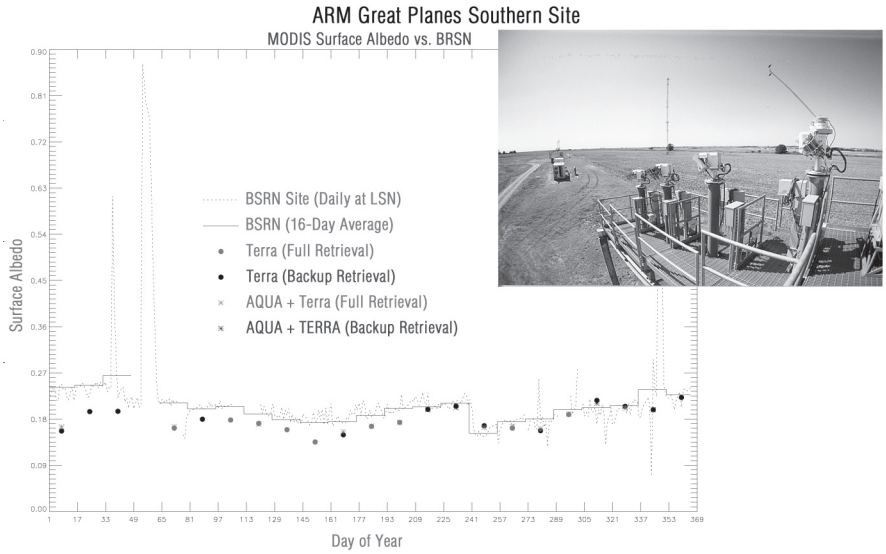

Figure 1: An example of combined field and satellite data. The continuous lines on the graph represent field measurements albedo values while the dots represent albedo estimates from MODIS. The proposed virtual experiment will build on this type of analysis.

Within this exercise, particular attention should be paid to the transition situations where a rapid and significant change of albedo values are expected, mainly corresponding to snow fall/melting and greening-up/senescence or harvesting of the vegetation.

Direct Comparison of Products with Field Measurements

The comparison of field measurements with satellite-derived products is hereafter called 'direct validation.' Both the exploitation of data from past field campaigns, dubbed 'virtual experiments,' and the organization of new field campaigns for 2006 were discussed.

Virtual experiments

To expedite a community-wide evaluation of products, participants agreed to initially exploit data from past field experiments (particularly 2003). Candidate sites include:

- ARM SGP (Southern Great Plains; semiarid grasslands and crops) and NSA (Northern Study Area in Barrow, Alaska; tundra), and BOREAS (boreal forest) sites; Point of Contact (POC): A. Trishchenko
- Bratts-Lake, Canada (northern grasslands); POC: B. McArthur
- Mongu, Zambia (Kalahari woodlands); POC: J. Privette
- Barrax site, Spain (agricultural site with large fields); POC: J. L. Roujean, F. Baret
- Amazonian site, Brazil (tropical forest): POC, R. Pinker

MISR, CHRIS/PROBA, and ASTER images could be used to more rigorously investigate scaling-up problems that occur over heterogeneous areas. Additional high spatial resolution images, such as Landsat, SPOT, and IKONOS, could be used in complement to document the spatial heterogeneity. Several up-scaling methods could be compared over these sites. In addition, it was proposed to use radiative transfer model simulations of landscapes as presented by S. Dutoit, to better evaluate the uncertainties associated with the scaling up techniques in heterogeneous conditions. Figure 1 shows some initial results from the ARM SGP site, comparing field measurements with MODIS-derived albedo estimates.

New experiments

Because many research problems (especially scaling) cannot be adequately resolved with past field data sets, the participants developed general plans to conduct a community field campaign focused on albedo. Suggested conditions for a new field experiment were the following:

- Based on existing and on-going field campaigns to reduce costs.
- Preferentially located over an area where rapid and significant albedo changes are expected.
- Preferentially located within the MSG/Meteosat field of view or over the North American mid-continent.
- Have the possibility to replicate albedo measurements at several places within the site to document the spatial variability.

Three possible sites were proposed for 2006. One site in Africa is within the Analyses Multidisciplinaires de la Mousson Africaine (AMMA) project area, where there is already a significant experimental effort deployed on ground. Year 2006 will coincide with the peak in experimental activities in the AMMA project. The airborne POLDER camera, which provides a very unique way to measure albedo from limited altitude, will be flown. This albedo validation campaign would potentially allow comparison of ground measurements acquired by several teams, as well as replicate sampling in several places. J.L. Roujean and F. Baret are leading the definition and initialisation of this campaign in collaboration with the AMMA. In North America, it may be possible to leverage some efforts associated with the North American Carbon Project (NACP) to conduct a mid-continent albedo field campaign in 2006. Finally, there are possible opportunities for an experiment within Russia, although the Siberia II effort is coming to an end. Participants agreed that the relative merits of these sites must be further investigated, and that one or possibly two 2006 field campaigns are a reasonable goal.

Conclusion

This second albedo validation meeting was successful in terms of participants, information gathered on current validation exercises, and development of plans for the future. It appears that current albedo products, despite the different sensors, algorithms and definitions, agree relatively well with each other and with ground measurements. This may result from the spectral and directional integrations required for albedo computation, since this is a process that tends to reduce some noise associated to the top of canopy reflectances as measured from the satellites, and thus yields relatively robust results. However, several issues must still be resolved to achieve the very demanding accuracy required by many users (better than 2% to 5% relative accuracy; e.g., Henderson-Sellers A. and M.F. Wilson, 1983). The challenges include problems associated with BRDF determination from limited directional sampling imposed by sun-view geometry and cloud occurrence, residual (or subpixel) clouds after cloud screening, residual atmospheric correction effects, temporal compositing, and narrow to broad-band spectral conversion.

Validation activities should focus both on inter-comparison of products achieved over an extensive and representative set of sites such as was defined during this meeting. Direct validation must also be developed, with due attention to the scaling-up problems over heterogeneous landscapes, and possibly focusing over rapid transition areas and periods where possible problems and differences between products may be more common. Exploitation of past field efforts (e.g., from 2003) as well as the execution of campaigns in 2006 was proposed to

complement the activities that were presented during this workshop. This will be the subject of discussion at the next meeting, possibly occurring in late 2005 or early 2006.

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Glossary

Satellite Instruments

ASTER – Advanced Spaceborne Thermal Emission and Reflection Radiometer
AVHRR – Advanced Very High-Resolution Radiometer
MODIS – Moderate-Resolution Imaging Spectroradiometer
MISR – Multi-angle Imaging Spectroradiometer
MERIS - Medium-Resolution Imaging Spectrometer
VEGETATION – a Wide Field-of-View Sensor on the SPOT-4 satellite
POLDER – Polarization and Directionality of the Earth's Reflectance
SEVIRI – Spinning Enhanced Visible And Infra-Red Imager (instrument for MSG)
CHRIS/PROBA – CHRIS (Compact High Resolution Imaging Spectrometer) imaging spectrometer onboard space platform PROBA (Project for On Board Autonomy)

Satellite Platforms

Aqua – NASA Earth Observing System, sunsynchronous afternoon satellite
Terra – NASA Earth Observing System, sunsynchronous morning satellite
ENVISAT – Environmental Satellite, European Space Agency
SPOT 4-5 – Systeme pour l'Observation de la Terre (France)
ADEOS 1-2 – Advanced Earth Observation Satellite
MYRIADE – CNES (France) satellite series
PARASOL – Polarization & Anisotropy of Reflectances for Atmospheric Sciences coupled with Observations from a Lidar (satellite in Myriade series)
GOES – Geostationary Operational Environmental Satellite (U.S.)
IKONOS – Space Imaging's earth imaging satellite
Landsat – Land Remote-Sensing Satellite (U.S.)
Meteosat – Geostationary Satellite (Europe)
MSG – Meteosat Second Generation

Data Projects

ISCCP – International Satellite Cloud Climatology Project
ECOCLIMAP – Global Database Of Land Surface Parameters At 1km Resolution In Meteorological And Climate Models

(continued from p.7)
in models is increasing also and in many, if not all cases is resulting in improved scientific results. A good start on data fusion of MODIS observations with other instruments is occurring, but much more can profitably be done in the future. This is true not only for instruments on the Terra and Aqua missions, but with other instruments on other spacecraft. In general, the mid to long-term future looks good with the Terra and Aqua MODIS instruments working well and the MODIS-derived VIIRS instrument projected for operation on the NPP mission and the NPOESS series.

Emphasis at the next meeting will be even more on science and applications with continued emphasis on the use and assimilation of MODIS observations in models along with data fusion. Posters along with plenary and discipline group presentations will be encouraged. This meeting will be between six months and one year from now—probably toward end of the calendar year.

NASA Helps Students "Get the Message" in Problem-Solving Competition

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

"Get the Message?" That's the question that NASA was asking students during this year's big worldwide educational problem-solving competition called "Odyssey of the Mind."

Students from all over the world gathered to participate in Odyssey of the Mind's 26th World Finals, a creative problem-solving competition, at the University of Colorado at Boulder, May 21 through 24. These students had advanced from competitions held earlier in the year at the local, regional, state or country levels and were in Boulder to compete for Odyssey's top awards.

"Odyssey of the Mind is a natural partnership with NASA's Science Mission Directorate (SMD), whose vision is to improve life here, extend life to there, and to find life beyond," according to Michael King, Earth Observing System Senior Project Scientist at NASA Goddard Space Flight Center, Greenbelt, MD. "Exploration of scientific principles and creative solutions through sound engineering is valuable training and exciting to students the world over. NASA's interest in developing a deeper understanding and awareness of Earth-Sun system processes and man's impact on his or her environment is enabled by teaching the world's students to think *outside the box* and solve complex problems on the environment."

For the challenge called "Get the Message?," teams presented an original performance that included a story told three times, each time using a different method of communication: a primitive method, an evolved method, and a futuristic method created by the team. The team created signals that represented a stage in a process of the Earth system that they displayed for each communication method. The presentation also included a narrator or host and a stage set.

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

Out of the 156 teams participating in the "Get the Message?" at World Finals, the following won top honors in their category:

Division I
1st Place: Saxe Middle School, New Canaan, CT
2nd Place: Saint Michael Lutheran School, Fort Myers, FL
3rd Place: Pine Ridge Christian School, Holland, MI
4th Place: Anglo-Chinese Junior School, Singapore, SG, Singapore
5th Place: Creative Primary School, Kowloon, HK, Hong Kong
6th Place: Washington Charter School TM GRN, Palm Desert, CA

Division II
1st Place: Lanier Middle School TM B, Houston, TX
2nd Place: Stone Valley Middle School TM A, Alamo, CA
3rd Place: Forest Hills Central Middle School A, Grand Rapids, MI
4th Place: William Penn Middle School TM A, Newtown, PA
5th Place: Manton School, Manton, MI
6th Place: River Oaks Baptist School, Houston, TX

Division III
1st Place: Massabesic High School, East Waterboro, ME
2nd Place: Highland School, Highland, WI
3rd Place: Cornwall High School, Cornwall, NY
4th Place: POK OI Hosp Chan Kai Mem Coll, Kowloon, HK, Hong Kong
5th Place: Beechwood School, Ft. Mitchell, KY
6th Place: A. C. Pope High School, Marietta, GA

Division IV
1st Place: Shippensburg University, Shippensburg, PA
2nd Place: Michigan State University, New Lothrop, MI

The 4th Place Hong Kong team in Division III also won the prestigious Renatra Fusca Creativity Award for their innovative approach to the problem resolution. This award is given to a team or individual for demonstrating outstanding creativity.

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

The Odyssey of the Mind program, founded in 1978, is an international educational program that promotes team effort and creative problem-solving for students from kindergarten through college. Thousands of teams from throughout the U.S. and about 35 other countries, including Argentina, Canada, China, Germany, Hungary, Japan, Kazakhstan, Lithuania, Malaysia, Poland, Russia, Singapore, Turkey, Uganda, the United Kingdom, and Uzbekistan participate in the program.

Above: The 4-ft. globe was a popular item at the NASA booth. Teams were anxious to hold the "Earth in their hands." Globe credit: Todd Ulrich, Worldfx. Photo credit: Fritz Hasler, Goddard Space Flight Center.

Top Left: Coors Arena at the University of Colorado was filled to capacity for opening ceremonies. Photo credit: Creative Competitions.

Middle Left: One team representing every state and country participated in a Parade of States and Countries that culminated with those team members sitting on the floor of the Coors Arena.

Bottom Left: This team's skit in "Get the Message" included evacuating everyone to a space hotel due to damage to the Earth's environment. Photo credit: Creative Competitions.

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

Unlocking the Mystery Behind Lightning's Puzzling Friend

— Mike Bettwy, michael_bettwy@ssaihq.com, NASA Goddard Space Flight Center, SSAI

Giant red blobs, picket fences, upward branching carrots, and tentacled octopi—these are just a few of the phrases used to describe sprites—spectacular, eerie flashes of colored light high above the tops of powerful thunderstorms that can travel up to 50 miles high in the atmosphere.

Sprites, so-named by a University of Alaska scientist inspired by the creatures in Shakespeare's "The Tempest," have been observed since the 1800s, though rarely visible from the ground. Aircraft pilots began reporting sightings of sprites in the 1950s and '60s, but they were not formally identified until 1989 when the Space Shuttle (STS-34) recorded the flashes as it passed over a thunderstorm in northern Australia. While many theories have been offered on the cause of this rare phenomenon, new NASA-funded research is settling the mystery and helping to determine the driving force behind these marvel displays of light.

Most researchers have long supported the theory that sprites are linked to major lightning charges. Still, some scientists believe that conditions high in the atmosphere, like meteoritic dust particles or gravity waves might also induce sprite formation.

Now, a study led by Steven Cummer of Duke University, Durham, North Carolina and Walter Lyons of FMA Research, Inc., Fort Collins, Colo. has found more evidence that sprites are generated by major lightning strikes. They also found the total charge, as it moves from the cloud to the ground, and multiplied by that distance, known as the "lightning charge moment," is most critical in the sprite's development. The study appeared in the April 2005 issue of *Journal of Geophysical Research-Space Physics*.

During the summer of 2000, researchers from across the nation participated in the Severe Thunderstorm Electrification and Precipitation Study. While the primary goal was to study severe thunderstorms and their link to heavy rain and hail, scientists also gathered important data on lightning's role in triggering events above thunderclouds, like sprites.

Armed with the aid of sophisticated instruments and sensors, Cummer collected information from three thunderstorm outbreaks across the central U.S. and compared the "lightning charge moment" in both sprite and non-sprite producing lightning.

"The idea was that if other factors contributed to lowering the electric field threshold for sprite initiation, they would probably not always be present and we would find that sprites occasionally form after just modest lightning strokes," said Cummer.

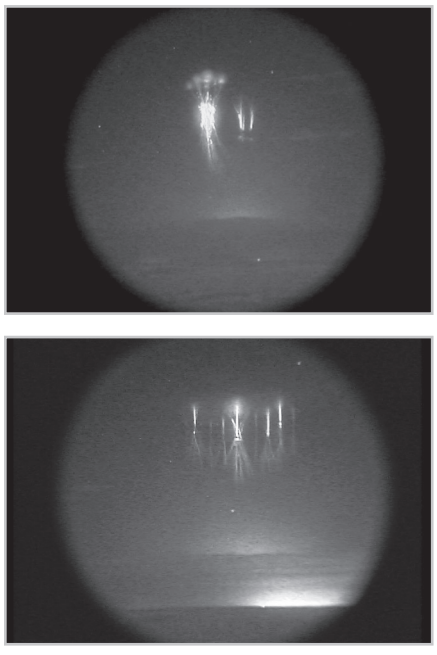
Simulations created with the help of NASA computer animations and other data showed that weak lightning strikes do not create sprites. They also found factors other than the cloud-to-ground charge transfer are generally not important ingredients in sprite development.

The nature of the charge does appear to make a difference, however, as sprites are very rarely created by negatively charged cloud-to-ground lightning strikes, probably because big negative strokes occur infrequently over the typical breeding ground for sprites in the U.S. High Plains.

Negative cloud-to-ground lightning strokes are initiated by a large concentration of negative charges in the cloud base, which tends to induce an area of positive charge on the ground, resulting in the discharge of electricity seen as lightning. A positive lightning stroke is exactly the opposite, with a positive charge concentration in the cloud resulting in a negatively charged area on the ground.

Sprites, like lightning strokes, are largely unpredictable and brief - lasting only 3 to 10 milliseconds and inherently difficult to study. But, the technique used in this study also proved that "a single sensor can monitor moment change in lightning strikes over a very large area, providing a reasonable way of estimating how often sprites occur globally," said Cummer. Much research to date has instead relied on the strategic placement of multiple low light video cameras.

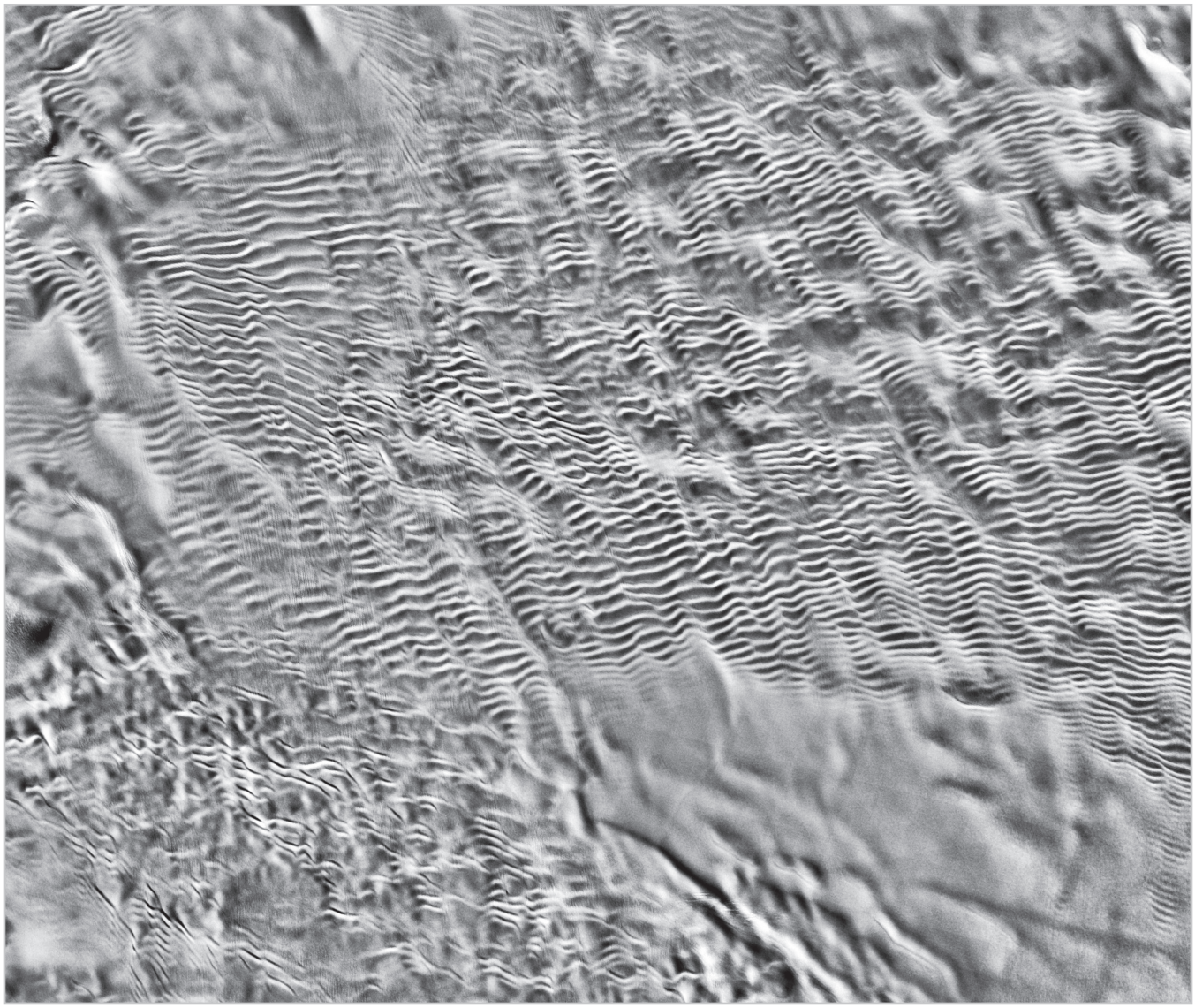
Sprites and other phenomena, including elves - that bring a millisecond flash of



Sprites over thunderstorms in Kansas on August 10, 2000, observed in the mesosphere, with an altitude of 50-90 kilometers as a response to powerful lightning discharges from tropospheric thunderstorms. The true color of sprites is pink-red. Credit: Walter Lyons, FMA Research, Fort Collins, Colorado

light that fills the entire night sky within a 100 kilometer (62 mile) radius of the associated lightning strike - are generating much interest because of their strong electric fields and electromagnetic pulses that may interact with the Earth's ionosphere and magnetosphere.

Some of the most recent research has shown that some lightning strikes might be associated with terrestrial gamma-ray flashes (TGFs), intense explosions of gamma rays lasting only about one millisecond that are emitted into space from the upper atmosphere. Scientists believe electrons traveling at nearly the speed of light scatter off atoms and decelerate just above thunderclouds, emitting TGFs. While many questions remain today, future technology will certainly allow for even more precise detection of these events, giving scientists valuable insight into their origins.



In Antarctica, relentless winds have created a unique type of snowdrift pattern known as megadunes. Formed by centuries of nearly continuous winds, megadunes are 1 to 8 meters high (3.3 to 26.2 feet), and 2 to 6 kilometers (1.2 to 3.7 miles) from crest to crest. They cover roughly 500,000 square kilometers (310,685 square miles)—a California-sized area in the East Antarctic Plateau. Megadunes ripple horizontally across these satellite images. Perpendicular to the megadunes is a corduroy-like pattern, most visible in the bottom satellite image. This pattern is created by linear sets of sastrugi, ubiquitous snow sculptures like frozen waves on the ocean.

This image uses a new approach of "stacking" satellite images from NASA's Moderate Resolution Imaging Spectroradiometer (MODIS). Here, six 250-meter-resolution MODIS images are stacked and filtered to yield an image with approximately 100-meter resolution. Satellite images courtesy of Mark Fahnestock, University of Maryland, College Park.

Ozone Levels Drop When Hurricanes Are Strengthening

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

Scientists are continually exploring different aspects of hurricanes to increase the understanding of how they behave. Recently, NASA-funded scientists from Florida State University looked at ozone around hurricanes and found that ozone levels drop as a hurricane is intensifying.

In a recent study, Xiaolei Zou and Yonghui Wu, researchers at Florida State University, found that variations of ozone levels from the surface to the upper atmosphere are closely related to the formation, intensification and movement of a hurricane.

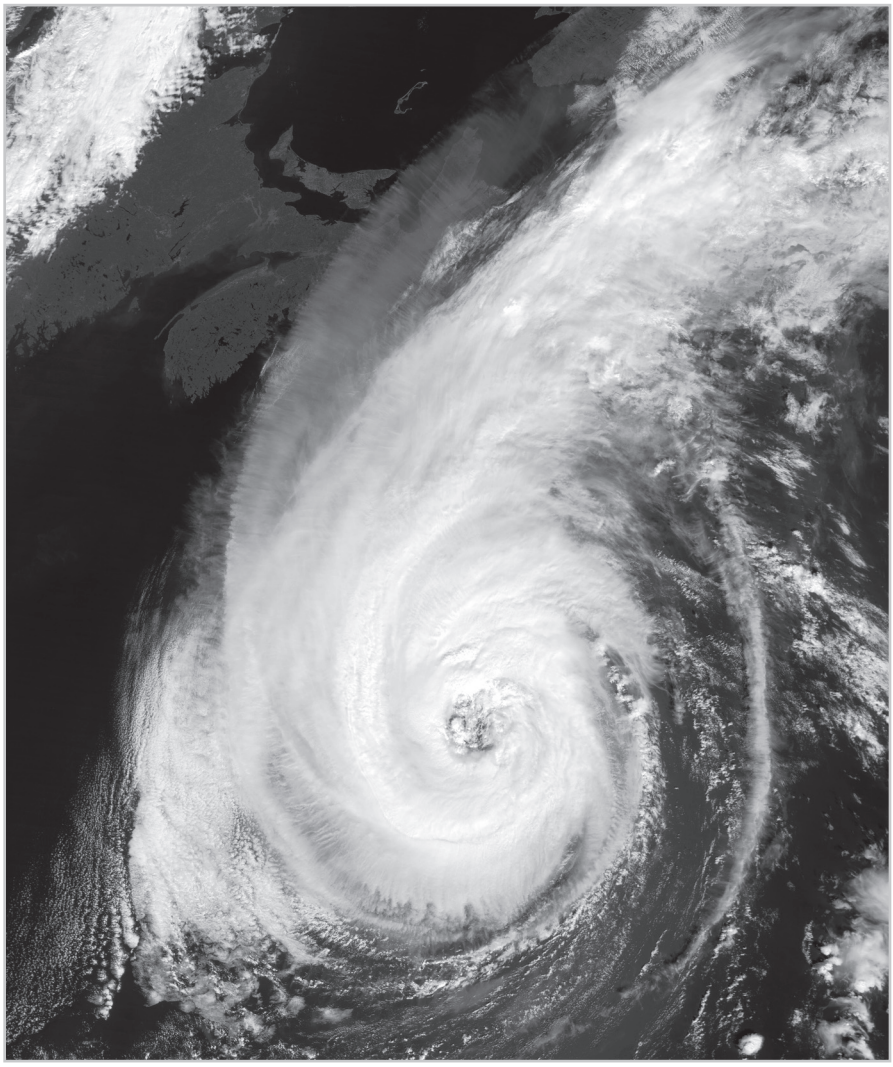
They studied ozone levels in 12 hurricanes and looked at total ozone levels, that is, from the ground to the upper atmosphere. Now scientists have clues on how a hurricane behaves when the ozone levels are high and low.

Zou and Wu noticed that over 100 miles, the area of a hurricane typically has low levels of ozone from the surface to the top of the hurricane. Whenever a hurricane intensifies, it appears that the ozone levels throughout the storm decrease. When they looked at the storm with ozone data, a hurricane's eye becomes very clear. Because forecasters always try to pinpoint the eye of the hurricane, this knowledge will help with locating the exact position and lead to better tracking.

The National Oceanic and Atmospheric Administration's National Hurricane Center (NHC) is the agency that issues hurricane forecasts. Out of the 12 storms analyzed, the ozone data and the NHC official report differed on the mean distance between the estimated eye by less than 18 miles during the most intense stage of the storms. As such, when Zou and Wu added the satellite observed ozone levels around a hurricane into a computer forecast model, it greatly improved the predicted track that the hurricane would take.

"This research highlights the benefits of Total Ozone Mapping Spectrometer (TOMS) data in hurricane track and intensity prediction, an important forecasting problem since hurricanes strike regions of high population and property growth, resulting in large natural disasters," said Zou.

The other interesting finding when analyzing ozone data around hurricanes, is that ozone levels give a clue that a storm will develop before other methods. The early spin of a tropical cyclone is weak and sometimes covered by clouds, and not easily detected by satellites that



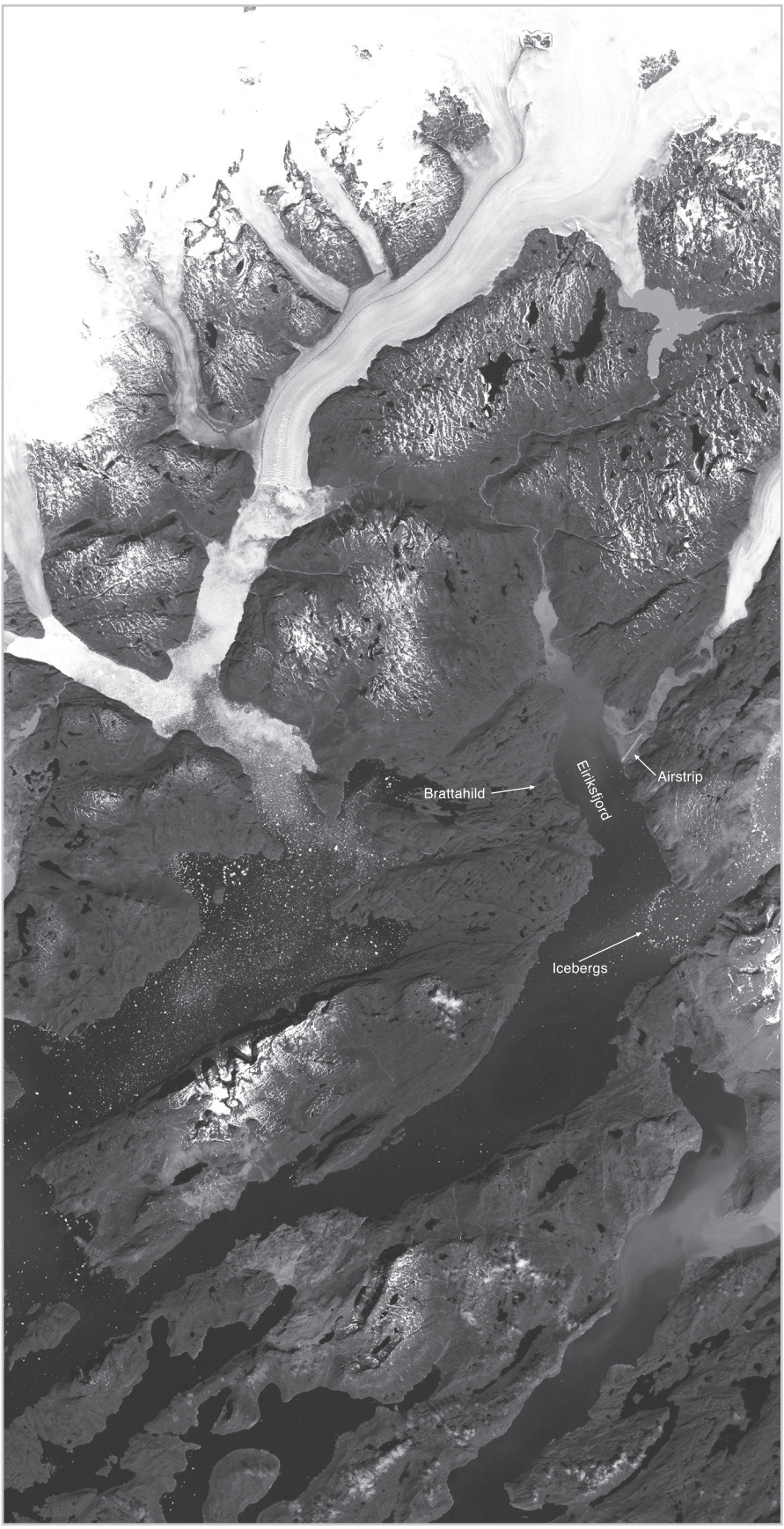
Hurricane Erin Nears the U.S. On September 11, 2001, Hurricane Erin was making her way northward in the Atlantic Ocean. In this MODIS image, the storm stretches from the latitudes of Virginia in the south, past Massachusetts's boot-shaped Cape Cod, and on up to Maine. Coastal areas along the eastern seaboard were affected by large swells produced by the storm. Credit: NASA/GSFC, MODIS Rapid Response Team.

provide pictures of clouds. The ozone data gives scientists a "look beyond the clouds."

Ozone is all around the world and in the upper and lower atmosphere. Ozone in the upper atmosphere protects life on Earth from harmful ultraviolet rays from the sun, which can cause sunburn and skin cancer. Ozone close to the surface is a pollutant, which on hot, humid days with little wind creates a haze, such as that over big cities, that is harmful to breathe.

By using NASA's satellite Earth Probe/TOMS total ozone data, forecasters can identify ozone amounts that are closely related to the formation, intensification, and movement of a hurricane. Zou and Wu also found a strong relationship between ozone, air pressure and spin within the hurricanes.

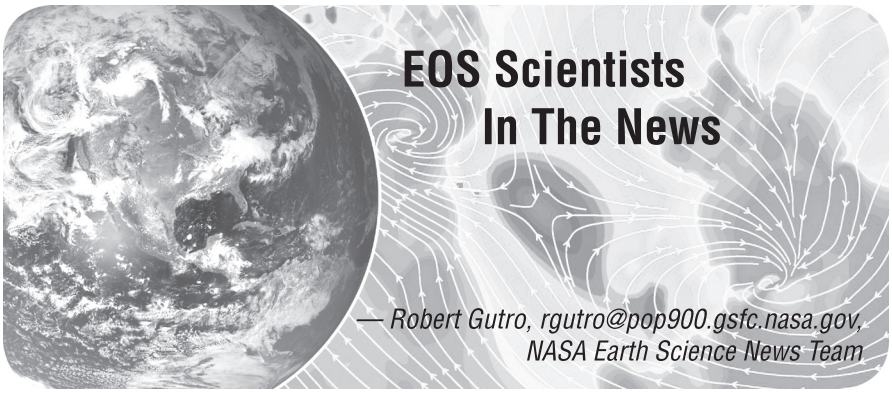
Zou said that the connections between ozone levels and hurricane behavior are a very important step in understanding the storms.



Naming an island that's 90% ice-covered "Greenland" may seem ironic, but the Norse settlers who arrived in AD 985 found a few pockets of vegetation amid the barren rock and snow. Most of these settlements were near the southern tip of Greenland, sheltered deep within narrow fjords. The settlement of Brattahlid was one of Greenland's wealthiest, founded by Erik the Red himself. Today the town of Qassiarsuk occupies the site of Brattahlid. In this image, Qassiarsuk's pastures stand out against the bare rocks surrounding the water of Eiriksfjord. White icebergs float in the fjord, and snow remains near the surrounding hilltops, even in August.

The Norse inhabited Greenland for almost 500 years (longer than English-speaking colonists have survived in North America), subsisting primarily on sheep and goat milk, caribou, and seal. Curiously, the Greenland Norse do not seem to have eaten fish. The Norse devoted agricultural production to hay to feed livestock during the long winters. The total population of the scattered settlements was about 5,000 people.

This image was acquired by the Enhanced Thematic Mapper Plus aboard NASA's Landsat-7 satellite on August 4, 2000.



EOS Scientists In The News

— Robert Gutro, rgutro@pop900.gsfc.nasa.gov,
NASA Earth Science News Team

Dryden Craft to Help Study Hurricane Formation, June 24; *Antelope Valley Press, Lancaster, Calif.* NASA's ER-2 will participate in the Tropical Cloud Systems and Processes mission. Includes quotes from Ed Zipser (University of Utah), **Ramesh Kakar** (NASA HQ), **Gerry Heymsfield** (NASA GSFC) and Frank Marks (NOAA). The article was a result of participation in the TCSP media teleconference with additional information about aircraft departure and crew provided by Dryden.

New Software Changes Wireless Technology Functions on Demand, June 23; *Science Daily*. **Jason Soloff** (NASA GSFC) discusses NASA's newest technology, called Software Defined Radio, or SDR, that gives an electronic device the ability to quickly and easily perform new functions on demand.

NASA Researchers Studying Tropical Cyclones, June 23; *Scripps Howard*, *Yahoo News*. **Ramesh Kakar** (NASA HQ) and **Robbie Hood** (NASA MSFC) discuss a field campaign that will deploy NASA hurricane researchers to Costa Rica next month to investigate the birthplace of eastern Pacific tropical cyclones.

NASA Satellite Data Capture a Big Climate Effect on Tiny Ocean Life, June 22; *PhysOrg.com*, *Science Daily*. NASA-funded scientist **Wendy Wang** (University of Maryland) finds that phytoplankton populations can change dramatically due to the physical processes associated with the climate phenomena El Niño and La Niña, with affects on ocean ecology and the Earth's climate.

Getting a Little Respect, June 22; *The Baltimore Sun*, *Hartford Courant*. Astrobiologist **Kennda Lynch** (NASA JSC) is interviewed in a story discussing new polls showing prestigious jobs favor people who help others—with scientists, teachers, and firefighters often topping the list.

NASA Helps Highlight Lightning Safety Awareness Week, June 20; *Science Daily*, *Innovations Report*. June 19-25 is National Lightning Safety Awareness Week and **Dennis Boccippio** (NASA MSFC) and **Jeff Halverson** (NASA GSFC) talk about NASA's ongoing lightning research that is helping forecast thunderstorms and improve aviation safety.

NASA Announces Dangerous Weather Media Conference, June 16; *SpaceRef.com*, *I-Newswire*. NASA hurricane researchers **Ramesh Kakar** (NASA HQ), **Gerry Heymsfield** (NASA GSFC), **Edward Zipser** (University of Utah), and **Frank Marks** (NOAA) hold a media teleconference to discuss the month-long Tropical Cloud Systems and Processes (TCSP) mission to Costa Rica.

NASA Scientists Receive Presidential Award, June 13; *SpaceRef.com*, *SpaceFlightNow.com*. A NASA-funded scientist, **David Alexander** (Rice University) and **Michael Bosilovich** (NASA GSFC) receive the Presidential Early Career Awards for Scientists and Engineers at a White House ceremony.

A Famous "FIRST" Launched by NASA to Study Earth's Energy, June 10; *Space Today*. New NASA research, led by **Marty Mlynczak** (NASA LaRC) will involve FIRST, an infrared sensor, to measure Earth's energy from 20 miles above the surface, showcasing NASA's newest technological advancement.

Ozone Levels Drop When Hurricanes Are Strengthening, June 8; *United Press International*, *Scripps-Howard*. NASA-funded scientists **Xiaolei Zou** (Florida State University) and **Yonghui Wu** (Florida State University) find that variations of ozone levels from the surface to the upper atmosphere are closely related to the formation, intensification and movement of a hurricane.

Southern California's Natural Air Conditioner, June 8; *Los Angeles Times*. **Bill Patzert** (NASA JPL) assists with a graphic feature discussing an annual June phenomenon fueled by the Caltalina eddy that shrouds portions of the California coast in cool, cloudy conditions.

NASA Funds Projects To Extend Earth Science Research, June 7; *SpaceRef.com*, *BBS News*. NASA's Science Mission Directorate, led by **Ghassem Asrar** (NASA HQ) has selected 23 projects that will harness Earth science data to improve decision-making processes.

Unlocking the Mystery Behind Lightning's Puzzling Friend, June 7; *LiveScience.com*, *Space Daily*. A NASA-funded study conducted by **Steve Cummer** (Duke University) finds that high intensity lightning charges are the key ingredient in sprite formation.

Aura Measures Unusual Arctic Ozone Conditions, June 2; *RedNova*, *Pasadena Star News*, *ScienceBlog.com*. **Gloria Manney** (NASA JPL) and **Phil DeCola** (NASA HQ) discuss observations from NASA's Aura spacecraft showing that

other atmospheric processes restored ozone amounts to near average and stopped high levels of harmful ultraviolet radiation from reaching Earth's surface in the Arctic this winter.

NASA and University Of North Dakota Sign DC-8 Agreement, June 2; *Yahoo News*, *SpaceRef.com*. NASA has signed a cooperative agreement with the University of North Dakota (UND), Grand Forks, to house and operate the agency's DC-8 jet aircraft, says **Ghassem Asrar** (NASA HQ).

Rainfall for Dummies: the 2004-2005 Near-record Rain Season, June 1. *KFWB News Radio 980AM* (CA); **Bill Patzert** (NASA JPL) discusses the "almost" record-breaking rain year in Los Angeles and the beginning of "June gloom."

Feature Story: Growing Up in Connecticut, June 2005; *Hartford Courant*. **Ed Johnson** (NASA SSC) is interviewed by Alexander-Bloch for a feature story about his life growing up in Clinton, Conn. and the paths that led him to become the director of the Applied Sciences Directorate at SSC.

NASA Launches New Hurricane Web Page, May 31; *Yahoo News*, *Kansas City InfoZine*. NASA launches an Internet resource page highlighting the agency's diverse hurricane research which involves many scientists including **Robert Atlas** (NASA GSFC), **Timothy Liu** (NASA JPL), **Robbie E. Hood** (NASA MSFC), and **Ramesh Kakar** (NASA HQ).

Forecast in Unpredictability, May 28; *Orange County Register* (CA). **Bill Patzert** (NASA JPL) is interviewed by columnist Gary Robbins about forecasting difficulty.

Solar Fireworks Signal New Space Weather Mystery, May 24; *Washington Post*, *MSNBC*, *Space Daily*. The most intense burst of solar radiation in five decades accompanied a large solar flare on January 20, says **Richard Mewaldt** (NASA JPL), **Robert Lin** (University of California-Berkeley) and **Richard Nightingale** (Lockheed Martin), shaking space weather theory and highlighted the need for new forecasting techniques.

April Showers Bring May Scorcher, May 21; *Los Angeles Times*. **Bill Patzert** (NASA JPL) is interviewed about unusually high temperatures in the Southwest, raising concerns about an early and severe fire season.

Web Site Explains How Climate Change Affects New York City, May 20; *PhysOrg.com*, *BlackAnthem.com*. A new highly-researched Web site, created with the help of **Cynthia Rosenzweig** (NASA GISS) provides scientific answers to basic questions about climate change, and how such changes might impact New York City.

NASA Successfully Launches Environmental Satellite, May 20; *Associated Press*, *CNN*, *New York Times*. Under the direction of **Karen Halterman** (NASA GSFC), NASA successfully launches a new environmental satellite, NOAA-18, for the National Oceanic and Atmospheric Administration (NOAA).

NASA-Related News Conferences At Annual 2005 Joint Assembly Meeting, May 20; *Media Village*, *Space Banter*. New findings from NASA missions and NASA-funded research were discussed at the 2005 Joint Assembly Meeting, including presentations by **Michele Dougherty** (NASA JPL), **Edward C. Stone** (NASA JPL), **Leonard F. Burlaga** (NASA GSFC), **Richard Mewaldt** (NASA JPL), **Jim Erickson** (NASA JPL), **Richard Morris** (NASA JSC), **Richard Gross** (NASA JPL), and **James Hansen** (NASA GISS).

News Tips: NASA Presentations At Annual 2005 Joint Assembly Meeting, May 20; *Media Village*, *Space Banter*. NASA and NASA-funded scientists presented findings on a variety of Earth and space science topics at the 2005 Joint Assembly Meeting, including discussions led by: **Linda A. Hunt** (NASA LaRC), **David J. Harding** (NASA GSFC), **Anne Thompson** (NASA GSFC), **Jacquelyn Witte** (NASA GSFC), **Siegfried Schubert** (NASA GSFC), **Joan Feynman** (NASA JPL), **Alexander Ruzmaikin** (NASA JPL), **Philip J. Pegion** (NASA GSFC), **Julio Bacmeister** (NASA GSFC), **Y. Chang** (NASA GSFC), Max J. Suarez (NASA GSFC), **Y. Tony Song** (NASA JPL), **Jeanne Sauber** (NASA GSFC), **Scott Luthcke** (NASA GSFC), **Claudia Carabajal** (NASA GSFC), **Jordan Muller** (NASA GSFC), **Richard Gross** (NASA JPL), **Ben Chao** (NASA GSFC), **Michael J. Garay** (NASA JPL), **David J. Diner** (NASA JPL), **Jeffrey R. Hall** (NASA JPL), and **Eric M. DeJong** (NASA JPL).

NASA, Others Advance Understanding of Heliophysics at Conference, May 20; *Media Village*, *News is Free*. As a precursor to the International Heliophysical Year (IHY) of 2007, NASA scientists and others, including **Nat Gopalswamy** (NASA GSFC) hosted three special sessions on the physics of the extended solar-geo-planetary system at the Spring 2005 Joint Assembly meeting.

Marshes Tell Story of Medieval Drought, Little Ice Age, and European Settlers near New York City, May 19; *Science Daily*, *All Headline News*. Aside from views of cattails and blackbirds, new research by **Dee Pederson** (Columbia University) and **Dorothy Peteet** (NASA GISS), shows the marshes in the lower Hudson Valley near New York City offer an amazingly detailed history of the area's climate, presenting evidence of a 500 year drought from 800 A.D. to 1300 A.D., the passing of the Little Ice Age and the impacts of European settlers.

L.A.'s Big Squeeze Continues, Straining Earthquake Faults, May 19; *Science Daily*, *PhysOrg.com*; New NASA research led by **Donald Argus** (NASA JPL) confirms that northern metropolitan Los

Angeles is being squeezed at a rate of 5 millimeters (0.2 inches) a year, straining an area between two earthquake faults that serve as geologic bookends north and south of the affected region.

Tropical Storm Adrian Set to Make Landfall, May 19; *Science Daily*. **Jeff Halverson** (NASA GSFC) and **Steve Lang** (NASA GSFC) discuss tropical storm Adrian: one of only five tropical cyclones to make landfall over Guatemala or El Salvador since 1966.

NASA Helps Students In Problem-Solving Competition, May 18; *ScienceBlog*, *SpaceRef.com*. Students from all over the world gathered to participate in the Odyssey of the Mind's 26th World Finals, a creative problem-solving competition supported by several organizations, including NASA's Science Mission Directorate, says **Michael King** (NASA GSFC).

JPL Open House, May 12; *La Canada Flintridge* (CA). **Bill Patzert** (NASA JPL), **Robert Manning** (NASA JPL), **Michael Werner** (NASA JPL), and **Keyur Patel** (NASA JPL) are interviewed in an article highlighting the Jet Propulsion Laboratory's open house weekend to inform the public about its "Spirit of Exploration."

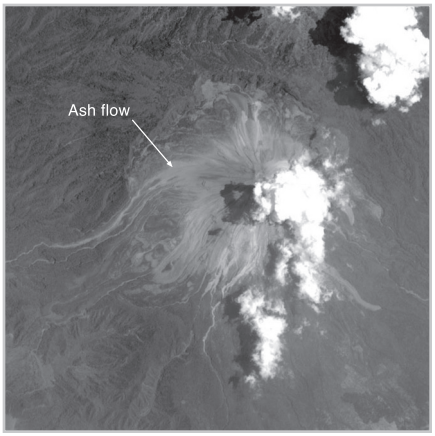
NASA and Students Partner for High Altitude Research, May 11; *Innovations Report*, *BigBlog.com*; NASA and student researchers at four universities combined efforts to analyze characteristics of the Earth's atmosphere from a one-of-a-kind, high-flying laboratory, says **Mark Christl** (NASA MSFC).

NASA and NOAA Set to Launch New Environmental Satellite, May 4; *Associated Press*, *ABC News*, *Washington Times*; NASA is set to launch the new National Oceanic and Atmospheric Administration (NOAA) Polar-orbiting Operational Environmental Satellite (POES), another critical link in the development of a global Earth-observation program, says **Karen Halterman** (NASA GSFC).

La Nada May Test Upgraded System, May 3; *Pittsburgh Tribune-Review*; **Bill Patzert** (NASA JPL) is interviewed as part of a story focusing on Pittsburgh's new weather emergency notification system and how a weak La Niña weather system developing in the Pacific Ocean—or "La Nada"—portends a busy hurricane season this year.

NASA and EPA Improve Crop Management, May 3; *Science Daily*, *Terra Daily*. NASA technology called hyperspectral imaging will help in distinguishing between traditional corn and bio-engineered corn, says **Brian Mitchell** (NASA MSFC).

Smog Season Begins Sunday; More Bad-air Days Expected Following Last Year's Record Low Number, May 1; *North County Times (CA)*; **Bill Patzert** (NASA JPL) is interviewed by Dave Downey about the risk for increased smog days this season and associated health effects.



The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) captured the image of the Colima volcano on June 3, 2005, just hours after two spectacular eruptions rumbled from the volcano. Two days later, on June 5, Colima experienced its strongest eruption in 20 years when it sent a dark column of ash more than five kilometers into the atmosphere at a rate of roughly 30 kilometers per hour, reports the Universidad de Colima's Observatorio Vulcanologico. A grey river of ash and rock flows down the west side of the peak, covering the vegetation.

NASA image created by Jesse Allen, Earth Observatory, using data obtained courtesy of the NASA/GSFC/METI/ERSDAC/JAROS, and U.S./Japan ASTER Science Team

Announcement

The Atmospheric Sciences Data Center (ASDC) at NASA Langley Research Center in collaboration with the CERES Science Team announces the release of the following data sets:
CER_SRBAVG_Terra-FM1-MODIS_Edition2C
CER_SRBAVG_Terra-FM2-MODIS_Edition2C

The Monthly TOA/Surface Averages (SRBAVG) data product contains the next generation of monthly mean gridded global Earth Radiation Budget (ERB) data averaged globally. These data represent a major improvement over previous data sets such as the Earth Radiation Budget Experiment (ERBE) and the CERES ERBE-like products (ES-4 and ES-9) in several key aspects. First, the accuracy of TOA flux is greatly improved by the use of new angular distribution models (ADM) based on improved scene identification. Second, high temporal resolution imager data from geostationary satellites are used to reduce temporal sampling errors. Finally, the SRBAVG product is the first ERB data set to contain detailed cloud properties that are consistent with the fluxes.

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

EOS Science Calendar

September 14-16, 2005
2005 SORCE Science Team Meeting, "Paleo Connections Between the Sun, Climate, and Culture," Durango California. Abstracts due August 12, 2005. Contact: Vanessa George, vanessa.george@lasp.colorado.edu. URL: *lasp.colorado.edu/sorce/2005ScienceMeeting*

September 20-23
Aura Science Team Meeting, Greenbelt, Md. Contact: Anne Douglass, *Anne.R.Douglass@nasa.gov*

October 3-7
International EOS/NPP Direct Broadcast Meeting, Benevento, Italy. Contact: *dbmeeting@backserv.gsfc.nasa.gov*

November 1-3
CERES Science Team Meeting, Hampton, VA. Contact: Sashi Gupta, *S.K.Gupta@larc.nasa.gov*.

November 7-11
Aura Validation Workshop, Netherlands. Contact: Anne Douglass, *Anne.R.Douglass@nasa.gov*.

Global Change Calendar

July 31-August 4
SPIE's Earth Observing Systems X Conference. San Diego, California. URL: *spie.org/conferences/calls/05/am/*

August 29-September 1
Eighth International Symposium on Signal Processing and its Applications, Sydney, Australia. Call for papers. URL: *www.elec.uow.edu/isspa2005/* Paper Submission: *isspa05.suvisoft.com/corg/submission/*

September 19-22
Sensors, Systems, and Next-Generation Satellites XI (RS03), Bruges, Belgium. Call for papers. URL: *spie.org/conferences/calls/05/ers/*

December 5-9
American Geophysical Union (AGU) Fall Meeting, San Francisco, CA. URL: www.agu.org/meetings/fm05/

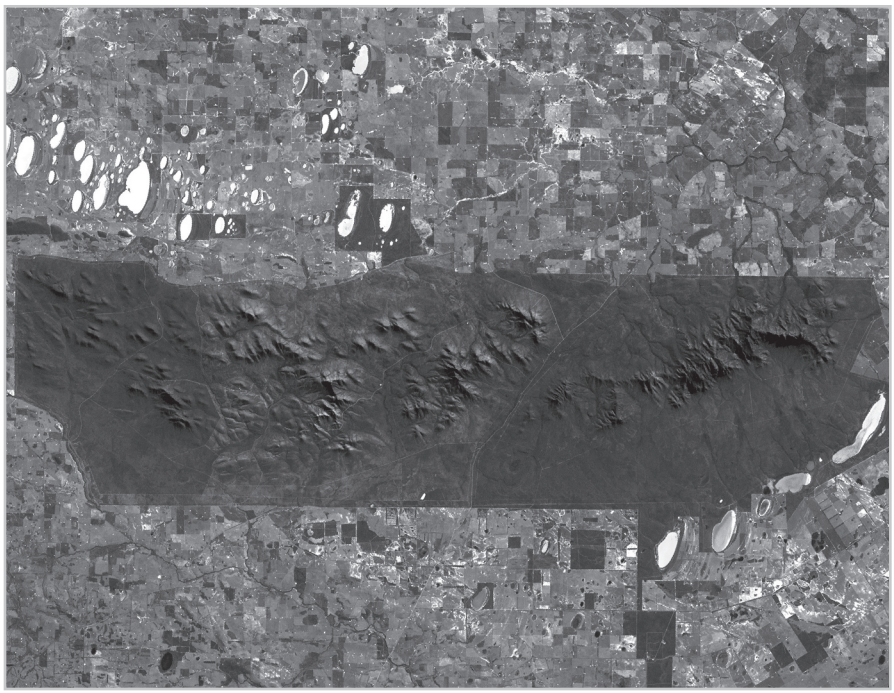
January 29-February 2
American Meteorological Society (AMS) 86th Annual Meeting, Atlanta, GA. URL: *www.ametsoc.org/meet/annual/index.html*

Announcement

SSEC is pleased to announce the release of IMAPP AMSR-E Level 2 Rain Rate/Rain Type software. The release consists of software that converts direct broadcast binary Level 1B output files into HDF-EOS formatted Rain Rate (mm/hr) and Rain Type (Convective Rain percentage) product files. The software has been converted from the original DAAC software to run on direct broadcast input files. The output files are very similar to the files distributed by the NSIDC DAAC. Please see the AMSR-E Rain Rate product web page, *nsidc.org/data/docs/daac/ae_rain_l2b.gd.html*, for information on the algorithm and algorithm developers. Linux platforms 8.0, 9.0 and Enterprise are supported with this release.

To acquire the software, please see the IMAPP web page for a link to the download site: *cimss.ssec.wisc.edu/~gumley/IMAPP/*

There is documentation included as part of the release that provides more details on how to run the software and a detailed description of the output files.



The Stirling Range National Park in the southwestern corner of Australia forms a rare patch of wooded hillsides and parkland in an area dominated by checkerboard plains of agricultural land. The Stirling Range reaches as high as 1,095 meters (3,600 feet) above sea level at Bluff Knoll, the tallest peak for a thousand kilometers or more in any direction. The range extends for some 65 kilometers, virtually all of it encased within the park named for the range. This Landsat 7 image shows the dramatic imprint of wide-scale agriculture in sharp contrast to the natural and essentially unaltered state of natural affairs within the park. The sharp boundaries on all sides of the park show where agriculture immediately gives way to protected land. The Enhanced Thematic Mapper Plus (ETM+) instrument on Landsat 7 acquired this scene on August 14, 1999.

NASA image created by Jesse Allen, Earth Observatory, using data obtained from the Unversity of Maryland's Global Land Cover Facility.

Code 610
National Aeronautics and
Space Administration

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

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