Earth Observing System

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In this issue . . .

EDITOR'S CORNER

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On December 18, 1999 Terra was successfully launched aboard an Atlas IIAS launch vehicle from Vandenberg Air Force Base

photo by Bill Ingalls/NASA Headquarters

I'm happy to report that on December 18, Terra was successfully launched aboard an Atlas IIAS launch vehicle from Vandenberg Air Force Base. Terra, formerly known as EOS AM-1, is the 'flagship' of the Earth Observing System, whose primary objective is to simultaneously study clouds, water vapor, aerosol particles, trace gases, land surface and oceanic properties, and the interactions between them and their effects on the Earth's energy budget and climate. Its launch marks the beginning of a new generation of Earth science, and is designed to provide scientists and policy-makers with information on the complex interactions between land, sea, atmosphere, and ice, and will enable periodic 'check-ups' on the health of the planet. The satellite achieved its initial elliptical orbit with a maximum altitude of about 650 km above the Earth's surface in about 13 minutes after launch. Ultimately, it will be in a Sun-synchronous polar orbit at 705 km.

The spacecraft, built by Lockheed Martin Missiles and Space in Valley Forge, Pennsylvania, is currently on orbit and undergoing activation. Late in January, flight controllers will begin the detailed checkout of the five state-of-the-art instruments in preparation for acquiring the first Earth science data.

NASA's Active Cavity Radiometer Irradiance Monitor Satellite (ACRIMSAT)—a satellite designed to measure the total amount of sunlight falling on the Earth's atmosphere, oceans, and land, and thereby improve predictions of long-term climate change—lifted off from Vandenberg Air Force Base at 11:13 p.m. Pacific time, December 20 aboard a Taurus launch vehicle.

The night launch of ACRIMSAT begins a five-year science mission to monitor incoming solar radiation and help scientists determine whether an increase in sunlight is contributing to a rise in global temperatures. The Active Cavity Radiometer Irradiance Monitor (ACRIM III) sun sensor, managed by NASA's Jet Propulsion Laboratory, is the third in a series of missions to measure variations in total incoming solar energy, known as total solar irradiance.

ACRIMSAT lifted off from Vandenberg Air Force Base at 11:13 p.m. December 20 aboard a Taurus launch vehicle.

The solar-monitoring satellite, a secondary payload riding along with the primary Korea Multi-Purpose Satellite, was deployed 16 minutes after launch, at 11:29 p.m., some 90 seconds after the primary satellite was released. Ground controllers at the McMurdo Ground Station in Antarctica acquired ACRIMSAT's signal about 20 minutes after launch, at about 11:33 p.m. The 115-kg satellite is currently circling Earth in a polar orbit at an altitude of 685 km.

With the successful launch of ACRIMSAT, NASA finished 1999 having successfully launched four EOS satellites into low-Earth orbit. Landsat 7 continues to perform extremely well eight months after its launch from Vandenberg Air Force Base on April 15, as does QuikScat, designed to make all-weather global ocean-surface wind speed and direction measurements with its SeaWinds scatterometer, also launched from Vandenberg on June 19—indeed a banner year for the Earth Science Enterprise!

Also in December, NASA announced that it will flight-test an instrument using new technologies to measure elements of the Earth's atmosphere and to support space based research aimed at reducing risks from severe weather. This measurement concept, known as the Geostationary Imaging Fourier Transform Spectrometer (GIFTS), has been selected as the next Earth-observing mission under NASA's New Millennium Program, and is scheduled for a 2003 launch.

The mission—known as "Earth Observing

3"—will test advanced technologies for measuring atmospheric temperature, water vapor, wind, and chemical composition with high resolution, in space and over time. Such sophisticated measurements have the potential for revolutionary improvements in weather observation and prediction, by providing unique observations of the spectral properties of clouds and the transport of pollutants in the atmosphere.

Managed by NASA's Langley Research Center, the mission uses an advanced imaging spectrometer based on breakthrough technologies such as a large-area focal-plane array, new data-readout and signal-processing electronics, and passive thermal switching. Today's geostationary satellites observe Earth, its atmosphere and oceans, in only a few selected spectral bands. This new instrument will extend observational capabilities to several hundred spectral bands that will provide both additional and more detailed information.

NASA selected this concept from four finalist ideas culled from 24 proposals submitted in response to a NASA Research Announcement released in September 1997. The theme for the solicitation was to test innovative approaches for observing Earth's surface and atmosphere from positions outside low-Earth orbits, with an emphasis on advanced measurement concepts and technologies.

The selection process was carried out by NASA Headquarters, and included evaluations of each concept study by external peer reviewers. The total NASA cost of the mission, including its contribution to the launch, is expected to be approximately $105 million.

The first Earth-orbiting mission under the New Millennium Program, Earth Observing 1, is scheduled for launch in April 2000. Managed by NASA's Goddard Space Flight Center, this mission will demonstrate an advanced land-imager system and hyperspectral imaging technologies that may eventually replace the current measurement approach used by Landsat satellites.

The next EOS Investigators Working Group meeting will take place April 11-13 in Tucson, Arizona at the Hilton East Hotel. The main themes of the meeting will be early science results from Terra, and topical sessions on ocean, land and atmospheric science findings from recent missions such as Landsat 7, QuikScat, and ACRIMSAT. EOS validation activities, new IDS team introductions, and European and Japanese Earth observation mission status overviews will also be presented. Logistics, travel information, and a draft agenda can be found at eospso.gsfc.nasa.gov/eos_homepage/logreg.html.

Congratulations

The Earth Observatory
earthobservatory.nasa.gov

In the September issue of Popular Science magazine, the Earth Observatory was chosen as one of the "50 Best Science & Technology Web Sites," and listed first among those recognized on their site for "Earth and the Environment."

The Earth Observatory was selected by the Washington, DC, Chapter of the Society for Technical Communication (STC is one of the largest, most prestigious professional writing organizations in the world) to receive an award and "Best of Show" in their Online Communication Competition.

The Earth Observatory has also been recognized in the following ways:

- GovSpot's Site of the Week
- The Scout Report for Science & Engineering
- StudyWeb Academic Excellence Award
- One of the top featured sites under "Fun Learning" on Educating.Net

The Earth Observer staff wishes to congratulate Earth Observatory Team Members:

David Herring, SSAI; Robert Simmon, GSFC DAAC; Kevin Ward, SSAI; Reto Stockli, USRA; Craig Mayhew, SSAI; John Weier, SSAI; Michael Heney, SSAI; Stephen Cole, Raytheon; Emilie Lorditch, Raytheon; Steven Graham, Raytheon; Marguerite Syvertson, JPL; Stephanie Stockman, SSAI; Annette Varani, U. of Colorado; Bill Bandeen, Raytheon; and Renny Greenstone, Raytheon.

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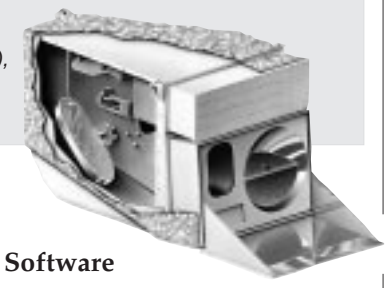
Science Editorial Board:

Michael King, NASA GSFC; Yoram Kaufman, NASA GSFC; Claire Parkinson, NASA GSFC; Darrel Williams, NASA GSFC; Mark Abbott, Oregon State U.; Michael Abrams, JPL; John Gille, U. of Colorado; James Hansen, NASA GISS; Ralph Kahn, JPL; V. Ramanathan, Scripps Institution of Oceanography; Steven Running, U. of Montana; and Bruce Wielicki, NASA LaRC.

Moderate Resolution Imaging Spectroradiometer (MODIS) Science Team Meeting Summary

— *Deborah Howard (dhoward@pop900.gsfc.nasa.gov), Science Systems and Applications, Inc.*



The complete set of these minutes and attachments is available in Portable Document Format (PDF) on the MODIS Meetings Page at modarch.gsfc.nasa.gov/MODIS/SCITEAM/minutes.html.

Introduction

The MODIS Science Team meeting was held on November 16–18, 1999 at the Sheraton Columbia Hotel in Columbia, MD. Vince Salomonson, MODIS Science Team Leader, welcomed participants and said Terra is ready for launch. The focus of the meeting was MODIS Science Team Launch preparedness.

EOS/MODIS Budget Status/Team Recompete

Michael King presented an overview of the EOS/MODIS Budget Status and Science Team Recompetition. A brief description of the EOS budget status is included in his editorial in the last *Earth Observer* (see *The Earth Observer*, September/October 1999, Vol. **11**, No. 5). *The Reference Handbook* (1999 edition) includes a substantial update from the 1995 version. It describes the science and contacts for 72 EOS Interdisciplinary Science Investigations. The new chart of missions is kept updated on the Web (see eospso.gsfc.nasa.gov/eos_homepage/missions.html).

Level 1 Software Status

Francesco Bordi presented an overview of MODIS Level 1 (L1) software status. The L1 product suite, which includes five PGEs, is ready for launch except for minor fixes that are to be completed within the next few weeks. Rich Hucek briefly reviewed the change history of Cloud Mask PGE03 and discussed the differences between recent versions.

Level 1 QA Plans

Bruce Guenther reported on L1B Quality Assurance (QA) plans and reviewed a map of planned validation activities drawn from his presentation on Validation and Operational QA of L1B at the May 1999 Science Team meeting. (For more details see: modarch.gsfc.nasa.gov/MODIS/SCITEAM/199905/attachments.html.) The MODIS Characterzation Support Team (MCST) has planned a range of validation activities, including operational, characterization, and vicarious activities.

GDAAC Operations Readiness: L1 Production, Archive, Distribution, and User Services

Steve Kempler reported on GDAAC Readiness regarding L1 production, archive, distribution, and MODIS user services. The DAAC has tested the performance of the system by ingesting and processing data and sending data to the MODIS Adaptive Processing System (MODAPS). The system is expected to improve and run more in an automated rather than manual mode. Two test modes, Test Set 1 (TS1) and TS2, run in parallel with the Operations (Ops) mode at the DAAC.

MODAPS Level 2/3 Production Readiness, Throughput Performance, Production Plan

Ed Masuoka reviewed MODAPS Level 2 and Level 3 production readiness, throughput performance, and production plans. To order products, use standing orders, FTP push, or order from MEBDOS. Masuoka said that post-launch algorithm updating and scheduling would be developed with Discipline representatives. A Terra data product availability schedule that includes MODIS product availability can be found on the Web at: grid2.gsfc.nasa.gov/~todirita/terra/terra_dataprod.html.

MODAPS to SCF Data Distribution Capacity and Readiness

Ed Masuoka reviewed Terra QA Science Computing Facility (SCF) Sites Network Requirements versus Measured Performance and QA data flows to MODIS SCFs and Readiness for Production. He said that the QA network requirements are fully ramped up, including the MODIS proposed flows. Bob Evans said that the Broadband Network Switch (BBNS) had some hardware problems. Masuoka advised contacting the operations manager of the Consoli-dated Space Operations Contract (CSOC) Network Operations Center on network problems.

GDAAC Operations Readiness: Level 2/3 Ingest, Archive, and Distribution

Steve Kempler discussed GDAAC Operations Readiness: L2/L3 Ingest, Archive, and Distribution. He described three ways to access MODIS Data from the GDAAC. These are access via the EOS Data Gateway (EDG) system, anonymous File Transfer Protocol (FTP), and subscription. Kempler said that sample products would be available and data would be automatically pushed to subscribers. The Science Investigator-led Processing Systems (SIPS) interface between MODAPS and the DAACs is working well.

Early Products

Yoram Kaufman gave an impromptu talk on planning for early products and images. A coordinated release of first images from all five Terra instruments is planned. He advised the MODIS team to be ready to produce some quick, possibly global, images.

Early Product Planning: MODIS Roles and Responsibilities

Al Fleig reviewed early product planning and MODIS roles and responsibilities. He discussed developing a standard for MODIS images and options for including MODIS and/or EOS logos, credits, and references. He suggested that sample images exemplify the uniqueness of MODIS capabilities.

Aqua Instrument Status

Neil Therrien reported on FM1 status. Thermal vacuum 3 (TV3) was completed in August 1999 and initial objectives were accomplished. The instrument is scheduled to ship to TRW on November 17, 1999. SBRS plans to continue analyzing issues and monitoring anomalies.

EDC Readiness: Transfer and Ingest from MODAPS, Distribution of MODIS Data, User Services

John Dwyer reviewed EDC DAAC Terra Readiness. EDC plans to release data to the public at about L+120, based on receiving data from MODAPS at L+60, as planned. They are also planning on receiving some early data at L+35. EDC has a dedicated e-mail address (edc@eos.nasa.gov) and Web page for user services (edc.usgs.gov/landdaac). They plan to work with the MODIS Land group on developing labeling for MODIS images.

NSIDC Readiness: Transfer and Ingest from MODAPS, Distribution of MODIS Data, User Services

Greg Scharfen reported on NSIDC readiness, summarized MOSS-3 testing, and presented highlights of the ORR. He said NSIDC is on track for MODIS operations. Testing is on schedule, but was affected by some metadata errors, low data volume, and slowed down MODAPS production. NSIDC is a 5x9 (5 days and 9 hours per day) DAAC that is smaller than the GDAAC, a 7x24 operation. It has developed a Web page that can be accessed through the MODIS Web page.

The MODIS Web Site

Michael Hohner presented an overview on the MODIS Web site and recent updates and plans for it. The MODIS Document Archive (MODARCH) contains about 8000 records, including meeting minutes and attachments, publications, and a historical archive of ATBDs. Hohner has redesigned and linked the MODIS Atmosphere page to their own Web site (see modis-atmos.gsfc.nasa.gov/). The MODIS Land and Ocean Discipline Groups are developing similar sites that will be linked to the MODIS Web pages. Hohner is coordinating MODIS Web development with the DAACs to reduce duplication of content.

Future changes to the MODIS site include new/updated images to provide a uniform look to the pages, reformatting to provide logical organization of information and provide a portal to other MODIS sites, and moving from a frames to a non-frames version of the site. This will make it easier for other sites, such as the DAAC, to link to MODIS.

Coordination of MODIS-Related Web sites

Chris Justice presented a preliminary draft of a map of MODIS-related Web sites and encouraged the group to coordinate their MODIS Web site efforts. MODIS-related Web sites include MODIS news, early images, meetings, and links to the MCST Level 1B sites, Land product status, SCFs, Atmosphere products, Oceans sites, the DAACs and other MODIS-related sites. Wayne Esaias suggested that it would be useful to develop a guide to the MODIS-related sites and advertise this structure/map on the MODIS Web site.

NOAA

Gene Legg reported on the National Oceanic and Atmospheric Administration (NOAA) MODIS progress. The NOAA system is a copy of the MODIS Adaptive Processing System (MODAPS). However, NOAA has limited the scope of their products to the United State mainland. They are keenly interested in MODIS Oceans, Atmosphere, and Land products.

Terra Launch Status

Kevin Grady presented an overview that traced the Spacecraft Status and progress of recent preparations for the upcoming Terra launch. Rehearsals and simulations

were conducted and the spacecraft was fueled on October 27, 1999. Once on-orbit, an approximately 90-day checkout periodis planned. At about Day 60, a Science Working Group for the AM Platform (SWAMP) will be convened to assess instrument checkouts and determine when a deep space maneuver would be scheduled.

SeaWiFS

Chuck McClain presented an update on SeaWiFS that included terrestrial and atmospheric applications. Using Global Area Coverage (GAC) and Local Area Coverage (LAC), the SeaWiFS project schedules coverage over validation sites and can also schedule over ships of opportunity. McClain said the DAAC has done a great job of distributing SeaWiFS data. The SeaWiFS project, MODIS Oceans Discipline team, and SIMBIOS project collaborate. SeaWiFS is planning to add some new products and would like to expand their product suite. McClain said they are looking for partnerships.

Closing Remarks

Vince Salomonson advised the MODIS Science Team to continue to plan for early images and how to label them. He asked for suggestions on when to hold the next MODIS Science Team meeting and recommended having an early results symposium at about 9 months after launch.

MODIS Discipline Group Meetings

The MODIS Atmosphere, Land, and Oceans Discipline Groups had breakout meetings after the MST plenary sessions. MODIS Science Team minutes were not taken for the Atmosphere group. Brief summaries of the Land and Oceans group meetings follow.

MODLAND

The Land Discipline group discussed versioning, metadata, and look-up table issues and the need for more feedback on MOSS-3 for the Land team. They also discussed early images and preparing for PR issues related to early images.

Oceans Group

The Oceans Discipline group discussed the MOCE-5 Cruise (October 1–21, 1999), MODAPS processing status, PI processing, Oceans science product status, QA, early images, validation activities, Oceans Web site contacts and coordination, and Oceans team members' projects and activities.

KUDOS • KUDOS • KUDOS • KUDOS • KUDOS

Dr. William K. Lau, of NASA Goddard Space Flight Center (Greenbelt, Md.), is the 1999 recipient of the William Nordberg Memorial Award for his Earth science research. Lau is the sixth recipient since the Goddard honor was first introduced in 1994.

Lau is the head of the Climate and Radiation Branch in Goddard's Laboratory for Atmospheres. He is recognized for his unique insight in explaining tropical atmosphere-ocean behavior and his leadership in various world climate research projects and NASA Earth Observing System interdisciplinary investigations, involving significant collaboration with research organizations, and universities in the U. S. and abroad.

Dr. Roger Barry, an Arctic climatologist and Chief Scientist of the National Snow and Ice Data Center, University of Colorado, was elected Fellow of the American Geophysical Union.

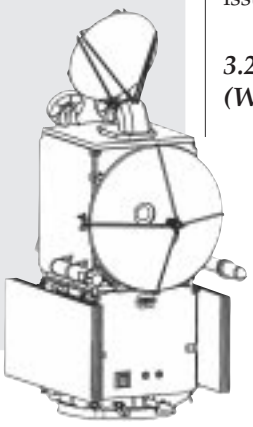
Nominated by his peers, Barry receives the award in recognition of his outstanding research, teaching and service in climatology. Specializing in polar and regional alpine climates, Barry became interested in meteorology at age 14 and has since studied climate both on the ground and using remote sensing satellite imagery. Barry is an EOS IDS investigator, a member of the DAAC User Working Group, serves as an IWG Panel member, and is an ATBD reviewer.

Dr. Michael D. King was awarded The Verner E. Suomi Award at the American Meteorological Society's annual meeting in Long Beach, California. The citation reads "for significant and fundamental contributions to remote sensing and radiative transfer, and for leadership in spacecraft experiments." Dr. King is the EOS Senior Project Scientist and a member of the MODIS and CERES Science teams.

The Earth Observer wishes to congratulate these outstanding scientists for their accomplishments in the world of remote sensing.

Summary of the Second Joint TOPEX/POSEIDON and Jason-1 Science Working Team Meeting

— *Lee-Lueng Fu (llf@pacific.jpl.nasa.gov), Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA.*
— *Yves Menard, Centre National d'Etudes Spatiales, Toulouse, France*



The second joint TOPEX/POSEIDON (T/P) and Jason-1 Science Working Team (SWT) Meeting was held on October 25-27, 1999 in St. Raphael, France, following the first International Conference on the Ocean Observing System for Climate (October 18-22). More than 200 members and guests attended the meeting. The meeting had three components: project status and plans (plenary), topical splinter meetings, and science results (posters).

1. TOPEX/POSEIDON Status

A review of the T/P mission operation since the last meeting in Keystone, Colorado (October 1998) focused on the status of the key instruments and the spacecraft. All systems are functioning well, and the prospects of an extended mission life beyond the launch of Jason-1 are looking good. A major event during the past year was the switch of the NASA dual-frequency altimeter (ALT) from its Side A to Side B. The slight deterioration of the performance of Side A was discussed in the Keystone meeting. The switching operation was performed last February. A calibration/validation effort was established to make Side B measurements consistent with Side A before the deterioration occurred. Preliminary analysis suggests that sea-surface heights from the two altimeters are within about 1 cm; additional data are needed to reduce the uncertainty to the desired level of 5 mm or less. A waveform re-tracking effort is also underway to produce a consistent data set throughout the mission.

2. Jason-1 Status

The status of each of the main systems of Jason-1 was presented. No significant issues were identified. System integration into the spacecraft is underway. Due to schedule slips in the delivery of the test benches, the testing of the overall system could not be performed according to schedule, causing an inevitable delay of the launch of Jason-1. A Joint Steering Group (JSG) Meeting was held preceding the SWT meeting. The JSG's conclusion called for a launch window between September 15-November 15, 2000 to be identified. A specific new launch date will be determined in January-February, 2000, based on the progress made in the interim.

3. Future Altimetry Missions

3.1 Jason-2

CNES is planning towards a 2004 launch of Jason-2 based on a Proteus spacecraft. Procurement of the spacecraft is scheduled to begin in 2000. The baseline mission will be a copy of Jason-1. Partnerships with EUMETSAT and U.S. NOAA are still open issues.

3.2 Wide-Swath Ocean Altimeter (WSOA)

A new mission concept has been developed by JPL through NASA's Instrument Incubator Program. This concept calls for the utilization of the technique of radar interferometry for making measurements of ocean topography over a swath of about 200 km at a resolution on the order of 10 km. Such a wide-swath ocean altimeter (WSOA) will be able to cover most of the ocean's surface within 10 days, making eddy detection and velocity-vector estimation possible. Mesoscale eddies are the most energetic component of ocean circulation, and their detection requires simultaneous flight of at least three conventional nadir-looking altimeters.

A study was conducted by JPL and CNES on the feasibility of flying WSOA on Jason-2. Preliminary findings of the study were presented. The most serious issue is the incompatibility between WSOA and the safe-hold mode of the Proteus spacecraft. This issue will be further investigated by CNES. Otherwise, a technology demonstration mission for WSOA on Jason-2 is feasible, with the coverage of the ocean significantly limited by the yaw-steering of the spacecraft. However, regional science experiments can be designed to benefit from the mission.

3.3 A Ka-Band Altimeter (ALTIKA)

Motivated by the potential benefits of a low-cost, high-performance altimetric satellite system for observing the oceanic mesoscales, a new concept of Ka-band altimetry (36 GHz) is under study at CNES and Alcatel. By increasing the

frequency, ionospheric effects become very low, so that the use of a dual-frequency instrument for ocean altimetry is no longer critical. On the other hand, cloud liquid water and precipitation (even light rain) attenuate the altimeter signal at the Ka band. It is thus important to analyze thoroughly the impact of rain on Ka-band altimeter measurements. Some preliminary progress has been made.

Another science opportunity of Ka-band altimetry is the application of the data over snow or even sand for which insufficient knowledge of radar penetration at the Ku band has been a limitation in the geophysical interpretation of the measurements. For instance, this is a major issue for the study of ice-sheet mass balance, which is presently of limited accuracy partly due to the penetration effects associated with the Ku-band ERS-1/2 altimeters. Additionally, Ka-band altimetry might improve the horizontal resolution which would benefit oceanic observations near coast, sea-ice, and small inland waters or even continental observations.

Two main technical areas are being explored. First, the bandwidth may be enlarged to 500 MHz so that a high vertical resolution can be achieved (0.3 m instead of 0.45 m for conventional Ku-band altimeters with a 320 MHz bandwidth). Second, the decorrelation time of sea echoes at Ka-band might allow the instrument's pulse repetition frequency to be increased to 4000 Hz for reducing measurement noise. Preliminary performance analysis shows that the noise may be as low as 1.2 -1.4 cm, better than is available with the present Ku-band altimeters.

A preliminary mission proposal named "ALTIKA" has been formulated. This mission would also include a dual-frequency (22/37 GHz) radiometer, a laser retroreflector array, and the DORIS system. Accommodation studies for a CNES microsatellite platform have demonstrated the technical feasibility of the concept of microsatellite altimetry.

4. Topical Splinter Meetings

4.1 Calibration/Validation and 1 mm Altimetry

The most challenging science goal of altimetry is to be able to measure the change of global mean sea level with an uncertainty less than 1 mm/year. To realize this goal, one needs to examine all the sources of measurement error to understand their spatial and temporal characteristics and seek ways to minimize their effects. This splinter group is established to review the performance of the T/P measurements and to formulate the calibration/validation plan for Jason-1.

Based on global tide-gauge analysis, the T/P measurement system drift has been estimated to be 2 mm/year. This estimate was made without application of the TMR (TOPEX Microwave Radiometer) drift correction. The importance of monitoring the vertical motion of land is illustrated at Soccoro where large subsidence could be mistakenly interpreted as sea-level rise. After the correction for the measurement system drift, the current rate of sea-level rise is about 3 mm/year. However, the true long-term rate of sea-level rise would not be known until the time series is at least a decade long.

The status and latest results of the Harvest Platform experiment were presented. With the recent purchase of the platform by Plains Resources, the future of the calibration experiment is better assured. Work is underway to upgrade the measurement systems in anticipation of Jason-1. Based on comparisons with data from the tide gauges and nearby buoys, ALT-B SWH and wind-speed data are unbiased at the 10-cm and 1-m/s levels, respectively. The relative SSH bias between Side B and early Side A is statistically indistinguishable from zero. The 1992-1999 time series of the platform vertical motion determined from GPS was analyzed, indicating that the vertical motion was difficult to determine at the mm/year level even with 5 or more years of continuous data.

Numerous studies were conducted on the estimation of the relative bias between ALT-A and ALT-B. Most results showed that the bias was less than 1 cm with an uncertainty of about 5 mm. Other measurements made by the two altimeters (significant waveheight, ionospheric free-electron content, and the radar backscatter) were also consistent with each other. Monitoring the difference between the radar backscatter from ALT-A and ALT-B revealed the effect of the degradation of ALT-A. Such a monitoring scheme is recommended for Jason-1.

Several investigations of the drift in the TMR measurement were reported. All the investigations were in agreement on the presence of a drift in the altimeter path-delay correction (due to tropospheric water vapor) of about –1 mm/yr (minus sign indicates the correction is decreasing erroneously) through mid-1996. Whether the drift ended near the end of 1996 is controversial, and further analysis is required to reach a conclusion.

The status of the Jason-1 Calibration/Validation (CALVAL) plan was discussed. Contributions from the project, Jason-1 investigators, and associated collaborators are represented in the plan. A major objective is to ensure the continuity of T/P and Jason-1 data. The expected overlap of

the two missions will be exploited, particularly during the verification phase in which the T/P and Jason-1 satellites will fly in close formation. Complementary contributions from dedicated verification sites, in situ networks, and global verification techniques will be used.

The CALVAL plan will be implemented throughout the mission. The assessment phase (2 months after launch) will be dedicated mainly to the system engineering assessment. The verification phase (the next 6 months) will then be used to validate algorithms, verify performance, issue a revised error budget, and make initial estimates of bias and drift (before the science data production starts). During the observational phase (the remainder of the mission), routine CALVAL activities will be undertaken to confirm the long-term performance, and to provide a permanent quality-control function for the data products.

The first draft of the CALVAL plan (issued in November '98) was updated in October '99. This plan includes project-related CALVAL activities as well as contributions from over 30 Jason-1 investigators covering all the aspects of the system (on-site verification, global in situ verification, wet tropospheric and ionospheric correction validation, sea-surface effects, POD verification, wind-wave validation, etc.).

The current draft of the Jason-1 CALVAL plan is available on a web site at CNES (sirius-ci.cst.cnes.fr:8090/HTML/information/missions/jason/calval.pdf). A revised version is scheduled for release by the end of March 2000. A CALVAL kick-off meeting has been proposed for the end of May in Washington D.C. (at the same time as the Spring AGU Meeting), coincident with the final meeting on algorithms and products.

4.2 Precision Orbit Determination (POD) and the Geoid

A goal of the Jason-1 POD is to approach a root-sum-squares accuracy of 1 cm (despite the requirement for 2.5 cm). The current state-of-the-art for T/P POD is approaching 2 cm. The 1-cm challenge is the theme of the splinter group. The proposed charter and current list of members of the POD Working Team was presented at the beginning of the meeting. It was proposed that the objective of the Jason POD Working Team is to provide a forum for the exchange of ideas and development of plans to attain three principal goals: (1) to assure that a level of orbit accuracy at least as good as currently being attained for T/P (of approximately 2 cm radial rms) is continued for the duration of the T/P mission and is also achieved for the Jason-1 mission, (2) to ensure a smooth transition from T/P to Jason-1 by minimizing differences in the characteristics of the orbit errors of the two missions, and (3) to investigate improvements in the models and techniques used for POD that might enable achieving the goal of 1-cm radial orbit errors. There was no question raised regarding the charter, so it is considered approved.

At the last SWT meeting, it was established that the reference systems currently in use could not be expected to cover the full extent of the T/P mission. The CNES reference system exhibited large drifts and, as a consequence, there was a recommendation by the SWT to transition to the International Terrestrial Reference Frame 97 (ITRF 97) as early as possible. The recommendation also included a provision for a reprocessing of the existing T/P orbits for mean-sea-level studies. CNES followed this recommendation in mid-1999, and has been delivering orbits referenced to ITRF 97 since cycle 247. CNES and NASA orbits now compare at the 1.5-cm level rms in the radial direction, which is the difference level that existed before the beginning of the drift in the CNES reference system. It was reported in the meeting that the current NASA reference system was, in the important respects, consistent with ITRF 97, and thus that a transition on the NASA side is not urgent.

Work on gravity-model development was reviewed. GRIM 5 shows residual rms improvements for most satellites, including a small but significant improvement on T/P, with reduced crossover variance. TEG 4 showed improvement in terms of marine geoid. These models, however, are still under development, and no major improvement is expected before data from CHAMP, which is scheduled for launch about mid-2000, can be incorporated. Further significant progress is anticipated with the Gravity Recovery and Climate Experiment (GRACE) and then the Gravity Field and Steady-State Ocean Circulation Explorer (GOCE) dedicated gravity missions. As a consequence, it was decided that there is no need or reason to reprocess the T/P orbit data in the near future. In addition, all of the current models with the addition of the ITRF 97 reference frame will be used for the transition from T/P to Jason-1. They will be used for the production of T/P and Jason-1 orbits until the end of the Jason-1 verification phase. Efforts of the POD Working Team will concentrate on assuring the necessary level of consistency between the NASA and CNES orbits.

The reduction of the radial orbit error from the current 2-3-cm level to the 1-cm level for Jason-1 will be possible only through the combined use of high-quality tracking data and the best models. Thus careful attention has to be paid to selecting these models. The standards which have

been selected for the Challenging Minisatellite Payload (CHAMP) were reviewed. Some questions remain regarding issues such as geocenter variation. It was clearly emphasized that Jason-1 should follow international and mission independent standards as closely as possible. Thus the baseline is to adopt the International Earth Rotation Service 2000 (IERS 2000) standards modified and augmented with models specific to T/P and Jason as needed for the best results. However, members of the POD Working Team should also act now so that the IERS 2000 standards reflect (as much as possible) what is needed for Jason-1. All the members of the SWT involved in the various IERS working groups are asked to contribute to this task.

The question regarding the selection criteria for the geoid model to be placed on the Jason-1 data products was addressed. The best marine geoid model is likely to be dependent on the incorporation of a priori ocean circulation model information, a somewhat circular process. There may be reasons to avoid a geoid model that incorporates ocean circulation knowledge, but unless there are objections, it will be assumed that the model that provides the best representation of the marine geoid will be the preferred choice. Oceanographers are encouraged to help evaluate the candidate geoid models, since the tests available to the POD Working Team are limited.

Several new high-precision, high-resolution mean sea surfaces (MSS) were presented in posters at the SWT meeting. The emphasis appeared to be on reducing the appearance of 'trackiness' in the surfaces in order to provide a better global reference surface that would be applicable to all altimeter missions. A sea surface based only on T/P data, on the other hand, is easier to construct and likely to better represent the mean sea surface in the narrow band along the T/P and Jason-1 groundtrack. It was also noted that the currently employed Inverted Barometer (IB) correction has a substantial geographical mean in some regions. Since the IB correction is usually applied to the altimeter data, except for long-term mean sea-level analyses, the reference mean sea surface should probably also be based on applying the IB correction. These issues affect the choice of the MSS model for Jason-1. Unless there is disagreement from the Jason-1 SWT, it will be assumed that the two slots for the mean surface models allocated in the GDR (geophysical data records) will be for a global MSS and an along-track MSS, both with the IB correction applied. The evaluation plans for selecting the geoid and MSS models for Jason-1 are expected to be finalized by March 2000. The evaluation should take a few months after that.

4.3 Sea-State Biases

Measuring mean sea level in the presence of ocean waves is one of the more difficult problems in radar altimetry. The resultant biases in sea-level measurement are usually corrected using an empirical approach with a residual error on the order of 1% of the significant wave height. This error has become a leading source of error in the T/P data. Significant improvements have been made in sea-state bias estimation algorithms and in the physical understanding of the bias. The sea-state bias splinter group recommended the use of new wind-speed and sea-state bias correction algorithms for Jason-1. The group also presented one information item on new physical understanding of the bias, which could lead to more significant improvements of sea-state bias estimation in the future.

Recommendation 1: Use a new jointly developed wind-speed estimation model for Jason-1. This new model will represent the bias dependence in terms of Ku-band backscatter and significant wave height. The model will be based on empirical data from extensive buoy and NSCAT data sets. While the WC91 model provides a bulk fit to the data the new model reduces the amount of remaining scatter. The new model is mainly motivated by the need for a better wind speed model for sea-state bias correction. The model will be jointly developed by the Southampton Oceanography Center (SOC), NASA/GSFC, and IFREMER. The model will be submitted for publication before the next SWT meeting. Initially the new model corrections will be applied offline to the Jason-1 data.

Recommendation 2: Use a new non-parametric sea-state bias correction for Jason-1 and T/P data reprocessing. The correction will represent the bias as a function of wave height and wind speed, but will use global non-parametric estimates derived from the T/P data set. Verification of these satellite estimates by direct measurements of the bias has been performed. In addition to the bias correction, two quality measures will be provided: a mean bias certainty and a residual bias variance. Results will be summarized and published before the next SWT meeting.

Information Item: The sea-state bias has been found to be highly correlated with wave slope. Wave slope is superior to wind speed for bias estimation and a sea-state bias model including slope is being investigated. The model also provides information on the residual bias. Methods of obtaining global wave-slope estimates are being investigated.

4.4 Tides and High-Frequency Aliases

The time interval of repeat measurements by radar altimeters is on the order of 10

days. High-frequency oceanic motions such as tides and other forms of variabilities with periods less than the Nyquist period would create distortions in the measurement of the low-frequency signals. This is the classical "aliasing" effect in time series measurement. Models of the open ocean tides have been significantly improved by the use of the multiple years' worth of the T/P data. The tidal signals can thus be removed from the T/P data with an rms residual signal of 2-3 cm in the open-ocean. Recent improvements in the coastal tide models as well as in the long-period tide models were reviewed in the meeting. The issue of internal tides was also discussed. It was deemed still a research topic, with no appropriate correction models identified.

Evaluation of new tide models for possible use in the Jason-1 data products was discussed. The task has been led by the CNES data center, AVISO. Up to five models will be evaluated in detail using T/P and ERS-2 data as well as a newly constructed in situ database from WOCE (the World Ocean Circulation Experiment). Manpower support is a serious issue for the task. Volunteers are being solicited.

In addition to tides, recent theoretical and modeling work has pointed out the existence of high-frequency barotropic variability forced by atmospheric pressure and wind. These sources of variability can create sea-level signals of several cm and cause aliasing in the low-frequency signals measured by altimetry. Other sources of high-frequency variabilities discussed in the meeting included internal waves and coastal upwelling events. It became clear in the meeting that more detailed knowledge was needed to characterize the unresolved signals and their impacts on altimetry. Recommendation was made for efforts to re-analyze *in situ* records from current meters, tide gauges, and bottom-pressure gauges, etc.

The inadequacy of the existing atmospheric pressure field in representing the daily cycle (primarily air tides) was addressed with a recommendation for a better climatology of daily cycles. It was also noted that the effects of air tides on sea level had already been included in most tide models, and that one should be careful not to account for them twice. Various model simulations were presented to show skills for removing the high-frequency signals. The model performance seems better for relatively long periods (5-20 days) but poor for periods shorter than 2 days. Recommendations for further studies include improved forcing fields, bathymetry, friction scheme, and data assimilation.

4.5 Algorithms and Data Products

The development of science algorithms and data products involves close interaction between the SWT and the Project. A standing review team (the Algorithms and Products Team) was established to review the development process of each algorithm through its sign-off for configuration control. This review mechanism and the resultant documents have been accepted as an alternative approach to the EOS Algorithm Theoretical Basis Documents.

Approximately 90% of the reviewers' comments received in the last meeting of the Algorithms and Products Team in June 1999 have been analyzed and incorporated into the revision of the documents. Some items are still to be addressed, essentially those concerning altimeter waveform processing. The package of revised documents is scheduled for distribution in the second half of December 1999 as well as late January 2000. Final approval of the algorithms is scheduled for the end of March 2000, which also marks the deadline for the selection of the following geophysical models: the tidal models, the mean sea surface and the geoid, bathymetry, coastline, and land/sea mask.

The definition of the Jason-1 data products was also reviewed. Both the JPL PO-DAAC and CNES AVISO are upgrading their T/P systems to support the operational character of the Jason-1 mission. Physical media (CD-ROMs and/or DVDs) will be used to disseminate fully validated science data products, whereas near-real-time data products will be made available through the Internet in an operational manner. AVISO is also considering the use of dedicated relay satellites to distribute them over Europe, so that dissemination delay and ground-network overloading would be minimized. Samples of Jason-1 products as they are presently defined will be made available to users for training and testing by mid-December 1999.

The requirements that constrain data processing during the T/P and Jason-1 tandem phase were discussed. This issue addresses the compatibility between T/P and Jason-1 products (at the geophysical and environmental correction level, or more deeply in the processing). The discussion was also related to the reprocessing of the T/P ALT-A data, such as the possibility of including the Jason-1 geophysical and/or environmental corrections into the reprocessed data products with the objective of making the T/P products compatible with Jason-1 products at least in terms of the geophysical and environmental corrections. The schedule for the ALT-A reprocessing should then be revisited so that it is compatible with the schedule of the Jason-1 geophysical models (end of March 2000).

Four short presentations were given on the altimeter and radiometer performance and algorithms: details on the Poseidon-2 performance resulting from the analysis of the results of ground tests of the instrument; the improvement of the acquisition and tracking algorithms of the Poseidon-2 altimeter; a new set of retrieval algorithms for the wet tropo-spheric correction, cloud liquid-water content, and sea-surface wind speed from radiometer measurements; and the JMR (Jason-1 Microwave Radiometer) bright-ness temperatures for land contamination near coastlines.

4.6 Multi-Satellite Altimetry

The prospect of having simultaneous flight of T/P with Jason-1 motivates this topic. The conclusion of the Keystone meeting calls for a formation flight of the two satellites along the T/P ground tracks with time separation of a few minutes during the initial calibration/validation phase of the Jason-1 mission. Such a scenario presents the first opportunity of having the same spot of the ocean observed by two altimeters for an extended period of time for comparison and cross calibration. After this phase of the mission is completed, the T/P satellite will be maneuvered into a different orbit for conducting new science experiments utilizing the two altimeters. The conclusion of the meeting calls for an emphasis on using the formation flight for testing ideas of making new measurements as a basis for developing new technologies and methodologies. An example is to estimate the geostrophic velocity vectors along the ground tracks. Such estimation is now available only at crossover points. T/P has made excellent measurements of the large-scale sea-level variability, but the velocity field is poorly sampled. Resolving the energy-containing component of the ocean currents is certainly a key science objective for future altimetric measurement using wide-swath techniques or low-cost multiple satellites.

The current strawman plan is to fly the two satellites in an interleaving orbit pattern with longitudinal separation of 1.4 degrees between the two ground tracks. The overflight times of the adjacent tracks should be synchronized for velocity estimation. A small working group will continue working on the problem to come up with more quantitative results based on eddy-resolving model simulations. The strawman plan will be revised accordingly, based on the new results.

A new idea for flying multiple low-cost altimetric satellites, developed by the Johns Hopkins University's Applied Physics Laboratory was presented. The new technology is based on the delayed-Doppler altimeter technique funded by NASA's Instrument Incubator Program. Multiple altimeters are to be deployed simultaneously into properly chosen formation flight orbits for specific science experiments including the measurement of geostrophic velocity vectors.

4.7 Outreach

Outreach is the act of bringing information, involving T/P and Jason-1 altimetry and their role in providing valuable information, to audiences including the general public, educators, students, data-applications users, and scientists.

Highlights of the outreach efforts made by JPL and AVISO during the past year were summarized in the meeting, including newsletters, monthly image releases, posters on El Niño/La Niña, lithographs about the missions, a new mean sea surface, a CD "Visit to an Ocean Planet," an educator's package (available via the Web), exhibits in various conferences, museums, aquariums, and shopping malls. More information on these activities can be found on the following web sites: www-aviso.cls.cnes.fr; and topex-www.jpl.nasa.gov.

It was stressed by NASA's Oceanography Program Manager that the Ocean Surface Topography team outreach effort needs to be cognizant of the broader scope of oceanography. That is, information derived from altimeters, along with ocean wind and color data are systematic measurements which will be in transition to operations. Hence, we need the following: a greater emphasis on applications, to build a wider group of stakeholders (people who routinely use our data to provide crucial information), and we need to make better connections and collaborate further with agencies such as NOAA and EUMESTAT. We need to put greater emphasis on altimetry as one part of an integrated observing system. Towards this end we need to have connections with international programs such as Argo (a global array of profiling floats) and the Global Ocean Data Assimilation Experiment (GODAE), to be an element in a national prediction system, an element of IGOS, and we need to coordinate with the wind mission counterparts to project the message about ocean forcing response.

CNES has been involved in a summer school for French professors. The altimetry exhibit, now in Paris, will be going to Montreal, Canada in 2001. CNES has produced a video on T/P and is now working on a Jason-1 video on applications. The CD-ROM is in the final stages of completion and will be issued with the next AVISO newsletter.

The University of Colorado's Center for Astrodynamics Research (CCAR) has continued to produce products towards meeting the needs of the applications community. Users include people in-

volved in research on whales, precision underwater activities such as cable-laying, fisheries management and the fishing industry, and the sailboat racing community. CCAR is redesigning its data system such that data are pushed rather than pulled. Much of the data are supplied in ASCII (gzipp) and a subscription service is about to be implemented (see www-ccar.colorado.edu/research/topex/html/topex.html).

An educational web site was hosted at the Texas A&M University, called Oceanworld (oceanworld.tamu.edu). The site is designed to meet the needs of both teachers and students in oceanography. Its use has been growing over the past year and its increased popularity is shown by the increase in web traffic. The students are making good use of the web, and large numbers of students have been reached through the web.

The plans for next year were discussed. AVISO will take the lead on products to support the Jason-1 launch. Ideas include a special website for the launch, Jason merchandise, a full series of applications sheets including El Niño and the Mediterranean Sea, video, and an educational CD-ROM. JPL will also produce materials, a list of which is being worked Another area of emphasis is to provide a stronger link between the SWT and other scientists as well as the general public using the data. Ongoing and planned activities include: SWT poster presentations on the web; altimeter data brochure; press release of significant results; linking individual PI's web sites to the Project sites; and providing inputs to the outreach image galleries.

5. Science Results

A total of 102 posters were presented on the topics of the splinter meetings as well as on mean sea-level change, new measurement techniques, low-frequency variability, and mesoscale and coastal phenomena. Some of the posters can be viewed at the following web address: sirius-ci.cst.cnes.fr:8090/HTML/information/frames/kiosque/users_uk.html.

The 7 years' worth of T/P data has provided the longest time series of sea-level variability for studying the change of the ocean in relation to the El Niño Southern Oscillation as well as ocean dynamics in terms of the planetary-scale waves, the interaction of boundary currents with oceanic gyres, ocean's response to wind and pressure forcing, and the ocean tides. Other applications range from the effects of ocean circulation on the solid Earth to the climatology of ocean waves, precipitation, and air-sea gas exchanges.

6. Next Meetings

To review the launch-readiness of the Jason-1 Calibration/Validation Team, a team meeting is planned for May 2000 in conjunction with the Spring AGU Meeting in Washington DC. The next full-up SWT meeting will be conducted in conjunction with the launch of Jason-1.

7. Acknowledgements

The authors would like to thank the following individuals who organized the splinter meetings and wrote the reports based on which this article was written: Jean-Paul Berthias, John Ries, Susan Digby, Vinca Rosmorduc, Bruce Haines, Seteve Nerem, Patrick Vincent, Shailen Desai, Philippe Gaspar, David Arnold , Pierre-Yves Le Traon, Detlef Stammer, Richard Ray, Rui Ponte, and Christian Le Probost

NASA Announces Earth System Science Fellowships for 2000

An announcement for the 2000-2001 Earth System Science Fellowships was released in December 1999. The deadline for submission of new applications to NASA is March 15, 2000. Information can be found at www.earth.nasa.gov/nra/current/graduate/index.html.

The applications are evaluated through a two-step review process: first through mail/panel review, and then by evaluation of a panel composed of members of academic institutions and research organizations, and representatives of the Office of Earth Science at NASA Headquarters.

The purpose of the Fellowship Program is to train a pool of highly qualified scientists to help analyze and interpret the wealth of data generated by the Office of Earth Science programs. NASA understands that the future of Earth science rests with today's students, who will be tomorrow's scientists. Financial support for pursuing an advanced education obviously plays a vital role in securing the necessary talent to further Earth system science objectives.

Fellowships are given for an initial 1-year term and may be renewed annually for up to 3 years, based on satisfactory progress as reflected in academic performance and evaluations made by faculty advisors. The amount of award is $22,000 per annum, including a $16,000 student stipend and an allowance of up to $6,000 consisting of $3,000 for student expenses and $3,000 for university expenses. The student allowance may be used to defray living expenses, tuition, fees, and other educational expenses. The university allowance may be used for tuition or travel by the faculty advisor or student in support of the student's research. Students receiving these stipends must not receive other Federal funding.

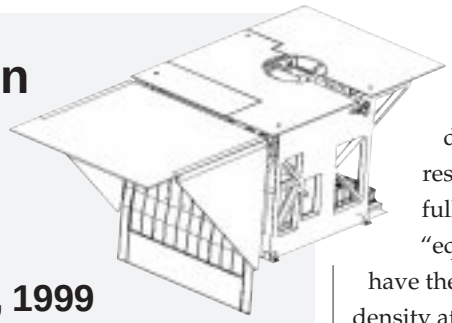
A total of 338 applications were received by the Office of Earth Science at NASA Headquarters for the 1999 Program. Over 103 universities and educational institutions from 40 states were represented. A total of 50 selections were made. The names and affiliations of the 1999 recipients and the titles of their proposals are shown on pages 14-15.

Additional information about this program may be obtained by visiting the web site listed above, or contacting Dr. Ming-Ying Wei, Code YO, NASA Headquarters, Washington, DC 20546.

Fellowship Recipient/ Advisor	*Institution*	*Title*
Bathke, Deborah Mosley-Thompson, Ellen	Ohio State University	Meteorological Processes Controlling the Spatial Temporal Variability of Net Accumulation Implication for the Mass Balance of the Greenland Ice Sheet
Baumgartner, Mark F Mate, Bruce	Oregon State University	Right Whale Ecology in the Northwest Atlantic Ocean
Baumgras, Lynne M Forster, Richard R	University of Utah	Implications of Arctic Warming as Determined by Snowmelt Onset Dates Observed with Remotely Sensed Microwave Data, Streamflow Measurements, and Hydrologic Models of Arctic Watersheds
Boehm, Matthew T Verlinde, Johannensen	Pennsylvania State University	Understanding High Tropical Cirrus
Brocklehurst, Simon H Whipple, Kelin X	Massachusetts Institute of Technology	The Impact of Glacial Erosion on the Relief Structure of Mountain Belts
Carr, David L Whitmore, Thomas M	University of North Carolina	The Migration Origins of Deforestation in a Protected Area: Colonization, Clear-cutting, and Corn in the Sierra de Lacandon National Park (SLNP), Guatemala
Carrasco, Jonathan J Wessman, Carol A	University of Colorado Boulder	Spatial and Temporal Response Nitrogen Deposition in a Heterogeneous Rocky Mountain Watershed
Chowdhury, Rinku R Turner, Billie L	Clark University	Conservation in the Southern Yucatan Peninsular Region, Mexico: Linking Landscape Ecology and Social Institutions
Drake, Jason B Dubayah, Ralph	University of Maryland College Park	Estimation of Tropical Forest Above Ground Using Large-Footprint Lidar
Gasparini, Nicole M Bras, Rafael L	Massachusetts Institute of Technology	The Signature of Climatic and Tectonic Processes in Alluvial Fans: A Numerical Modeling and Remote Sensing Study
Gates, Amelia M Avallone, Linnea M	University of Colorado Boulder	In Situ Measurements of Carbon Dioxide in the Upper Troposphere and Lower Stratosphere
Gewin, Virginia L Dick, Richard P	Oregon State University	Global Climate Change Effects on Carbon Sequestration Mediated by Soil Micro-Organisms
Gumbo, Davison J Turner, Billie L	Clark University	Socializing Miombo Geology: Change in Woodland Use and its Meaning for Sustainable Livelihoods
Guttikunda, Sarath K Carmichael, Gregory R	University of Iowa	Assessment of the Impact of Asian Emissions on a Local, Regional and Global Scale
Harris, Wylie N Boutton, Thomas W	Texas A&M University	Hydrologic Consequences of Shrub Savana Expansion
Harrison, John A Pamela A Matson	Stanford University	Land Use Change, Agricultural Runoff, and Greenhouse Gases in Two Estuaries of Southern Sonora, Mexico
Heliker, Brent Ehleringer, James R	University of Utah	The O of Atmospheric CO_2: Seeing the Grassland Through the Blades
Hilley, George E Arrowsmith, J. Ramon	Arizona State University	The Effects of Tectonic Processes and Climatic Fluctuations on Landscape Development
Horii, Cassandra V Wofsy, Steven C	Harvard University	Nitric Acid and Nitrogen Dioxide Flux Measurements Over a North-American Forest
Howard, Erica A Foley, Jonathan A	University of Wisconsin Madison	Effects of Logging Activity on Biophysical Processes and Carbon Cycling Within Canadian Boreal Forests During Succession
Huang, Yi Turco, Richard P	University of California Los Angeles	Investigation of Aerosol/Cloud Interactions Using a Coupled High-Resolution Dynamics/Microphysics Numerical Model: Development Validation and Application to Field Measurements
Kennedy, Robert E Cohen, Warren B	Oregon State University	Combining Field Measurements and Satellite Imagery with a Probabilistic Model to Quantify Uncertainty in Modeled Net Primary Productivity Estimates
Kiang, Nancy Y Benning, Tracy L	University of California Berkeley	Measurement and Modeling of Carbon, Water and Energy over a California Oak Savanna: Linking the Biophysical and the Ecological
Klimczak, Connie M Krishnamurti, Tiruvala	Florida State University	Inter- and Intra-Annual Variability of the North American Monsoon: A Numerical Modeling Study

Fellowship Recipient/ Advisor	*Institution*	*Title*
Lewicki, Jennifer L Brantley, Susan	Pennsylvania State University	Eddy Correlation Measurement of CO_2 Flux in Volcanic-Hydrothermal Environments
Louis, Valerie Russek-Cohen, Estelle	University of Maryland College Park	Global Climate Change and Cholera: Modeling of Cholera Occurrence in Selected Coastal Area Using Satellite Remote Sensing, In Situ Observations, and Epidemiological Data
Manson, Steven M Turner, Billie L	Clark University	Integrated Assessment and Projection of Land-Use/Cover Change in the Southern Yucatan Peninsular Region in Mexico
Margulis, Steven A Entekhabi, Dara	Massachusetts Institute of Technology	Adjoint Sensitivity Analysis of the Coupled Land-Atmosphere System
Martin, Roberta C Emerson, Steven R	University of Washington	Improving Mode Parameterizations of Gas Exchange: Quantification of Bubble Dynamics by Measurement of Natural Gas Saturations and by Remote Sensing of Whitecap Coverage
Matthew, Brendan M Anastasio, Cort	University of Washington	Formation, Detection, and Quantification of Oxidized Halogen Species in Aerosols from the Marine Boundary Layer
Mauer, Edwin P Lettenmaier, Dennis P	University of Washington	Opportunities of Improving Western Water Management through Remote Sensing and Hydrologic Modeling
McKinley, Galen A Marshall, John	Massachusetts Institute of Technology	Temporal Variability of Air-Sea Gas Fluxes: Estimation and Incorporation into an Inverse Model of the Global Carbon Cycle
Nawri, Nikolaj W Baer, Ferdinand	University of Maryland College Park	Tornadoes: Coherent Flow Structures in Atmospheric Turbulence
Neu, Jessica L Plumb, Raymond A	Massachusetts Institute of Technology	An Investigation of Stratospheric Transport Using the "Leaky Pipe" Model
Olander, Lydia P Vitousek, Peter M	Stanford University	Physio-Chemical and Biological Control Over the Fate of Nitrogen and Phosphorus in Tropical Soils
Popescu, Sorin C Wynne, Randolph H	Virginia Polytechnic Institute and State Uni.	Estimating Forest Vegetation Biomass Using Airborne Lidar Measurements
Powell, Rebecca L Clarke, Keith C	University of California Santa Barbara	Monitoring Population and the Extent of Human Settlement in the Brazilian Amazon with Synthetic Aperture Radar
Ryan, Jessee J Rutledge, Steven A	Colorado State University	Lightning and Radar Observations from Ground-Based and Spaceborne Platforms: Applications for TRMM
Shi, Wei Morrison, John M	North Carolina State University	Water, Heat and Salt Budget in the Northern Indian Ocean
Thompson, David W. J Wallace, John M	University of Washington	The Arctic Oscillation Signature in Northern Hemisphere Climate
Thornton, Joel Cohen, Ronald C	University of California Berkeley	Atmospheric NO_2: Laser-Induced Fluorescence Detection at the Part Per Trillion Level from Aircraft and Balloons
Toole, Dierdre A Siegel, David A	University of California Santa Barbara	A Top-Down Approach to Understanding and Predicting Dimethylsulfide Variability in the Sargasso Sea Using Ocean Color Imagery
von Fischer, Joseph C Hedin, Lars O	Cornell University	Have We Grossly Underestimated Methane Production and Consumption? Application of a New Stable Isotope Technique to Measure Methane Turnover in Soils
Walker, Christopher C Magnusdottir, Gudrun	University of California Irvine	Low Latitude Non-Linear Behavior of Rossby Waves Composed of a Spectrum of Phase Speeds
Westley, Marian B Popp, Brian	University of Hawaii	Sources and Isotopic Compositions of Nitrous Oxide from the Subtropic North Pacific & Eastern Tropical North Pacific
Witter, Jeffrey B Newhall, Christopher.	University of Washington	A New Mechanism for Degassing at High-Sulfur Volcanoes
Yin, Xungang Nicholson, Sharon E.	Florida State University	The Water Balance of Eastern African Great Lakes
Zhou, Liming Myneni, Ranga B	Boston University	The Relation Between Interannual Variability in Atmospheric CO_2, Sea (ENSO) and Land Surface Temperature and Global Vegetation Dynamics Observed from an 18-Year Satellite Sensed Dataset

19th Tropospheric Emission Spectrometer (TES) Science Team Meeting



Harvard University, September 22, 1999

— *Reinhard Beer (Reinhard.Beer@jpl.nasa.gov), TES Principal Investigator, Jet Propulsion Laboratory, Pasadena, CA*

The meeting began with Tom Glavich (JPL) giving an update on the TES instrument development. An important milestone was a successful CDR in June of this year, so instrument design is now essentially complete.

The Partial Engineering Model is currently undergoing testing and procurement of Protoflight hardware has begun. A very important test was to determine that the interferometer section itself remains undistorted on going from room temperature to 180K and back again. There are, of course, some expected dimensional changes but no twist or warpage. This means that the interferometer can be aligned at room temperature with good confidence that it will remain so at 180K.

Helen Worden (JPL) then gave an update on algorithm development. The biggest issue was the revision of the Algorithm Theoretical Basis Documents, due on Oct. 1. This was successfully accomplished.

Assignments of Standard Product species was also a topic. The immediate task is to assemble climatologies from whatever sources are available. The assignments are listed in the table.

A major highlight of the meeting was the presentation of the Harvard GEOS 3-D chemical-dynamical model of the global atmosphere that uses Goddard's Data Assimilation Office (DAO) input for the meteorology. In particular, a 3-month, 4-hour time-step, movie of continental outflow from east Asia created considerable interest.

Reinhard Beer (JPL) then led a discussion on global sampling strategy. The current baseline is "4-days-on, 4-days-off" but it has been suggested that "8-days-on, 8-days-off" might be better. It was, therefore, agreed that Harvard would run their model for an entire model year (1994), upon which JPL would superimpose a set of strategies to see which one does the best job of capturing the features of the model. The results will also be invaluable for the design of our Level 3 product. [Ed. Note: the model data were delivered to JPL in early November].

CH_4, N_2O	H. Worden (JPL) & F. Murcray (U. Denver)
CO	R. Beer (JPL) & M. Luo (JPL)
H_2O, T	F. Murcray (U. Denver), S. Clough (AER) & D. Rider (JPL)
HNO_3	A. Goldman (U. Denver)
NO	C. Rodgers (Oxford U.)
NO_2	C. Rinsland (NASA LaRC)
O_3	S. Clough (AER) & C. Rinsland (NASA LaRC)
CO_2	K. Bowman (JPL) & H. Worden (JPL)

This discussion lead naturally into a consideration of strategies for reducing data volume were insufficient resources available to analyze the full data set. One suggestion was an "equal area" approach that would have the effect of reducing sampling density at high latitudes. This discussion is on-going.

Daniel Jacob (Harvard U.) gave an overview of the outcome of the Snowmass meeting where, for almost the first time, the in situ tropospheric chemistry community met with the remote sensing community. A number of interesting ideas emerged from this meeting, especially several suggestions for GTE-type missions that could be operated in concert with satellite overpasses.

David Rider (JPL) expanded on this theme in the context of TES post-launch validation. Intercomparisons with HIRDLS, OMI and MIPAS are already in the planning stage.

Steven Larson (JPL) discussed our SIPS ("PI mode") data processing proposal. The TES team is eager to see this proposal succeed because everyone feels that a better product will result.

It was agreed that the next Science Team meeting will be held in Denver in March in concert with the next CHEM platform science team meeting. The TES team also noted with great regret the imminent retirement of our stalwart champion at HQ - Joe McNeal, but wish him well for his future activities.

Minutes of 15 th PoDAG Meeting

— *Ron Weaver (weaver@kryos.colorado.edu), DAAC Manager, National Snow and Ice Data Center*

The fifteenth meeting of the NSIDC User Working Group was held in Boulder on September 27-29, 1999. Following are the recommendations, action items and minutes from this meeting. Further details of this, previous, and future meetings of the PoDAG may be found on the NSIDC website: www-nsidc.colorado.edu/NASA/PODAG/.

Recommendations

- PoDAG suggests that the NSIDC manager and the PoDAG chair participate (ex-officio) in the NRC panel review of the DAACs.
- SSM/I globally gridded radiance and derived cryospheric products should be continued even after the launch of the AMSR sensor to guarantee the longest possible passive microwave time series based on SMMR and SSM/I data. Koni Steffen will write a separate letter to Vanessa Griffin and others.
- NSIDC DAAC scientist(s) should provide information about the quality and the regional differences of the various sea ice concentration products to the lay user.
- PoDAG strongly supports the data distribution of the Pathfinder data sets and products from TOVS, AVHRR, altimeter and scatterometer sensors through the NSIDC DAAC.
- The NSDIC DAAC scientific staff are encouraged to publish validation, quality-checking results, and applications of newly archived data sets in the open scientific literature.

Minutes

NASA HQ Overview—Kim Partington, Manager, NASA Polar Program

The key science questions to be addressed by the Polar Program were reviewed, along with the breakdown of the budget.

The NRC Review of NSIDC DAAC was discussed. Recommendations yet to be acted upon are to work more closely with the Alaskan SAR Facility, and to encourage working visits by scientists.

The NRC Polar Research Board review of the direction and strategy for providing the polar research community with NASA-data sets was summarized. The need for input from PoDAG and for a site visit to NSIDC was outlined.

The NASA Research Announcement on Pathfinders and Interdisciplinary Science closed on September 27, 1999. Pathfinders are to focus more on science and not just do data analysis. Interdisciplinary science also covers some polar-related activities.

A NASA Research Announcement on SAR and allied data analysis is being prepared. An unresolved issue is the Radarsat Memorandum of Understanding, and access to SAR data beyond November 2000. The NRA is designed to encourage the use of both derived and basic SAR products as well as integration with additional data sets.

NSIDC Update since 14th PoDAG Meeting, November 1998—Ron Weaver, DAAC Manager

See www-nsidc.colorado.edu/NASA/PODAG/MEETING15 for details.

Meeting Discussion Issues:
There are no critical issues requiring immediate attention.

Longer Term Questions:
How long after the EOS AMSR/AMSR-E data become available should the SSM/I processing be continued?

Should AVHRR data processing be continued for 18 months after the launch of the AM-1 (Terra) platform?

How does PoDAG feel about charging for data products?

CRYosphere SYStems (CRYSYS) to Monitor Global Change in Canada—Anne Walker, PoDAG Member

Walker reported that the CRYSYS group submitted an EOS IDS team proposal to continue their successful project, even though they receive no funding from NASA. Their scientific goals are the monitoring and understanding of regional and larger scale changes of the cryosphere system in Canada. They published an overview paper in the Canadian Journal of Remote Sensing, provided support for the Canadian Cryosphere Information

Network, and provided input for the Cryosphere Plan of the Canadian GCOS.

Current and Future Activities of the World Climate Research Programme (WCRP)—Roger Barry, DAAC Scientist

WCRP programs that are relevant to the polar community include: the Global Energy and Water Cycle Experiment (GEWEX), the Climate Variability/Predictability (CLIVAR) initiative, the Arctic Climate System (ACSYS) program, the emerging Climate and Cryosphere (CLIC) effort, and the Global Climate Observing System (GCOS) as well as the Global Climate Terrestrial Observing System (GTOS) which cover monitoring.

ACSYS will be transitioning in 2001-2003 to CLIC. The CLIC Task Force is developing the Science and Coordination Plan which has the elements of defining the importance and role of the cryosphere in climate, identifying the key science questions along with a strategy for addressing each of these. The Task Force wil be putting CLIC into the context of other global change research, outlining data and data management issues, and developing a planning strategy and timetable.

Arctic Climate System (ACSYS) Observation Products Panel—Koni Steffen, PoDAG Chair

The following sea ice products were recommended for use in the European Centre for Medium-Range Weather Forecasts (ECMWF) 40-year Reanalysis (ERA-40: 1958-present) scheduled to commence production in early 2000.

1958-1972: Arctic and Antarctic Research Institute (AARI) 10-day sea ice observations on the EASE-grid for the Arctic. Climatic conditions for the Southern Ocean.

1972-1976: ESMR passive microwave-derived ice concentrations and extent.

1977-1978: Analyzed fields from the U.S. and Canadian National Ice Centers.

1979-1998: SMMR and SSM/I passive microwave-derived ice concentration and extent using the Bootstrap algorithm for both hemispheres.

Terra Update—Ron Weaver, DAAC Manager

Key dates are the Science Operations Readiness Review on November 9-10, 1999; launch; launch + 120 days when the first products are received at NSIDC; and launch + 180 days when release of data and 25%-50% of total products commences.

Snow and ice products will be produced from the following instruments: MODIS, ASTER, GLAS, and AMSR. MODIS products distributed by NSIDC will initially amount to about 8 GB/day.

ASTER GLIMS Update—Greg Scharfen, NSIDC

NSIDC DAAC will continue working with the ASTER Science Team and scientists at the U.S. Geological Survey in Flagstaff, Arizona to develop the Global Land Ice Monitoring System (GLIMS). GLIMS is a cooperative effort with regional partners who are specialists in the study of selected glaciated areas. The partners will use data from ASTER and other instruments to routinely map glacier surface area, length, width, ablation area, and ice motion vectors. NSIDC DAAC is assisting with the provision of glacier inventory data for validation and will archive the derived products.

AMSR, AMSR-E Report from the Instrument Team—Don Cavalieri, PoDAG Member

The ADEOS-II mission (AMSR) is scheduled for launch in November 2000 by NASDA of Japan. The EOS PM platform (AMSR-E) is scheduled for launch in December 2000. Geophysical products will be generated by the Global Hydrology Research Center, Marshall Space Flight Center. The AMSR-E sea ice products (Level 3) are concentration, radiating temperature, and snow thickness on sea ice.

NSIDC DAAC will archive and distribute Levels 1B, 2 and 3 data. NSIDC DAAC will also archive the sea ice and snow validation data sets.

GLAS Update—Jay Zwally, PoDAG Member

The planning for the ICESat/GLAS Science Investigator-led Processing System (SIPS), or I-SIPS, and its relation to NSIDC-DAAC was outlined. See the 15th PoDAG meeting web page for details.

AVHRR Pathfinder Update—Ted Scambos, NSIDC

The recommendation from the 14th PoDAG meeting was as follows. "AVHRR Pathfinder data acquisition should include one year data overlap with the EOS AM (Terra) platform MODIS sensor. TOVS and SSM/I should have one year overlap with EOS PM platform, since it is the first satellite with sounder and passive microwave sensors. Processing these data sets should facilitate the data priority and other tasks recommended by PoDAG."

NSIDC response: "Little planning efforts remain for AVHRR, TOVS, and SMMR/SSM/I Pathfinders. NSIDC DAAC will continue acquisition of 1 km

and 5 km AVHRR data for both polar regions until at least 18 months after MODIS data acquisition starts. Additional data will be acquired as needed to fill gaps in the current archive for the period 1993 to 2000."

Additional Information:

14.5 years at 5 km resolution are available through 1995 with an additional year covering the SHEBA project in the Arctic. All 1-km AVHRR imagery is available. There is an online subsetting tool available to assist with data acquisition. The effort required to learn how to use the data is formidable, as no tools for data use/manipulation are available. A proposal to a recent NRA on Pathfinders may provide further funding.

PoDAG Comments on NSIDC Workplan—Ron Weaver, DAAC Manager

NRC recommendations should be used to identify data sets to be archived by NSIDC DAAC.

Gridded sea ice concentration and snow depth data sets on a one degree latitude-longitude sampling are being developed for convenient use by the GCM community, as discussed at the last PoDAG meeting.

There was a concern that the NSIDC Data Set Review Board was operating without much association with PoDAG, and so routine briefings on its activities are to be arranged for PoDAG.

TOVS Pathfinder Update—Axel Schweiger, University of Washington

NSIDC DAAC has completed the archival of the TOVS Pathfinder time series (1979-1996). Negotiations will continue with the TOVS Pathfinder team for the delivery to NSIDC DAAC of the TOVS Level 1B data. A plan will be developed for the ingestion and archival of this data set.

POLES Interdisciplinary Project—Axel Schweiger, University of Washington

This project is winding down, and discussions are underway with NSIDC DAAC for them to archive the products generated by the project.

PoDAG Terms of Reference—Roger Barry, DAAC Scientist

- Represent the cryospheric user community.
- Review NSIDC DAAC data sets and data set priorities.
- Suggest new products, data sets, etc., to NSIDC DAAC.
- Provide constructive feedback to NSIDC DAAC on its performance regarding data set ingest, archival, and distribution.

Decision-making for Product Archiving and Distribution - Fostering Quality and Continuity—Michelle Holm and Jim Maslanik, NSIDC

Questions to be considered:

- What data sets should be maintained?
- What criteria should be applied to make these decisions?

Case study of an emerging problem: By counting algorithms and map projections, ten sea ice data sets are available. This is expected to become more problematic.

PoDAG guidance is needed in such situations on whether any data sets should be replaced or discontinued, as well as how to preserve the continuity of data sets.

Considerations for Decision-Making

- Quality of relationship with data provider.
- Scientific validity and quality of product.
- User investment in product.
- Efficient use of resources.
- Timeliness of product availability.
- Assessment of usage of product.

New Data Sets for NSIDC DAAC

Koni Steffen (PoDAG Chair) described the AVHRR monthly mean surface temperature fields for Greenland produced by Joey Comiso. This is a small data set with a limited number of months processed so far. Archival is recommended.

Mark Drinkwater (PoDAG Member) presented scatterometer images for high latitudes which show decadal changes in backscatter that are not present in passive microwave emissions. Data volume is 0.8 GB per year for both hemispheres with 8 years currently available. Data archival should be investigated.

DAAC Subsetting Services on Terra-era Data Sets—Siri Jodha Singh Kalsa, NSIDC

The background and motivation for using a standard data format at NSIDC DAAC was presented. The use of HDF allows easy access to and manipulation of data, including subsetting. A variety of projections can be handled in addition to the EASE grid used extensively at NSIDC. An IDL-based tool for HDF-EOS is under development to facilitate use of the growing archive of high latitude data.

Wrap-up

The PoDAG agenda needs to be circulated well ahead of time for comment.

Science priorities of data sets and services are the main input to the NSIDC DAAC Work Plan, which is a living document.

Membership: PoDAG needs to represent users of data. Dorothy Hall will be invited to be a member of PoDAG as a representative of the MODIS user community. (As of December 8, 1999, she has accepted.)

A key member(s) of the Alaska SAR Facility users working group (ASFUWG) will be invited to the next PoDAG meeting to foster closer collaboration between PoDAG and ASFUWG. Likewise, the members of the PoDAG and NSIDC DAAC staff will attend the next meeting of the ASF User Working Group.

Next meeting: February 7-9, 2000 at NSIDC.

Action Items

PI's End to End Processing:

Archiving and distribution of SIPS generated data sets should/could be done through affiliation with a DAAC. Koni Steffen, Dave Bromwich, Greg Hunolt, and Ron Weaver will discuss with Martha Maiden.

IDS (Dozier, Barron):

Request information on snow related data products that are to be produced by these IDS teams. Try to answer whether they should be archived at the NSIDC-DAAC. Richard Armstrong/Anne Walker

Ice Sheet Motion Vectors:

Assess level of effort needed to archive ice sheet motion vectors and the corresponding pointers to the high-resolution satellite images for the Antarctica. Ted Scambos/Jay Zwally

MODIS User Profile:

Request user profile from MODIS team for their ice products, such as number of users, data volume, temporal and spatial data need, applications. If this information is not available, send out a user survey. Greg Scharfen/Dave Bromwich

AVHRR Pathfinder Tools:

Develop tools to manipulate the AVHRR Pathfinder data set. Ted Scambos/Koni Steffen

Data Review Board Update:

The NSIDC data review board should inform all PoDAG members every three months on their activities by e-mail mail or an updated Web page. Mark Parsons/Dave Bromwich

Data Review Board Summary:

The NSIDC data review board will summarize their findings at every PoDAG meeting – presentation and discussion. Mark Parsons/Dave Bromwich

Scatterometer Data Set:

Contact JPL DAAC to discuss level of effort to process and archive scatterometer data for polar regions. Archiving and distribution should remain at JPL DAAC. Ron Weaver/Mark Drinkwater

MODIS Albedo/SST:

More interaction with the MODIS team is needed to guarantee best possible data products for the ice community. We should form an "interest group" for albedo and SST/IST to interact on a regular basis (science related issues), and we should encourage a MODIS Team member to participate in the PoDAG meetings. Julienne Stroeve/Koni Steffen

NSIDC Home Page Address:

Assess options for changing the NSIDC home page address from www-nsidc.colorado.edu to www.nsidc.xxx. Ron Weaver/Dave Bromwich

The EOS Land Validation Core Sites: background information and current status

— *J. Morisette (jeff.morisette@gsfc.nasa.gov), J. Privette, C. Justice, D. Olson, J. Dwyer, P. Davis, D. Starr, D. Wickland*

Overview

The EOS Land Validation Core Sites[1] will provide the user community with timely ground, aircraft, and satellite data for EOS science and validation investigations. The sites, currently 24 distributed worldwide, represent a consensus among the instrument teams and validation investigators and represent a range of global biome types (see Figure 1 and Table 1; Privette et al., 1999; Justice et al., 1998). The sites typically have a history of *in situ* and remote observations and can expect continued monitoring and land cover research activities. In many cases, a Core Site will have a tower equipped with above-canopy instrumentation for near-continuous sampling of landscape radiometric, energy and CO_2 flux, meteorological variables, and atmospheric aerosol and water vapor data. These will be complemented by intensive field measurement campaigns. The data collected at these sites will provide an important resource for the broader science community. These sites can also provide a foundation for a validation network supported and used by all international space agencies.

Background

Following a number of years of consensus building among the EOS instrument teams, the Science Working Group for the AM-1 Platform (SWAMP) decided at its meeting in December 1997 to focus much of its land validation activity on a set of "Core" sites (Justice et al., 1998). This focus would allow collaboration within and among science teams and reduce the duplicated effort that would result from validation efforts at disparate sites. This decision resulted in an EOS community effort to establish the EOS Land Validation Core Sites. Although their development was led by MODLAND[2], the sites are intended for use by all satellite sensors.

The sites will not only encourage synergy between validation activities of the EOS sensor teams, but also help foster international collaboration and a common set of locations for validation campaigns for other science teams. The Core Sites have been incorporated in the Landsat 7 science team's Long Term Acquisition Plan (LTAP)[3] and the SeaWiFS team[4] will be providing subsetted data for the sites. ESA's Land-Surface Processes and Interactions Mission (LSPIM)[5] has incorporated the Core Sites into their mission and experiment plan (personal communication with Claire Jacobs, SC-DLO, Wageningen, The Netherlands). Ongoing coordination is pursuing the possibility of integrating the Core Sites into the validation strategies of NASA's EO-1 New Millennium Program[6], Japan's GLI mission[7], and ESA's Envisat MERIS sensor[8]. The Core Sites were presented to the Committee on Earth Observing Satellites Working Group on Calibration and Validation (CEOS WGCV)[9] at its workshop in London, May 26-28, 1999 (Dowman et al., 1999).

The BOREAS Northern Study Area (NSA) site[10] provides an example of the multi-project coordinated activity envisioned for all Core Sites. This site will be utilized by the NASA-sponsored "BigFoot" project[11]. The BigFoot project will focus on validation of the MODIS Land Team's (MODLAND) land cover, leaf area index (LAI) and net primary production (NPP) products (see Justice et al., 1998b for a description of MODIS land products). In addition to the BigFoot work, the BOREAS Northern Study Area (NSA) site has significant historical data, gathered during the U.S.-Canada BOREAS study[12].

The historical data sets are being archived as part of the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center's (DAAC's) support of NASA field campaigns in ecology and biogeochemistry. The BOREAS NSA site is also part of the Canadian Center for Remote Sensing (CCRS)[13] LAI network. CCRS is coordinating with BigFoot on field measurements and image analysis. This coordination will focus on: 1) how previous BOREAS and CCRS efforts can provide insight for MODLAND validation, 2) the potential for the BigFoot approach to be incorporated into the CCRS LAI network, and 3) how that network might contribute to additional validation measurements for the related MODLAND products. In addition, the Global Observation of Forest Cover (GOFC)[14] program is currently considering the validation activities at the BOREAS NSA site as a means of developing

collaboration between the MERIS and GLI teams by having scientists from those programs participate in upcoming field measurement activities (personal communication, Frank Ahern, CCRS). Researchers associated with the Krasnoyarsk, Russia, Core Site[15] joined BigFoot at the NSA in this spirit.

While the other sites have varying amounts of activity, a common database and acquisition protocol is being developed for all Core Sites. This includes field data archive; storage and retrieval; satellite and airborne image acquisition; archiving, and dissemination; commercial satellite data products; and supporting non-satellite data (i.e. historical site characterization data and GIS layers). The combined data and resources available at the Core Sites will build on existing networks and help encourage continued and future collaboration.

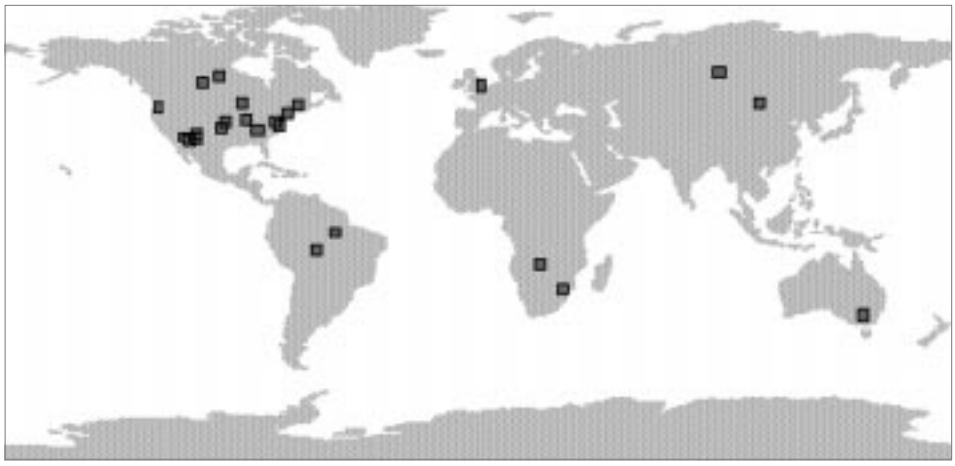


Figure 1. EOS Land Validation Core Sites (a map with site names is given at ***modarch.gsfc.nasa.gov/MODIS/LAND/VAL/core_sites.html***).

Acquisition and Availability of Core Site Data

1.1. A metadata access system for site data

Perhaps the most unique characteristic for validation sites is the field work, either ongoing measurements or short-term intensive observational periods, for a site. Traditionally, data from multiple field campaigns at various sites have not been available through one centralized database. Individually, the NASA-sponsored campaigns such as FIFE[16] and BOREAS[12] have made significant steps toward this goal. The ORNL DAAC will perform a key role in centralizing the distribution and archiving of field data useful for validation of EOS Terra Land Products. To facilitate this effort, the DAAC has employed the Mercury system (Cook et al., 1999)[17]. Mercury is a Web-based system that allows the searching of distributed metadata files to identify data sets of interest and direct the user to them.

The Mercury system provides both the team collecting the data and the data users significant advantages relative to the traditional data management systems. Data sets remain with those responsible for the data collection, thus allowing them to maintain full control of the quality, version, and availability of their data sets. The ORNL DAAC provides these collectors with a metadata editor tool[18] that can be used to help organize their field data. This tool can be helpful to any investigator wishing to create metadata for their fieldwork - even if just for their own records. Once the URL of the data's location is registered through the metadata tool, the Mercury system harvests the metadata and creates a pointer to the data. The scientist maintains full control of his/her site. The scientist has the option of temporarily removing the data or restricting access by requiring a password from users. This allows for the metadata to be created and registered as soon as possible, yet provides some time for initial quality checks on the data before making it available to the general public. Mercury will facilitate the availability of field data sets needed for EOS Land Validation. It provides a realistic system by which EOS Validation Investigators can allow public access to their data within six months of data collection, as required by the EOS Validation Program[20]. Others collecting validation data are strongly encouraged to utilize the Mercury system.

1.2. Image data

The land validation efforts for EOS will follow the approach adopted by other major intensive field campaigns; such as BOREAS[12], FIFE[16], and the MODIS prototype Validation Experiments[21, 22], by acquiring imagery from multiple sources over a range of spatial resolutions. For the Core Sites, this will include airborne imagery and commercial satellite imagery at several-meter resolution, ETM+[23] and ASTER[24] data in the 15-30 meter range, and SeaWiFS[4], MODIS Land Products (Justice et al., 1998)[2] and MISR Local Mode[25] data at the 250 m to 1 km range. The airborne data will be archived through the Mercury system described above. NASA's Science Data Buy (SDB)[26] program has allocated resources for the acquisition of one Space Imaging IKONOS scene[27] over each of the Core Sites. Also available through the SDB program are

Table 1. EOS Land Validation Core Site Information

	Site Name	Country	Latitude	Longitude	Elevation	Biome	TM/ETM+ Path/Row*	MODIS Tile (vert./hori.)	MODIS Line/Sample (w/in tile)	Active Networks	Possible Networks	Tower
1	ARM/CART	OK, USA	36.64	-97.5	300m	Grassland/ Cereal Crop	28-27/34	5/10	403/210	BigFoot, FLUXN, GLCTS	BSRN	yes
2	BARC, USDA ARS	MD, USA	39.03	-76.9	50m	Broadleaf Cropland	15/33	5/12	1116/35	AERONET, FLUXNET		yes
3	Barton Bendish	East Anglia, UK	52.61	0.53	25m	Broadleaf Cropland	201/23	3/18	887.30/37.62			no
4	Bondville	IL, USA	40.01	-88.3	225m	Broadleaf Cropland	22/32	4/11	1199/284	AERONET, BigFoot	SurfRad. BSRN	yes
5	BOREAS NSA	Canada	55.88	-98.5	300m	Needleleaf Forest	33/21	3/12	494/569	BigFoot, FLUXNET		yes
6	BERMS*	Canada	53.98	-105	475m	Needleleaf Forest	37/22	3/11	722/980	FLUXNET		yes
7	Cascades/H.J Andrews LTER	OR, USA	44.5	-122	1000m	Needleleaf Forest	45/29	4/9	660/388	AERONET, FLUXNET, GLCTS, LTER		yes
8	Harvard Forest LTER	MA, USA	42.37	-72.3	200m	Broadleaf Forest	13/30	4/12	916/794	BigFoot, FLUXNET, GLCTS, LTER		yes
9	Howland	ME, USA	45.3	-68.8	100m	Needleleaf Forest	28-Nov	4/13	564/191	AERONET, FLUXNET, GLCTS		yes
10	Ji-Parana	Brazil	-10.22	-61.9	200m	Broadleaf Forest	231/67	10/11	26/1090	LBA		yes
11	Jornada LTER	NM, USA	32.5	-107	1300m	Shrubland/ Woodland	33/37	5/8	900/1195	GLCTS, LTER		yes
12	Konza Prairie LTER	KS, USA	39.08	-96.6	350m	Grassland/ Cereal Crop	28/33	5/10	110/598	FLUXNET, GLCTS, LTER		no
13	Krasnoyarsk	Russia	57.27	91.6	350m	Needleleaf Forest	144/20	3/22	321/1115			yes
14	Maricopa Ag. Cnt.	AZ, USA	45.75	106	1400m	Broadleaf Cropland	37/37	5/8	832/739			no
15	Mongu	Zambia	33.07	-112	400m	Shrubland/ Woodland	175/70	10/20	654/288	AERONET, GLCTS, SAFARI 2000		yes
16	SALSA San Pedro	AZ, USA/ Mexico	-15.45	23.3	1000m	Shrubland/ Woodland	35/38	5/8	991/788			no
17	Sevilleta LTER	NM, USA	31.74	-110	1500m	Grassland/ Cereal Crop	33/36	5/9	682/214	LTER		no
18	Skukuza, Kruger NP	South Africa	34.32	-107	1500m	Shrubland Woodland	168/77	11/20	600/1043	AERONET, GLCTS, SAFARI 2000		yes
19	Tapajos	Brazil	-25	31.7	200m	Broadleaf Forest	227/62	9/12	388/639	LBA		under construction
20	Uardry	Australia	-2.86	-55	50m	Grassland/ Cereal Crop	93/84	12/29	527/118			no
21	Mandalgovi	Mongolia	-34.39	145	100m	Grassland/ Cereal Crop	131-132/28	4/25	510/496			no
22	Virginia Coast Reserve	VA, USA	37.5	-75.7	~0m	Broadleaf Cropland	14/34	5/11	300/1194	LTER	BSRN (near by)	yes
23	Walker Bran	TN, USA	35.9	-843	300m	Broadleaf Forest	19/35	5/11	492/204	FLUXNET, GLCTS		yes
24	Wisc.: NTL LTER/Park Falls	WI, USA	46	-89.6	450m	Needleleaf Forest	25/28	4/11	480/929	FLUXNET, LTER		yes

* "Boreal Ecosystem Research and Monitoring Sites", formerly BOREAS SSA

precision orthorectified Landsat 5 scenes from the early 1990s. These scenes will provide a baseline image with which to geocode other image data. The University of Maryland (UMD) Global Land Cover Facility (GLCF)[28] will archive the precision TM scenes. The Core Sites are scheduled for MISR Local Mode acquisition where the data will be available through the Langley DAAC via the EOS Core System (ECS). Landsat ETM+, ASTER, and MODIS data will be available through the EROS Data Center (EDC) DAAC. SeaWiFS data will be archived by the SeaWiFS program at Goddard Space Flight Center[4].

The current plan is to acquire from one to five ETM+ and ASTER scenes per year for each Core Site, depending on the activity related to each site, selected to coincide with field campaigns and/or vegetation phenology. With the assistance of EDC, the MODIS Land Discipline team will query and order ETM+ and ASTER data needed for validation investigations. The highlighted areas in Table 2 will be used for scheduling priority data collections at the Core Sites.

The MODIS data available for the Core

Sites will be 200 km x 200 km subsets from the original MODIS Level L3 and L4, 1200 km x 1200 km, MODIS Tiles. The subsetted data sets will contain daily and multi-day composites. The decision to produce MODIS subsets over the validation sites was based on the need for rapid and convenient access to high temporal resolution data. Spatial subsetting over the sites will help reduce the data volume and permit ftp access and on-line storage of MODIS data for all of the Core Sites.

1.3. Science Networks

Data from several science networks will be used to support and complement the validation work at the Core Sites. These include the AERONET sun photometer network (primarily for atmospheric aerosols and water vapor, Holben et al., 1998)[29, 30], the FLUXNET CO_2 /H_2O flux network[31], Long Term Ecological Research (LTER)[32] sites, Global Land Cover Test Sites (GLCTS)[33], the BigFoot Project[11], and, potentially, the Surface Radiation Budget Monitoring (SurfRad)[34] and Baseline Surface Radiation Network (BSRN)[35] networks. There is also overlap with the SAFARI 2000[36] and LBA[37] project sites. The Core Site selection was in part based on a site's participation with one or more of these networks. The network information for each site is listed in Table 1.

1.4. Background Data and GIS Layers

In 1999 the validation community developed a prioritized list of parameters required to characterize each site and a strategy for assembling the in situ measurements (list of parameters, frequency, and volume of data). The basic data for sites includes monthly climate, LAI, NPP, fPAR, albedo, vegetation and soil characteristics, and crown allometry. Although the goal is to have measurements at each site coincident with satellite overpasses, there is a need to compile extant data for sites. The extant data from literature, reports, monitoring stations, Web sites, etc. provide a baseline for the site and an

Table 2. ETM+ and ASTER Priority Acquisition Windows (shaded areas show priority targets for acquiring one or more ETM+ and ASTER scenes).

Site	Month 1	2	3	4	5	6	7	8	9	10	11	12
ARM/CART					■	■		■	■			
BARC, USDA ARS							■	■	■			
Barton Bendish						■	■	■				
Bondville						■	■	■				
BOREAS, NSA							■	■	■			
BERMS								■				
Cascades LTER							■					
Harvard Forest LTER							■	■				
Howland							■	■				
Ji-Parana							■	■				
Jornada LTER					■				■	■		
Konza Prarie LTER						■		■				
Krasnoyarsk	■	■	■			■	■					
Maricopa Ag.Cnt.												
Mongu		■						■	■			
SALSA, San Pedro					■				■	■		
Sevilleta LTER					■				■	■		
Skukuza, Kruger NP		■						■	■			
Tapajos						■	■	■				
Uardry	■	■	■	■								
Mandalgovi						■	■	■				
Virginia Coast Reserve										■		
Walker Branch						■	■	■				
Wisc.: NTL LTER/Park Falls							■	■				

indication of long-term variability. The ORNL DAAC has implemented a relational database management system to standardize and store ancillary site data. The database is especially designed to document the source and measurement characteristics of ancillary data. The ORNL DAAC compiled site data from the Walker Branch Watershed, Harvard Forest LTER, BOREAS Northern Study Area, Bondville, and Konza Prairie LTER sites in 1999.

Most site measurements are based on data collected on field plots ranging in size from a square meter to a hectare; however, the intent is to characterize field conditions of the satellite pixels, e.g., 1 km 2 for MODIS. The ORNL DAAC compiled data on climate, soils, land cover, and NDVI for all sites from a set of global databases that represented average conditions surrounding the Core Site's center coordinates (see Table 1). For example, average values for 14 parameters representing soil texture, water holding capacity, and nutrient status for the top 30 cm of soil for 5 cells were extracted from an IGBP Global Soils database. Dominant land cover from the University of Maryland 1 km Global Land Cover product was extracted for the 1 km 2 pixel centered over the site and the number of unique land cover types (with a possible maximum of 14 cover types) in a 5x5 neighborhood patch. Cells around each site provide an indication of the homogeneity of each site.

The University of Maryland's Commercial Remote Sensing for Earth System Science (CRESS) program has extracted several GIS layers from global source products. Extracting the subsets from the global dataset allows for comparability of these products across sites. These global products, subsetted around the Core Sites, are available through the University of Maryland Geography Department[38]

The data layers that have been generated for the Core Sites include:

- EDC IGBP land cover;
- UMD 1 km land cover;
- percent tree cover;
- FAO Soils data;
- GTOPO 30 elevation, and
- a reference layer with airports, municipal boundaries, major cites, rivers, and ETM+ footprints.

Access to Core Site data

All of the data available for the Core Sites will be accessible through the Internet. The various sources of data are all linked through each site's WWW page, available through the MODIS Land Discipline's Validation activities page[39]. Each site's WWW page serves as a data access starting point, providing links to the satellite data, the Mercury search page, and the ancillary data layers available through CRESS, and other related web sites

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WWW Reference

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2 MODIS Land Discipline Team, **modis-land.gsfc.nasa.gov**
3 Landsat Long term acquisition plan, **ltpwww.gsfc.nasa.gov/IAS/htmls/igs.html**
4 SeaWiFS homepage, **seawifs.gsfc.nasa.gov/SEAWIFS.html**
5 Land-Surface Processes and Interactions Mission, **www.estec.esa.nl/vrwww/LSPIM**
6 Earth Observing – 1, **eo1.gsfc.nasa.gov**
7 GLI homepage, **www.eorc.nasda.go.jp/ADEOS-II/GLI**
8 MERIS homepage, **envisat.estec.esa.nl/instruments/meris**
9 CEOS WGCV homepage, **wgcv.ceos.org**
10 BOREAS NSA Core Site page, **modarch.gsfc.nasa.gov/MODIS/LAND/VAL/core_sites/boreas_nsa.html**
11 BigFoot program, **www.fsl.orst.edu/larse/bigfoot**
12 BOREAS, **boreas.gsfc.nasa.gov/BOREAS/BOREAS_Home.html**
13 Canadian Center for Remote Sensing, **www.ccrs.nrcan.gc.ca/ccrs**
14 Global Observation of Forest Cover, **www.gofc.org/gofc**
15 Krasnoyarsk Core Site page, **modarch.gsfc.nasa.gov/MODIS/LAND/VAL/core_sites/krasnoyarsk.html**
16 FIFE, **www-eosdis.ornl.gov/FIFE/FIFE_Home.html**
17 Mercury Homepage, **mercury.ornl.gov**
18 Mercury Metadata Editor login, **www-eosdis.ornl.gov/cgi-bin/MDE/MERCURY/access.pl**
19 Mercury Land Validation Search, **mercury.ornl.gov/servlet/landval**
20 EOS Validation program, **eospso.gsfc.nasa.gov/validation/valpage.html**
21 Grassland PROVE, **modarch.gsfc.nasa.gov/MODIS/LAND/VAL/prove/grass/prove.html**
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23 Landsat 7, ETM+ homepage, **mtpe.gsfc.nasa.gov/landsat**
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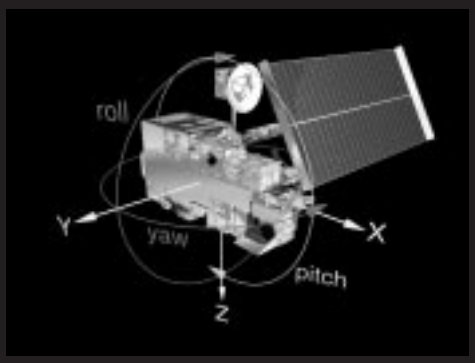
25 MISR Langley DAAC Project Guide, **charm.larc.nasa.gov/GUIDE/campaign_documents/misr/misr_ov.html**
26 NASA's Science Data Buy program, **www.crsp.ssc.nasa.gov/databuy**
27 Space Imaging: IKONOS, **www.spaceimaging.com**
28 UMd Global Land Cover Facility, **glcf.umiacs.umd.edu**
29 AERONET homepage, **aeronet.gsfc.nasa.gov:8080**
30 AERONET status at the EOS Land Validation Core Sites, **modarch.gsfc.nasa.gov/MODIS/LAND/VAL/EOSaeronet.html**
31 FLUXNET homepage, **daacl.esd.ornl.gov/FLUXNET**
32 U.S. Long Term Ecological Research Network, **lternet.edu**
33 Global Land Cover Test Sites, **edcwww.cr.usgs.gov/landdaac/pathfinder/pathpage.html**
34 Surface Radiation Budget Monitoring network, **www.srrb.noaa.gov/surfrad/surfpage.htm**
35 Baseline Surface Radiation Network (BSRN), **bsrn.ethz.ch**
36 SAFARI 2000 homepage, **safari.gecp.virginia.edu**
37 Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA), **www.cptec.inpe.br/lba**
38 University of Maryland Geography Department, Commercial Remote Sensing for Earth System Science, **www.inform.umd.edu/landcover/cress/eoscchar.htm**
39 MODIS Land Team Validation page, **modarch.gsfc.nasa.gov/MODIS/LAND/VAL**

Terra Engineering Competition



This competition is for high school students, and is planned and sponsored jointly by the EOS Project Science Office, the GSFC Education Office, Morgan State University, and Swales Aerospace. The Round One problem is focused on Terra's on-orbit calibration attitude maneuvers.

Who

Student teams in High Schools from Maryland, the Washington, D.C. metropolitan areas, and the northeast NASA region.

What

Students work in 4-6 member teams to solve real world engineering challenges encountered in the Terra Earth Observing System mission.

When

- **Round One solution submitted: Postmarked no later than Feb. 25, 2000.**
- **Round One winners notified no later than March 10, 2000**
- **Final hands-on competition: April 19, 2000, 9 AM-4 PM.**

Where

- **Final competition at Howard B. Owens Science Center, Greenbelt, Maryland, near NASA Goddard Space Flight Center.**

How

- **Use the contest web site (education.gsfc.nasa.gov/Terra/Contest.html) to solve the Round One engineering problem.**
- **Maximum of 10 Round One team finalists will be chosen to partici-pate in the final round.**
- **Winning teams recognized after the final competition at an awards ceremony**
- **Winning prize: A complete computer system for the winning team's school and individual prizes for each winning team mem ber.**

For details, please see education.gsfc.nasa.gov/Terra/contest.html

Goddard Space Flight Center
Educational Program
Code 130.3
Greenbelt, Maryland 20771
(301) 286-7504

EOS Scientists in the News

— *Emilie Lorditch (elorditc@pop900.gsfc.nasa.gov), Raytheon ITSS*

"Terra Launch Spotlights NASA's Earth Observing System," (Dec. 10) by Andrew Lawler. **Ghassem Asrar** (NASA HQ) says that Terra is great for focusing on specific scientific questions while continuously providing data. Asrar, **Bruce Wielicki** (NASA LaRC), and **Mark Abbott** (Oregon State Univ.) are optimistic that Earth Observing System projects like Terra will result in valuable information for future Earth science research.

"Will the Arctic Ocean Lose All Its Ice?," Science (Dec. 3) by Richard A. Kerr. **Andrew Rothrock** (Univ. of Wash) has found that Arctic sea ice has thinned from 3.1 m to 1.8 m in the last decade or 15%. Rothrock says that Arctic ice has shrunk by 40% in less than 30 years.

"Arctic Sea Ice is Rapidly Dwindling," *Washington Post* (Dec. 3) by Curt Suplee. **Claire Parkinson** (NASA GSFC) is working with a team of researchers that discovered that less than 2% of the Arctic sea ice melting is due to natural climate change. Parkinson's research also appeared in *USA Today*, *Baltimore Sun*, and the *Associated Press*.

"Plumbing Antarctica for Climate Clues," *Science News* (Nov. 27) by Richard Monastersky. **Richard Alley** (Penn State) has been studying the shrinking of the Antarctic ice sheet to learn more about climate changes. Alley says that with appropriate satellite data, researchers can see exactly what is happening to the ice sheet and learn more about the impact it will have on climate.

"Storm Damage Soars in La Niña Years," *Science News* (Nov. 27) by Richard Monastersky. **Roger Pielke, Jr.** (NCAR) compares structural damage totals for all storms since 1925. Pielke says that the United States has a greater risk of getting hit by more storms packing more energy during La Niña years.

"Experts Hope to Clear up Warming Controversy," *Environmental News Network* (Nov. 24). **David Rind** (NASA GISS) has used computer climate models to examine changes in solar radiation over the past 400 years. Rind found that the Sun has not played a significant role in climate change in the past few decades.

"Studying Deep Ocean Currents for Clues to Climates," *New York Times* (Nov. 9) by William K. Stevens. **Richard Alley** (Penn State) has been investigating climate clues to figure out if the climate is warming due to natural changes or human-induced changes. Alley says that other researchers are offering possible explanations about climate change that have a good chance of being proven in the near future.

"Global Warming Will Threaten California's Environment," *Associated Press* (Nov. 4). **Christopher Field** (Carnegie Inst.) has been looking at the impact of global warming on California. Field found that wetter winters caused by global warming could lead to flooding and water shortages in California.

"Under Antarctica, Clues to an Icecap's Fate," *New York Times* (Oct. 26) by Malcolm W. Browne. **Ghassem Asrar** (NASA HQ) discusses research being conducted by **Kenneth C. Jezek** (Ohio State). Jezek is examining radar pictures of Antarctica that contain clues about how climate changes will affect low-lying parts of the world such as Bangladesh, the Netherlands, and New York City.

"La Niña Reappears in Pacific," *Associated Press* (Oct. 22). **William Patzert** (NASA JPL) observed the TOPEX-Poseidon satellite data that shows La Niña returning in the Pacific. Patzert says that because La Niña has returned there will be a wet winter across the Pacific Northwest and a dry winter in the Pacific Southwest.

"Global Maps From Landsat Scenes Take Shape," *Space News* (Oct. 18) by Ben Iannotta. **David Skole** (Michigan State Univ.) is assessing the first images released from Landsat 7 to make global maps. Skole says there is still a lot of work that needs to be done before the data can be released to the public as finished images.

"Talks to Focus on Most Abundant Greenhouse Gas," *Environmental News Network* (Oct. 12). John Gille (NCAR) helped to organize the American Geophysical Union Chapman Conference on Water Vapor that will bring more than 80 participants from the United States and abroad to discuss the role of water vapor

(Continued on page 30)

Earth Science Education Update

Earth Science Education Proposals Selected

— *Nahid Khazenie (nkhazeni@hq.nasa.gov), Education Program Manager, Office of Earth Science, NASA Headquarters*
— *Steve Graham (steve.m.graham.2@gsfc.nasa.gov), EOS Project Science Office, Raytheon ITSS*

Congratulations to the outstanding proposals selected for award and subsequent funding through NASA's Earth Science Enterprise Education Program, in partnership with NASA's Office of Human Resources and Education and NASA's Office of Equal Opportunities Programs. ESE received and reviewed 163 proposals in response to the NRA and depended substantially on a rigorous review process to prioritize projects and allocate limited funds. The following projects were selected:

Teacher Enhancement

Aponte-Avellanet, Ibis L, University of Puerto Rico: Interactions and Diversity: Earth System Science and Beyond

Benson, Bernard W, University of Tennessee Chattanooga: Pre-Service Teacher Enhancement Program

Hayden, Linda B, Elizabeth City State University: Mathematics of the Great Dismal Swamp

Kuglin, John R, University of Montana: Earth Science Enterprise Research Program

Limaye, Sanjay S, University of Wisconsin Madison: Earth Science Component for Academic Professional Enhancement (ESCAPE)

Locke, Sharon M, University of Southern Maine: ACCESS Earth: Promoting Accessibility to the Earth System Sciences for Persons with Disabilities

Odell, Michael R L, University of Idaho: NOVA Online ESS

Panah, Assad I, University of Pittsburgh: An Interdisciplinary Teacher Training Program on Earth System Science Using Information Technology, 2000-2002

Strong, William R, University of North Alabama: Earth System Science On-Line Course—An Opportunity in Geography Education

Student Enrichment

Chambers, Lin H, Langley Research Center: Students' Cloud Observations On-Line (S'COOL), A Unique Project with Emphasis on Grades 4 and Under

Hayden, Linda B, Elizabeth City State University: You Be the Scientist with Satellite Imagery in EZ/EC Communities

Moon, Thomas, Montana Technical University: STEP Careers in Research Exploration Program

Morris, Vernon R, Howard University: Celebrating 20th Century Pioneers in Atmospheric Sciences

Olson, Tim Salish, Kootenai College: Remote Sensing of Tribal Lands: Earth System Science Student Research Experiences at Salish Kootenai College

Yamaguchi, Janet, Discovery Science Center: The Dynamic Earth

Curriculum Support

Blount, Grady, Texas A&M University Corpus Christi: The Translingual Earth System Science Education Center

Butcher, Ginger, Goddard Space Flight Center: The Pigeon Adventure—An Adventure through Remote Sensing History

Gobert, Judith M, Salish Kootenai College: NASA Native Earth Systems Science Curriculum Project (NESCP)

Kahn, Ralph A, Jet Propulsion Laboratory: Practical Uses of Math And Science (PUMAS)

Pickle, John D, AER, Inc.: Enhancement of the Global Systems Science Student Guide Series for the Digital Earth Initiative

Vierling, Lee A, South Dakota School of Mines & Technology: Earth Systems Connections: An Integrated K-4 Science, Mathematics, and Technology Curriculum

Informal Education

Byrd, Deborah, EarthTalk, Inc.: NASA/ Earth & Sky Broadcast Fellowship

Stauffer, Barbara, National Museum of Natural History: Global Links

Vandiver, Raymond J, Oregon Museum of Science & Industry: Eyes on Earth

Digital Earth

Gordin, Douglas N, Michigan State University: Pending Availability of Funds: (Transforming Learning and Traveling through the Digital Earth)

Rodriguez, Waldo J, Norfolk State University: Scenario Based Learning—Inquiry for a Digital Earth

Passport To Weather And Climate — Live From The Storm

"Passport to Weather and Climate" is 9th in the award-winning series of interactive learning adventures from "Passport to Knowledge" that are designed to link students and teachers with America's leading researchers via video and the Internet, and to enliven the curriculum by connecting real world research to essential science concepts. The program includes video broadcasts, hands-on activities, and on-line resources.

Video Broadcasts — Two, one-hour programs airing over public television stations and NASA-TV:

Program 1: *The Who, What, Where, When and Why of Weather* — Airs Tuesday March 7, 2000, 13:00 hours eastern time. This show will feature NASA Goddard's TRMM and NASA Marshall's Mesoscale Lightning Experiment. The program will include visuals from NASA Goddard Space Flight Center, and state-of-the-art studies of hurricanes.

Program 2: *Research To The Rescue!* — Airs Tuesday April 11, 2000, 13:00 hours eastern time.

Hands-On Activities: An original 64 page Teacher's Guide, with copy masters of worksheets and oversize poster will be available online (without cost), or in a convenient printed format (fee.) A Multimedia Teacher Kit with Resource Video will also be published in Jan-Feb 2000 (fee.)

Online: Participating teachers and students will enjoy e-mail interactions with weather and climate researchers, receive online updates, and connect via moderated mail list with fellow learners. A comprehensive website will debut in Jan. 2000 with animations and data, and links to existing meteorological resources.

For more information or to sign up for the mail lists: passporttoknowledge.com/ptk_storm.html.

Passport To Weather And Climate and Live From The Storm specials are made possible, in part, by support from NASA and the National Oceanic and Atmospheric Administration.

Thacher Scholarship Announced

The Institute for Global Environmental Strategies (IGES) announces the Thacher Scholarship, in honor of former IGES Board Member, the late Peter S. Thacher. Mr. Thacher was also Chairman of the Earth Council Foundation-US. Since retiring from the United Nations in 1983 at the rank of Assistant Secretary-General, Mr. Thacher was principally associated with the World Resources Institute, and was senior advisor to Maurice Strong, the Secretary-General of the UN Conference on Environment and Development. Mr. Thacher dedicated more than three decades of work at an international level on remote sensing and other practical applications of space science. He played a special advisory role for NASA and provided a unique and extremely valuable contribution to geographic information systems on local, regional, and global levels.

The Thacher Scholarship will be awarded to an exceptional high-school student displaying the best use of satellite remote sensing in understanding the changing planet. $4,000 will be provided directly to the student for educational expenses.

The winning student will be selected from the Center winners of the NASA Student Involvement Program's "Watching Earth Change" competition <www.nsip.net>. The selection will be made by a group of judges chosen and convened by IGES. Announcement of the scholarship winner will be made at the NSIP National Symposium in May, 2000.

Contributors to the Thacher Scholarship are: IGES; WT Chen & Company, Inc.; and Mr. & Mrs. J. Andrew Chopivsky.

For more information, please see www.strategies.org or contact Colleen Steele, colleen_steele@strategies.org.

EOS Scientists in the News

(Continued from page 28)

as a greenhouse gas. Gille says that the conference will focus on atmospheric water vapor, the greenhouse effect, rainfall, and evaporation.

EOS researchers: Please send notices of recent media coverage in which you have been involved to:

Emilie Lorditch
EOS Project Science Office, Code 900,
Goddard Space Flight Center, Greenbelt, MD 20771
Tel. (301) 441-4031; fax: (301) 441-2432;
e-mail: elorditc@pop900.gsfc.nasa.gov

Science Calendar

February 10-11
AIRS Science Team Meeting, Pasadena, CA. Contact Hartmut H. Aumann, e-mail: aumann@jpl.nasa.gov.

February 14-15
GLAS/ICESat Science Team Meeting, Austin Texas. Contact Bob Schutz, e-mail: schutz@csr.utexas.edu.

February 23-25
AVIRIS Earth Science and Applications Workshop, Jet Propulsion Laboratory. Contact Robert Green, e-mail: rog@gomez.jpl.nasa.gov, URL: makalu.jpl.nasa.gov.

March 29-31
CHEM Science Team Meeting, Boulder, Colorado. Contact Anne Douglass, e-mail: douglass@persephone.gsfc.nasa.gov

April 11-13
EOS Investigator Working Group Meeting (IWG), Tucson, AZ. Contact Mary Floyd, e-mail: mfloyd@westover-gb.com. For hotel and registration information see URL: eospso.gsfc.nasa.gov/eos_homepage/logreg.html.

Global Change Calendar

February 17-22
American Association for Advancement of Science (AAAS), Washington, DC. Call (202) 326-6736, URL: www.aaas.org.

March 7-10
Oceanology International 2000, Brighton, UK. Call for Papers. Contact Christine Rose, Conference Executive, Oceanology International 2000, Spearhead Exhibitions Ltd, Ocean House, 50 Kingston Road, New Malden, Surrey KT3 3LZ, UK. Tel. +44 (0) 20 8949 9222; Fax: +44 (0) 20 8949 8186/8193; e-mail: christine.rose@ spearhead.co.uk; URL: www.spearhead.co.uk.

March 14-15
Adaptive Sensor Array Processing Workshop, MIT Lincoln Laboratory. Call for Papers. Contact Edward J. Baranoski, e-mail: kballos@ll.mit.edu, URL: sam2000.uconn.edu.

March 27-31
28th International Symposium on Remote Sensing of Environment, Cape Town, South Africa. Call for Papers. For abstracts submission: abstracts@mikom.csir.co.za, or see Website at www.isrse.co.za, Fax: +27 21 883 8177; tel. +27 21 886 4496 (ask for Deidré Cloete); postal: The 28th ISRSE Technical Committee, P.O. Box 452, Stellenbosch, 7599, South Africa.

April 4-8
The Association of American Geographers (AAG), Pittsburgh, PA. Contact: (202) 234-1450, e-mail: gaia@aag.org, URL: www.aag.org.

May 1-2
13th Annual Towson University GIS Conference Geographic Visualization: Turning a Sea of Data Into Data You can See, Baltimore, MD. Contact Jay Morgan, tel. (410) 830-2964, e-mail: jmorgan@towson.edu, URL: www.towson.edu/cgis.

May 22-26
ASPRS: The Imaging and Geospatial Information Society, 2000 Annual Conference, May 22-26, 2000. Washington, DC. Call for Papers. For abstracts submission see Website at www.asprs.org/dc2000; tel. (410) 208-2855; Fax: (410) 641-8341; e-mail: wboge@aol.com.

June 12-14
Sixth Circumpolar Symposium on Remote Sensing of Polar Environments, Yellowknife, Northwest Territories, Canada. E-mail: circumpolar2000@gov.nt.ca, tel. (867) 920-3329, URL: www.gov.nt.ca/RWED/rs/circumpolar2000.

July 16-23
International Society for Photogrammetry & Remote Sensing (ISPRS) 2000, Amsterdam. Call for Abstracts. Contact organizing secretariat, tel. +31 20 50 40 203; Fax: +31 20 50 40 225; e-mail: isprs@congrex.nl.

July 16-23
33rd COSPAR Scientific Assembly, Warsaw, Poland. COSPAR Secretariat, 51, bd.de Montmorencym 75016 Paris, France, tel. (33)-1- 45250679; Fax: (33)-1-40509827; e-mail: cospar@paris7.jussieu.fr

July 24-28
IEEE 2000 International Geoscience and Remote Sensing Symposium, 20th Anniversary, Hilton Hawaiian Village, Honolulu, Hawaii. Call for Papers. See conference website at www.igarss.org.

July 24-29
International Radiation Symposium (IRS-2000), Saint Petersburg State University, St. Petersburg, Russia. For further information contact Evgenia M. Shulgina, St. Petersburg State University, Research Institute of Physics, 1 Ulyanovskaya, 198904, St. Petersburg, Russia; Fax: +7 (812) 428-72-40; e-mail: Evgenia.Shulgina@pobox.spbu.ru; or shulg@troll.phys.spbu.ru.

August 6-17
31st International Geological Congress & Scientific Exhibits, Rio de Janeiro. Contact Tania Franken, tel. 55 21 537-4338; Fax: 55 21 537-7991, e-mail: geoexpo@fagga.com.br, URL: www.31igc.org.

August 21-25
10th Australasian Remote Sensing & Photogrammetry Conference, Adelaide, Australia. Contact secretariat, tel. (02) 6257 3299. Fax: (02) 6257 3256, URL: www.adelaide.edu.au/10arspc.

October 9-12
Optical Remote Sensing of the Atmosphere and Clouds II, Sendai, Japan. Contact Jinxue Wang, e-mail: jwang@ucar.edu; or SPIE, tel. (360) 676-3290, e-mail: spie@spie.org; URL: www.spie.org/web/meetings/calls/ae00/confs/AE01.html.

October 16-20
ERS-ENVISA Symposium "Looking at our Earth in the New Millenium," Gothenburg, Sweden. Call for Papers. Contact Prof. J. Askne, e-mail: askne@rss.chalmers.se; URL: www.esa.int/sympo2000/.

December 5-8
The 5th Pacific Ocean Remote Sensing Conference (PORSEC2000), GOA, India. See URL: members.tripod.com/~porsec2000/

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