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In this issue ...

EDITOR'S CORNER

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I just returned from the American Geophysical Union's (AGU) Annual Conference in San Francisco where there were approximately 9,000 attendees. NASA's Earth Science Enterprise was well represented with numerous posters and sessions chaired by representatives of the SORCE, ICESat, Aqua and Aura teams. There were three NASA Earth Science Press Conferences that were well attended: ICESat Findings; 25 years of TOMS: Season of an Ozone Hole; and Urbanization's Climate Effects. This was an outstanding venue for showcasing ESE's research during 2003. Thanks to the Earth Science News Team and Public Affairs for their efforts in publicizing our research, and thanks to all the other participants for a job well done.

The Landsat 7 ETM+ instrument operated normally from shortly after launch on April 15, 1999, until May 31, 2003. On May 31 the scan line corrector (SLC) within the ETM+ instrument became inoperable and routine data collection was suspended between early June 5 and mid-July—this "down time" was needed to determine that no further harm could be done to the instrument by operating it again. All image data collected after May 31 have data gaps resulting in about 25% of the data within any given image not being acquired. Fortunately, the superb radiometric and geometric performance of the ETM+ instrument has not been affected by the inoperable scan line corrector. USGS EROS Data Center began distributing SLC-impaired data sets to the public on October 22; since the cost of fulfilling a user's request has not gone down, the price of these data remains the same as before the anomaly. USGS is currently working with NASA's Landsat Project Science Office to develop new products to fill the data gaps with data from scenes acquired before or after a given scene of interest. However, it will probably be mid-2004 before these new products are routinely available. If your area of interest happens to fall near the center of a Landsat scene you are in luck, as the centermost 40 - 60 km of each Landsat scene

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does provide complete coverage even with the inoperable scan line corrector. Further details can be found on page 24 of this issue.

As we look back on 2003, we have had many successes. SORCE is operating almost flawlessly and, for the first time ever, detected a solar flare in total solar irradiance data. The associated sunspot group also produced the largest recorded decrease in Total Solar Irradiance since the inception of solar irradiance measurements from space. While there have been problems with ICESat's Laser 1, Laser 2 has already sent back more than 160 million shots. The first set of laser measurements revealed features of the polar ice sheets with details never before seen. GRACE's performance is spectacular. In just 30 days, it exceeded the information gained in over 30 years of previous study. MODIS data are now being provided to the U.S. Forest Service Remote Sensing Applications Center (RSAC), the National Interagency Fire Center (NIFC), and the U.N. Global Fire Monitoring Center, for fighting fires around the globe. MISR has assisted scientists in studying many things from Houston's air pollution to the effects of earthquakes in India.

I'm happy to report that, of the 348 proposals received in response to NASA's Research Announcement, 59 were selected, offering opportunities for researchers to initiate new and successor interdisciplinary research investigations within the Earth Science Enterprise's Earth Observing System Interdisciplinary Science Program (EOS/IDS). The investigations selected can be found at *research.hq.nasa.gov/code_y/nra/current/NRA-03-OES-03/winners.html*.

In addition to the EOS/IDS proposals recently selected by NASA Headquarters, the results of NASA's Research Announcement on 'Earth System Science Research using Data and Products from TERRA, AQUA and ACRIM Satellites' were recently announced. There were 192 proposals selected from among 566 proposals submitted in response to this NRA, in addition to PIs and Team Leaders of the 8 science teams on these platforms. The investigations selected can be found at *research.hq.nasa.gov/code_y/nra/current/NRA-03-OES-02/winners.html*.

I want to take this opportunity to wish you a new year full of exciting new discoveries that will broaden our knowledge of this wonderful planet we call home.

On the first day of winter, a magnitude 6.5 earthquake rumbled along the central California coast. In general terms, the tectonic activity of central California is caused by the northwestward slide of the plate of rock underlying the Pacific Ocean against the plate underlying North America. The preliminary report from the U.S. Geological Survey is that the December 22, 2003, quake centered 6 miles northwest of San Simeon was the result of reverse faulting in the Oceanic fault zone in the Santa Lucia Mountains. The earthquake region is pictured here in this Landsat satellite image from April 19, 2002. Image by Robert Simmon, based on Landsat data provided by the Global Land Cover Facility, University of Maryland.

CERES Science Team Meeting

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The 29th Clouds and the Earth's Radiant Energy System (CERES) Science Team meeting was held in Hampton, Virginia, on November 17-18, 2003. This final meeting of the original CERES Science Team was originally scheduled for September 23-25. 2003, but was postponed due to the disruption caused by Hurricane Isabel. Parts of the work scheduled for the original meeting were covered during three telecons held in October. Both the telecon results and the Science Team meeting results are included in this report. The next meeting will be held jointly with the European Geostationary Earth Radiation Budget (GERB) Science Team at the National Center for Atmospheric Research (NCAR) in Boulder, CO, March 29–April 2, 2004. The March/April meeting will highlight release of up to 3 years of new CERES global Terra data products, validated from Level 1 through Level 3. This will be the first redefinition of the top-of-atmosphere (TOA) radiation budget since the Earth Radiation Budget Experiment (ERBE) in 1988. The March/April CERES Science Team meeting will be the first for the re-competed science team.

Telecon Results

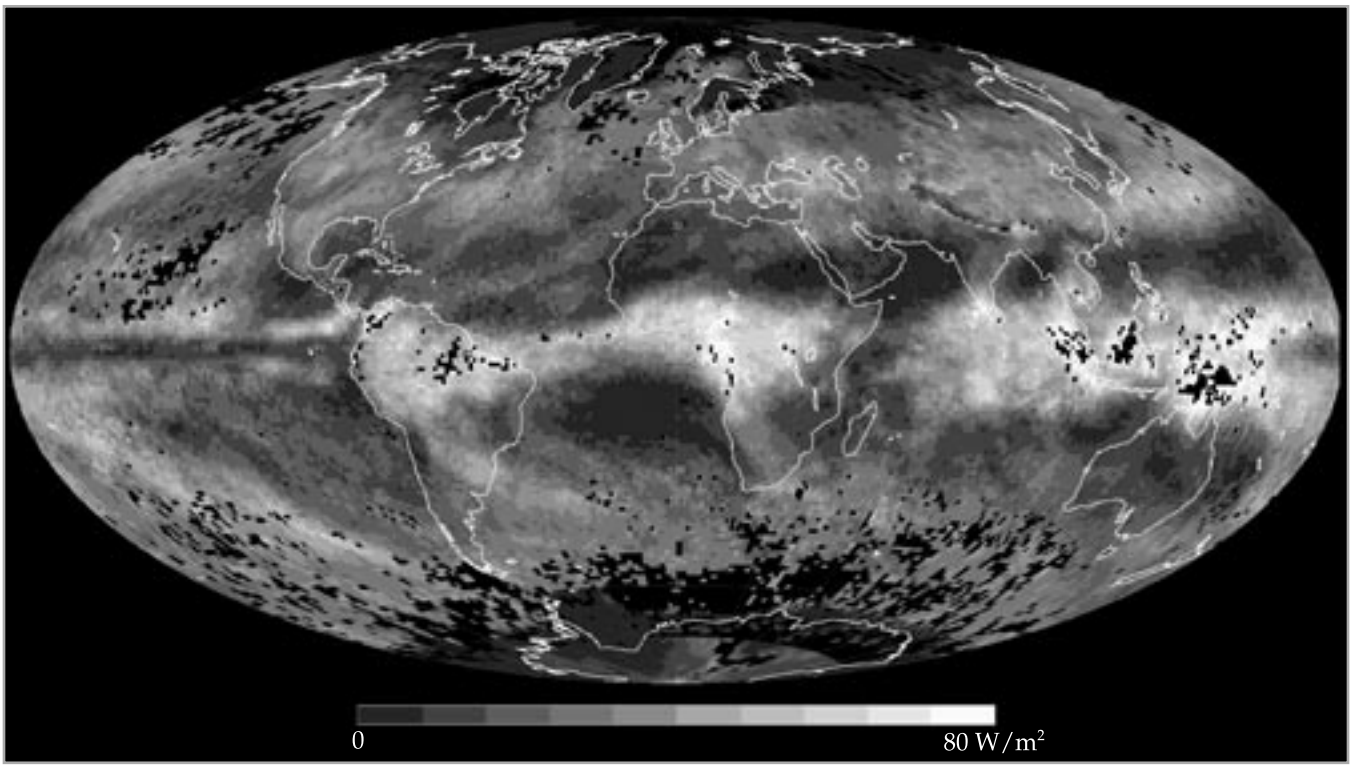
ECMWF vs. GEOS-4: At the first telecon, the science team discussed whether European Center for Medium Range Weather Forecasts (ECMWF) or the new Goddard Earth Observing System (GEOS-4) analysis data should be used for the reprocessing of Terra data. **Fred Rose** (Analytical Services and Materials, Inc., (AS&M)) showed that there were no significant differences between ECMWF and GEOS-4 water-vapor fields for the total column or the upper troposphere. **Pat Minnis** (LaRC) showed that ECWMF surface skin-temperature fields were slightly better, but only over night-time desert regions. However, ECMWF changes its assimilation system every few months. The accuracy of GEOS-4 was sufficiently close to ECWMF to make a frozen analysis system product from GEOS-4 preferable to ECMWF for producing CERES climate datasets. It was recognized that there are risks in the future availability of GEOS-4 analysis, and the team decided that an informal interface agreement indicating commitment by the GSFC Global Modeling and Assimilation Office (GMAO) that produces GEOS-4 as well as the NASA HQ modeling program should be obtained before proceeding. While this is underway, GEOS-4 is proceeding with re-analysis back to the start of the Terra period at 8 times real time. This is the rate needed to keep ahead of the CERES Terra reprocessing effort at the LaRC Atmospheric Sciences Data Center (ASDC).

Terra/Aqua Instrument Report: At the second telecon, **Kory Priestley** (LaRC) summarized the status of Terra and Aqua instrument calibration for the validated Edition2 Terra and Edition1 Aqua data. The present calibration meets accuracy requirements but, like Terra, Aqua will require an Edition2 version to correct the residual calibration drifts of about 0.5% in 2 of the 6 channels. The other 4 channels have shown no gain changes.

Aqua ERBE-like Products: Also at the second telecon, **Takmeng Wong** (LaRC) showed the validated Edition1 Aqua ERBE-like TOA fluxes and compared them to Terra, in particular for diurnal cycle changes. The data were consistent, and the science team approved the calibration Level 1b radiances as well as the ERBE-like TOA flux data products.

Cloud Algorithms: At the third telecon, **Patrick Minnis** (LaRC) presented night-time polar cloud algorithm improvements, which showed markedly improved near-terminator cloud retrievals, and showed improved results using the GEOS-4 assimilation data by turning on surface emissivities and adjusting thermal infrared thresholds by 30%. **David Kratz** (LaRC) showed that the new polar-night cloud retrievals greatly reduced surface longwave flux biases and also reduced the random errors. The team accepted the cloud algorithm changes for the Terra Edition2 reprocessing.

Angular Distribution Models (ADMs): Also at the third telecon, **Norman Loeb** (Hampton University, (HU)) presented the validation and error analysis for the new global Terra ADMs. The new ADMs are a dramatic improvement



Longwave Cloud Forcing from CERES, January, 2001.

over ERBE. In the polar regions, the new ADMs are also a large improvement over previous theoretical snow and ice anisotropy models. The science team approved their use in the new Terra Edition2 reprocessing which started at the end of October 2003.

Science Team Meeting

The Hampton meeting focused on Co-Investigator reports and a status review of the time interpolation and spatial averaging beta data products and the surface and atmosphere radiation budget products. These products are in final beta status and planning for major release of validated Edition2 data products at the next CERES Science Team meeting.

TRMM and Terra Averaged Products: **David Young** (LaRC) and **David Doelling** (AS&M) presented an update on the development and validation of the Level 3 monthly mean CERES data products from the Tropical Rainfall Measuring Mission (TRMM) and from Terra. Algorithms for the retrieval of cloud properties from geostationary imager data have been improved to reduce artifacts due to snow and improve the cloud mask over land regions. The new CERES monthly mean products were compared in detail with the CERES ERBE-like results. A particularly significant finding was that the annual global mean net flux is approximately 5 Wm^{-2} in both the ERBE-like and the new data products. Future validation work will concentrate on examining the cause of this imbalance.

TRMM/Terra CRS Results: **Tom Charlock** (LaRC) reported on the TRMM/Terra Clouds and Radiation Swath (CRS) results and status. Charlock described CRS as a high-volume product with the Surface and Atmosphere Radiation Budget (SARB); shortwave (SW), longwave (LW), and window fluxes at surface, 500-200-70 hPa and TOA levels; also cloud and aerosol forcings at the surface and TOA. The archived, low-latitude TRMM CRS Edition2B bias for surface insolation was 7.6% (34 Wm^{-2} at 40 land radiometer sites in 1998); the bias for downwelling LW at the surface was much better at only -0.5% (2 Wm^{-2}). The large error in TRMM insolation was ascribed to aerosols, which could not be retrieved over land during TRMM. The Terra surface insolation bias was 2.4% (12 Wm^{-2}). When compared with CERES observations at TOA, the global mean monthly biases for untuned calculations were 1-3 Wm^{-2} for SW and less than 1 Wm^{-2} for outgoing LW radiation. A map over the Pacific with Asian dust quantified positive aerosol forcing (albedo enhancement) in clear regions

and negative aerosol forcing over some clouds. Off-line calculations with Chesapeake Lighthouse and Aircraft Measurements for Satellites (CLAMS) data at the CERES Ocean Validation Experiment (COVE) site demonstrated the extraordinary utility of this sea platform for aerosol forcing studies at the surface and TOA. **Seiji Kato** (HU) presented a new gamma-weighted two-stream approximation to the Langley Fu-Liou code, which will produce a more-accurate SW SARB by accounting for the distribution of cloud optical depth within CERES footprints.

Data Management: **Erika Geier** (LaRC) presented the CERES Data Management status. She presented the CERES data sets which have been released since the May 2003 meeting, highlighting the Aqua Edition1 BDS (Bidirectional Scans), ES8 (ERBE-like Instantaneous TOA Estimates), ES4 (ERBE-like Monthly Geographical Averages), and ES9 (ERBE-like Monthly Regional Averages) and the Aqua/Terra combined Edition1 ES4 and ES9 data sets. She also presented the CERES data-sets which are expected to be processed before the next meeting in March 2004, highlighting the Terra Edition2A SSF (Single Scanner Footprint TOA/Surface Fluxes and Clouds), SFC (Monthly Gridded TOA/Surface Fluxes and Clouds), SRBAVG (Monthly TOA/Surface Averages), CRS, and FSW (Monthly Gridded Radiative Fluxes and Clouds); the Aqua Edition2 BDS, ES8, ES4, and ES9; and the Aqua/Terra combined Edition2 ES4 and ES9 data sets. **Jim Koziana**, representing the Langley ASDC, reviewed the CERES Data Sets page, highlighted the new browse images, and presented customer order statistics.

Outreach: **Lin Chambers** reported that the CERES Students' Cloud Observations On-Line (S'COOL) Project now has over 1600 participating schools in 63 countries. More than 27,000 ground observations have been reported to date, and there are now more than 4000 matching ground and satellite pairs to be analyzed. S'COOL held its 5th annual teacher workshop in June 2003 with 17 teachers from 4 states attending. Also in June a paper about S'COOL was published in the Bulletin of the AMS. **Shi-Keng Yang** participated in a 2-day conference in Taiwan about S'COOL and clouds, and reported that several past high school S'COOL participants are now studying ocean and atmospheric science in college. This year S'COOL was featured as a data collection activity for Earth Science Week. S'COOL materials have recently been translated to German and Italian, and an extensive outreach effort is underway with Italian speakers, as well as foreign language teachers in the U.S. Four new S'COOL products were peer-reviewed through NASA's Earth Science Enterprise and all received high marks.

Investigator Presentation Highlights

Grant Matthews (AS&M) reported on the status of the European GERB instrument, which is presently flying aboard the Meteosat Second Generation satellite. The GERB instrument is a scanner which alternately measures outgoing total and SW radiances. The LW radiance is obtained by subtracting the SW from the total. GERB processing, makes use of high-resolution imager data from the Spinning Enhanced Visible and Infrared Imager (SEVIRI), and produces SW and LW radiative fluxes every 15 minutes on a 10 km x 10 km spatial grid. GERB processing personnel work closely with their CERES counterparts and use many algorithms and procedures developed for CERES. Comparisons of early GERB products with CERES Terra and Aqua data are already being made.

Man-Li Wu (GMAO/GSFC) presented comparisons of the fields of clear-sky outgoing LW radiation and surface skin temperature from the new GEOS-4 assimilation with corresponding results from ECMWF operational analysis. The ECMWF data have been used for CERES processing during the last six years, and GEOS-4 data have been examined and selected recently to replace the former. The new results showed that GEOS-4 products are comparable or better than the ECMWF analysis. Also, the GEOS-4 data will be produced with a frozen analysis/assimilation system for the entire duration of the CERES project, a critical requirement for CERES climate data-sets.

Lin Chambers (LaRC) presented an intercomparison of March 2000 TRMM and Terra data, the only month of overlap. This study is the first step towards an evaluation of the use of geostationary data for interpolation between CERES measurements. Errors were assessed for time, space, and angle matching, as well as scene identification problems, for both TOA fluxes and a few cloud properties.

David Randall (Colorado State University) presented results of a study in which a 2-D cloud-system super parameterization was incorporated into a General Circulation Model (GCM), and retrieved properties of convective and stratiform clouds were compared with observations. When the cloud parameterization was non-interactive with the GCM radiation module, convective-cloud amounts were much larger

than the observed values. Results were greatly improved when cloud parameterization was made interactive with the radiation module. He concluded that cloud processes interact with each other on small spatial and temporal scales, and, therefore, future cloud parameterizations will have to be unified representations of these interacting processes.

Robert Cess (State University of New York at Stony Brook) presented an analysis of gridded ERBE data for the December-January-February season averaged over 5 years (1985-1989) to examine cloud properties from different sources. The ratio of SW to LW cloud radiative forcing (CRF) as a function of TOA net CRF was used as an indicator of cloud properties. The analysis was centered over a convective region in the tropical western Pacific and a marine stratocumulus region off the coast of South America. Results of simulations with a GCM using cloud properties derived from International Satellite Cloud Climatology Project (ISCCP) and High-resolution Infra-red Radiation Sounder (HIRS) data both agreed with ERBE results.

Michel Viollier (Laboratoire de Meteorologie Dynamique, (LMD), France) presented results from an analysis of CERES ERBE-like TOA SW fluxes from both Terra and Aqua. He examined whether the lower SW flux values from Terra and Aqua compared to those from the ERBE period were attributable to temporal sampling differences. He showed that Terra, with its morning equatorial crossing time, misses the afternoon convective activity over continents and underestimates fluxes over those regions. Aqua, on the other hand, misses the reflected flux from morning marine stratus and underestimates over those regions. Combined fluxes from Terra and Aqua provided a much better comparison with the diurnal variations derived from METEOSAT-5 data. In a separate presentation prepared by **Robert Kandel** (LMD), Viollier showed several examples of the antiquated and inadequate information on Earth radiation budget still present in astronomy databases. He stressed the need to establish better communication with the astronomy community.

Alexander Ignatov (NOAA/National Environmental Satellite, Data, and Information Service, (NESDIS)) presented comparisons of the two aerosol products in the CERES Single Scanner Footprint (SSF) data, one derived with the single-channel method and the other with the Moderate-Resolution Imaging Spectroradiometer (MODIS) multichannel algorithm. The two products generally covered different domains and showed some differences. Over common domains, the two showed remarkable agreement. The differences were attributable to sampling differences and to ambient cloud amounts. **Tom Zhao** and **Istvan Laszlo** (both from NOAA) also presented comparisons of the two aerosol products and their validation against Aerosol Robotic Network (AERONET) observations. They showed that the differences between the two were regionally dependent and were attributable to cloud contamination and surface disturbance.

David Doelling (AS&M) presented an in-depth report on the intercalibration of the MODIS, Visible-InfraRed Scanner (VIRS), and geostationary (GEO) imager 0.65-µm data used for interpolation of CERES fluxes. Calibration is checked using three methods: 1) a direct correlation between viewing-geometry-matched MODIS and GEO data; 2) GEO-to-GEO correlations using noon data at overlapping longitudes; and 3) an independent check of the visible gain using the mean albedo of deep convective clouds. The three methods produce very consistent results and demonstrate the effectiveness of the deep convective clouds as stable calibration targets.

Xiquan Dong (University of South Dakota) presented validation results of CERES cloud properties derived from MODIS data using ground-based measurements from the Atmospheric Radiation Measurement (ARM) Southern Great Plains (SGP) site. All low and high clouds chosen for this study were single-layer overcast cases. For low clouds, these results were derived using the lapse-rate method. Dong found excellent agreement in optical depth and height for thick clouds for both day and night. Retrieved droplet effective radius and liquid water path for stratus clouds were slightly lower than site measurements. Cirrus droplet size, optical depth, ice-water path, and height all showed larger differences.

James Coakley (Oregon State University) presented results of an analysis of global VIRS data for February-March 1998 to determine view-dependent biases in cloud properties derived using the partly cloudy pixel retrieval scheme. The analysis was limited to single-layer low-level clouds over ocean regions. Optical depth and droplet radius were found to increase with increasing altitude. Optical depth also increased with increasing regional cloud cover; droplet radius remained constant for regional cloud cover greater than 0.1. Clouds in partly cloudy pixels were found to have smaller optical depth and droplet radius than those in overcast pixels within the same

region. These retrievals also exhibited plane-parallel biases.

Leo Donner (NOAA/Geophysical Fluid Dynamics Laboratory (GFDL)) presented a recent study of the interactions between deep-convection and stratiform clouds using results of his deep convection parameterization in the GFDL Model AM2. Model results compared favorably with dynamical and microphysical data on mesoscale anvils collected during the Florida Area Cirrus Experiment (FACE). Magnitude of SW cloud radiative forcing in 3-D simulations was found to be greater than in 2-D. Cumulus vertical velocities and convective mass fluxes, examined over several regions, were always higher in 3-D. Stratiform mass flux was found to be less in the melting layer for all regions studied. There was less cloud liquid, cloud ice, and snow but more graupel in 3-D. Microphysics was found to be closely linked to convective vertical velocities which differed greatly between 2-D and 3-D simulations.

Bing Lin (LaRC) presented estimates of surface energy fluxes over tropical oceans using data from CERES and other instruments onboard the TRMM satellite. Surface SW and LW fluxes were available from a set of CERES surface flux models. Turbulent fluxes were derived using TRMM Microwave Imager (TMI) data with Tropical Ocean Global Atmosphere/Coupled Ocean Atmosphere Response Experiment (TOGA-COARE) algorithms. He showed good agreement between these flux estimates and those derived from shipboard observations. Lin stated that such estimates can be used for validating the results of data assimilation models.

Anand Inamdar (Scripps Institution of Oceanography) presented results of a study of the relationship between atmospheric LW cooling and the vertical distribution of moisture. He also examined the interannual variability of atmospheric LW cooling using TRMM and Terra SSF data. He showed that, in the window region, the atmosphere cools by emitting from the lower troposphere to the surface, and increased moisture in the lower troposphere results in enhanced cooling. Increased moisture in the upper troposphere, on the other hand, results in lowered cooling due to strong absorption in water vapor rotational bands.

Lou Smith (National Institute of Aerospace) compared CERES and GERB SW radiances for the short period in which the two instruments operated simultaneously. The GERB instrument is still in the commissioning phase located at 10°W longitude, and these comparisons are preliminary. CERES scanners have to be operated in the rotating azimuth plane (RAP) mode in very specific directions to maximize the opportunities for coincident measurements. Correct geolocation of CERES and GERB footprints has proven to be very difficult. A few comparisons, for which improved geolocation was available, showed good agreement. **Peter Szewczyk, Science Applications International Corporation** (SAIC), discussed CERES operations for a GERB validation campaign in Valencia, Spain.

Zhonghai Jin (AS&M) presented comparisons of TOA and surface clear-sky SW fluxes computed with a coupled ocean-atmosphere radiative transfer (COART) model with CERES retrievals and surface measurements made during the CLAMS field experiment conducted in July-August 2001. CERES footprints were matched with the site to 15 km. COART model radiances agreed well with CERES measurements inside and outside the sunglint regions. CERES/SARB and model fluxes also showed good agreement but ERBE-like fluxes showed errors in the sunglint regions. Surface fluxes from SARB and the two surface-only models showed good agreement with site measurements.

Robert Lee (LaRC) discussed the precision of solar and Earth irradiances measured by the non-scanner active cavity radiometers (ACRs) flown aboard the Earth Radiation Budget Satellite (ERBS). These instruments, which were launched onboard the ERBS in 1984, have provided good data until the end of 2002 and are still operating. An extension of in-flight calibration to irradiance measurements was accomplished despite failure of the elevation drive in October 1999. He presented results showing that the non-scanner ACRs achieved an accuracy of 0.3 Wm^{-2} in Earth irradiances during the 1984-1999 period and a precision of 0.5 Wm^{-2} was still achieved after 1999. Lee also presented estimates of lunar radiation budget obtained from all CERES instruments flown aboard TRMM, Terra, and Aqua. He showed that CERES thermistor bolometer sensors can measure the broadband SW and LW filtered radiances of the lunar disc to an accuracy of 0.2 $Wm^{-2}sr^{-1}$. An effective emitting temperature of the whole lunar disc was estimated to be about 400 K from the LW radiance measurements. He emphasized that these were the first-ever estimates of the lunar radiation budget.

Minutes from the September Aura Meeting

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An Aura Science Team meeting was held Sept. 30 – Oct. 3, 2003, at the Pasadena Convention Center in Pasadena, CA. Working Group meetings were held on the first day of the meeting. The remaining three days of the meeting featured reports from the Aura project and each of the four instruments, working group reports, an update of plans for aircraft missions that will provide validation data for Aura measurements, and contributed science presentations.

The Project Scientist, **Mark Schoeberl**, welcomed participants. NASA Headquarters Program Scientist, **Phil DeCola**, expressed his view that Aura data should be in the hands of the community well within a year of launch. He also presented information from the recent Atmospheric Composition Focus Area Review, showing the role of the Aura mission. The Aura team has been challenged to develop validation plans that combine the scientific goals of the Aura team with the goals of the aircraft mission community, exploiting the strengths of each type of data. A further challenge is to develop a plan to include Unmanned Aerial Vehicles (UAVs) in the validation program. DeCola stated that the Aura community should be part of the solution for the transition from the present sub-orbital fleet to the future.

Project Manager **Rick Pickering** reported on the status of the Aura platform. Aura was in thermal vacuum at the time of this meeting. The new proposed launch date is no earlier than March 19, 2004. He explained some recent issues with the High Resolution Dynamics Limb Sounder (HIRDLS) and plans to resolve these issues. The time-line that leads to the March 19, 2004, date has no slack and little allowance for resolution of unanticipated problems. Carolyn Dent, in charge of Project Mission Operations, explained spacecraft tests that have taken place recently, the upcoming mission rehearsals, and a schedule for each instrument for launch and early operations.

The Principal Investigators for each instrument team were asked to present the current status of the instrument, the algorithms, and plans for launch and early operations. **Joe Waters** introduced several members of the Microwave Limb Sounder (MLS) team. **Bob Jarnot** explained how necessary hardware and software reworks and testing of MLS were completed during the summer. **Nathaniel Livesey** provided information about the performance of the MLS algorithm. **Dave Cuddy** described the status of the Science Investigator Processing System (SIPS). **Joe Waters** gave plans for post-launch data processing, data inspection, and stated his intention that data will be available to the science community soon after launch. He showed a very aggressive schedule. They ask that those using the data prior to validation contact MLS before using data for any purpose.

Reinhardt Beer spoke for the Tropospheric Emission Spectrometer (TES). The vibrations from HIRDLS show up in the TES spectra, but the impact is not known. The TES retrieval algorithm shows success using model simulations; a simulated retrieval for the ozone column between the surface and 100 hPa exhibits most features of the initial field. The TES SIPS is in good shape. The TES Earth shade will be opened at launch + 30 days. TES will commence routine operations following an extended check-out period at about L+8 months. TES can be ready to take data 60 days following launch. This is important because the INTEX mission is slated for July/August 2004. Although TES will not support this mission with representatives in the field, INTEX can provide important correlative information for TES. Thus it is important that TES be operational during the mission.

Pieternel Levelt presented the status of the OMI mission. The largest concern for OMI is the calibration. The on-ground calibration is incomplete. Plans for in-flight calibration, therefore, require special attention. It will require extra time on orbit to meet the requirements. In-flight calibration is expected to be complete at L+6 months. There will be a Dutch Announcement of Opportunity for validation of OMI data. This will not provide direct funding to respondents; funding will be sought from appropriate national agencies.

John Gille (co-PI) presented information on HIRDLS, particularly the consequences of the failure of the coun-

ter balance motor in the cooler. After changes to remove the driver current, the noise decreases below specification in the region that will be used in normal operations. There is increased vibration that may impact the lifetime of HIRDLS and TES operations, thus this problem and possible paths to ameliorate it remain under investigation. The HIRDLS algorithm takes into account line-of-sight gradients; the importance of this is clearly demonstrated. **John Barnett**, co-Principal investigator, reported on HIRDLS calibration and explained various possibilities for the scan modes for HIRDLS. It is possible to obtain dense profile coverage with a small effort that will be important for support of aircraft missions providing validation information. HIRDLS will begin taking geophysical data at L+26 days.

Working Group Reports

The **Aerosol Working Group** (**Steven Massie**, chair) reported on plans for aerosols from each instrument. The HIRDLS instrument has four independent channels for aerosols and will retrieve aerosol information iteratively with retrieval of temperature and gases. HIRDLS may be able to detect polar mesospheric clouds. OMI will produce TOMS-like aerosol products including aerosol optical depth. OMI is interested in regional change in aerosol optical thickness and the climatic impact of such changes. The TES instrument is most sensitive to smaller aerosol particles. A key product of MLS is the ice water content—MLS is sensitive to larger particles. Plans have also been made to obtain maximum information in the likely event of volcanic eruptions. **Mark Schoeberl** recommended that the aerosol group extend its involvement to consider other members of the A-train, specifically including MODIS and CALIPSO.

Stephanie Stockman reported recent activities of the **Education and Public Outreach Working Group** (**Ernest Hilsenrath**, chair). The American Chemical Society has published a third issue of Chem Matters concerned with Aura. Activities are also planned for National Chemistry Week. The atmospheric element "Change is in the Air" of the "Forces of Change" exhibit at the Smithsonian National Museum of Natural History will open in June 2004 and will contain a scale model of Aura. Draft copies of the Aura brochure have been distributed to the instrument teams, with the goal of having the final copy reviewed and printed before the December 2003 American Geophysical Union meeting.

The new **Meteorological Products Working Group** (**Gloria Manney**, chair) was informed about recent improvements to the NASA Goddard Global Modeling and Assimilation Office (GMAO) assimilation system. The system present at launch (1° lat x 1.25° lon horizontal resolution) will be replaced within about a year with a 0.5° lat x 0.625° lon system that will address known defects in the present system including weak convection. Products with the native vertical coordinate will be available to remove a layer of interpolation when used in analysis of observations. **Man-Li Wu** of GMAO, the representative for Aura to GMAO, showed how GMAO responded to problems in their system when initial comparisons were made with Clouds and the Earth's Radiant Energy System (CERES) observations.

The **Algorithm Working Group** (**Nathaniel Livesey**, chair) reported on a new algorithm exercise wherein each team will use a single day's model output to simulate what their instrument will observe and then retrieve as many constituents as feasible. Retrievals will use both noise-free and noisy radiances. The results of this comparison will be available to interested persons through the Aura Validation Data Center (AVDC).

The **Data Systems Working Group** (**Scott Lewicki**, chair) reported success in completing the Aura file format guidelines. A product inter-comparison based on format using these guidelines will use results of one of the spacecraft system tests. There is a problem with the Interactive Data Language (IDL) readiness to support read and write capability for files in the HDF-5, and users are encouraged to contact Research Systems, Inc. (RSI) to make them aware of the need for this capability.

The **Validation Working Group** (**Lucien Froidevaux** and **Anne Douglass**, co-chairs) Tuesday meeting included a presentation on the overall Aura validation implementation plan showing the roles of aircraft campaigns, balloon launches, extra ozone and water vapor sondes, and a mobile facility to provide measurements in clean and polluted areas. There were separate short presentations on new instruments and also presentations from liaisons on data from other satellites. There was a discussion of the Canadian Middle Atmosphere Nitrogen TRend Assessment (MANTRA) balloon campaign, and the possibility of coordinating that campaign with the first Aura Validation Experiment (AVE) flight in October 2004. Headquarters has given provisional approval for the Aura Validation Data Center (AVDC) that will be a very useful tool for conducting the valida-

tion program as well as collecting data.

On Thursday during the plenary session **Schoeberl** provided an overview of the plan to the entire team, emphasizing the reasoning used to develop the schedule for aircraft missions. **Paul Newman** discussed AVE in more detail, emphasizing the January 2004 pre-AVE mission and its selected payload. **Brian Toon** presented the evolution of the Tropical Composition and Climate Coupling Experiment (TC3) to Tropical Composition and Climate Coupling and CRYSTAL Experiment (TC4). Current plans are to combine Aura validation goals and TC4 science goals with missions involving other agencies in Costa Rica (July, 2005) and Darwin, Australia (January, 2006). A component hosted by NASA in Guam will be delayed until January 2007 due to budget and commitment to other field missions.

There were 43 science presentations during this meeting (22 oral and 21 poster). The abstracts from this meeting are posted with the meeting agenda on the Aura web site, *aura.gsfc.nasa.gov*. Below is a brief summary of the oral talks.

Steven Pawson presented an overview of the NASA Goddard stratospheric ozone assimilation system. Recent improvements to the assimilation of BUV and TOMS data improve the tropospheric ozone residual relative to the ozone sondes.

Doug Allen reported on simulations using the Navy Operational Global Atmosphere Prediction System (NOGAPS) which show that the use of a three-dimensional ozone field rather than a zonal mean climatology leads to significant temperature differences.

Richard Rood described the use of data assimilation to monitor the performance of sensors, and discussed implications for climate data records.

P. Veefkind described the use of a data assimilation system and chemistry transport model to account for the stratospheric contribution to the column NO_2, leading to an improved tropospheric product.

Ross Hoffman described characterization of errors for assimilation of TES data to provide the best possible representation of the chemical structure of the troposphere and the best possible information for prediction of the global environment.

David Lary described constituent climatologies in flow-tracking coordinates developed from UARS data. Development of the climatologies revealed an unexplained seasonal minimum in water vapor in the upper stratosphere and mesosphere.

Bill Read used measurements of water vapor obtained from the wings of the 183 Hz radiometer band from UARS MLS to show that the seasonal cycle of water vapor in the lower stratosphere is out of phase with that in the upper troposphere.

Jessica Smith used data from aircraft to show that supersaturation in the upper troposphere is observed more frequently within clouds than out of clouds.

Steven Massie used MODIS aerosols and Polar-Orbit Earth Observation Mission (POAM) observations to argue that intense fires in Siberia, which take place approximately every 5 years, introduce aerosols to the stratosphere that should be detectable by HIRDLS.

Veefkind showed that accounting for Raman scattering decreased the systematic errors at high latitudes in the total ozone product derived from the Global Ozone Mapping Experiment (GOME) using the Differential Optical Absorption Spectroscopy (DOAS) method of retrieval.

Gregory Engel discussed the accuracy of "coincident" *in situ* and remote observations made from aircraft. Although data precision is simpler to quantify, data accuracy is most important for validation of remote measurements from satellite.

Levelt reported that high school students and adult scientists can use the simple instruments available to the Global Learning and Observations to Benefit the Environment (GLOBE) participants in the Netherlands to obtain data of similar quality to that obtained using a professional sun photometer. These data can be used in validation of MODIS aerosol optical depth.

Elliot Weinstock emphasized that validation of satellite data requires the existence of other data sets that have already been validated, and that the systematic differences between different *in situ* data sets must be resolved or systematic errors in the global data sets may not be discovered.

Elizabeth Weatherhead showed how noise, accuracy, and variability contribute to the ability to deduce trends from data records. The obvious good constituent for global trends has low noise and low autocorrelation (memory) so that the measurements are nearly independent.

Andrey Meshkov showed results of

laboratory microwave measurements that will improve the parameterization of the dry and moist atmospheric absorption continua that is important for retrieval for instruments like Aura MLS.

Jim Anderson used the example of lower stratospheric ozone loss to form a hypothesis and test it using a combination of aircraft and satellite measurements. He emphasized the role of Aura measurements to place *in situ* observations in geophysical context.

Robert Chatfield used back trajectories to show that the structure in Southern Hemisphere Additional Ozonesondes (SHADOZ) ozone profiles depends on biomass burning, lightning, and convection. He also showed that the same "ozone paradox" that exists in the south Atlantic is seen in the Indian Ocean but much more briefly.

Andrew Dessler used observations of relative humidity from the Upper Atmosphere Research Satellite (UARS) MLS and water vapor from UARS Halogen Occultation Experiment (HALOE) to investigate the water vapor feedback. Observations from the two instruments were shown to be consistent with each other, and to be inconsistent with two competing hypotheses, that mixing ratio stays constant for global warming versus the hypothesis that the relative humidity says constant.

Elizabeth Moyer showed that the water vapor measured during a summer Costa Rica mission was generally undersaturated, indicating that the air had been desiccated elsewhere. Convective systems were shown to hydrate the air to restore saturation conditions. Model results suggest that the conditions to be experienced during a winter mission will differ greatly.

Mark Filipiak presented a method in which analyzed meteorological fields are used to average the vertical velocity binned by equivalent latitude. This vertical velocity will be used with ozone measured by EOS MLS to calculate the flux of ozone from the stratosphere to the troposphere.

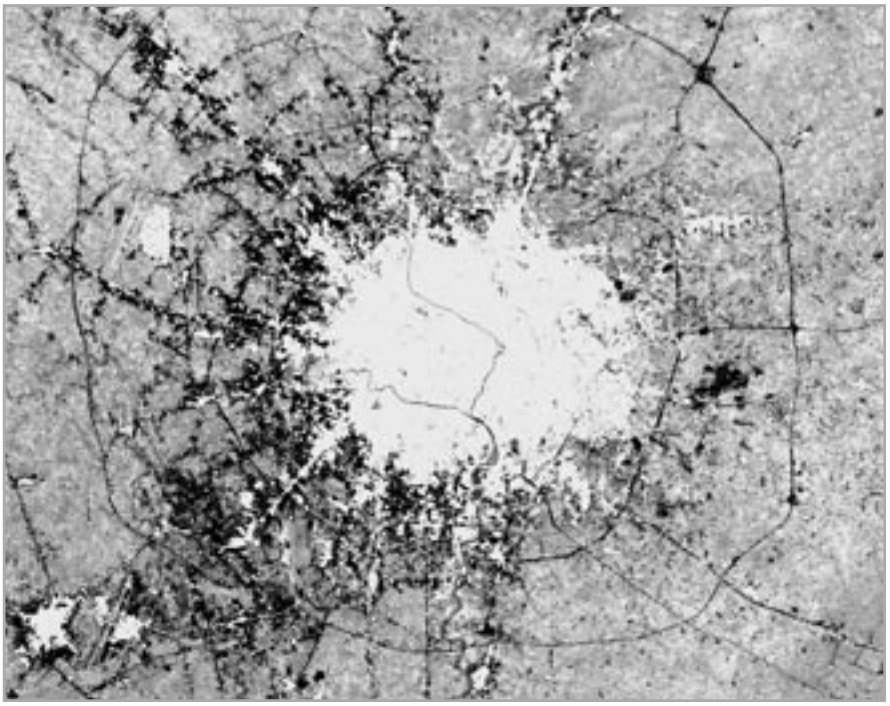
David Sayres found that the criteria for coincidence between the *in situ* measurements from the WB-57 and the remote sensing measurements from the ER-2 required that the measurements be made both within a few minutes (temporally) and 2 km (spatially) of each other. When these criteria were satisfied, the remote and *in situ* measurements of cloud ice agreed within about 10%.

In the final paper of the meeting, **Darryn Waugh** discussed interannual variability in upper tropical troposphere meteorology, and its effect on tracer transport, emphasizing intrusions of air with middle-latitude ozone and potential vorticity into the tropics.

In addition to the oral presentations, there were 21 poster presentations. The subjects of the posters included calibration/validation (2), data systems (2), algorithms (8), instruments to provide correlative data (4), and analysis (5). The poster abstracts are included on the Aura web site.

The 2,000+ year-old city of Chengdu, China, grew dramatically between July 1990 and July 2000. This Landsat image of Chengdu is part of a study that is using high- and moderate-resolution satellite data to monitor patterns of urbanization across the Earth. Light areas show the extent of the urban area in 1990, while black areas show what was built up in the 10 years after that. In many cases, the urban build up has moved out of the core of the city along roadways, which radiate out from the city like spokes on a wheel. A new roadway makes a black ring around the city and is connected to the core by many new "spokes." Urban expansion has mostly been on the western side of the city, approaching the mountain foothills.

Image courtesy Annemarie Schneider, Boston University, and NASA Landsat Science Team.



Minutes From HDF/HDF-EOS Workshop VII

—Lori J. Tyahla, lori_tyahla@sesda.com, Global Sciences & Technology, Inc.
—Richard Ullman, Richard.E.Ullman@nasa.gov, NASA Goddard Space Flight Center

Overview

HDF/HDF-EOS Workshop VII was held at the Hilton Hotel in Silver Spring, MD, September 23-25. Approximately 85 people attended.

The first full day was devoted to hands-on tutorials as in previous years. The tutorials included general and advanced HDF and HDF-EOS design and programming topics. The second day began with a plenary session that included presentations by the sponsors of the workshop: NASA Earth Science Data and Information System (ESDIS), the National Center for Supercomputing Applications (NCSA), and the National Polar-orbiting Operational Environmental Satellite System (NPOESS). This was the first HDF workshop to be co-sponsored by the NPOESS Integrated Program Office (IPO). HDF5 will be used for NPOESS data record products. A presentation by the EOSDIS Core System (ECS) contractor—the developers of the HDF-EOS Library—was also given.

Summary of Plenary Presentations

Richard Ullman (NASA ESDIS) gave an overview of HDF-EOS, as many attendees did not participate in prior workshops. He provided a brief description of the EOSDIS and described the goals for the standard data format. He explained the difference between HDF and HDF-EOS and gave a history of HDF-EOS and lessons learned since its use began. He also discussed the new direction for data standards for NASA's Earth Science Enterprise.

Mike Folk (NCSA) presented the status of HDF work at NCSA. Topics included who is supporting HDF, upcoming library and tool releases and features, and collaborations with the EOS tools teams such as the ECS contractor and the Data Usability Group supporting Ullman. He concluded with a list and brief descriptions of other activities in which they are involved including projects with the Department of Energy, the National Archives and Records Administration, and several others.

Alan Goldberg (NPOESS IPO) described the NPOESS mission, and provided an overview of the contract and the top-level architecture. He discussed their approach to data processing and standards. Because the system is operational (the time from observation to delivery to operational user is only 30 minutes) as well as archival, algorithms and their implementation must be approved by the Program contractor. The NPOESS program will not have its own profile of HDF, but will use formal software configuration management processes in tandem with a "programming handbook" to ensure consistency and adherence to standards.

Larry Klein (Earth Observing System Data and Information System Core System-ECS) presented the status of HDF-EOS activities. He first gave a brief introduction to the grid, swath, point, and zonal average data structures followed by short descriptions of HDF-EOS 2 and HDF-EOS 5. He listed the HDF-EOS library development that had taken place since the last workshop in December 2002 and discussed available tools, such as the HDF-EOS-to-GeoTIFF (HEG) Converter and HDFView. Klein's group has been working with NCSA to possibly add HDF-EOS modules to the HDF Java tool.

Mini-presentation/Poster Session

A total of 23 mini-presentations highlighting posters were given. The topics fell into two large categories: 1) interoperability, formats, and standards, and 2) tools.

Interoperability, Formats, and Standards

Several presentations and posters regarding the use of XML to address data/application interoperability issues were given. **Matt Smith** (University of Alabama, Huntsville) gave an overview of the Earth Science Markup Language (ESML) which is based on XML. The use of ESML components enables different data formats to be read by the same library while eliminating the need to write format converters specific to each format. Smith described the components as ESML files (one for each significantly different data format) that contain markups, one ESML schema that defines rules for the markups,

and one ESML library which "parses and interprets the description file and figures out how to read the data."

David Han (National Space Science Data Center at GSFC) gave a similar presentation and poster. They have developed a Commond Data Format Markup Language (CDFML), based on XML to facilitate interoperability among the many formats used in the Solar and Space Physics community (Common Data Format (CDF), netCDF, HDF, etc.). His group has developed several converters and is using these in conjunction with the Simple Object Access Protocol (SOAP, also XML-based) to develop a data translator web service.

Arlindo DaSilva (Global Modeling and Assimilation Office, NASA/GSFC) described the Earth System Modeling Framework (ESMF) project, begun in February 2002, that seeks to "increase software reuse, interoperability, ease of use and performance portability in climate, weather, and data assimilation applications." The ESMF I/O layer must support gridded data (both structured and unstructured), observational data, and at least eight different data formats, including NetCDF, HDF 4, HDF 5, HDF-EOS, GRIB, BUFR, IEEE binary, and GrADS-compatible binary. The ESMF has adopted the Climate Forecast (CF) conventions which are now described in XML. They are independent of NetCDF, specify standard dimensions, and specify standard units for these dimensions and other quantities. The ESMF team will work with the CF team to extend the conventions to support some of the formats, and others will simply co-exist with the conventions.

Other approaches to interoperability issues were offered. **Russ Rew** (University Corporation for Atmospheric Research – UCAR – Unidata Program) presented plans for an enhanced netCDF-4 interface to HDF5 data. Their goals are to "combine desirable characteristics of netCDF and HDF5, while taking advantage of their separate strengths, preserve format and Application Program Interface (API) compatibility for netCDF users, and demonstrate benefits of combination in advanced Earth science modeling efforts." The goals will be met by merging the netCDF library with the HDF5 library and extending the netCDF API, according to the Unidata web site (*www.unidata.ucar.edu/packages/netcdf-4/*).

Other groups are still examining the feasibility of using HDF and HDF-EOS. **Marlo Maddox** (Community Coordinated Modeling Center, NASA/GSFC) provided an overview of space-weather models and challenges. Their challenges are similar to those of the ESMF in that they need to support various data formats and interfaces and the data are currently not self-describing. The Center is examining CDF (Common Data Format developed at the National Space Science Data Center at NASA/GSFC) and HDF5 as possibilities for the future. They have performed testing on CDF thus far and will perform HDF5 tests and then compare the results.

Don Keefer (United States Geological Survey) and Mike Folk (National Center for Supercomputing Applications) are exploring use of HDF5 and HDF-EOS datatypes by the National Archives and Records Administration (NARA) for non-remote-sensed, geospatial data types. As part of this exercise, they are identifying technical requirements and I/O efficiency for visualization and performance and storage issues associated with data-format conversion.

MuQun Yang (NCSA) presented the results of a performance study exploring the performance of parallel HDF5 in parallel computing environments and the compression feature inside HDF5 when applied to the Weather Research and Forecasting (WRF) model. The study concluded that parallel I/O is not trivial and that various data compression methods (szip, shuffling with gzip, and "chunking" with MPI-IO inside HDF5 library) can improve performance. Please see the NCSA web site (*hdf.ncsa.uiuc.edu*) for more information on these compression methods.

Richard Ullman (NASA/ESDIS) gave a presentation on metadata and interoperability standards. He briefly described the metadata of the EOSDIS Core System (ECS) and the Global Change Master Directory (GCMD), and the Version 0 interoperability protocol, and listed three of the most relevant standards of the Federal Geographic Data Committee (FGDC). He noted that NASA offices (particularly the ESDIS project and the Geospatial Interoperability Program) have been proactive participants in working with the International Standards Organization Technical Committee 211: Geographic Information/Geomatics (ISO TC211), the Committee on Earth Observation Satellites Working Group on Information Systems and Services (CEOS WGISS), and the OpenGIS Consortium (OGC). He stated that established metadata practices are as important as the "myriad of national and international standards and working groups." Standards have evolved in tandem with EOSDIS and will continue to evolve in the foreseeable future. Ullman also pre-

sented a list of major lessons learned regarding metadata.

Tools

Lori Tyahla (Global Science & Technology, Inc.) provided an overview of the HDF-EOS Tools and Information web site (*hdfeos.gsfc.nasa.gov/hdfeos/index.cfm*). In the past year and a half the web site has been redesigned and deployed incrementally. The web site has a new major section, Information and Documentation, that contains user guides, reference manuals, Frequently Asked Questions (FAQs), XML-related information, and tutorials and overviews for HDF and HDF-EOS. The documents are fully searchable to assist users in determining which document best suits their needs. The web site also has tools available for download (or links to sites distributing them); an online user forum; a workshops section containing presentations from all seven HDF/HDF-EOS Workshops and information about upcoming workshops; and a few other items of interest.

Robert McGrath (NCSA) presented information related to converting between HDF4 and HDF5 and vice versa. The following are available from the NCSA web site (*hdf.ncsa.uiuc.edu*): comprehensive mapping document from HDF4 to HDF5, conversion utilities and libraries, user's guide, reference manual, and programmer's notes for conversion. He also noted that the conversion utilities and libraries work on all platforms on which HDF4 is supported. McGrath also discussed a new tool called H5diff (analogous to the Unix "diff" command) that compares 2 HDF5 files. It identifies missing, mismatched objects, and different data values, and compares attributes and attribute values.

Matt Smith (Information Technology and Systems Center, University of Alabama in Huntsville) explained that the HDF-EOS Web-based Subsetter (HEW) is undergoing integration into the EOSDIS Core System (ECS) via the EOSDIS Data Gateway (EDG) v3.5.1. The system is operational at the National Snow and Ice Data Center (NSIDC), is undergoing testing at the EROS Data Center (EDC), and is soon to be tested at the Goddard DAAC. Other HEW developments include a new packaging option, called HSE (HEW Subsetting Engine), designed for sites "that want subsetting, but do not want to host the full HEW installation or even the standalone HEW back-end." Version 1.0 of the HSE was to be available by mid-October 2003.

Bob Bane (Data Usability Group, GSFC) presented a tool called HDF-EOS 5 Validator that employs XML to validate HDF-EOS 5 files against guidelines. This tool is "mainly for data producers to use to check the format of their files before delivering to users." The tool ensures that a file contains all metadata and data that it is supposed to and that the items are of correct name, type, and size. In a separate presentation, **Jingli Yang** (Data Usability Group, GSFC) described two other tools that use XML Document Type Descriptions (DTDs). The HDF-EOS Data Extractor (HEEX) is a command-line tool that enables HDF-EOS data to be converted to Binary or ASCII. The xml2he5 tool (also a command-line tool) converts an XML file (that conforms to the DTD) to an HDF-EOS 5 file.

Zhangshi Yin (Data Usability Group, GSFC) gave a presentation describing the HDF-EOS Metadata Updater (HEMU) tool. This tool enables data producers or users to update metadata inside an HDF-EOS file (HDF-EOS2 and HDF-EOS5). HEMU can be used to extract metadata from a dataset to an editable text file, replace metadata with text from an external file, and update metadata with text from an external file.

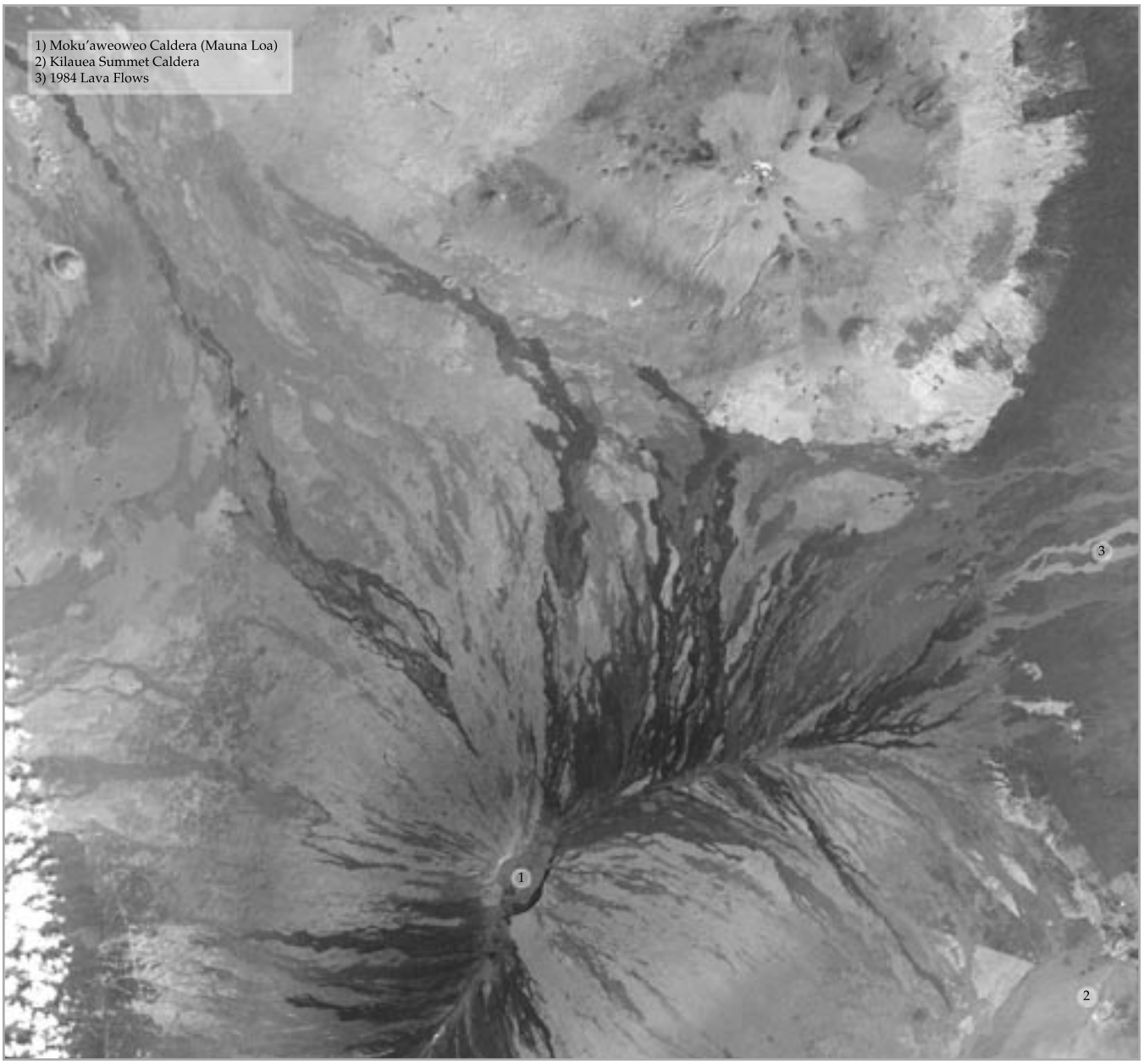
Peter Cao (NCSA) presented developments in the HDFView tool. HDFView is a Java-based visual tool to browse and edit HDF4 and HDF5 files. Modular HDFView is the same tool but with replaceable I/O and Graphical User Interface (GUI) components. Advantages of replaceable modules include the ability to add a new file format without modifying the GUI, user-customization of the view, and the ability to replace modules without having to modify the rest of the source code. The first release of the Modular HDFView is expected in December 2003. They are also considering working with the ECS developers to enable the tool to read HDF-EOS files, perhaps via a "plug-in."

Dimitar Ouzounov (Goddard Earth Science Distributed Active Archive Center (GES DAAC)) described HDFLook-MODIS, a GUI-based tool for use with HDF4.x and HDF-EOS 2.x scientific data sets. The tool can also run in operational and command-line mode. HDFLook-MODIS can visualize data; convert to different formats; has mapping, reprojection, subsetting (channel, parameter, spatial), and subsampling capabilities; and can perform multi-granule processing functions such as mosaicking and stitching. Ouzounov showed a few examples of each. He also listed the operational and system integration uses, which include routine generation of Level 1B browse images for MODIS data from the Terra and Aqua satellites at the GES DAAC,

spatial on-the-fly subsetting of MODIS Level 3 Ocean products from the Data Pool (GES DAAC), on-demand parameter subsetting of MODIS Ocean Level 2 products (GES DAAC), and an operational Terra MODIS preprocessing system (Yasuoka Lab, Institute of Industrial Science, University of Tokyo).

This Landsat image from February 5, 2000, shows Mauna Loa, the biggest volcano in the world, on the "Big Island" of Hawai'i. Most of the surface of the volcano is covered by lava flows that have been laid down in the last 10,000 years, although geologists believe the volcano is probably between 600,000 and 1 million years old. The rivers of hardened lava make dark etchings across the massive volcano's flanks. The peak reaches up 9 kilometers from the ocean floor, extending to an altitude of 4,170 meters (13,681 feet). On the northeast and southwest sides of the Moku'aweoweo caldera at the summit are two rift zones, from which fountains of lava periodically erupt. The trails of lava from the last eruption of Mauna Loa, in 1984, snake down from the northeast rift zone into the vegetation of the lower slopes. At bottom right of the image is Kilauea Volcano, whose spectacular lava flows spill, sizzling, into the ocean. Both volcanos are part of Hawai'i's Volcanos National Park.

Image by Robert Simmon, based on Landsat 7 data archived by the Global Land Cover Facility



Introducing the MODIS Atmosphere Level 2 Joint Product

—Brad Wind, bwind@climate.gsfc.nasa.gov, NASA Goddard Space Flight Center

What It Is

This article is about a recently inaugurated MODIS atmosphere Level 2 product. The new product is easier to use than its many, sometimes lengthy, names imply. Some call it the Joint Product or Joint Atmosphere Product; some "ATM L2" for "Atmosphere Level 2," from the product's Earth Science Data Type designation. Still others call it a "subset MODIS atmosphere Level 2" product. To be clear, this buzz all concerns the same new data file. The names are used interchangeably to refer to the new MODIS atmosphere Level 2 file that began production on October 14, 2003 for the Aqua (ESDT: MYDATML2) and Terra (ESDT: MODATML2) platforms. The product is made by program-executable (PGE) 83 and bears the following collection description:

A selection of the most useful atmosphere Level 2 aerosol, cloud, and water vapor parameters at 5- and 10-km spatial resolution. Native 1-km cloud, water-vapor and cloud-mask fields are also included, but subsampled every 5th line and pixel.

Motivation

Why create a post-launch product of the best of the standard at-launch Level 2 MODIS atmosphere products? Low-bandwidth, resource-constrained computing environments make the standard at-launch MODIS atmosphere products difficult to use, especially off-Center. Stated differently, MODIS atmosphere Level 2 product file sizes and data surfeits obstruct science in the community. The new MODIS Atmosphere Level 2 Joint Product, having begun production from Julian days 285 (Aqua) and 286 (Terra), was designed to be small enough to minimize data-transfer and storage requirements, yet robust enough to be useful to a significant number of MODIS data users. For those unfamiliar with Level 2 MODIS atmosphere products, the effective daytime compression ratio of the source Level 2 atmosphere files to this new Joint Product that derives from them is, conservatively, 97:3. A single ATM L2 file represents a savings of almost 100 Megabytes. The Joint Product's lean design enables a full 24-hour period of 288 high-resolution granules to fit on a single CD and, more importantly, months of this MODIS atmosphere data to be publicly accessible via simple, fast anonymous ftp from Goddard's data pool.

Another positive feature of the Joint product is enhanced program-executable (PGE) tracking capability. Tracking PGE versions used to create various parameters is important to the vast majority of scientific research efforts. Since the Joint Product collects scientific data sets (SDSs) from a number of L2 products, each created with a unique PGE version, this task is exacerbated. To help solve this problem, a new local attribute "source_info" is added to each SDS in the Joint Product. This local attribute contains: 1) the file name of the source HDF product, 2) the PGE ID number and PGE version used to create the source file, and 3) the source SDS name. PGE version information provided can be interpreted using PGE version history pages. These pages are found by clicking on the PGE History links on the MODIS Atmosphere product processing and availability calendar (on the MODIS Atmosphere website—see URL below). This new tracking feature allows scientists to more easily monitor the evolution of various parameters by tracking bug fixes and enhancements implemented in the algorithm software.

Contents

Anticipating users' basic needs required difficult trade-offs. First, the Joint Product does not contain all MODIS atmosphere Level 2 SDSs. Instead, it contains only key parameters. To be comprehensive, these are gleaned from the complete set of standard at-launch Level 2 atmosphere products: Aerosol, Water Vapor, Cloud, Profile, and Cloud Mask. The key SDSs contained within ATM L2 cover a full set of high-interest parameters produced by the MODIS Atmosphere group, and are stored at 5-km and 10-km (at nadir) spatial resolutions. Table 1 lists the SDSs contained in the ATM L2 product, together with their respective spatial and storage sizes.

Trade-offs

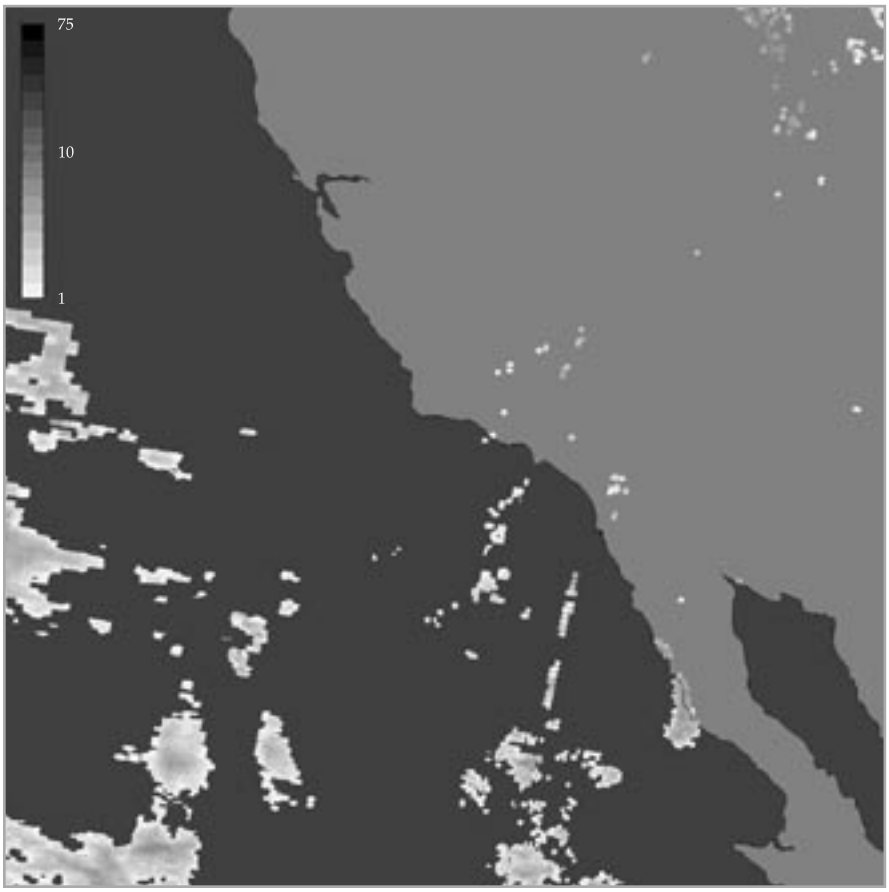
Besides frugal selection of SDSs, a few limitations were introduced into the Joint Product to reduce the file size. First, some parameters that were stored at 1-km resolution in their original (source) Level 2 product file were subsampled to 5 km in the Joint Product. These include the cloud mask, cloud optical thickness, cloud effective radius, cloud quality assurance (includes cloud phase information), cirrus reflectance, and precipitable water (near-IR) parameters. Second, geolocation arrays that were stored as 4-byte floating-point real numbers in the original (source) product file were compressed to 2-byte scaled integers. This sacrifices 0.001 degrees of geolocation accuracy. Finally, only a limited set of QA (quality assurance) arrays made it into ATM L2 and only for parameters where these extra bits were absolutely crucial to the use and/or interpretation of the science arrays.

	5-km		10-km
219	Latitude	54	Latitude_10km
219	Longitude	54	Longitude_10km
		54	Solar_Zenith_10km
219	Cloud_Optical_Thickness	54	Viewing_Zenith_10km
219	Cloud_Effective_Radius	54	Relative_Azimuth_10km
109	Cloud_Quality_Assurance		
219	Cirrus_Reflectance		
219	Cloud_Top_Pressure		
219	Cloud_Top_Temperature	54	Aerosol_Optical_Depth
109	Cloud_Fraction	54	Aerosol_Optical_Depth_Ratio_Small
219	Precipitable_Water_Near_Infrared_Clear	27	Aerosol_Solution_Index_Ocean_Small_Average
219	Precipitable_Water_Infrared_Clear	27	Aerosol_Solution_Index_Ocean_Large_Average
109	Cloud_Mask	27	Aerosol_Quality_Assurance
2298	**Kilobytes**	**459**	**Kilobytes**
Total:	~2.8 Megabytes per daytime granule		

Table 1: Joint Atmosphere Product Components

Geolocation

An inherent complexity of the Joint Product is its need for dual geolocation arrays. The Aerosol (04_L2) parameters are computed and stored at a different resolution (10 km) than the rest of the parameters in the Joint Atmosphere product file (5 km). The 5-km resolution geolocation is **copied** from center (3, 3) 1-km cell in the 5x5 1-km region. The 10-km-resolution geolocation is **computed** by averaging the four central 1-km cells [(5,5), (5,6), (6,5), (6,6)] in the 10x10 1-km region. Because of this dichotomy, two sets of geolocation (one at 5-km and one at 10-km) were included in the Joint Product. The first (default) geolocation set is for the 5-km-resolution parameters; these have the SDS names: *Latitude* and *Longitude.* The second set is for the 10-km-resolution parameters; these have the SDS names:



Cloud optical thickness data from the MODIS intrument aboard Terra. Darker areas indicate optically thicker clouds, whereas lighter areas indicate thinner clouds. Clear ocean is black and clear land a solid gray.

Latitude_10km and *Longitude_10km.* Users should ensure they are using the correct geolocation array when working with various parameters in the file.

Acquiring

The preferred method of obtaining Joint Product files is to use the *Goddard DAAC Data Pool*:

1. '*cd*' into a directory where you would like the data files to go.
2. ftp to the Goddard ECS ftp server by typing: *ftp g0dps01u.ecs.nasa.gov*
3. When the server asks for a name, type: *anonymous*
4. When the server asks for a password, type your e-mail address.
5. '*cd*' into the MODIS Atmosphere Aqua (*MOAA*) or Terra (*MOAT*) directory.
6. '*cd*' into the ATML2 directory; *MYDATML2.003* (Aqua), *MODATML2.004* (Terra).
7. '*cd*' into the directory of the day's data. For example, October 25, 2003 is '*2003.10.25*'
8. Turn-off ftp interactive mode prompting by typing: *prompt*
9. To get the full day of files, type: *mget *hdf*
10. Quit the ftp session by typing: *bye*

There is also a web interface for this ftp site at *daac.gsfc.nasa.gov/data/datapool/* Alternatively, the Joint Product can be ordered through the *EOS Data Gateway* as follows:

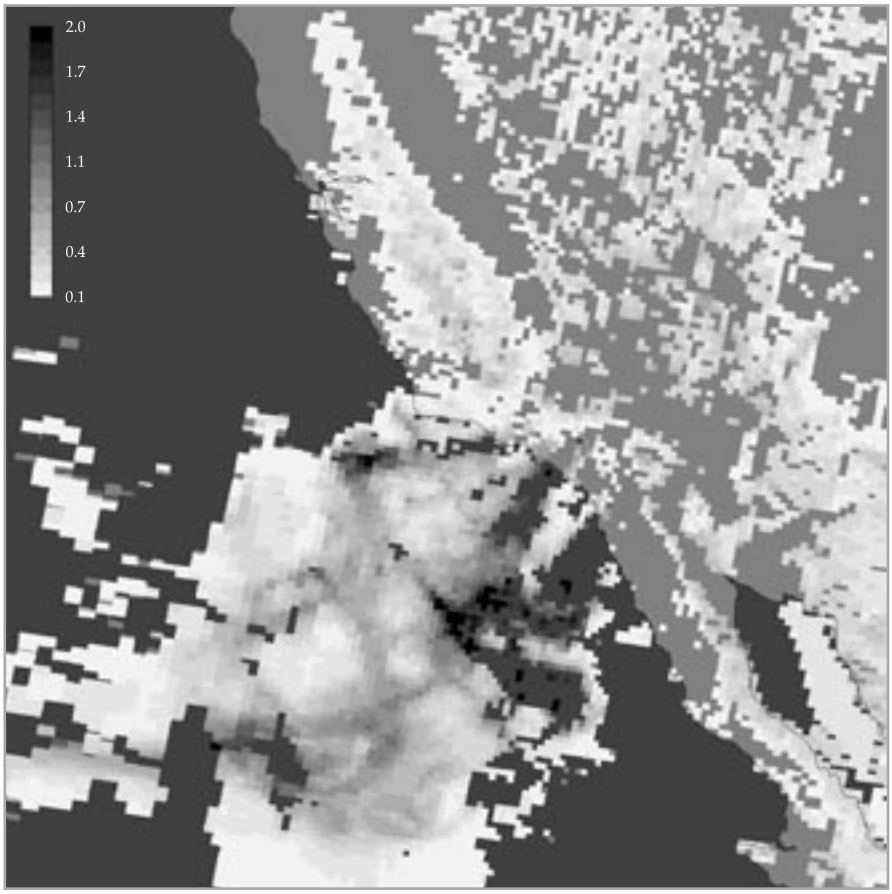
1. Go to *redhook.gsfc.ansa.gov/~imswww/pub/imswelcome/*
2. Click on "*Enter as guest*" (One may also register).
3. In the "*Data Set Lookup*" box in the upper left portion of the page, enter the following dataset selection word in the text box: *atml2*
4. Click "*GO*"
5. Follow the instructions given on the web site to further refine your selection and complete your order.

Tools

The ATM L2 product conforms to all HDF -EOS standards. Adherence to these standards makes the product compatible with all existing MODIS atmosphere Level 2 visualization software. Non-projected images visualize equally well for ATM L2 as for all other MODIS atmosphere Level 2 products. Some software bases projection capabilities, however, on *de facto* conventions regarding MODIS geolocation arrays. As noted previously, the data type of geolocation arrays in ATM L2 files is smaller than in other MODIS atmosphere Level 2 products, and there are two sets of geolocation arrays instead of a single latitude/longitude pair. This means any compatibility problems with projection features result from their particular code's inflexibility respecting ATM L2's geolocation differences. Sufficiently robust software, i.e., code that does not assume *de facto* conventions about geolocation array data type and names, is able to project ATM L2 arrays seamlessly. Otherwise, the Joint Product follows all *de facto* conventions of the at-launch MODIS atmosphere Level 2 products.

MODIS Data Support Team–sponsored

On October 26, 2003, the MODIS instrument aboard the Terra spacecraft captured this image of the California region during the wildfires that swept the state between October 21 and November 18, 2003. The image shows the Aerosol Optical Thickness of the smoke plumes from the wildfires. The dark areas indicate optically thicker aerosol present, whereas light areas indicate optically thinner aerosols.

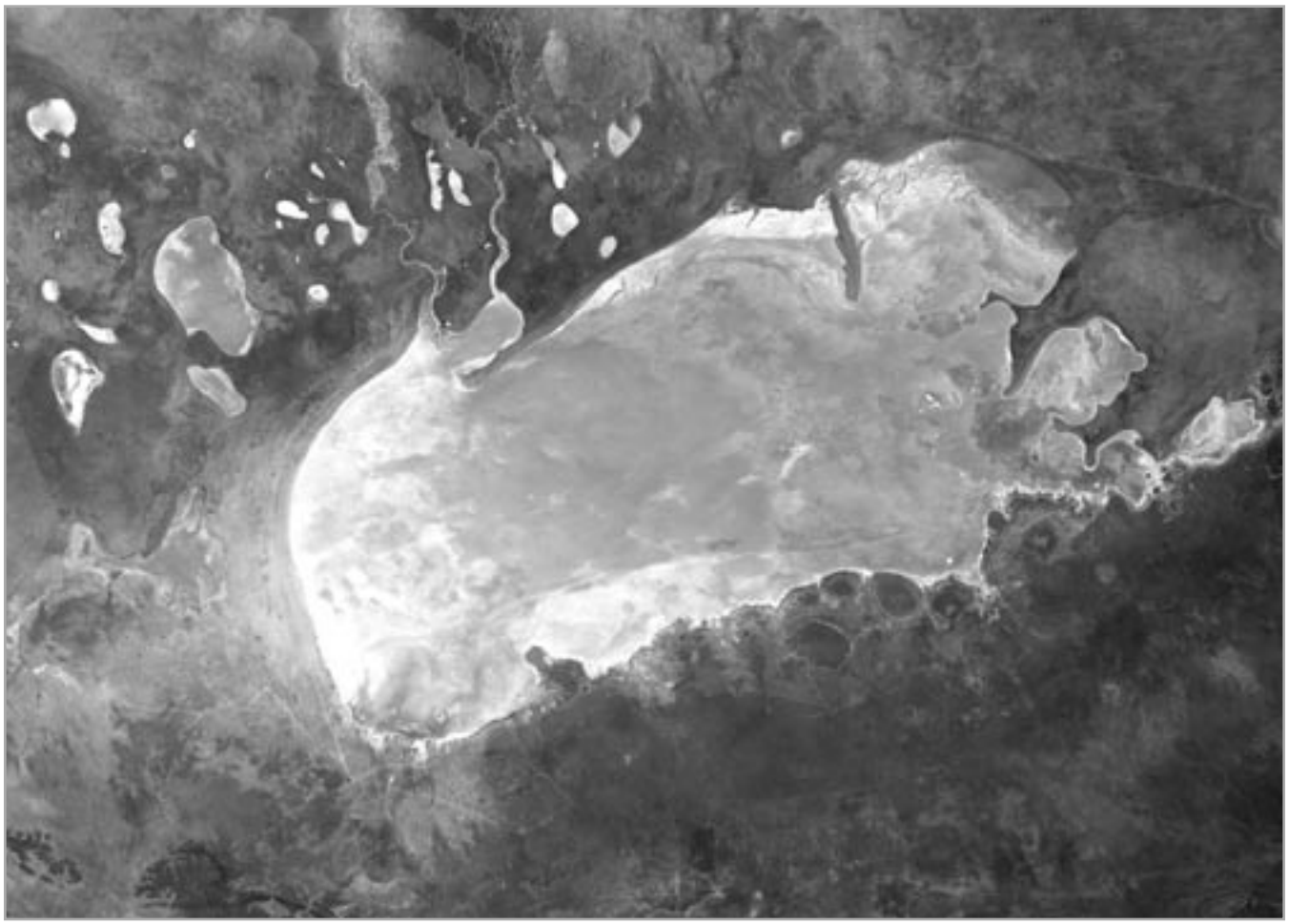


software utilities and scripts for working with MODIS atmosphere Level 2 data files are available for download from: *daac.gsfc.nasa.gov/MODIS/software.html*

HDFLook is one highly recommended software application for visualizing MODIS atmosphere Level 2 files and ATM L2 files in particular. Versions prior to 3.5 do not support projected visualizations of ATM L2 arrays. A fully compatible version of HDFLook and a useful shell script to instrument it to visualize projected images of both 5-km and 10-km arrays from Joint Product files, are available now from the MODIS Atmosphere website (see URL below).

Additional Information

Additional information about the Joint Product, including links to useful tools and scripts for working with the product, may be found at the MODIS Atmosphere website: *modis-atmos.gsfc.nasa.gov/* Click on the link that says '*Joint*' (at the top of the page). The same code that runs in operations to produce ATM L2 files can be compiled and run, with or without toolkits, on systems having both HDF and a C compiler installed. By running the code on sets of MODIS atmosphere Level 2 files, users may create ATM L2 files of their own, without needing to procure ATM L2 files. For the latest news about this and other Joint Product developments, check out the MODIS Atmosphere website (*modis-atmos.gsfc.nasa.gov*).



The Etosha Pan dominates Etosha National Park in Namibia. The salt pan desert is roughly 130 kilometers long and as wide as 50 kilometers in places. The salt pan is usually dry, but fills with water briefly in the summer months, when it attracts pelicans and flamingos. Periannual springs attract a variety of game and birds throughout the year, including the endangered black rhino and the endemic black face impala. In the dry season, winds blowing across the salt pan pick up saline dust and carry it across the country and out over the southern Atlantic. This salt enrichment provides minerals to the soil downwind of the pan on which some wildlife depends, though the salinity also creates challenges to farming and agriculture. This scene was acquired by the Landsat 7 Enhanced Thematic Mapper Plus (ETM+) on September 11, 1999. Data provided by the Landsat 7 Team at NASA's Goddard Space Flight Center.

Summary of the Alaska Satellite Facility User Working Group Meeting

—Harry Stern, harry@apl.washington.edu, Polar Science Center, Seattle

The Alaska Satellite Facility (ASF) User Working Group (UWG) met in Fairbanks on November 19-20, 2003. ASF has a new management team and a new name—the Alaska Satellite Facility (previously the Alaska Synthetic Aperture Radar (SAR) Facility). ASF received a very positive assessment from the UWG.

The operational agencies, NIC (National Ice Center) and NOAA (National Oceanic and Atmospheric Administration), are pleased with the rapid delivery of near-real-time SAR imagery, often less than two hours after reception. Data users praised the User Services Office and the acquisition planners for being responsive and helpful.

ASF has a new NASA contract through March 2008, which funds its core activities. The first two years include support for reception and processing of data from the currently orbiting SAR satellites, RADARSAT-1 and ERS-2, with 24 hours/day operation of the Receiving Ground Station (RGS). RGS service will be reduced in years 3-5. DAAC operations are currently reduced from 24 hours/day to 18 hours/day (7 days/week).

The Japan Aerospace Exploration Agency (JAXA) is planning to launch the Advanced Land Observing Satellite (ALOS) in September 2004. ASF, in partnership with NOAA, is the Americas ALOS Data Node. ASF expects to receive 200-300 terrabytes of SAR and optical data per year. Data-policy negotiations were completed in October. All users in North and South America will receive their data through ASF (except those who are directly involved with a Japanese-sponsored project such as the Kyoto & Carbon Initiative). ASF has submitted proposals to four U.S. Federal agencies for funding to support the Data Node.

The UWG recommended that ASF improve users' ability to see what SAR data are available in the ASF archive and in the Canadian Space Agency (CSA) archive. The Earth Observing System (EOS) Data Gateway (EDG) was not deemed suitable for browsing through lots of coverage maps, and the CSA archive is not visible at all. Users should have access to all frame locations and times, either in the form of maps or in the form of metadata files from which they can plot the coverage themselves. This would facilitate data mining and encourage new users and applications of the data. ASF, as with other satellite data facilities, only processes about 10-20% of its acquired data into image products.

A new set of software tools will be available from ASF at the end of January. The goal of the tools is to lower the barrier to entry into SAR data analysis. The UWG suggested that ASF could also create an on-line forum where users could contribute their own (unsupported) software and trade tips on ASF's software tools.

ASF has a new hard-copy newsletter, to be published quarterly. To subscribe, send a note to uso@asf.alaska.edu or call 907-474-6166.

Ben Holt from JPL will replace Harry Stern as the UWG chairperson. More-detailed notes from UWG meetings are available on the web site: *psc.apl.washington.edu/ASFUWG*.

MODIS Monitors Florida's Ocean Dispersal of the Piney Point Phosphate Treated Wastewater

—Chuanmin Hu, hu@seas.marine.usf.edu, College of Marine Science, University of South Florida
—Frank E. Muller-Karger, carib@marine.usf.edu, College of Marine Science, University of South Florida

Starting July 20, 2003, the Florida Department of Environmental Protection (FDEP) initiated a process of transporting and discharging treated wastewater from a closed and abandoned phosphate fertilizer plant to deep offshore waters of the Gulf of Mexico (GOM). This process resulted from an emergency situation arising at the Piney Point plant, which was abandoned in early 2001 by the Mulberry Corporation after claiming financial difficulty. Over 1.2 billion gallons of acidic wastewater were left unattended in open-air holding ponds located along the southern margin of Florida's Tampa Bay estuary. The threat of spillage into Tampa Bay grew as the ponds gained volume with seasonal Florida rains during 2002 and particularly in 2003.

Heavy rainfall during late 2002 and early 2003 prompted FDEP to request an emergency permit from the U.S. Environmental Protection Agency (EPA) to treat the wastewater and dispose of it in the ocean, i.e., in the GOM off the coast of Florida. FDEP converged on offshore dispersal by barge after examining several dozen possible alternatives, each of which was unpalatable to the public. The State of Florida consulted with environmentalists, fishermen, resource managers, and the general public as well as scientists of various backgrounds and disciplines to converge on a solution. Offshore dispersal was seen as an effective method to manage the wastewater and ameliorate impending danger to the estuary. The dispersal location was chosen to be in water depth >200m within the Loop Current pathway for rapid dilution and transport. Once initiated, the dispersal of this water has led to the expression of concerns due to fear of possible pollution, stimulation of harmful algal blooms, impact on coastal water quality, and potential harm to pelagic or bottom fisheries of the GOM, and the Florida Keys, as well as adjacent and downstream areas.

Satellite Monitoring

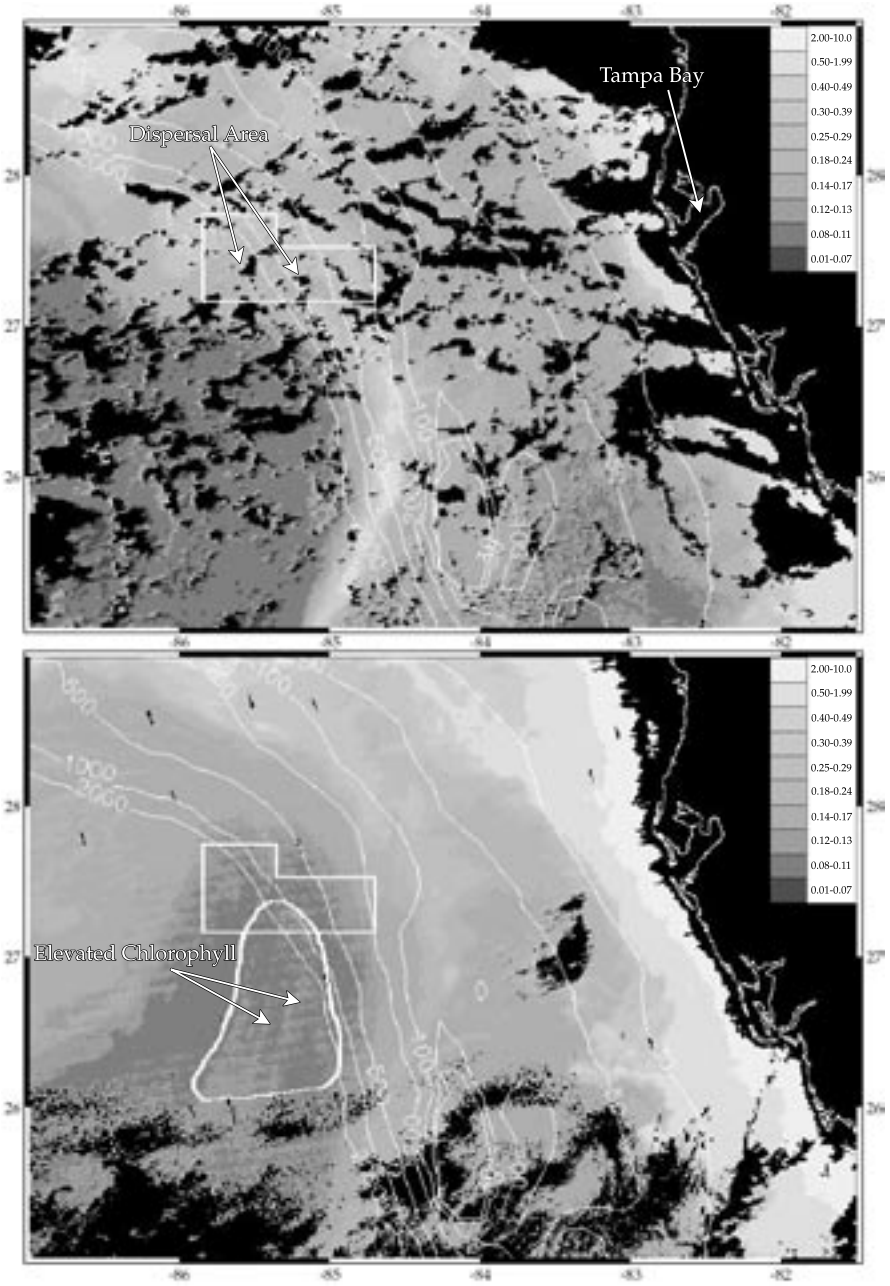
The dispersal started on July 20, 2003, when the barge "New York" dispersed 5.5 million gallons of treated wastewater in the designated area (Figure 1) in less than two days. To date there have been 21 barge operations that have discharged about 136 million gallons in the area, and this process is expected to run periodically through late November 2003.

Several tools have been used to monitor the dispersal, including *in situ* water sampling, surface drifters, numerical models, and remote sensing with satellite ocean-color sensors. In particular, MODIS has played a critical role in documenting the water circulation and color change through time. Weekly reports have been generated online at *imars.usf.edu/Piney_Point/reports*. Here we report briefly how MODIS data are used in the monitoring.

MODIS Direct Broadcast (DB) data are captured at a downlink station at the University of South Florida College of Marine Science with a SeaSpace X-band antenna. These data are processed and broadcast in near real-time (see *modis.marine.usf.edu*). Data products are tailored for several areas, and customized imagery (including ocean color and sea surface temperature (SST)) as well as data files (in HDF format) can be downloaded during image browsing.

MODIS real-time chlorophyll and SST data products are used to identify any anomaly feature and trace its motion. Figure 1a shows a MODIS chlorophyll image (SeaWiFS-analog chlorophyll algorithm) for 31 July 2003. The dispersal area (outlined as a white box) is at the northern edge of the Loop Current and is under significant influence of freshwater influx from the northern Gulf of Mexico, including the Mississippi River plume. Since the nutrient contribution from the discharge is insignificant compared to that from the Mississippi, the "chlorophyll" seen downstream along the Loop Current edge is not enhanced by the discharge in any significant or even measurable manner. The water is advected by the Loop Current to the Florida Straits, and further to the Atlantic along the Gulf Stream.

Between late May and late September, elevated chlorophyll in ocean-color imagery on the West Florida Shelf



Figures 1a (top) and 1b (bottom): These maps show the area where the treated wastewater was dispersed. The arrows in the bottom image point to a few chlorophyll "streamers" (elevated chlorophyll concentrations as compared with the background water) that were found within the outline ellipsoid-shaped area.

(WFS) was caused by influx of fresh water from the north, including the Mississippi plume. We have repeatedly observed such southeastward transport of river plume waters into this region in past years as SeaWiFS data have been available since September 1997 (Hu et al., 2003).

Starting in early October 2003, the dispersal area appeared to be free of the river influence for the first time. Figure 1b shows a MODIS chlorophyll image for October 15. The most recent wastewater discharge had been on October 10 and 11. Any effect of the wastewater could be expected to be downstream (south of the dispersal area) and contained within the large anti-cyclonic (clockwise) eddy present in the area. Using the highly sensitive MODIS instrument, we detected several "streamers" with slightly elevated chlorophyll concentrations downstream of the dispersal box, embedded in extremely clear ocean water (see features annotated by arrows in Figure 1b). These streamers correspond to chlorophyll concentrations of approximately 0.12-0.14 mg m^{-3}, which is only slightly higher than concentrations in the surrounding clear water of the eddy (of 0.1- 0.11 mg m^{-3}).

This slightly elevated (20%) phytoplankton biomass can be partially explained by the wastewater discharge. However, there may be other nutrient sources that cannot be discounted in a turbulent oceanic feature such as deep mixing. Here we emphasize that the streamers, with only 0.01 – 0.02 mg m^{-3} difference above the background, are detectable only because of the extraordinary sensitivity of the ocean-color channels in the MODIS satellite sensors, and the fact that the satellite provides a synoptic view relative to anything that could be observed with a ground-based platform. It would be difficult, if not impossible, to detect these features, and to reconstruct their spatial pattern, from ship-based observations.

Discussion

MODIS has been extremely valuable in our monitoring effort for several reasons. One, the real-time capability guarantees fast response (data products online within 1-2 hours of satel-

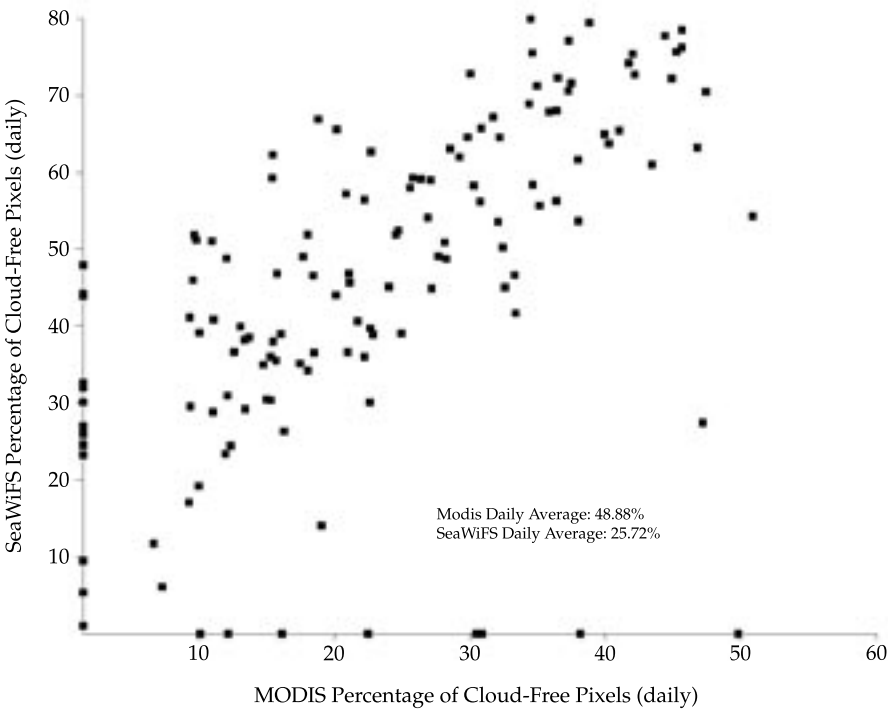


Figure 2: Cloud-free percentage from daily MODIS and SeaWiFS data from June 1 to October 15, 2003. Zero value means no data collection. Area: 22° to 31° N, 91° to 79° W.

lite overpass); two, unlike SeaWiFS, MODIS data are public domain, and there is no restriction on their use and reproduction; and finally, the combination of MODIS/Terra and MODIS/Aqua provides improved coverage in terms of avoiding cloud cover. Figure 2 shows the statistics of the daily percentage of cloud-free pixels from both MODIS and SeaWiFS for our area of interest: 22° to 31°N and 91° to 79°W. Clearly, the combination of multiple passes from Terra and Aqua increases the effective coverage by nearly 100%, and the average daily coverage is about 49%, adequate for daily monitoring of the marine environments.

MODIS real-time products are only "provisional" and may be slightly off in accuracy because of the time lag for calibration and algorithm updates. However, the precision of these provisional MODIS products is very high. The ability to detect small and weak patterns is important for real-time monitoring. To evaluate long-term color changes, reprocessed, higher-quality MODIS data as well as SeaWiFS data can be obtained from the NASA GES DAAC.

Can a similar monitoring project be established for other areas? MODIS global high-resolution data (1-km, 500-m, and 250-m) are available online at the GES DAAC. They can be browsed at *rapidfire.sci.gsfc.nasa.gov/realtime/* within a few hours of the satellite measurements. This promises an ability to monitor other areas where a downlink station does not exist but software is available to the community to generate higher level products.

Acknowledgements

This work was supported by the FDEP and by NASA (grant NAG5-10738). We thank NASA Headquarters (James Dodge) and SeaSpace Corp. for their support and assistance to establish the MODIS data receiving station. We also thank Judd Taylor, Brock Murch, and Doug Myhre (USF) for their assistance in preparing the satellite data.

References

Hu, C., F. E. Muller-Karger, D. C. Biggs, K. L. Carder, B. Nababan, D. Nadeau, and J. Vanderbloemen 2003: Comparison of ship and satellite bio-optical measurements on the continental margin of the NE Gulf of Mexico, Int. J. Remote Sens. **24**:2597-2612.

Landsat 7 Anomaly - Scan Line Corrector Failure

—*Jim Irons, James.R.Irons@nasa.gov, NASA Goddard Space Flight Center*

Background

The Landsat 7 satellite was launched on April 15, 1999 with a single remote sensing instrument on board, the Enhanced Thematic Mapper-Plus (ETM+). The sensor performed flawlessly for over four years, acquiring more than 550,000 digital image scenes of the earth's land mass (each scene covers a 183-by-170 km surface area). A component of the ETM+ called the scan line corrector (SLC), however, malfunctioned on May 31, 2003. The ETM+ continues to acquire useful data, but the malfunction has had an impact on the imagery.

As the Landsat 7 satellite circles the earth in a near-polar orbit, the ETM+ employs an oscillating mirror to scan a 183 km swath across the ground track of the satellite. The SLC consists of two parallel mirrors in an assembly located behind the scanning mirror within the primary optical path of the sensor. Normally, the SLC mirror assembly oscillates plus-or-minus one degree in synchronization with the scanning mirror to compensate for the forward motion of the satellite. The synchronized mirrors directed the ETM+ line-of-sight along a sequence of contiguous swaths oriented perpendicular to the satellite ground track forming continuous images of the land surface. The SLC ceased oscillating on May 31, 2003 for unknown reasons. Without an operating SLC the ETM+ line-of-sight now traces a zig-zag pattern across the satellite ground track (Fig. 1).

Intensive efforts to restore SLC operation have not proven successful. The failure appears permanent. The U.S. Geological Survey (USGS) and the National Aeronautics and Space Administration (NASA) are now focused on providing useful ETM+ image products from data acquired after the failure.

Effects on ETM+ Imagery

The ETM+ still acquires data for approximately 75% of any particular scene. The missing data form alternating wedges that increase in width from the center to the edge of a scene (Fig. 2).

The SLC failure has not otherwise affected the radiometric response of the ETM+ detectors or the ability to accurately geolocate image pixels. Consequently, as of October 22, 2003, the USGS Earth Resources Observation System (EROS) Data Center (EDC) has begun to offer ETM+ digital image products for data acquired on or after July 14, 2003. These products are referred to as SLC-off products. Missing data are represented by "fill" pixels containing zeros. The other pixels are radiometrically corrected and geolocated to the same accuracy as data acquired before the SLC failure.

The center of an SLC-off data product will be similar in quality to previous ETM+ images, but the scene edge will contain alternating scan lines of missing data. Fig. 3 shows a pair of before-and-after ETM+ images for the same scene

ETM+ SLC-Off Image Ordering

SLC-off data products can be searched and ordered via the Earth Observing System (EOS) Data Gateway (*edcimswww.cr.usgs.gov/pub/imswelcome*). SLC-off product access through other Landsat 7 search and order systems (e.g. Earth Explorer, GloVis) may eventually be supported, but not until a future date.

Data prices for initial SLC-off products are the same as for Landsat 7 data collected prior to the SLC anomaly. As required by public law, the USGS must charge for data products according to the cost of fulfilling user requests (COFUR). These costs have not been reduced by this anomaly.

Future Data Products

The USGS and NASA are investigat-

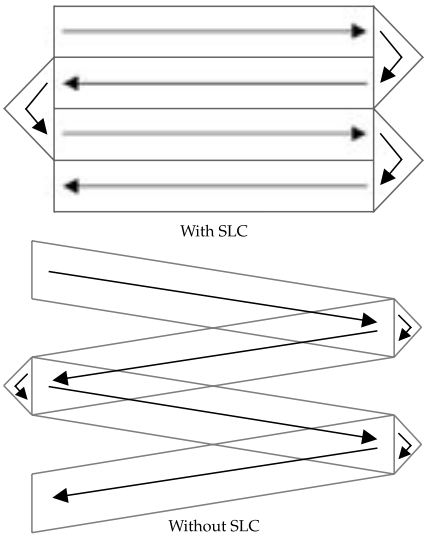


Figure 1: ETM+ Line-of-Sight

ing methods for replacing the missing pixels in SLC-off images. Interpolation methods and compositing of multi-date or multi-sensor data are under study. New products may be offered in the future depending on study results and Landsat community interest.

Further Information

For further information please visit the web sites at the following URLs.

SLC-Off Data Products:
landsat7.usgs.gov/slc_off.html

SLC-Off Acquisition and Scheduling:
landsat7.usgs.gov/slc/acq.php

SLC-Off Data Description:
landsat7.usgs.gov/slc/product.php

SLC-Off Sample Data:
landsat7.usgs.gov/slc/sample.php

SLC-Off Usability Report:
landsat7.usgs.gov/documents/SLC_off_Scientific_Usability.pdf

EOS Data Gateway:
edcimswww.cr.usgs.gov/pub/imswelcome/

Figure 2: Scan Gap Dimensions

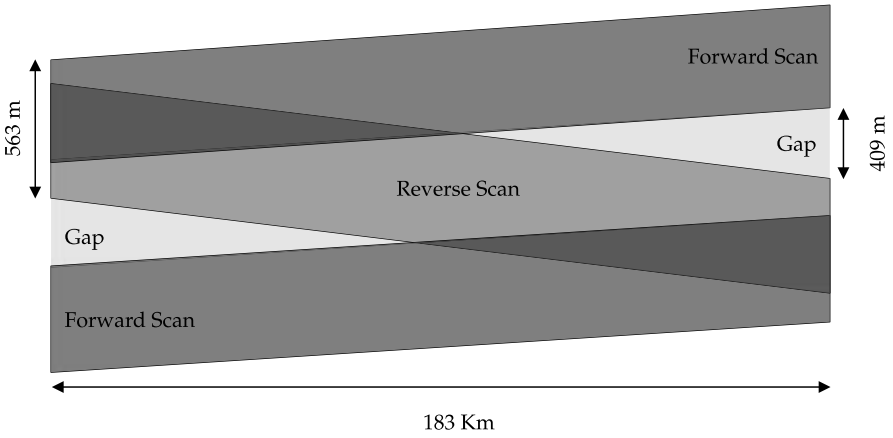
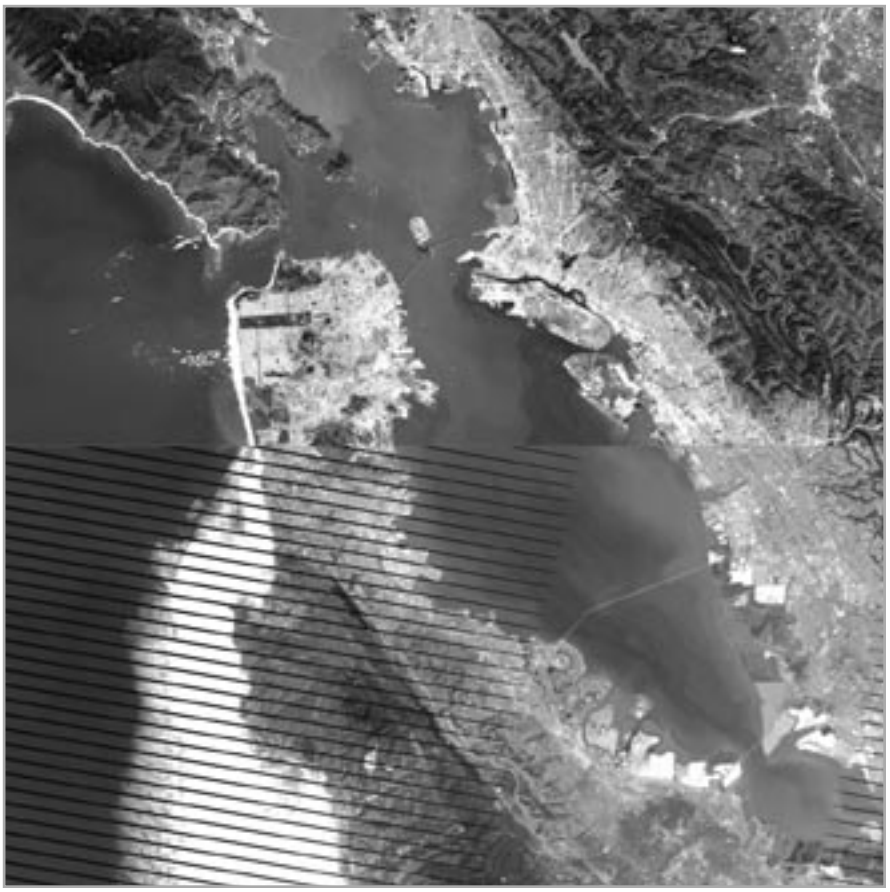


Figure 3: Landsat 7 ETM+ Images of the San Francisco Bay area acquired before (top) and after the Scan Line Corrector (SLC) Failure (bottom). Note that the images show partial scenes, from the western edge through the scene center.



Black Soot and Snow: A Warmer Combination

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— Rob Gutro, rgutro@pop900.gsfc.nasa.gov, NASA Goddard Space Flight Center
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Published on the Earth Observatory Website: earthobservatory.nasa.gov/NasaNews/2003/2003122216328.html

New research from NASA scientists suggests emissions of black soot alter the way sunlight reflects off snow. According to a computer simulation, black soot may be responsible for 25% of observed global warming over the past century.

Soot in the higher latitudes of the Earth, where ice is more common, absorbs more of the sun's energy and warmth than an icy, white background. Dark-colored black carbon, or soot, absorbs sunlight, while lighter colored ice reflects sunlight.

Soot in areas with snow and ice may play an important role in climate change. Also, if snow- and ice-covered areas begin melting, the warming effect increases, as the soot becomes more concentrated on the snow surface. "This provides a positive feedback (i.e. warming); as glaciers and ice sheets melt, they tend to get even dirtier," said Dr. James Hansen, a researcher at NASA's Goddard Institute for Space Studies, New York.

Hansen and Larissa Nazarenko, both of the Goddard Institute and Columbia University's Earth Institute, found soot's effect on snow albedo (solar energy reflected back to space), which has been neglected in previous studies, may be contributing to trends toward early springs in the Northern Hemisphere, thinning Arctic sea ice, melting glaciers and permafrost. Soot also is believed to play a role in changes in the atmosphere above the oceans and land.

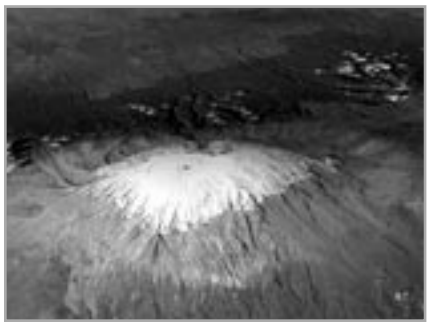
"Black carbon reduces the amount of energy reflected by snow back into space, thus heating the snow surface more than if there were no black carbon," Hansen said.

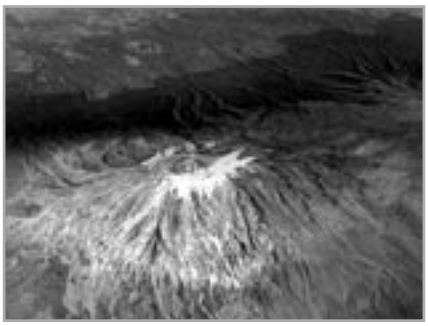
Soot's increased absorption of solar energy is especially effective in warming the world's climate. "This forcing is unusually effective, causing twice as much global warming as a carbon-dioxide forcing of the same magnitude," Hansen noted.

Hansen cautioned, although the role of soot in altering global climate is substantial, it does not alter the fact greenhouse gases are the primary cause of climate warming during the past century. Such gases are expected to be the largest climate forcing for the rest of this century.

The researchers found that observed warming in the Northern Hemisphere was large in the winter and spring at middle and high latitudes. These observations were consistent with the researchers' climate model simulations, which showed some of the largest warming effects occurred when there was heavy snow cover and sufficient sunlight.

Hansen and Nazarenko used a leading worldwide-climate computer model





Soot also affects melting of alpine glaciers. Some scientists believe the snow cap of Mount Kilimanjaro will be gone in two decades. Researchers say the ice fields on Africa's highest mountain shrank by 80% in the past century. The snow cap formed some 11,000 years ago. The Landsat satellite captured these images of Kilimanjaro February 17, 1993 and February 21, 2000. Credit: NASA/USGS

to simulate effects of greenhouse gases and other factors on world climate. The model incorporated data from NASA spacecraft that monitor the Earth's surface, vegetation, oceans and atmospheric qualities. The calculated global warming from soot in snow and ice, by itself in an 1880-2000 simulation, accounted for 25% of observed global warming. NASA's Terra and Aqua satellites are observing snow cover and reflectivity at multiple wavelengths, which allows quantitative monitoring of changing snow cover and effects of soot on snow.

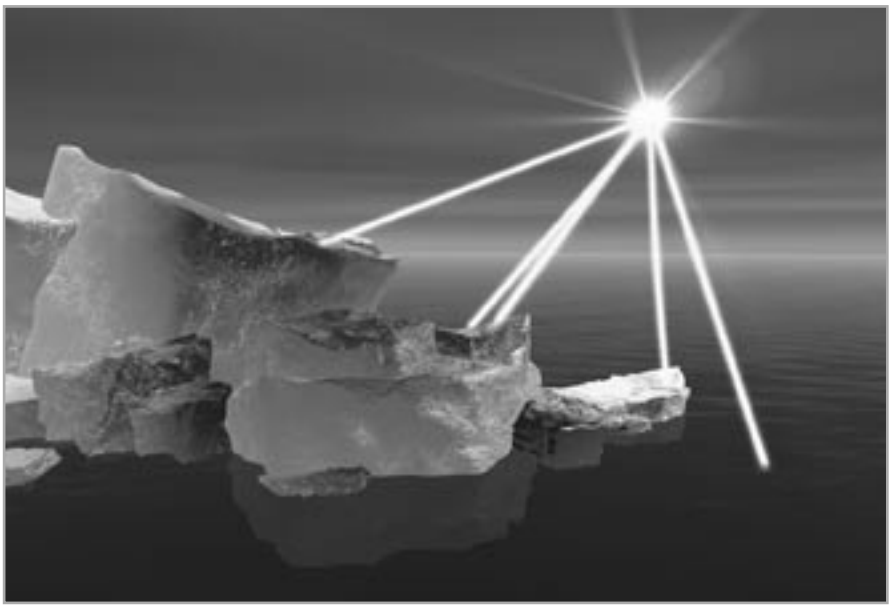
The research is in the paper "Soot Climate Forcing via Snow and Ice Albedos," appeared online in the *Proceedings of the National Academy of Sciences*.

This research was funded by NASA's Earth Science Enterprise. The Enterprise is dedicated to understanding the Earth as an integrated system and applying Earth system science to improve prediction of climate, weather and natural hazards using the unique vantage point of space.

For more information and images on the Internet, visit:
www.gsfc.nasa.gov/topstory/2003/1223blacksoot.html

A previous, related NASA release, "NASA Finds Soot Has Impact on Global Climate," is at:
www.gsfc.nasa.gov/topstory/2003/0509pollution.html

These are conceptual images showing how polar ice reflects light from the sun. As this ice begins to melt, less sunlight gets reflected into space. It is instead absorbed into the oceans and land, raising the overall temperature, and fueling further melting. Darker, soot-covered ice reflects less light as well, part of the warming effect. Credit: NASA



San Diego's Burning, Dec. 19; *Medical Economics* magazine interviewed **Bill Patzert** (NASA/JPL). Reference: *www.memag.com/be_core/m/index.jsp*

Scientists 'Reconstruct' Earth's Climate Over The Past Millenium, Dec. 13, *Innovations Report* (Germany); *Sciencedaily*, *Spatial News*; Using the perspective of the last few centuries and millennia, **Drew Shindell** (NASA/GISS) was one of the speakers in a press conference at the AGU Fall Meeting who discussed the latest research involving climate reconstructions and different climate models.

Heat, Pollution Changing Precipitation, Dec. 13; *ABC News*, *Associated Press* and many more; The massive amounts of heat and pollution that rise from the world's cities both delay and stimulate the fall of precipitation, cheating some areas of much-needed rain and snow while dousing others. **Steve Burian** (Univ. of Utah), **Daniel Rosenfeld** (Hebrew Univ.), **Menglin Jin** (Univ. of Maryland at College Park), and **Marshall Shepherd** (NASA/GSFC) were all quoted from this AGU press conference.

Earth's Magnetic Field Weakens 10 Percent, May Mean Flipping of the Planet's Poles, Dec. 11; *ABC News*, *The Associated Press*, *Atlanta Journal Constitution*, *USA Today*, *Washington Post*; **Charles Jackman** (NASA/GSFC) was one of the panelists in an AGU meeting press conference about the Earth's magnetic field decreasing 10 percent over the past 150 years.

NASA Scientists Discover Spring Thaw Makes A Difference, Dec. 11; *Ascribe Newswire*, *Innovations Report*, *Spacedaily*, *Spaceflight Now*, *Spaceref*; Using a suite of microwave remote sensing instruments aboard satellites, scientists such as **Kyle McDonald** and **Erika Podest** at NASA/JPL and **John Kimball** of the University of Montana, Missoula, have observed a recent trend of earlier thawing across the northern high latitudes.

NASA Satellites Watch World's Cities Grow, Dec. 15; *MSNBC*, *Spatial News*; The work of **Annemarie Schneider** of Boston University was featured about using NASA satellites to watch changes in urban areas.

Satellite Makes 3-D Maps of Ice Sheets, Dec. 10; *ABC News*, *Associated Press*, *Canadian TV Network News*, *Yahoo.com*, and more; After less than a year of work, ICESat has churned out the most detailed, three-dimensional maps ever of the ice sheets blanketing Greenland and Antarctica. **Jay Zwally**, **James Spinhirne** (both NASA/GSFC); **Bob Schutz**, (University of Texas at Austin); and **Waleed Abdalati** (NASA HQ) were quoted in various articles.

NASA Learning To Monitor Coral Reef Health from the Sky, Dec. 9; *Sciencedaily*, *Spacedaily*; Coral reef health may be accurately estimated from sensors on airplanes and satellites in the future, according to **Liane Guild** (NASA/Ames).

Warm Florida, Dec. 2003: *Earth & Sky Radio*; **Bill Patzert** (NASA/JPL) was interviewed for the Earth & Sky Radio Series program. For show dates, see: *www.earthsky.com*

Scientists Pierce Night With Laser, Dec. 8; *Rocky Mountain News*, *ABC 7 Denver*, *Daily Camera*, *CBS 4 Denver*; The success of an atmospheric test conduced by NASA's Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) team in Boulder, Colo., was discussed by **Mark LaPole** (Ball Aerospace).

Technology Removes Need for Human Pilots, Nov. 24; *Reuters*; Article briefly mentioned Ames' project to fly a small UAV over vineyards to assess potential for frost damage to grape crops.

NASA: Plants Unharmed by Weak Microwaves, Nov. 20; *Bizjournals.com*, *Spacedaily*, *Silicon Valley Business journal*, *WVXU-FM NPR Radio, Cincinnati* (and other NPR stations); This article quotes Ames scientist **Jay Skiles** who tested alfalfa for the effects of microwaves.

Scientist Chosen For Wetlands Project, Nov. 14; *Journal of South Mississippi Business*, *Sun Herald*; **Marco Giardino** (NASA SSC) has been chosen by the

JASON Project to be one of six host researchers for Disappearing Wetlands, which will run through the 2004-2005 school year.

Researchers Tracing The First Sparks Of Life, Nov. 3; *San Francisco Chronicle*; mentions NASA Ames research, "that theorized that clay mineral in early Earth were capable of storing energy and helping primitive bio chemical compound assemble into the earliest forms of RNA."

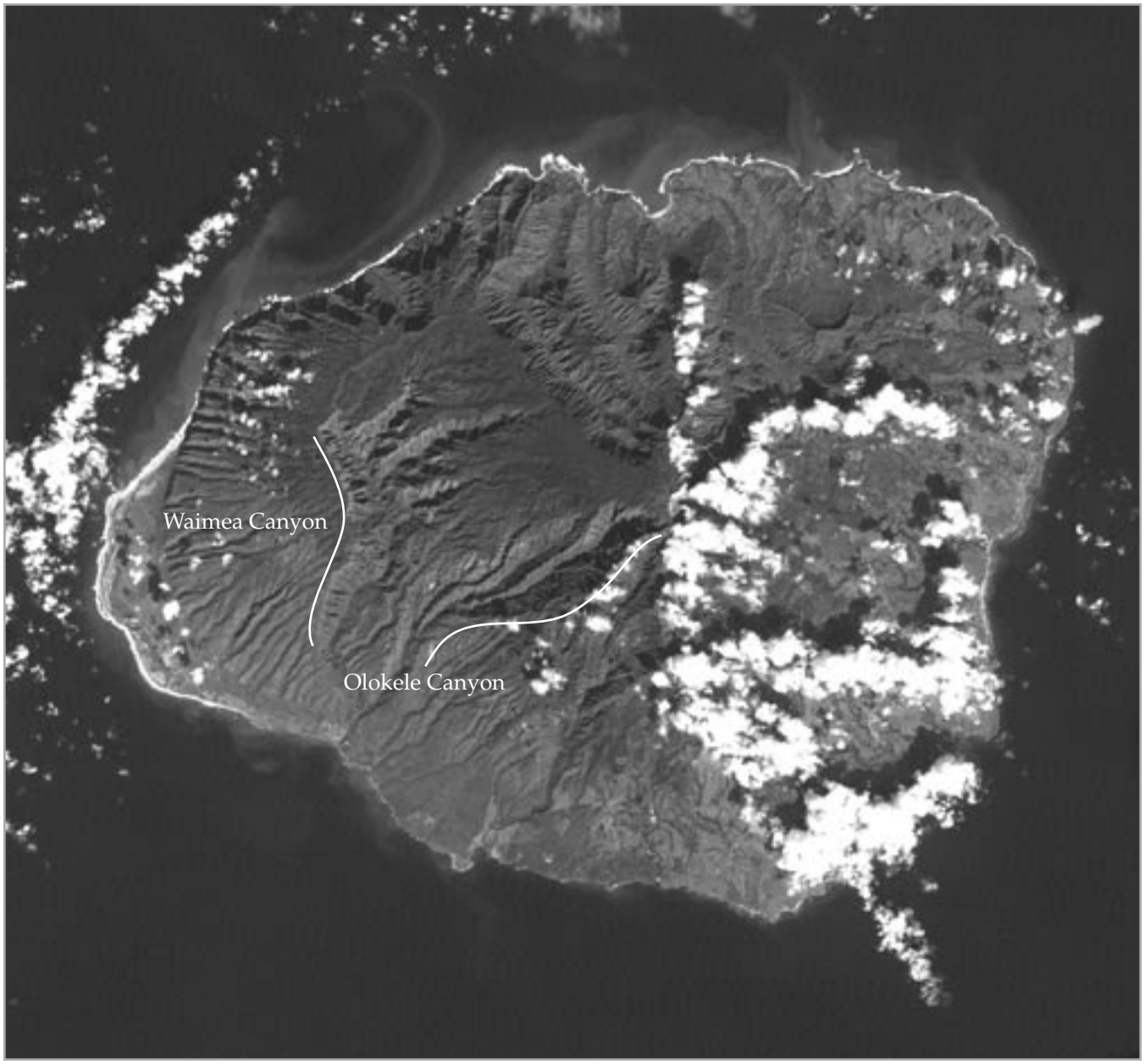
NASA Scientists Reach Out to Czech Republic Students, Sept. 24; *Prague 4*, *Prima Television*; **Irene Ladd** (NASA LaRC) talked about the educational benefits of the surface ozone protocol in the GLOBE program.

Predicting Earthquakes From Space, Dec. 3; **Popular Mechanics**; This article mentions that Ames' supercomputers are being used in the QuakeSim project.

Waimea Canyon is a spectacular gorge on the island of Kaua'i. Roughly 3,600 feet (1,097 meters) deep and 10 miles (16 kilometers) long, it is one of the most scenic regions of the Hawai'ian islands. The canyon has a unique geologic history—it was formed not only by the steady process of erosion, but also by a catastrophic collapse of the volcano that created Kaua'i.

This image was acquired on December 26, 2000, by the Enhanced Thematic Mapper Plus instrument aboard NASA's Landsat 7 satellite.

Image by Robert Simmon, based on data provided by the Remote Sensing of Coral Reefs, Earth Sciences and Image Analysis Lab, NASA JSC



Earth Science Education Update

—Ming-Ying Wei, ming-ying.wei-1@nasa.gov, NASA Headquarters
—Diane Schweizer, diane.schweizer@nasa.gov, NASA Headquarters
—Theresa Schwerin, theresa_schwerin@strategies.org, Institute for Global Environmental Strategies

Join NASA's Earth Crew!

It takes a NASA team of dedicated people to safely send an astronaut to space and back again. There are also a lot of NASA employees conducting research in many areas right here on Earth. A new NASA team is being formed, called Earth Crew. Each Earth Crew comprises students, teachers, and other adults dedicated to supporting the Educator Astronauts as they prepare for and explore space. In addition, Earth Crew members will participate in ground-based projects and missions. NASA is currently recruiting students, educators, and families to join the Earth Crew. Interested in joining? Go to: *edspace.nasa.gov/earthcrew/earthcrew.html*.

Earth Explorers — NATIVE VIEWS FROM SPACE

NASA's Earth Explorers series celebrates Native American month with a profile of James Rattling Leaf and a discussion of how Native Americans are using NASA satellite imagery to improve their quality of life and promote Earth science education.

Rattling Leaf, a member of South Dakota's Rosebud Sioux tribe, is helping Native Americans to see interactions between Earth's various components—land, air, water, and living things—in a new light. As director of the Land and Natural Resources Program at Sinte Gleska University's (SGU) Sicangu Policy Institute, Rattling Leaf heads several projects under the NativeView initiative aimed at improving resource management, agriculture, economic development, and education through the use of NASA data and technology. See the full article at *www.nasa.gov/vision/earth/lookingatearth/F_Native_Views_Space.html*.

Do you know a NASA Earth Explorer who would be a good subject for this series? We're looking for explorers of all ages-scientists & researchers, students, and educators-who are connected by their curiosity about Earth system processes. Send your nominations to: Dan Stillman, *dan_stillman@strategies.org*.

NEW TUTORIAL AVAILABLE — Creating Reprojected True Color MODIS Images

This tutorial describes in detail a method for creating high-quality, true-color MODIS images using freely-available software and MODIS Level 1B image and geolocation data. Both IMAPP (International MODIS/AIRS Processing Package) and DAAC (Distributed Active Archive Center) format MODIS Level 1B data may be used. Examples of MODIS true color images created using this method are available at: *terra.ssec.wisc.edu/~gumley/images.html*. The tutorial documentation, source code, and sample data are available at: *ftp://origin.ssec.wisc.edu/pub/IMAPP/MODIS/TrueColor/*.

For the complete meeting update, visit: *earth.nasa.gov/education/edreports/*

EOS Science Calendar

2004

February 3-4

U.S. ASTER Science Team Meeting, Pasadena, CA. Contact: Elsa Abbott, *elsa.a.abbott@jpl.nasa.gov*, tel.818-2815.

Global Change Calendar

2004

February 15-20

American Society of Limnology and Oceanography/the Oceanography Study (ALSO/TOS) conference, Honolulu, HI. URL: *also.org/honolulu2004/*

February 24-27

8th Specialist Meeting on Microwave Radiometry and Remote Sensing Applications, Rome, Italy. URL: *www.microrad04.org*

March 22-23

Seventeenth Annual Towson University GIS Conference, Towson University, Baltimore, MD. Contact: Jay Morgan, Email: *jmorgan@towson.edu*, URL: *cgis.towson.edu/tugis2004*

May 2-7

2004 Gordon Research Conference, Biogenic Hydrocarbons and the Atmosphere, Il Ciocco, Barga, Italy. URL: *www.grc.org*

May 23-28

American Society for Photogrammetry and Remote Sensing (ASPRS) Annual Conference, Denver, CO. URL: *www.asprs.org/denver2004*

June 16-24

8th Biennial HITRAN Conference, Cambridge, MA. URL:cfa-www.hanuand.edu/HITRAN

July 12-23

International Society for Photogrammetry and Remote Sensing (ISPRS), Istanbul, Turkey. URL: *www.isprs2004-istanbul.com*

July 18-25

35th COSPAR Scientific Assembly, Paris, France. Abstracts due February 15, 2004. URL: *www.copernicus.org/COSPAR/COSPAR.html*

August 1-6

Stratospheric Processes and their Role in Climage (SPARC) 3rd General Assembly, Victoria, British Columbia, Canada. URL: *sparc.seos.uvic.ca*

August 1-6

The Ecological Society of America 89th Annual Meeting, Portland, OR. URL: *www.esa.org/portland/*

September 4-9

The 8th Scientific Conference of the International Global Atmospheric Chemistry Project (IGAC). URL: *www.igaconference2004.co.nz*

September 20-24

International Geoscience and Remote Sensing Symposium (IGARRS), Anchorage, Alaska. URL: *www.ewh.ieee.org/soc/grss/igarss.html*

October 13-16

Surface Ocean Lower Atmosphere Study (SOLAS) 2004 Open Science Conference, Halifax, Nova Scotia, Canaca. URL: *www.uea.ac.uk/eng/solas/ss04.html*

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