The Earth Observer

A Bimonthly EOS Publication

March/April, 1995 Vol. 7 No. 2

INSIDE THIS ISSUE

Editor's Corner

Much of the activity in the last few months has centered around study teams formed by Dr. Charles Kennel, Associate Administrator of Office of Mission to Planet Earth, to look at innovative ways to implement the EOS Program in the post-2000 era. The motivation for this activity arises from the following significant events: (i) the Department of Commerce gave its tentative approval, pending identification of construction-of-facility funding, for construction of a NOAA building on the Goddard Space Flight Center "East Campus," adjacent to the new EOSDIS Building (to be opened this summer) and the approved-for-construction Earth System Science Building that will house the majority of Earth Scientists at Goddard; (ii) the realization that NASA in general, and EOS in particular, are likely to be directed to live under a funding cap in the post-2000 era; (iii) the necessity to articulate a mechanism for infusion of new technology into the post-2000 era; (iv) the need to identify an implementation of Landsat capability for a launch readiness date of 2004; and (v) the approval of Administrator Dan Goldin to proceed with the Common Spacecraft procurement with a firm contract for two spacecraft (PM-1, Chemistry-1) and option for two more.

The first element mentioned above arises from both the recent motivation to foster closer collaboration between NASA's research and development missions and NOAA's operational missions, and the converged National Polar Orbiting Environmental Satellite System (NPOESS-1) to be ready for launch in

☞

2004. Dr. Kennel formed three teams composed of NASA and NOAA personnel to assess an observational and programmatic strategy for the follow-on missions to the first 24 measurement types (MODIS, CERES, GLAS, etc.)—a science team (chaired by Michael King), a flight team (chaired by Chris Scolese), and a data systems team (chaired by John Dalton). In addition, there are 3 teams looking specifically at the NASA and NOAA alignment on a broader scale than EOS and MTPE, each of which are co-chaired by NASA and NOAA personnel.

Following the culmination of these study teams, preliminary recommendations will be presented to the Investigators Working Group meeting in Santa Fe, June 27-29, and will be background information for a review of the U.S. Global Change Research Program by the National Academy of Sciences' Board on Sustainable Resources. This review, to be co-chaired by Ed Frieman (Scripps Institution of Oceanography), and Berrien Moore (University of New Hampshire), and will be conducted in La Jolla, July 19-28, at the request of Congressman Robert Walker.

In the past several months the *Earth Observing System Educators' Visual Materials* was produced and distributed to NASA's Central Operation of Resources for Educators (CORE), Lorain County Joint Vocational School, 15181 Route 58 South, Oberlin, OH 44074 [(216) 774-1051, ext. 293 or 294], where it is now available for purchase for $60 (plus $6 for shipping and handling). This package was produced as a result of the numerous requests that have been received over the years from educators who desperately needed materials that could be used in the classroom. These materials include descriptions of Earth science themes (e.g., clouds and radiation, ocean productivity, greenhouse gases, ozone depletion), accompanied by 2-7 color slides for each theme; NASA fact sheets on seven different topics (e.g., polar ice, volcanoes, global climate change, El Niño), together with color slides to illustrate each; a glossary; list of acronyms and abbreviations; and a self-explanatory auxiliary set of slides containing satellite images and a description of EOS goals, objectives, expected accomplishments, and sensors that contribute to each of the seven high priority themes.

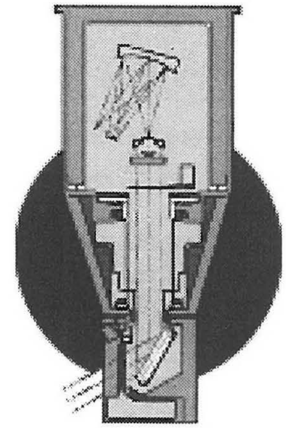
The *EOS Directory*, which contains the affiliation, phone and fax numbers and e-mail address of all EOS investigators, associates, project and program personnel, and DAAC users' group personnel, has recently been added to the World Wide Web (http://spso.gsfc.nasa.gov/spso_homepage.html), thereby enabling on-line access to the latest information on EOS investigators. In addition, we have added Adobe Acrobat PDF (portable document format) versions of all Algorithm Theoretical Basis Documents (ATBDs) so that anyone with Acrobat Reader, a freely-distributed pdf reader, can view on-line the entire ATBD document (including equations, figures, and text). Acrobat files are platform independent and supported on Macintosh, Windows, and UNIX computers.

Finally, I would like to express my thanks, on behalf of the Earth Science community, for the marvelous job that Dr. John Klineberg has done as Director of Goddard Space Flight Center. He has been an extraordinarily strong supporter of the Earth Observing System and Mission to Planet Earth, and has paid close attention not only to budget and scheduling challenges but also to scientific priorities. He is an excellent listener who is responsive to input from the scientific community both inside and outside Goddard. His management experience has been invaluable during the past 5 years he has served as Director of Goddard, which culminates 25 years of government service. His interaction with the aerospace industry, Congressional leaders, other NASA Centers, and the University community, will make him a hard act to follow. I would like to extend my best wishes for his continued success in future endeavors.

—Michael King
EOS Senior Project Scientist

Science Team Meetings

Stratospheric Aerosol and Gas Experiment III (SAGE III)



—**Lelia Vann** (l.b.vann@larc.nasa.gov), SAGE III Science Manager, Aerosol Research Branch, NASA Langley Research Center

On February 28 and March 1, a Stratospheric Aerosol and Gas Experiment (SAGE) III Science Team meeting was conducted in Boulder, CO. The SAGE III Principal Investigator, M. Patrick McCormick, kicked off the meeting with introductions, a summary of events leading up to this meeting, and a quick overview of the meeting agenda.

The objectives of this science team meeting were to:

◊ introduce the Science Team to the Program/Project Team;
◊ provide top-level programmatic information;
◊ discuss science minimum success criteria;
◊ identify EOS DAAC/DIS requirements;
◊ formulate Integrated Product Teams; and
◊ assign Algorithm Theoretical Basis Document (ATBD) development tasks.

The SAGE III Program Manager, Vicki Hall, presented the program overview and pointed out that the Office of Mission to Planet Earth (MTPE) issued SAGE III an "Authority To Proceed" letter on November 29, 1994, for three missions:

1. 1998 METEOR 3M-1 mission
2. 2001 Space Station Attached Payload mission
3. Flight of Opportunity (FOO) mission (launch date to be determined)

The SAGE III Program Scientist, Jack Kaye, gave the NASA HQ science perspective. He expressed enthusiasm about SAGE III having an international commitment and about how highly the Payload Panel spoke of SAGE III at the MTPE Joint Working Group meeting. He spoke of his vision for Russian cooperation by creating a science partnership (Research Opportunity) with Russian scientists instead of just a flight opportunity. McCormick told the group of his previous discussions with Charles Kennel (NASA Associate Administrator for MTPE) and Dr. Kaye about getting two Russian scientists on the SAGE III Science Team. He also would like to get a couple of Russians involved in the SAGE III algorithm development, possibly on a rotational basis to NASA-LaRC. A meeting with the Russian team is planned for April 3-7, 1995, at NASA-LaRC.

The SAGE III Deputy Project Manager, Debra Carraway, summarized the SAGE III project schedule, organization, and the Systems Requirements Review (SRR) that was held just prior to this meeting (see article in this issue on page 23). She emphasized the need for the Science Team to be thinking about minimal science requirements in the event that descoping options are needed for future project cost containment.

The SAGE III Project staff presented an overview of the METEOR-3M and Space Station (SS) missions and the instrument development status.

Joseph Zawodny, Co-Investigator, led the discussions for the science minimum success criteria. He pointed out that the SAGE III measurements had already been reduced by a factor of two prior to its selection. The Joint Working Group and the Payload Panel decided what minimum measurements are to be made. All our measurements are integrated and are all tightly coupled. Our current measurements are our contract with the EOS. The team members agreed that they would work with the Project if and when problems arise to help work around any design problems that may occur.

Michael Cisewski, LaRC-Lockheed, presented the mission concept for the METEOR mission and the SS mission.

Larry Klein, GSFC-Hughes, presented an overview of the EOS Data and Information System (DIS) and Paula Detweiler, LaRC-CSC, presented an overview of the Langley Distributed Active Archive Center (DAAC). She introduced the Science Team to the Version 0 Langley DAAC Information Management System (IMS). A handout was passed out to the team that shows how to order and receive data. She also informed the team members to look on the EDHS (EOS Core System Data Handling System) document homepage for documents that will assist them in processing data on the upcoming Version 1 system.

William Chu, Co-Investigator, presented the Algorithm Theoretical Basis Document (ATBD) requirements and schedule for reviews and product delivery. He emphasized the importance to support the EOS requirements and the need to be able to process data in near real time. He identified 9-10 data products. The draft version is due in August of this year, and the final version is due by the end of December.

Michael Rowland, LaRC-SAIC, discussed a common language to be used for the development of the data products.

The Integrated Product Teams were discussed and agreed to during the meeting. An outline of the Aerosol ATBD was presented and discussed in detail. Several subgroups were formed to discuss particular assignments in the development of the ATBD for each data product.

In closing, McCormick led a discussion about when and where to hold the next Science Team meeting. Because the first draft of the ATBD is scheduled for delivery in August, it was suggested that a meeting was needed prior to this first delivery. It may be appropriate to conduct this meeting in conjunction with the SAGE III Preliminary Design Review which is scheduled for July in Boulder. No decision was reached on the specific date and place, but it was agreed that a meeting should be conducted prior to the first draft delivery date of August. ■

EOSDIS PRODUCT USE SURVEY

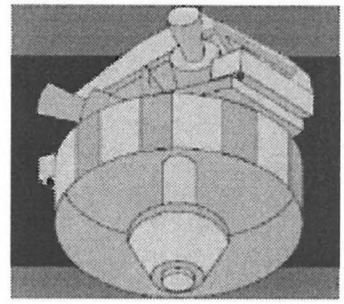
Developers of EOSDIS are surveying potential science users to determine their interest in various EOSDIS products. The information is critical to design. It is needed to determine the size of the data servers and communication links required, and to estimate the load on the system from requested data searches.

An e-mail message will be sent to 1000 potential science users requesting that they access and complete the survey via WWW. In addition to the selected individuals, all scientists who are likely to use Earth science data are invited to complete the survey, which takes about 15 - 30 minutes. To access and complete the survey via WWW use the following URL: http://observer.gsfc.nasa.gov/egsus/intro.html.

Please take the time to help EOSDIS develop a system to meet your science needs.

—Ghassem Asrar

Geoscience Laser Altimeter System (GLAS)



— **Bob Schutz** (schutz@ucsr.ae.utexas.edu), University of Texas at Austin, and
Bernard Minster (jbminster@ucsd.edu), University of California at Santa Barbara

The GLAS Science Team met at the Byrd Polar Research Center of The Ohio State University on March 2-3, 1995. The meeting was opened with welcoming comments and introductions by Ken Jezek, Director of the Center. Attendees included all members of the Science Team, representatives of the Instrument Team, EOS representatives and Ohio State University participants.

Bob Schutz (Team Leader) reviewed the science objectives that GLAS is designed to address. He reviewed the general aspects of the instrument and mission design and how GLAS will meet the objectives for the cryosphere, atmosphere and land applications. The link to the IPCC recommendations on the cryosphere were discussed.

The GLAS data products were reviewed and discussed and the DAACs where each of the data products will reside were presented. The overall context of the data products within EOSDIS was summarized and it was noted that the data would be readily available to the community. There would be no period of exclusive access of the data, although the calibration/verification assessment of the instrument in the first 90-120 days may delay the rapid flow of data during this interval.

The Laser Altimetry Project Scientist, Jay Zwally (GSFC), reviewed the evolution of GLAS into the current concept as a free-flyer with a three-year design, but five-year goal. He described the current study of new concepts that was recently begun under the direction of John Oberright and Dan Mark, both from GSFC. Zwally also summarized the January meeting of the Cryosphere Working Group and he discussed aspects of the new IPCC Report.

Instrument and Spacecraft Status

Bert Johnson (GSFC) and Rob Afzal (GSFC), on behalf of the instrument team, summarized the status of on-going instrument development activities. They described the receiver breadboard being developed by X. Sung at Johns Hopkins University and the updated version of the laser altimeter simulator software, which has been enhanced to handle surface roughness and variability in reflectivity.

Significant progress has been made in the laser transmitter development. A laser transmitter breadboard has been developed to evaluate the beam quality and operation over the design lifetime. With the GLAS requirement of operation at 40 Hz, a design goal of 3.15 billion shots per laser has been adopted. This design goal provides for laser operation for approximately 2.5 years, thus an instrument design with three lasers would achieve the 3-year goal with redundancy.

A quarter scale breadboard laser oscillator/amplifier assembly has been constructed that exhibits good Gaussian beam quality. The oscillator beam produces a 4 nsec pulse width with 10% jitter and 2 mJ power followed by amplifiers to increase the pulse energy. About one week after the team meeting, an experiment on the diode pump arrays achieved well over 4 billion shots with a 17% power reduction using an accelerated pulse rate of 200 Hz, well within the specifications. This milestone demonstrated the viability of the design goals.

Additional tests on optics survivability have been initiated using an accelerated test with a 500 Hz laser system. This system, known as AGES, achieved 3.1

billion shots about one week after the GLAS Team meeting and has exhibited excellent performance.

Dan Mark (GSFC) described the plans and initial results for the GLAS study. Preliminary results from the study team, which is examining all aspects of the mission, has concluded that the current small satellite design could be launched in the year 2000 with an overall cost savings. A final report of the study is due in the May-June time period.

Cryospheric Science Applications

Ken Jezek and Ingrid Zabel (Ohio State) reviewed potential GLAS cryospheric applications. They noted that the frequencies used by radar altimeters, such as TOPEX or ERS-1, tend to penetrate the snow layer to depths that are dependent on factors such as snow wetness, whereas laser altimetry will measure the snow surface elevation. The combination of laser and radar altimetry could provide an estimate of snow depth in regions such as the percolation zone, where the radar measurement is dominated by the return signal from the most recent annual ice layer and the laser return is from the snow surface.

Terry Wilson (Ohio State) noted GLAS may contribute to understanding the rifting processes in the Transantarctic Mountains, especially in regions where the surface structures are below the ice surface. Studies with radar echo soundings suggest that a high correlation exists between surface elevation and bedrock topography.

Ian Whillans (Ohio State) reviewed the various contributions to the characterization of the ice surface. He noted that sastrugi topography grows with time after a blizzard. He discussed the scale of surface topography in terms of the vertical and horizontal size of the features as well as their temporal stability.

Kees van der Veen (Ohio State) discussed the problem of separating long-term changes in the surface from variations at shorter time scales. He noted the need for a long-term data set, but also noted the importance of initiating the collection of essential measurements.

Steve Forman (Ohio State) noted that GLAS may contribute to measurements of coastal erosion in the Arctic. Submerging areas erode quickly because of permafrost changes.

Airborne and Spaceborne Activities

Bob Thomas (NASA HQ) reviewed the NASA program in polar research. He made the observation that when GLAS is launched, the data collected in the airborne laser altimeter will provide data sets spanning 10 years over particular regions of the ice sheet. The combination of aircraft data and GLAS will provide an early assessment of mass balance in those regions.

Jack Bufton (GSFC) discussed the status of the laser experiment he will fly on the Shuttle, STS-72. This experiment will provide data for analysis of the performance of the laser altimeter over a variety of mid-latitude surface topographies (land, vegetation, water). The laser footprint of 100 m is similar to the GLAS footprint of 70 m.

The generation of a digital elevation model (DEM) using a scanning airborne laser altimeter (AOL) was discussed by Bea Csatho (Ohio State). The DEMs have high resolution of a few tens of centimeters and were created from parallel AOL swaths measured along a selected ERS-1 ground track.

Tony Schenk (Ohio State) described a possible procedure for calibration of airborne laser altimetry using photogrammetry. The proposed technique may be applicable to GLAS calibration as well.

James Choe (University of Texas) described his analysis of 1993 and 1994 airborne laser altimetry over Greenland along an ERS-l track. He described the technique he uses to correct for the troposphere delay and noted that comparison of laser data along nearly coincident tracks requires information on the cross-track slope, such as the DEM.

Charlie Vaughn (NASA Wallops) discussed the problem of geolocating the laser footprint of the airborne altimeter. The contribution to the vertical component from roll and pitch biases and the bias determination was summarized.

Jim Spinhirne (GSFC) described an analysis using the ISCCP data base to examine the seasonal variation of clouds in the polar regions. Initial estimates of the coverage of ice sheet altimetry returns can be given, but much better knowledge of the distribution of cloud optical thickness is needed. The establishment of a few ground-based lidar systems in the polar regions would enable a useful characterization of the cloud factor in GLAS measurements

GLAS Orbit, Algorithm Theoretical Basis Document

Bob Schutz (University of Texas) reviewed the constraints and considerations that led to the following recommended GLAS orbit paramters: 94° inclination, 705 km altitude, 182-day repeat cycle, frozen orbit. The reasons for recommending a retrograde orbit (94°) vs. a prograde orbit (86°) that provides comparable coverage were reviewed. The 4-degree region at the pole where no data can be collected by a nadir-viewing altimeter at this inclination was discussed within the context of the tradeoffs of science and analysis techniques. The possibility of reducing the size of the "hole" by changing to a more nearly polar orbit was examined in detail after the meeting. In early April, the Team reiterated the 94° inclination based on considerations associated with the characteristics of altimeter crossovers over the Greenland and Antarctic ice sheets.

The GLAS data products were reviewed and a discussion of the algorithm theoretical basis documents for the data products was conducted. The GLAS Science Management Plan addressed the individual team tasks related to the ATBD aspects. Working group meetings for the preparation of the GLAS ATBDs are planned.

The meeting concluded with the GLAS Team thanking the Byrd Polar Research Center for their kind hospitality. The next regular meeting will be in the September/October time period. ■

Landsat 4 and 5 Digital Data Available From USGS

Department of the Interior, U. S. Geological Survey, Reston, Virginia 22092
Public Affairs Office — Mitch Snow (703) 648-4460
Release: January 10, 1995

Approximately 44,500 Landsat Thematic Mapper (TM) scenes acquired from July 16, 1982 through September 27, 1985 by Landsats 4 and 5 are now available for purchase in digital formats from the U.S. Geological Survey's (USGS) Earth Resources Observation Systems (EROS) Data Center (EDC).

TM scenes can be acquired by any customer, without restrictions on data use or sharing. Individual scenes are rated from 0-100% cloud cover and may show a choice of several acquisition dates for the same site during each year.

TM digital products are priced according to the type of geodetic reference data applied to the product. Systematically corrected TM scenes are processed using predicted geodetic position information downlinked with the sensor data. Precision corrected TM scenes are registered to topographic maps and are geodetically accurate to approximately one pixel. Products are framed according to the World Reference System 2 (WRS2) standard, and each WRS scene contains approximately 75 MB for each of 7 spectral bands. The radiometric correction process applied to each TM product is identical. Both products are available in one of several customer-specified map projections.

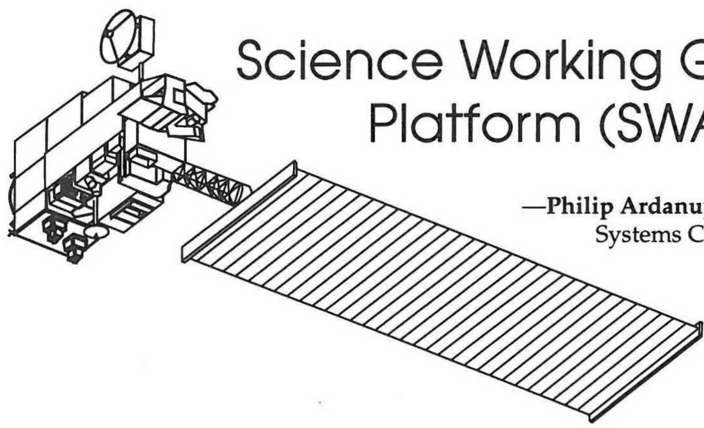
TM digital products are sold on either 9-track or 8-mm tape media for:

Landsat TM Systematically Corrected $425.00
Landsat TM Precision Corrected $600.00

TM photographic products are not available.

More than 350,000 scenes of Landsat Multispectral Scanner (MSS) data collected between 1972 and 1992 will continue to be available to any customer, without restrictions, at $200 per scene.

For further information on Landsat data contact: Customer Services, U.S. Geological Survey, EROS Data Center, Sioux Falls, SD 57198, Tel: (605) 594-6151, FAX: (605) 594-6589, Internet: custserv@edcserver1.cr.usgs.gov



Science Working Group for the AM Platform (SWAMP)

—**Philip Ardanuy** (pardanuy@ltpmail.gsfc.nasa.gov), Research and Data Systems Corp.

The Science Working Group for the AM Platform (SWAMP) met at the Greenbelt Marriott on March 1-2, 1995. Representatives of every AM instrument team, as well as several other Earth Observing System (EOS) and platform scientists, were in attendance. Michael King presented an overview of the EOS Project. The various speakers then described instrument design, development, and testing progress. Issues affecting all instruments, and those overlapping certain instruments, were presented. Piers Sellers thanked those who attended the SWAMP for contributing to a successful meeting. The next "mini-SWAMP" meeting will be held at the EOS-IWG in Santa Fe in June, and there will be a "full-up" SWAMP somewhere on the East Coast in October 1995.

Project Science Office (PSO) Overview

King indicated that the Algorithm Theoretical Basis Document (ATBD) process has been more beneficial and difficult than originally envisioned. The Multiangle Imaging Spectroradiometer (MISR) group is the first science team to have all of its ATBDs delivered and online. Online access of every ATBD is the goal. Multiple formats in the delivered ATBDs complicated the process. The PSO is working to enhance the calibration and validation components of this program. Jim Butler is the new EOS Calibration Scientist. He spent last week in Japan calibrating the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) and Ocean Color and Temperature Scanner (OCTS) integrating spheres. Dave Starr is the new EOS Validation Scientist.

The next Investigator Working Group (IWG) meeting will be held June 27-29 in Santa Fe, NM. One half-day will be designated for breakout meetings on the EOS science plan. Part of the IWG will be devoted to reviews and discussions of these chapters.

AM-1 Overview

Chris Scolese reported that the spacecraft Critical Design Review (CDR) was completed successfully, along with the Headquarters external readiness review. In addition, the ASTER interface CDR, MISR CDR, and the Measurement of Pollution in the Troposphere (MOPITT) Interface CDR were completed during the past 4 months. These went very well, with no issues identified. The Clouds and the Earth's Radiant Energy System (CERES) flight unit has been integrated and is in testing. The MODIS Engineering Model (EM) ambient testing is underway with very good instrument performance. Spacecraft subsystem EMs and life test units are progressing. Emphasis has shifted to completing instrument EM integration and spacecraft integration and test. The ASTER Thermal Infrared (TIR) is significantly behind schedule due to the pointing mechanism—this is the greatest schedule concern at this time. Efforts are being made to advance the MISR delivery date to simplify spacecraft integration.

Current plans are to hold coordinated ASTER/MODIS/MISR Science Quarterly Management Reviews to foster the exchange of ideas. The reviews will look at algorithm development, calibration, validation, production processing software, science computing facility, and instrument operations. Covered are progress against plans, schedules, changes in scope, interfaces, and issues identification, with emphasis on schedule adherence. To reduce risks, Hughes no longer plans to move the Santa Barbara Research Center (SBRC) facility until after the first MODIS unit is delivered.

Following are the major AM project objectives at this time:

- ◊ Deliver first CERES flight unit to TRMM (September 1, 1995)
- ◊ Complete spacecraft design (April 1, 1995)
- ◊ Complete testing of MODIS, ASTER, MISR, and MOPITT EMs (April 1, July 1, July 1, October 1, 1995, respectively)
- ◊ Begin fabrication of instrument flight units for EOS AM-1 (prior to October, 1995)
- ◊ Continue science software development towards beta delivery in the first quarter of FY96
- ◊ Deliver launch vehicle test adapter to Lockheed Martin Astro Space for spacecraft modal survey (December 15, 1995)
- ◊ Complete CAPL-2 flight on the Space Shuttle (prior to June 1995)
- ◊ Resolve TRW solar array mounting, cost, and schedule concerns
- ◊ Resolve ASTER scan mirror repointing disturbances

MODIS Instrument Status

Vince Salomonson reported that the Moderate Resolution Imaging Spectroradiometer (MODIS) EM is working at SBRC. Some data from the MODIS EM are being received at Goddard for analysis. The Team is working to reduce noise in the electronics to the 1 count level, and this has resulted in a 1-month schedule slip (which slack can accommodate). MODIS is feeling pretty good about progress to date. The dedicated MODIS test facility is in place at SBRC. Significant work remains on closing out the ATBDs, but rapid progress is being made. The Peer-Review Panel felt the atmosphere group was too small relative to the oceans group: the Announcement of Opportunity (AO) process will address this. Also, the Panel noted some duplication of products within MODIS, and a lack of connection with the MISR and CERES teams.

Software beta deliveries are in for 19 of 37 science products. By May 1, all but 5 product algorithms are expected to be in at Goddard. The Ocean Team will deliver the ocean algorithms as an integrated set. The beta delivery is more than a set of dummy modules, as the software creates and passes the planned parameters. But, scientifically, it is not the launch-ready algorithm set. The EOSDIS processing capacity (available MFLOPS) seems to be improved to largely meet MODIS needs, but networking and storage are still a concern.

CERES Instrument Status

Bruce Barkstrom presented the CERES status. The Tropical Rainfall Measuring Mission (TRMM) instrument copy is under fabrication, with calibration this Spring. Based on the peer review of calibration issues, the Team will try to improve ties to the National Institute of Standards and Technology (NIST), but must account for geometry and spectral output in the vacuum chamber and improve the coherence of the error budget.

ATBD revisions are being placed online (approximately 1,000 pages) as postscript versions. The team is aiming towards code delivery of "Release 1" for TRMM early in 1996. The Science Team is working through the algorithms and providing an operations concept for normal processing. Validation plans are to be discussed at the next CERES Science Team meeting (and are not accounted for by EOSDIS).

MISR Instrument Status

A MISR update was presented by Dave Diner. Average power, mass, and data rate of the EM are all well within allocation. The longest and shortest focal length lenses have been successfully assembled and tested—they meet or exceed all performance requirements. The charge-coupled devices' (CCDs) performance and yields meet or surpass expectations. The pointing angles on the MISR optical bench are manufactured to better than required tolerances.

Following extreme thermal cycling, angles returned to within <1 pixel deviation. The Primary Support Structure (PSS) was received from Loral (an aluminum honeycomb/graphite epoxy). MISR will decide whether to use the EM PSS for flight by May 1. The electronics are extremely quiet, with <1 digital count of noise at room temperature. One EM camera was put through and survived vibration testing.

The CDR was held December 1994, and MISR was assigned 17 action items and 4 advisories, and permission to proceed to the Protoflight Model (PFM) was granted. The MISR ATBD Peer Review was held May 11, 1994. The ATBDs were updated in December concentrating on reviewers' responses, and a second update is expected in 1995. A Calibration Peer Review will be held March 27-28. The Science Data Processing System (SDPS) Beta System Design Review is scheduled for June 1995.

ASTER Instrument Status

Hiroyuki Fujisada made the ASTER presentation. ASTER is in the PFM design phase, with subsystem EMs finished with their development testing. The Shortwave Infrared (SWIR) and TIR boresight jitter due to cryocoolers show very small directly measured values (1 arcsecond peak-to-peak for the SWIR subsystem and 0.6 for the TIR). Disturbance to other instruments from both cryocoolers will be very small. All ASTER system and subsystem CDRs were performed successfully. Allocation values in the Unique Instrument Interface Document (UIID) for ASTER are satisfied except for pointing. ASTER Ground Data System (GDS) contractors were selected in November 1994. The first interface meeting between the EOS Data and Information System (EOSDIS) and ASTER's Ground Data System (GDS) is currently underway.

There are several issues for ASTER development. Pointing system EM delivery to the ASTER system was delayed. Delivery occurred on February 13. The TIR scanner pointing mechanism may affect instrument boresight jitter and stability. There are delays in the TIR scanner development.

Beta software version goals include the conversion of prototypes and specifications to production software. MODIS, MISR, and National Meteorological Center (NMC) interfaces have not been implemented. Hierarchical Data Format (HDF) is not used, Level 1 is dummied in, and error handling is not fully implemented. Beta software is proceeding on schedule for an April completion. The system will be integrated and delivered to the EROS Data Center (EDC) Distributed Active Archive Center (DAAC) in January 1996 as soon as the DAAC is ready.

MOPITT Instrument Status

The MOPITT presentation was made by Jim Drummond. Instrument Interface CDR was successfully held in mid-December. Module testing is in progress. The MOPITT calibration facility is being integrated and the EM is due in late April 1995. The CDR will be held on April 27, 1995. ATBD rewrites are beginning. Three members were added to the algorithm development team. A line-by-line model was replaced with an initial fast transmittance module, speeding up computations by 3 to 4 orders of magnitude. The retrieval was changed to a maximum likelihood method. MOPITT is using a 3-D chemical transport model to get initial *a priori* profiles and covariance matrices, which can be used, along with the Science Data Processing (SDP) Toolkit/AM Platform simulation data, to obtain MOPITT test data. The team is beginning to use the MODIS Airborne Simulator (MAS) to evaluate cloud detection and declouding approaches.

Integration and Testing (I&T)

The I&T Interface Control Document (ICD) is the key document detailing instrument provider and spacecraft provider plans, obligations, data, and activities. The focus for the coming year will be reconciling activity details, consolidating test data bases, and developing procedures. There is a preferred instrument integration order. Instrument performance will be checked regularly throughout spacecraft I&T via instrument-defined comprehensive performance tests. Once collected, instrument testing represents a continuous compatibility check. As feasible, instrument data collection and reduction should be maximized. Contamination control will be rigorously pursued during I&T. Spherical Integrating Source

(SIS) testing is an integral component of the I&T process.

I&T issues extend across all aspects of instrument design, testing and operations, including Government-furnished equipment, data collection, data processing and archiving, limited life items, and environmental issues. Complete identification of instrument performance metrics is required to serve as a reference during I&T checks. In addition, external standards or targets, and system and/or subsystem compatibility are recommended standards for I&T. Additional I&T meetings are planned. The science community should be cognizant of I&T and focus on the resolution of inconsistencies. The project is looking at revising the integration schedule to install MISR first.

Lunar Calibration Issue

The issue of whether to configure the platform to permit instruments to view the moon for calibration purposes remains controversial. Engineering tradeoffs between the risks and thermal effects of periodic spacecraft maneuvering and the need for precision calibration differ for each instrument. Among the issues to be resolved are:

◊ Benefits *per se* (space, moon)

◊ Maneuver trajectories

◊ Frequency of maneuver

◊ Engineering considerations

◊ Schedule and document delivery date

CERES has a critical requirement to view deep space limb-to-limb. The entire Earth Radiation Budget Experiment (ERBE) data set is pinned on two such space looks spaced about 2 years apart. This was performed to remove an instrument artifact in ERBE, and a similar effect is seen in CERES. MODIS has a similar requirement. Regardless of our knowledge of the lunar spectral albedo today, taking the lunar data will allow us, even 20 years from now should lunar knowledge improve, to go back and retroactively apply the improved knowledge to understand the observations.

Hugh Kieffer is heading up a small team to write a white paper on the scientific and operational aspects of lunar calibrations. This report, assessing the maneuvers necessary to view deep space and the Moon, and the scientific benefits of such, will be presented at the next EOS IWG.

Gridding

The long debate over standard EOS-wide gridding schemes is hopefully almost over.

MISR data are intrinsically unregistered on the ground (by band by zenith angle). MISR uses a Space-Oblique Mercator (SOM) projection to develop a virtual MISR instrument for which all data are registered. To combine MODIS and MISR at Level 3, one may resample each to the International Satellite Cloud Climatology Project (ISCCP) grid. To merge MODIS and MISR at Level 2, a function is needed which resamples MODIS to the SOM grid. MISR and MODIS will coordinate this externally from the SWAMP. This issue will be resolved for the next SWAMP meeting.

Digital Elevation Model (DEM) Update

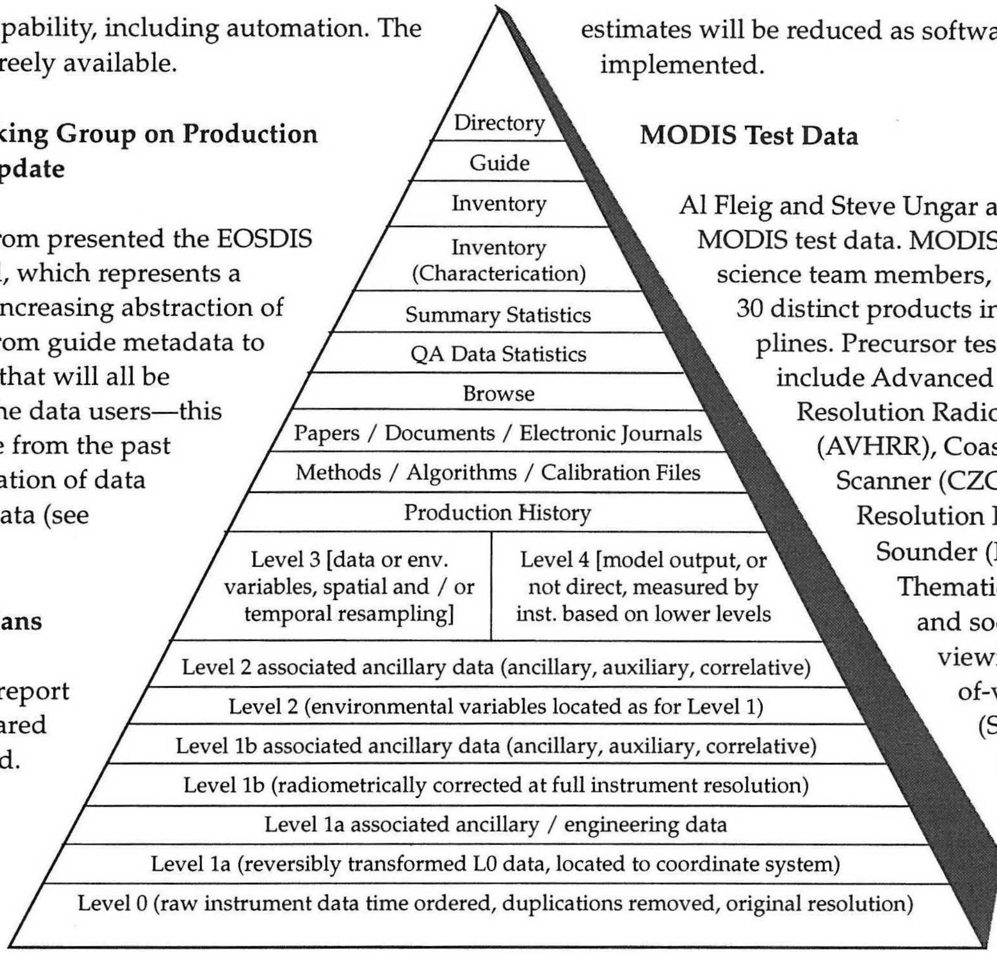
Martha Maiden reported that first priority is given to an initiative to produce a publicly available 1 km DEM. This builds on the existing Committee on Earth Observation Satellites (CEOS) "Globe" program, which includes a Defense Mapping Agency (DMA) contribution, Digital Charts of the World (DCW) where available, National DEMs at 1 km by negotiation, supplemental gap filling, and a possibility of using satellite techniques. The second priority is 100 m global data. This expands on a MISR data access initiative. A joint Instrument Science/EOSDIS Working Group is being established to oversee implementation.

There is a proposed NASA/ESA project to develop DEMs using ERS SAR data and interferometric SAR techniques. Amazonia is a typical area with no DEM coverage, in part due to extensive cloud cover in that region. Satellite techniques (e.g., SAR) can be used to fill this in.

The plan is for processing system readiness by October 1995. Presently, JPL is prototyping the processing capability, including automation. The data will be freely available.

Ad Hoc Working Group on Production (AHWGP) Update

Bruce Barkstrom presented the EOSDIS data pyramid, which represents a hierarchy of increasing abstraction of data forms, from guide metadata to Level 0 data, that will all be available to the data users—this is a departure from the past strict demarcation of data versus metadata (see figure).



Validation Plans

A validation report is being prepared and integrated. Instrument team contributions should include prelaunch algorithm test/development requirements such as field experiments, operational surface networks, and existing data requirements. In addition, postlaunch requirements such as field campaigns, buoys, other satellite data, extensive data sets, and a common registration site, should be included. Instrument representatives for validation include: John Barker (MODIS), Tom Charlock (CERES), Jim Conel (MISR), Simon Hook (ASTER), and Laurie Rokke (MOPITT).

Sizing Issues

EOSDIS can meet the processing requirements, due in part to the phasing of processing loads and a decrease in the requirements. Capacity estimates are uncertain and estimates by instrument teams are based on current knowledge. A better understanding of built-in contingencies is needed, and the requirements must be validated by AHWGP. It is expected that capacity estimates will be reduced as software versions are implemented.

MODIS Test Data

Al Fleig and Steve Ungar addressed MODIS test data. MODIS contains 23 science team members, with more than 30 distinct products in three disciplines. Precursor test data types include Advanced Very High Resolution Radiometer (AVHRR), Coastal Zone Color Scanner (CZCS), High Resolution Infrared Sounder (HIRS), MAS, Thematic Mapper (TM), and soon the Sea-viewing Wide Field-of-view Sensor (SeaWiFS). Test data can be modified instrument data resampled, rearranged, and reformatted. Test data can also be synthetically calculated rather than measured data. Uses of test data include algorithm development, algorithm transfer, algorithm and SDP toolkit integration, and SDPS resource usage and algorithm testing.

The MODIS Team Leader Computing Facility (TLCF) is producing synthetic data for geolocation based on available AVHRR and TM control points. The TLCF is creating synthetic data for algorithm transfer, integration, and operational testing.

CERES Test Data

The CERES Team is developing the test plan (tests and test data) to consider the following instrument and processing test issues: Is the instrument working properly and are we interpreting it properly? Can we create and read files? How good are our resource estimates? Can we handle exceptions? Do the algorithms produce good numbers? System testing will take place with Release 1 software. It will probably use the "best available" prelaunch data sets. CERES science testing uses 1 month of AVHRR/HIRS in conjunction with ERBE to wring out preliminary algorithms.

MISR Test Data

The MISR team discussed their test data. Test data are based on prototyping software; Advanced Solid-State Array Spectroradiometer (ASAS) data are also being used. Test data will come from MISR simulations, AVHRR, ASAS, Along-Track Scanning Radiometer (ATSR), AVIRIS, and Landsat. Initial testing is by subsystem, with each using the test data most appropriate. No data are passed between subsystems. The MISR-developed simulation program will be used to construct MISR data for end-to-end processing. Simulated data will be inserted into MISR packets and extended to full MISR granules. This will allow for a test of subsystem interfaces, and is intended to test software, not algorithms.

ASTER Test Data

ASTER test data development is underway. Algorithm developers provide files containing input simulated Level 1B radiance data, and expected results. Production staff add data dropouts, metadata, etc. The Japanese are developing three versions of Level 1 test data. The third will be complete at the end of 1995 and covers a full 60x60 km scene; it uses AVIRIS and Thermal Infrared Multispectral Scanner (TIMS) data.

MOPITT Test Data

Paul Bailey addressed MOPITT data simulation philosophy and realities. Spacecraft ground (thermal vacuum, etc.) data are virtually useless for testing production science software (beyond simple Level 0 ingest); they are not characteristic of Earth/atmosphere scenes. Each production processing step has its own unique pathological scenarios, with Level 1 not the same as Levels 2 or 3. Also, different processing steps need different quantities of input data for verification. "End-to-end" testing leads to a very complex simulator if all pathological conditions are to be modeled into Level 0. The simulator software becomes as complicated as the production software. This is difficult to verify and expensive to build.

It is most cost effective to build separate simulators for each data level that models the pathological problems for the next software level. Testing verifies the data interfaces, input and output. Benign simulations are used to verify flow between the processing steps.

With respect to beta delivery, MOPITT will deliver all test data including ancillary data necessary to run Science Data Processing (SDP) software. The DAAC must be able to make this ancillary data available in an "operational" context. For MISR Version 1 delivery, it is anticipated that the DAAC ingest data from ancillary sources corresponding to agreed-upon scenarios. MOPITT would use the same source of ancillary data in creation of simulated data sets. Version 2 delivery is handled the same as Version 1, but extended to a wider range of scenarios, possibly using the MODIS test set as a source of cloud data, etc. Ancillary data required includes temperature (including surface) and moisture at standard levels, and DEM as supplied by SDP toolkit.

ESDIS Update and Beta Deliveries

Steve Kempler addressed the current ESDIS status. Current AM instrument science software deliverables include:

1. Beta (interface and initial sizing) delivery between September, 1995 and March, 1996
2. Version 1 (engineering delivery) between June, 1996 and December, 1996
3. Version 2 (science delivery) between July, 1997 and January, 1998
4. One additional "delta" delivery allowed per team between Version 2 and launch

A symmetric multiprocessing (SMP) class of hardware platforms has been selected. The SDP Toolkit TK4 was delivered February 28, 1995. There is a minimal impact on efficiency for TK4 delivered functions (this is about 80 percent of the toolkit). TK5 will be delivered July 95 and will contain process control, metadata access, status message, and prototype EOS Hierarchial Data Format (HDF) tools. The selection and procurement of a graphics package is due in March.

There will be a Science Software Integration and Test (SSIT) Workshop to bring together instrument teams and DAAC personnel to better understand the SSIT process, delineate roles, and begin developing documented agreements.

Requirement for "Rapid-View" Data

Quick-look went away during downsizing. This included Level 0 data, as well as Levels 2 and 3. ASTER was most affected due to the shipping delays, but instrument teams all require some mechanism for anomaly resolution, etc. From a spacecraft point of view, this need can be satisfied. ESDIS also is able to meet the need using "rapid-view" data, with no impact to costs, if this is worked in a less formal way than leveling requirements.

The need for such rapid view has been born out in recent missions, such as the Upper Atmosphere Research Satellite (UARS). For example, since September 1991, 299 of the 300 crashes of the Solar Stellar Irradiance Comparison Experiment (SOLSTICE) instrument were recovered viewing the near-real-time data, including about 30 events overlooked by the Flight Operations Team (FOT). UARS demonstrated that regular AM Project access to near-real-time data will provide early detection of instrument anomalies and reduce the resulting loss of data.

The goal is to provide a viable approach for expediting preprocessed science data to users for the purposes of instrument activation, calibration, anomaly resolution, and rapid scientific evaluation. The solution is to make expedited data sets available to users from the DAACs within a nominal 2 to 3 hours after receipt. This would be a small subset in addition to the normal full Level-0 processed data stream.

Ancillary Data Update

Matthew Schwaller addressed the policy regarding ancillary data acquisition. External data sets are those of interest to Mission to Planet Earth (MTPE) activities, generated by non-NASA agencies, that may or may not reside at EOSDIS DAACs. There are three types:

1. Required for product generation
2. Required for validation, calibration, and algorithm development
3. Required for research

Generally, in cases (1) and (2), EOSDIS will assume all responsibility for providing data access. In other cases, for example, where non-production data are required by one or a few investigators, more responsibility will fall on the investigators. The number and volume of external data sets needed for EOS standard product generation must be well-defined. Significant access issues exist. EOSDIS will generally not fund the acquisition of datasets which do not now exist. Needs must be explicitly expressed so research for the best means to acquire data may begin. ■

Ocean Color Multisensor Calibration Meeting

— **David Herring** (herring@ltpmail.gsfc.nasa.gov), MODIS Administrative Support; Science Systems and Applications, Inc.

Introduction

During the third week in February, some 80 oceanographers, engineers, computer scientists, and program and project managers within the international Earth science community held a 3-day meeting at the University of Miami to discuss the future strategy for handling global ocean color remote sensing data from multiple platforms. Co-chairs for the meeting were Robert Frouin, MODIS Co-Program Scientist, and Wayne Esaias, MODIS Ocean Discipline Group Leader.

At the meeting, participants created the framework for reaching their goal as presented by NASA Headquarters: *to develop a plan and approach for conducting coordinated cross-calibration and validation of ocean color satellite sensors.* NASA is specifically interested in establishing data system requirements necessary for the combined use of satellite ocean color products from SeaWiFS, MODIS, OCTS, GLI, MERIS, POLDER, and other ocean color sensors, to address the needs for decadal-scale observations within the NASA Mission to Planet Earth (MTPE) and international Global Change research community. The meeting participants' objective is to submit a report by early May 1995 to NASA MTPE that addresses the following:

◊ scientific and agency needs and objectives,
◊ radiometric calibration requirements and approach,
◊ global geophysical product algorithm validation,
◊ multisensor data comparison and merging procedures,
◊ data and data system requirements for multisensor data,
◊ international and national coordination, and
◊ five-year budget requirements.

On Wednesday, February 22, the international contingent met in an all-day plenary session to share status reports on their respective projects, and to set the stage for addressing the issues listed above. On Thursday, meeting participants were divided into five groups to discuss discipline-specific concerns. On Friday, the attendees reconvened for a Final Plenary Session to report on each groups' conclusions and/or recommendations.

Radiometric Calibration and Characterization of Sensors

Chuck McClain, SeaWiFS Project Scientist, reported on Group 1's recommendation to build on the framework developed under the joint SeaWiFS-MODIS calibration and validation program. McClain suggested that a U.S. Ocean Color Intercalibration Executive Committee be formed to oversee this program. McClain also urged the ocean color community to continue developing measurement protocols—laboratory and field.

Regarding laboratory calibration efforts, McClain stated that the ocean color community should strive to expand the scope of the SeaWiFS Calibration Round-Robin beyond the present radiometric source round-robins which have been hosted at San Diego State University Center for Hydro-Optics and Remote Sensing (although round-robins of this nature should be continued). For instance, the National Institute of Standards and Technology (NIST) could initiate training workshops to facilitate these additional round-robins. McClain recommended that the ocean color community develop a pre-launch sensor characterization standard that describes the key parameters and tests that should be performed and documented.

Regarding post-launch on-board calibration and stability, McClain suggested that the community could develop a cumulative description of the solar calibration, internal lamp calibration, calibration pulse, dark current, and sensor engineering data collection schemes for the present suite of ocean color sensors. He endorsed the support that the EOS Project is giving Hugh Kieffer for the lunar measurement program. McClain said the community should obtain, if possible, witness filter samples for all U.S. ocean color instruments and maintain samples in a vacuum environment. NASA HQ should also support efforts, such as field studies, to evaluate and correct sensor anomalies such as stray light and bright target recovery.

Regarding vicarious calibration, McClain stated that the community should support additional calibration mooring sites, and other vicarious calibration programs at both high latitudes and high altitudes. Atmospheric optical measurements near calibration mooring sites should be supported. Additionally, U.S. initialization cruises for every ocean color mission launch should be supported. A common atmospheric correction scheme for all applicable ocean color sensors should be implemented by the community. McClain recognized that international agreements for data exchange must be established whereas few currently exist. Ultimately, a plan must be developed and supported by the community for evaluating and comparing onboard and vicarious calibration information and associated uncertainty budgets.

McClain stated that NASA should support an ocean color calibration data archive for pre- and post-launch satellite calibration, characterization, and sensor engineering data. Additionally, match-up data and calibration round-robin data should be archived.

Global Geophysical Product Validation

Wayne Esaias and Frank Muller-Karger, University of South Florida, presented a summary of Group 2's deliberations. Esaias defined validation as "the process of defining the spatial and temporal error fields and regional limits for a given biological/ geophysical product throughout the mission." Esaias stated that comparison of satellite-derived values with real *in-situ* values is the basis for determining the accuracy of a data product in extended ranges. Error fields can also be interpreted in terms of the spatial and temporal statistics of the geophysical variables of interest. Every mission has a very basic, minimal validation program, but none are global in scope. Some validation programs are tuned to specific regions and sensors of interest. Esaias said the international sharing of validation data (*in-situ* and ancillary) increases the spatial and temporal coverage by about a factor of 10 over individual projects, and enables cross-comparison of data products. Esaias added that the community should use the sun photometer network to help with vicarious calibration.

Esaias said there is a need to identify key regions that may have inadequate *in-situ* validation activities ongoing. Global survey cruises and focused field expeditions can be used to collect uninterrupted time series data on important variables. Esaias pointed out some key areas of concern: extreme optical environments, high latitude bio-optical moorings, increased sampling of the Southern Ocean, the tropical Atlantic (and northwest Africa to characterize its dust), and major river plumes. He recommended that the GSFC Wallops Flight Facility be used to obtain aerosol optical depth data.

Validation data collection efforts should emphasize normalized water-leaving radiance, chlorophyll-*a*, aerosol optical depth, diffuse attenuation coefficient (k), sea surface temperature, productivity, coccolith, suspended sediments, and fluorescence. Esaias stressed that there is a need to implement quality control measures in collecting validation data.

Muller-Karger stated that there is a need for data consistency, as well as standardized, simplified collection methods. He recommended establishing an ocean color working group with an international forum to define methods and protocols for compiling and distributing data products. Muller-Karger also recommended augmenting each international partner's validation database several fold so that the effort becomes global in scope. In short, access to data should be easy and completely open to international partners.

Muller-Karger suggested developing a global automated observation network for physical oceanography and ocean biogeochemistry. The intent is to establish a near real-time validation database that facilitates fine tuning of data products. He pointed out that the basic technology for such a network does exist, but needs more development (for example, biofouling is a concern). Muller-Karger encouraged the community to take advantage of ships of opportunity wherever possible—consideration should be given to using commercial vessels that frequent shipping lanes and fishery areas, as well as operational assets such as NOAA and U.S. Navy vessels. He recommended that ocean color community delegates conduct a feasibility study to identify vessels and shipping lanes. Additionally, technology and protocols must be refined to ensure data quality, while an international framework is established to ease sampling restrictions in foreign waters.

Multisensor Product Comparisons and Merging Data

Janet Campbell, University of New Hampshire, asserted that the only methods for monitoring global oceanic (or terrestrial) primary production require observations from space. Therefore, she said, our long-range goal is to produce a continuous time series of bio-optical and geophysical variables derived from ocean color satellite data. This database will enable oceanographers to monitor changes in coastal and open ocean biological production that might occur as a direct or indirect result of climate change and human population growth.

The time series will begin in 1996 with SeaWiFS and OCTS data and, subsequently, data from the MERIS, MODIS, and GLI sensors will also be incorporated. Campbell pointed out that all of these sensors draw from the common heritage of the Coastal Zone Color Scanner, and thus, there is a basis for merging data. Because of their high degree of compatibility, data from SeaWiFS and OCTS will be the easiest to merge. Changes in spatial and spectral resolution will make the task more challenging as the later sensors come on line.

It is unclear whether data from other sensors (POLDER, MOS Priroda, and others) will be merged because these sensors employ techniques or have other differences that may render them incompatible. Group 3 proposed creating a data set that would allow oceanographers to determine whether the data from these sensors can be merged directly, versus providing important comparative information.

The purpose of the time series is to monitor environmental change. Thus, the variables chosen include (to begin with): a CZCS-like pigment concentration (derived from CZCS bands) that will enable us to begin the time series in 1978 with CZCS data, chlorophyll-*a*, diffuse attenuation coefficient, and aerosol optical depths. Other variables (e.g., primary productivity, coccolithophore concentration, etc.) will be added as these become operational products at a later date.

Campbell does not recommend the production of time series for variables (e.g., water leaving radiances, epsilons, etc.) solely for the purpose of interpreting the higher-level derived variables. These data sets will exist within the project. However, she anticipates the need to make adjustments or corrections to make data sets compatible. No doubt, data from the earlier satellites (SeaWiFS and OCTS) will have to be "corrected" to make them compatible with later sensors. To this end, she recommends the creation of a Test Data Set (or Diagnostic Data Set) that will contain the information necessary to figure out how to accomplish the adjustments. This information (calibration constants, sensor gains, raw digital counts, algorithm parameters, etc.) is readily available and accessible during the initial processing of the data, but is highly inaccessible after the data are processed. Thus, Campbell recommends a Diagnostic Data Set should be created by each sensor project at the time the initial data are processed.

The Diagnostic Data Set will contain data and ancillary information for individual pixels located at a fixed spatial grid. The grid-point spacing will be relatively large in open ocean areas, but will get finer near shore. The total number of grid points will be on the order of 30,000 globally. Thus, the diagnostic data volume will be manageable, not overly burdensome, but extremely valuable in later years as oceanographers work out the details of how to merge the data from multiple sensors over a 15-year time period.

Data System Requirements

Gene Feldman, SeaWiFS Data Processing Manager, stated that recommendations on a data system could not be spelled out until processing requirements from Groups 1 - 3 are better defined. Feldman suggested that he should establish a home page on the World Wide Web for the ocean color community. The page could help clearly identify who the members of that community are, as well as the members' respective missions. Additionally, a Mosaic-like browser could be implemented for every ocean color project affiliated with distributed data servers running SEABASS, or a similar system in which *in-situ* data are available for public use.

Feldman recommended putting together an actual data set package from a field program (e.g., the Southern Ocean JGOFS [Joint Global Ocean Flux Study] October 1996 - April 1997 campaign) that includes current ship data, as well as data from buoys, moorings and other sources. Metadata for each data set should also be preserved and made available. Additionally, while JGOFS is in operation, spacecraft ocean color missions also in operation should provide access to coincident satellite data in near real-time to the JGOFS researchers and data users.

Feldman also recommended designating a group/program/investigator to develop an ongoing effort to support the collection, formatting, cataloging, and distribution of ocean color, *in-situ*, and/or field support data. Feldman said that this designate may provide links to a highly distributed system, or coalesce the data into a DAAC. Feldman added that a standard grid, such as the ISCCP 1-km nested grid, must be adopted.

National and International Coordination

Robert Frouin stated that oceanographers need long-term data sets to study interannual phenomena, such as global and coastal change, carbon cycling, and spatial scaling. Currently, there are six satellite sensors capable of global coverage that are scheduled to launch within this decade—a great opportunity to start building a long-term database. To take advantage of this opportunity, the ocean color community must develop composite calibration/validation data sets; pool metadata on sensor characteristics; compare and assess algorithms for product extraction; arrange for Level 1 data exchange after launch; and evaluate and distribute final products.

Frouin reiterated the need to establish a science working group on ocean color (such as an extended JUWOC, or Japanese-U.S. Working Group on Ocean Color) to make recommendations and take the lead on strategic planning. International space agencies, government bodies, and the Committee on Earth Observations Satellites (CEOS) should take the lead in setting policies, establishing multilateral agreements, writing memoranda of understanding, or whatever is needed for sharing data among the international community. Additionally, the United States should establish an interagency work group on ocean color to facilitate the coordination of programs, funding, etc.

Frouin recommended using pilot projects to lay the foundations for international collaboration. These pilot projects could help force the community to resolve problems relating to multi-sensor calibration and validation, data formatting and exchange issues, sharing agreements, etc. ■

Airborne Science Flight Opportunities

— **Andy Cameron** (acameron@mtpe.hq.nasa.gov), Airborne Science Support Office, NASA HQ

The accompanying table is an update of a similar table published in the May/June 1994 issue of *The Earth Observer*. The intent is to let investigators know of planned scientific flight opportunities that may offer the possibility of shared resources for Earth observation. Some of the missions shown require deployments that could provide possible "piggyback" opportunities in the areas to be over flown during such "ferry" flights. In some instances, advanced knowledge of the mission will facilitate arrangements for sharing of data.

In these times of federal downsizing and fiscal reductions, the need for outyear planning has become of paramount importance. Critical scientific activity must be identified as early as possible to insure that proper funding and logistics planning can maintain each program's effectiveness. Entries in the table do not necessarily indicate firm commitments to carry out these missions, but should nevertheless serve as a guide to the possibilities for cooperative airborne research activities.

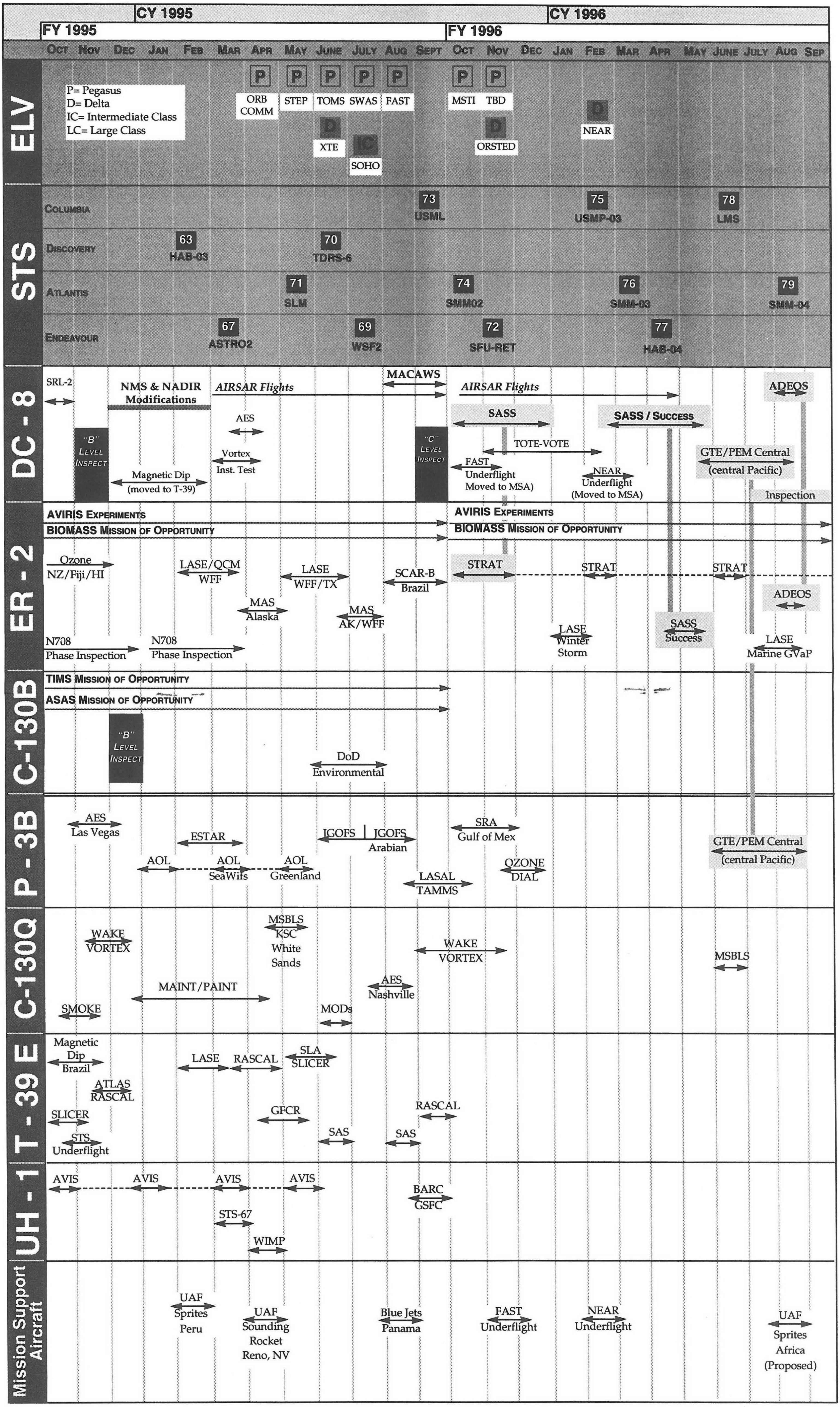
The EOS Project Science Office at the Goddard Space Flight Center would like to extend the usefulness of tables like that of NASA flights shown here, and invites reports from other groups describing planned flights that could provide opportunities for sharing.

Following is a list of the acronyms for the various organizations and missions that appear on the table.

ADEOS	Advanced Earth Observing Satellite
AES	Airborne Emission Spectrometer
AOL	Airborne Oceanographic Lidar
ARC	NASA Ames Research Center
ASAS	Advanced Solid-state Array Spectroradiometer
ASTRO	Astronomy Platform (Shuttle)
ATLAS	Atmospheric Laboratory for Applications and Science
AVIRIS	Airborne Visible/Infrared Imaging Spectrometer
AVIS	Airborne Vegetation Index Sensor
BARC	Beltsville Agricultural Research Center
BOREAS	Boreal Ecosystem-Atmosphere Study
CY	Calendar Year
DIAL	Differential Absorption Lidar
DoD	Department of Defense
ELV	Expendable Launch Vehicle (Rocket, Pegasus etc.)
ESTAR	Electronically Scanned Thinned Array Radiometer
FAST	Fast Auroral Snapshot Explorer
FY	Fiscal Year
GFCR	Gas Filter Correlation Radiometer
GSFC	Goddard Space Flight Center
GTE/PEM	Global Tropospheric Experiment/ Pacific Exploratory Mission
HAB	Habitation Module, Shuttle/Space Station
JGOFS	Joint Global Ocean Flux Study
KSC	Kennedy Space Center
LASAL	Large Aperture Scanning Airborne Lidar
LASE	Lidar Atmospheric Sensing Experiment
LMS	Logistics Module, Shuttle
MAC	Multiple Aircraft Campaign
MACAWS	Multiagency Airborne Coherent Atmospheric Wind Sounder

Continued on Page 22

NASA Outyear Airborne Strategy (Updated April 1, 1995)



MAG	Magnetic, Geo-Magnetic or Io-Magnetic
MAG-DIP	Magnetic Dip Campaign
MAS	MODIS Airborne Simulator
MODIS	Moderate-Resolution Imaging Spectroradiometer
MSA	Mission Support Aircraft
MSBLS	Microwave Shuttle Beam Landing System
MSTI	Miniature Seeker Technology Integration
NEAR	Near Earth Asteroid Rendezvous
NMS & NADIR	Navigation Management System & Nadir Port (for sensor viewing)
ORB COMM	Communications Satellite
ORSTED	Danish Geomagnetic Field Mapping Mission
OZONE	Ozone Monitoring Mission
QCM	Quartz Crystal Microbalance
RASCAL	Raster Scanning Airborne Laser
SAR	Synthetic Aperture Radar
SAS	Subsonic Assessment
SASS	Stratospheric Aerosols, Subsonic Assessment Program
SCAR-B	Smoke, Clouds, and Radiation, Mission-B
SeaWiFS	Sea-viewing Wide Field-of-view Sensor
SFU-RET	Space Flyer Unit-Return (Japan)
SLA	Shuttle Laser Altimeter
SLICER	Scanning Lidar Imager of Canopies by Echo Recovery
SLM	Space Lab Module (Mir Docking)
SMM	U.S./Russian Mir Docking Mission
SMOKE	Smoke used to make aircraft "WAKE/VORTEX" visible
SOHO	Solar and Heliospheric Observatory
SRA	Scanning Radar Altimeter
SRL	Shuttle Radar Laboratory
STEP	USAF Space Technology Program
STRAT	Stratospheric Tracer Transport Experiment
STS	Space Transport System, Space Shuttle
SWAS	Sub-millimeter Wave Astronomy Satellite
TAMMS	Turbulent Air Motion Measurement System
TDRS	Tracking and Data Relay Satellite
TIMS	Thermal Infrared Multispectral Scanner
TOMS	Total Ozone Mapping Spectrometer
TOTE	Tropical Ozone Transfer Experiment
UAF	Upper Atmospheric Flash
USML	U.S. Microgravity Lab (Shuttle)
USMP	U.S. Microgravity Payload
VOTE	Vortex Ozone Transfer Experiment
WAKE/VORTEX	Aircraft Wing Vortex Experiment
WFF	NASA Wallops Flight Facility
WIMP	Water Impact Payload
WSF	Wake Shield Facility
X-STORM	Thunderstorm Research Program
XTE	X-ray Timing Explorer

Ad Hoc Working Group on Production (AHWGP): **Just In Time**

—**Bruce R. Barkstrom** (brb@ceres.larc.nasa.gov), Co-Chair, AHWGP

During most of last summer and early fall, the EOS Ad Hoc Working Group on Production (AHWGP) worked feverishly to get improved estimates of computer loadings, data archival rates, and network traffic. On October 3, the early instrument teams (ASTER, CERES, LIS, MISR, MODIS, and MOPITT) had submitted their initial scenarios to the modeling group at Hughes, together with revised network loadings from many of the IDS teams. About two weeks later, the AHWGP presented some initial results from this effort to the Investigators Working Group at Hunt Valley, Maryland. Over the next several months, the results worked their way into a variety of estimates that were used for the EOSDIS Core System (ECS) Preliminary Design Review. This review was satisfactorily completed toward the end of February, with the review board feeling pleased with the progress being made towards a solid EOSDIS design.

When the AHWGP started its work, production was viewed as a "continuous process", with little data captured on either the discrete nature of the data product files or on the ebb and flow of process activations. When the new information came in from the AHWGP, one of the first jobs that the Project and Hughes undertook was to see how different the estimates were. Interestingly, the previous estimates of total MFLOPS (millions of floating point operations per second) and storage rates appear to be traceable to the new estimates. However, we are now in a position to provide more reliable engineering because the modeling effort can probe the effect of loading the computers and disks with queues of "jobs" waiting to be processed.

As a result of our improved understanding, production of the standard data products appears to fit within the resource envelope for EOSDIS; although the rate of processing has gone up (in MFLOPS), the rate at which data has to be archived has decreased markedly. It looks as though the decreased cost of storage offsets the increased cost of processing.

However, the work of the AHWGP (and related efforts) is far from complete. We have started to expand our data collection efforts to include instruments not on the early satellites. For the instrument teams we have worked with previously, we have begun trying to estimate the impact of validation, quality control, and various kinds of exceptions. Hughes has moved well along in being able to simulate both standard processing and the effects of various kinds of perturbations on the system. Most of the early instrument teams have begun to use these simulation results in designing their operational processing scenarios. We will be pulling these results together in time for the Critical Design Review of EOSDIS. Again, we would expect to get together in a Modeling Workshop, perhaps before the IWG meeting in Sante Fe.

It is also important to observe that the success of the Ad Hoc Working Group on PRODUCTION has led to an Ad Hoc Working Group on CONSUMPTION, led by Bill Emory and Dave Emmitt. The AHWGP had its hands full trying to deal with the collection of production information and is very pleased to have other hands pick up a critical part of collecting what we need to know for a successful EOSDIS.

If we take a longer view of what the AHWGP is trying to do, we can perhaps summarize it in terms of avoiding "unnecessary delay and capacity" in getting good data to data users. Our needs here parallel those of industry in designing efficient production of other goods. We also want to minimize the delays, maximize the efficiency of hardware and software use, and, most of all, avoid wasting our time and that of our user communities. In industry, such an approach is called "Just In Time" manufacturing. It aims to reduce the backlog of production (data products waiting to be processed or queries to be answered) and minimize wasted production capacity.

Just In Time manufacturing seems like a good metaphor for what we have to do in designing the production processing (and complex query answering) in EOSDIS. Production is not simple. A recent textbook for industrial engineers (*Manufacturing Systems Engineering* by Stanley W. Gershwin, pp. 15 and 16) has some interesting comments on what we have to do: "Complex systems that are poorly understood become increasingly complex over time. We experience such systems constantly in our daily lives, and such experiences are frustrating and wearing. Examples are unfortunately abundant: they include the tax code, the medical insurance system, many aspects of the legal system, price, wage, and rent control schemes, and many government social service agencies.

"I would propose the following mechanism to explain this phenomenon: when a system is poorly understood, simple rules are created to achieve some goal. They fail to move the system toward the goal. Instead, problems appear. More well-intentioned but misguided rules are added to solve the problems, but they only lead to new problems. This continues until nobody really understands what the rules are, what the goals of the organization are, or what the consequences of new rules would be. It also becomes increasingly difficult to change the system because of its dispiriting complexity.

"When rules proliferate, the system is poorly understood. Additional rules are worse than band-aids to cure cancer; they are the cancer. The only solution is to develop an understanding of the system. This understanding may be difficult to achieve, but the operating policies that result from such an understanding will be surprisingly simple, and the system will work."

That kind of understanding is what the AHWGP is trying to achieve. In future work, we will try to apply some of the theory behind Just In Time production to simplify what we have to do, and save us all the difficulty that comes from lack of understanding. ■

Stratospheric Aerosol and Gas Experiment III Systems Requirements Review

—**Lelia Vann** (l.b.vann@larc.nasa.gov)
SAGE III Science Manager, Aerosol Research Branch,
NASA Langley Research Center

On February 27 and 28 a Systems Requirements Review (SRR) of the Stratospheric Aerosol and Gas Experiment (SAGE) III was conducted at Ball Aerospace, the instrument developer's facility located in Boulder, CO.

The SRR objectives were to:

- baseline science and mission requirements,
- confirm that top-level requirements are sufficient and that subsystem allocations have been established and documented,
- confirm that the instrument concept presented by the Project Team can meet objectives and requirements within programmatic constraints, and
- confirm that the Project Team has a good understanding of risk and technology development issues.

This review replaces the Conceptual Design Review and is an attempt to implement the design review process identified in the new NASA Handbook on the development of space systems. The major difference between this review and the Conceptual Design Review is the emphasis that the instrument concept can meet the objectives and requirements within programmatic constraints. Major emphasis is placed on all NASA projects to stay within cost or be subject to the Agency's 15% overrun termination policy.

SAGE III is a major part of the Mission to Planet Earth's (MTPE) strategic plan. The overall objective of MTPE is to monitor changes in the environment and to provide an understanding of the Earth system that allows credible predictions of future change. SAGE III will provide data to satisfy key parts of this objective.

The Phase C/D funds to Ball Aerospace began on January 13, 1995, for a first instrument delivery date of December 1, 1997.

The SAGE III instrument is being developed to maintain the robust concept and design of the SAGE II instrument. The SAGE II worked well and was very reliable. It used solar occultation to examine the atmosphere. SAGE III operates in the same way, but it has added lunar occultation. This allows the observation of some atmospheric gases that exist only at night. It also greatly expands the global coverage. Instrumentally, the most significant fundamental design change is the replacement of single diodes, each representing a wavelength channel, with an 800-element CCD (Charge Coupled Device) linear array of detectors covering the wavelength range 290 nm to 1550 nm. Use of the linear array provides 1-nm resolved channels for measurements of multiple absorption features of a particular gaseous species and for multiple wavelength broadband extinction by aerosols, both of which greatly increase the retrieval accuracy. Ball Aerospace built the SAGE II and has a letter contract to build the new instrument.

The LaRC SAGE III Project staff presented the mission requirements. Because the instruments are flying on three different platforms (identified on page 3 in a separate article on the SAGE III Science Team meeting), different launch and flight environments will be encountered. The project design philosophy is to design a generic instrument and only make changes as required by the particular flight. The known requirements for the Russian and the Space Station (SS) flights were presented. For the SS flight, the SAGE instrument may be mounted onto an ESA developed pointing system "hexapod" for instrument pointing requirements and integrated onto an EXPRESS pallet platform that is being designed for external payload attachment to the SS. The SAGE instrument would be mounted onto the hexapod and the hexapod would be mounted onto the EXPRESS pallet. The EXPRESS pallet will be launched on the Shuttle and once in orbit will be robotically installed onto the SS. Both the hexapod and EXPRESS pallet are "new" developments and therefore create a potential risk to the program. It was recognized that interface agreements between ESA for the hexapod and SS for the EXPRESS pallet are needed as soon as possible.

The LaRC SAGE III Project staff presented the system performance requirements and allocations. The mass allocation presented was estimated based on the SAGE II instrument. It was suggested by the review team that a "bottoms up" estimate be used to ensure that these allocations are adequate. It was also suggested that a weight contingency be established and maintained by the project. The SAGE III has been defined by NASA as a Class C flight experiment.

In summary, the SRR went well in spite of the lack of a contract and the lack of complete definition of the launch and orbital environment. ■

EOSDIS Core System Announcement of WWW Server

The **EOSDIS Core System (ECS) Science Office** has established a World Wide Web (WWW) server to keep scientists and developers in the EOS investigator and general research communities informed of the status of the ECS project, as well as to solicit feedback. The URL is: **http://ecsinfo.hitc.com/** or **http://observer.gsfc.nasa.gov**. This server has been designed to facilitate information flow between the EOS user community and EOS developers.

JPL Physical Oceanography DAAC Distributes TOGA Data Set Collection

— **Chris Finch** (cjf@seafloor.jpl.nasa.gov), Jet Propulsion Laboratory

The JPL PO.DAAC announces the availability of TOGA data sets on CD-ROM. The Tropical Ocean and Global Atmosphere (TOGA) CD-ROM is a set of Compact Disks-Read Only Memory (CD-ROMs) that contain 15 data sets that, together, meet most of the TOGA project data requirements. The following is a quotation from the TOGA International Implementation Plan:

"The highest priority requirement for TOGA is a consistent high-quality decade-long series of data describing the relevant components of the climate system."

The purpose of the TOGA CD-ROM set is to make selected TOGA data sets easily available to a variety of users. The users will be predominantly ocean scientists, but will also include scientists from the meteorological and climatological communities.

A primary goal of the Jet Propulsion Laboratory (JPL) Physical Oceanography Distributed Active Archive Center (PO.DAAC) is to serve the needs of the oceanographic, geophysical, and interdisciplinary science communities that require physical information about the oceans. By producing and distributing such a product, the PO.DAAC will be providing data of interest to its primary user community.

Background

TOGA, a part of the World Climate Research Program (WCRP), is a ten year project (1985–1994) to study the coupled ocean-atmosphere system. The scientific objectives of TOGA, as stated in the *TOGA International Implementation Plan*, are:

◊ To gain a description of the tropical oceans and the global atmosphere as a time-dependent system, in order to determine the extent to which this system is predictable on time-scales of months to years, and to understand the mechanisms and processes underlying its predictability.

◊ To study the feasibility of modeling the coupled ocean-atmosphere system for the purpose of predicting its variations on time-scales of months to years.

◊ To provide the scientific background for designing an observing and data transmission system for operational prediction if this capability is demonstrated by coupled ocean-atmosphere models.

To achieve these goals, TOGA measured atmospheric and oceanographic variables for the ten year period and is performing modeling studies of the coupled ocean-atmosphere system aimed at prediction of the system.

The TOGA CD-ROM project is an effort to distribute both *in situ* and model data from the WCRP TOGA project. In 1990, the NASA Ocean Data System (NODS, the former name of the PO.DAAC) undertook the TOGA CD-ROM Pilot Project. The International TOGA Project Office (ITPO) arranged for the transfer of 9 data sets containing observations and model results to NODS at JPL, which were then assembled into a CD-ROM. The final result, JPL Publication 90-43, *TOGA CD-ROM Description* (Halpern, *et al.*), was distributed to the TOGA research community by the ITPO. This is referred to as the Pilot CD-ROM.

In April of 1991, a TOGA CD-ROM Review was held at JPL. Information gathered by the ITPO from a questionnaire sent out with the data contained many favorable comments and constructive criticisms. As a result of this meeting, it was decided that the JPL PO.DAAC should propose to the ITPO to publish a

TOGA CD-ROM set that covers the entire TOGA project period, from 1985 to 1994. The following guidelines for the development of the TOGA CD-ROM were established:

◊ All data sets on the Pilot CD-ROM would be included, plus additional data sets and additional parameters to be provided by the European Centre for Medium-range Weather Forecasts (ECMWF).

◊ ASCII and gridded binary code (GRIB) would remain the only data formats used.

◊ Additional software should be developed, preferably in the "C" language, for enhanced data manipulation and visualization.

◊ At least part of the software should be portable to as many hardware configurations as possible.

The following additional guidelines were established at the PO.DAAC:

◊ Maintain the highest possible compatibility with the Pilot CD-ROM.

◊ Maintain the integrity and individuality of each data set.

◊ Fit the data for 1 year on a single CD-ROM.

◊ Enhance data format consistency and usability wherever possible.

This plan expanded the number of data sets to 14. The actual number of data sets on the CD-ROM is 15, which includes 3 data sets not in the original plan. The additional planned data sets which did not make this edition should be included in future versions. Unfortunately, the goal of software portability has not yet been met, but will be addressed in future releases of TOGA CD-ROM data and software.

The TOGA CD-ROM Package

The TOGA CD-ROM Package consists of a set of 6 CD-ROMs containing *in situ* and numerical model data for the years 1985 through 1990 formatted according to the ISO-9660 standard, one CD-ROM containing application software for visualizing and extracting data on a PC-compatible system, a document that describes the data and software, and two documents describing the ECMWF model. Macintosh-compatible software of limited functionality (data extraction only) is also included on the software CD-ROM.

TOGA Software

PC-Compatible TOGA CD-ROM Interface Software – The TOGA CD-ROM Interface Software is designed to locate, view, and extract data of interest to the investigator based on time, location, parameter, or data set. The graphical user interface allows the user to browse through the data contained on a CD-ROM and select files for viewing. The user can also browse through lists of data files created by either searching the CD-ROM for data files matching specific criteria or by selecting the files manually. The menus may be traversed with the mouse or the keyboard using the <Alt> key with the underscored letters in the menus.

Macintosh TOGAextract Software – The TOGAextract program is designed to locate and extract data of interest to the investigator based on time, location, parameter, or data set. TOGAextract has no facility with which to view images of the data, but can output "raw", 8-bit images of the gridded data sets (CAC, ECMWF, FSU, GEOSAT, GPCP, ISCCP, LODYC, NCAR, and ORSTOM). ASCII output can be obtained from all data sets.

Other Supplied Software – The following other software packages are supplied with the TOGA CD-ROM: OPCPLOT, oceanographic charting software for the worlds oceans, produced by USGS Minerals Management Service; PCSHOW, software for viewing images on the PC, developed by NCSA; IMDISP, more software for image display on the PC, developed at the JPL Planetary Data System; ATLAST, PC software to plot and examine oceanographic section data, developed by Peter Rhines; NCSA Image for image display on the Macintosh, developed by NCSA; Imagic, also for image display on the Macintosh, developed by Charles L. Norris and William J. Emery; and OceanAtlas, a Macintosh version of ATLAST, developed by John Osbourne and James H. Swift. Documentation files are included with the software, when available, which more fully document the software.

For more information on the TOGA data product, contact:

JPL PO.DAAC User Services Office
Jet Propulsion Laboratory
Mail Stop 300-320
4800 Oak Grove Dr.
Pasadena, CA 91109
telephone: 818-354-9890
FAX: 818-393-2718 (Attn: User Services Office)
e-mail: podaac@shrimp.jpl.nasa.gov

References

Collins, D.J., 1991: Physical Oceanography Version 0 Distributed Active Archive Center Science Support Plan. *JPL Internal Document D-9247*, 43 pp.

Finch, C.J., 1994: Physical Oceanography Distributed Active Archive Center TOGA CD-ROM Users' Guide, *JPL Internal Document D-11538*, 126 pp.

Halpern, D, H. Ashby, C. Finch, E. Smith, and J. Robles, 1990: TOGA CD-ROM Description. *JPL Publication 90-43*, 43 pp.

ITPO, 1991: *Report of TOGA CD-ROM Project Planning Meeting*, International TOGA Project Office, 11 pp.

ITPO, 1992: *TOGA International Implementation Plan*, Fourth Edition, International TOGA Project Office, 73 pp. ■

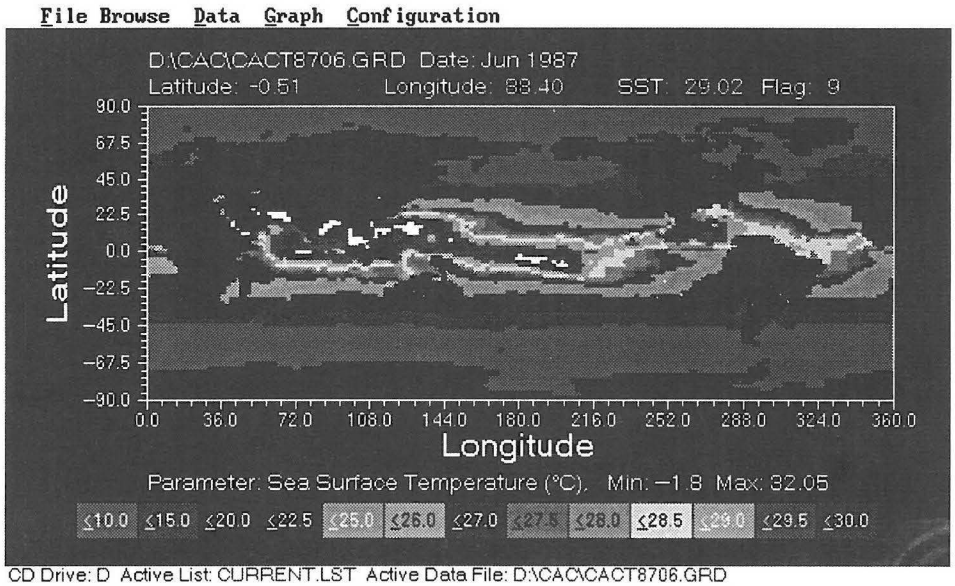


Figure 1. TOGA CD-ROM Interface Software CAC sea surface temperature graphic display.

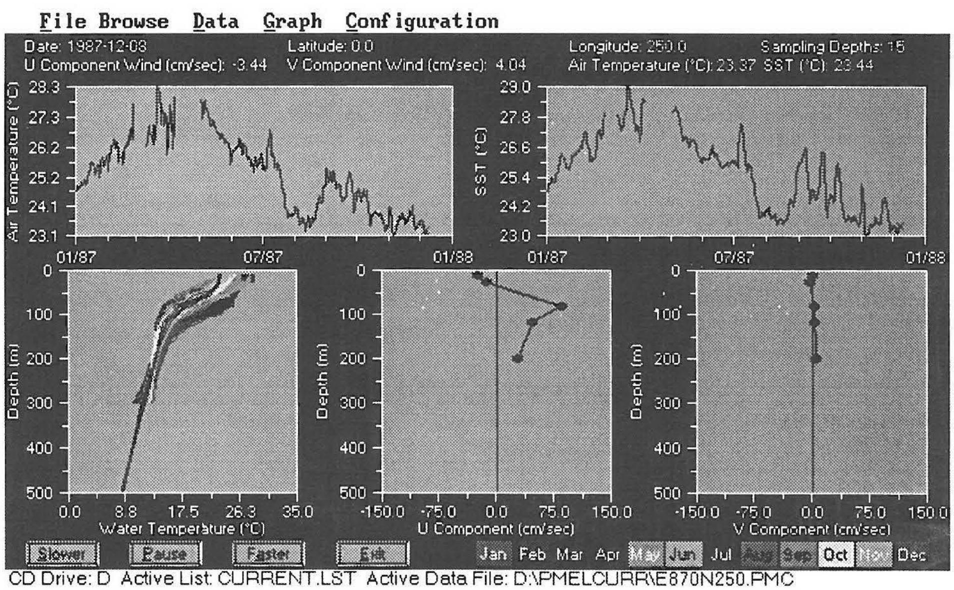


Figure 2. TOGA CD-ROM Interface Software PMELCURR moored current meter graphic display.

Summary of Workshop on Results from the GEOS-1 Five-Year Assimilation

—**S. Schubert** (schubert@albatross.gsfc.nasa.gov), and **R. Rood** (rood@dao.gsfc.nasa.gov), Data Assimilation Office, Goddard Space Flight Center, Greenbelt, MD 20771

I. Introduction

A three-day workshop on results from the Data Assimilation Office (DAO) five-year assimilation (Schubert et al. 1993) was held March 6-8 at the Goddard Space Flight Center. The primary objective of the workshop was to provide timely feedback from the data users concerning the strengths and weaknesses of Version 1 of the Goddard Earth Observing System (GEOS-1) assimilated products. A second objective was to assess user satisfaction with the current methods of data access and retrieval.

There were a total of 49 presentations, with about half (23) of the presentations coming from scientists outside of Goddard. The total attendance was about 120. The first two days were devoted to applications of the data. These included studies of the tropical circulation; geodynamics applications; consituent transport; momentum and energy diagnostics; precipitation and diabatic heating; hydrological modeling and moisture transport, cloud forcing and validation, various aspects of intraseasonal, seasonal, and interannual variability, ocean wind stress applications; and validation of surface fluxes. The last day included talks about several related efforts at the National Meteorological Center (NMC), the National Center for Atmospheric Research (NCAR), the Center for Ocean-Land-Atmospheres (COLA), the United States Navy, and the European Centre for Medium-Range Weather Forecasts (ECMWF). This was followed by talks from several members of the DAO on current and future development efforts. The workshop concluded with a general discussion on data quality, data access experiences, and suggestions for future development of the GEOS system.

The workshop findings highlighted a number of strengths and weaknesses of the GEOS-1 data assimilation products. The following is an attempt to summarize these findings and outline the development activities designed to address the deficiencies. First, however, we shall briefly review the mission of the DAO, and how the five-year assimilation and the workshop fit into the overall development activities of the DAO.

The DAO has as its primary mission the development of a global assimilation system suitable for ingesting the Earth Observing System (EOS) and other satellite and *in situ* observations to produce dynamically, physically, and chemically consistent, gridded high-level data products for studying the Earth System. Such a synthesis of the various observations, which have widely differing error characteristics and irregular temporal and spatial coverage, is deemed vital to enhance the utility of the EOS satellite observations. In addition to synthesizing the available observations, data assimilation provides numerous value-added products; these include estimates of quantities or processes not readily observable (e.g., vertical motion, surface fluxes, and latent heating), and objectively determined estimates of the errors of the final synthesized data products. The emphasis on climate applications, and the large range of potential applications of the data, make it imperative that the DAO obtain feedback on the quality and usefulness of the data products from a broad spectrum of users.

In recognition of the need for timely user feedback, Version 1 of the GEOS system was fixed or "frozen" in March 1993, and a committment was made to generate a five-year assimilation (March 1985 - February 1990) suitable for climate applications. The idea of a reanalysis of historical observations with a fixed data assimilation system was first suggested a number of years ago (Bengtsson and Shukla 1988) as a way of improving the utility of current meteorological observations for climate studies by eliminating the spurious climate signals often found in operational NWP analyses. In addition to the DAO effort, there are a number of other reanalyses currently underway at NMC (Kalnay and Jenne 1991), ECMWF (Bengtsson and Shukla 1988), and the United States Navy. While some limited intercomparisons between these products have already been made (and presented at the workshop), the next year should see an abundance of studies addressing the quality of the various products. The DAO reanalysis is now completed through the end of 1993. It is planned to have the entire 15 year period (1979-93) assimilated with the GEOS-1 system by the end of 1995.

II. Workshop Results

The results of the workshop are summarized below in terms of the strengths and weaknesses of the assimilated product that have been identified by the various investigators. We discuss also the relevant development efforts that address the deficiencies. To help assess the quality of the products, various technical reports have been prepared documenting the current version of the GEOS data assimilation system (DAS). The GCM is described in Takacs et. al. (1994), Suarez and Takacs (1995), and Molod et al. (1995). Takacs et al. (1994) also provide a complete listing and description of all the diagnostic quantities available from the data assimilation system. The analysis system is described in Pfaendtner et al. (1995). Some early results and a user guide to all the datasets available from the five-year assimilation are provided in Schubert et al. (1995). All documents are available online or in hard copy form. Further information about data access may be obtained by sending e-mail to data@dao.gsfc.nasa.gov.

The primary strength of the GEOS-1 assimilation system lies in its ability to capture many of the key climate variations associated with El Niño and La Niña events, monsoons, droughts and other low frequency variations. This appears to be, in part, due to the incorporation of an incremental analysis update procedure (Bloom et al. 1995), which virtually eliminates the shocks associated with data insertion, and allows the model to respond gradually to the observations. Also, the GCM's physical parameterizations appear to respond quite realistically to the low frequency variations in boundary forcing. The results on low frequency variability include the following:

◊ The global signature of low frequency variations in the atmospheric moisture field compares favorably with SSM/I data. This signal appears to be captured better in the GEOS-1 assimilation than either the NMC reanalysis or the ECMWF operational products.

◊ The tropical zonal winds and pressure fields have been successfully used to describe and analyze various aspects of the large-scale circulation such as the Madden-Julian Oscillation and westerly wind bursts. The large scale tropical divergent wind field captures the evolution of the Madden-Julian Oscillation quite well.

◊ Various El Niño signals are successfully captured in the GEOS assimilation. These include a large cloud forcing anomaly in the central equatorial Pacific associated with 1986/87 El Niño that compares favorably with ERBE data. Also, the tropical Pacific precipitation anomalies associated with the 1987/88 El Niño/La Niña event compare favorably with outgoing longwave radiation (OLR) observations. The monsoon precipitation anomalies associated with the 1987/88 El Niño/La Niña event are also consistent with OLR observations.

◊ The reduced precipitation during the 1988 drought and the much enhanced precipitation during the 1993 wet conditions over the United States compare favorably with surface observations. In general, the monthly precipitation anomalies compare favorably with station observations, though there are cases where this is not true.

◊ GEOS-1 captures the seasonal placement of upper tropospheric moisture patterns quite well. The spatial correlations between GEOS-1 fields and observations (TOVS brightness temperatures) are similar to those found with ECMWF analyses.

A number of shorter term fluctuations are also well represented in the assimilation. These are primarily associated with fluctuations in the zonal wind and/or the boundary layer winds and surface stresses. Over land, these results indicate that the performance of the GCM's planetary boundary layer (PBL) parameterization generates very realistic wind fields, since the GEOS-1 DAS assimilates few wind observations below 850 mb. Over the oceans, the results suggest that both the surface wind/pressure analysis and the PBL parameterization are performing well. The relevant results are:

◊ The GEOS-1 equatorial winds appear to successfully capture the subdaily atmospheric tidal variations.

◊ Comparisons with length of day measurements suggest that the GEOS-1 momentum variations are well captured for periods as short as 8-9 days. Comparisons between NMC and GEOS-1 reanalyses shows coherence on all time scales longer than 3 days, which is shorter (better) than has been typically obtained from operational analyses. This suggests the reanalyses are in closer agreement than operational series have been in the past for this quantity.

◊ The horizontal winds, convective cloud mass flux, detrainment information, and PBL depth are of sufficient quality to to be used with some success as input to a 3-D tropospheric transport model for the tracers freon F-11 and radon Rn-222. In particular, Northern Hemisphere synoptic events are well captured; however, interhemispheric exchange is not well modeled.

◊ GEOS-1 wind stress provides good estimates of ocean transport through the Florida Straits. The GEOS wind stress generally provides improvements over the operational ECMWF results, but tends to overestimate amplitudes beyond about 10 days.

◊ Variations in the low level winds over the Great Plains are quite realistic despite the lack of observations going into the GEOS-1 DAS below 850 mb.

The following climate mean quantities are generally consistent with available verifying observations, and/or are consistent with or better than found in other analyses:

◊ The climate mean and seasonal evolution of the basic prognostic fields appear to be well captured in the GEOS analysis. Differences with ECMWF analyses over the Northern Hemisphere land masses are small. The largest differences occur over the tropics, and the Southern Hemisphere oceans, where observations are sparse and model bias is apparently playing a role (more on this below).

◊ The clear sky longwave flux and albedo are in good agreement with ERBE measurements.

◊ The general patterns of tropical convection and their seasonal evolution are consistent with available observations, but details of local maxima and amplitudes are not.

◊ GEOS -1 wind stress fields have been employed to force an ocean model in the North Pacific with some success, particularly in producing the subpolar circulation.

The greatest deficiencies in the GEOS-1 products are tied to biases in the humidity and cloud fields. There are several reasons for this. Moisture biases of the GCM are clearly playing a role, as well as exhibiting deficiencies in how the available moisture observations (currently only radiosonde) are being assimilated. One of the most disturbing aspects of the results is the manner in which the observations and model first guess appear to generate spurious feedbacks (Molod et al. 1995). A number of development activities are geared to addressing these deficiencies. For example, substantial improvements in the moisture field have been obtained with the assimilation of SSM/I observations. The introduction of downdrafts, a cloud water/ice scheme, improvements to the PBL (moist turbulence scheme, an improved mixed layer), further tuning of the convective parameterization, and the assimilation of relative humidity (instead of mixing ratio) should alleviate many of these problems. Improving the weaker-than-observed moisture gradients will likely require increased horizontal resolution. Some of the key moisture and cloud-related problems are:

◊ A much too wet upper troposphere (300 mb) over the Pacific Ocean compared with available observations. Also, the horizontal moisture gradients between very moist and very dry regions of the upper troposphere are too weak.

◊ The tropics and subtropics over the oceans are too dry compared with the vertically integrated moisture from SSM/I.

◊ Longwave and shortwave cloud radiative forcing (LCRF, SCRF) are overestimated over regions of deep convection in the ITCZ, especially during Northern summer.

◊ Middle-latitude LCRF and SCRF are weaker than ERBE especially over the storm tracks of both hemispheres. The vertical distribution of diabatic heating and vertical heat transport may also be too shallow in these regions (especially the North Atlantic).

◊ Low level coastal stratiform clouds are underestimated.

There are various problems with the precipitation, and near-surface temperature and humidity fields. Over land, these include substantial errors in the diurnal cycle. Some of these appear to be tied to the convective parameterization and should be remedied with the introduction of the changes outlined above. Improvements to the diurnal cycle and longer term impacts of soil moisture variations must await the introduction of a land surface model (currently being implemented). The known problems are as follows:

◊ Precipitation

◊ Summertime precipitation over eastern North America is overestimated.

◊ The amplitude of the diurnal cycle of the precipitation over the southeast U.S. is too large with little evidence of a nocturnal maximum over the Great Plains.

◊ Wintertime precipitation is too low over the Northern Rockies and along the southern coast of the United States.

◊ Over India, data in the gap between the western Ghats and the Bay of Bengal are missing.

◊ Too much rain occurs over continental Europe and northern Asia in July and too little over the Mediterranean during January.

◊ The assimilation produces too many days with small rain amounts and not enough days with no rain compared with station observations. The most intense rain amounts also appear to be underestimated. However, it was shown that this may not be the most meaningful comparison, since the observations represent point measurements while the values from the assimilation represent a grid square.

◊ The 1988 drought over the United States appears to extend too far into the summer with warmer-and-drier-than-observed conditions in July.

◊ The near-surface temperature is too cold over the northern United Sates and Canada during winter.

◊ Subtropical deserts are less reflective than in ERBE. The diurnal cycle of out-going longwave radiation over land shows significant phase shifts with respect to ERBE.

A number of other problems have been identified. For example, the model's zonal wind bias introduces a bias in the assimilation in data sparse regions. Current model experiments suggest that much of the westerly bias (and related cooling at high latitudes) can be eliminated with the introduction of gravity wave drag. Problems associated with noise at the poles have been addressed with the generalization of the dynamics module to allow rotation of the poles. Comparisons with NMC results suggest that increased vertical resolution in the PBL should improve the representation of the low level winds. These, and other problems, are noted in the following list of deficiencies:

◊ The Hadley cell appears to be too weak during Northern winter (based on comparisons with ECMWF and NMC).

◊ There is a zonal mean bias at 40S-50S in sea level pressure and the zonal wind.

◊ The northward component of the summertime low level wind over the Great Plains appears to be underestimated.

◊ Various quantities including the temperature and sea level pressure show evidence of noise near the poles.

◊ The magnitude of the wind stress appears to be underestimated over the North Pacific.

III. Data Access and Retrieval

Feedback on experience with data access and retrieval was rather limited. One of the major findings, however, was that most users were accessing the data directly from the NCCS Unitree system, instead of from the Goddard DAAC. A large number of users have also obtained the monthly means from the local DAO server. Most users were satisfied with the access from the NCCS Unitree system which is geared to high speed near-online (robotically-controlled) data access. Complaints were generally associated with data organization and occasional glitches with the retrieval system. Those accessing the monthly means from the DAO server were also generally happy with this type of access, and especially the online documentation; however, the large sizes of the files gave some users problems due to their limited local storage capabilities. For those people obtaining the data from the Goddard DAAC, the experiences were somewhat mixed. Some of the early users had difficulties obtaining the data in a timely manner. The problems were primarily associated with "growing pains" of the DAAC, and the more recent users appear to be satisfied with DAAC performance. The Goddard DAAC received very high marks for responsiveness to user concerns and suggestions. From a more general perspective, there is a concern that the mode of access provided by the DAACs (search and order) is not satisfactory for many users accustomed to high-speed interactive access.

The major complaints centered on the large file sizes of the DAO output and the lack of a subsetting capability. This is an important issue which the DAACs and data providers must address. The options range from providing a more efficient organization of the files (including smaller file sizes), to providing several popular versions (organizations) of the data, to providing an on-demand subsetting capability. The first option may not satisfy enough of the users, while the last option would very likely quickly overwhelm the current resources of the DAACs.

Acknowledgments: Funding was provided by NASA Headquarters through the support of Kenneth Bergman. Jean Rosenberg (workshop coordinator) provided excellent logistical and technical support. Travel arrangements were made by Denise Dunn of the Universities Space Research Association.

References

Bengtsson, L., and J. Shukla, 1988: Integration of space and *in situ* observations to study global climate change. *Bull. Amer. Meteor. Soc.*, **69**, 1130-1143.

Bloom, S.C., L.L. Takacs, A.M. da Silva and D. Ledvina, 1995: Data assimilation using incremental analysis updates. *Mon. Wea. Rev.*, submitted.

Kalnay, E., and R. Jenne, 1991: Summary of the NMC/NCAR reanalysis workshop of April 1991. *Bull. Amer. Meteor. Soc.*, **72**, 1897-1904.

Molod, A., H.M. Helfand and L.L. Takacs, 1995: The climate of the GEOS-1 GCM and its impact on the GEOS-1 data assimilation system. *J. Climate*, submitted.

Pfaendtner, J., S. Bloom, D. Lamich, M. Seablom, M. Sienkiewicz, J. Stobie and A. da Silva, 1995: Documentation of the Goddard Earth Observing System (GEOS) Data Assimilation System-Version 1. NASA Tech. Memo. No. 104606, volume **4**, Goddard Space Flight Center, Greenbelt, MD 20771.

Schubert, S. D., R. B. Rood and J. Pfaendtner, 1993: An assimilated data set for Earth science applications. *Bull. Amer. Meteor. Soc.*, **74**, 2331-2342.

Schubert, S., C.-K. Park, C.-Y. Wu, W. Higgins, Y. Kondratyeva, A. Molod, L. Takacs, M. Seablom and R. Rood, 1995: A Multiyear Assimilation with the GEOS-1 System: Overview and Results. NASA Tech. Memo. No. 104606, volume **6**, Goddard Space Flight Center, Greenbelt, MD 20771.

Suarez, M.J., and L.L. Takacs, 1995: Documentation of the Aries-GEOS Dynamical Core, Version 2. NASA Tech. Memo. 104606, volume **5**, Goddard Space Flight Center, Greenbelt, MD 20771.

Takacs, L.L., A. Molod and T. Wang, 1994: Documentation of the Goddard Earth Observing System (GEOS) General Circulation Model, Version 1, NASA Tech. Memo. No. 104606, volume **1**, Goddard Space Flight Center, Greenbelt, MD 20771. ■

National Institute of Standards & Technology Workshop On IR Metrology and National Needs

—**Milt Triplett** (milt_triplett@netqm.nichols.com), Nichols Research Corp., Huntsville, AL.

National Institute of Standards & Technology (NIST) began its low background infrared source calibration efforts in the early 1970s. Since that time many needs have changed and applications have expanded. With the changes that are occurring, it becomes appropriate to review how NIST's calibration efforts have expanded, the rationale behind the development sequence used, new requirements being solicited, and new capabilities being developed. To accomplish those objectives, a two-day workshop was held on December 6 and 7, 1994, at NIST in Gaithersburg, MD. The meeting was called "NIST IR Metrology Standards and National Needs - 1994." It included prepared presentations from both NIST and NIST users, a meeting of the Users Advisory Board, and facility tours. Workshop organizers were Raju Datla, Group Leader, Infrared Radiometry, NIST; Robert L. Hinebaugh, Program Manager, Ballistic Missile Defense (BMD) Metrology, Newark Air Force Base, OH; and Milton Triplett, Nichols Research, Huntsville, AL, and chairman of the Users Advisory Board.

Most of the papers presented described methods and equipment used to test infrared sensors. For this Workshop, the term "infrared sensor" refers to a system, which includes infrared-energy-capturing telescopes, detectors, signal conditioning, signal processing, and possibly data processing. These sensors can be subdivided into broad application categories such as air/ground-based, space-based, Earth-viewing, space-viewing, and combined. These applications also serve to identify the key issues involved in ground testing and calibration. How these categories set key measurement parameters is tabulated as follows:

Category	Issue/component	Parameter
Air/Ground-Based	Front window emission	Transmission, interior
Space-Based	Cold optics sensitivity	Measurement
Space-Viewing	Space background	Measurement sensitivity
Earth-Viewing	Background	High background
Combined	Combined environment	Both high and low background

Infrared sensors used to measure point-source targets are commonly tested in chambers equipped with blackbodies and collimators. Blackbodies give the desired broadband energy output. The collimator makes the target appear to the sensor as a realistically distant object. For accurate calibration, the flux entering the sensor must be known. There are two approaches to determining this flux in a calibration facility: (1) measure the output of the blackbody and any intervening optical transmission or reflection and (2) measure the flux in the region in front of the sensor. The flux level at the blackbody is the easiest (and sometimes the only feasible) measurement but leaves the most questions. Measuring the flux in front of the sensor involves much of the same technology and difficulty as building the sensor itself but is much more direct.

In the 1970s, the National Bureau of Standards (now NIST) built a low background chamber equipped with a power substitution calorimeter. This chamber was used to calibrate blackbodies from the Air Force's Arnold Engineering Development Center and from the Army's Portable Optical Sensor Tester (POST) chamber. Concurrently, engineers from the active sensor test chambers proposed a round-robin telescope for measuring the flux in each chamber. The uncertainty level that could have been achieved with detector technology of that era is unclear. However, funding was never available for such at attempt.

When the Strategic Defense Initiative (SDI) program started in the early 1980s, it became clear that an improved calibration capability was needed. New chambers to test both exoatmospheric and endoatmospheric sensors were being proposed. A meeting was held at Nichols Research in 1985 under the sponsorship of the US Army Strategic Defense Command (SDC) to examine calibration source status and requirements. It was learned that the calibration chamber at NIST had developed an internal leak that would be very expensive to repair. Further, it was felt that lower flux levels needed to be measured and a more rapid turnaround time for calibration was needed. These items resulted in SDC drafting a set of requirements for and obtaining funding from SDIO for the facility that has now become the Low Background Infrared (LBIR) facility.

The LBIR's requirements were set to measure the total energy output from a blackbody within a small solid angle around the centerline. This technique produces a NIST traceable blackbody source package. Another technique is to use a NIST traceable temperature transducer and to assume that the blackbody source package can be characterized by the planck function . T ests performed in the LBIR chamber to date have demonstrated that this is frequently not true. Warm housings, warm choppers, and improperly aligned apertures produce non-Planckian results not related to source temperature measurement error.

Many blackbody sources are used at flux levels lower than the original LBIR requirements. The reduction in output is typically produced by integrating spheres, output aperture area, or neutral density filters. Integrating spheres are subject to spectral output shifts from contamination. Small aperture areas are subject to total or partial plugging from outgassing. Small aperture areas also cause difficult in quantifing diffraction effects. Neutral density filters are frequently not neutral but are variable with wavelength. All these effects spawned the improvement plan that has been ongoing since the completion of the original LBIR chamber. Work has proceeded toward making spectral measurements, improved measurement sensitivity to support spectral calibrations and sources plus attenuators, and attenuators as a separate component. Concurrently, work has proceeded toward a detector calibration capability. This will support both detector and sensor test chambers. NIST is currently developing a radiometer for measuring the collimator output flux in sensor calibration chambers used in NASA's EOS program.

NIST is currently soliciting a definition of needs from all potential users (DoD, DOE, NASA, commercial, etc.). The results of this survey will be used to determine what test capabilities need to be developed. Potential users with identifiable needs are urged to contact Raju Datla at NIST (rdatla@micf.nist.gov). ■

Registration Form

The EOS-Investigators Working Group Meeting

June 27-29, 1995

Picacho Plaza Hotel
Santa Fe, New Mexico

Please complete the EOS-IWG Registration Form below and fax to Kelly Whetzel at (301) 220-1704, e-mail: whetzel@ltpmail.gsfc.nasa.gov, or complete the form in WWW, http://spso.gsfc.nasa.gov/eos_observ/3_4_95/registration_form.html. Your registration must be received by June 5, 1995.

_____________ Yes, I plan to attend.

_____________ No, I will not be able to attend. _____________ I will be sending a representative.

Please have representative fill out a separate registration form.

Name: ______________________________

Affiliation: ______________________________

Address: ______________________________

City: ____________ State: ________ Zip: ________ Country: ____________

Phone number: ________________ Fax number: ________________

E-mail address: ______________________________

Hotel Information (for information purposes only):

Picacho Plaza Hotel
750 N. St. Francis Drive
Santa Fe, New Mexico 87501

Rates: $94.82 (includes tax) for single or double occupancy.

Call the hotel directly, (505) 982-5591, to make reservations under the group name EOS IWG.

Date and time of arrival: ______________________________

Date and time of departure: ______________________________

EOS Reception

An EOS Reception will be held the evening of June 28, 1995. The cost for the reception will be approximately $30-$35 per person. Further details will follow in logistics information. Attendees need to sign up for this reception in advance to ensure enough space is reserved to accommodate everyone. This information is very important for planning purposes.

_____________ Yes, I will attend the reception _________ # of Guests

_____________ No, I will not attend.

The GLOBE Program
Building a Partner for Mission to Planet Earth

— Rick Chappell (info@globe.gov), GLOBE Program

In recognition of the 25th Earth Day, students all over the world are kicking-off an environmental science and education network that brings together young people, educators, and scientists to study and share information on the global environment.

Vice President Al Gore announced the vision for the Global Learning and Observations to Benefit the Environment Program (GLOBE) during last year's Earth Day celebration. Over 1,900 U.S. schools have signed-up as charter members of the GLOBE Program in 1995 and over 20 foreign countries have signed agreements to participate in the program.

Three major objectives have been identified for the program: the enhancement of environmental awareness, the stimulation of higher student achievement in science and mathematics, and the acquisition of data on environmental change that will be of value to the science community. This latter objective lays the ground work for GLOBE to be of ultimate benefit to the Mission to Planet Earth program in which tens of thousands of students will make Earth-based observations which can support the remotely sensed data from the Earth Observing System.

The GLOBE Program is designed for K-12 students. Under the guidance of teachers who have attended GLOBE training workshops, the students take regular measurements using protocols and instruments specified by GLOBE scientists. Students then submit their data through the Internet to a central facility located at the NOAA Forecasting Systems Laboratory in Boulder, CO.

Under the leadership of the Scientific Visualization Laboratory at NASA Goddard Space Flight Center, data from students all over the world are processed and combined with other science sources to create global images that are sent back to the students over the Internet for classroom study. In addition, remote sensing images from Landsat and NOAA satellites will be made available to the students. These global images can be viewed on the World Wide Web at www.globe.gov.

GLOBE students use GPS receivers to locate a habitat near their school on which they will carry out ground-truth observations related to a specific 30 meter by 30 meter pixel on the satellite image. The student data will be made available to the environmental science community for use in studying global environmental change. Scientists will give mentoring reports back to the students to let them know what has been learned.

An international group of environmental scientists identified the specific measurements to be made. The National Science Foundation is sponsoring a competitive search and selection for scientists and educators to evaluate and define the evolution of GLOBE measurements and educational materials.

Student measurements fall into three categories — atmosphere, hydrology and biology. These categories match nicely with the goals of the Earth Observing System. With student data being reported from thousands of locations around the world, GLOBE can complement the data provided from the larger area satellite images. The GLOBE program is interested in input from the scientific community to ensure that student data are optimized for Mission to Planet Earth support.

Teacher training workshops were held in March and April at 14 Space Grant Universities. Additional workshops are scheduled for the summer.

The GLOBE Program is well underway and already beginning to achieve program goals. GLOBE offers a great opportunity to involve students, their families, their teachers and their communities in the exciting quest of understanding the global environment.

For information on how a school can join GLOBE, write to The GLOBE Program, 744 Jackson Place, NW, Washington, D.C. 20503, or email: info@globe.gov. This information is also available on the World Wide Web at www.globe.gov. ■

Introducing CIESIN's Gateway

The Consortium for International Earth Science Information Network is proud to announce the availability of CIESIN's Gateway. CIESIN's Gateway is a state-of-the-art distributed information system providing users with an intuitive interface facilitating integrated data and information searching, viewing, browsing, and ordering. As a system which employs parallel searching of heterogeneous databases, CIESIN's Gateway totally transforms the ways in which researchers can interact with massive amounts of data stored in different formats at distant locations via modem or a network connection. Other systems only allow for the sequential exploration of data and consume days and even months of research time to locate what CIESIN's Gateway can locate in seconds. Currently, CIESIN's Gateway makes it possible to search for and retrieve data and metadata (data about data) available from CIESIN's archives, NASA's EOSDIS and Global Change Master Directory (GCMD), CIESIN-developed information resources from the U.S. EPA and USDA, and CIESIN's Information Cooperative partners.

CIESIN's Gateway clients for MS-Windows, Sun-OS, and a character based interface are currently available for beta testing. Versions for other versions of UNIX and a Macintosh client are in development.

For more information on CIESIN's Gateway, including access to client software and documentation, use the URL: http://www.ciesin.org/gateway/gw-home.html

For more information on CIESIN, browse the CIESIN Home Page: http://www.ciesin.org

CIESIN User Services can be contacted on-line at ciesin.info@ciesin.org, or by phone at (517) 797-2727, 9-5 pm EST.

—Christopher Davis

Science Calendar

• 1995 •

May 16-17	Oceans DAAC Users Working Group Meeting, Jet Propulsion Laboratory, Pasadena, CA. Contact Victor Zlotnicki at (818) 354-5519 (vz@pacific.jpl.nasa.gov).
May 22-26	ASTER Science Team Meeting, Flagstaff, AZ. Contact Anne Kahle at (818) 354-7265 (anne@lithos.jpl.nasa.gov).
May 24	TES Science Team Meeting, San Juan Institute, San Juan Capistrano, CA. Contact Reinhard Beer at (818) 354-4748 (beer@atmosmips.jpl.nasa.gov).
June 1-2	EOS Workshop on Land-Surface Evaporation and Transpiration, NASA/GSFC, Greenbelt, MD. Contact Jim Washburne at (602) 621-9944 (jwash@hwr.arizona.edu).
June 5	LIS Science Software Review, Huntsville, AL. Contact Steve Goodman at (205) 544-1683 (steven.goodman@msfc.nasa.gov). See homepage wwwghcc.msfc.nasa.gov:5678/ghcc_home.html.
June 6-7	LIS Science Team Meeting, Huntsville, AL. Contact Steve Goodman at (205) 544-1683 (steven.goodman@msfc.nasa.gov). See homepage URL above.
June 6-8	MISR Science Team Meeting, Jet Propulsion Laboratory, Pasadena, CA. Contact Daniel Wenkert at (818) 354-3943 (yow@jord.ple.nasa.gov).
June 20-22	AIRS Science Team Meeting, Suitland, MD. Contact Hartmut H. Aumann at (818) 354-6865 (hha@airs.jpl.nasa.gov).
June 27-29	EOS/IWG, Sante Fe, New Mexico. Contact Kelly Whetzel at (301) 220-1701 (whetzel@ltpmail.gsfc.nasa.gov).
July 5-7	MIMR Science Advisory Group (SAG) Meeting, ESRIN, Frascati, Italy. Contact Drusilla Wishart at (+31) 1719-85674 (dwishart@vmprofs.estec.esa.nl).
September 20-22	CERES Science Team Meeting, NASA/Langley Research Center. Contact Bruce Barkstrom at (804) 864-5676 (brb@ceres.larc.nasa.gov).

Global Change Calendar

May 8-11	Eastern European Regional Workshop on Greenhouse Gas Emission Inventories, Thermal Hotel, Budapest, Hungary. A compilation of papers will be published. For further information, contact Alexei Sankovski at (202) 862-1137; FAX: (202) 862-1144.
May 15-18	Preliminary Announcement and Call for Papers, Workshop on Pollution Monitoring and GIS, LESPROJEKT—Forest Management Institute, Brandys and Labem, Czech Republic. For further information, contact Tomas Benes at (+42) 202 3581, ext. 330; (+42) 202 3727; FAX: (+42) 202 3371.
May 16-18	CORM 95—An International Conference on Recent Advances in Atmospheric Radiometry, Westin Hotel, Ottawa, Canada. Contact Ronald Daubach at (508) 750-2613; FAX: (508) 750-2152.
May 30-June 2	American Geophysical Union Spring Meeting, Baltimore, MD. Contact Karol Snyder at (800) 966-2481.
May 29-June 2	African Regional Workshop on Greenhouse Gas Emission Inventories & Emission Mitigation Options: Forestry, Land-Use Change, & Agriculture, Johannesburg, South Africa. Proceedings will be published. Contact Barbara Braatz at (202) 862-1177, FAX (202) 862-1144.
June12-16	A lecture series titled "Understanding the Earth as a Coupled System: The El Niño Southern Oscillation Experience," Goddard Space Flight Center, Greenbelt, MD. This is part of the Graduate Student Summer Program in the Earth System Sciences. Contact Paula Webber at (301) 805-8396, email: paula@gvsp.usra.edu.
July 2-14	International Union of Geodesy and Geophysics, Boulder, CO. Contact Karol Snyder at (800) 966-2481, FAX (202) 328-0566.
July 10-14	International Geoscience and Remote Sensing Symposium, Congress Center, Florence, Italy. Contact IEEE Geoscience and Remote Sensing Society, 2610 Lakeway Drive, Seabrook, TX 77586-1587. Tel. (713) 291-9222; FAX: (713) 291-9224; e-mail: stein@harc.edu.
August 14-18	International Symposium on Radiative Transfer, Kusadasi, Turkey. First announcement and call for papers. For further information contact: Prof. M. Pinar Mengvc, Dept. of Mechanical Engineering, U. of Kentucky, Lexington, KY 40506-0046; Tel. (606) 257-2673; FAX: (606) 257-3304; e-mail: menguc@ukcc.uky.edu.
August 20-25	10th International Photosythesis Congress. Contact Chairman Agency—Photosynthesis and Remote Sensing, Les Portes d'Antigone, 43 Place Vauban, 34000 Montpellier, France. Tel. (+33) 67.15.99.00; FAX: (+33) 67.15.99.09. Abstract can be sent by e-mail to Gerard.Dedieu@cesbio.cnes.fr.
September 3-9	17th Cartographic Conference, Barcelona. Call for papers. Contact David Sanchez Carbonell, ICC '95. Conference Secretariat, Institut Cartografic de Cataluyna, Balmes, 209-211, E-08006 Barcelona. Tel. (+34) 67-15-99-00, FAX (+33) 3-2128-89-59.
September 4-6	15th Symposium of the European Association of Remote Sensing Laboratories (EARSeL), University of Basel, Switzerland, and workshops on hydrology and meteorology, September 6-8. Contact EARSeL Secretariat, Attn: M. Godefroy, Bureau B-418, 2 avenue Rapp, F-75340 PARIS Cedex 07, France. Tel. (+33)1-45 56 73 60; FAX: (+34) 1-45 56 73 61.
September 18-20	Third Thematic Conference on Remote Sensing for Marine and Coastal Environments: Needs, Solutions, and Applications, Westin Hotel, Seattle, Washington. Sponsors: ERIM, MSRC, EPA. Contact Robert Rogers at (313) 994-1200, ext. 3453; FAX: (313) 994-5123.
September 25-29	Global Analysis, Interpretation, and Modelling (GAIM), The First GAIM Science Conference, Garmisch-Partenkirchen, Germany. GAIM is an Activity of the International Geosphere-Biosphere Programme (IGBP). For further information contact: IGBP Secretariat, Institut für Meteorologie, Freie Universität Berlin, Carl-Heinrich-Becker-Weg 6-10, 12165 Berlin, Germany or Dr. Dork Sahagian, GAIM Task Force Officer, Institute for the Study of Earth, Oceans and Space, U. of New Hampshire, Morse Hall, 39 College Road, Durham, NH 03824-3525, U.S.A. Tel. (603) 862-1766; FAX: (603) 862-1915; e-mail: gaim@unh.edu.
• 1996 •	
February 27-29	Eleventh Thematic Conference on Geologic Remote Sensing, Las Vegas, Nevada. Contact Robert Rogers, ERIM, Box 134001, Ann Arbor, MI 48113-4001. Tel. (313) 994-1200, ext. 3453; FAX: (313) 994-5123; e-mail: raeder@vaxc.erim.org.

Code 900
National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

The Earth Observer

The Earth Observer is published by the EOS Project Science Office, Code 900, NASA Goddard Space Flight Center, Greenbelt, Maryland 20771, telephone (301) 286-3411, FAX (301) 286-1738, and is available on World Wide Web at http://spso.gsfc.nasa.gov/spso_homepage.html. Correspondence may be directed to Charlotte Griner (cgriner@ltpmail.gsfc.nasa.gov) or mailed to the above address. Articles, contributions to the meeting calendar, and suggestions are welcomed. Contributions to the Global Change meeting calendar should contain location, person to contact, telephone number, and e-mail address. To subscribe to *The Earth Observer*, or to change your mailing address, please call Hannelore Parrish at (301) 441-4032, send message to hparrish@ltpmail.gsfc.nasa.gov, or write to the address above.

The Earth Observer Staff:
Executive Editor: Charlotte Griner
Technical Editors: Bill Bandeen
Renny Greenstone
Tim Suttles
Design and Production: Winnie Humberson
Distribution: Hannelore Parrish

Printed on Recycled Paper