Earth Observing System

EOS

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In this issue ...

EDITOR'S CORNER

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I'm sure you share my excitement over the successful launch of NASA's Aqua satellite on May 4. The launch, orbit insertion, and solar array deployment were flawless, and initial checks on the operation of all instruments were normal. Aqua will provide unprecedented information about the Earth's water cycle, and significantly contribute to the science data acquisition strategy of NASA's Earth Observing System, Aqua is the second in a series of large EOS missions, following the launch of Terra on December, 18, 1999. Please see the article on the next page for more details about the Aqua launch and the instruments on onboard.

Other recently launched EOS missions continue to operate very well. Day to day operations for the joint U.S./French Jason-1 ocean surface topography mission, launched on December 7, were transferred from the French Centre National d'Etudes Spatiales to NASA's Jet Propulsion Laboratory, Pasadena, California on April 26. The Stratospheric Aerosol and Gas Experiment (SAGE III), launched on December 10, continues to operate nominally, routinely acquiring solar occultation events, and the Gravity Recovery And Climate Experiment (GRACE) mission, launched on March 17, is now acquiring operational science data. Other important missions coming up include the Ice, Clouds, and Land Elevation Satellite (ICESat), which will measure polar ice sheet masses as well as cloud and aerosol layers in the atmosphere, and the Solar Radiation and Cloud Experiment (SORCE), which will monitor incoming solar irradiance.

This unusually frequent period of Earth science mission launches highlights the comprehensive global monitoring campaign of NASA's Earth Observing

(Continued on page 2)

System, and will enable greatly increased understanding of the Earth as an interrelated system. I look forward to some very exciting new findings from the Earth science research community in this era of unprecedented Earth observation capabilities.

I'm pleased to announce the availability of new Aqua, MODIS, and GRACE scientific brochures from the EOS Project Science Office. These reference materials are also available from *eospso.gsfc.nasa.gov/eos_homepage/brochures.html*. They describe the science objectives, instrument characteristics, data products, and applications of these missions and instruments. Printed copies of these and many other EOS scientific and educational materials can be obtained by contacting the EOS Project Science Office (contact information on back cover of this newsletter).

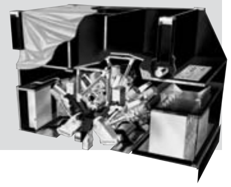
Finally, I would like to congratulate Piers Sellers on his selection to fly on Space Shuttle mission STS-112 in August of this year. Piers is a co-investigator on the MISR science team and was formerly the principal investigator on an EOS interdisciplinary science investigation and Terra (then known as EOS AM-1) Project Scientist from 1992-1996. He was a senior biospheric scientist who worked at Goddard Space Flight Center from 1984-1996. He has been training with the Space Shuttle program at Johnson Space Center for 5 1/2 years and will serve as a mission specialist on STS-112.

Aqua is Launched!

On May 4, 2002 at 2:55 AM PST the Aqua spacecraft was carried into orbit from the Western Test Range at Vandenberg Air Force Base in California onboard a Delta II rocket. As its name implies, Aqua will focus on studying Earth's water cycle. Aqua will collect data on global precipitation, evaporation, and the cycling of water. This information will help scientists all over the world better understand the Earth's water cycle and determine if the water cycle is accelerating as a result of climate change. Aqua will complement many of the observations being made by the Terra spacecraft (launched in December 1999) as both platforms carry identical versions of the Moderate Resolution Imaging Spectroradiometer (MODIS) and the Clouds and the Earth's Radiant Energy System (CERES) instruments. Aqua will cross the equator daily at 1:30 p.m. as it heads north. The early afternoon observation time contrasts with Terra, which crosses the equator between 10:30 and 10:45 a.m. daily. Aqua's afternoon observations combined with Terra's morning observations will provide important insights into the daily cycling of key scientific parameters such as precipitation and ocean circulation. In addition to MODIS and CERES, Aqua also carries a very sophisticated atmospheric sounder package consisting of three separate instruments: the Atmospheric Infrared Sounder (AIRS); the Advanced Microwave Sounding Unit (AMSU); and the Humidity Sounder for Brazil (HSB). An Advanced Microwave Scanning Radiometer (AMSR-E) provided by the National Space Development Agency (NASDA) of Japan rounds out the suite of six instruments onboard Aqua.

Minutes from the MISR Science Team Meeting

– *David Diner, david.j.diner@jpl.nasa.gov, Jet Propulsion Laboratory, California Institute of Technology*
– *Graham Bothwell, Jet Propulsion Laboratory, California Institute of Technology*



INTRODUCTION

A meeting of the MISR Science Team was held at the Pasadena Convention Center from December 5-7, 2001. The overall purpose of the meeting was to identify what we have learned so far from the MISR experiment, and to make decisions for advancing MISR data to a mature state that facilitates science investigations for the team and the community at large. Specific objectives included sharing scientific results; reviewing progress in advancing the maturity of our algorithms and data products; prioritizing the next phase of work; and reviewing, modifying, and completing the product maturity transition plan.

DAY ONE

The first day was given over to presentations on the status of the MISR instrument and of the various algorithms.

David Diner (Jet Propulsion Laboratory - JPL) is MISR principal investigator and opened the meeting. He outlined the purpose of the meeting and defined specific objectives as set forth in the Introduction.

Graham Bothwell (JPL) reviewed instrument operations and the status of the MISR science data system. The instrument continues to run superbly.

Bruce Barkstrom (new manager of the Langley DAAC) presented the next report, emphasizing that one of the most important roles of the DAAC is to capture the knowledge embodied within the MISR team, so that the data will be useful to future users despite evolution in the data system and archival arrangements.

Jeff Walter (Langley DAAC) described the data production system performance, as well as recent hardware and software upgrades. Production issues are being actively worked. **Charlene Welch** (Langley DAAC User Services) showed that data distribution numbers are impressive, and growing.

Bob Vargo (JPL) facilitated a discussion on the perceived importance of having a quality-assessment-based data management system for searching through MISR data. It was concluded that such a system would be useful, but that development of good visualization and analysis tools, browse products, and Level 3 products is of higher priority.

Kyle Miller (JPL) reported on the status of Level 1 processing. He reported a success rate of better than 96% in system robustness, with the 4% failure rate due to anomalies such as data gaps, instrument out-of-sync conditions, bit flips, and the like. Work to achieve a goal of >99% success rate is scheduled. One of the requests from the Science Team meeting in June 2001 was for an improved browse product. Miller reported that this is now operational at the DAAC. It consists of georectified color pole-to-pole JPEG's from each camera for every swath, at 2.2 km resolution. A browse product browser is also under development.

Carol Bruegge (JPL) reported on the status of radiometric calibration. The MISR on-board calibrator (OBC) continues to provide bi-monthly calibrations. The absolute radiometric scale was established by the June 11, 2000, vicarious calibration (VC) experiment at Lunar Lake, Nevada. Results of this experiment were used to adjust the on-board primary photodiode standard, and the radiances from all channels were increased by 9% following this adjustment. The OBC provides camera-relative calibration via views of diffuse sunlight. Goniometer scans of the calibration panel deployed near the North Pole do not match the preflight bidirectional reflectance factor (BRF) database. A correction based on these goniometer measurements is believed to compensate for a 4% bias in the response of the aft vs. forward cameras. With this in place, good agreement between MISR and AirMISR multi-angle radiances was found over Railroad Valley, Nevada. This is significant because AirMISR makes use of a single camera which is gimballed to the nine MISR angles. Based on this information, the team agreed to upgrade the L1B1 radiometric product status from Beta to Provisional.

Veljko Jovanovic (JPL) reported on the geometric calibration status of the MISR cameras. All of the cameras except Da (70º aft) are co-registered to within 1 pixel. A systematic bias is present in the Da camera geometric model, and improvements to this model are under development. Additionally, reference orbit imagery (ROI), a set of data which will enable the use of image matching to compensate for residual camera geolocation errors, is being accumulated. Testing to date indicates that ROI improves the quality of camera registration. Software to deal with geolocation problems associated with intermittent instrument out-of-sync conditions is expected in 2002. For the time being, however, the team agreed to upgrade the L1B2 georectified radiance product status from Beta to Provisional.

Larry Di Girolamo (University of Illinois) reported on the status of MISR cloud masks. He reported that a bug in the production code for the radiometric camera-by-camera cloud mask (RCCM) was incorrectly computing relative -view, solar azimuth angle and thereby degrading the quality of the RCCM. JPL implemented a fix in the production code, and the RCCM over ocean now works very well. Quality over land will not improve until the automated threshold selection procedure is implemented. Nevertheless, it was decided to release the RCCM at the Beta maturity level so that users could become familiar with the product.

Mike Wilson (University of Illinois) is a colleague of Di Girolamo and he reported that the MISR band-differenced angular signature (BDAS) algorithm can detect very low, thin clouds over ice cover, even when surface features are visible through the cloud. BDAS may have potential to be used as a cloud mask that would enable the creation of a sea-ice mapping capability. Since BDAS was originally envisioned as a cirrus detector, there was discussion as to whether different thresholds would need to be implemented in order to provide both capabilities. This will be the subject of additional work.

Catherine Moroney (formerly of University of Arizona but now at JPL) reported on the status of the Level 2 top-of-atmosphere/cloud software. The first version of the cloud classifiers code was released to the DAAC for operational processing. "Blockiness" in the stereo height fields is still present, and is due to blunders in the wind retrievals. **Roger Davies** (University of Arizona) reported that relative height variations seem to be accurately retrieved by the stereo processing. Getting the simultaneous height and wind retrievals working well, with good quality assessment, could potentially be valuable to NESDIS and NCEP, because the heights corresponding to the winds are very important. Local albedos are working well, but over scenes with heterogeneous clouds, the coarse resolution albedos are not working properly. Understanding and fixing this problem will be a high priority over the coming months.

Kathleen Crean (JPL) reported on the status of Level 2 aerosol/surface software. The latest version is very stable. Several algorithm upgrades have been included, such as use of the land algorithm in coastal areas, where the water algorithm was failing (perhaps due to violation of the assumed surface boundary condition). She also reported on upgrades to the code that generates the lookup table used in aerosol retrievals, the Simulated MISR Ancillary Radiative Transfer (SMART) Dataset, and the creation of a new set of component particles upon which the aerosol retrievals are based.

John Martonchik (JPL) followed Crean's presentation with a technical description of some of the algorithm upgrades that are in progress, including a new "optically thick aerosol" algorithm that will be invoked whenever the radiometric and stereo cloud masks indicate non-clear conditions. Its goal is to retrieve aerosols over thick dust clouds, at the same time rejecting water clouds. Martonchik also described comparisons of MISR optical depth retrievals against Aeronet. In general, correlations look good though MISR values appear biased high by a few tens of percent over both land and ocean. This will be examined in greater detail before transitioning from Beta to Provisional. A discussion of the new set of component particles and mixtures was held, and several recommendations were provided to the JPL team.

Earl Hansen (JPL) facilitated a discussion on data visualization. **Harold Annegarn** (University of Witwatersrand) suggested that a three-level hierarchy of visualization tools, including one for beginners, one for more advanced users, and one that enables combining MISR with other data sets would be very useful. **Roger Davies** made a pitch for a tool that would animate the colocated nine-angle data for individual scenes.

DAY TWO

This entire day was devoted to 15-minute science summaries of displayed posters from science team members. Today's focus was on Clouds and Aerosol Science relating to MISR.

Eugene Clothiaux (Pennsylvania State University) described the goals of the polar cloud project which was initiated at the June 2001 meeting. He envisions a product that will enable seeing changes in albedo, sea ice, and cloud cover over a season, and another product that captures a monthly cloud climatology for the Arctic. He also wants to show statistically what MISR does in comparison with MODIS and demonstrate how they complement each other.

Roger Marchand (Pacific Northwest

National Laboratory) described comparisons of MISR and AirMISR radiometry over clouds at the Oklahoma ARM site with 3-dimensional radiative transfer simulations. Residual differences were <4% at all angles, enhancing confidence in recent upgrades to the instrument radiometric calibration.

Tom Ackerman and Evgueni Kassianov (both of PNNL) described the use of MISR data for retrieval of cumulus cloud thickness in the tropics.

Roger Davies showed a gallery of MISR cloud imagery, highlighting the heterogeneity of most clouds. He described spatial heterogeneity and angular signature consistency tests indicating that at MISR's resolution, 1-dimensional radiative transfer theory applies to <10% of Earth's clouds.

Peter Muller showed examples of comparing MISR and MODIS cloud-top heights with ground-based radar at the ARM Southern Great Plains site and Chilbolton in the UK. Both MODIS and MISR slightly underestimate cloud-top height in cases where the radar indicates values above 6 km. MISR misses high clouds in some cases; this appears to be related to scenes with multiple cloud levels or mixed and scattered clouds.

Donald Frank (GSFC Data Assimilation Office) reported on his assessment of MISR cloud-tracked wind retrievals. MISR has the potential of filling in gaps where other measurements do not exist. Frank indicated a strong need for a quality assessment/confidence flag on the heights and winds. It was agreed that this would be given a high priority before the product would be declared Provisional.

Stu Pilorz (JPL) described the methodology he used for recommending a new set of component particles to be used in MISR aerosol retrievals. Evidence was accumulating that MISR is more sensitive to smaller particles than previously anticipated, so the new particle set includes a wider range of effective radii.

Ralph Kahn (JPL) described results from recent intensive aerosol campaigns, including the Puerto Rico dust experiment (PRIDE), SAFARI-2000, ACE-Asia, and the Chesapeake Lighthouse (CLAMS) experiment. These data also show some upward biases of MISR optical depths, and investigating this will be a high priority. Co-investigator **Jim Conel** described aerosol retrievals over the California Central Valley, and showed a good agreement in retrieved aerosol properties with values obtained from a sunphotometer.

V. Ramanathan (Scripps Institution of Oceanography) gave a talk on aerosol impacts on climate and interactions with clouds. He became interested in MISR recently as a way to address these issues, in particular using the angular sampling to investigate whether greater aerosol abundances are having an influence on cloud bidirectional reflectance.

Mike Smyth and Amy Braverman (both of JPL) described the status of MISR Level 3 products. In response to feedback from the last team meeting, the resolution of parameter means is now planned to be 0.5°. However, due to the data volumes involved, covariances will be maintained at 1°. Level 3 software is undergoing checkout at the DAAC. Beta release will occur when the team is satisfied that the Level 2 inputs are of sufficient quality to justify the global summaries.

DAY THREE

On the final day of the meeting, the Poster Summaries continued, the focus today being on Surface Science related to MISR. In addition, there were discussions on future missions that would follow after MISR. The last discussions concerned future meetings that the team needed to know about.

Science Posters

Yuri Knyazikhin (Boston University) discussed the MISR LAI/FPAR algorithm status and MISR's ability to distinguish among different biomes.

Anne Nolin (University of Colorado) gave an update on use of MISR for cryospheric studies. Specific applications focus around albedo retrieval, macro-scale surface texture, and sea ice characterization. MISR's ability to distinguish between smooth and rough blue ice in Antarctica is a unique application.

Wedad Abdou (JPL) prepared a presentation on validation of MISR bidirectional reflectance retrievals over Sua Pan, Botswana. Due to illness, her presentation was given by **Dave Diner**. The measurements matched well with surface truth measured by PARABOLA.

Mark Helmlinger gave the final presentation on field measurements and plans.

Follow-on Missions to MISR

Mark Schoeberl (GSFC) initiated a dialog with the MISR team on future mission prospects. One concept he described is the Constellation for Aerosols and Cloud Heights (COACH), which uses multiple spacecraft in formation flying to acquire multi-angle data. Stereo cloud heights would be retrieved by observing the same point simultaneously from different spacecraft, as opposed to the current MISR approach where there is a time delay between the different views from a single vantage point. Schoeberl also presented the concept of using a MISR successor instrument as part of a mission to measure black carbon content of aerosols, using measurements of ocean glint within an algorithm proposed by Yoram Kaufman of GSFC. The mission is also envisioned to include polarimetric measurements akin to the EOS Polarimter (EOSP), a CERES scanner, and possibly a lidar.

Dave Diner presented some of his ideas regarding successors to MISR. He argued that some objectives, such as retrievals of aerosol and cirrus microphysical properties, can benefit from an enhanced instrument with 9 cameras, 400-km swath, and additional shortwave infrared spectral bands, such as 1375 and 1630 nm. Radiometric calibration would be important for such a mission. Other objectives, such as stereo cloud height and wind retrieval, would benefit from a simplified instrument with perhaps 5 angles and a broader swath, and potentially multiple small satellites in different orbits so as to give rapid global coverage. Geometric calibration would be more important than radiometric calibration for this concept.

Future Meetings

Anne Nolin described the planning for the upcoming Third International Workshop on Multiangular Measurements and Models (IWMMM-3), to be held in Steamboat Springs, CO, June 10-12, 2002. **Nancy Ritchey** of the Langley DAAC talked about the MISR Data User's Workshop to be held on June 9 in Steamboat Springs. Hands-on experience with MISR data is planned for up to 20 participants.

The meeting concluded with a review of action items from the previous and current meetings.

ISRSE Meeting Held in Buenos Aires

The 29th Annual International Symposium on Remote Sensing of Environment (ISRSE) was held at the Hotel Pan Americana in Buenos Aires, Argentina from April 8-12. There were numerous presentations on EOS research. The picture at the top left is of Associate Administrator Ghassem Asrar, EOS Senior Project Scientist Michael King and King's wife Diana. At the bottom left, the Associate Administrator speaking during one of the sessions, and below, the Earth Science Enterprise display in the exhibit hall.

Minutes from the AIRSAR Earth Science and Applications Workshop

– *David Imel, imel@jpl.nasa.gov, Jet Propulsion Laboratory*

Introduction

On March 4-6, 2002, the Airborned Synthetic Aperture Radar group hosted the 2002 AIRSAR Earth Science and Applications Workshop at the Doubltree Hotel in Pasadena, CA. Over 100 scientists, engineers, students, and other AIRSAR data users from the U.S., Europe, Asia, and Australia participated in 9 sessions where 75 papers were presented. The workshop was designed this year to emphasize not only science results from recent AIRSAR data collection campaigns, but also to facilitate the discussion of the future directions for the AIRSAR instrument, proposed data collection campaigns, and new concepts for radar instruments and algorithms which could be helpful to AIRSAR investigators.

There were nine sessions:
- AIRSAR Frequently Asked Questions
- PacRim 2000 Results
- SAR Technology and Algorithms
- Plenary Session
- Solid Earth and Natural Hazards
- Coastal and Ocean Applications
- New Missions and Concepts
- Ecology, Biomass and Land Cover
- Hydrology and Polar Science

What follows is a brief summary of the presentations from each session. In addition to the presentations, papers were submitted by the authors in advance. The proceedings for the workshop were distributed on CD-ROM to the participants, and are available online at *airsar.jpl.nasa.gov/documents/workshop.*

AIRSAR Frequently Asked Questions Session

This session served as a mini-tutorial about the AIRSAR program, led mostly by AIRSAR group members. **Bruce Chapman** led off by addressing (if not concretely answering for each investigator!) the most frequently asked question: "When am I getting my data?" He also described AIRSAR data formats. **David Imel** followed with a detailed description of each of the data artifacts that can be observed in AIRSAR data, and how they could affect science results. **Anhua Chu and Yunling Lou** described the data calibration and performance, showing that AIRSAR data are well-characterized. **Elaine Chapin** advised investigators how to plan flight lines to get the most out of their sites, after which **Chris Jennison** (Dryden Flight Research Center) summarized the five-year plan for the NASA DC-8 AIRSAR platform, and described how to submit a flight request for AIRSAR data over a site. **Walt Brown**, the "Father" of the AIRSAR group, gave an historical narrative of the orgins of the AIRSAR program in the late 1960's as the JPL "Rocket Radar."

PacRim 2000 Results Session

Spectacular data sets were displayed and discussed during this sessions, including a presentation by **Roland Fletcher, Damian Evans and Ian Tapley.** They presented on archaeological findings over Angkor, Cambodia. Here, previously unknown temples were discovered using AIRSAR data. Ancient roadways are discernable in radar (but not optical) imagery and agricultural fields as imaged by the radar show both their present day and their ancient orientations distinctly. **Ian Tapley** also presented a live computer 3D visualization of MacQuarie Island, illustrating that AIRSAR truly generates "radar holograms of the Earth" and demonstrating the unique perspectives obtainable from such a data set. **Kristina Rodriguez and Jeffrey Weissel** showed that L-band SAR data can be used to accurately identify landslide areas in Central Taiwan. Several presenters showed that AIRSAR data was useful for quantifying biomass in specific vegetation types of local interest, e.g., rice in the Philippines (**Hugh Turral**), Queensland Australia woodlands (**Richard Lucas, et al.**), Korean forests (**Kyu-Sung Lee et al.**), and Malaysian oil-palm fields (**Laili Nordin**). The PiSAR group from Japan (**Makoto Satake et al.**) showed comparisons of the AIRSAR sensor with the CRL (Communications Research Laboratories, Japan) airborne L-band and X-band sensor over calibration sites. These comparisons are helping to pave the way for the calibration and validation of the PALSAR sensor which will be launched on ALOS.

SAR Technology and Algorithms Session

Scott Hensley highlighted the use of AIRSAR data for developing new SAR processing technology . **Charles Le**

demonstrated how AIRSAR data is being used to develop radio-frequency interference rejection algorithms. **Shane Cloude and Thomas Flynn** introduced new classification methodologies. **Malcom Wright** described the new high speed optical data link (1-2 Gbits per second) to be demonstrated by AIRSAR.

Plenary Session

Diane Evans (Director of Earth Science at JPL) gave welcoming remarks. She was followed by **Craig Dobson** (NASA HQ), who described AIRSAR's role within NASA's Earth Science Enterprise (ESE). He emphasized the strategic questions which the ESE is asking, and highlighted those addressed by SAR. Of the 23 strategic questions, 18 are directly addressed by SAR. Craig also described the realities of the Earth Science fiscal environment. **Ian Tapley** described the decade of Pacific Rim missions which has just transpired, highlighting the broad range of research topics and results from those missions. **Mike Kobrick** showed some of the more recent SRTM (Shuttle Radar Topography Mission) processed data. He illustrated how AIRSAR was the testbed for the development of the SRTM radar — how the AIRSAR interferometric baseline exactly scales to space as the SRTM interferometric baseline. A lively discussion of the SRTM data release policy followed. After this, **Soren Madsen** described the key role that an airborne radar has to play, even as we focus as an agency on spaceborne missions.

Solid Earth and Natural Hazards Session

This session touched on three areas: deformation measurements, volcanology, and search and rescue. Volcanology, in particular, seemed to be the most ubiquitous topic in this session. **Lucas Moxey, Rick Gurritz, et al., and Zhong Lu et al.** described the Alaska Okmok Volcano AIRSAR data sets in the first two papers of the session, followed by New Zealand volcano studies (**Nicki Stevens**), volcano hazard prediction (**Gaffney, Minster and Rose**), and an evaluation of the utility of AIRSAR data for landform and geological mapping. Following a description of multi-scale data fusion for geological mapping (**Clint Slatton**), the session concluded with two presentations describing previous Search and Rescue efforts with AIRSAR data in Montana and the (then) upcoming experiment in the San Bernadino Mountains, with an impassioned appeal by the San Bernadino County Sherriff's Department's **Mike Tuttle** for help in locating downed aircraft.

Coastal and Ocean Applications Session

David Imel described the evolution of the AIRSAR along-track interferometry (ATI) capability. **Dukjin Kim**, spoke next and showed results of PacRim 2000 AIRSAR ATI data off the South Korean coast, verifying that the C-band and L-band current measurements are in agreement and that ships can be used to "auto-calibrate" or internally validate ATI data sets. **Libe Washburn, Paul DiGiacomo, and Ben Holt** described the planned IceSAR'02 field campaign AIRSAR measurements of mesoscale eddies off the Southern California coast, and explained how the existing HF radar data could be used to help validate these measurements. **Delwyn Moller** presented a concept for a spaceborne ATI mission to measure coastal and river currents. **Ernesto Rodriguez** showed how the SRTM data sets can be used to remove the topographic phase from ATI scenes. **Fabrizio Lombardini** (University of Pisa, Italy) described the enhancements possible with a multi-baseline ATI system, and **Roland Romeiser** (University of Hamburg, Germany) described ATI validation experiments with the German Aero-Sense instrument.

Novel Concepts and Missions Session

The third and final day of the workshop began with a session devoted to novel concepts and missions. **Son Nghiem** (JPL) described how SAR may be the ideal sensor for detection and monitoring of icebergs. **Doug Comer** explained how the Department of Defense is responsible for preserving any archeological or culturally significant site on its lands, and how SAR remote sensing may be the best way to identify these sites. **Paul Rosen** detailed the requirements for airborne repeat-pass interferometry and showed some of the applications of such a capability to surface change, earthquake prediction, and hazard management. **Ron Muellerschoen** immediately followed Rosen's talk proving that the GPS technology required for repeat-pass interferometry has now been demonstrated aboard AIRSAR. **Yunling Lou** presented several plans of the AIRSAR group for technology demonstrations, including digital receivers, improved calibration, remote control of the radar, real-time (single-bit) full-resolution SAR interferometry processing, repeat-pass interferometry, and polarimetric interferometry. **Tony Milne and Chris Jennison** concluded the presentations of the session with descriptions of the science objectives and logistical possibilities of a "Pole-to-Pole" Pacific Rim follow-on mission. The mission would include volcano sites over the Aleutian Islands, possibly sites on the Kamchatka Penninsula, cal/val sites for PALSAR in Japan, follow-on sites from PacRim 2000 in Malaysia and Japan, sites in Australia and New Zealand, a campaign over the Antarctic to focus on glacier motion (and possibly a demonstration of iceberg detection), and ending with a return trip through South and Central America that would focus on carbon cycle studies. The session was then thrown open for a panel and audience discussion about the challenges and opportunities facing the AIRSAR program. Emerging from the discussion were two technology demonstration priorities: repeat-pass interferometry and real-time SAR processing.

Ecology, Biomass, and Land Cover Session

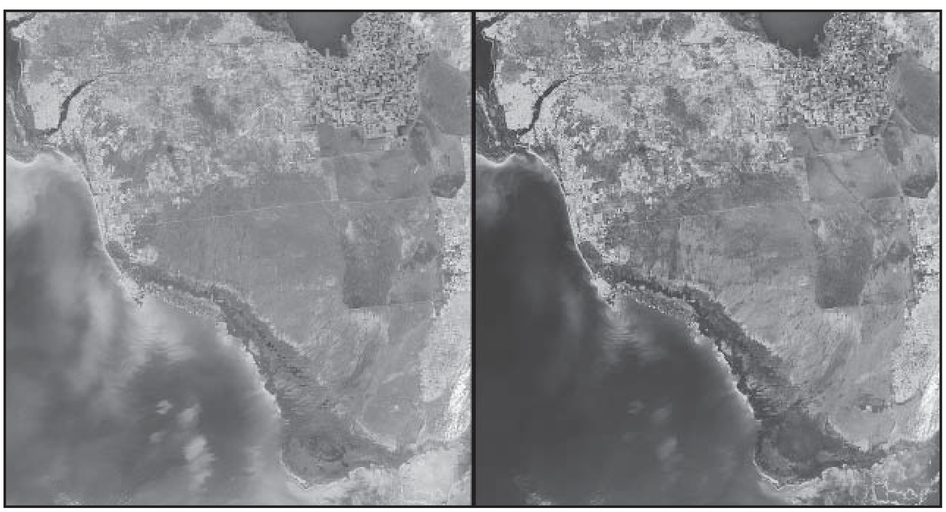
Sassan Saatchi and Robert Treuhaft presented techniques for obtaining biomass estimates over forests using AIRSAR data. **Richard Lucas** described mangrove community classification with AIRSAR data, and **Tony Milne** showed examples of flooding and agricultural classification over the Tonle Sap Basin in Cambodia. **Phil Dennison** described the use of AIRSAR data to characterize chaparral stand age and correlated that information to fire hazard assessment. **Paul Siqueira** described a generalized approach to biomass and other kinds of modeling which takes into account system noise to make optimal model parameter estimates.

Hydrology and Polar Science Session

George Leshkevich described the Great Lakes Winder Experiment (GLAWEX) to measure ice type, thickness and extent with coincident ground truth provided by a Coast Guard ice-cutter (the campaign has since been successfully completed, see *airsar.jpl.nasa.gov/documents/index_2002_airsar_deployment.html*). **Jiancheng Shi, Eni Njoku, Jakob van Zyl, and Eun Young Kwon** described algorithms and experiments to obtain soil moisture measurements with AIRSAR. **Philippe Paillou** described a new P-band sensor: the RAMSES facility. Doug Alsdorf described the use of repeat-pass interferometry to obtain very accurate measurements of lake-level changes using the double-bounce of the radar off of tree stands near and in the lakes.

Conclusion

Overall, the 2002 AIRSAR Earth Science and Applications Workshop afforded a great venue for surveying the breadth of applications of AIRSAR data, for providing a unique opportunity to meet other AIRSAR investigators and forge new collaborations, and for helping the AIRSAR community plan for future technology demonstrations and science data missions. For more information about the workshop and about AIRSAR, please visit our website at: *airsar.jpl.nasa.gov*.



Florida's River of Grass

Florida's Everglades is a region of broad, slow-moving sheets of water flowing southward over low-lying areas from Lake Okeechobee to the Gulf of Mexico. In places, this remarkable 'river of grass' is 80 kilometers wide. These images from the Multi-angle Imaging SpectroRadiometer (MISR) show the Everglades region on January 16, 2002. Each image covers an area measuring 191 kilometers x 205 kilometers.

On the left is a natural view acquired by MISR's nadir camera. A portion of Lake Okeechobee is visible at the top, to the right of image center. South of the lake, whose name derives from the Seminole word for 'big water,' an extensive region of farmland known as the Everglades Agricultural Area is recognizable by its many clustered squares. Over half of the sugar produced in the United States is grown here. Urban areas along the east coast and in the northern part of the image extend to the boundaries of Big Cypress Swamp, situated north of Everglades National Park.

The image on the right is a combination of the 46º backward, nadir and 46º forward-viewing camera angles to create a composite–very useful for detecting surface water, which appears blue in color imagery. (Note the clouds are not visible in this image.) Wetlands visible in these images include a series of shallow impoundments called Water Conservation Areas which were built to speed water flow through the Everglades in times of drought. In parts of the Everglades, these levees and extensive systems such as the Miami and Tamiami Canals have altered the natural cycles of water flow. For example, the water volume of the Shark River Slough, a natural wetland which feeds Everglades National Park, is influenced by the Tamiami Canal. The unique and intrinsic value of the Everglades is now widely recognized, and efforts to restore the natural water cycles are underway.

Long-Term Archive (LTA) Workshop Results

– *Matt Schwaller, matt@rattler.gsfc.nasa.gov, Goddard Space Flight Center*
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– *Graham W. Bothwell, Jet Propulsion Laboratory*

Introduction

The long-term archiving of EOS data was the topic of a workshop held on January 29 and 30 at NASA GSFC. The workshop was organized and hosted by the EOS Science Working Group on Data (SWGD), and was chaired by **Robert Wolfe**, who represents MODIS on many SWGD activities. The EOS Project Science Office and the ESDIS Project provided logistic support. Some 32 participants attended the workshop, covering a wide range of expertise and affiliation. They represented the following organizations:

- NASA: Headquarters, ESDIS, and the Terra Project Science Office
- Past missions: UARS and Landsat
- Partner agencies: NOAA and USGS
- DAACs: GSFC, EDC, NSIDC, and LaRC
- EOS Instrument/Science Teams: MODIS, MISR, MOPITT, ASTER, CERES, TES, OMI, and GLAS.

Long-Term Archiving (LTA) Policy

Martha Maiden (NASA Headquarters) described NASA's LTA policy. The policy is dictated by two existing Memoranda of Understanding (MOUs), one each with NOAA and USGS. The NASA-USGS MOU on the Earth Observing System (signed in 1993) states that "USGS will fund long-term archive functions. USGS will fund archive and distribution functions, including operations and maintenance costs for EOS and related data more than 3 years old ...." In practice, the USGS National Satellite Land Remote Sensing Data Archive (NSLRSDA) at USGS EROS Data Center (USGS/EDC), and perhaps other related data systems at USGS/EDC, will be the site for EOS long-term archives of NASA's "land" data products.

The NASA-NOAA MOU is less specific about LTA of NASA's Earth science data products, stating that "NOAA will use its best efforts to ... assume responsibility at a time to be agreed upon for active long-term archiving and appropriate science support activities for atmospheric and oceans data for the EOS program."

A recent "letter of intent" provided additional clarification to the NASA-NOAA LTA policy, and was signed by NASA's Associate Administrator for the Earth Science Enterprise (ESE) and NOAA's Assistant Administrator for Satellite and Information Services for the National Environmental Satellite Data and Information Service (NESDIS). It specifically calls for NOAA/NESDIS and NASA/ESE to "Agree that the NOAA NESDIS Comprehensive Large Array-data Stewardship System (CLASS) shall serve as the national atmospheric and oceanic long-term data archive" and to "Agree that appropriate atmospheric and oceanic data records from NASA's Earth Science Enterprise program will be included in this national archive."

A Call To Action

The EOS SWGD called the January workshop in recognition of two fundamental facts, firstly the importance of long-term preservation of EOS data, and secondly the need to become engaged early in the planning for LTA by USGS and NOAA.

The EOS SWGD also acknowledged previous work on LTA conducted by The U.S. Global Change Research Program (USGCRP 1998). The National Research Council Committee on Earth Sciences also made significant progress in defining the goals and objectives of LTA for Earth science research (NRC CES 2000a and 2000b). Both the USGCRP and the CES challenged the Earth science research and operational community to ensure a LTA "not only for today's generation of users but also for the next generation of scientists and citizens whose needs have yet to be expressed but must be provided for" (CES 2000a).

EOS SWGD Workshop Results

This brief report can only provide a summary of the presentations and results from the LTA workshop. Interested readers may wish to go on-line to find the original presentations of workshop participants at *swgd.gsfc.nasa.gov*.

Overall, the workshop helped clarify the LTA needs of Terra, Aqua, Aura, and other spacecraft science teams. It was clear from the presentation and discussion that there are unique challenges and characteristics for each mission, and indeed for each data product. One of the critical conclusions drawn from the discussion was that generalizations don't necessarily apply to Earth science data products. Thus, it is likely that the LTA plan for each data product may depend on its unique characteristics, production history, and pattern of use.

Another outcome of the workshop was a better understanding and appreciation of the plans and possibilities for LTA within NOAA and USGS. As mentioned above, current policy calls for NOAA's CLASS system to be the LTA for NASA's oceans and atmospheric data. **Rob Mairs** (NOAA/NESDIS) explained that the initial configuration for CLASS will be built on archives at the National Climatic Data Center (NCDC) in Asheville, North Carolina, and the NESDIS facilities in Suitland, MD. Thus the target for testing, prototyping, and operational LTA of EOS oceans and atmospheres data will be directed to CLASS at these sites.

John Faundeen (USGS/EDC) described NSLRSDA and related systems at USGS/EDC as the targets for LTA of NASA's ESE land data products. USGS will initially migrate "heritage" data products already in the active archive at the Land Processes DAAC to LTA facilities at USGS/EDC. A plan is under development that calls for the transition of these data products (including SIR-C X-SAR data, Global Land Cover Characteristics data, and others) from the Land Processes DAAC to the USGS/EDC LTA by the end of fiscal year 2002.

Key Actions and Recommendations

The workshop generated a significant number of recommendations and actions; a summary of these is provided below in more or less priority order. The full set of actions and recommendations is available on the web at the URL given in the section above.

An important issue recognized by the workshop is that arrangements with NOAA and USGS for the long-term custody of Terra and subsequent data have yet to be finalized. While it is impracticable and unnecessary to have everything spelled out beforehand, there are certain critical items that have potential for significant impact on viability of the arrangements, and on continuing usefulness of the data. In this regard, the workshop recommended specifically that the nature of long-term "science stewardship" of data be understood and agreed between NASA and it partner agencies, including questions such as maintaining knowledge about the data sets and how to use them after the original science teams have disbanded.

The LTA workshop also recommended that transfer of data sets to the LTA should begin as soon as feasible. It was further recommended that transfers should begin early, with stable data sets for both current and future missions. It was recommended that the initial targets for LTA should include Level 0 data, pre-launch calibration data, and related documentation. It was recognized that the final higher-level science products, particularly time-series data, might not be stable, and thus candidates for transfer, until the last reprocessing occurs after the end of the mission. It was noted that LTA planning for satellite mission instruments and data products should begin at the start of a mission, with concrete LTA milestones planned throughout the mission. Otherwise there is a risk of being unable to handle the unique aspects of individual instruments and products, which may be very different from one another, and that the resources and knowledge needed for establishing the LTA may not be available.

Workshop participants acknowledged that requirements for individual instruments will need to be communicated knowledgeably to the NOAA and USGS LTA. Many questions remain about how this can be accomplished. Issues such as multiple versions, on-demand processing (especially for ASTER products), reprocessing, and others will need to be addressed. It was noted that NASA, NOAA, and USGS will need to coordinate LTA schedules and goals, and that science teams will need to be part of this process.

Workshop participants recommended that instrument teams and DAACs must be engaged in the advisory panels and committees within NOAA and USGS that specify and administer long-term archiving for those agencies. It was also noted that EOS teams should verify the suitability of the functions and services provided by the NOAA and USGS LTA. This advice and verification could take the form of "tire-kicking" or other appropriate review of prototypes, early implementations, and on-going operations.

Finally, it was recommended that NASA investigators must have on-going access to the long-term archives of EOS and related NASA data under conditions similar to those available at present.

Next Steps

By the end of the workshop, some 16 separate items were identified for NASA, NOAA, USGS and Science Team action. Again, details can be found on the SWGD web site. The list below provides a sample of the identified actions.

- Identify the evolutionary path for the DAACs and their roles in the LTA process.
- Determine how reprocessing is handled in the longer term with respect to NASA responsibilities.
- Determine how multiple versions are to be handled by NOAA and USGS.

- Confirm that NOAA/USGS LTAs will include any or all of the supporting data such as prelaunch calibration data; if not, then alternative mechanisms within NASA will need to be facilitated.
- Determine long-term handling for archive software.
- Determine how subsetting and other specialized services will be provided for LTA data requests.
- Develop a set of guidelines for new or emerging missions to accommodate LTA.

The final action in the above list has particular relevance for the on-going Strategic Evolution of ESE Data Systems (SEEDS) formulation. One of the key objectives of SEEDS is to develop guidelines to new or emerging missions. A set of guidelines for LTA will help guarantee that the set of data products and services generated at the beginning of a new mission has a graceful path to LTA at the end of the mission. A report of the SWGD deliberations and findings was presented to a SEEDS workshop on February 5 by Robert Wolfe. That presentation is included on the SWGD web site page about the SWGD workshop.

Conclusion

The LTA workshop brought together all of the interested parties for the first time: NASA, NOAA, USGS, the EOS instrument teams, DAACs, etc. The relevant issues associated with the LTA process were identified and discussed openly between the parties. NASA now has a better foundation for proceeding with LTA development, both in formulation of concepts, agreements between organizations, and development of a pilot program. The identified recommendations and issues should in many instances be directly applicable to formulation of the SEEDS concepts. The momentum needs to be continued; detailed plans and commitments for LTA of NASA's Earth science data need to be in place well before the end of the mission.

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National Land Cover Data Base 2000 Update

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Background

Land cover is perhaps the most essential commodity developed from satellite and other remotely sensed data (Foody 2002). Despite the long list of uses of satellite data, there remains a consistent and recurring need for land cover information because of the numerous applications that depend on these data.

With the advent of the Landsat program in 1972, it became possible to routinely map land cover over large areas of the country. This ability was further enhanced in 1982 with the development of the Landsat TM sensor. However, the ability of Landsat to provide nationwide land-cover data was not tapped until the 1990s.

The Multi-Resolution Land Characteristics (MRLC) Consortium was initiated in order to meet the consistent and recurring needs of several Federal agencies for satellite remote sensor and land-cover data. One of the Consortium's projects was a national land-cover mapping effort (Vogelmann et al. 2001). Known as the NLCD, this dataset provides land cover for the lower 48 states from ca. 1992 Landsat 5 Thematic Mapper (TM) imagery (**http://landcover.usgs.gov/nationallandcover.html**).

The NLCD overcomes a fundamental problem with all previous land-cover mapping activities: lack of data beyond a given jurisdictional boundary. Prior to the NLCD, applications dependent on land cover could not extend beyond the state or county boundaries where the current land-cover data stopped. In part because of the cross- jurisdictional nature of NLCD, numerous projects dependent on land cover have turned to NLCD to serve their needs (Table 1).

The recurrent need for land-cover, remote sensor, and other geospatial data has fostered the continuation and growth of the MRLC Consortium. New partners have joined the Consortium, and current plans include acquisition of ca. year 2000 Landsat 7 ETM+ data and development of land cover for all 50 states and Puerto Rico.

Objectives

The MRLC 2000 strategy includes two main data goals: the acquisition of three ca. year 2000 multi-seasonal Landsat 7 ETM images per path/row that are preprocessed using common methods, and the creation of a land-cover database (called the National Land cover Database 2000 [NLCD 2000]) covering all 50 states and Puerto Rico.

Data Layers

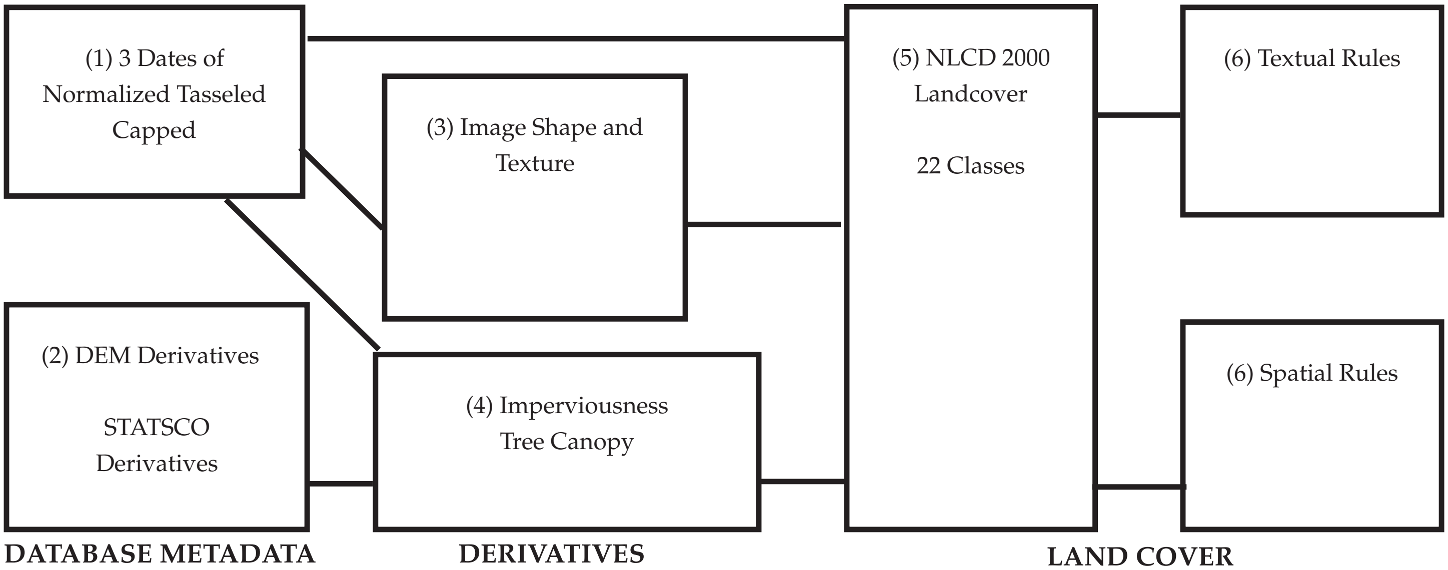
To achieve the first goal, data from Landsat 7 (with some Landsat 5 data augmenting the Landsat 7 coverage) are processed to these specifications:

1. A minimum of three dates per path/row (representing different seasonality) for the conterminous lower 48 U.S. states, Alaska, Hawaii and Puerto Rico;
2. geometric, terrain-corrected registration to within one pixel spatial accuracy;
3. data referenced to the national Albers Equal map projection;
4. imagery resampled using cubic convolution to 30-m pixels; and
5. all eight TM bands processed (including thermal and pan bands) for Landsat 7 data.

These Landsat data are available on CD-ROM media for a price of $45 per CD, and are distributed with the associated Digital Elevation Model (DEM) used for terrain correction. These data are currently available to all users, with the stipulation that the data be used or disseminated for scientific purposes or other non-commercial applications only. Data availability and ordering information can be found on the Land Cover Program home page at URL *landcover.usgs.gov*.

The second goal of MRLC 2000 is the creation of the value-added database of land cover, (NLCD 2000), generated across all 50 states and Puerto Rico using both Landsat 7 ETM+ imagery and ancillary data. This database (defined as multiple interlinked data layers that are useful either as individual components, or in combination) is planned to accommodate a wide variety of potential users who can tap into the database for both derived land-cover products, and other intermediate data layers that will be standardized and consistent for the United States. Figure 1 on the next page outlines the

FIGURE 1 - Conceptual Model of NLCD Database



organization of the database. Descriptions of each component are listed in the box on the right.

Discussion

The NLCD 2000 database provides a comprehensive set of data layers that foster further exploration, development, application, and sharing of land-cover information by users at national and regional scales. The standardized nature of each data component at reasonable accuracies will allow users the ability to develop data applications that either use layers in combination or individually. Conceptually, a potential user could modify land-cover model parameters directly in any standard software package by manipulating rule-set parameters according to more local information. In this scenario, NLCD 2000 acts as a framework to provide standardized ingredients and a general "recipe" empowering less sophisticated users to generate local value-added land cover without extensive preparation. Further

The diagram above illustrates the components of the database. The six components are described below .

(1) Normalized tasseled cap (TC) transformations of Landsat 7 imagery for three time periods per scene (early, peak and late). Requirements include three acquisition dates for each path/row covering early, peak and late green-up. Scene selection is based on information derived from the multi-temporal normalized difference vegetation index (NDVI) data of the conterminous U.S. acquired by the advanced very high-resolution radiometer (AVHRR) from 1994-1998. Images are first radiometrically corrected using standard methods at the USGS EROS Data Center to eliminate band bias and gain anomalies (Irish 2000). Secondly images are converted to at-satellite reflectance for the 6 reflective bands and to at-satellite temperature for the thermal band according to Markham and Barker (1986) and the Landsat 7 Science Data Users Handbook (Irish 2000). This method provides an important first-step to standardizing imagery, but some atmospheric, phenological and topographic noise still remain. Images are then transformed into Tasseled Cap bands using a new TC transformation based on Landsat 7 at-satellite reflectance normalized scenes developed to represent a variety of landscapes across the United States (Huang et al. 2002).
(2) Ancillary data layers, such as DEM and STATSCO. DEM derivatives include slope, aspect, elevation and a positional index. STATSCO soil data derivatives include the Unit for Soil Available Water Capacity (AWC), the Unit for Soil Organic Carbon (OC), and Soil Quality.
(3) Image shape information generated from image segmentation output calculated into four shape measures including convexity, compactness, fractal dimension, and form. Texture is generated from a standard deviation-based texture measure enhanced by an adaptive 3x3 window filter (Woodcock and Ryherd, 1989).
(4) Image derivatives of percent imperviousness and percent tree canopy per-pixel based on empirical relationships with Landsat data, established using regression tree techniques. One-meter digital orthophoto quadrangles are used to derive reference data needed for calibrating the relationships between canopy/imperviousness and Landsat spectral data (Huang et al. 2001).
(5) Classified land-cover data derived from the Tassel Capped imagery, ancillary data, and derivatives. For NLCD 2000, decision tree classification was the method chosen because it offers an efficient robust method to classify huge quantities of information in documentable form.
(6) Metadata that allows users to assess both spatial records of decision tree output (similar to spectral clusters) as well as generic rule-set text for review and importation. This comprehensive metadata approach will allow users access to classification reasoning and will potentially allow local modification of the classification database.

this database could provide a common "language" for users to trade classification methods and results.

In addition to the database layers, the end user of NLCD 2000 can also anticipate access to additional products derived from the land-cover classification (Figure 1, Box 5). The National Land-Cover Pattern Database (Riitters et al. 2000; *www.srs.fs.fed.us/4803/landscapes/lncpdindex. html*) is expected to provide landscape pattern measurements (e.g., contagion, forest density) to quantify and map key indicators of spatial pattern that are related to endpoints such as biological diversity, water quality, and human use impacts. This database will complement the NLCD 2000 image-based databases (Figure 1, Boxes 1 through 5), and provide even more opportunity for researchers to access and use all the MRLC 2000 information.

There is also an opportunity for the EOS program to utilize the NLCD2000. Currently the MODIS land team is communicating with NLCD to explore benefits of coupling the higher spatial resolution data products of NLCD with the higher temporal resolution MODIS products. Several possibilities are being considered:

• Including 250-m, 500-m, or 1-km MODIS reflectance data and/or Vegetation index data as an input layer in the NLCD suite.
• Using the MODIS land cover products as a temporal complement starting with year 2000 data and continuing through the operational life of MODIS (note MODIS landcover change products are anticipated to become available in 2002).
• Atmospherically correcting the NLCD ETM+ scenes with information available from MODIS
• Coordinating on accuracy assessment where reference data for NLCD could also be used to validate MODIS land cover products.

These discussions are in the initial phase, and the results are more for research than for operational products to include with the official NLCD products. However, there is general agreement this partnership could be mutually beneficial for both parties. The production of the operational NLCD 2000 will be implemented in a phased approach using the mapping regions developed by USGS. Full production development is based upon available funding from MRLC 2000 partners and cooperators, but is anticipated to begin in FY 2002.

Note: The U.S. Environmental Protection Agency through its Office of Research and Development partially funded and collaborated in the research described herein. It has not been subjected to Agency review and therefore does not necessarily reflect the views of the Agency, and no official endorsement should be inferred.

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Minutes from the HDF Workshop

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Introduction

The fifth annual Hierarchical Data Format (HDF) and HDF-EOS Workshop was held in conjunction with the Science Data Processing (SDP) workshop on February 26-28. Over 200 people attended the joint workshop; the HDF discussion benefited from the wider focus of the SDP Workshop. The HDF related hands-on tutorials on the first day, "How to Program in HDF" and "HDF Tools," were extremely well attended. Despite the fact that there were too many students for each to have direct use of a computer to work the examples, attendees expressed satisfaction with the lessons. The subsequent two days featured presentations and discussions.

The HDF presentations were organized as a separate "parallel track" of the workshop. Presentations included information about the status of new developments in the HDF library and API and the EOS standard. A wide variety of tools for application of HDF and HDF-EOS data were also described. The maturity of these tools reflects the growing use of the standard and especially of EOS data in HDF-EOS from the Terra satellite. The associated discussion provided good feedback to help guide future development. Copies of all "HDF track" presentation material are available on the web at *hdfeos.gsfc.nasa.gov*. The following HDF and HDF-EOS related talks were presented:

Welcome to HDF Workshop V.

Richard Ullman (NASA ESDIS Project) provided a basic overview of the definition, purpose and use of HDF-EOS. HDF is NASA's standard file format for EOS Standard Products. HDF-EOS defines a "profile" for use of HDF for specific remote sensing measurement types. The HDF-EOS types are Point, Swath, and Grid. HDF-EOS built with HDF4 is the standard for Terra, Aqua, SAGE III and SORCE standard data products. HDFEOS5, built on HDF5 is the standard for Aura and ICESat. This presentation provided a basic overview of the definition, purpose, and use of HDF-EOS.

HDF Update

Mike Folk (NCSA) gave a brief description of HDF4 and HDF5, followed by an update on HDF4 and HDF5 activities over the past year, and future plans. Recent activities include release of the libraries and tools, development of an "HDF5 Lite" Applications Programming Interface (API), and tuning of HDF5 for high performance computing environments.

HDF-EOS Development - Current Status and Schedule

Larry Klein (Emergent Information data. Klein described HDF-EOS5 main data structures, Swath, Grid, and Point. He outlined the programming model for the Swath, Grid, and Point API's and briefly reviewed the main HDF5 features incorporated into the HDF-EOS5 library. Finally, he described the capabilities of application tools provided with the library.

HDF-EOS Aura File Format Guidelines

Cheryl Craig (NCAR/HIRDLS Project) presented a brief overview of the Aura satellite and instruments. She touched on changes made since HDF-EOS Workshop IV. She also presented File Guidelines for HDF-EOS files to be used in conjunction with Aura.

Transitioning from HDF4 to HDF5

Robert McGrath (NCSA) spoke about this transition. There is a separate article on page 19 of this Newsletter that discusses this issue in depth. HDF4 users who are interested in switching to HDF5 face the problem of what to do with legacy HDF4 data and software. NCSA has published a recommended mapping to show how HDF4 objects can be converted to HDF5. The h4toh5 utility implements this mapping and can convert an HDF4 file to a conceptually identical HDF5 file. A libh4toh5 will provide C calls to convertHDF4 objects. Limited experiments show that these default conversions are efficient and effective, but they may not be what is needed for all cases.

Results of HDF Performance Study

Elena Pourmal (National Center for Supercomputing Applications - NCSA) gave this presentation. She indicated that performance tests are being conducted to compare HDF4, netCDF, FITSIO, HDF5, and PHDF5 on a number of criteria. These include: common file I/O operations such as write/read with datatype conversion, hyperslab subsetting, access to large data sets, access to large numbers of objects and tables access.

Parallel HDF

Elena Pourmal (NSCA) also reported that many scientists anticipate an increase in the need to process EOS data on high performance platforms, many of which will involve parallel computing and I/O. HDF5 is designed and implemented to take advantage of the power and features of such computing systems. She presented basic concepts of parallel I/O with HDF and touched on the kinds of environments on which parallel HDF5 has successfully been deployed. She also showed some performance results.

MLS Software using HDF

Paul Wagner (JPL) spoke about software being prepared for the Microwave Limb Sounder (MLS) instrument on Aura. This software creates HDF and HDF-EOS formatted data products. He presented selected details about the different software levels, the types of products output by each level, and how the products are being implemented in HDF4. He also spoke briefly about the transition of these products to HDF5.

Tools for MISR Standard Products

This presentation was given by **Kyle Miller and Brian Rheingans** (both of the JPL/MISR Instrument Team). MISR standard products employ an extension to the HDF-EOS Grid API called stacked block. There is very little tool support for reading stacked block geolocation information. Consequently, it is difficult for users to co-locate MISR data and other HDF-EOS data, even data from other Terra instruments. This presentation demonstrated some tools that the MISR team has been working on which read MISR geolocation information and reproject MISR data to allow for eas manipulation by standard commercial tools.

A Visualization Tool for HDF and HDF-EOS: view_hdf

Kam-Pui Lee (SAIC) and **Peter Spence** (CERES Data Management Team) both presented on view_hdf. This is a visualization and analysis tool for accessing data stored in HDF and HDF-EOS files. It is being developed by the CERES Data Management Team at NASA Langley Research Center and is distributed by the NASA Langley Atmospheric Sciences Data Center. This tool has added many new features since it was presented at previous HDF and HDF-EOS Workshops. They demonstrated usage of view_hdf with CERES products.

A Tool for Visualizing MISR Data: misr_view4.0

Nancy Ritchey (NASA LaRC Atmospheric Sciences Data Center) spoke here. The Multi-angle Imaging SpectroRadiometer (MISR) instrument onboard the Terra spacecraft was designed to improve our understanding of interactions between radiant energy, clouds, aerosols, and the surface and to characterize certain physical properties of the atmosphere and surface. This unique instrument captures moderately high-resolution global imagery of upwelling radiance in four spectral bands at each of nine widely spaced angles. The application misr_view was developed by the Visualization and Earth Science Applications Group of the Image Processing Applications and Development Section at NASA's Jet Propulsion Laboratory (JPL) for use with data products from MISR and the airborne instrument, AirMISR. It is a graphical user interface-driven display and analysis tool and it is based on Interactive Data Language (IDL). The software and User's Guide are available free of charge from JPL. The latest release, misr_view 4.0, contains many new features and enhancements which were demonstrated during Ritchey's presentation.

HDF-EOS Data Applications at the Goddard Space Flight Center DAAC

James Johnson (GSFC DAAC) reported that the Goddard DAAC has been archiving and supporting data sets written in the HDF and HDF-EOS formats for some time. Recently, the Goddard DAAC has been developing applications for users to access the data files written in HDF and HDF-EOS. He presented an overview of these activities.

Facilitating Access to EOS Data atthe NSIDC DAAC

Siri Jodha Singh Khalsa (NSIDC DAAC) presented an overview of HDF-EOSrelated tools available through the National Snow and Ice Data Center (NSIDC) DAAC.

HDF Work at UAH: ESML - Earth Science Markup Language, HEW-UAH + HDF-EOS Web-based Subsetter

Matt Smith (Information Technology and Systems Center/University of Alabama at Huntsville–ITSC/UAH) gave this talk.He reported that HEW (HDF-EOS Webbased subsetter) can extract a subset of any grid or swath data file that is in HDFEOS format. As a stand-alone subsetter, HEW uses a user-friendly web-based front-end to gather the user's subsetting criteria and then submits the subsetting job to the batch queue. The subsetter engine (back-end) can also be used separately by substituting a site-specific front-end in place off HEW's web-based interface. Smith demonstrated an update of HEW. The Earth Science Markup Language (ESML) is being developed at ITSC as a

NASA Earth Science Technology Office prototype. The primary goal of the ESML project is to enable independently developed applications and services to effectively utilize distributed heterogeneous data products. Other HDF-EOS work at UAH's Information Technology and Systems Center were also presented - including the Algorithm Development and Mining (ADaM) system and the Subsetter/Format Converter (SFC).

"Ask the Experts" discussion

Richard Ullman, Robert McGrath, and Larry Klein led this time. This was open discussion about the future direction for HDF and HDF-EOS.

IDL Support for HDF4 and HDF5

Linda Hunt (RSI, Software Development) spoke about how Research Systems is committed to supporting the HDF community and has recently updated its set of HDF4 routines. IDL HDF5 routines are currently under development and an early version of routines to read and query HDF5 files should be available by the time of the workshop. Her presentation summarized existing IDL HDF4 routines with more extensive coverage of recent additions and updates. Hunt also discussed the proposed initial release of IDL HDF5 and plans for future work.

MATLAB Features for Working With HDF and HDF-EOS Data

Christopher Lawton and Robert Comer (both of MathWorks) reported that MATLAB, the core of the family of technical computing products from MathWorks, Inc., has included full support for the Hierarchical Data Format (HDF) since 1998. Since 1999, MATLAB has also supported HDF-EOS, the extension to HDF developed in support of NASA's Earth Observing System (EOS). MATLAB is both an interactive tool and a high-level programming language. His presentation included a demonstration of some of the MATLAB features.

Generalized Conversion of HDFEOS Products to GIS-Compatible Formats

Larry Klein, Ray Milburn, and Abe Taaheri (all of Emergent Information Technologies, Inc.) jointly presented on a tool developed for generalized conversion of HDF-EOS data to GIS-compatible formats. The tool provides reprojection, resampling, subsetting, and stitching capabilities. Output file options are GeoTIFF, native binary, and HDF-EOS Grid formats. The tool is operable on Sun and SGI platforms, and is accessible by command line and GUI interfaces. Initial testing has been performed on a variety of MODIS, ASTER, MISR, and Digital Elevation Model products.

The LEISA Atmospheric Corrector (LAC) on Earth Observer 1 (EO1)

George McCabe (NASA GSFC) reported that the LEISA Atmospheric Corrector (LAC) on Earth Observer 1 (EO-1), currently flying in formation with Landsat 7, is recording spectral images stored in HDF format. The LAC instrument team processes Level 0 to Level 1R radiometrically corrected data in HDF format and will produce georectified data products in HDF-EOS format. The LAC is a wedge filter-type sensor, the first of its kind in space flight, and presents some unique processing issues in producing data products. Regarding the concerns of the user verifying instrument performance as well as the science user, this presentation addressed HDF formatting of metadata, maintaining integrity of data values, traceable/reversible modifications, efficient extraction of subsets, and data fusion issues.

Conversion from HDF4 to HDF5: Hybrid HDF-EOS Files

– *Robert McGrath, mcgrath@ncsa.uiuc.edu, University of Illinois Urbana/ Champaign*

INTRODUCTION

Version 2.6 and earlier of HDF-EOS were built on top of the HDF4 library (this is now termed HDFEOS4) **[2]**. Version 5 of HDF-EOS is built on top of HDF5 **[3]**. Files created with HDFEOS4 cannot be read with HDFEOS5 and vice versa. In some cases, programs will use data in one or both formats, with multiple reader or writer modules. In other cases, it may be desirable to convert older files from HDFEOS4 to an equivalent HDFEOS5 file.

Since the HDF-EOS objects are equivalent, files can be translated by reading the HDFEOS4 file and writing an equivalent HDFEOS5 file. For example, the heconvert program **[4]** converts an HDFEOS4 file to an equivalent HDFEOS 5 file. All the EOS objects—the Grid, Swath, and Point objects, and associated metadata—are read from the HDFEOS4 (HDF4) file and written to an equivalent HDFEOS5 (HDF5) file.

This is not the end of the story, however. Most HDF-EOS data products contain standard HDF objects as well as the HDF-EOS objects. In addition to the Grid, Swath, and Points managed by the HDFEOS library, these "hybrid" files may also contain:

- Product-specific attributes and annotations;
- browse images; and
- product specific ancillary datasets or tables.

These HDF objects are created through calls to the HDF4 library, they are not managed by the HDF-EOS library.
The heconvert utility converts only the objects and metadata managed by the HDF-EOS library, and consequently cannot convert other HDF objects that may be present. The result is that the file created by heconvert may omit some of the objects and metadata from the original. To fully convert "hybrid" files, it is necessary to read the additional HDF4 objects, and write equivalent HDF5 objects.

The National Center for Supercomputing Applications (NCSA) library, HDF4 to HDF5 Conversion Library (H4toH5 Library) **[5]**, is a library of routines that reads individual HDF objects or groups of objects from an HDF4 file and writes equivalent HDF5 objects to an HDF5 file, using a default translation **[6]**. This library can be used by C applications to create a custom conversion for specific data products.

In this experiment, the heconvert utility is augmented using the H4toH5 Library. In addition to the standard conversion of HDF-EOS objects, the experimental program identifies and converts non-EOS objects in an EOS dataset, creating a more complete HDFEOS5 file.

METHOD

Sample Data

A sample of HDF-EOS files was selected from the EOS-SAMPLER CD **[7]** (SeeTable 1 on the next page). The heosls utility **[2]** was used to list the objects in the file (see sample file in box below). In each case, the file has one or more HDF-EOS objects

The following code (slightly condensed) is used for the heosls utility and shows the contents needed for ceres.hdf (see Table 1 on next page):

FILE NAME: ./ceres.hdf
NCSA HDF Version 4.1 Release 2, March 1998
HDF-EOS Version: HDFEOS_V2.6
"CERES_ES8_subset" SWATH
"StructMetadata.0" Global Attribute
"coremetadata" Global Attribute
"archivemetadata" Global Attribute
"SubsetMetadata.0" Global Attribute
VDATA "CERES_metadata" (CERES)

TABLE 1 – Sample Data Used (from EOSDIS Terra Sampler #1 - See Reference **[7]**)

Case	**Original File From HDF-EOS Sampler**	**HDF4 Size (bytes)**
ceres	CER_ES8_Terra-FM2_Test_SCF_016011_20000830.subset_70_20_-140_40.200001012_204110Z.hdf	76,196,301
aster	ASTLIB_0008301851.hdf	124,464,518
mod02hk	MODIS/MOD02HKM.A2000242.0140.002.2000247230108.hdf	275,064,875
mod04-242	MODIS/MOD04_L2.A2000242.0140.002.2000264223516.hdf	10,455,467
mod04-243	MODIS/MOD04_L2.A2000243.1850.002.2000252164712.hdf	10,455,471
mod05	MODIS/MOD05_L2.A2000243.1850.002.2000252164414.hdf	20,149,501
mod06	MODIS/MOD06_L2.A2000243.1850.002.2000252173103.hdf	69,590,548
mod35	MODIS/MOD35_L2.A2000243.1850.002.2000244222700.hdf	47,504,592

(Grid, Swath, Point) and corresponding StructMetadata.0. Each file also contains standard HDF4 objects (VData tables, SDS datasets, annotations). These latter objects are not managed by the HDF-EOS library. They are product-specific, created by the data processing software and written directly using the HDF4 library. Thus, these files are different examples of "hybrid" files, containing both HDF-EOS and regular HDF objects.

The file on the bottom of page 19 contains one Swath, and the corresponding StructMetadata.0. The HDF file also contains four important HDF4 objects:

- A lone Vdata, 'CERES_metadata', with 14 fields of product specific values.
- Three SDS annotations: 'coremetadata', 'archivemeta', 'SubsetMetadata.0'

The Vdata and annotations are not managed by the HDF-EOS library.
The other test files had different objects, but all had both EOS and non-EOS objects.

Procedure

The experiment used the heconvert utility **[4]** to convert the sample data files from HDFEOS4 to HDFEOS5. The heconvert utility was augmented with calls using the prerelease of the NCSA H4toH5 Library **[5]**, in order to additionally convert some or all of the non-EOS objects. The software configuration is summarized in Table 2 on page 21.

In the control condition, the heconvert utility was run on the test input file, with a command similar to:
heconvert -i ceres.hdf -o ceres-cont.he5.

For the experimental condition, the source code to heconvert was modified to add a single subroutine that attempts to convert the regular HDF4 objects in the file into the HDFEOS5 file. The subroutine has a series of calls to the H4toH5 Library **[5]**, which was about 50 lines of code. These calls locate and read the objects of interest in the HDF4 file, and write equivalent objects to the HDF5 file. The experimental code handles:

- All HDF4 file annotations;
- all SDS global annotations;
- all HDF images;
- all lone Vdatas; and
- all independent SDS.

The experimental code is called when the '-hybrid' option is selected, e.g.:
heconvert -hybrid -i ceres.hdf -o ceres-exper.he5.

Each conversion was repeated at least five times to estimate a best-case time. The output files were examined with the standard h5dump utility and other tools.

RESULTS

Table 3 shows the conversion times and the size of the converted HDF5 files. As would be expected, the converted files are almost the same size as the input file. The files from the experimental condition were slightly larger than the control, reflecting the additional objects that were converted.

The conversion times varied because of system and network load. The times reported in Table 3 are the best observed times from at least 5 trials. As would be expected, these times are highly correlated with the size of the data, and show a conversion rate of about 700-800 KB/sec across the different files. The network disk

TABLE 2 – Summary of System Configuration

Software/Hardware	Version/Operating System
heconvert	See Reference [4]
HDF-EOS 4	2.6
HDF4	4.1.R5
HDF-EOS 5	5.1
HDF5	5.1.4.2-patch1
H4toH5Library	1.0 beta (pre-release)
Sun SPARC 5	Solaris 2.7
NFS partition	10Mbits/network

has a maximum theoretical speed of about 1100 KB/sec, so the conversion appears to be substantially I/O bound, as might be expected.

The content of the output files was examined using the h5dump utility. As expected, in the control condition, the product specific objects were not copied by heconvert, and consequently they are missing from the output file. For example, in the case of the ceres.hdf file, the control conversion created an output file with the Swath and the StructMetadata.0. The other objects are not present in the output.

The other datasets were similar: the HDF-EOS objects are converted, but the product specific objects are not.

In the experimental case, the output files have all the objects converted by the control condition, plus some or all of the other objects. For example, for the ceres.hdf file, the HDF5 file contains the same HDF5 objects for the Swath and the HDF-EOS metadata as the control. In addition, the product specific annotations are copied to the output file (as attributes of "/") and the Vdata is created (as a Compound Dataset under "/").

In some cases, the demonstration program does not convert all of the HDF4 objects. For example, the aster.hdf dataset has several Vgroups with product-specific Vdatas and SDSs (e.g., the Vgroup "Ancillary_Data"). These objects were not converted, so the output HDF5 file is still incomplete.

The H4toH5 Library can convert Vgroups and their members. However, in order for a general-purpose program to identify which Vgroups are from HDF-EOS and which are not, it is necessary to check every Vgroup individually. This was not attempted for this experiment. We would expect that users would create product specific conversion utilities, in which case the objects that need to be converted from the HDF4 file should be well understood

TABLE 3 – Results: Size of output file (bytes) and run time of conversion (min:sec)

Data File	HDF4 Size	Control: HDF5 Size	Conversion Time (min:sec)	Experiment: HDF5 Size	Conversion Time (min:sec)
mod04-242	10,455,467	11,255,895	0:31	11,314,359	0:32
mod04-243	10,455,471	11,255,895	0:32	11,314,367	0:32
mod05	20,149,501	20,906,324	0:50	20,964,036	0:50
mod35	47,404,592	47,623,160	2:00	47,682,720	2:03
mod06	69,590,548	69,155,580	3:00	69,216,068	2:59
ceres	76,196,301	77,127,264	2:51	77,183,172	2:13
aster	124,464,518	123,872,432	5:40	123,982,208	5:39
mod02hk	275,064,875	275,876,364	11:11	276,082,296	11:10

for each product.

DISCUSSION AND CONCLUSIONS

This experiment demonstrates the use of the H4toH5 Library to construct a customized conversion utility for "hybrid" HDF-EOS files. The standard heconvert utility was extended with approximately 50 lines of code to handle several classes of standard HDF4 files. The conversion accurately detects many of the additional objects and performs a complete conversion into the HDF5 file. The running time is essentially identical to the original utility.

It should be noted that the H4toH5 Library performs a default conversion of the HDF4 objects, which may not be the desired result in all cases. It seems likely that when a data product is developed for HDF5, it will be designed to use HDF5 most effectively, and therefore would need not and should not be expected to conform to the default mapping in **[6]**. For example, the way HDFEOS5 stores the Grid, Swath, and Point objects in HDF5 is not the default conversion of the constituent HDF4 objects. In HDFEOS4 the 'StructMetadata.0' is stored as a global annotation. In HDFEOS5, this is stored as a Dataset (which is definitely the best choice), rather than an attribute. This is an example of a case where the design for HDF5 should not follow the default mapping.

The non-HDF-EOS objects in datasets may well deserve non-default conversions as well. For example, in the ceres.hdf dataset, the HDF4 objects are created in a default location (under "/"), and the attributes have default names: such as "coremetadata_GLOSDS," etc. For a realistic conversion, it is likely that these would be put in more appropriate locations in the output file, under the Group "/HDFEOS/ADDITIONAL," or some other place in the file. Thus, a product specific converter utility should design the desired HDF5 file, and then create a custom conversion to implement it.

The H4toH5 Library Applications Programming Interface (API) has optional parameters which can customize the conversion. For example, the group and name of the HDF5 object to be created can be specified. In this demonstration, the conversion used the default locations and names for the objects it created. For a product-specific conversion, parameters could be set to implement the desired layout of the HDF5 file. But, the H4toH5 Library cannot do all possible conversions; there will likely be cases where the conversion must be specifically designed for a dataset or project. For example, converting the annotation 'StructMetadata.0' to an HDF5 dataset cannot be done by the H4toH5 Library.

It is important to point out that the H4toH5 Library can be mixed with other calls to HDF4 and HDF5. It would be possible to insert one or more objects from an HDF4 file (or from several different HDF4 files) into an HDF5 file along with other objects written through HDF5. Also, the converted objects can be modified after they are converted. For example, we have used the NCSA H5View program **[9]** to delete and rename attributes created by the conversion library.

In conclusion, this experiment shows that the H4toH5 Library provides a toolkit to more easily construct conversion utilities for NASA HDFEOS files. Specifically, we showed that the H4toH5 Library could be used to extend the heconvert utility to handle at least some hybrid files. This toolkit might be used to create standard converters for standardized data products that are defined in both HDF4 and HDF5. It might also be used for more ad hoc conversions, e.g., for a small science team that needs to convert HDF output from a program to be read using HDF5, or a future data service that needs to construct a value-added data product based on data from both HDFEOS4 and HDFEOS5. Overall, it is clear that it is feasible to convert HDFEOS4 files to HDFEOS5 when needed. For some purposes and users, it may be sufficient to continue to use current HDFEOS4 data and add future HDFEOS5 data when needed. In other cases, it may be necessary to migrate software to HDFEOS5, and to convert HDFEOS4 data into HDFEOS5. In this experiment, we have shown that both of these options are technically viable.

A more detailed version of this document is available from: *hdf.ncsa.uiuc.edu/h4toh5/Experiment2*

The beta release of the H4toH5 Library is available now from NCSA at: *hdf.ncsa.uiuc.edu/h4toh5*

Readers are encouraged to try this library and send comments, suggestions, and bugs to: *hdfhelp@ncsa.uiuc.edu.*

ACKNOWLEDGMENTS

The Author acknowledges the following contributions:

- **MuQun Yang** of NCSA was the primary developer for the H4toH5 Library.
- Executable versions of the heconvert utility are available from the HDF-EOS tools **[4]**. Thanks to Ray Milburn who helped us obtain source code for this study.
- The heosls utility is available from the HDF-EOS tools **[2]**.

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- Other support provided by NCSA and other sponsors and agencies **[10]**.

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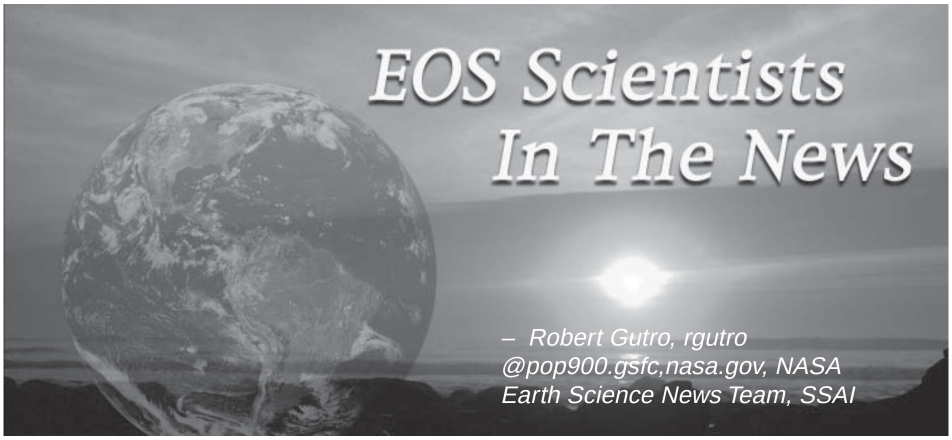
Powerful F4 Tornado Rips Through Southern Maryland

A number of severe thunderstorms swept through the mid-Atlantic states on April 28, bringing high winds, hailstones, and heavy rains to many areas. The intense storms spawned at least two tornadoes, one of which was briefly an F4 twister–with winds well over 200 mph. The powerful tornado carved out a path of destruction across St. Marys and Calvert Counties in southern Maryland, located on the western side of the Chesapeake Bay. The worst of the damage was in the town of La Plata, where most of the historic downtown was destroyed. The tornado—the strongest ever recorded to hit the state and perhaps the strongest ever recorded in the eastern U.S.—flattened everything in its path along a 24-mile (39 km) swath running west to east through the state.

The tornado's path can be seen clearly in this pan-sharpened image acquired on May 1 by the Advanced Land Imager (ALI), flying aboard NASA's EO-1 satellite. La Plata is situated toward the lefthand side of this scene and the twister's swath is the bright stripe passing through the town and running eastward 6 miles (10 km) toward the Patuxent River beyond the righthand side of the image. This stripe is the result of the vegetation flattened by the storm. The flattened vegetation reflects more light than untouched vegetation.



Weather Forecast: Wait, April 29 (Los Angeles Times) Bill Patzert (NASA/JPL) discusses the current state of El Niño and the difficulties with forecasting such events.

Jason 1 Mission Transfers Day-to-Day Operations, April 26 (Ascribe News) Lee-Lueng Fu (NASA/JPL) comments on the handover of Jason 1 mission operations from CNES to JPL.

Iceberg Clogs Antarctic Food Chain, April 26 (Discovery.com, UPI, Agence France Presse) Research by Kevin Arrigo of Stanford University and Thorsten Markus of NASA/GSFC showed that the calving of large icebergs in the Antarctic is adversely affecting the growth of phytoplankton and affecting the food chain.

Clouds Play Vital Role in Planetary Greenhouse, April 24 (Cosmiverse.com) EOS Researchers Bruce Wielicki (NASA/LaRC) and Thomas Charlock (NASA/LaRC), explain CERES role on NASA's Aqua satellite and how they are using CERES and MODIS data to gain a better understanding of how clouds and aerosols affect the Earth's radiation balance.

JPL Involved in Water Study, April 24 (Los Angeles Times) George Aumann and Avi Karnik (NASA/JPL) discuss the upcoming Aqua launch and the objectives of the AIRS instrument.

Satellite Quartet to Track Most Precious Earth Resource, April 22 (Associated Press) Bill Patzert and Mike Watkins (NASA/JPL) discussed various Earth Observing System satellites, including Jason, GRACE and Aqua, in studying Earth's hydrological cycle. Moustafa Chahine (NASA/JPL) and Bill Kuo (NCAR) were quoted in a Space.com article.

Atomic Clock Research Hones GPS Accuracy, April 12 (Wireless Newsfactor) Lute Malecki (NASA/JPL) is studying how improvements in atomic clocks are improving GPS research.

"NASA News", April 11 (NASA Tech Briefs) refers to a principal investigator (David Imel, NASA/JPL) who explains how a synthetic aperture radar operates.

Dryden Aircraft Flies Simulated Search, Rescue Mission, April 5 (Aerotech News and Review) David Imel (NASA/JPL) explains how the AIRSAR synthetic aperture radar operates.

Scientists Track Lifecycles of Rain, April 5 (Discovery.com, UPI, SpaceDaily.com) Mike Bosilovich explained how a new computer model can track rain from its source region to where it falls.

...While NASA Finds New Ways To Save Your Bacon, April 4 (A V Web Newswire) David Imel (NASA/JPL) explains the

mission and also describes the work that EOS researcher Bruce Wielicki (NASA/LaRC), and the CERES science team have done to understand how clouds affect the Earth's radiation budget.

NASA Wrestles With Balky Terra Instrument, March 27 (Space.com) William Barnes, a MODIS sensor scientist (NASA/GSFC) said Goddard flight controllers successfully rebooted a critical sensor on NASA's Terra satellite.

Latest El Niño Seen Less of a Climate Bully, March 22 (Reuters) Bill Patzert (NASA/JPL) discusses the current state of El Niño.

New Satellites to Map Gravity More Precisely, March 19 (New York Times) Mike Watkins (NASA/JPL) discusses the role of the GRACE mission in studying Earth's gravity field.

Recent Shifts in Pacific Winds May Support El Niño Formation, March 18 (SpaceDaily.com) Tim Liu (NASA/JPL) was featured in this article about his research on wind data for the Pacific Ocean obtained by NASA's QuikSCAT.

Gravity Field Focus of Mission, March 8 (Pasadena Star-News) Ab Davis and Mike Watkins (NASA/JPL) discuss the GRACE mission and its role in improving our knowledge of Earth's gravity field.

El Niño Effect on Antarctic Seas Seen, March 6 & 25 (USA Today, Associated Press, Space News) Dr. Ron Kwok (NASA/JPL) and Joey Comiso (NASA/GSFC) discuss research into how the Southern Oscillation affects the Antarctic continent.

Orbiting Gravity Mappers Might Spot Oil Fields, March 4 (Aviation Week) Dr. Lute Malecki (NASA/JPL) discusses the Quantum Gravity Gradiometer project,

(Continued on page 26)

Earth Science Education Program Update

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

EARTH SCIENTIST FOR A DAY

Imagine taking snow measurements and recording cloud observations for NASA researchers. Sound like a difficult job? How about for a sixth grader? Think again. This opportunity came to over 1,750 students in the Upper Midwest through a program led by Kevin Czajkowski at the University of Toledo. Czajkowski and a team of researchers developed an educational outreach program, funded by the NASA New Investigator Program, that enabled teachers and students to collect data for a global change study.

Beginning in summer 2000, the University of Toledo hosted a "Global Change and Remote Sensing Seminar" for elementary and secondary teachers in Ohio, Michigan, and Pennsylvania. Teachers learned about climate-related topics, such as solar radiation, weather observing techniques, satellite imagery, and global climate change issues. They also developed classroom lesson plans, which introduced students to principles of remote sensing and global climate change through handson data collection. Back in their classrooms, teachers helped the students identify and record cloud cover and type, 24-hour snow depth, and snow water equivalent.

Czajkowski compared the students' snow data with Moderate Resolution Imaging Spectroradiometer (MODIS) snow cover data over the midwestern U.S. The results of these comparisons were revealed in a Webcast to all participating schools on the last day of Earth Week, April 26, 2002. Plans are to continue the Global Change and Remote Sensing Seminars for at least five more years and the project will recruit teachers for next winter's program. For more information, see: *Earthobservatory.nasa.gov/Study/ForADay/*.

VOLVO OCEAN RACE AROUND THE WORLD

The Volvo Ocean Race is an around-theworld yacht race that began in England in September 2001. Its 32,000-mile route takes the crews and the 64-foot sailboats through some of the most rough and remote regions of the world's oceans. Theyachts arrived in the Chesapeake Bay area on April 17 for an 11-day stopover. The race will finish in Germany in June. The Volvo Ocean Adventure website is the educational component of the race and contains a variety of environmental topics and is a collaboration of 20 universities and scientific institutions around the world, including NASA.

NASA is supporting the Volvo Ocean Adventure by providing content, images and near-real-time maps for the regions of the world's oceans in which the yachts will be sailing. Each of the yachts is equipped with an instrument package to measure sea surface temperature and ocean color (from above-water radiometers), and these measurements are telemetered back to the race office several times per day. For more information see: *www.volvooceanadventure.org/article.php/home.html.*

EDUCATION RESOURCES

CLIMATE TIME LINE INFORMATION TOOL
www.ngdc.noaa.gov/paleo/ctl/

The Climate Time Line Information Tool (CTL) is being developed and evaluated by science educators at the University of Colorado and NOAA as a tool for exploring the complex world of climate science and history. The developers ultimately see the prototype supporting science concepts such as systems, cycles, energy transfer, patterns and scale, and science as inquiry. The site's basic design is an interactive matrix that uses the "powers of ten" approach to frame 1) climatic processes and 2) specific climate events of the past at varying time scales. Each time scale has its own list of sources and links to more information. The web site is a work in progress and the developers would like feedback from science educators and students. Audience: college level instruction.

CLOUDS IN THE GREENHOUSE
science.nasa.gov/headlines/y2002/22apr_ceres.htm?list474867

As vexing as they are beautiful, clouds play an important role in Earth's planetary greenhouse. This recent story on Science@NASA provides information on the role clouds play in our climate system, how NASA researchers are studying them, and links to related resources.

EARTHLIGHT AT NIGHT
hantwrp.gsfc.nasa.gov/apod/image/0011/earthlights_dmsp_big.jpg

This site shows the whole planet at night and illustrates interesting urban and transportation patterns as illuminated by human-made lights. Attention-grabbing patterns emerge: the scarcity of lights for North versus South Korea, the ribbon of lights along the Nile river, the township and range of the U.S. high plains grid, and the lifeline of lights along the Trans-Siberian Railroad in Russia. Visit the site to see them!

GREEN COMMUNITIES-STUDENTS AND SUSTAINABILITY
www.epa.gov/greenkit/student.htm

From EPA, this page is designed for teachers who wish to introduce the concepts of sustainability into their classrooms. The site has a variety of individual or group education resources, especially for science fairs. Subjects include stream ecology, brown fields, endangered species, energy, international development, non-point pollution sources, and much more. The site separates these resources into three categories: K-8, 9-12, and teacher references.

SCIENCE NEWS

For the latest NASA Earth science news, visit the NASA Earth Observatory (*earthobservatory.nasa.gov*) or Science@NASA (*science.nasa.gov/*).

EOS SCIENTISTS IN THE NEWS
(Continued from page 24)

while Mike Watkins discusses the GRACE mission.

Future Volcanic Eruptions May Cause Ozone Hole Arctic, March 4 (UPI, Space Daily, Weather.com) Azadeh Tabazadeh (NASA/Ames) said her research shows an ‘ozone hole’ could form over the North Pole after future major volcanic eruptions.

Assorted stories, February 2002. NASA Marshall scientists at the Global Hydrology and Climate Center at the National Space Science and Technology Center continued to be featured in articles related to a global lightning-distribution map they created using satellite data. Articles appeared in: Aviation Week & Space Technology (Feb. 7, 2002), the Boston Globe (Feb. 12), the Toronto Globe and Mail (Feb. 28), the Mobile Register (Ala.) (Feb. 27), the Daily Commercial in Leesburg, Fla. (Feb. 27), the News Press in Fort Myers, Fla. (Feb. 27), and the Tullahoma News (Ala.) (Feb. 6). Scientists mentioned or quoted in these articles included Hugh Christian, Dennis Boccippio and Rich Blakeslee.

KUDOS

The Earth Observer staff wishes to congratulate these colleagues on their outstanding accomplishments.

- The **National Academy of Engineering** has elected 74 new members and seven new foreign associates to its membership. The following EOS colleagues were among those elected:

  Robert E, Dickinson, professor, Earth and atmospheric sciences, Georgia Institute of Technology, Atlanta, "for pioneering contributions to a wide range of topics in atmospheric dynamics and Earth system modeling."

  Warren M. Washington, senior scientist and head, climate change research section, National Center for Atmospheric Research, Boulder, CO, "for pioneering the development of coupled climate models, their use on parallel supercomputing architectures, and their interpretation."

- The **National Academy of Science** elected 72 new members and 15 foreign associates from 12 countries in recognition of their distinguished and continuing achievements in original research. Among those elected was **Veerabhadran Ramanathan and Victor C. Alderson**, Professor and director respectively for the Center for Clouds, Chemistry, and Climate, Scripps Institution of Oceanography, University of California, San Diego, La Jolla.

- The **National Science Board (NSB)** has elected Warren Washington, National Center for Atmospheric Research (NCAR), to serve as its chairman.

EOS Science Calendar

June 17-19

Second Public Workshop on the Strategic Evolution of ESE Data Systems (SEEDS), San Diego, CA, Contact: Kathy Fontaine, e-mail: Kathleen.S.Fontaine.1@gsfc.nasa.gov, tel: (301) 614 5582. URL: www.westoverconferences.com/secondseeds/Index.htm.

July 15-19

Community Outreach Workshop on MODIS Vegetation Variables (VI/LAI/FPAR/NPP), University of Montana, Missoula, MT. Contact: Steven Running, e-mail: swr@ntsg.umt.edu. URL: www.forestry.umt.edu/ntsg/MODISMTG.

July 17-19,

SORCE Science Working Group, Steamboat Springs, CO. Contact: Vanessa George, e-mail: vanessa.george@lasp.colorado.edu. URL: lasp.colorado.edu/sorce/July02SummerMeeting.html.

July 22-24

MODIS Science Team Meeting, Greenbelt, MD. Contact: Barbara Conboy, e-mail: bconboy@pop900.gsfc.nasa.gov. URL: modis.gsfc.nasa.gov/sci_meetings/.

July 22-26

The International Tropical Rainfall Measurement Mission (TRMM) Science Conference, Honolulu, Hawaii. Contact: Robert Adler, e-mail: robert.adler@gsfc.nasa.gov.

Global Change Calendar

June 5-7

59th Eastern Snow Conference, Stowe, VT. Contact Ken Rancourt, email: K.rancourt@mountwashington.org.

June 11-13

Third International Symposium on "Remote Sensing of Urban Areas," Istanbul, Turkey. Call for Papers. Contact Filiz Sunar Erbek, e-mail: fsunar@srv.ins.itu.edu.tr, URL: www.ins.itu.edu.tr/rsurban3.

July 7-10

Second Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA) Science Conference, Manaus, Brazil. Contact Flavio Luizao of the National Institute for Space Research (INPE), Manaus, Brazil, e-mail: luizao@cptec.inpe.br.

July 9-12

2002 Joint International Symposium on GeoSpatial Theory, Processing and Applications, Ottawa, Canada. Call for Papers. For details, tel. +1 613 224-9577; e-mail: exdircig@netrover.com; URL: www.geomatics2002.org.

September 2-6

ISPRS Commission V Symposium, Thessaloniki, Greece. Call for Papers. Contact Prof. Alexandra Koussoulakou, e-mail: kusulaku@eng.auth.gr.

September 3-6

Pan Ocean Remote Sensing Conference (PORSEC) 2002, Bali, Indonesia. Contact Bonar Pasaribu, e-mail: bonarpp@indosat.net.id, URL: www.porsec2001.com.]

September 9-13

ISPRS Commission III Symposium 2002, Graz, Austria. Contact Institute for Computer Graphics and Vision, tel. +43 316 873-5011, email: office@icg.tugraz. ac.at, URL: www.icg.tu-graz.ac.at/isprs.

September 18-25

Joint CACGP/IGAC 002 International Symposium, "Chemistry Within the Earth System: From Regional Pollution to Global Change," Crete, Greece. Contact Maria Kanakidou, email: mariak@chemistry.uoc.gr, URL: atlas.chemistry.uoc.gr/IGAC2002.

September 23-27

Conference on Sensors, Systems, and Next Generation Satellites VIII (RS03), an SPIE Symposium on Remote Sensing, Crete, Greece. Contact Steve Neeck, email steve.neeck@gsfc.nasa.gov, or SPIE, email: spie@spie.org.

October 14-19

COSPAR Scientific Commission A, Houston, TX. Contact Robert Ellingson, email: bobe@metosrv2.umd.edu, tel. 301-405-5386.

October 23 - 27

SPIE's Third International Asia-Pacific Environmental Remote Sensing Symposium 2002: Remote Sensing of the Atmosphere, Ocean, Environment, and Space, Hangzhou, China. URL://spie.org/Conferences/Calls/02/ae/.

October 26-28

3rd International Symposium on Sustainable Agro-environmental Systems: New Technologies and Applications, Cairo, Egypt. Contact Derya Maktax, e-mail: dmaktav@ins.itu.edu.tr.

December 3-6

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

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