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Editor's Corner

As reported in the last issue of *The Earth Observer*, the Clinton Administration submitted its budget request to Congress for FY95 (which begins October 1). The NASA budget submission for the Office of Mission to Planet Earth was $455.1 M for EOS and $284.9 M for EOSDIS, for a total obligation authority of $740 M. This budget request, taken together with the projected runout requirement through FY00, represents approximately a 9% reduction in the budget for the EOS program compared to the budget approved only one year ago. As a consequence, Goddard Space Flight Center received guidelines from the Associate Administrator of Mission to Planet Earth that included directions to maintain the launch readiness date of the AM-1 spacecraft at June 1998, make available the elements of EOSDIS necessary to support AM-1 in June 1998 and TRMM in August 1997, split the altimetry mission into a laser and radar mission, hold the ADEOS II/SeaWinds launch readiness date at February 1999, and prepare a request for proposals for the common spacecraft (PM-1, Chemistry-1, and AM-2) for release in May 1994.

The magnitude and profile of the budget adjustments have severe consequences on the implementation of the EOS program that is currently baselined. There are any number of possible impacts to the EOS Mission, including 9-month or greater launch delays for PM-1, Chemistry-1, AM-2, Color, etc. Due to the far reaching consequences of this budget reduction, and the further need to obtain important observations and analyses to support the U.S. global change program, Dr. John Klineberg, Director of Goddard Space Flight Center, has established 3 teams to independently examine the requirements and implementation approaches within the EOS program. These teams include a core Science Team (which I chair), a Project Team (chaired by Chris Scolese, AM Project

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INSIDE THIS ISSUE

SCIENCE TEAM MEETINGS

ARTICLES

ANNOUNCEMENTS

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.

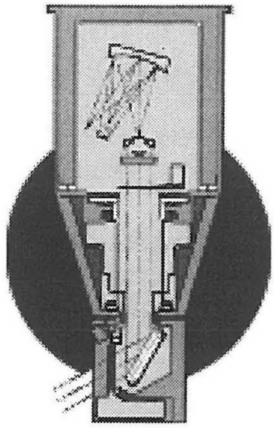
Finally, I would like to express my thanks, on behalf of the Earth Science community, for the marvelous job that Dr. John Klineberg has done as Director of Goddard Space Flight Center. He has been an extraordinarily strong supporter of the Earth Observing System and Mission to Planet Earth, and has paid 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.

ment (based on the April 1993 funding profile) to a schedule of deliverables. Preliminary core-algorithm software (for cloud-free conditions) and algorithm theoretical basis documents have been received from some team members. The selection of the core algorithm, earlier planned for the 4th quarter of 1995, is not required until the 2nd quarter of 1996. The next delivery for core-product algorithms (including the capability to retrieve under cloudy conditions) is scheduled for December 1994.

Core-Algorithm Development

The AIRS core-algorithm development process makes extensive use of simulated data. The simulated data from AIRS/AMSU and MHS are generated by the instrument simulation team. The data are distributed (on Internet) to the algorithm development teams, who retrieve the data products. The data products are then returned (also on Internet) to the data system team, which evaluates the accuracy of the retrieved data compared to the truth. The previous simulated data sets were called WRITE test and FLAT test. The FLAT test temperature and moisture profiles were obtained from "satellite tracks" crossing a mesoscale circulation model covering the North American continent. The model was provided by Eugenia Kalnay (NOAA/NMC). The conditions for the FLAT tests were clear scene, daytime, wavelength-dependent emissivity, and non-lambertian reflectivity (both to be retrieved as part of the temperature and moisture retrieval algorithm), and a constant surface pressure of 1000 mb. Dave Gregorich (JPL/CSLA) reviewed the FLAT test scores. The three teams (Goldberg/NOAA NESDIS, Smith/U. Wisconsin and Susskind/NASA GSFC) all retrieved the temperature profiles with slightly better than the required 1-degree rms error and a better than 10% water column error. The first-guess algorithm (Rosenkranz, MIT), based entirely on the microwave data, achieved a 1.6 degree rms temperature error and 12% water column error.

Mitch Goldberg and Joel Susskind both use a sequential physical retrieval algorithm, which estimates first the temperature profile, then the moisture profile, and then the combined profiles. Goldberg uses 300 channels and fits the observed brightness temperatures within the noise without having to iterate. Susskind's current retrieval uses 420 channels with iteration. Larry McMillin used a classification regression retrieval approach with 500 channels, which looks very promising in terms of speed and accuracy. Bill Smith reported on improvements made with a non-linear simultaneous retrieval algorithm. It is a physical retrieval with an iterative solution in the "eigenvector" domain. The first guess is obtained from regression. The retrieval effectively uses 600 channels.

Phil Rosenkranz (MIT) submitted a theoretical basis document for his "microwave only first guess" profile retrieval algorithm. It is an iterative algorithm using the minimum-variance method. Using his own simulations he showed that as long as the clouds are non-precipitating, there is no accuracy degradation in the temperature retrievals from AMSU-A and moisture retrievals using the MHS data. In the clear case the microwave-only retrieval cannot match the retrieval accuracy obtained with the infrared channels.

Sung-Yung Lee (JPL) discussed the results obtained with a prototype code for cloud-free retrievals delivered by Goldberg, Smith, and Susskind, and Rosenkranz's first guess microwave retrieval. He was able to compile and execute all of them, with only minor difficulties, on a SUN Sparc 2. Significant CPU runtime differences are showing up between the different retrievals. The AIRS data product generation system (PGS) has to keep up with the data coming in from space, producing four retrievals per second. Scaling the runtime per retrieval time from the performance of the SUN Sparc 2 to the performance of current top-of-the-line Sparc stations suggests that the AIRS processing can be done with a trivially parallel computer system, using a small Sparc "farm" on a local area network.

Cloud Simulation

Zhao (NOAA/NMC) discussed details of the GCM run for July 19, 1993, which defines the temperature and moisture profile field for the first AIRS cloudy data simulation effort. July 19, 1993 was a case of strong summer convection. The model covers the western half of the North American continent and has a 40-km grid-point spacing. In addition to the vertical cloud distribution, the model specifies liquid water content and cloud ice content. Longwave and shortwave radiation flux, total moisture, and precipitation can be derived from the model.

Dave Gregorich (JPL) presented details on using the July 19, 1993 GCM to simulate the cloudy field data for the infrared channels of AIRS, and the AMSU-A and MHS channels. The satellite ground tracks are selected to cover representative conditions. Additional points between the GCM grid points were generated using bilinear interpolation to approximate the 15-km AIRS footprint. The initial data set will have no temperature gradients over one AMSU-A footprint (covering 3x3 AIRS and MHS footprints), but will have (unknown) cloud amounts at only one (unknown) pressure level. A set of first-guess profiles derived from the GCM forecast will be provided (for those who think they can make use of it). Ozone comes from climatology, the terrain has the proper elevation (as opposed to the FLAT tests), and the surface has wavelength-dependent emissivity and reflectivity, which have to be retrieved by the algorithm. These data were made available to the team in mid-April.

The AIRS instrument includes four broad channels between 0.4 and 1.0 micrometers with 2.5-km footprints at nadir. Catherine Gautier (UCSB) will integrate the infrared simulation and the vis/near-IR simulation under cloudy conditions. She will use fractals to simulate the clouds, starting with the fractional cloud cover for the 15-km footprints in the IR, listed in the truth data.

Product Validation

Bob Haskins (JPL) discussed the AIRS data validation, starting with the validation of the retrieval physics before launch, using ground campaigns. After launch the validation will use ground truth data available from the global radiosonde and surface station network, coordinated surface campaigns, and underflights. The first of the ground-based campaigns was the CAMEX (Convection and Moisture Experiment) ER-2 overflights at Wallops Island at 20-km altitude. The AIRS validation effort will be coordinated, as much as possible, with ongoing or planned campaigns such as TOGA/COARE, FIRE, NOAA satellite underflights, etc. Use of the AIRS Engineering Model (available in 1998) for data product algorithm development is currently not in the budget. The validation plan is in the AIRS budget, but the EOS Project has not approved the budget.

George Aumann (JPL) presented a concept and time scale for the validation of the AIRS core data products after launch. The concept uses the combination of ground-truth data from the existing global network of radiosondes and surface stations, time and spatially collocated with AIRS/AMSU/MHS data to refine the algorithms and accuracy estimates at the Team Leader's Computer Facility (TLCF). The pacing parameter is the need for statistically significant sample sizes from enough combinations of latitude, surface conditions, temperature and ozone profiles, seasons, etc. He argued that eight months after launch is a reasonable estimate for delivery of an upgraded core-product algorithm. The existing global network of radiosondes and surface stations is described in "Preliminary System Description Document for the AIRS/AMSU-A/MHS Radiosonde Match System," presented by Larry McMillin (NOAA/NESDIS) at the Team meeting in April 1992. This system will be tested on NOAA-K,L,M data.

The CAMEX ER-2 flights from Wallops Island in September 1993, funded from the NASA HQ R&D budget, represent the first participation of the AIRS team in a campaign to validate algorithms and data products. Bjorn Lambrigtsen (JPL) presented an overview of the results and lessons learned. The ER-2 carried three instruments to obtain AIRS, AMSU-A and MHS-equivalent data: the HIS (High-resolution Interferometer Sounder), U. of Wisconsin; the MTS (Microwave Temperature Sounder), MIT; and the MIR (Microwave Imaging Radiometer moisture sounder), GSFC. Also on the ER-2 was a MODIS-like instrument, MAMS (Multispectral Atmospheric Mapping Sensor), MSFC.

The flights were supported on the ground by four radiosonde stations (Smith, UW, and Schmidlin, GSFC), an uplooking interferometer (Smith, UW), and an uplooking LIDAR (Melfi, GSFC). The flights provided valuable spectroscopic data (more on this from Smith, Strow, and Revercomb below) and valuable lessons for future campaigns. Almost everything that could go wrong, did: The MAMS produced good data, but failed during the overflights of Wallops that were done explicitly for AIRS. The MTS had a number of failures.

The ER-2 lost hydraulic pressure and had to make an emergency landing.

Timely data distribution is a serious concern. Almost six months after the CAMEX flights only the HIS, LIDAR, and radiosonde data are available for analysis by AIRS team members. Larrabee Strow (UMB) used part of the CAMEX data from HIS to fix a bug in GENLN2 (the standard line-by-line algorithm used by "almost" everybody) due to a bad interaction between the CO_2 continuum and line mixing. This bug does not show up when using GENLN2 to calculate lab/homogeneous path spectra. Hank Revercomb (UW) used the HIS data and empirical models to improve the algorithms for the foreign-broadened water vapor continuum and the self-broadened water vapor continuum in the 6.3 micrometer water band. In some areas the error (the difference between calculated and observed temperatures) has decreased from 10 K to 1 K. This error has to be compared with the instrumental noise of 0.1 K. Bill Smith (UW) showed how the uplooking spectra can be used to obtain accurate temperature profiles from the surface to 740 mb. A very pronounced dry layer over Wallops was detected by the LIDAR and confirmed by the radiosondes, but was not clearly detectable in the uplooking spectra.

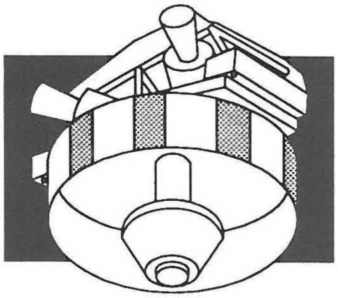
Each AIRS team member responsible for a research data product presented a brief concept of the data product validation:

- Catherine Gautier (UCSB) is developing two research products: the downwelling shortwave and longwave flux. She plans to use models and data from group sites (like ARM) to validate the data.
- Larrabee Strow (UMB) will determine the CO, CH_4, and CO_2 abundance. He described a correlation algorithm used to determine the CO abundance. For data validation he will depend on MOPITT data from the EOS-AM platform. MAPS, a shuttle experiment coordinated with DC-8 underflights, may also provide usable data.
- George Aumann (JPL) submitted a document which described the theoretical basis of the algorithm to determine the sea surface wind speed using the combination of AIRS/AMSU/MHS data. Pre-launch algorithm validation will be derived from SSM/I and NOAA-K,L,M data, as well as ER-2 flights over ocean buoys. The validation after launch will use regression with the global ocean buoy network. The same approach is used at present for the SSM/I surface wind-speed product.
- Hank Revercomb (UW) is working on data products for outgoing longwave spectral flux, minor gases (ozone, carbon monoxide, methane), and spectral emissivity. Outgoing longwave spectral flux will be validated relative to the broad-band CERES data. The minor gases will be retrieved with a maximum-likelihood algorithm. The ozone retrievals will be validated using data from ARM sites and ozonesondes. Validation of the other minor gases will use coordinated ER-2 and DC-8 underflights of the EOS-PM platform. The surface spectral emissivity will be validated using aircraft overflights of the ARM site. Spot checks will be made using a Michelson interferometer, mounted down-looking on a truck.
- Phil Rosenkranz (MIT), jointly with Dave Staelin (MIT), submitted a revised AMSU/MHS algorithm description to obtain sea-ice cover, oceanic liquid water, land snow-ice cover, and the precipitation index. All algorithms use a two-layer neural network. The emissivity for different surface types will be approximated by a 4-parameter function developed by N. Grody (1988).
- Mous Chahine (JPL), as a Team Member, is working on cloud properties, described in "Theoretical Algorithm Description: Cloud Properties." He will make use of pre-and post-launch aircraft campaigns (see Haskins presentation) for the validation of spectral cloud properties.

The next team meeting will be held at the World Weather Building in Camp Springs, MD, on May 17 through 19, 1994. Key topics will be results of retrievals with clouds, improved cloud simulation, more results from CAMEX, and AIRS spectral calibration. ❑

GLAS Science Team

Report of the GLAS Science Team Meetings:
November 15-17, 1993, at Goddard Space Flight Center and March 1-2, 1994, at the National Snow and Ice Data Center in Boulder, Colorado. This report summarizes both meetings.
—by **Bob Schutz** (schutz@utcsr.ae.utexas.edu), with input from GLAS Team Members



November 15-17, 1993 Meeting

Phase A Study

A significant aspect of the meeting at Goddard Space Flight Center was the presentation of the status of the GLAS Phase A study conducted at GSFC. Jay Zwally (GSFC) and Greg Smith (GSFC) introduced the study. Tom Karras (GSFC) summarized the study, Dave Goodwin (Swales) gave a mission overview, Lauri Newman (GSFC) provided an overview of the orbit studies, George Roach (GSFC) summarized conceptual spacecraft configurations, and Paul Clemens (GS&T) gave a ground system overview.

The Phase A study proceeded from the "EOS ALT/GLAS Mission Requirements Document," developed by the GLAS Team, and the "EOS Level I Program Requirements: EOS Chemistry and Special Flights Project." Primary attention was given by the study team to the spacecraft concept recommended by the EOS IWG that the GLAS and ALT instruments fly on separate spacecraft to accommodate the distinctly different orbit requirements derived from the science requirements.

The final presentation for the Phase A study was given in December 1993. In summary, the Phase A study concluded that there were "no major show stoppers" and that the "spacecraft system has margin and growth using medium launch vehicles" such as the Delta-Lite or LLV2.

Instrument Team Report

Reports on the GLAS instrument status were given by the Instrument Team. Jim Abshire (GSFC) summarized the status and FY94 plans, including the development of Pre-Phase A concepts. The Instrument Team has supported the GSFC-Code 402 Phase A studies. As part of the instrument risk reduction and definition efforts, a laser altimeter software simulator has been developed, laser definition and design has been refined, a laser/stellar reference system concept has been developed and studied, and breadboarding of the detector and receiver electronics has been initiated.

Jay Smith (GSFC) presented the systems engineering status. The concept of using the star cameras for simultaneous laser pointing and attitude determination was summarized, and the GLAS instrument layout and the GLAS laser specifications were provided.

The GLAS laser transmitter effort was reviewed by Rob Afzal (GSFC). The effort has initiated studies to study radiation effects on candidate laser materials and minimization of optical damage risks.

A progress report on the GLAS breadboard receiver was given by X. Sun (Johns Hopkins). The experiment setup and preliminary measurements, as well as studies of radiation damage, were presented. Jan McGarry (GSFC) discussed the status of the GLAS software simulator and the technical plan for the three-dimensional upgrade. Bert Johnson and Ron Follas (GSFC) presented the GLAS instrumentation implementation.

Status of Digital Elevation Models (DEM)

Although the GLAS data products will contribute to improvements in DEM, a reference DEM will facilitate the GLAS analyses. Duncan Wingham (University College London) summarized the status of DEMs and the scope for their improvement. He noted that present global models are substantially in error on scales of 100 km or smaller and that considerable variability in accuracy exists, depending on the region. Furthermore, high resolution (< 1 km) models exist only for 20% of the world's land surface. A status report on DEM availability was published in *Geophys. Res. Letters*, 1992, by Dr. Wingham.

Aircraft Experiment Reports

Bob Thomas (NASA HQ), Bill Krabill (NASA Wallops) and Jack Bufton (GSFC) reviewed the June-July, 1993, Southern Greenland aircraft flights using the NASA P-3 aircraft. High-precision GPS positioning was used to determine the aircraft position to support analysis of the scanning laser altimeter. One set of flights was devoted to operating the airborne laser altimeter in a non-scanning mode using characteristics that emulate the GLAS system, particularly the 70-meter laser spot size. The GLAS emulation data set has been distributed to team members for analysis.

Jeff Ridgway (Univ. California/San Diego) summarized an aircraft experiment conducted in Long Valley, California, using the NASA T-39. As in the Greenland experiment, GPS navigation was used. The flight tracks covered a variety of surface topographies, including land and lakes. The data set has been distributed to the team members.

David Harding (GSFC) summarized airborne laser altimeter measurements of vegetation height and sub-canopy topography and Jim Garvin (GSFC) discussed potential volcanological GLAS applications. Results from an aircraft experiment in the Pacific Northwest (Gifford Pinchot Forest) demonstrated profiles of both vegetative canopy top returns and ground returns. Although the laser spot size in the experiment was about 10 meters in diameter, the larger GLAS footprint can be partially simulated by synthesizing several smaller footprints.

Airborne lidar measurements made in the South Pacific were presented by Jim Spinhirne (GSFC).

Japanese lidar plans and activities were reviewed by T. Noguchi (NASDA), Prof. F. Nishio (Hokkaido Educational University) and M. Ishizu (Communications Research Laboratory).

Other Issues

The GLAS orbit was reviewed, and the team reiterated the recommended 94-degree orbital inclination to provide desired coverage of the polar regions, while still enabling ground track crossovers with satisfactory geometrical characteristics. A 183-day ground-track repeat allows a track separation of approximately 2 km or less at latitudes greater than about 83 degrees. This ground-track repeat will also assist applications to improve global DEM resolution. The use of 705-km altitude and proper orbit planning will enable nearly simultaneous GLAS lidar measurements with one of the EOS MODIS instruments for multi-day intervals.

Barbara Putney (GSFC) gave a science data processing overview on behalf of EOSDIS and David Hancock (Wallops) reviewed the ground data system and data products. Bob Schutz (Univ. Texas) summarized the team responsibilities and tasks for 1994, including the team member roles in the generation of the GLAS data products.

March 1-2, 1994 Meeting

The meeting was held at the National Snow and Ice Data Center in Boulder. Roger Barry welcomed the GLAS Team and provided an overview of the NSIDC activities and data archive.

Tom Taylor (GSFC) provided a status summary on behalf of the EOS Chemistry and Special Flights Project Office. Instrument updates since the last GLAS Team meeting were given by Jim Abshire and Jay Smith (GSFC).

Bob Thomas (NASA HQ) presented the plans for the 1994 Greenland experiments. These experiments will again be conducted using the NASA P-3 aircraft from Wallops Flight Center. Whereas the 1993 flights concentrated in Southern Greenland, the 1994 flights will focus on Northern Greenland. Most of the flights will be conducted with the NASA Airborne Oceanographic Lidar (AOL), which includes a profiling laser altimeter. A flight with modified optics to emulate the GLAS footprint (70 meters) will be conducted over a variety of ice terrain. The flights will be conducted from Thule, and the GLAS emulation flights will include a portion of an ERS-1 ground track and a flight over the

Jakobshavn Glacier; the latter will provide large footprint data over rough surface features. As in previous experiments, GPS will enable determination of the aircraft position. However, since the DoD activation of anti-spoofing (AS), some concern exists over the possible degradation in aircraft positioning.

Jack Bufton (GSFC) reviewed the 1993 Greenland aircraft experiment which emulated GLAS and the flights in Long Valley to measure volcanic landforms. The data sets from both experiments have been distributed to the GLAS Team as pathfinder data sets for definition of the GLAS instrument, algorithms, and data analysis. The data sets include laser altimeter, GPS data (airborne and ground-based) and laser gyroscope for aircraft attitude. From these records the horizontal position and elevation of each laser footprint can be determined, thereby enabling contruction of the Earth surface topography along the laser footprint track.

A four-level process for analysis of these data has been developed and applied to the 1993 Greenland and Long Valley data. In Level-1 processing the raw laser pulse time-of-flight data are corrected for laser pulse amplitude-dependent timing errors, altimeter range offset, and correct alignment with universal time to msec precision. In Level-2 processing a kinematic trajectory for the aircraft platform is derived from the differential combination of airborne and ground-based, high-rate (1 sample per sec) GPS data. In Level-3 processing each Earth surface laser spot is geolocated by an application of rotation matrices to the laser time-of-flight data, pointing-angle data (and pointing offsets), and the displacement of the airborne GPS antenna from the laser transmitter. The surface elevation data in this processing are derived from a conversion of the pulse time-of-flight data to distance units and correction for laser atmospheric propagation based on the 1976 U.S. Standard Atmosphere. The output of Level-3 processing is a data record of measurement time, spot latitude, spot longitude, and spot surface elevation. The nadir-profiling laser altimeter Level-3 results are then compared in Level-4 processing with existing ground-truth, other laser or radar altimeter data sets, and digital elevation models. Processing of low-aircraft-altitude (~500 m) pathfinder data sets for the Greenland and Long Valley, CA campaigns has been accomplished and indicates data quality (precision) at the 10-cm level. This is particularly true of the Greenland results that were acquired at a low aircraft altitude above the ice sheet surface. Measurement bias between observations on successive days for the same surface targets is as small as ~5 cm in the Greenland data and as large as ~20 - 30 cm in the Long Valley data. A major portion of the error budget in the Long Valley, CA data is thought to be the GPS-derived aircraft trajectory; however, several improvements in the GPS processing can still be made.

Bernard Minster (Univ. California/San Diego) reviewed the September 1993 aircraft flights conducted over the Long Valley, California caldera and the flight over Death Valley using the NASA T-39. The region has a geologic history of extensive vulcanism, and the Long Valley central dome has recently been undergoing resurgent uplift of up to 4 cm per year. The surveys, financed through a collaborative effort between several agencies (notably NASA and DOE) were conducted from the NASA Wallops Flight Facility T-39 aircraft, outfitted with a nadir-profiling laser altimeter, GPS guidance system for in-flight navigation, two GPS P-code receivers for post-flight navigation processing, a Litton LTN92 inertial unit for attitude recovery, and both video and still cameras. In addition, two base-station GPS dual-frequency P-code receivers were deployed in order to permit differential navigation, and the NASA DOSE permanent TurboRogue receivers at the CASA site were operated by JPL at a high data acquisition rate (1 Hz) during the flights. The aircraft flew at a mean altitude of 500 meters above ground, at speeds of 80 to 100 meters/sec. The laser had a divergence of 1.7 mrad, and output of 50 pulses per second, yielding a footprint of 0.9 meters and a sampling interval of 2 meters per pulse. High-altitude surveys were also flown over the Sierra Nevada and Death Valley, to simulate a wide footprint similar to that expected from a satellite instrument such as GLAS. Precision flying yielded multiple profiles along nearly identical paths, including crossing profiles over geologically interesting features, and also along previously flown TOPSAR (DC-8) swaths. The results obtained so far indicate that such surveys, if repeated at regular intervals, hold promise for measuring systematic changes in surface heights associated with tectonic and volcanic uplift. The complete data set has been compiled and organized in standard format and is readily available through the GLAS team.

Charles Bentley (University of Wisconsin) reviewed the reasons for interest in the West Antarctic ice sheet. The ice sheet is mostly marine in character, meaning that its bed lies mostly far below sea level. Simple theoretical models suggest that a marine ice sheet may be inherently unstable, in the sense that the grounding line, the boundary between the grounded and floating portions of the ice sheet, should retreat spontaneously and rapidly until no grounded ice sheet remains. If this were to occur, and the simple models suggested that it could happen in only a century or so, it would raise sea level around the world by about 6 meters. The simple models, however, fail to properly take into account the complication to the dynamics introduced by the presence of ice streams, fast-moving streams of ice within the ice sheet. Since these ice streams carry virtually all the ice discharge from the interior, understanding their behavior is crucial to understanding the physics of the whole system. Field measurements show that some ice streams are grossly out of mass balance; one discharges half again as much ice as is fed into it from its catchment basin, whereas its neighbor stagnated about 130 years ago and now discharges only a small fraction of its input. This is clearly not a steady-state situation; it must be causing rapid changes in surface elevation that could be detected easily by a laser altimeter (the utility of a radar altimeter is more problematical because of the highly crevassed nature of ice-sheet surfaces). In fact, rapid changes in ice-stream speed (20% in 10 years) have already been detected in a few places. Measurements that cover the whole vast region, however, can only be completed from an overflying satellite.

Bentley also summarized work at the Geophysical and Polar Research Center, University of Wisconsin, which is devoted to the analysis of radar altimetry from three missions — Seasat, Geosat, and ERS-1. Many of the algorithms and analytical techniques developed in the process will be readily adaptable to the analysis of laser altimetry. The study of Seasat and Geosat data has centered on a 60-deg sector in East Antarctica where the ice sheet extends its farthest north. Evidence of a secular change in height over the decade between the two missions is being sought. The main obstacle to a ready determination is the clear presence of relative orbit errors between the two missions; indicated heights from Geosat are about half a meter higher than those from Seasat over the ocean north of the continent; these then change more or less smoothly to half a meter lower over the interior ice sheet. There is no obvious discontinuity in the indicated height differences at the boundary of the continent, as one would expect if there had been a secular change in ice-sheet height, but the data are particularly poor in the coastal region (this is an excellent example of why a laser altimeter is needed).

Another aspect of Bentley's work has been analysis of the Geosat waveforms of the returned signals to estimate the relative proportions of surface and volume scattering and the characteristics of each. One of the parameters determined is the surface roughness of the ice sheet. Near 72 deg S the rms roughness is typically slightly less than a meter. This is substantially larger than one would expect for the small-scale roughness (sastrugi) alone, and undoubtedly reflects larger-scale undulations within the kilometers-wide radar footprint. It is the sastrugi that will be important for the laser altimeter.

Work with ERS-1 has been limited so far because of the lack of any of the re-tracked data. However, using the quick-look ocean product with "precise" orbits (OPR-2) Bentley has found that the OPR-2 data could be used to get an elevation map of the Ross Ice Shelf that is good enough to reveal what appears to be an "ice plain" at the junction between one of the West Antarctic ice streams and the ice shelf.

Jay Zwally (GSFC) provided an introduction and demonstration of the data system for ice applications that has been developed to support Seasat, ERS-1, and Geosat. The applicability of the system to GLAS was discussed. The data base management system allows the selection of along-track altimeter data for specific locations and times from the full data set, which spans almost 10 years. The system enables the user to browse and plot a variety of parameters stored in the along-track data record. Results of along-track elevation change were shown from analysis of Seasat and Geosat that are consistent with elevation changes determined from recent Greenland aircraft flights.

A preliminary analysis of the degradation of static and kinematic GPS data quality in the presence of AS was presented by Tom Herring (MIT). The data sets analyzed were obtained from the global GPS tracking network and from one kinematic GPS survey with Trimble SSE receivers. The pseudorange accuracy of early-generation receivers (Rogue SNR-8 generation) shows severe degradation under AS conditions (range noise increased by 2000%); intermediate-generation receivers (Trimble SSE and Turbo Rogue) show relatively severe range noise increase (100-400%); and the most-recent-generation receivers (Ashtech Z12) show degradation but much less than other receivers (~30%). While the increase in range noise does not translate directly to increase in phase noise, the lower quality range data does affect the performance of automatic data-cleaning algorithms. A recent comparison by the Jet Propulsion Laboratory of the quality of geodetic results after AS was turned on shows a degradation of between 20 and 50% in the quality of results compared to non-AS data. Of particular significance to the GLAS instruments is that the worst degradation was in the height determinations. Initial results obtained in kinematic applications of GPS showed frequent loss-of-lock on the L2 channel (the one most affected by AS); and the GPS receiver required up to 10 seconds to regain lock on the L2 channel. The general conclusion was that AS will have, at least initially, a significant impact on GPS operations. However, as with previous attempts at denying access to accurate GPS results, work-arounds should be possible with increased costs, either through the purchase of new equipment or in analysis effort. The impact of AS on the upcoming Greenland laser altimeter is an important aspect of the experiment.

Bob Schutz and Mike Lisano (University of Texas/Austin) summarized recent studies for GLAS calibration and orbit determination. Schutz gave a review of the GPS receiver performance on TOPEX/Poseidon (T/P). Based on analyses performed by different groups using different software, as well as comparisons with orbits determined by satellite laser ranging (SLR) and the French tracking system, DORIS, the consensus is that the radial component of the T/P orbit is being determined to better than 3 cm (rms). Comparisons between GPS solutions and SLR/DORIS show differences at the 2-3 cm level radially and 10 cm in the horizontal component. A series of papers will be published soon in *Geophysical Research Letters* on the GPS results. There are several implications that can be drawn for GLAS. If the GLAS tracking systems (GPS and SLR) perform as well as with T/P, the orbit error will be within the error budget. However, the GLAS orbit characteristics differ from T/P in altitude (GLAS: 705 km; T/P: 1335 km) and inclination (GLAS: 94 degrees; T/P: 66 degrees). These differences lead to different sensitivities in the satellite force model. Preliminary GLAS simulations with assumed errors in atmospheric density and Earth gravity, however, indicated that the GLAS error budget can be met. Further study and simulations will be conducted in 1994. Studies have been initiated to examine the ground-based calibration-array requirements. This array, consisting of detectors that will be illuminated by the spaceborne laser, will be used for laser pointing calibration/verification. The current studies are focused on determining the detector spacing, size and geographic location requirements.

Atmospheric Measurements

Progress is being made on the modeling of the performance of the GLAS instrument for atmospheric measurement. An IDL simulation and display program, which was developed last year, has been further applied. The program takes data from aircraft lidar field programs and computes the expected signal based on expected GLAS instrument parameters. In particular, data from the tropical Western Pacific that were acquired from the ER-2 high-altitude aircraft during several field experiments last year have been studied. The results indicate that GLAS should be able to profile all significant cloud and boundary-layer aerosol structure. There are still uncertainties to be resolved in the detector that will be used for GLAS atmospheric signals. Results will be dependent on the efficiency of the detector that is used. The next necessary project to be undertaken is to apply the simulated GLAS data to retrieval algorithms for cloud and boundary-layer properties. The limited funding for GLAS work to date is a problem for future progress. Other ongoing activities include detector performance studies and data analysis.

The next GLAS Team meeting will be in the July-September time period. ☐

From *EOS.News*—Friday, May 13, 1994

CONVERGENCE DECISION

On May 5, President Clinton approved the convergence of civil and military polar-orbiting satellite systems into a single operational program. Currently, the Department of Defense (DoD) and the National Oceanic and Atmospheric Administration (NOAA) acquire and operate separate polar-orbiting environmental satellite systems which collect data needed for military and civil weather forecasting. The decision requires convergence of the DoD Defense Meteorological Satellite Program (DMSP) and the NOAA Polar-orbiting Operational Environmental Satellite (POES) program. This will result in a single national system which will provide data needed to meet U.S. civil and national security requirements, and to fulfill international obligations. EOS, and potentially other NASA programs, will provide new remote sensing and spacecraft technologies that could improve the operational capabilities of the converged system. The decision implements a recommendation contained in the *National Performance Review*, published last September. The savings are estimated to be up to $300 million during 1996-1999, with additional savings thereafter.

CONVERGENCE PLAN

The goal of the converged program is to reduce the cost of acquiring and operating polar orbiting operational environmental satellites, while continuing to satisfy U.S. operational civil and national security requirements. As part of this goal, the operational program will incorporate appropriate aspects of the NASA EOS. The converged program will be conducted in accordance with the following principles: (1) operational environmental data from polar-orbiting satellites are important to the achievement of U.S. economic, national security, scientific, and foreign policy goals; (2) assured access to operational environmental data will be provided to meet civil and national security requirements and international obligations; (3) the U.S. will ensure its ability to selectively deny critical environmental data to an adversary during crisis or war yet ensure the use of such data by U.S. and Allied military forces—such data will be made available to other users when it no longer has military utility; and (4) the implementing actions will be accommodated within the overall resource policy guidance of the President.

The converged system on-orbit architecture will consist of 3 low-Earth-orbiting satellites. This is a reduction from the current 4 satellites (2 civilian and 2 military). The orbits of the 3 satellites will be spaced evenly throughout the day with nominal equatorial crossing times of 5:30, 9:30 and 1:30. This converged system can accommodate international cooperation, including the open distribution of environmental data.

A single Integrated Program Office (IPO) staffed by representatives of DoD, DOC, and NASA will be established by October 1, 1994 to plan for, design, acquire and operate the next generation polar-orbiting weather satellite system for the U.S.A. The DOC, through NOAA, will have lead agency responsibility for the converged system. NOAA will have lead agency responsibility to support the IPO for satellite operations. NOAA will also have the lead for interfacing with national and international civil user communities, consistent with national security and foreign policy requirements. DoD will have lead agency responsibility to support the IPO in major systems acquisitions. NASA will have lead agency responsibility to support the IPO in facilitating the development and insertion of new cost-effective technologies to meet operational requirements. The 3 agencies are developing a process for identifying, validating, and documenting requirements for the converged system. The 3 agencies will jointly pursue negotiations with the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) on a European-built and-operated satellite as part of the converged system.

Recommendation For The Nodal Crossing Time For The EOS-PM Platform

—**John Lundberg** (lundberg@utesr.ae.utexas.edu) and **Byron Tapley**, EOS Mission Design Panel

PURPOSE

The issue of selection of the orbital phasing of the EOS-PM platform relative to the EOS-AM platform has been placed before the Mission Design Panel. The current scenario of crossing times for these sun-synchronous orbits is such that the EOS-AM platform will have a descending 10:30 AM equator crossing time and the EOS-PM platform will have an ascending 1:30 PM equator crossing time. The principal issues to be discussed in this review are 1) the advantages and disadvantages of altering the EOS-PM orbit from the current scenario, and 2) the recommendation of a particular scenario for the EOS-PM platform. To begin this review, the general characteristics of the current baseline scenario will be discussed. This review will discuss the impact of changing the EOS-PM platform from its current afternoon ascending orbit. Finally, using this analysis, a recommendation is made.

REVIEW OF THE CURRENT SCENARIO

The orbits of both the EOS-AM and -PM platforms have been modeled after those used for the Landsat satellites. For purposes of this review, it is assumed that the orbits of both platforms are sun-synchronous (inclination of 97°) with repeating ground tracks. Also, it is assumed that the EOS-AM platform will have a descending node that occurs at 10:30 AM local time. The principal issue under review is the relative phasing between the two orbits.

Single Satellite Coverage

The sun-synchronous characteristic results in equator crossings (nodes) that occur at the same local time each day with the descending crossings occurring 12 hours (local time) from the ascending crossings. Thus, for the EOS-AM platform, the descending equator crossings occur at 10:30 AM local time and the ascending equator crossings occur at 10:30 PM local time. From this it can be seen that the EOS-AM platform will observe the Northern Hemisphere between 10:30 PM and 10:30 AM and the Southern Hemisphere between 10:30 AM and 10:30 PM. Similarly, under the current scenario, the EOS-PM platform will observe the Northern Hemisphere from 1:30 PM to 1:30 AM and the Southern Hemisphere from 1:30 AM to 1:30 PM (see Figure 1).

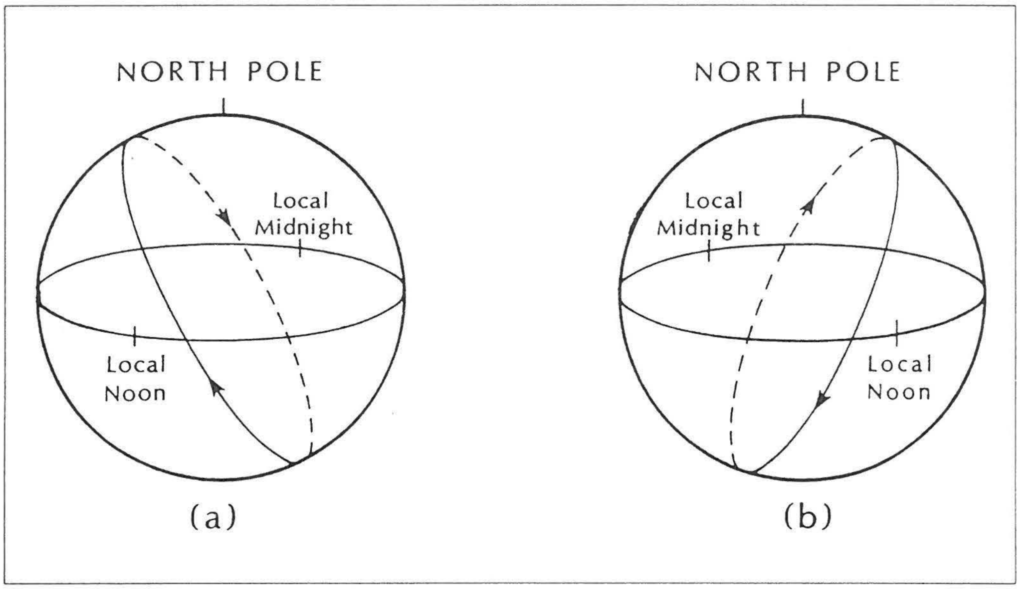


Figure 1. Relative orientations of sun-synchronous orbits with a) an ascending node at 1:30 PM local time and b) a descending node at 10:30 AM local time.

The ground tracks of the EOS-AM and EOS-PM orbits will repeat every 16 days after making 233 orbital revolutions. During the course of one repeat period, the ascending nodes of these orbits will occur in a unique pattern. First, it is noted that the nodes of two consecutive orbits will be 24.72° apart. Also, the 233 ascending nodes will be uniformly distributed around the equator with a spacing of approximately 1.545°. The ground-track pattern of this orbit will produce a near repeat (an equator crossing within 1.545° of a previous crossing during the same 16-day period) every 7 and 9 days (see Figure 2). The ascending node that lies midway between the nodes of consecutive orbits will occur eight days after these two nodes (see also Figure 2). It is also noted that the ascending node shifts to the west 10.815° (=7x1.545°) after one day, which is within 1.545° of 24.72°/2, i.e., the first ascending node of day 2 is 10.815° from the first ascending node of day 1 and 13.905° of the second ascending node of day 1. Thus, a platform carrying a sensor with a cross-track scan angle of +/-45.5° will provide global coverage every two days. This condition is satisfied by the wide-field-of-view instruments that are to fly on the EOS-PM platform: MIMR (+/-60°), AIRS (+/-49.5°), AMSU-A (+/-49.5°), MHS (+/-49.5°), MODIS (+/-55°), and CERES (+/- 78°).

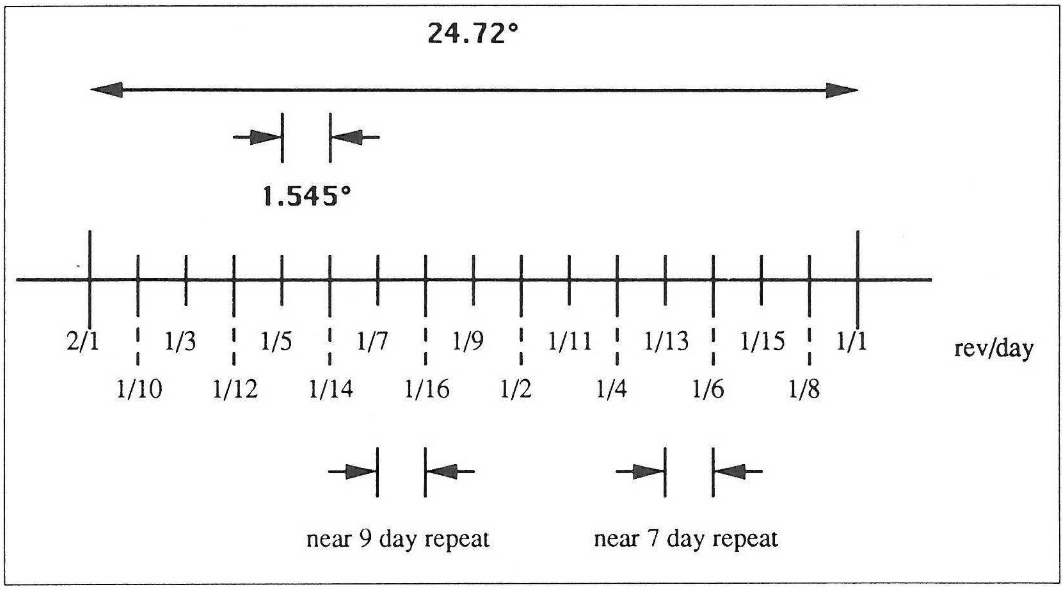


Figure 2. Ascending node layout pattern for a 16-day repeat ground track with 233 orbital revolutions (Landsat, EOS-AM, EOS-PM) indicating the near-repeat periods of 7 and 9 days. The node 1/1 is a relative starting point from which to examine the positions of subsequent nodes that start each day of the repeat cycle. The descending nodes will produce a similar pattern layout.

Selection of 1:30 PM Ascending Nodes for EOS-PM

The selection of 1:30 PM ascending nodes for the EOS-PM platform will provide complementary coverage to the EOS-AM platform. The relative positioning of the EOS-PM ground track to that of the EOS-AM platform is displayed in Figure 1. The times and locations at which the ground track crossovers occur can be selected by adjusting the relative orientation of the nodal locations. This would be accomplished by selecting the time between the EOS-AM descending-node and the EOS-PM ascending-node crossings. For example, if the ascending node of EOS-PM occurs approximately 81.1 minutes after the descending node of EOS-AM, the respective nodal locations will occur over the same points on the equator with a time difference of three hours. The selection of the relative phasing will determine the diurnal measurement times at a particular latitude.

The selection of 1:30 PM ascending nodes for the EOS-PM platform will result in nearly uniform coverage of both hemispheres. The Northern Hemisphere will be sampled between 10:30 PM and 10:30 AM by the EOS-AM platform and between 1:30 PM and 1:30 AM by the EOS-PM platform (see Figure 3). Thus, measurements will not be collected over the Northern Hemisphere between 10:30 PM and 1:30 AM local time. For the Southern Hemisphere, coverage will occur between 10:30 AM and 10:30 PM by the EOS-AM platform and between 1:30 AM and 1:30 PM by the EOS-PM platform, and measurements will not be collected between 10:30 AM and 1:30 PM.

Under this scenario, complete global coverage will only be accomplished every two days by the large-field-of-view instruments. However, nearly global coverage can be achieved after one day by selecting the one-day coverage of the EOS-PM platform to fill the one-day gaps of the EOS-AM coverage as much as possible.

Also, under this scenario, the diurnal sampling will be degraded for latitude bands near 70° N and 70° S (see Figure 3).

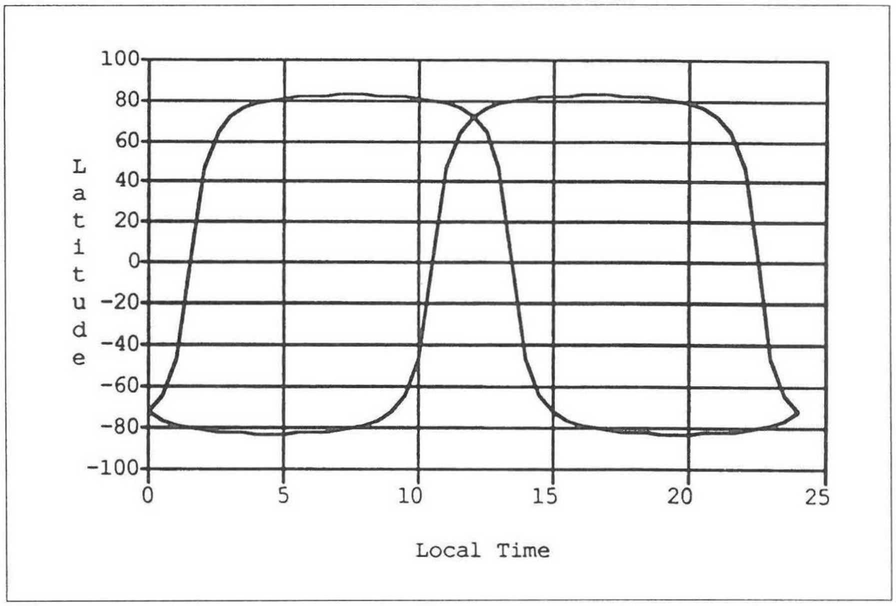


Figure 3. Latitude versus local time for EOS-AM descending node at 10:30 AM and EOS-PM ascending node at 1:30 PM. Note that the Sun is positioned at approximately 12 hours local time.

ALTERNATIVE SCENARIOS

Selection of 1:30 PM Descending Nodes for EOS-PM

The selection of 1:30 PM descending nodes for the EOS-PM will provide certain advantages depending on the relative phasing of the nodal crossing times with those of the EOS-AM platform.

(1) If the descending nodes of the EOS-PM platform coincide with those of the EOS-AM such that their 16-day repeat cycles start at the same node and Earth-fixed longitude (i.e. node 1/1 in Figure 2 has the same Earth-fixed longitude for both orbits), then the EOS-PM platform will cover the same area on the surface 3 hours after the EOS-AM platform does. This allows for the same-day sampling of the diurnal cycle (morning and afternoon measurements). Global coverage for the large-field-of-view instruments is accomplished every 2 days.

(2) If the descending nodes of the EOS-PM platform are shifted such that the first node of day 1 (node 1/1) of the EOS-PM platform coincides with the first node of day 9 (1/9 in Figure 2) of the EOS-AM platform, complete global coverage can be accomplished every day for the large-field-of-view instruments. Sampling of the diurnal cycle (morning and afternoon measurements) over the same point will be accomplished over a two-day period.

With the selection of a descending 1:30 PM crossing time for EOS-PM, the Northern Hemisphere will be covered between 1:30 AM and 1:30 PM by the EOS-PM platform and between 10:30 PM and 10:30 AM by the EOS-AM platform (see Figure 4). Thus, there is no coverage of the Northern Hemisphere between 1:30 AM and 10:30 AM local time. Similarly, the Southern Hemisphere will be covered between 1:30 PM and 1:30 AM and between 10:30 AM and 10:30 PM local time. Thus, the Southern Hemisphere will not be covered between 1:30 PM and 10:30 PM local time.

Note that under this scenario, diurnal sampling will be degraded for latitudes near 80° N and 80° S.

Selection of 10:30 AM Ascending Nodes for EOS-PM

The principal reasons for selecting a 1:30 PM equator crossing time for the EOS-PM platform are to enhance the diurnal sampling and to provide different solar-viewing orientations. If the orbit of the EOS-PM platform is selected to have a 10:30 AM ascending node, both hemispheres will have coverage the entire day (see Figure 5). However, diurnal sampling will be degraded for latitudes near the equator.

RECOMMENDATION

For the purposes of providing the maximum science return, it is recommended that the EOS-PM platform be placed in a 1:30 PM ascending node orbit. This recommendation is based upon the following points:

(1) This arrangement will provide greater diurnal sampling since the coverage outage is reduced from 9 hours in a hemisphere to 3 hours. The data outage for this scenario occurs around midnight for the Northern Hemisphere and around noon for the Southern Hemisphere.

(2) This arrangement will still provide global coverage for the wide-swath instruments every two days. While a 1:30 PM descending node arrangement could reduce this to one day, the 1:30 PM ascending arrangement will provide different solar viewing angles over a particular location.

(3) The limited diurnal sampling near the equator for the alternative scenario in which the EOS-PM platform has a 10:30 AM ascending node is unacceptable. ❑

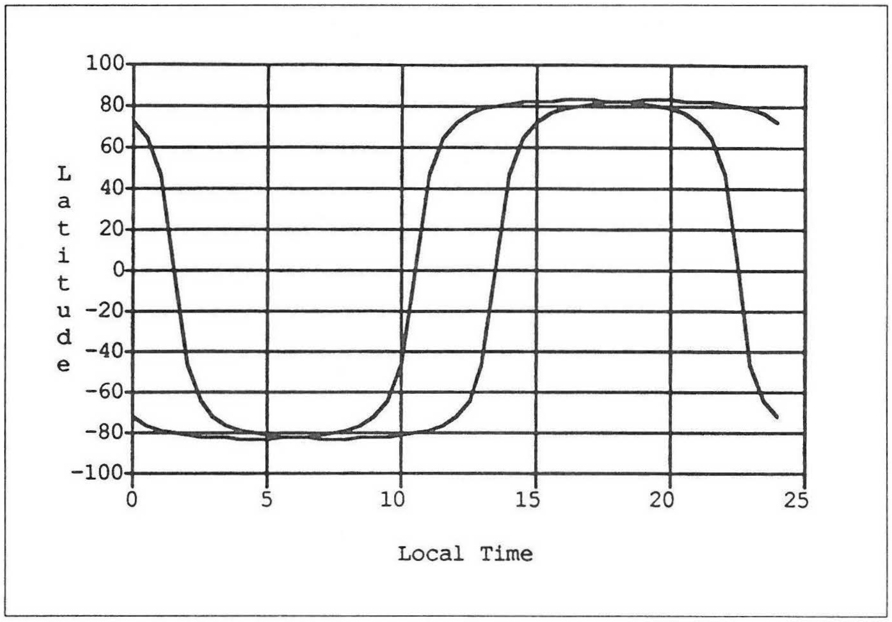


Figure 4. Latitude versus local time for EOS-AM descending node at 10:30 AM and EOS-PM descending node at 1:30 PM. Note that the Sun is positioned at approximately 12 hours local time.

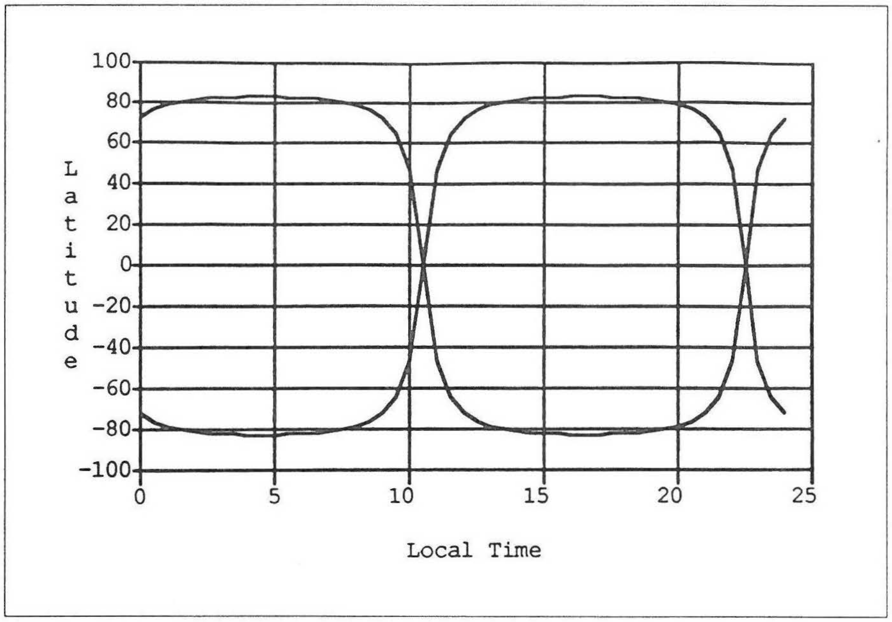


Figure 5. Latitude versus local time for EOS-AM descending node at 10:30 AM and EOS-PM ascending node at 10:30 AM. Note that the Sun is positioned at approximately 12 hours local time.

Data Assimilation for EOS: Where's the Data Coming From?

—**James G. Stobie** (stobie@dao.gsfc.nasa.gov) and **Richard B. Rood**, Data Assimilation Office, Code 910.3,
NASA/Goddard Space Flight Center, Greenbelt, Maryland

The Goddard EOS Data Assimilation System (GEOS DAS) combines a wide variety of observations into a dynamically consistent approximation of the state of the atmosphere. The current prototype system uses observations acquired by the National Meteorological Center (NMC) and climatic data from the National Center for Atmospheric Research (NCAR). In the EOS era (1997 and beyond) the NMC-provided data will continue to be used but will be heavily augmented with new EOS observations. In addition, many of the climatic data sets currently used for "boundary conditions" will be replaced with EOS measurements.

Figure 1 shows the data flow for the current GEOS DAS, which is the prototype from which the operational system will evolve. The shaded area in the middle is the GEOS DAS itself. The heart of the GEOS DAS is the prognostic model, which produces global gridded data sets. The main observational input for the prognostic model comes from the analysis module, which combines the first guess with worldwide observations via a technique known as optimal interpolation (OI). The other important input for the prognostic model is a series of boundary conditions based on climatology provided through either NMC or NCAR. In addition to providing the gridded data sets, the prognostic model also provides the first guess for the next analysis cycle. That is, the process shown in Figure 1 is for one 6-hour segment of the total data assimilation process. For a more complete description of the current GEOS DAS see Schubert *et al.* (1993).

The observations used by the current system are listed in Table 1.

Table 1 **Prototype Observations**

Data Type	**# Processed Per Day**
Surface Observations	20,000
Ocean Buoys	2,500
Rawinsondes	1,500
Aircraft Reports	7,000
Satellite Cloud-Drift Winds	8,500
Satellite Temperature Profiles (TOVS)	20,000

Table 2 **Prototype Boundary Conditions**

Field	**Source**
Orography	NCAR (originally from Navy)
Land Surface Type	NCAR (originally from Navy)
Sea Surface Temperature	NCAR/NMC (monthly means)
Albedo	NCAR/NMC (monthly climatology)
Sea Ice	NCAR (monthly mean)
Snow Cover	NMC (monthly climatology)
Land Surface Roughness	NCAR (monthly climatology)
Soil Moisture	Based on model precipitation
Surface Temperature	Based on model radiation

The Goddard Data Assimilation Office (DAO) has complete holdings of these data from 1985 to the present and for the First GARP Global Experiment (FGGE) year, 1979. The DAO also has partial holdings of these data from 1980 to 1984.

The boundary conditions for the prototype system are given in Table 2.

Figure 2 shows how the new EOS data will flow into the operational GEOS DAS beginning in 1997. The worldwide observations received from NMC will still be used just as they are in today's prototype. In addition, data from the new EOS instruments will flow in via the various DAACs. The list of potential sources of EOS observations for the GEOS DAS is shown in Table 3. Besides providing new observational data for the GEOS DAS, certain EOS instruments will also provide improved boundary conditions for the prognostic model. These are listed in Table 4.

In summary, the GEOS DAS will access data from nearly every EOS DAAC to provide either current observations for the analysis module or boundary conditions for the prognostic model. All of these data will be assimilated into gridded data sets that will be archived at the Goddard DAAC.

References

Asrar, G. and D. J. Dokken ed., *EOS Reference Handbook*, 1993.

Schubert, S.D., *et al.*, *Bull. Amer. Meteor. Soc.*, **74**, 2331-2342, 1993. ❑

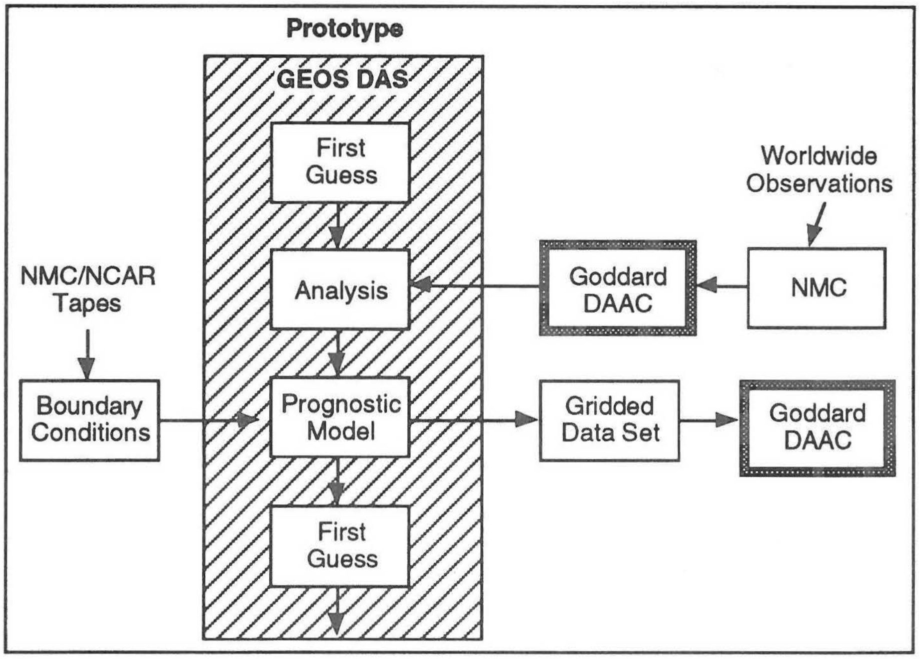


Figure 1. The data flow of the current GEOS DAS, which is the prototype from which the operational system will evolve.

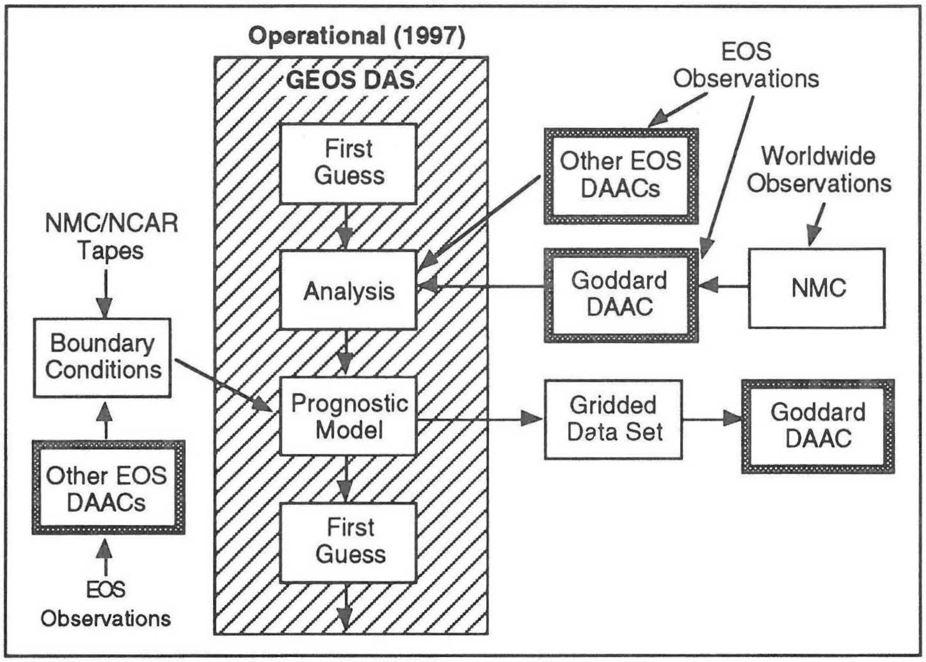


Figure 2. The EOS data flow in the operational GEOS DAS, beginning in 1997.

Table 3 **Additional EOS Observations**

Instrument	DAAC
AIRS/AMSU/MHS	Goddard
GLAS	Goddard/U. of Colorado
HIRDLS	Goddard
MIMR	Goddard/U. of Colorado/JPL/Marshall
MLS	Goddard
MODIS	Goddard
SAGE III	Goddard/Langley
TOMS	Goddard
TMI	Goddard
ASTER	Langley/EROS Data Center
CERES	Langley
EOSP	Langley
MOPITT	Langley
MISR	Langley/EROS Data Center
TES	Langley
ERS-1	U. of Alaska-Fairbanks
JERS-1	U. of Alaska-Fairbanks
ERS-2	U. of Alaska-Fairbanks
SMMR	U. of Colorado
SSM/I	U. of Colorado/Marshall

Table 4 **EOS Boundary Conditions**

Field	Source (DAAC)
Orography	Same as prototype*
Land Surface Type	Same as prototype
Sea Surface Temperature	JPL
Albedo	Langley
Sea Ice	U. of Alaska-Fairbanks
Snow Cover	U. of Colorado
Land Surface	Marshall

* For "prototypes," see Table 2.

From *EOS.News*

EOS OCEAN INTERDISCIPLINARY WORKSHOP

Representatives from the EOS Interdisciplinary Science Investigation (IDS) teams that focus on ocean-related topics gathered at a workshop March 8-10 in Monterey, CA. Presentations covered IDS team activities in researching biogeochemical cycles, circulation, numerical models and data assimilation, and fluxes of heat, moisture, gases, and momentum. The need for EOS to be a global mission was stressed; the trend of representing data sets without high latitudes as global must be fought through development of high-latitude algorithms and smoothing routines for EOS global data products.

Ocean data assimilation systems were discussed from several angles: primary production models will probably require an estimate of mixed-layer depth, an assimilated data product available only for limited testing from the U.S. Navy; EOS investigators have demonstrated that data assimilation is possible with a global observing system (TOPEX/Poseidon) and *in situ* data (TOGA, WOCE); and several examples were given of the use of regional circulation models to determine the strengths and weaknesses in sub-grid-scale parameterizations that limit current ocean data assimilation efforts. Ocean data assimilation was clearly a topic needing further work to bridge requirements and capabilities for EOS.

Investigators using non-NASA data sources reported good support from EOSDIS for ERS-1 scatterometer data, but questioned the degree of planning for upcoming missions (e.g., Radarsat). One proposal was to request that NASA support scientists keep abreast of the activities of non-NASA instrument science teams. Group discussions also focused on broader issues such as the need for an integrated science plan for EOS and the realization that long-term planning for *in situ* observations in the EOS era must begin soon. The need for strong grass-roots and political support for EOS was recognized, and it was proposed that EOS investigators take the lead by seeking endorsements from all relevant scientific societies and fostering public and political recognition of the need for better understanding the role of oceans in climate and global change.

From *EOS.News*

MTPE EDUCATION ACTIVITIES: GLOBE

On Earth Day, April 22, Vice President Al Gore formally announced the Global Learning and Observations to Benefit the Environment (GLOBE) Program. GLOBE will be an environmental education program where students and teachers from around the world will make local measurements of the environment. GLOBE will include significant NASA involvement, beginning with several NASA employees detailed to the GLOBE program office.

MTPE EDUCATION ACTIVITIES: SUMMER 1994

Summer fellowships, institutes, and workshops provide opportunities for teachers and students to learn first-hand about Mission to Planet Earth (MTPE) research. The following programs are sponsored by NASA through the Office of Mission to Planet Earth, NASA Headquarters:

1) The second Goddard Space Flight Center (GSFC) Space Academy will be held from June 5 to August 12 with 24 advanced undergraduate and graduate students recommended and co-funded by their state's Space Grant Consortium. Students are teamed with a GSFC mentor for individual research projects and also participate in group activities, including field trips in the Washington, DC area and to the NASA/Goddard Institute for Space Studies (GISS) in New York. Contact: Gerry Soffen, GSFC, (301) 286-1122, gsoffen@ccmail.gsfc.nasa.gov.

2) Summer Fellowships in Ocean Remote Sensing Program supervised by the Maryland Sea Grant College will be held June 6 to August 26. The fellowships are targeted for advanced undergraduate and graduate students, with significant participation by NASA/GSFC scientists. Contact: Larry Harding, University of Maryland, (301) 405-6372.

3) The Summer Institute for Atmospheric and Hydrospheric Sciences will be held at NASA/GSFC June 6-August 12. The program is directed at undergraduates entering their senior year and majoring in one of the physical sciences. Contact: Earl Kreins, GSFC, (301) 286-5056.

4) The fourth USRA-GSFC Graduate Student 1994 Summer Program in the Earth System Sciences will be held June 13 to August 19. Participating students will pursue specially-tailored research projects in conjunction with NASA/GSFC scientists, with an emphasis on interdisciplinary studies. During the first week, all students and the general public are invited to attend a concentrated public lecture series entitled *Observing the Earth from Space: Observations, Modeling, and Predictions of the Earth Science System and Global Change*. Contact: Paula Webber, USRA, (301) 552-8772, paula@gvsp.usra.edu.

5) The Aspen Global Change Institute (AGCI) will hold three summer science sessions, which will convene leading physical and social scientists to discuss their current research and explore major themes in Earth system science. Program topics will include: 1) Radiation Feedbacks and the Credibility of Atmospheric Models, July 10-23; 2) Anticipating Global Change Surprises, July 31-Aug. 13; and 3) Biological Invasion as a Global Change, Aug. 21-Sept. 3. Contact: John Katzenberger, AGCI, (303) 925-7376.

6) The fourth Summer School for the Earth Sciences: *Processes of Global Change*, will be held August 22-26 at the California Institute of Technology. This lecture series is directed toward Ph.D. students and recent (within 5 years) graduates. Up to 250 students will be accommodated in the program. Partial travel support is available for a limited number of students (available only to those living in the U.S.; civil servants are not eligible for support). Applications are due June 1. Contact: Marguerite Schier, (818) 354-2039.

7) The NASA/GSFC-Maryland Pilot Earth Science and Technology Education Network (MAPS-NET) project will hold a teacher workshop from July 11-15, at the University of Maryland. The purpose of this workshop will be to review and finalize a training manual being developed to accompany a teacher training workshop entitled *Atmospheric Observations From Space*, to be published as part of the series *Looking at Earth from Space*. Participants will include teachers from previous MAPS-NET workshops who will capture and analyze imagery from environmental satellites and participate in science lectures on clouds, weather systems, the ozone hole and the greenhouse effect.
Contact: Gerry Soffen, Goddard Space Flight Center, (301) 286-1122, gsoffen@ccmail.gsfc.nasa.gov.

Production of TOPEX/Poseidon Altimetry Data Record Has Begun

—**Robert Benada**, **Susan Digby**, and **Elaine Dobinson**, Jet Propulsion Laboratory

Reprint from *Science Information Systems Newsletter*

In cooperation with the French Centre National d'Etudes Spatiales (CNES) Archivage Validation et Interpretation des Donnees des Satellites Oceanographiques, the JPL Physical Oceanography Distributed Active Archive Center (PO.DAAC) has created a merged altimetry data product containing both the U.S. and the French altimetry measurements. This merged geophysical data record (MGDR) product is now available for distribution to the Earth science community.

The objective of the TOPEX/Poseidon mission is to determine ocean topography with a sea surface height measurement precision of 3 cm (~1 in) and a geocentric sea level measurement accuracy of 13 cm (~5 in). The JPL PO.DAAC MGDR product contains global coverage data from both the U.S. and French altimeters with high-precision orbits and environmental corrections. The data are distributed by the PO.DAAC on CD-ROMs (using the ISO 9660 standard) and in an integer format usable on VAX, Unix, PC, and Macintosh. Each CD-ROM contains two 10-day cycles of data, precision orbit and cross-over files for each cycle, and read software for VAX and Unix.

TOPEX/Poseidon Mission

On August 10, 1992, the joint U.S./French altimetric satellite, TOPEX/Poseidon, was launched on an Ariane rocket from Kourou, French Guiana. The satellite was maneuvered to an orbit with a 10-day-repeat ground track of 127 revolutions. (See Figure 1.) The equatorial track spacing is approximately 315 km (195 mi). The height and inclination are 1335 km (827 mi) and 66.04 degrees, respectively. The nominal mission life is three years with a possible two-year extension.

The satellite has two nadir-looking altimeters onboard. One is the NASA instrument, which is a dual-frequency (Ku and C band) altimeter whose general design is similar to the Geosat altimeter. The other is the French (CNES) instrument, Poseidon, which is a proof-of-concept solid-state altimeter that operates only in Ku band. As they share the same antenna and cannot operate simultaneously, they operate based on an antenna sharing plan. Obtaining maximum ocean coverage requires that data from both altimeters be used. Other instruments onboard are the nadir-looking TOPEX Microwave Radiometer (TMR) that provides radiometer data used to make wet troposphere corrections to the altimeter range and three systems used for precision satellite tracking; laser retroreflectors, a passive system of corner reflectors used for ground-based laser tracking, which is used to produce the NASA precision orbit; DORIS, a tracking beacon using the worldwide system of French ground stations that is used to produce the CNES precision orbit; and a Global Positioning System (GPS) receiver, an experimental instrument using the constellation of GPS satellites.

Range is determined by measuring the round-trip time from the antenna to the sea surface. The altimeters' Ku carrier frequency is 13.6 GHz with a chirp pulse bandwidth of 320 MHz. The pulse-limited footprint diameter is 2 km (~1 mi) for calm seas and 7 km (~4 mi) for 5-m (~16 ft) significant wave height.

Merged Data Record Content

The MGDR contains all data from both altimeters in a common format. Each record contains the time-tagged

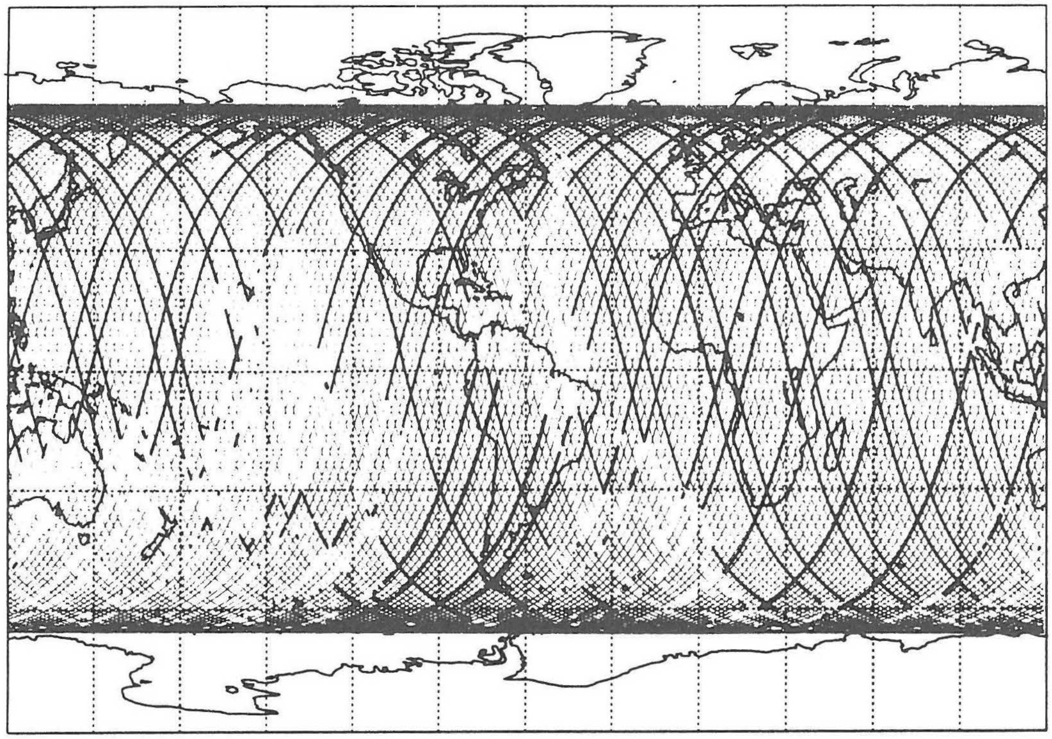


Figure 1. The satellite ground track showing data taken by the TOPEX altimeter in light, thin lines and the POSEIDON altimeter in dark, heavier lines.

geolocated range and altitude, instrument and environmental correction, and other instrument measurements. Sea surface height is calculated by subtracting the range from the satellite altitude. The sea surface height can then be corrected for instrument and environmental effects by selecting and adding the corrections from the MGDR. The environmental corrections include wet (from both TMR measurements and weather models) and dry tropospheric path delay, ionospheric path delay, and electromagnetic bias. The altimeter also measures significant wave height (SWH) to within 0.5 m (~19 in) or 10% of SWH and the radar backscatter coefficient to within 0.25 decibel (dB) precision, 1.0 dB absolute. Estimates of the wind speed (based on radar backscatter), geoid, mean sea surface, and various tides are also present. Brightness temperatures at nadir from the TMR at 18, 21, and 37 GHz are given.

The TOPEX/Poseidon data are considered research data for two reasons. First, the data consist entirely of files comprising headers and data records containing over 100 parameters for each second. The data are swath data and there are no images. Software to extract the parameters from each record is the responsibility of the investigators. Second, and perhaps more importantly, data analysis is still in its early stages. The instrument performance was shown to be very good during the verification phase. The precision orbit accuracy is better than 10 cm (~4 in). However, the use of the data to examine ocean properties is just beginning and there is, as of yet, no consensus on how to filter the data. Hence, a suite of parameters and flags has been included to allow users to use their own selection criteria.

MGDR Data Format and Production Schedule

The PO.DAAC MGDR is distributed on CD-ROMs containing two 10-day repeat cycles of merged data. Each cycle is in its own subdirectory and contains a single ASCII header file that describes the cycle and up to 254 pass files. A pass is one-half revolution and extends from lowest to highest latitudes for ascending passes and vice versa for descending passes. Each cycle contains 254 passes, although certain passes may not be present because of maneuvers or data dropouts.

The first MGDR, delivered in early October 1993, contains cycles 13 and 14. PO.DAAC is in the process of working off the backlog, producing CD-ROMs for cycles 1-12 and 15 to the present. Afterwards, MGDRs will be produced as soon as all input data are available, about two months after real-time data collection from the satellite. The delay is due to the time required for production of the precise orbit by NASA and CNES.

Role of the Active Archive Center

As one element of the Earth Observing System Data and Information System, the mission of PO.DAAC is to archive and distribute data relevant to the physical state of the oceans. The goals of PO.DAAC are to serve the needs of the oceanographic and geophysical sciences research communities and to provide data in support of interdisciplinary research. The primary means of achieving these goals are through acquiring, compiling, processing, and distributing data obtained from spaceborne and conventional instruments; producing and distributing higher level data products; and providing an increasing range of data services to the broad research community.

To facilitate the full and open access to quality data for global-change research, the data archived by PO.DAAC will be freely available upon request to the scientific community for scientific and educational purposes. Datasets available through PO.DAAC will not carry periods of exclusive use or access. The use of the datasets provided by PO.DAAC implies an obligation that proper credit be given to the data source, including the author of the dataset, and that two reprints of all published papers or reports be sent to the PO.DAAC.

To order the TOPEX/Poseidon merged ground data record contact the PO.DAAC User Services Office at (818) 354-2296 or (818) 354-0906; PO.DAAC.JPL on OMNET or podaac@shrimp.jpl.nasa.gov on Internet. ❑

Message to Article Contributors:

Since all future issues of *The Earth Observer* will be placed on World Wide Web for the convenience of those who would like to read the newsletter electronically, we are requesting a change in the method of submission for graphs and images that accompany articles submitted for publication. Using File Transfer Protocol (FTP), please transfer your files to spso.gsfc.nasa.gov anonymously. Use the following procedure (user input is italicized).

1. *ftp spso.gsfc.nasa.gov*
2. Name: *anonymous*
3. Password: *guest* (or any word will do)
4. ftp> *cd /pub* /*change directory to public area
5. ftp> *binary*
6. ftp> *put picture.gif* /*place a file there
7. Send e-mail message to cgriner@ltpsun.gsfc.nasa.gov, or winnie@ltpsun.gsfc.nasa.gov to let them know you have placed your file.

Color images or graphs (8 bit) in GIF, TIFF, JPEG, xbm, PICT, or PostScript are acceptable. Please remember that all graphs and images must convey your message in black and white for the newsletter; however, color can be used in WWW Mosaic files.

Send your articles electronically to cgriner@ltpsun.gsfc.nasa.gov as you normally do.

If you cannot send your file electronically, we will still accept hard copies of your graphs and images.

We appreciate your cooperation.

—Editor

From *EOS.News*

LANDSAT DECISION

On May 10, the Vice President announced the President's decision to continue the Landsat remote sensing satellite program and to restructure Federal agency responsibilities for acquiring and operating the next satellite, Landsat 7. Acquisition responsibilities will transfer from DoD to NASA. The Department of Commerce will operate the satellite and its ground system in cooperation with the Department of the Interior, which will maintain the national archive of Landsat data. This decision supports the continuity of the only source of global, calibrated, high-spatial-resolution measurements of the Earth's surface that can be compared to the current 20-year Landsat data set.

LANDSAT PLANS

The U.S. Government will: (a) provide unenhanced data which are sufficiently consistent in terms of acquisition geometry, coverage characteristics, and spectral characteristics with previous Landsat data to allow quantitative comparisons for change detection and characterization; (b) make government- owned Landsat data available to meet the needs of all users at no more than the cost of fulfilling user requests consistent with data policy goals of P. L. 102- 555; and (c) promote and not preclude private sector commercial opportunities in Landsat-type remote sensing.

The Landsat strategy is composed of the following elements: (1) ensuring that Landsat satellites 4 and 5 continue to provide data as long as they are technically capable of doing so; (2) acquiring a Landsat 7 satellite that maintains the continuity of Landsat-type data, minimizes development risk, minimizes cost, and achieves the most favorable launch schedule to mitigate the loss of Landsat 6; (3) maintaining an archive within the United States for existing and future Landsat-type data; (4) ensuring that unenhanced data from Landsat 7 are available to all users at no more than the cost of fulfilling user requests; (5) providing data for use in global change research in a manner consistent with the Global Change Research Policy Statements for Data Management; (6) considering alternatives for maintaining the continuity of data beyond Landsat 7; (7) and fostering the development of advanced remote sensing technologies, with the goal of reducing the cost and increasing the performance of future Landsat-type satellites to meet U.S. Government needs, and potentially, enabling substantially greater opportunities for commercialization.

Affected agencies will identify funds necessary to implement the National Strategy for Landsat Remote Sensing within the overall resource and policy guidance provided by the President. In order to effectuate the strategy enumerated herein, the Secretary of Commerce and the Secretary of the Interior are hereby designated as members of the Landsat Program Management in accordance with section 101(b) of the Landsat Remote Sensing Policy Act of 1992, 15 U.S.C. 5602(6) and 5611(b). Specific agency responsibilities are provided below.

DOC/NOAA will: (1) in participation with other appropriate government agencies arrange for the continued operation of Landsat satellites 4 and 5 and the routine operation of future Landsat satellites after their placement in orbit; (2) seek better access to data collected at foreign ground stations for U.S. Government and private sector users of Landsat data; (3) in cooperation with NASA, manage the development of, and provide a share of the funding for, the Landsat 7 ground system; (4) operate the Landsat 7 spacecraft and ground system in cooperation with the DOI; (5) seek to offset operations costs through use of access fees from foreign ground stations and/or the cost of fulfilling user requests; (6) and aggregate future Federal requirements for civil operational land remote sensing data.

NASA will: (1) ensure data continuity by the development and launch of a Landsat 7 satellite system which is at a minimum functionally equivalent to the Landsat 6 satellite in accordance with section 102, P. L. 102-555; (2) in coordination with DOC and DOI, develop a Landsat 7 ground system compatible with Landsat 7 spacecraft; (3) in coordination with DOC, DOI, and DoD, revise the current Management Plan to reflect the changes implemented through this directive, including programmatic, technical, schedule, and budget information; (4) implement the joint NASA/DoD transition plan to transfer the DoD Landsat 7 responsibilities to NASA; (5) in coordination with other appropriate agencies of the U. S. Government develop a strategy for maintaining continuity of Landsat-type data beyond Landsat 7; (6) and conduct a coordinated technology demonstration program with other appropriate agencies to improve the performance and reduce the cost for future unclassified Earth remote sensing systems.

DoD will implement the joint NASA/DoD transition plan to transfer the DoD Landsat 7 responsibilities to NASA. DOI will continue to maintain a national archive of existing and future Landsat-type remote sensing data within the United States and make such data available to U. S. Government and other users. All the agencies affected by these strategy guidelines were directed to report within 30 days to the National Science and Technology Council on their implementation. The agencies will address management and funding responsibilities, government and contractor operations, data management, archiving, and dissemination, necessary changes to P. L. 102-555 and commercial considerations associated with the Landsat program.

EDHS-The ECS Data Handling System

—**Kris Wheeler** (kwheeler@eos.hitc.com), Hughes Information Technology Corp.

The EDHS is the on-line distribution and storage system for documents about the EOSDIS Core System (ECS). It is maintained by Hughes Applied Information Systems (HAIS). The overarching objective was to design EDHS to be accessible with free and generally well-known tools, yet able to provide more than just "basic WAIS service." To meet the goal of accessibility, EDHS utilizes the World Wide Web (WWW) and WAIS technologies as delivery vehicles, since they are available worldwide via the Internet. Baseline service has been enhanced in three ways:

- Multiple document formats that allow on-line and print capabilities of both text and graphics across as many platforms and software applications as possible.
- Metadata search that goes beyond standard searches against full-text WAIS databases and also gives the user a good feel for what the document is about before it is viewed or downloaded.
- Multi-level access that provides the Earth science community access to documents generated by and related to the project.

To Access Mosaic

The January/February 1994 issue of *The Earth Observer* (pp. 10-12) offers excellent instructions for obtaining Mosaic and other servers from NCSA. As an alternative to downloading the files from the NCSA machine mentioned in *The Earth Observer*, users may choose to get the Mosaic distribution from the EDHS anonymous ftp server:

Host address: edhs1.gsfc.nasa.gov (or 192.150.28.25)
User ID: anonymous
Password: <your e-mail address>

Type cd /pub to move into the /pub directory where you will find the following files and subdirectories:

- README.FIRST - detailed information on filename conventions and how to locate files
- ls-lR - a recursive listing of all files contained under /pub
- freeware - public domain packages relevant to the EDHS project
- shareware - packages available for a nominal fee
- unix - source code in src and executables in bin
- pc - zip files for IBM PCs running Windows
- mac - binhexed files for Macintosh computers

To download the README.FIRST file to your computer for more detailed information about the files on this server and how to retrieve them, type get README.FIRST. The file can then be converted into your preferred word processing package for viewing and/or printing.

If you are unfamiliar with ftp or with the conventions and utilities used to uncompress files that are distributed over the Internet, it is probably best to get help from your system administrator or someone at your site who is familiar with ftp.

Retrieving the EDHS Home Page

Once you have launched Mosaic, pull down "Open URL" under File on the menu bar and enter: http://edhs1.gsfc.nasa.gov. Follow instructions within the Mosaic home page for placing the EDHS home page on the "Hot List"; this will make it possible to launch EDHS in the future without entering the URL.

EDHS Collections and Access

By far the largest collection within EDHS is the Community Collection, which will expand to house all documentation describing the development of ECS over its 10-year life cycle. This will include:

(1) Contract Data Requirements List (CDRL) items that have been approved for use on the project, as well as those CDRLs GSFC has released for wider distribution that are undergoing final review. Documents that have not reached final approval are so indicated on the title page and should be treated as such by the reader.
(2) Technical Reports/White Papers/Newsletters generated within the ECS project that, while not a part of the CDRL, are important to understanding ECS development and are authorized for dissemination.
(3) ECS-related documents that have not been generated within the HAIS ECS project but are considered important to documenting and/or statusing ECS development.
(4) Presentation materials from major milestone and other periodic reviews.
(5) Periodic and scheduled reports used to monitor status of ECS-related activities.

There are three ways the collections may be accessed:

(1) Full text—this employs search using a particular search word or a phrase. A list of relevant documents is returned and you then decide and select the document you wish to retrieve.
(2) Metadata—this search uses the same search method as above. In this case, though, the returned list highlights "metadata" or summary information that you can view first before you decide on a document.
(3) Catalog—this lists all documents/reports given for each collection in chronological order of entry; this may be the fastest way to access something if you know what you are looking for.

There are also hyperlinks to other home pages that service the Earth science and NASA communities. By clicking the corresponding phrase (in color and/or underlined) the reader may go the GSFC home page and then the EOS Project Science Office information server.

As the EDHS gets up and running, you may find that some things are incomplete, and some things may "break" while changes are being made. Please bear with us, and help us by using the electronic comment form (look under Quicklinks for Experienced Users) or by sending email to edhsadmin@eos.hitc.com with suggestions or observations that may help us in providing a better service. We hope to hear from you! ☐

From *EOS.News*

GCDIS AVAILABLE

On April 1, 1994, Version Alpha of the Global Change Data and Information System (GCDIS) became available to the public. The multi-agency GCDIS links databases and information from many agencies and foreign governments using Gopher servers and the Internet. The NASA contribution consists of 19 different on-line information systems and several dozen file servers in the U.S.A. NASA will provide data, images, and information from the Distributed Active Archive Centers (DAAC), the Scientific and Technical Information System, the EOSDIS Testbed at the University of Colorado, and several other systems at Goddard Space Flight Center and Ames Research Center. NASA also contributes the Global Change Master Directory, which indexes global change data from all agencies in the GCDIS. EOSDIS will also provide product lists, descriptions, points-of-contact, and other important information to help the user navigate the system. GCDIS can be accessed over the Internet at esdim2.nodc.noaa.gov using Gopher.

VEGETATION PREPARATORY PROGRAMME

The next satellite to be launched in the Systeme pour l' Observation de la Terre (SPOT) series, SPOT 4 in 1997, will include a complementary instrument, VEGETATION, to provide moderate resolution (1.15 km at nadir) images of the land biosphere with global coverage every two days. VEGETATION will have four spectral bands in the visible to infrared: 430-470 nm, 610-680 nm, 780-890 nm, and 1580-1750 nm. To prepare the user community for the availability of VEGETATION data, a preparatory program has been announced by the Commission of the European Communities (CEC). Some activities defined as essential to the development and promotion of VEGETATION include: support for development or adaptation of applications, primarily for sectorial policy of the European Union (for agriculture, forestry, environment, etc.); research and development on the use of remote sensing; and definition of products or algorithms. Interested parties should submit a letter of intent by May 1, 1994. For more information and instructions, contact the VEGETATION International Users Committee, Institute for Remote Sensing Applications, Joint Research Centre, I-21020 ISPRA (Varese), Italy; tel:+39-332-789765; fax:+39-332-789536. A Call for Proposals is expected to be sent out in June or July for proposals due October 1, 1994.

The Roles and Requirements of Visualization in NASA's EOS Era

—**Mike Botts**, Earth Systems Science Laboratory, The University of Alabama in Huntsville

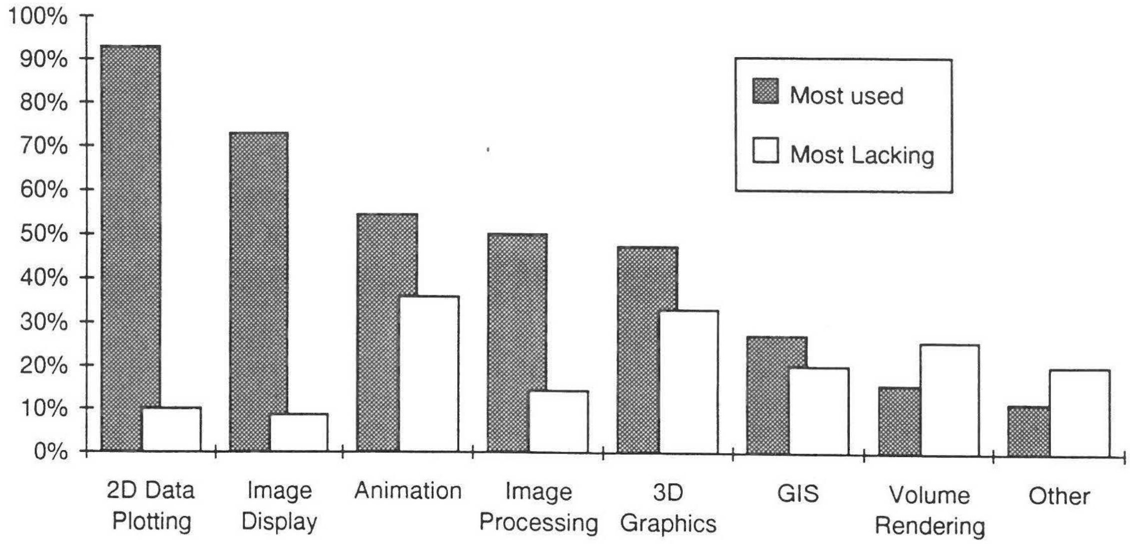
Reprint from the *Science Information Systems Newsletter*

Visualization is vital to the success of NASA's Mission to Planet Earth (MTPE). It is estimated that the Earth Observing System (EOS), the cornerstone of the mission, will generate nearly a terabyte of data each day. Without adequate visualization tools, as well as improved automatic processing software, this volume of data will quickly overwhelm the scientific community. The data processing and analysis requirements of the EOS mission are collectively considered one of the grand challenges of the present computing era and will surely be a driving force in pushing the leading edge of visualization development and scientific analysis in the future.

In recognition of this role of visualization in the Mission to Planet Earth, Dixon Butler, Director of NASA's Operations, Data, and Information Systems Division, Office of Mission to Planet Earth, requested in the spring of 1992 an investigation into the state of scientific visualization with regard to the EOS mission. Up until that time, NASA had given considerable attention to the data retrieval, data management, and scientific objectives nodes of the EOS data pipeline, but had given minimal attention to visualization tools within the EOS project. The justification for this approach was primarily rooted in the belief that Commercial Off-The-Shelf (COTS) software, as well as development activities within other NASA programs and other agencies, would be adequate to meet these needs.

In order to assess the validity of this assumption, and to highlight any possible deficiencies in present and future visualization tools that might impede the success of EOS, more than 50 groups of scientists and developers at some 30 sites were visited and interviewed regarding present and future visualization requirements, as well as ongoing and anticipated visualization

Figure1. Most used/most lacking components of visualization



development activities. These sites included government facilities, universities, national supercomputer centers, and commercial vendor facilities. In addition, an e-mail survey was conducted with about 250 EOS scientists in order to determine their requirements for, and experiences with, visualization tools. The results from these studies, as well as the authors' recommendations to NASA Headquarters, have been reported in *The State of Visualization with Regard to the NASA EOS Mission to Planet Earth*, which is available from the author. This article presents a brief synopsis of that report, as well as a discussion on actions that NASA has taken following the report.

The State of Visualization

Visualization is recognized here as the unification of several fairly mature computer applications, including image processing, 2D data plotting, 3D computer graphics, volume rendering, geographic information system, and computer-human interaction. Plotted in Figure 1 are the responses of 70 EOS scientists to questions regarding which visualization components are most used and most lacking in their present tool suite. Whereas each of these components provides important capabilities to the Earth system scientist, each also has specific deficiencies for meeting EOS needs. In addition, a balanced unification of these components into a single tool or into a well-integrated collection of tools requires continued effort. Applications of scientific visualization within the EOS project include scientific investigation, data validation, model and algorithm development and validation, data browse, information transfer, and mission operations.

Due to rapidly increasing CPU and graphics power available to scientists at their desktops, two major transitions are occurring within the scientific computing environment, including transitions from centralized to distributed computing and from batch-mode operations to interactive computing. Both of these transitions are putting more computing power and control directly into the hands of the scientist. It is this interactivity that will result in the greatest benefits to be derived from scientific visualization. However, without the proper software to take advantage of this power, these benefits will not be realized. These transitions are demanding changes in the roles played by scientists and computer specialists, as well as requiring changes to our visualization and analysis tools. The mode of handing off visualization jobs to computer specialists is no longer adequate. The moviemaking era of visualization was a necessary and important phase of these transitions, but does not represent the total required direction for visualization. The most important immediate direction for visualization efforts is that of putting useful and usable interactive tools into the hands of the scientist.

Many of the techniques and components of visualization required for meeting EOS scientific objectives are available today. However, the actual use by the scientists of even our present visualization capabilities is well behind these capabilities. Why aren't scientists using the visualization capabilities that are available to them today? Reasons include:

- The present tool is not extensible or is too inflexible.
- The tool is too difficult to learn and use.
- It is too difficult to get existing data into the tool.
- The tool does not adequately link visualization and analysis.
- The collection of tools, as well as the data, exist within a complex heterogeneous computing environment.
- The tool does not do what the scientist needs to do.
- Scientists are not aware that the tool exists or that it meets their needs.
- The tool is too costly.
- Scientists do not have access to adequate hardware for running the tool.
- It is too difficult to communicate the results of the finding to others, because (a) it is too difficult to get color prints or video, (b) it is difficult or impossible to interact remotely with colleagues, or (c) the publishing industry is too technically and philosophically archaic to meet the present needs for color hardcopy, animation videos, algorithm and application exchange, and voice and sound annotation.

Figure 2 shows the response of 70 EOS scientists as to the "biggest problems" with present visualization tools.

Visualization Bottlenecks

With few exceptions, hardware capabilities are not, at present, a major limitation of our visualization environment. The commercial marketplace is probably adequate for assuring necessary advances in hardware technology. The primary bottleneck is the lack of

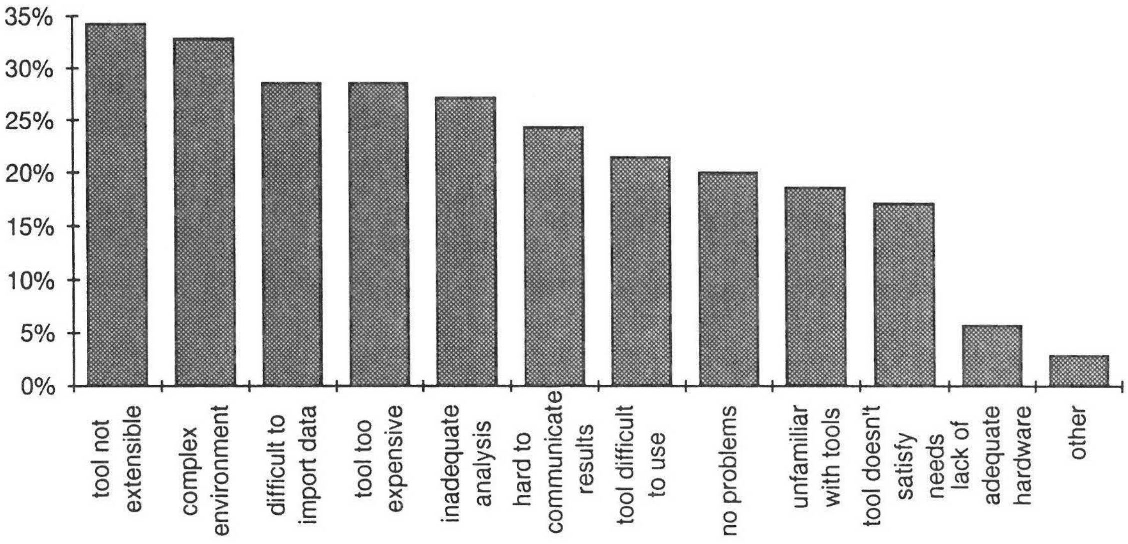


Figure 2. Problems with existing visualization tools.

adequate software that allows scientists to take advantage of this power and to interactively visualize and analyze their data within our complex computing environment. Although commercial vendors have begun to make impressive strides in providing visualization tools, it is questionable that COTS software, alone, will be adequate for meeting all of the visualization needs of EOS. Therefore, NASA must determine the best strategy for balancing NASA-funded software development with a dependence on COTS software.

Visualization Development

There are both advantages and disadvantages to relying on either COTS or in-house-developed software for meeting the visualization needs of EOS. A proper balance between COTS, public domain, and in-house-development is advantageous, but this balance must be accomplished with adequate and properly directed support. If NASA is to rely more heavily on COTS software in the future, then it must reevaluate and improve the way it deals with COTS developers.

NASA-funded development has resulted in several significant, leading-edge visualization and analysis tools, particularly within the Applied Information Systems Research Program (AISRP), NASA's Office of Aeronautics and Space Technology activities, and to a lesser extent, within the Earth science programs. Unfortunately, with particular regard to visualization, the development environment within NASA, in general, has in the past been characterized as lacking a firm commitment or plan for meeting the true visualization needs of the science communities

Required in-house development is of two types: (1) development of general tools to meet the needs of a wide range of users, not being met by existing software, and (2) extension, modification, and integration of existing tools to meet application-specific requirements.

A particularly difficult challenge for NASA will be recognizing and supporting in-house "diamonds"—experimental development efforts that hold much promise for scientists; and preventing, recognizing, and dealing with "dinosaurs"—old development programs with limited momentum and decreasing application. Present mechanisms for the transfer of successful development activities into usable and maintainable technology are inadequate.

Areas of Required Concentration

There are several main areas of concern with regard to meeting the visualization requirements of NASA scientists. These include:

- Integration of visualization with data management and analysis: Data management, analysis, and visualization represent a triad of functionality required to meet scientific objectives. This triad must be properly balanced and adequate bidirectional links must exist between each of the components.

- Application development for the scientist as the end-user: Visualization tools should meet the actual needs of the scientist, be simple and intuitive to use, and be logical to the scientist rather than to a computer specialist.

- Providing extensibility without complexity: Extensibility of visualization tools is a vital requirement, particularly for COTS software. This extensibility must be provided without a significant increase in complexity of use, or any resulting complexity must be hidden from the scientist by customized interfaces.

- Application-specific programming without redundant programming: Redundant programming within the visualization community is extensive. Often new development activities, which are undertaken in order to provide new application-specific functionality, spend a large portion of effort on redundantly programming functionality that already exists in several other programs.

- Simplification of the complex heterogeneous computing environment: Scientists and computer specialists are forced to operate within a complex heterogeneous computing environment, consisting of incompatible operating systems, graphics protocols, networks, file formats, and output devices. Efforts to homogenize this environment will help to a limited degree, but would probably be only temporary relief. There is a vital need for utilities that shield scientists from dealing with unnecessary complexities, allowing them to concentrate on analysis of data.

- Development of new techniques and components: The exploration of new techniques for analyzing and visualizing data should continue. However, in most cases, the introduction of new techniques should require only the development of a module or component that can be added to existing applications.

- Education and communication: Many of the present challenges in visualization are the result of a lack of proper communication and education of scientists, developers, and project managers, alike.

- Distribution and maintenance: The distribution, maintenance, and support of COTS, public domain, and in-house software is a significant challenge. A major challenge with in-house development is the distribution and maintenance of successful application developments, and the transition of such programs from the experimental stage through maturing and operational stages.

- Specific challenges that the Mission to Planet Earth will impose on visualization tools are: (1) the presence of large datasets, (2) the availability of vast quantities of data, (3) the need for interusability between multiple datasets from different sensors and scientific disciplines, (4) the importance of temporal, as well as spatial, domains, and (5) the need to fully investigate the information within multiband and multiparameter data.

Recommendations to NASA Headquarters and the Mission to Planet Earth program included:

- Establish a vision and directions for visualization/analysis tools
- Establish a visualization/analysis working group to evaluate issues and directions
- Establish visualization/analysis assistance centers to aid scientists
- Improve NASA-funded development efforts
- Use the Pathfinder project to test the full data path, including visualization and analysis
- Set up vendor programs
- Improve software licensing and hardware/software procurement
- Improve publishing standards and provide for remote interactive visualization between colleagues

Follow-up

Since publishing *The State of Visualization with Regard to the NASA EOS Mission to Planet Earth*, several activities have been undertaken or begun at NASA Headquarters. A sample of these includes:

- A new NRA was released by the AISRP in summer 1993, with partial focus on EOS-type problems and an emphasis on building on existing technology and establishing teams of computer specialists and scientists.

- AISRP sponsorship of a special visualization session and demo area at the AGU Spring '93 meeting, with subsequent special publication, provided exposure of many tools to Earth and space scientists.

- A new branch within MTPE at NASA Headquarters will focus on technological advancements required for EOS, including visualization.

- An NRA will soon be announced from the MTPE program that will focus on Information Systems Technology Development and Adaptation for EOSDIS, and will encourage teams of both computer specialists and scientists.

- There are ongoing efforts to improve scientific and visualization publishing through experimental CD-ROM issues of scientific journals.

- The EOS Pathfinder project has been expanded to consider the Interuse Experiment, which considers a full data path approach to ensuring the indisciplinary use of multisensor data through the use of standard presentation of geolocation information, as well as visualization and development tools for projecting, gridding, and mosaicking satellite data.

- Initial funding was provided by the AISRP for a software assistance center at the University of Colorado.

For further information or to receive a copy of *The State of Visualization with Regard to the NASA EOS Mission to Planet Earth*, contact the author at: (205) 895-6257 Ext. 227; botts@stromboli.atmos.uah.edu ☐

From *EOS.News*

PATHFINDER CONFERENCE

The Second InterPathfinder Conference was held March 30 to April 1, 1994 in Washington, DC. The objective of this conference was to provide feedback to EOS and EOSDIS on the issues of end-to-end production, archiving, and distribution of large satellite data sets for global change research. In addition to conference proceedings, a Pathfinder-lessons-learned document is being created for distribution. There were also discussions on the HDF data format, algorithm implementation, validation responsibilities and procedures, and interuse of the data sets. There now exist long sequences of AVHRR, Landsat, TOVS, SSM/I, and GOES data, with many new global-change-oriented products. A digital data sampler of one day (20 March 1988) is available online through anonymous ftp, gopher, or Mosaic at the Internet address pathfinder.arc.nasa.gov. This sampler shows types of data, data descriptions, algorithms, references, and pointers to source archives.

Update on Data Support at the Goddard DAAC

—**Paul Chan** (daacus@nssdca.gsfc.nasa.gov), Code 902.2, Goddard Distributed Active Archive Center

The Goddard DAAC is processing, archiving, and distributing a wide variety of data sets related to physical measurements of the upper atmosphere, the global biosphere, and atmospheric dynamics. Figure 1 relates the Goddard DAAC's data holdings to the EOS-mandated data responsibilities.

The Goddard DAAC began distributing UARS data to the science community in October 1993. Distribution of SeaWiFS ocean color data to authorized users will begin shortly after satellite launch, in early 1995. The TOGA-COARE field observation data, 4-D Assimilation data (time series subset), and TOVS Pathfinder and Pathfinder AVHRR Land data are also archived and distributed, with the Pathfinder efforts giving the DAAC experience in processing, archiving, and distributing *massive* data sets.

How Does the Goddard DAAC's Data Support Activity Work?

First the DAAC and its User Working Group determine the status of each data set. Those that are being prepared for archiving, like SeaWiFS; being processed by the DAAC, like TOVS Pathfinder; cited for reprocessing; and receiving increasingly large user demands are considered "active" and ready for the Goddard DAAC staff to create data information and establish other user services for them. Those services include writing a Read Me file, compiling metadata, writing a user's manual, and building a special Read Program for non-HDF data.

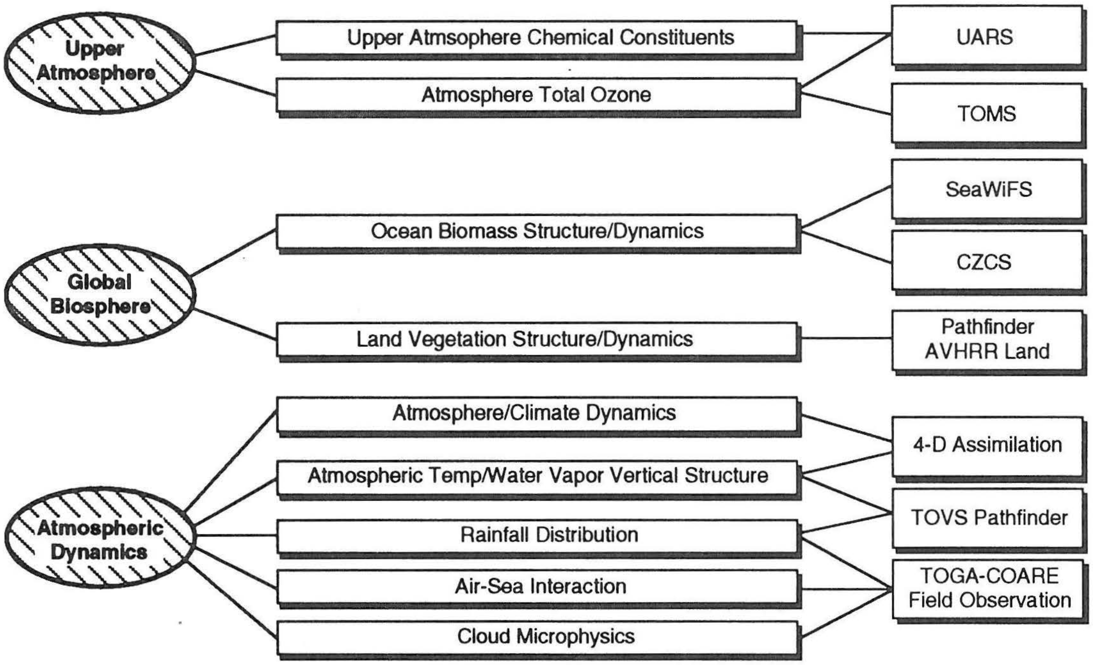


Figure 1. Relation of the Goddard DAAC's data holdings to the EOS-mandated data responsibilities.

The following data sets are "active" as of April 1994.

Ocean color: SeaWiFS Levels 1, 2, and 3
CZCS Levels 1, 2, and 3
Upper atmosphere chemistry: TOMS Level 3, UARS Level 3A
Atmospheric dynamics: 4-D Assimilation (150 GB time series subset), TOVS Pathfinder Level 3 (Path A, including processing)
Land biosphere: Pathfinder AVHRR Land Level 3 (including processing)
Field observation: TOGA-COARE (data sets from NASA PIs)

When the archival process is complete and the demand on user services is stable, the data set will be considered "mature," and a new one will take its place on the active list. Distribution and user services continue for mature data sets.

A New Approach to Data Support

The Goddard DAAC recently organized Data Support Teams made up of members from the science support, user services, and operations groups within the DAAC. Each team assumes stewardship of a data set for its entire life cycle; from inception to operational distribution to users. This "team per data set" approach enables:

- improved user community relations because of a single contact point for data preparation and dissemination,
- retention of knowledge of the data set by the team,
- faster turnaround for addressing, diagnosing, and solving problems,
- more interaction among science support, user services, and operations staff, and
- accountability for a particular data set.

LIFE CYCLE TASKS	Sea WIFS	CZCS	UARS L3A	TOMS L3	4 D	TOVS L3	AVHRR	TOGA COARE
Define implementation criteria (requirements, data info., reprocessing, support level...)	▨	DONE	DONE	DONE	DONE	DONE	DONE	DONE
Resource impact analysis	DONE	DONE	DONE	DONE	DONE	DONE	DONE	DONE
Define project interface (format, protocol...)	DONE	DONE	DONE	DONE	DONE	DONE	DONE	DONE
Implement needed hardware	▨	DONE	DONE	DONE	DONE	DONE	DONE	DONE
Implement needed software (format software, ingest software...)	▨	DONE	DONE	▨	DONE	DONE	DONE	▨
Create data information (ESDIS guide, Read Me, user's manual, Read Program)	▨	▨	▨	▨	▨	▨	▨	▨
Readiness test of end-to-end scenario	7/15	DONE	DONE	6/15	DONE	DONE	DONE	DONE
Operation & user services staff training	▨	▨	▨	▨	▨	▨	DONE	▨
Operation support (ingest, archival, distribution)	2/1/95	▨	▨	7/1	6/1	▨	▨	▨
User services support	2/1/95	▨	▨	7/1	6/1	▨	▨	▨

Gray cells = ongoing activity

Figure 2. Support status for the data sets.

Team responsibilities for the three phases of the data life cycle are as follows:

Early: Establish implementation criteria—requirements specification, support level, etc.
Resource impact analysis
Implementation planning

Active: Software and hardware implementation—data ingest software, read program, etc.
Data information preparation—Read Me file, metadata, user's manual, etc.
Training of user services and operation staff
Readiness test of end-to-end scenario
Operation support—data ingest and quality assurance

Mature: Data distribution
User services support

Team leaders change with each phase and are chosen from among the team members based on expertise requirements. For example, the early phase requires significant experience in management and coordination of data preparation, while the mature phase requires experience in user services. Team leaders who rotate out of that role remain on the data support team.

Figure 2 summarizes the status of support for the data sets. As of today, all eight active data sets are in the active stage, which is the most resource intensive. We will keep you abreast of changes in future issues of this publication. ❑

From EOS.News

GOES-NEXT LAUNCHED

The next generation of the Geostationary Operational Environmental Satellite (GOES) was initiated with the launch of GOES-I on April 13, 1994. Upgrades from previous GOES include improved spatial accuracy (e.g., storm tracking to within a few kilometers, previously 10-20 km), sharper images (going from 64 to 1024 shades of gray in cloud images), more infrared channels for atmospheric sounding, and simultaneous imaging and sounding. The launch of the satellite and the deployment of the solar panels went smoothly. NASA conducted the launch and oversaw the two-week process of boosting the satellite to geostationary orbit and the satellite checkout period that followed. This satellite, renamed GOES-8, replaces the European Meteosat that has been used for weather monitoring over eastern North America. GOES-8 delivered its first images in early May and will be turned over to NOAA in 6 months for operational use in time for the hurricane season.

NSUN WORKING GROUP MEETING

The second meeting of the NASA Science User Networks (NSUN) was held at NASA Ames Research Center on March 31, 1994 to discuss the development of the evolving user network environment for the EOS Data and Information System (EOSDIS). The primary focus of this meeting was to review current work in progress of the EOSDIS User Model and plans for Network Prototyping. The user model developed for the EOSDIS Core System (ECS) by Hughes Applied Information Systems (HAIS) listed 44 application scenarios determined from interviews with selected EOS investigators. The working group recommended that HAIS should 1) include scientists early and often during model development, 2) make reports describing the user model available to the scientific community as soon as possible, with special attention to the methodology, assumptions, and analysis of the results, and 3) include members from the NASA Science Internet (NSI) organization in the development of the external network component of the user model. Plans for NASA prototype networks were also discussed. The existing internal network between EOSDIS data centers has a bandwidth of 256 kbps which is being upgraded to 512 kbps. An analysis of EOS network prototyping included 21 EOS investigator locations and the EOS investigators accessing EOSDIS data centers. The working group created a Networks Prototyping Subgroup to define prototype activities such as: scientific conferencing; supercomputer model access (e.g., computer-to-computer and computer-to-user); online real-time data retrieval; access by mobile/remote scientists (in the field); and data compression standards (circuits and protocols). The next meeting is scheduled for July 20-21, 1994.

EOS Science Calendar

June 8-9	TES/AES Science Team Meeting, University of Denver, CO. Contact: Reinhard Beer at (818) 354-4748; (beer@atmosmips.jpl.nasa.gov).
July 19-21	Payload Panel Meeting, Washington D.C., Contact: Berrien Moore at (603) 862-1766; FAX: (603) 862-1915; (B.Moore.UNH/OMNET).
November 14-18	8th Joint ASTER Science Team Meeting, Japan. Contact Hiroji Tsu at +81-3-3533-9380; FAX: +81-3-3533-9383, or Anne Kahle at (818) 354-7265; (anne@lithos.jpl.nasa.gov).

Global Change Calendar

• 1994 •

July 11-21	30th COSPAR Scientific Assembly, Hamburg, Germany. Contact G. Haerendel at Internet: hae%mpe.mpe-garching.mpg.de.
July 27-28	The International Conference on Climate Change, Washington Hilton Hotel, Washington, DC. Contact International Climate Change Conference, P.O. Box 236, Frederick, MD 21701, phone: (301) 695-3762.
August 8-12	1994 International Geoscience & Remote Sensing Symposium (IGARSS), Pasadena, CA. Contact IGARSS Business Office, phone: (713) 291-9222; FAX: (713) 291-9224.
September 5-9	Call for Papers for ISPRS Commission III Symposium, Spatial Information from Digital Photogrammetry and Computer Vision, Munich, Germany. Contact Christian Heipke, Secretary, ISPRS Commission III 1992-1996, Chair for Photogrammetry and Remote Sensing, Technical University Munich, Arcisstr. 21, D-80290 Munich, Germany. Phone: +49-89-21052671 (2677), FAX: +49-089-2809573, or e-mail: chris@photo.verm.tu-muenchen.de.
September 12-15	First International Airborne Remote Sensing Conference and Exhibition: Applications, Technology, and Science, Strasbourg, France. Contact Robert Rogers, ERIM, Box 134001, Ann Arbor, MI 48113-4001, phone: (313) 994-1200, ext. 3234; FAX: (313) 994-5123.
October 25-27	Second International Conference on Carbon Dioxide Removal. Sponsored by Research Institute of Innovative Technology for the Earth (RITE), and New Energy and Industrial Technology Development Organization (NEDO). For further information contact ICCDR-2 Local Secretariat: Ms. Yukiko Morita, c/o Planning and Survey Dept., RITE, 9-2 Kizugawadai, Kizu-cho, Soraku-gun, Kyoto 619-02, Japan. Phone: +81-7747-5-2301; FAX: +81-7747-5-2314.
Oct. 30-Nov. 3	1994 International Snow Science Workshop. Contact Liam Fitzgerald, ISSW '94. Box 49, Snowbird, UT, USA (801) 521-6040.
November 8-10	Technology 2004 Conference & Laser Tech '94, Washington D.C. Convention Center. For further questions call Leonard Ault at (202) 358-0721 or Michael Hackett at (202) 728-2080.
November 13-16	First IEEE International Conference on Image Processing, Austin Convention Center, Austin, TX. Contact icip@pine.ece.utexas.edu.

• 1995•

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.

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The Earth Observer Staff:
Executive Editor: Charlotte Griner
Technical Editor: Renny Greenstone
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