THE EARTH OBSERVER

A Bimonthly EOS Publication

January/February, 1996, Vol. 8 No. 1

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Editor's Corner

The National Academy of Sciences' Board on Sustainable Development (BSD) review of the MTPE/EOS component of the U. S. Global Change Research Program (USGCRP) has resulted in a substantial number of studies by NASA and the Payload Panel since last September. On November 7-9, 1995, NASA convened a workshop at the Goddard Institute for Space Studies (GISS) to respond to the recommendations of the BSD to focus the tropospheric chemistry components of Chemistry-1 on the global distribution of ozone and its precursor gases. Over forty scientists from the U.S. and abroad participated in this workshop, including both tropospheric chemists (modelers, experimentalists, and remote sensing experts) and experts in the remote sensing and characterization of tropospheric aerosols. The workshop report (available on World Wide Web at http://spso.gsfc.nasa.gov/spso_homepage.html) contains the following tropospheric ozone conclusions: (i) a critical science need is to understand the mechanisms that control the distribution and temporal changes of tropospheric ozone *and* its precursors (NO_x, CO, hydrocarbons, water vapor), (ii) the Tropospheric Emission Spectrometer (TES) offers the first and only planned opportunity for global and simultaneous mapping of tropospheric ozone and its critical precursors with suitable horizontal and vertical resolution, (iii) observations from space must be complemented by a strong program of *in situ* measurements from aircraft, (iv) rapid development of global tropospheric chemistry models is essential, and (v) space-based measurements must resolve the vertical distribution of ozone in the troposphere to allow interpretation of the data in terms of the effects of ozone on both climate and the biosphere.

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In addition to recommendations on tropospheric chemistry, the workshop drew the following conclusions with respect to tropospheric aerosols: (i) tropospheric aerosols are of considerable environmental importance, both due to their direct effect on the Earth's radiation budget, as well as their indirect effect on modifying cloud radiative properties, (ii) current spaceborne sensors (AVHRR, SAGE II, and TOMS) have already provided valuable information on tropospheric aerosols, even though they were not designed for this purpose, (iii) next generation sensors (POLDER, MODIS, MISR, SAGE III, EOSP, and GLI) will provide higher quality aerosol products, (iv) lidar appears to be the only technique capable of obtaining the vertical distribution of aerosol properties, and (v) rapid development of global tropospheric aerosol models capable of interpreting the data from spaceborne sensors is essential. In both tropospheric chemistry and tropospheric aerosols, there was a clear realization for the need for additional laboratory studies to enhance the potential of spaceborne observations.

In addition to this analysis of the approach to tropospheric ozone and its implications for Chemistry-1, NASA has also: (i) focused the Earth science component of the New Millennium Program on instrument development, (ii) established a process for providing new measurements using advanced technologies e.g., Earth System Science Pathfinders, (iii) completed a significant scrub of EOSDIS plans for data downlink (command and control of spacecraft and instruments) and Level-0 and Level-1B (calibrated, geolocated) data processing, and (iv) developed a concept for the establishment of a federation of partners for the production and distribution of EOSDIS higher level data products.

All of these responses were presented to the BSD Committee on Global Change Research (CGCR) during their meeting on March 6-8. The CGCR was highly complimentary of the extraordinary effort that NASA, as well as numerous EOS investigators, has put into responding to the recommendations from their meeting last July. Of significant importance, however, is their conclusion that NASA should slow down the implementation of a federated approach for EOSDIS, paying careful attention to innumerable details of the implementation, selection, and governance of an EOSDIS federation of Earth System Information Partners. This is consistent with the Payload Panel recommendations (elsewhere in this issue) to convene a Bylaws Committee to meet, write, and dissolve, with no formal position guaranteed in the subsequent federation.

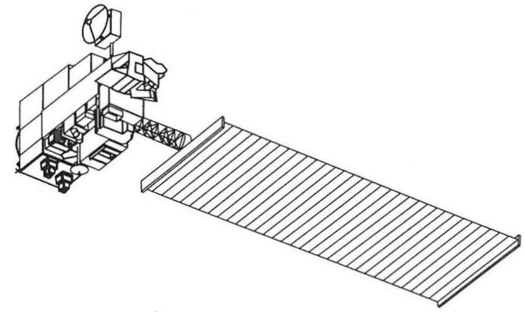
The Reshape Implementation Options Study, co-chaired by Sam Venneri (director of the Spacecraft Systems Division of NASA's Office of Space Access and Technology) and Charles Vanek (Associate Director of Flight Projects, Goddard Space Flight Center), was presented to NASA Administrator Dan Goldin on February 12 (available on World Wide Web at the Project Science Office homepage). Conclusions of this study can be summarized as follows: (i) the Reshape program approach to infusing new technology to save costs is sound, (ii) for AM-2 and beyond, an aggressive approach to inserting new technology can result in significantly reduced budgets, (iii) for PM-1 and Chemistry-1, it is unlikely that alternative approaches will achieve significantly reduced costs without incurring substantial program delays, (iv) the information system cost reductions were validated, and (v) investing the savings in technology insertion will provide dramatic payback.

Finally, an Investigators Working Group meeting is now scheduled for May 13-15 in Greenbelt, Maryland. As in the past couple of years, the primary focus of this meeting is to (i) learn of recent progress and exciting accomplishments obtained thus far by various EOS investigations, including seasonal and interannual climate-related events, global productivity and the carbon cycle, and chemistry-aerosol-climate processes, (ii) to discuss and finalize chapters of an EOS Science Implementation Plan that is being coordinated by the Science Executive Committee (SEC), and (iii) to discuss plans for calibration and validation of EOS instruments and data products. In addition, there will be a banquet to honor Dr. Charles F. Kennel who is leaving NASA, where he has served as Associate Administrator for Mission to Planet Earth for the last $2\frac{1}{2}$ years. On behalf of the Earth Science community, I would like to extend my best wishes for his continued success in future endeavors as Executive Vice Chancellor of UCLA.

— **Michael King**
EOS Senior Project Scientist

Report of the EOS Payload Panel Meeting

November 28-30 1995



— Mark R. Abbott (mark@oce.orst.edu), Chair of Payload Panel

Note: The individual reports of the three Working Groups that met during the Payload Panel meeting were the source of much of this report and were originally included as Appendices. Because of space limitations, the Appendices are not printed here, but they are available on the World Wide Web at the address shown on the back cover, or they may be obtained by writing to the EOS Project Science Office.

BACKGROUND

The EOS Payload Panel met in Annapolis, Maryland, to consider three basic issues:

- The Office of Mission to Planet Earth's (MTPE) plans for an integrated observing strategy including new sensor technology as well as convergence with operational observing systems;
- EOSDIS in light of the recent National Research Council (NRC) Board on Sustainable Development (BSD) recommendation to develop a system based on a "federation of partners selected through a competitive process;" and
- The EOS strategy for study of atmospheric chemistry in regards to the BSD recommendation to focus CHEM-1 tropospheric measurements on ozone and its precursors.

The Panel focused on the short-term need to respond to the BSD report on these three issues. It also began to develop a long-term strategy to address the specific points raised in the first two issues of an integrated observing strategy and an EOSDIS federation. In both areas, the Panel confronted the need to balance the scientific needs for continuity and stability and the equally important needs for innovation and flexibility. Maintaining this tension is in a sense a process of risk management. For example, frequent insertion of new sensor technology may jeopardize long-term continuity of climate data sets, while reliance on copies of single sensors does not allow for improvements in sensor technology or changes in scientific understanding. The challenge for the Payload Panel is to develop a process whereby these risks can be assessed and balanced against scientific return.

It is well-known that the Earth system is complex and varies on many time and space scales. For these reasons, the scope of the scientific issues is far beyond the capabilities of a single satellite sensor or a single scientist. Thus, the development of EOS involves complex interactions between science and engineering and between scientific disciplines.

The present direction of EOS and MTPE as a whole is towards a "federation" of both observing and information systems. That is, there is a broad range of satellite missions ranging from one-time experiments to long-term research measurements to operational systems. There is a similar variety in *in situ* observations as well. EOSDIS has similar variety in the responsibilities and activities of its many elements. However, in both federations, there is an underlying need to bring some coherence and harmony to the overall system. For example, an open-ended federation of EOSDIS may not support the timely acquisition, processing, and distribution of EOS data, while a centralized system may not allow the timely infusion of rapidly evolving computer technology. It is this need to reconcile stability and innovation with centralized and distributed management that will occupy much of the future deliberations of the Payload Panel.

In the past 30 years, NASA has

employed two models for addressing both the scientific and management needs of Earth science. The first model, used in the early developmental period of the space era and exemplified by the Nimbus program, was based on a strong entrepreneurial spirit in the science community. This period witnessed the rapid development of technology and observational systems to meet the needs of individual scientific disciplines. Less emphasis was given towards long-term data continuity, interdisciplinary research, or to providing widespread data access to the broader Earth science community. In some cases, complete, calibrated, processed data sets were not available until several years after the satellite sensor had ceased functioning. In recent years, a second model has arisen that can be called the "EOS" model. It exploits the capabilities developed in the Nimbus era, but emphasizes the collection of data sets that meet interdisciplinary needs over extended time periods. Management was driven strongly by large-scale, coordinated planning efforts, focusing on global-scale issues such as climate change. Each of these models sets a different "balance point" between innovation and stability. By evaluating a complex (and usually implicit) model of risks, costs, and scientific return, both approaches are used to help decide how to balance these two elements of Earth science.

Although both models clearly have strengths and weaknesses, it is important to recall that both developed under an economic and political environment that is different from the one facing science today and for the foreseeable future. Science resources are unlikely to be spared in the process of Federal budget deficit reduction, and there is much greater emphasis on accountability on how these funds are spent. In such an environment, our challenge is to develop a vision that can combine the strengths of the Nimbus and EOS models in an environment of cost constraints and public accountability.

Summary of Findings and Recommendations

EOS Integrated Observing Strategy

The science driving the Earth Observing System (EOS) requires 24 categories of consistent measurements extending over the life of the program and, in many cases, beyond. Meeting this demand will be extraordinarily challenging in an environment characterized by simultaneous changes in funding levels, launch options, and technological capabilities. The problem may be described as that of finding the appropriate balance between consistency and innovation within a cost-constrained environment.

<u>Reshape Implementation Options Study</u>

A study was initiated by NASA Headquarters to review both the observing and information systems strategy for EOS, beginning with the PM-1 and CHEM-1 platforms. Because of the rapid pace of this study (approximately 60 days), there has been limited opportunity for those outside of NASA to be involved. Nevertheless, *it is essential that the scientific community provide input to this study and review its results. In particular, options to disperse the PM-1 and CHEM-1 payloads over many smaller spacecraft will have serious negative impacts and will damage the scientific return from these missions.*

This review will also provide a technical roadmap that will help insert emerging technologies, such as those developed in the New Millennium Program (NMP), into future EOS missions. *As we discuss in more depth below, this process must have strong and effective science input to ensure that the critical scientific objectives of EOS are enhanced by emerging technologies and not jeopardized.*

<u>New Millennium Program</u>

The stated goals of the NMP are to identify new capabilities, emerging in key technical areas, that can significantly enhance the ability to achieve Mission To Planet Earth (MTPE) objectives.

It is clear that the NMP offers important opportunities to enhance the vitality of the whole range of MTPE missions through science-driven technological innovation and significant cost savings. The present NMP program has developed three broad objectives to advance the goals of MTPE. However, the success of NMP rests on the details of its implementation, and the Payload Panel can provide valuable scientific input in the development of these detailed plans. *MTPE and the Payload Panel should establish a Technology Task Force with the primary responsibility for providing suggestions and promoting new NMP concepts based on science goals.* The task force should:

(1) have early briefings on the justifications associated with the current list of NMP candidates in order to better understand the balance between science, potential cost savings, and technological innovation that drives the current program;

(2) help provide a focal point, within the broader EOS community, for discussing the technological innovations required to address our most pressing science needs; and

(3) make suggestions and define priorities based on science needs for consideration by NMP.

Earth System Science Pathfinder (ESSP)

The Earth System Science Pathfinder (ESSP) has been conceived as a means to expand the types of observations that can be made to support the broad science objectives of MTPE. Because both NMP and ESSP have emerged in the same time frame, emphasizing new aspects of the MTPE program, there is an initial tendency for them to be confused. However, ESSP is focused primarily on the demonstration of the capabilities of new observing techniques to provide important data to augment the 24 EOS Measurements. There will be a continuing need to clearly define and differentiate between them as much as possible, and establish clear criteria.

We recommend that NASA, with input from the broad scientific community, outline the MTPE science priorities and map existing and planned programs against these priorities. This will lead to the identification of scientific objectives that can benefit from future ESSP (and NMP) missions.

We recommend that MTPE adopt a two-stage proposal process that would involve a short, initial proposal. Successful proposers would be asked to submit complete proposals to the second stage. Teaming with industrial partners could be part of this complete proposal.

We endorse the suggestion that proposals be selected on the basis of the most science that is demonstrably feasible and relevant to MTPE in light of the total cost of the proposal.

We recommend that the Principal Investigator be responsible for at least part of the science resulting from the experiment and not be viewed simply as a data provider. A guest investigator program should be used where appropriate to open the data reduction and interpretation to the larger community.

The National Polar-orbiting Operational Environmental Satellite System (NPOESS)

The National Polar-orbiting Operational Environmental Satellite System (NPOESS) will address operational requirements in the areas of imaging, sounding, climate, ozone monitoring, and space environment measurements. NPOESS could potentially meet some of the EOS science requirements in these areas.

The Payload Panel endorses MTPE's basic approach of working to coordinate measurements required for long-term Earth observation from the EOS research platforms with those provided by the operational platforms of the NPOESS series. This will require careful planning to ensure that the operational requirements of NPOESS and the research needs of the EOS community are simultaneously met. The latter include, for example, the requirements for accurate calibration, data validation, and consistent data processing over long periods and ready access to archived data sets.
The Payload Panel recommends that an NPOESS Task Force be established, with the charge to:

(1) review NPOESS performance requirements in view of EOS remote sensing expertise; and

(2) explore NASA/NPOESS synergism in the PM-2 timeframe.

Early Development of Flight Instruments

Many of the activities related to new sensor concepts and test deployments used to be the purview of the Research and Analysis (R&A) program at NASA. Given the declining R&A budget and competition for funds, this activity has declined in recent years. However, with new programs such as NMP and ESSP, it is possible to re-establish these links between sensor technology and science applications.

We recommend that MTPE develop mechanisms to ensure a balance between scientific research and the development of new observing techniques, and to support the connections between the R&A program and these new technology efforts. This would further facilitate the use of balloon and aircraft platforms to test scientific and instrument concepts before they are *committed to space flight. Not only would this strengthen the R&A activity as well as provide scientific oversight into the technology development effort, it would also strengthen the link between R&A and EOS activities.*

The overall effort should be viewed as a process to move new science and new sensor capabilities from development, to test flights, to research missions such as EOS, and eventually into operational programs such as NPOESS.

EOSDIS Costs, Standard Data Products, and Federation

Cost Models

Information on EOSDIS costs has increased dramatically in recent months. Explanations of the EOSDIS budget by the Earth Science Data and Information System (ESDIS) project at NASA Goddard have significantly improved over earlier attempts, and should serve short-term needs. Further refinements by the EOS Project Science Office will aid in communicating links between cost and functionality. The Independent Cost Evaluation (ICE) project being run by MTPE will also provide additional information about the cost of EOSDIS relative to other efforts that maintain and distribute large amounts of data. The ICE results will provide corroborating data for the community cost model being developed under the direction of Bruce Barkstrom. The Barkstrom model appears solidly based, and is critical for a real evaluation of cost and functionality information needed as a management tool to aid in decision making. However, it is essential that the Barkstrom model be rigorously validated, especially in regards to nonlinear effects. *We recommend that these efforts continue in parallel. In particular, the Barkstrom model will be a critical resource to evaluate changing costs of EOSDIS as both the technology and user base evolve.*

EOS Standard Data Products

A standard data product has the following attributes:

- its algorithm is well-documented and it has been subjected to strict peer review through the Algorithm Theoretical Basis Document (ATBD) process;
- the computer code associated with the algorithm is developed along strict guidelines especially in terms of documentation;
- a well-developed plan is established for product validation and quality assurance; and
- the code is under change control, and any changes in algorithms or code, along with validation and quality assurance, are managed in an open, accessible manner.

We developed three categories for standard data products:

(1) Standard products that have a long heritage in terms of their algorithms and are presently used in climate models as either diagnostic variables or as input variables. Other products that have wide acceptance in the Earth science community also fall into this category. These "Category One" standard products will be produced routinely at launch. After the initial post-launch phase, it is expected that these products and their associated algorithms and coding will change only infrequently.

(2) Standard products that have a shorter heritage than Category One products. They are designed to take advantage of new sensor capabilities, and they will eventually move into Category One as experience with them grows and their algorithms mature. It is the best judgment of the community that these Category Two products represent the next-generation Category One products. Many of these products may not be produced routinely at launch and their implementation will change frequently.

(3) Products that are expected to be widely used by the Earth science community, such as monthly averages, etc. They represent higher order data sets that are derived from the standard data products. These products often are much smaller in volume than the Category One products and are frequently available on-line.

Another way to look at this process is from the standpoint of risk. That is, how much risk are we willing to tolerate in the data product (both in terms of the quality of the product and the stability of the processes used in its creation)? The decision will be based in part on how this risk is eventually translated into higher quality products. Our decisions will need to balance stability (and lower risk) with evolution (and higher risk).

The movement of products between categories (as well as the addition of new standard data products) should be overseen by the Data Product Configuration Control Board (CCB). This Board will regularly assess the maturity of each data product based on the ATBD review process and the evolving needs of the Earth science community. The Board will also assess validation and QA plans and will evaluate usage patterns of each product. When products are added or moved, the Board will evaluate potential impacts on other products as well as resource implications. However, the Board will not develop detailed implementation plans but instead will let these evolve as a result of interactions between the data producer and the responsible EOSDIS partner (DAAC, or perhaps federation member).

The Data Product CCB should be composed of representatives of the EOS program and project offices, EOSDIS, the EOS science community, and the general Earth science community. It must ensure that there are effective interactions between scientists responsible for data production and scientists interested primarily in using the data products. This Board will also oversee associated changes in the Execution Phase Project Plan.

<u>*Federation*</u>

The goals to be achieved by federating are:

(1) to increase the base of technological, scientific, and management expertise that contributes to EOSDIS. This should increase the community participation and thus ownership of the data system;

(2) to increase the versatility and flexibility of EOSDIS to incorporate and take advantage of new information systems technology and to address new science problems; and

(3) to distribute the funds to a broader community with the intent of achieving savings through the use of financially-efficient organizations that can provide data services with low overhead. If the federation is successful, it should also provide an infrastructure to which federation members are motivated to bring their own resources.

Federation and recompetition are not equivalent. Recompetition is a mechanism of transformation. We recommend that the federation be defined now, and that some elements of the federation begin immediately with the goal of achieving complete federation within five years. Competition for the elements of the federation should take place in stages so as not to disrupt the essential activities to meet the requirements of the early missions, viz., TRMM, AM-1, SAGE III, and ACRIM.

Separating federation from an immediate recompetition introduces the danger that no real changes in the management and governance of EOSDIS will occur. While a reasoned, progressive approach is desirable for the transformation, the transformation must be rapid enough and radical enough that it ensures that changes will occur.

One of the most important aspects of achieving a successful federation is diligent, strong, and flexible leadership. The vision of the federation at the five-year horizon must be held solidly by the leadership. MTPE must nurture and facilitate the move towards the vision. Without diligence, the inertia of the system to maintain itself will win. There are three elements necessary for this leadership:

- *A governing body made up of representatives who are members of the federation.* The ultimate goal should be to have the Governing Board determined by the constituency of the federation. Initial constituency of the Governing Board should be drawn from the Payload Panel, the EOSDIS Data Panel, instrument team data producers, ECS, ESDIS, DAACs, Universities, outside agencies, supercomputer centers, information scientists, potential value-added providers, the extended user community, and MTPE.

- *The MTPE Enterprise must be committed to the federation process, and be willing and able to change funding paths to assure that resources flow to the organizations responsible for getting the job done.* MTPE will have to recognize the Governing Board of the federation, and help the Governing Board achieve the goals of the federation.

- *An integrator (or system orchestrator) should be an explicit component of the leadership of the federated system.* The integrator should have well-defined functions to collect and disseminate information on the overall performance and directions of the federation to MTPE and the federation Governing Board. The integrator will propose minimal standards and tools that will facilitate the integration of the federation elements. The integrator must provide support to MTPE and the federation Governing Board as they develop a vision for the long-term directions of the federation.

Overall leadership of the federation rests with MTPE and the Governing Board, with the integrating organization providing critical support. The integrator should be obtained from outside the government and the federation. By having strong links to the corporate and technological community, the integrator will help MTPE with the infusion of successful, appropriate ideas that arise from the commercial and research communities. This partnership between MTPE, the Governing Board, and the integrator will help ensure flexibility and responsiveness in the federation while maintaining a consistency of purpose and direction.

We recommend that a Bylaws Committee be formed, and bylaws that transcend the individuals of the federation must be written. These must allow the functioning of the federation with a flux of individuals through the system. The Bylaws Committee should meet, write, and dissolve, with no guaranteed formal position in the subsequent federation.

We have a complex problem with a variety of solutions made up of ingredients that are changing rapidly. A true federation allows investigation of solution paths that are appropriately focused on specific problems. It better assures that there will be successful components. It reduces the risk of single-point failure. It assures that paradigms will have been tested that can help accommodate and correct less-successful components in a cost-effective way. It allows organizations that have already developed recognized expertise to become members of the federation, reducing the overhead in the system. Federation is risk mitigation.

Atmospheric Chemistry

The Payload Panel concurs with the recent workshop on "Tropospheric Chemistry Measurement and Modeling Strategy" held at the Goddard Institute for Space Studies. In particular,

- only the Tropospheric Emission Spectrometer (TES) on the EOS CHEM-1 platform will provide globally the required vertical profiles of key tropospheric species;
- NO and HNO_3, precursors of ozone, must be measured if anthropogenic and natural impacts are to be separated, as required when formulating policy options; and
- there is a natural synergy between TES and the stratospheric instruments on CHEM-1.

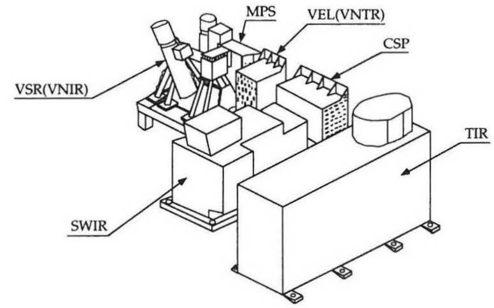
Continued scrutiny of the CHEM-1 payload, including TES, has identified several cost reductions that have significantly reduced the weight, power, and data rate requirements of these sensors. In particular:

- TES is now at the minimum capability required to collect vertical profiles of tropospheric ozone and its precursors;
- the list of standard data products is now restricted to key tropospheric measurements of O_3, NO, HNO_3, and CO;
- an aircraft version of TES is being used along with data from other aircraft, balloon, and Shuttle-borne sensors to evaluate the expected precision and accuracy of the more difficult tropospheric species, especially NO_x;
- only the CHEM-1 payload has the synergy and full complement of instruments needed to meet stratospheric science requirements while providing (with TES) the first global mapping of tropospheric ozone and its precursors; and
- further cuts in measurement capability or splitting of the CHEM-1 payload will result in the loss of key science.

The Panel considered tropospheric aerosol measurements as well. *While the passive sensors on AM-1, PM-1, and AM-2, along with ancillary platforms, e.g., SAGE-III, will provide global distributions of tropospheric aerosols, full characterization of the radiative and chemical effects will require both active and passive sensors in coordinated observations.* Based on these observations and the understanding gained, we may begin to define the sampling requirements for tropospheric aerosol missions beyond the first set of EOS platforms.

We recommend that NASA convene a series of workshops that will include new technology efforts, e.g., NMP and ESSP, the broader science community, and international partners. These workshops should begin soon to start to lay the basis for future programs. ■

The 10th Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Science Team Meeting



— Y. Yamaguchi (yasushi@gsj.go.jp), Geological Survey of Japan

The 10th ASTER Science Team meeting was held November 14-17, 1995, at the World Import Mart in Ikebukuro, Tokyo, Japan. There were approximately 90 participants representing the ASTER Science Team, JPL ASTER Science Project, EROS Data Center (EDC), Earth Remote Sensing Data Analysis Center (ERSDAC), Japan Resources Observation Systems Organization (JAROS), the ASTER Ground Data System (GDS) developers, the instrument vendors, and the Japanese algorithm development contractors. The four-day meeting was composed of two plenary sessions and several individual Working Group meetings.

H. Tsu (ERSDAC), ASTER Science Team Leader, welcomed the participants and opened the Plenary Session. D. Nichols (JPL) updated the current EOS Project status on behalf of S. Lambros (GSFC), who could not come to the meeting due to the U.S. government shutdown. M. Pniel (JPL) reported on recompetition of the DAACs. A. Kahle (JPL), U.S. ASTER Science Team Leader, and D. Nichols reviewed the recent U.S. ASTER Team's activities. T. Kawakami (ERSDAC) overviewed the current status of the whole ASTER Science Team activities and future tasks. There are many things already completed so far, e.g., refinement of standard data product algorithms and completion of the Functional Requirements for Mission Operation. However, the ASTER Science Team still needs to continue work on various issues such as calibration/validation planning and review of data product specifications. Y. Yamaguchi (Geological Survey of Japan [GSJ]) presented the ASTER data product update. He proposed a new category, a semi-standard data product that is a sort of a sub-category of the EOS specialized data products and will include two Japanese data products; (1) radiance registered at sensor with ortho-image correction; and (2) relative digital elevation model (DEM).

H. Watanabe (ERSDAC) updated the status of the ASTER GDS development, and was followed by presentations from the GDS developers. The ASTER Science Team submitted requirements for the GDS at the time of the previous Science Team meeting in May 1995, and GDS Preliminary Design Review (PDR) meetings in June/July, 1995. The GDS developers are currently designing the GDS targeting the Critical Design Review (CDR) to be held in January/February 1996. The presentations covered the current design status such as the GDS user interface, data product algorithm implementation, and scheduler development.

M. Kudoh (JAROS) presented updates on the ASTER instrument development status. ASTER subsystems are now in the final fabrication phase of the flight models. ASTER Engineering Model (EM) integration and test had been successfully completed by September 1995. Detailed results of the EM system tests were presented by the ASTER System contractor, NEC.

F. Sakuma (National Research Laboratory of Metrology [NRLM]) reported the status of the EOS AM-1 preflight cross-calibration experiment. Measurements of the ASTER VNIR integrating sphere were performed in February 1995 jointly by the National Institute of Standards and Technology (NIST), GSFC, University of Arizona, and NRLM. They are currently preparing to publish the results at SPIE'96 in Denver.

H. Fujisada (Electrotechnical Laboratory [ETL]) reviewed the ASTER Level-1 processing algorithm and software development status. The beta version algorithm was completed at the end of March 1995, and the version 1 algorithm will be delivered to ASTER GDS by the end of December 1995.

S. Rokugawa (Tokyo University) reported the current status of the ASTER Airborne Simulator (AAS) and future campaign plans. He asked the science team members to submit flight requests and ground measurement requirements. The AAS is now scheduled to fly over a few test sites in the western U.S. in May or June 1996. S. Hook (JPL) presented recommendations from the EOS Land Surface Imaging Airborne Sensor Working Group to examine aircraft scanner needs for land imaging to support the ASTER and MODIS instruments. The recommendation also includes a proposal to build a new MODIS/ ASTER Simulator (MASTER).

Issues to be addressed in the meeting were pointed out by the responsible Team members. Y. Yamaguchi (GSJ) and K. Okada (Japan Petroleum Exploration Co. [JAPEX] Geoscience Institute [JGI]) requested the discipline working groups to compile priority maps for ASTER global data set acquisition by December 1995. The integrated global prioritization map will be presented to the Science Team for approval at the next Science Team meeting in 1996. Y. Yamaguchi proposed organizing an *ad hoc* working group in order to develop the ASTER scheduler algorithms for data acquisition prioritization. H. Fujisada (ETL) laid out issues of Level-1b processing prioritization and the definition of the Level-3 data products. A. Morrison (JPL) requested each working group to finalize the ASTER test site list and to complete the site descriptions for the validation data base. P. Slater (University of Arizona) distributed a questionnaire regarding joint field campaigns planned in 1996. G. Geller (JPL) said that it is necessary to develop the first draft of specific quality assessment (QA) information for product headers.

The discussions of the splinter sessions on the second to fourth days were summarized by each working group chairperson at the second plenary session in the afternoon of the fourth day.

K. Arai (Saga University), Radiometric Calibration Working Group, briefly reviewed the ASTER pre- and in-flight calibration plans. He introduced a field campaign plan for 1996 and encouraged the team members to participate in it.

S. Rokugawa (Tokyo University), Temperature-Emissivity (T-E) Separation Working Group, said that further discussions were needed to identify the relations of atmospheric correction, T-E separation, and scene classification algorithms.

Y. Yamaguchi (GSJ), Geology Working Group, summarized the status of the global prioritization maps to be provided from this working group. There were presentations on the Mt. Fitton test site by Tom Cudahy (Commonwealth Scientific and Industrial Research Organization [CSIRO]), on research plans on natural coal fires in Xinjiang, China, by M. Urai (GSJ), and on global glacier monitoring by B. Raup (U.S. Geological Survey).

H. Fujisada (ETL) summarized the discussions at the Level 1 Processing Working Group and Geometric Correction Working Group. The current Level-1 processing algorithm was explained in detail at the splinter meeting.

The major topics discussed at the Geometric Correction Working Group were a proposal for a geocoded ortho-image as a Level-3 data product, and a Ground Control Point (GCP) and orbit model application to enhance geolocation performance. It was decided to investigate the various levels and types of the inter-telescope registration quality so that this information will be included in the product header.

Y. Yamaguchi (GSJ) reviewed the discussions at the Operation and Mission Planning Working Group. The Japanese and U.S. ASTER Science Projects agreed to work together to support the ASTER Operation Team (AOT) in developing the prototype scheduler algorithm and prioritization function. The other issues to be resolved include utilization of a World Reference System (WRS), revision of the baseline uplink timeline, a cloud prediction utilization approach, and a scenario for user selection of expedited data set processing.

F. Palluconi (JPL) and T. Takashima (National Space Development Agency of Japan [NASDA]) Atmospheric Correction Working Group updated the status of the atmospheric correction algorithms. The adjacency effect is being viewed as a post-launch improvement. An alternative TIR algorithm using ASTER data only is being developed by M. Moriyama (Nagasaki University). Delivery to the EROS Data

Center DAAC for the beta version of the U.S. atmospheric correction algorithm will occur early in 1996.

Y. Yasuoka (National Institute for Environmental Studies [NIES]) summarized the status of the global prioritization maps to be supplied from the Ecosystem and Landsurface Climatology Working Group. There were also many presentations to introduce the activities by the working group members, e.g., an intercomparison study on models of sensible heat flux, research plans on coral reef mapping, soil mapping, vegetation indices, ground truth data base, and scaling with ASTER and MODIS.

M. Kishino (The Institute of Physical and Chemical Research), Oceanography, Limnology, Lake and Sea Ice Working Group, presented an example of the global prioritization maps. The validation test sites for the specialized data products such as water surface temperature, polar sea ice, turbidity, and aquatic plants were agreed to at the splinter meeting.

Y. Miyazaki (GSJ), DEM Working Group, reviewed the DEM generation flow. It is necessary to insure compatibility of the DEM products to be generated at the Japanese ASTER GDS and the U.S. DAAC, and to create a first draft of QA data for DEM products. The global prioritization map for DEM generation was agreed to after coordination among the U.S. and Japanese working group members. This prioritization map includes the areas which have been inadequately mapped at a scale of 1:50,000 or larger with relief greater than 200 m, and the East Asia region. DEM test sites were also listed with the individual DEM investigators who are responsible for providing the test site attributes.

Y. Ninomiya (GSJ), Spectral Library Committee, said that there is still a need to survey existing spectral data bases such as Brown University's spectral library. This group will continue efforts to make the measured spectra available to the public and to clarify architecture and attributes of the spectral library.

S. Rokugawa (Tokyo University), Airborne Sensor Working Group, said that band addition and modification for the MASTER (MODIS/ ASTER Simulator) were proposed and approved at the splinter meeting. The ASTER Airborne Simulator (AAS) will join the joint cross-calibration field campaign scheduled in May/June 1996.

A. Kahle (JPL) summarized the discussions of the Higher Level Data Product Working Group. The status of the standard product algorithms and software were briefly reviewed in order to identify issues to be resolved. The Science Team will have to input the specific header, metadata, and browse data contents to the ASTER GDS soon. Steps to reach compilation of QA parameters were defined at the splinter meeting. Validation plans for the ASTER algorithms are to be contained in the ATBDs and will be peer reviewed in the near future.

H. Tsu (ERSDAC) adjourned this very fruitful meeting and thanked all the participants. The next ASTER Science Team meeting will be held in Pasadena, California, during the week of June 10, 1996. ■

Kudos

At the annual meeting of the American Meteorological Society, the following MTPE/ EOS colleagues were given awards:

Roy W. Spencer and John R. Christy — A Special Award "for developing a global, precise record of the Earth's temperature from operational polar-orbiting satellites, fundamentally advancing our ability to monitor climate."

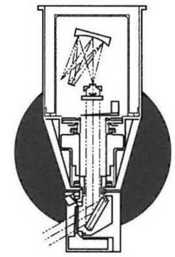
Dennis L. Hartmann — The Editor's Award "for wise judgment and comments that invariably improved the quality of published papers for the *Journal of Climate.*"

The following were elected Fellows 1996:

Mark R. Schoeberl
Anne M. Thompson

We wish to congratulate these colleagues for their outstanding contributions to the science world and the EOS community.

Stratospheric Aerosol and Gas Experiment (SAGE) III Science Team Meeting



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

On January 18, 1996 a Science Team meeting for the Stratospheric Aerosol and Gas Experiment (SAGE) III was conducted at the Langley Research Center (LaRC).

M. Patrick McCormick, SAGE III Principal Investigator, kicked off the Science Team meeting with highlights of the Earth Observing System (EOS) Program, showing that several of the SAGE III data products (namely, aerosols, ozone, and clouds) are considered highly critical data sets within the EOS program and the overall EOS flight schedule. Currently, four flights of SAGE III are shown on the flight schedule. Efforts are being made to participate in flights of the French SPOT mission and a Canadian mission (SciSAT).

Lemuel E. Mauldin, SAGE III Project Manager, presented an overview of the instrument and discussed the status of the charge coupled device (CCD) testing and the verification unit.

The Science Team members or their representatives gave an overview of their accomplishments and future work, as summarized below.

Albert A. Chernikov's activities were described by Yuri A. Borisov, Central Aerological Observatory (CAO) in Russia. CAO could provide data validation based on ground, balloons, and rocket measurements in Russia, as well as, develop the methodology for comparing these measurements with the SAGE III data.

William P. Chu, LaRC, is the lead scientist for the algorithms, software, simulation, calibration, and verification teams. His activities involve developing the algorithms and software requirements, and consulting on test setups for the CCD and other instrument hardware. In addition, he is writing the transmission algorithm theoretical basis document (ATBD).

Derek M. Cunnold, School of Earth and Atmospheric Science at Georgia Institute of Technology, has been responsible for the development of the ozone ATBD. He presented results of SAGE I and II trend studies and evidence for the residual coupling of aerosol and ozone in the 600 nm channel. It has been concluded that a multichannel approach would minimize the coupling between aerosol and ozone spectral signatures.

John De Luisi, NOAA/ERL in Boulder, presented improvements in the understanding of the Umkehr effect and the uncertainties of the retrieved ozone profiles, including the uncertainties of stratospheric aerosol corrections. The SAGE data fit prominently into this work because the expected results will lead to increased credibility of the long-term ozone profile trends determined from Umkehr observations dating back to 1958.

For the creation of a long-term climatology of stratospheric aerosol properties, De Luisi will use SAGE data, dustsonde data, ground-based lidar data, and sunphotometer data. The new Umkehr algorithm improved the agreement of ozone retrievals in layers 3, 2, and 1. De Luisi noted a particular concern with layer 3 and to some extent with layer 4, because it appears that the retrieved Umkehr concentrations do not agree well with expected values as determined by SAGE II and satellites.

Philip A. Durkee, Naval Postgraduate School (NPS), was not able to attend but provided a brief summary of his activities. These include AVHRR aerosol analysis and validation studies using measurements from various field experiments. New observations with a remotely piloted aircraft are being planned.

Nikolai A. Elansky, Russian Academy of Sciences, would like to set up, develop, and coordinate a ground-based network in Russia for the correlation/validation of the SAGE III ozone, nitrogen dioxide, and aerosol measurements over Russia. He named four planned sites.

Benjamin M. Herman, University of Arizona, Tucson, has been supporting the development of the SAGE III algorithms that are presented in each of the SAGE III ATBD documents (transmission, solar occultation, and lunar occultation). Future work will refine the aerosol and pressure/ temperature inversions, and quantify the coupling between measurements and update the algorithm sections in each ATBD.

Peter V. Hobbs, University of Washington, did not attend but provided a brief summary of his activities relevant to SAGE. Among various activities cited were a collaboration with NASA scientists on direct aerosol closure experiments in the Arctic, which showed the contributions from tropospheric and stratospheric aerosols. Also as part of SCAR-B he obtained an extensive data set on aerosols from biomass burning in Brazil.

Hobbs' future work plans revolve primarily around the TARFOX field project, which will take place next summer. The goal of TARFOX is to carry out a direct aerosol closure experiment on the U.S. East Coast in order to quantify direct aerosol radiative forcing in a strongly polluted environment. TARFOX will provide an excellent field trial for the types of campaigns that will be needed to validate and utilize SAGE III data.

Geoffrey Kent, Science and Technology Corporation, has primarily been developing the cloud presence algorithm theoretical basis. He presented several areas of improvement and development for future work. Just two of these are called out here: (1) study use of wavelengths between 0.525 µm and 1.02 µm since these have a potential application at altitudes below 6 km; (2) study use of lunar data (above 15 km) for potential application to the detection of polar stratospheric clouds (PSCs).

Jacqueline Lenoble, Université des Sciences et Technologies de Lille, described aerosol observations by balloon-borne instruments. The observations were made in France and in Sweden: (1) RADIBAL (RADIomètre BALlon, in French) is a near-infrared polarimeter with two channels at 850 and 1650 nm, which observes the radiance and the polarization diagrams during the balloon ascent or descent. Comparison flights following the Mt. Pinatubo eruption in June 1991, June 1992, May 1993, and October 1994 show a strong increase of the particle effective radius after the eruption (from 0.20 to 0.48 mm at 20 km) followed by a slow decrease (respectively 0.34 mm in 1993 and 0.31 mm in 1994); this fully confirms the values derived from SAGE II aerosol spectral extinction. (2) BALLAD (BALloon Limb Aerosol Detection) observes the Earth's limb from the float altitude at three wavelengths 850, 600, and 450 nm, before sunset, including its polarization at 850 nm. BOCCAD (Balloon OCCultation for Aerosol Detection) operates after BALLAD is turned off and follows the sun during its occultation through the Earth's atmosphere. The two instruments are complementary and should provide the ozone profile and aerosol extinction profiles at 450 and 850 nm, as well as information about the aerosol particles from their phase function and their polarization.

Volker A. Mohnen's activities were described by Jianjun Lu, SUNY in Albany, NY. Working with SAGE II extinction measurements from 1985 to 1990, they have separated extinction due to aerosols from that due to clouds and separated the time-frame into volcano-perturbed (1985) and volcano-free (1988-1990) periods. Among their findings were these: (1) aerosols in volcano-free years showed seasonal variation with spring maximum and latitudinal asymmetry with larger extinction in the northern hemisphere than in the corresponding southern hemisphere. Volcanic influence increased the seasonal variation and latitudinal asymmetry. (2) tropopause folding events showed seasonal difference with late winter-early spring maximum and latitudinal asymmetry with more foldings in the northern mid-latitudes.

V. Ramaswamy, NOAA/GFDL, presented a general circulation model (GCM) study which has been carried out to investigate the role of the 1979-1990 observed ozone depletion on the thermal structure of the lower stratosphere. The simulated temperature response in the global lower stratosphere is generally one of cooling. The ozone-induced cooling of the lower stratosphere over the past decade is substantially larger than the effects due to the increases in the well-mixed greenhouse gases. Thus there appears to be a strong influence of the ozone depletion on the lower stratospheric climate — one that has occurred over a relatively short time period (~decade).

David Rind, NASA/GISS in New York, discussed several different projects underway for 1996. Among his major activities and findings have been: (1) a review of the SAGE III relative humidity product. The major question which needs to be addressed is whether relative humidity should be calculated with respect to water or to ice at temperatures between 0° and -40°C. (2) A comparison of SAGE II data with ISCCP deep convective clouds indicates that with greater convection, i.e., during sunset, there is reduced water vapor in the stratosphere. There is a question as to whether this is a physical effect, extending well above the tropopause, or a retrieval problem due to light scattered from below.

Philip B. Russell, NASA Ames Research Center, has been responsible for the development of the aerosol ATBD. He presented recent work on the AMES radiometer with specific attention to the correspondence between SAGE III and radiometer channels and the upcoming TARFOX experiment.

Vinod Saxena, North Carolina State University, has been responsible for deriving the aerosol microphysical characteristics between 13-30 km and averaged columnar characteristics in a unit column between 15-25 km poleward of 50 degrees South (near Antarctica) during the austral springs of 1990 (background profile), 1991, 1992, and 1993, and summers of 1991 (background profile), 1992, 1993, and 1994.

Eric P. Shettle, Naval Research Laboratory in Washington, D. C., has been responsible for the spectroscopic assessments for gaseous constituent retrievals in the visible and ultraviolet spectral regions. He concluded that a list of priority spectroscopic research (O_2, OClO, and NO_3) should be forwarded to the EOS Investigators Working Group (IWG) for concurrence and funding.

Gabor Vali, University of Wyoming, Laramie, presented data from the new 94 GHz airborne radar (on the University of Wyoming KingAir aircraft) that was used to correlate reflectivity from ice crystal clouds with optical extinction coefficient. The method promises to provide another possibility for validation of the SAGE data. On its own, the 94 GHz airborne radar has proven to be a powerful tool for cirrus studies; with the radar and with the coincident *in-situ* observations of crystal sizes and shapes, cloud structure and microphysical composition can be simultaneously examined on scales from a few meters up.

Steven C. Wofsy, Harvard University, has been responsible for the development of the OClO ATBD. He was not present for the Science Team meeting but provided a summary of his on-going studies. His group has noted that a significant abundance of OClO has only been observed during the polar winter and at night in the polar spring. The studies suggest that OClO concentrations will only become large enough to play a significant role in ozone destruction if temperatures become low enough to initiate heterogeneous catalytic cycles on polar stratospheric clouds (PSCs) and cold sulfate aerosols. In contrast, the NO_3 abundance is expected to decrease substantially after such heterogeneous processing.

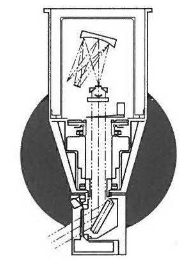
The contribution of bromine to polar ozone depletion is also to be studied.

Joseph M. Zawodny, LaRC, has been responsible for the development of lunar occultation measurement algorithms for the SAGE III experiment. The proposed method uses a multiple linear regression technique to assess vertical profiles of O_3, NO_3, NO_3, and OClO from broadband lunar occultation measurements (380-680 nm at 1-2 nm resolution). SAGE II took part in a blind O_3 intercomparison at Mauna Loa in mid-1995. The results were extremely favorable for SAGE II.

The next Science Team meeting is scheduled be held at LaRC May 8 - 10, 1996. The ATBDs should be ready for concurrence by the Science Team at that time. ■

Stratospheric Aerosol and Gas Experiment III (SAGE III) Algorithm Review

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



On January 17 and 18, 1996 an algorithm review for the Stratospheric Aerosol and Gas Experiment (SAGE) III was conducted at the Langley Research Center (LaRC). M. Patrick McCormick, SAGE III Principal Investigator (PI) from LaRC, chaired the review.

Recently, two Russian scientists were nominated to join the SAGE III Science Team, namely: Nikolai P. Elansky, Russian Academy of Sciences, and Albert A. Chernikov, Central Aerological Observatory. The Russian delegation at the meeting included Elansky, Yuri A. Borisov, and Oleg Postyliakov.

The SAGE III Science Manager stated that the primary objectives of this review were to: (1) obtain the Science Team's concurrence on the algorithms and to ensure agreement on the approach taken in the Algorithm Theoretical Basis Documents (ATBD); and (2) decide on any alternative channel approaches.

The secondary objectives of this meeting were to discuss critical spectroscopy and to provide information on data products, telemetry, mission operations, software development, data processing, configuration management, etc.

William P. Chu (LaRC) gave an overview of the development plan for the ATBDs. The ATBD schedule was presented and the formal ATBD review in November 1996 was emphasized. Two versions of the software have to be delivered: the engineering version by early 1997 and the flight version by early 1998. Ultimately, the software for the algorithms is to be delivered to the Distributed Active Archive Center (DAAC) for processing the SAGE III data.

Four of the nine ATBDs (aerosol, cloud, ozone, and OClO) have been made available to the Science Team for internal review. The other five will be made available for internal review by the end of March.

There are essentially four different types of algorithms: SAGE II-type, simultaneous (water vapor), global and simultaneous (oxygen), and differential retrievals (mostly lunar). The general steps in the solar and lunar retrievals were described.

The SAGE III Standard Data Products Table taken from the NASA EOS Execution Phase Project Plan was presented. This table is scheduled to be baselined within the next few months. Several comments were made that clarification was needed for some of the columns and could be provided as notes at the bottom of the table. Derek M. Cunnold (Georgia Tech) said that the temperatures (2 K at 70 km) on the table seemed to be too optimistic. Joseph M. Zawodny (LaRC) responded that the accuracy on the table is not representative of all altitudes but are the "best" that we can do in particular altitude ranges.

Benjamin M. Herman (University of Arizona) presented an overview of the prototype algorithm and described the forward problem for a solar occultation experiment.

Chu followed with a description of the solar occultation measurement geometry, contributions to extinction, typical sunrise science data output, and concluded with the refraction calculation. The refraction calculation will use the same procedure as that used with SAM II, SAGE I, and SAGE II, which is based on analytical solutions to the refraction integral for any given temperature profile. Two important areas that need attention are decoupling of gases during the retrievals and how accurately the species can be separated.

Zawodny discussed both the radiometric and positional calibration techniques. He stated that any changes in wavelength in the spectrometer could only be induced by temperature changes in the grating and the charge coupled device (CCD) detector. The current plan is to perform a readout across the sun at an altitude of 150-180 km and perform a wavelength fit to the exoatmospheric solar spectrum. Cunnold asked if we could determine the degradation of the filter function well enough to do NO_2 trends and Zawodny replied that there was no reason to think that there will be degradation since the bandpass is determined by the CCD geometry. Zawodny stated that there will be no way to monitor the 1.55 micrometer channel wavelength in flight. Chu added that the 1.55 micrometer channel is broadband and slight shifts should not be too disruptive. Zawodny stated that the users of this channel must account for possible degradation of this channel, and Chu added that we will have ground-based instruments to monitor for degradation.

The scan mirror scans the sun field-of-view (FOV) in a zigzag fashion. Spectral calibration of the relative reflectivity is maintained over a range of angles by looking at the Sun from 300 down to 100 km. A small slope is both apparent and expected in the measurements at very high resolution (1-2 counts out of 4000).

Next, Zawodny explained how we determine where the instrument is looking. The global positioning system (GPS) will tell us where the instrument is; and we know the position of the Sun and Earth. Refraction can be accounted for with the National Meteorological Center (NMC) data initially. Also, the scan mirror scans at a constant rate. Given these, the tangent altitude and position of the FOV on the Sun will be calculated. Spacecraft attitude, rate, and acceleration can also be determined.

Zawodny stated that if the scan hits a cloud, the scan waits (0.1-0.2 seconds) then, if the Sun does not reappear in the FOV, the scan mirror reverses direction. Other discussions on the spacecraft maneuvers during data taking, degradation of the sunseeker over time, vertical resolutions, etc., were also held.

Mark C. Abrams (Science Applications International Corporation [SAIC]) presented a comparison of the SAGE II/SAGE III retrievals. He presented a flow diagram for each of the SAGE III solar occultation measurements and the lunar occultation measurements. David H. Rind (Goddard Institute for Space Studies [GISS]) pointed out that we should indicate that the NMC data are being used as a "first guess" for the temperature in the SAGE III algorithm and then the actual SAGE III temperature measurements will be used. Steven C. Wofsy (Harvard University) pointed out that we should make sure that we are doing things correctly before we drop the SAGE II-type inversion, which used NMC data throughout.

Abrams discussed the approach planned for the aerosol and ozone retrievals. He emphasized the importance of maintaining continuity with the SAGE record and stated that minimal changes between the SAGE II and SAGE III algorithms will be made.

Er-Woon Chiou (SAIC) presented the water vapor retrieval by describing the forward problem, calculation of the slant path transmittance, removal of the interfering species, inversion of water vapor, and simulation studies. Rind pointed to the SAGE III Standard Data Products Table again. It shows water vapor down to 3 km. He said that we should be able to measure to the ground (0 km). The Science Team agreed that this table needed to be updated to accurately reflect what we plan to deliver. The emissivity growth approximation (EGA) method will be used to calculate the slant path transmittance.

Michael C. Pitts (SAIC) presented the need and algorithm approach for retrieving temperature and pressure profiles. These measurements allow SAGE III constituent retrievals to be independent of external data products; allow for the presentation of data on pressure surfaces and in mixing ratios; and provide a self-calibrated, accurate temperature data set for trend studies. The retrievals utilize the oxygen A-band located in the visible region centered near 760 nm. The spectra will be measured from 740 to 780 nm with 2-nm resolution. The retrieval process utilized will reduce the solar radiance measurements into atmospheric transmittance profiles at each wavelength, calculate the slant path transmittance using the EGA method, remove the Rayleigh scattering, separate several species (aerosol, ozone, etc.), and invert the temperature and pressure. The temperature and pressure inversion approach using the Carlotti global fitting was described and simulated retrievals were shown.

Zawodny presented the lunar

occultation retrieval approaches for the O_3, NO_2, NO_3, and OClO species. He explained a typical lunar occultation event and showed transmission versus wavelength profiles for O_3, O_2, NO_2 and H_2O with continuum at a tangent altitude of 20.0 km. Retrieval error estimates based on expected instrument performance were also shown.

Geoffrey S. Kent (Science and Technology Corporation) provided a status report of the cloud ATBD and discussed the cloud algorithm and data product. The cloud science objective is to identify the presence of cloud in each event at all altitudes between 6 and 30 km. The theoretical basis for the cloud algorithm is different from the other data products because clouds are extracted from the aerosol extinction data. The algorithm proposed uses aerosol extinction data at 0.525, 1.02, and 1.55 μm and relies on the wavelength variation in extinction to distinguish aerosol from cloud. Two methods which were used to separate the aerosol and cloud in the SAGE II data set were explained, and then the proposed method of separating aerosol and cloud in the SAGE III data set was explained. The proposed SAGE III algorithm performance was better than the SAGE II two-wavelength method but is questionable at times of strong volcanic activity.

Zawodny presented an alternative channel selection for the CCD, which would move channels into the Chappuis bands for ozone (differential ozone channels). Comparison charts of the current versus proposed plan were shown for the science telemetry volume and CCD utilization. Obie Bradley (LaRC) will use Zawodny's proposal to conduct a feasibility study. Phil B. Russell (NASA Ames Research Center) showed similar channel selections for his airborne system. Wofsy stated that differential measurements were what we should be doing if feasible. At this time, Wofsy added, there is a fair amount of OClO present during the twilight and that 3 additional channels for OClO might be worthwhile as well. It was decided that Wofsy's OClO computations would be used by Zawodny to do a feasibility study of a solar OClO measurement.

Eric Shettle reported on the quality of the laboratory spectroscopy for the SAGE III measurements. There is disagreement in the evaluation of Ritter and Wilkerson data for oxygen (760 nm) and the differences in ozone data will show up as "structure" in differential measurements. It was agreed that a consensus is needed for SAGE III spectroscopy measurement priorities. This priority list will be presented at the next EOS Investigators Working Group (IWG) meeting.

The consensus of the Science Team was to incorporate Zawodny's alternative channel plan (differential ozone and relocated aerosol channels, etc.) into the ATBDs. The solar retrieval of OClO, using three additional channels will be added into the ATBD as a "Research Product" and Zawodny will make an assessment of its feasibility.

For species which vary rapidly during sunrise or sunset, the slant-path column amounts will be a "Research Product" and should include neutral density, path length, and refraction correction angle.

Scott R. Quier (SAIC) gave an overview of the software development requirements placed on SAGE III as an EOS instrument. The software development process will consist of a series of builds. This approach has the advantage of limited risk and readily available executable code. There will be no beta release for the software.

Abrams presented the potential ancillary products such as potential temperature and geometric altitude versus geopotential height. There were discussions about derived products being archived versus giving the equations to the users. Also, some data like the NMC data is already available at the DAAC so there would be no need to store it with the SAGE III data set as well.

Mike S. Cisewski (GATS, Inc.) gave an overview of the mission, data formats, and the CCD data. For the SAGE III/Meteor-3M mission, the command station is located at the Russian Space Agency Mission Control Center. The command link is from LaRC to Moscow and the data link is from Wallops Flight Facility to LaRC. There are five basic data formats: low rate engineering, solar science, solar line calibration, lunar science, and ancillary data. During the mission, each day's science data are transmitted to both Russian and U.S. data stations twice every 24 hours. On the U.S. side, the data are transmitted to the Wallops Flight Facility, temporarily archived, data quality checked, and sent to LaRC. Cisewski also discussed the CCD data formats, channel selection, and spare channel availability. He assured the scientists that his goal was to get the maximum amount of science data down. The Mission

Operation Center (LaRC) will perform Level-0 processing and send this data to the LaRC DAAC and the Science Computing Facility.

Michael W. Rowland (SAIC) presented an overview of the approach and methods planned for SAGE III Level-1 and Level-2 processing.

Patricia L. Erickson (SAIC) presented an overview of the data management test flow and the configuration management flow.

Anne C. Edwards (SAIC) has a preliminary Home Page underway. Plans are to have the ATBDs available on the Home Page so interested parties can download the documents at their home sites whenever the newest version hits the street. ■

Availability of Questionnaire Analysis and EOSDIS Cost Model Documentation

— Bruce R. Barkstrom (brb@ceres.larc.nasa.gov), Langley Research Center

As many of you know, we at Langley Research Center (LaRC) gave a questionnaire to members of the EOS Data Panel last fall and followed that up with a modified version for the EOS Payload Panel. During the intervening months, I have been working on the analysis of that information and have had considerable help from the LaRC DAAC in putting that questionnaire on-line. We are pleased to announce that both the analysis and the questionnaire are now on-line. We are also making the documentation for the EOSDIS Community Cost Model (CCM) available through this mechanism as well.

The community survey results are at http://asd-www.larc.nasa.gov/cost_model/survey.html

The material available here includes a "postscript" file with the report analyzing the survey responses for both groups, an ASCII text file of the Data Panel questionnaire, and the responses from these two questionnaires (in tab-delimited ASCII that can be readily imported into most spreadsheets). We have also included the numerical results of the analysis (again in tab-delimited ASCII) and the Ada code used in this work. While the responses, the results, and the code may not be needed by everyone, they are included for those interested.

The documentation for the EOSDIS Community Cost Model is available at http://asd-www.larc.nasa.gov/cost_model/cost_model.html in the form of "postscript" files. At present, we are working our way through a number of scenarios for planning on production, as well as some more formal material providing an overview of how the cost model computations will be performed. In the next month or two, we will be supplying the documentation for the object model structure of the model itself. All of the documentation is being done with TeX, and will perhaps be migrated to other forms of output. However, the current author does not have time to rearrange the output from TeX to any form of file except "postscript."

If you are coming in through the World Wide Web, the address is: http://asd-www.larc.nasa.gov/ASDhomepage.html following which you may go down to special services and click on EOSDIS Cost Model to get to the survey and the documentation. The on-line version of the questionnaire is located at the LaRC DAAC whose www address is: http://eosdis.larc.nasa.gov/

To ease submission of answers, the on-line survey is broken into a number of single-page entries that can be answered one at a time. It would make life easier if you could do them all at once, but we will try to work with the answers even if they come in separately.

Kate Costulis has helped me with getting the cost modeling documentation on line within our division. Anne Racel at the LaRC DAAC has done the work on the survey. Their help is gratefully acknowledged. ■

Quality Assessment For MISR Level 2 Data

— Ralph Kahn (kahn@jord.jpl.nasa.gov), Kathleen Crean, David Diner, Earl Hansen, John Martonchik, Stuart McMuldroch, Susan Paradise, Robert Vargo, Robert West, Jet Propulsion Laboratory

Having good data quality assessment (QA) is essential if the MISR data are to be scientifically meaningful to our users. Recognizing this, the EOS Project has asked each instrument team to create a detailed plan for reporting the quality of its data. We are currently participating in the effort to figure out how effective QA plans can be developed and implemented at a reasonable cost. In a previous article, we described the method we are using to identify QA indicators (Kahn *et al.*, "How Will We Choose Which Quality Flags and Constraints to Report for MISR Level 2 Data?," *The Earth Observer* **7**, p.32-33, May/June 1995). We present here an overview of how QA for MISR Level 2 data can be accomplished.

Following recommended EOS QA procedures (Internal EOS Communication, Bob Lutz, Hughes STX, 1996), we anticipate the need for parts of the MISR QA activity to occur: (1) in the Product Generation System (PGS) Software, (2) with the Distributed Active Archive Center (DAAC) operator, and (3) at the JPL-based Science Computing Facility (SCF).

We plan to automate the routine QA processing. Human involvement will be limited to: (1) spot checking of the data stream, and (2) investigating "anomalies." This puts most of the QA burden on the PGS Software, which will create "indicators" of key aspects of the data quality and algorithm performance. These indicators will be stored with other outputs from the Level 2 data stream. Here is a top-level diagram of this activity:

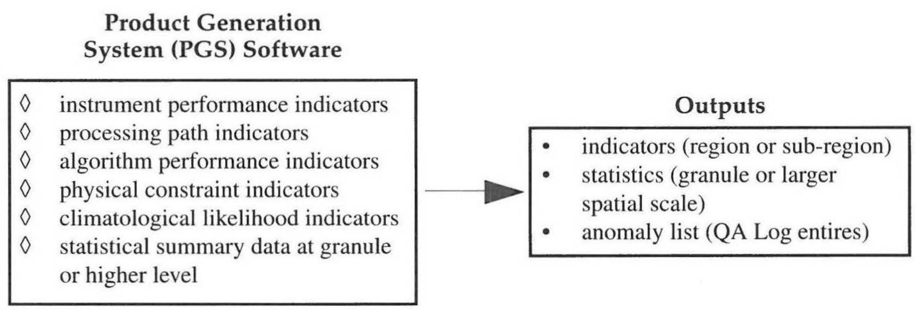


Figure 1. Automatic QA Within the Product Generation Software

A general description of these indicators is given in the Appendix. The MISR Level 2 QA Parameter Table lists all the indicators and their allowed values. Some examples of the entries in the QA Parameter Table are shown in Table 1. We assume that external inputs to the PGS Software, such as atmospheric surface pressure and wind speed from a data assimilation model, will be delivered with their own quality indicators, generated under the guidance of the cognizant science teams. The PGS contains tables of climatological values for all the external parameters needed by the MISR algorithms; these will be used as default values if the external input data are unavailable, or are flagged as being of low quality. Such cases will be reported in a processing path indicator.

We are planning to keep all QA Log information from the entire Level 2 data stream in a format which is easily searchable using at least: (1) the date of the entry, (2) the processing step in the data stream which produced the entry, (3) the physical location on the Earth, and (4) the error or warning code associated with the entry. This will make it easy to compare entries from different parts of the PGS Software when investigating anomalies.

Some of the indicators will be designated as "alarms." These will be used for near-real-time QA of the MISR data stream. QA operations at the DAAC will involve monitoring alarms, and possibly examining displays of data created by the real-time data stream. The operator will respond by recording anomalies in the QA Log, and contacting the SCF about the anomaly in a timely manner, for further action. The algorithm is being designed so that the DAAC operator, with the concurrence of the SCF, can switch off certain alarms to avoid excessive output. This may be particularly useful at the beginning of the MISR mission, before thresholds in the algorithm have been optimized and other characteristics of the data stream have been studied under routine operating conditions.

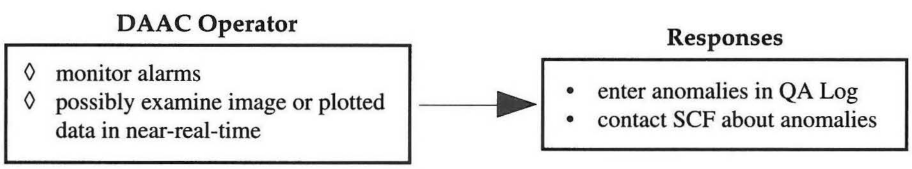


Figure 2. QA Operations at the DAAC

At the SCF, QA amounts to performing those tasks that require the attention of the MISR Instrument Team, and completing any processing steps that can not be automated at the DAAC. We anticipate the following QA activities at the SCF:

◊ Examining summaries of QA data produced routinely by the PGS.

◊ Performing in-depth analysis of algorithm and software results on samples taken from the MISR Level 2 data products.

◊ Performing any special investigations indicated by routine examination of QA data, by anomalies reported at the DAAC, or by data users at the SCF or elsewhere.

◊ Evaluating instrument and algorithm results using data from the MISR field validation program.

◊ Documenting SCF QA activities in the QA Log.

◊ Producing those routine statistical summaries that require the accumulation of time series of QA data, which might not be feasible to stage at the DAAC.

Among the issues that remain to be worked out for the pre-launch MISR Level 2 QA effort are: refining the QA Parameter Table, designing the DAAC interface and Level 2 QA Log, and establishing procedures for investigating anomalies and for field validation analysis at the SCF.

Of course, the final assessment of our QA plan itself must wait until bits begin to flow through the data stream. But we welcome further discussion of all aspects of this subject with our EOS colleagues.

Appendix. General Description of MISR Level 2 QA Indicator Types

1. **Instrument Performance** — Instrument performance indicators that affect spectral, radiometric, and geometric performance are monitored for engineering purposes, and to effect updates to the instrument calibration parameters. The Level 1 data stream will produce summaries of instrument performance in three areas: (1) radiometric quality, (2) geometric quality, and (3) missing data. These metrics will be compared with sets of limits, and the relevant performance implications will be encoded into data quality indicators.

2. **Processing Path Indicators** — Decisions made along the data processing stream, such as which retrieval path to follow, are retained as part of the processing record. For example, choices will be made as to whether an ocean, a Dense Dark Vegetated surface, or a heterogeneous land aerosol retrieval is attempted, whether near-real-time inputs or climatology are used for column ozone abundance, and whether cloud phase is set by observations or by model inputs.

3. **Physical Constraints** — There are many physical constraints that can be applied to the retrieved results, some of which may be used as indicators of data quality. Some examples are: the requirement of non-negative radiances, albedo within the range of zero to one, and an upper bound on the total aerosol optical depth based on the darkest pixel in the scene.

4. **Algorithmic Constraints** — Since keeping track of the assumptions and numerical behavior of the algorithm is part of the algorithm development effort, these constraints are relatively easy for us to identify. They include such items as: (1) convergence characteristics of numerical methods (residuals and number of iterations); (2) the limits of intrinsic assumptions made in the parameterizations used, such as

an ocean surface roughness model that is meaningful only within a certain range of wind speeds; and (3) case limitations, such as treating pixels that may cross radically different terrain types, e.g., coasts, if the algorithm is designed to assume an "average" terrain type, and rejecting pixels that are too cloudy or with terrain too rough for the algorithm to work.

5. **Climatological Constraints** — These are "statistical" constraints, which may be interpreted as warnings, but do not necessarily represent errors. An "unlikely" result may mean a misinterpretation of the data, or a discovery. Indicators based upon such constraints will be very helpful for the first-order analysis of the MISR Level 2 results. For example, the MISR Aerosol "Climlikely" Product, which is the retrieval algorithm's predicted aerosol climatology, may indicate that it is more likely to find biomass burning particles than mineral dust particles over a tropical rain forest. We are hoping to develop climatologies for as many of the MISR-retrieved physical parameters as possible (surface albedo and view-dependent reflectances, cloud cover, etc.), so comparisons with expectation for these quantities can also be made routinely. ■

Table 1: Examples of Entries in the MISR Level 2 Retrieval QA Parameter Table

Indicator	Possible Values of Indicator, or Units of Numerical Values	Spatial Resolution	Applies To:	DAAC Alarm Criterion
Region classification flag	Topographically complex Cloudy (according to MISR Cloud altitude binned cloud fraction) No acceptable subregions Acceptable	Region	--	none
Column ozone abundance and uncertainty	Dobsons	Region	--	none
Ozone data source	Current Assimilation Model data Climatology data	Region	--	none
Algorithm type flag	Dark water Dense, dark vegetated surface Heterogeneous surface No retrieval performed	Region	--	none
Optical depth upper bound	Dimensionless	Region	Each aerosol mixture	none
Residuals between observations and models	Dimensionless	Region	Each aerosol mixture	none
Number of regions observed in swath	0 - 27264	Swath	--	none
Number of regions processed using dark water algorithm	0 - 27264	Swath	Regions regardless of retrieval result	none
Number of regions not processed due to regional topographic complexity	0 - 27264	Swath	--	If this number divided by the total number of regions observed in swath > 0.50, then set alarm.

ANNOUNCEMENT

The National Research Council's Space Studies Board report titled "Earth Observations from Space: History, Promise, and Reality," as prepared by the Board's Committee on Earth Studies (CES) under the direction of John McElroy, Dean of Engineering at the University of Texas, Arlington, is now available. Copies may be ordered free of charge from Carmela Chamberlain, Space Studies Board, HA584, National Research Council, 2101 Constitution Avenue, Washington, DC 20418, or via e-mail at cchamber@nas.edu.

Organization and Implementation of Calibration in the EOS Project — Part 1

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Introductrion

The Earth Observing System (EOS) is an international multi-satellite program in global remote sensing of the Earth. The goal of the EOS mission is to advance the scientific understanding of the Earth as a system, i.e., land, oceans, atmosphere, and the influences of natural and anthropogenic processes on this system through the development of a deeper understanding of the components and their interactions within the system. In order to achieve this goal, EOS must produce accurate, precise, and consistent long-time series of radiometric measurement data from multiple instruments and multiple platforms. Understanding and correctly interpreting these data require the ability to determine what portion of the observed signal represents changes in the spectral-flux responsivity of the satellite sensor during the mission. The simultaneous goals of acquiring accurate data over many years and correctly identifying systematic effects depend crucially on: (1) calibrating all instruments against a set of recognized physical standards, (2) carefully characterizing the instruments' performances at the system level, (3) adhering to good measurement practices and established protocols, (4) intercomparing instrument measurements where possible, and (5) establishing traceability for all instruments to the common scale of physical quantities maintained at the national standards laboratories.

This two-part article outlines the overall organization and implementation of calibrations in the EOS project based on requirements that were established in 1989. Part 1 describes the organizational structure of the EOS Calibration Program and its position in the EOS Project Science Office's Panel for Data Quality. Part 1 also describes the implementation of the program with respect to planning, documentation, and peer reviews. Part 2, to be published in a future issue of *The Earth Observer*, describes the program's pre-flight and on-orbit calibration efforts and outlines their implementation through the National Institute of Standards and Technology (NIST)-supported measurement assurance programs, the United States Geological Survey (USGS)/Northern Arizona University (NAU) lunar radiometric measurement program, and other methods that will be used to ensure the accuracy of the Level 1B data. Where appropriate, examples of ongoing calibration programs relevant to the EOS AM-1 instruments are provided.

EOS Calibration Requirements

The requirements for instrument calibration and Level 1B data, i.e., radiance data, validation were outlined early in the EOS project (EOS Level 1A Requirements Document 1989), and the calibration approach summarized in these articles is based on those requirements. The NASA/NIST calibration activities for the Sea-Viewing Wide Field-of-View Sensor (SeaWiFS) (see Johnson *et al.* 1996 a, b and references therein) and the multi-agency, ultraviolet intercomparison experiments (Thompson *et al.* 1996) have been used as baseline programs for evaluating and meeting the original EOS requirements and in formulating a key portion of the EOS Calibration Program. The NASA/NIST interagency collaboration in EOS calibration is described in part 2 of this article.

Organization of EOS Calibration Program

Figure 1 shows the organization of the EOS Calibration Program. The head of the EOS Project Science Office (EOS/PSO), the EOS Senior Project Scientist, established the position of EOS Calibration Scientist early in the program. In 1994 the EOS Panel for Data Quality (EOS/PDQ) was formed, and formal agreements between the EOS Project Science Office and NIST and the USGS were executed (King 1994). The EOS Calibration Scientist, a member of the EOS Panel for Data Quality, provides technical support and reports directly to the Chairman of this Panel and to the EOS Senior

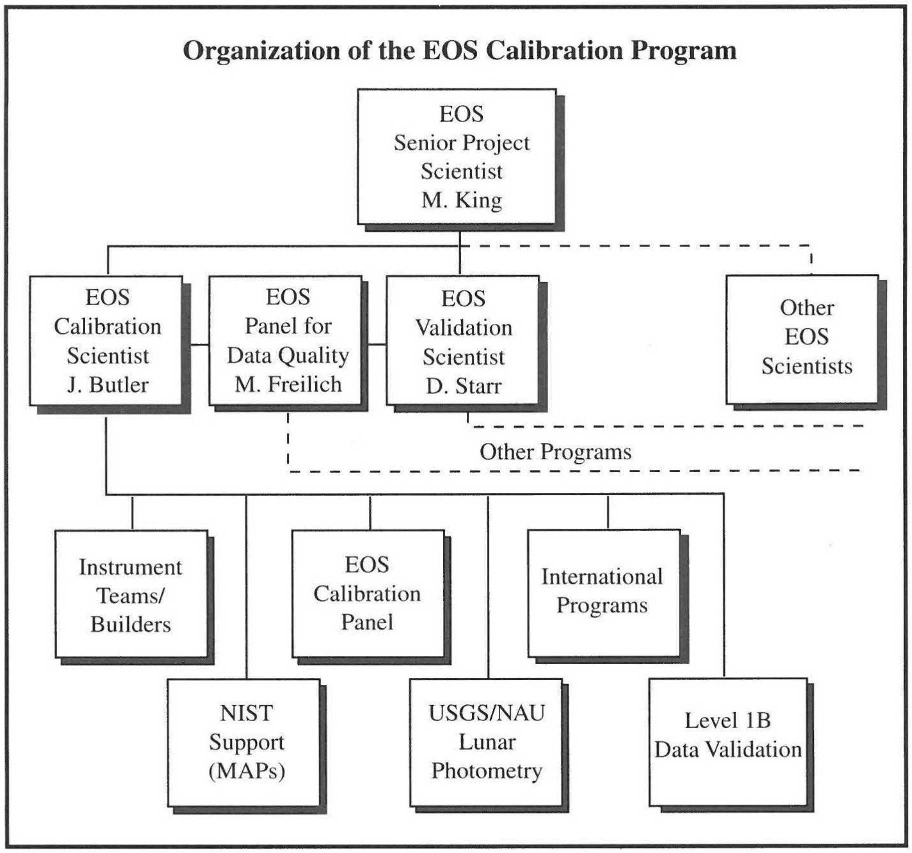

Figure 1.

Project Scientist. The EOS Calibration Scientist is responsible for the following:

◊ communication between the EOS Instrument Calibration, Level 1B Data Validation, and Platform Scientists, i.e., the instrument teams, and instrument manufacturers, and the EOS Project Science Office on all matters relating to instrument radiometric calibration and characterization;

◊ documentation of the results achieved in the EOS Calibration Program;

◊ implementation and supervision of the technical component of interagency agreements and contracts between the EOS Project Science Office and supporting programs at other institutions, currently consisting of NIST, i.e., the technical monitor for metrology support in the EOS project, and NAU and USGS, i.e., the institutions conducting the lunar radiometric measurement program;

◊ representation of the NASA efforts in radiometric calibration for Earth science to other related domestic and international programs; and

◊ organization of the EOS Calibration Panel (EOS/CP), consisting of experts in metrology and space-based radiometry, to serve as expert reviewers.

Also in 1994, the position of EOS Validation Scientist was established. As seen in Figure 1, the EOS Validation Scientist reports to the Chairman of the EOS Panel for Data Quality and to the EOS Senior Project Scientist and is responsible for the promotion of coordinated field experiments, algorithm development, review of data analysis procedures, and communication of validation issues between EOS and other related programs (King 1995).

Each EOS Instrument Team and/or Instrument Manufacturer has identified individuals to represent calibration, validation, and platform issues, so that responsibilities and lines of communication are clearly established and key calibration issues can be addressed by the appropriate calibration personnel. The EOS Instrument Calibration Scientists, representing the Instrument Teams, are the specific points of contact for the EOS Calibration Scientist, the EOS Panel for Data Quality, and ultimately the EOS Project Science Office on matters concerning instrument calibration and instrument Level 1 data validation.

Technical support for the EOS Calibration Scientist is provided by the EOS Calibration Panel. Membership is decided by the EOS Calibration Scientist, but in general individuals or institutions are included because of their expertise, experience, and position in the EOS Calibration Program. The areas of interest of the EOS/CP include preflight and on-orbit instrument calibration and characterization, and all ancillary activities associated with estimating the accuracy of the results of the EOS-sponsored measurements. These latter activities are part of the general measurement assurance programs (MAPs) for EOS, described in part 2 of this article.

Implementation of the EOS Calibration Program

Implementation of the EOS Calibration Program occurs through a combination of detailed analyses, scientific reviews, measurement assurance programs, calibration meetings, Level 1B data validation field programs, and completion of necessary ancillary data bases such as the lunar radiometric data base. Close cooperation between the calibration and validation aspects of the program is essential, especially in matters concerning on-orbit validation of instrument Level 1B data.

The implementation of the EOS Calibration Program is accomplished through a number of important, parallel calibration tasks. These tasks are shown in Figure 2 and include the following:

◊ planning, documenting, and reviewing progress and results in the EOS Calibration Program at EOS Calibration Panel meetings;

◊ gathering calibration facility, field instrument, and test site information for the Committee on Earth Observation Satellites (CEOS) calibration/validation database, i.e., Cal/Val Dossier, for use in planning future Level 1B data validation activities;

◊ formulating peer review panels for reviewing Instrument Calibration Plans and Calibration Algorithm Theoretical Basis Documents (ATBDs), which are written by the EOS Instrument Investigation Teams;

◊ reviewing all aspects of an instrument's calibration plan at those Calibration Peer and ATBD Reviews;

◊ coordinating the hands-on participation by EOS cal/val scientists in a number of NIST-sponsored measurement exercises/comparisons, training, and workshops, and artifact round-robin measurement activities;

◊ developing at NIST EOS-specific radiometric artifacts, e.g., radiometers, sources, or standard reference materials, that will be used to assess the radiometric accuracy of the ground support equipment used in calibrating EOS spaceborne or *in situ* sensors;

◊ supporting the USGS/Northern Arizona University (NAU) lunar radiometric measurement program; and

◊ promoting and participating in EOS organized joint validation field programs.

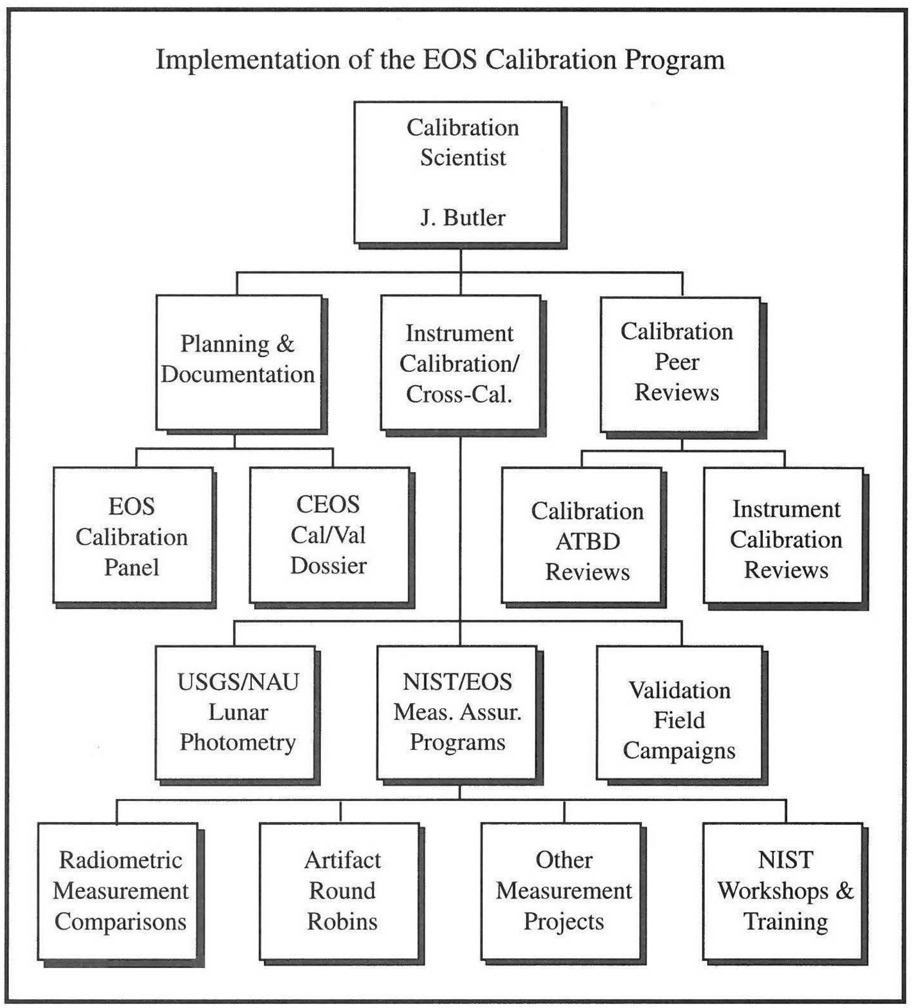

Figure 2.

The remainder of this article will examine the first four items. The last four items are described in part 2 of this article.

Planning and Documentation

EOS Calibration Panel

The EOS/CP provides technical support to the EOS Calibration Scientist and to the EOS Project Science Office in the areas of pre-flight and on-orbit calibration, instrument cross-calibration, Level 1B data validation, and long-term Level 1B data stability. Specific tasks of this panel include:

◊ advising and reviewing EOS calibration programs and documentation;

◊ identifying the calibration requirements of EOS instruments;

◊ participating in pre-flight and on-orbit measurement-intensive Level 1B data validation activities;

◊ critiquing and reviewing the plans of the EOS Calibration Scientist and the EOS Panel for Data Quality with respect to the science objectives of the EOS Project.

The EOS/CP is scheduled to meet once a year, with the next meeting planned for early 1996. Meetings will be coordinated and chaired by the EOS Calibration Scientist. Meeting results will be reported as articles to *The Earth Observer* and distributed as formal minutes. Current members of the EOS/CP include the EOS Calibration Scientist, Instrument Calibration Representatives, Instrument Principal Investigators, Level 1B data Validation Instrument Investigators, representatives from instrument manufacturers and NIST, and invited members from the remote sensing calibration community.

CEOS Cal/Val Dossier

Critical information necessary for planning is being electronically gathered in the form of a cal/val database for the CEOS. This effort continues and expands the previous effort of the CEOS Working Group on Calibration and Validation (WGCV) (CEOS Pilot Cal/Val Dossier 1993). Questionnaires on calibration laboratories; remote sensing field sites; and field instruments have been developed by a CEOS Dossier Development Team made up of the Deputy EOS Senior Project Scientist, the EOS Calibration Scientist and the EOS Validation Scientist. These questionnaires have been electronically distributed to key personnel performing calibration and validation in support of remote sensing programs. When completed, this on-line database will be available for use by the CEOS members, the EOS scientists, and the broader international Earth science community. The home page address to access the questionnaires is: http://spso.gsfc.nasa.gov/calval /calval_hpage.html.

Peer Reviews

The critical review of the calibration of EOS instruments is met using two complementary procedures. The first involves carefully evaluating the instrument calibration plans, and the second involves evaluating the theoretical algorithms used to convert instruments' raw digital output, i.e., Level 0 data, to calibrated, geolocated radiance data, i.e. Level 1B data.

Instrument Calibration Reviews

According to the EOS Background Information Package (BIP) Announcement of Opportunity No. OSSA-1-88 Part One: Guideline for Proposal Preparation (1988), a calibration plan is required from each EOS Instrument Investigation Team at the time of instrument proposal. This plan is updated and submitted by each team at the approximate time of the instrument engineering preliminary design review (PDR). At the time of the instrument engineering Critical Design Review (CDR), a final, mature version of the Instrument Calibration Plan is required. The Instrument Calibration Plan describes the approaches that the Instrument Investigation Team will use to produce the Level 1B data (geolocated and calibrated spectral radiances or band-averaged radiances). These approaches include a description of the test program used to calibrate and characterize the instrument before launch and the program(s) used to monitor the calibration and characterization of the instrument after launch. The instrument calibration plan must include an uncertainty budget that describes the performance of the instrument at the time of delivery, and the anticipated performance on orbit. The plan describes how calibration traceability in SI units (Taylor 1995) is established and maintained. In all cases, the method of traceability to the instrument's corresponding national standards laboratory is explained. It is the responsibility of the EOS Instrument

Team Leader to deliver the Instrument Calibration Plans to the EOS Project Science Office.

The Instrument Calibration Plans generated at the time of the engineering PDR and the CDR are reviewed by a peer panel of calibration scientists and engineers, consisting of representatives of other instrument calibration teams, the EOS/CP, scientists from the team of the instrument under review, and representatives from NIST. Of the five individual instruments on EOS AM-1, MODIS, CERES, MISR, and ASTER have been reviewed (see, for example Bruegge [1995]). The final AM-1 calibration peer review, for MOPITT, is to be held in early 1996, and calibration peer reviews are currently being scheduled for the EOS PM-1 and EOS Chem instruments.

Calibration ATBD Reviews

In January 1994 the EOS Project Science Office requested that instrument teams produce a document describing in detail the algorithms used in the production of their data. This ATBD document describes the measurement equations and algorithms used in the transformation of raw Level 0 data to geolocated Level 1B radiances (or from Level 1B to Level 2 data) for a particular instrument. Calibration ATBDs are reviewed by a panel assembled by the EOS Project Science Office with the EOS Calibration Scientist acting in a support capacity. The review team evaluates the calibration ATBD in the areas of pre-flight and on-orbit calibration, general measurement approach, traceability of the measurements to SI units, extent and reliability of the sensor characterization measurements, estimation of uncertainties, plans for revising the radiometric calibration coefficients, maintenance of radiometric scales (for the field instruments as well as subsequent flight sensors), and methods used to communicate with other instrument teams (required for cross-calibration, validation, and all other calibration activities).

Summary

Achieving the goals of the EOS mission, namely to advance the scientific understanding of the Earth as a system and to distinguish between and determine the natural and anthropogenic influences on that system, depends on the production of accurate, precise, and consistent long-time series of measurements from multiple instruments on multiple platforms. The EOS Program Office and Project Science Office recognize the paramount importance of calibration in achieving those goals. Therefore, a state-of-the-art program in EOS calibration is being conducted under the auspices of the EOS Panel for Data Quality and is being headed by the EOS Calibration Scientist. Implementation of the program is multifaceted and involves planning and documentation, peer reviews, measurement comparison programs, measurement assurance programs, training, and workshops.

Part 1 of this article has examined the organizational structure of the EOS Calibration Program and the implementation of that program from the standpoint of planning and documentation and peer reviews. Part 2 of this article, to be published in a future issue of *The Earth Observer*, will examine the measurement comparison activities, measurement assurance programs, Level 1B data validation field programs, and calibration workshops.

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The Cooperative University-based Earth System Science Education Program (ESSE)

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Since 1991 the Universities Space Research Association (USRA) has led the Cooperative University-based Earth System Science Education Program (ESSE) under NASA sponsorship to develop programs and curricula in Earth Systems and Global Change Science at the undergraduate level. At that time twenty-two universities were selected to develop and offer courses at the survey and senior levels to provide a scientifically based appreciation of topical issues in global change, and to engage advanced students and faculty from different disciplines in addressing Earth Science and Global Change issues. Over 4000 students and 100 faculty and staff were involved in the program during the 1993/94 academic year. Response from a survey of the original participants indicates that the program has been successful in establishing an Earth System Science Education support group and forum for the discussion of courses, curricula, and learning modules.

As the program evolved, the need became apparent for a shared repository of educational resources for the Earth sciences which would be beneficial to all participants, as well as to the broader Earth science community. In 1994 the program established a server on the Internet with a World Wide Web Home Page (http://www.usra.edu/esse/ESSE.html) designed to foster the collaborative development of educational materials and to assist the organization of relevant source material already available on the Web. The content and organization of the server are being updated continuously with input from the program participants and others interested in studying and teaching about the Earth as a system.

In August of 1995 an additional twenty-two colleges and universities were selected to continue the program through the end of the decade, building upon the success of, and suggestions from, the original program participants. In addition to the continued maintenance of the server content, the program is exploring ways to further increase its impact upon undergraduate Earth System Science Education. A prototype *Journal of Earth System Science Education* is being established with the goal of providing peer review, publication, and recognition for the authors of quality learning modules. The ESSE program is also preparing to team with other Earth Science Education initiatives such as Project ALERT (Augmented Learning Environment for Renewable Teaching), which aims to reach students training to be teachers, and possibly the education component of the Inter-American Institute for Global Change Research, which aims to address the need for advanced study of regionally significant environmental issues in the Americas. ■

Mission To Planet Earth Education

— Nahid Khazenie (khazenie@gsfc.nasa.gov), Goddard Space Flight Center, and
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NASA's Office of Mission to Planet Earth supports NASA's strategy for communicating science to the public, and specifically, as stated in the Mission to Planet Earth Strategic Plan, seeks to "...foster the development of an informed and environmentally aware public." Science communication must be embedded in everything NASA does, as an essential component of the agency mission. Broader participation by key groups in communicating science, most notably the scientific community, is essential. Coordination between scientists and the formal education community fosters the inclusion of ever greater content richness in the education system.

The long-range objectives for MTPE's science education programs adhere to a complement of overriding principles, which recognize education, in a broad sense, as one of the ultimate products of the program. The goal is to implement a sustainable Earth system science education program that is consistent with externally imposed education standards. Attention to equity and diversity must be a component in all MTPE education activities, and leveraging the expertise of external organizations is critical to meeting the demand for educational and informational tools and activities in a constrained budget environment. Within this context, contributions by MTPE to the advancement of formal education are a major aspect of how the success of the program will be measured.

MTPE has taken several steps to foster coordination between the scientific and educational communities. A strategy for the MTPE education program was developed jointly by MTPE science program and NASA education representatives; thus, the implementation plan encompasses both communities. One key recommendation from the agency's Science Communication Steering Committee focuses on broadening the scientific community's participation in the communication of NASA's results. As a result, MTPE will, whenever feasible, incorporate a call for communication proposals into all research solicitation announcements in the form of either supplemental grants or selection criteria. Partnerships are encouraged in the announcements between the science principal investigators and communication experts to deliver accurate, relevant information.

Another mechanism for fostering coordination is a newly established peer review process in MTPE for evaluating education-related, unsolicited proposals. Each proposal is now peer reviewed by science and education experts and then considered against the MTPE strategy for education before final disposition. Therefore, all approved grants demonstrate strategic scientific as well as educational merit in their plans.

Objectives: MTPE Educational Approaches

MTPE and the NASA Education Division have been working with NASA Center representatives to strategically plan the MTPE Education Program. MTPE's education team consists of education and science representatives from each NASA field center and NASA Headquarters. The NASA Goddard Space Flight Center (GSFC) is the lead center for the MTPE program, and plays a critical role in coordinating all of MTPE's educational activities. The education team is responsible for development and implementation of overall MTPE educational programs.

The major responsibility for the MTPE education team is to conceptualize and develop proposed plans and approaches for Mission to Planet Earth's educational initiatives and aid in implementation and coordination of these plans with all NASA centers and NASA Headquarters. These educational programs are designed to benefit the education community at all grade levels across the nation. In addition, major effort is devoted to coordination and collaboration with other agencies such as the National Oceanic and Atmospheric Administration (NOAA), the Environmental

Protection Agency (EPA), the National Science Foundation (NSF), the Department of Education, and private sector research and academic institutions. This broad coordination will ensure that the information content of the Educational Programs is complete, accurate, and up-to-date. It also ensures that the resources are combined and utilized in a partnership to allow for the widest possible national dissemination of all educational programs and products.

The education team has prioritized the MTPE education program resources to achieve the following objectives:

◊ train the next generation of scientists to use an interdisciplinary, Earth system science approach;

◊ continue to educate and train educators as research evolves and capabilities change;

◊ raise awareness of policy makers and citizens to enable prudent policy determination regarding global change;

◊ improve science and math literacy;

◊ improve interface between educators and scientists and secure greater support by scientists for broad education efforts;

◊ explore mechanisms to leverage the development of materials and products, where reasonable, to:

- increase resource availability
- increase knowledge base
- encourage the development of an external capability, expert in translating scientific research into usable forms for a continuum of customers nationally; and

◊ educate the populace to be better caretakers of Earth for future generations.

Prioritization of educational activities is not clear-cut. In order to meet these objectives, the education team studies and evaluates a complement of activities, using various implementation approaches. Certain priority elements are considered when implementing a focused, sustainable program. In the pre-college portion of the program, emphasis is placed on training the educators, as research evolves and capabilities change. Another top priority element is systemic change, to make the most significant impact on the nation's education system with respect to Earth system science, and thus improve science and math literacy generally across the country.

Getting the Job Done: MTPE Education Planning Working Groups

Working groups have been established to address individual concerns and make recommendations about implementation approaches in order to identify and create a balanced, strategic program. The focus areas of these working groups are summarized below:

(1) Teacher Preparation Program: This team was responsible for recommending a program outline and mechanism for implementation (perhaps through solicitation or grant augmentation) of a national, teacher preparation program.

(2) In-service Teacher Training Program: This team was responsible for recommending a plan and mechanism to better leverage existing NASA programs and replicate the efforts across the nation (possibly through distance learning) to better train individuals already in the teaching profession.

(3) Curriculum Support Materials Review: This team was responsible for reviewing the current inventory of MTPE curriculum support products, recommending deletions and identifying areas of need, based on the review, and suggesting mechanisms to disseminate the resultant inventory to the broadest possible customer base.

(4) Systemic Change — U.S. Global Change Education Workshops: This team was responsible for managing and organizing the regional workshops at the NASA Centers and making recommendations on any follow-on activities that NASA might support that involves the U.S. Global Change Education State Teams.

A recommendation/status from each Group was forwarded to the full MTPE Education Strategy Team at the end of June, 1995. The recommendations were analyzed and, as budgets allowed, the implementation phase began at the end of the summer 1995.

Summary

The MTPE education team supports and ensures NASA's strategy for communicating science to the public. The team focuses on broader participation by the scientific community and coordination between scientists and the formal education community in order to foster the inclusion of accurate content in our national education system to prepare and provide an informed citizenry to face the national and global challenges of the future.

Acknowledgment

The authors would like to thank Mark Pine and Mitchell Hobish, Robert Price, and Gerald Soffen for their contributions to the article. ■

USGS Maps Now Available on CD-ROM

Department of the Interior, U.S. Geological Survey

Pennsylvania is the first in a state-by-state series of digital topographic maps of the U.S. available on CD-ROM from the U.S. Geological Survey.

The CD-ROMs, computerized images of USGS topographic maps, in digital raster graphic (DRG) format, have been produced through a partnership arrangement with the Land Information Technology Company, Ltd., of Aurora, Colo.

Topographic maps are among the most popular and versatile products that the USGS produces. They depict natural and cultural features of the landscape, such as lakes and streams, highways and railroads, boundaries, elevation, and geographic names. Over the years they have been popular with the general public for outdoor, particularly recreational, uses and with scientists and engineers in support of research and technical applications.

Dr. Donald M. Hoskins, Pennsylvania State Geologist, and an early supporter of the program, met with the USGS in December 1994 to establish the first cooperative agreement to produce DRGs of Pennsylvania. Many other state agreements have since been signed with the USGS, and production work is underway. CD-ROMs for parts of Pennsylvania and Washington state are available, with full coverage of the U.S. expected by 1998, after some 57,000 USGS maps are converted to CD-ROM format.

"Topographic maps on CD-ROM are a new product for the USGS," said James R. Plasker, associate chief for operations of the USGS mapping division. "Through the data production agreement with Land Info and in partnerships with the states, the USGS has an opportunity to complete nationwide DRG coverage in the next two years."

Each CD-ROM includes the USGS topographic maps for a 1-degree block.

The USGS will also continue to print and distribute the paper topographic maps for which it is best known.

DRG versions of topographic maps are useful as a backdrop for other digital images. They have been used to collect digital cartographic data and to revise maps. When combined with digital aerial photographs or digital terrain models, DRG data can be used to produce hybrid products, such as image maps and shaded relief maps.

Each DRG file has its own descriptive file that provides information including file identification, data sources and dates, scanning specifications, and georeferencing information. Viewing software, product specifications, and assorted text files are also included on the CD-ROMs. Two viewing software packages are provided: Aerial View Lite image display software provided by Gary Mart and ArcView software from Environmental Systems Research Institute (ESRI) of Redlands, Calif. The agreements among USGS, ESRI, and Gary Mart to provide both data and software in a useful format are typical of government-wide alliances with private companies to provide useful products and services to the public.

For information on ordering DRGs on CD-ROM, contact any Earth Science Information Center or call 1 (800) USA-MAPS. The cost of each CD-ROM is $32 plus $3.50 handling on each order.

For technical information on the use of DRG data on CD-ROM, contact:

Rolla-ESIC
U.S. Geological Survey
1400 Independence Rd., MS 231
Rolla, MO 65401-2602
(573) 308-3500; Fax (573) 308-3615
E-mail: esic@mcdgs01.cr.usgs.gov ■

JPL Physical Oceanography DAAC Users Working Group Meeting

— Victor Zlotnicki (vz@pacific.jpl.nasa.gov), NASA Jet Propulsion Laboratory, FAX (818) 393-6720; Tel. (818) 354-5519

The JPL Physical Oceanography (PO) DAAC Users Working Group (UWG) met on the morning of February 13, 1996, at the Town and Country Hotel, venue of the Ocean Sciences Meeting near San Diego.

Members present were David Glover (chair), William Emery (co-chair), Tim Liu, and Victor Zlotnicki. Also present were Don Collins, Glen Shirtliffe (Hughes EOSDIS Core System [ECS] science liaison at JPL) and Giulieta Fargion (Hughes-ECS).

D. Glover started the meeting by inquiring on the status of FY 1996 funding. Collins explained that guidelines from NASA Goddard Space Flight Center (GSFC) were to plan on using the same funding we requested in the annual proposal.

On the FY 1996 priorities, D. Collins stated that the highest priority was NSCAT (T. Liu pointed out that NSCAT is on schedule; any foreseeable slips would be for only a week or two). Most software to process NSCAT is ready; a glitch was found in some latitudes, and is being pursued. A workshop to encourage users to become familiar with the HDF format is planned in the first week of June, together with the NSCAT workshop at JPL.

On TOPEX/Poseidon, D. Collins informed the UWG that Merged Geophysical Data Record (MGDR) reprocessing is on schedule. It will start with cycle 130 and proceed forward, as older cycles are reprocessed. (At this point there is still a small unresolved technical issue, the Sea State Bias coefficients, which the TOPEX/Poseidon Science Working Team must resolve before reprocessing can start). He also pointed out that PO-DAAC will be distributing the TOPEX/Poseidon Outreach CD-ROM. Michael King, EOS Senior Project Scientist, will receive whole parts of this CD to include in the EOS Outreach material. The NSCAT Project is also pursuing educational outreach activities, but with an active group of top-level California educators.

D. Collins proposed that an historical Sea Surface Temperature atlas that MIT (R. Newell) and the U.K. Meteorological Office have been publishing on paper have its next issue published on CD-ROM media, with appropriate data formats, etc., by the PO-DAAC. The UWG had no objection.

The Marshall Space Flight Center DAAC appears on the verge of being closed, and active discussions have occurred among DAAC Managers and GSFC as to a smooth transition of its datasets. D. Collins proposed to bring to PO-DAAC the SSM/I Ocean Geophysical Products and possibly, from AMSR, that part of the full data stream needed to process SeaWinds and the higher level products. W. Emery pointed out that the GSFC DAAC was also interested in handling AMSR.

The ERS-1 altimeter reprocessing activity is also going on as scheduled (U. Texas). The test CD was distributed at the San Francisco AGU meeting (12/95), inputs were received, and final versions are underway.

Other interesting datasets for PO-DAAC to consider holding were brought up, such as R. Leben's (U. Colorado) merged TOPEX and ERS-1 altimetry dataset. It was subsequently learned that R. Leben prefers to wait until the reprocessed ERS-1 dataset is out to combine this better dataset with TOPEX/Poseidon before wider distribution of his dataset.

The issue of whether to give wide distribution to small datasets offered by members of the community came up. V. Zlotnicki thinks PO-DAAC should become involved only after one or two persons other than the dataset creator have looked at the dataset, because of the implicit seal of approval that a data center's distribution gives to its products. The UWG, however, thinks these small datasets should be given the widest possible distribution as soon as possible. Zlotnicki agreed to aggressively seek derived data products for distribution.

V. Zlotnicki asked the UWG to what extent PO-DAAC should fund scientists in the community-at-large to create products deemed useful to the community. At present such funding comes only from other sources, and PO-DAAC simply funds the additional cost of preparing the dataset for distribution, e.g., reformatting, etc, and that funding is usually spent within JPL. The UWG expressed no objection to PO-DAAC funding scientists in the community-at-large to prepare datasets.

On recompetition, D. Collins briefed the UWG on PO-DAAC's plans to propose the SeaWinds activity. At that time, however, there were no guidelines to proceed further. NASA expects to issue an Announcement at Opportunity in the summer of 1996.

D. Collins briefed the UWG on the hardware coming to JPL as part of the ECS. It will take up close to 700 ft^2, thanks to careful stacking of components; the mass storage device, a 20 ft x 20 ft footprint, cannot be shrunk further. The new hardware also includes uninterrupted Power Supplies, which PO-DAAC does not presently have, and changes to the A/C system.

PO-DAAC will have to write an FY 1997 proposal in April, before knowing the full details of the competition AO. It was agreed to plan for a May 1996 meeting. ■

NASA Science Institutes Plan Released

— Don Savage, Phone: (202) 358-1547, NASA Headquarters, Washington, DC

March 1, 1996
RELEASE: N96-14

NASA has released its NASA Science Institutes Plan report, following a six-month period of study by the NASA Science Institutes Team and modifications based on public comments.

The NASA Science Institutes concept began May 19, 1995, when NASA Administrator Daniel S. Goldin released results of an internal review conducted by the Agency's "Zero Base Review" (ZBR) Team. The ZBR science recommendations included a proposal that science "institutes" be formed at many of NASA's Centers, with goals to strengthen the quality of NASA science, to bind NASA scientists more effectively to the external community, and to increase the effectiveness of the links between the external community and NASA's immense engineering and technical resources.

The report is available to media representatives by calling the NASA Headquarters Newsroom at (202) 358-1600. The general public may obtain a copy by calling (202) 358-2877. In addition to the report, a question and answer fact sheet, a Benchmarks Report, and a NASA Science Institutes Report Forward are available. These documents are available on the internet via anonymous file transfer at: ftp.hq.nasa.gov in the directory pub/oss/inst/, or on the World Wide Web at http://www.hq.nasa.gov.office.oss ■

Improved Computerized Maps Available from the U.S. Geological Survey

—Jerry Waters, (703) 648-6025, United States Department of the Interior, Geological Survey, Reston, VA 22092

January 24, 1996

Technical Announcement
National Mapping Division
U.S. Geological Survey

Improved computerized maps are now available on compact disc-read only memory (CD-ROM) from the U.S. Geological Survey (USGS). These high-quality files, known as digital line graph (DLG) data, depict boundaries, transportation systems, and many natural and man-made features.

The DLG data were collected at a scale of 1:2,000,000 (one inch equals nearly 32 miles). No data source more than five years old was used in updating the DLGs, which were originally collected in 1979 and 1980.

Besides the popular DLG optional distribution format, these data are also now available on CD-ROM in the Topological Vector Profile (TVP) of the Spatial Data Transfer Standard (SDTS). The SDTS is an effective mechanism for the transfer of spatial data between dissimilar computer systems.

"These data provide an accurate and up-to-date framework for statewide, regional, and national mapping projects, planning efforts, Earth science investigations, and many other applications," according to Eric Anderson, chief of the USGS Mapping Applications Center in Reston, Virginia, which produced the latest DLG data.

"Users of our older DLG files have provided us with many good suggestions for improving these small-scale data, and we have responded by incorporating the best recommendations in our latest CD-ROM products," said Anderson. "Among many others, the Bureau of the Census and the National Park Service made major contributions to this effort," said Dick Witmer, acting chief of the USGS National Mapping Division. "We are pleased with the high level of cooperation from the many agencies that were involved."

"This project is a good example of how federal mapping and natural resource management organizations work together to reduce duplication of effort. The USGS will maintain this national data set, but we depend on our cooperators to update the map features, such as National Park boundaries, that are not the responsibility of the USGS."

The DLG data have been released in two formats on CD-ROM. One disc contains data in the popular "DLG Optional" format. The other CD-ROM disc contains data in the SDTS TVP format. Each CD-ROM is available for $32 plus a $3.50 handling fee, and is available from USGS-Information Services, Box 25286, Denver, Colorado 80225

The USGS stock number for the CD-ROM containing data in the optional format is 01-DLG-02M. The stock number for the CD-ROM containing data in SDTS TVP format is 01-DLG-02M-S.

The USGS is promoting the use of the STDS and is providing 1:2,000,000-scale digital cartographic data in SDTS format to the public at no cost via the Internet. World Wide Web users can retrieve these data at the following Universal Resource Locator (URL): http://sun1.cr.usgs.gov/glis/hyper/guide/2mil/.

SDTS transfers can also be retrieved from the Internet by direct file transfer protocol (anonymous FTP) at the following address:

edcftp.cr.usgs.gov
username: anonymous
password: enter your e-mail address

For World Wide Web users the URL is: ftp://edcftp.cr.usgs.gov/pub/data/DLG/2M/. ■

NASA Awards Grant For Smithsonian Global Change Exhibit

— Douglas Isbell, Phone: (202) 358-1753, NASA Headquarters, Washington, DC
Randall Kremer, Phone: (202) 786-2950, National Museum of Natural History

RELEASE: 96-32
February 14, 1996

NASA's Mission to Planet Earth program has awarded a $500,000 grant to the Smithsonian Institution's National Museum of Natural History to support planning for a new museum exhibition hall titled "Forces of Change."

"Forces of Change" will feature a series of regional case studies demonstrating the ways in which the Earth's environment is changing and how humans affect or are affected by these processes. Initial case studies on the Antarctic polar region, the Hawaiian islands, the Chesapeake Bay estuary, and the Great Plains grasslands will offer museum visitors interactive, state-of-the-art displays on how natural forces influence their daily lives.

"NASA is excited to have the opportunity to work with the Museum of Natural History in communicating the results of the most recent studies of the global environment through an inventive forum that blends scientific research and educational outreach," said Dr. Robert Harriss, Science Division director for Mission to Planet Earth.

Additional programming in the form of books, film and lecture series, CD-ROM packages, and classroom materials will be developed in conjunction with each case study. The exhibition will continually challenge visitors to learn more about the world in which they live and to think about their roles in shaping that world, according to Acting Museum Director Donald J. Ortner.

"This generous grant from NASA enables the National Museum of Natural History to advance a ground-breaking exhibition which fully realizes our charter mission to be dedicated to understanding the natural world and our place in it," Ortner said. "We plan to create an exciting exhibition series to help visitors better understand the interdependencies between humans and the environment."

The "Forces of Change" project is being developed with extensive consultation among scientists, anthropologists, and educators at the museum. Many other experts from outside the museum, including artists, photographers, environmental engineers and maritime historians, will also be involved in the project to ensure a thorough and balanced discussion of the topic, Ortner said. "A date for the anticipated opening of the hall will be announced after the completion of the planning process."

NASA's Mission to Planet Earth is a comprehensive science research enterprise designed to observe the Earth's land, atmosphere, and oceans from a global perspective using satellites, aircraft, and ground-based measurements. Such studies will yield improved weather forecasts, better tools for managing agriculture and forests, information for ocean-related industries and coastal planners, and, eventually, an ability to predict how the Earth's climate will change in the future. ■

ANNOUNCEMENT

Eric Barron, Chairman of the EOS Science Executive Committee and Principal Investigator of the EOS Interdisciplinary Investigation "Global Water Cycle: Extension Across the Earth Sciences," was recently named chief editor of the new electronic journal, *Earth Interactions.* This journal is a joint venture of the American Geophysical Union, the American Meteorological Society, and the Association of American Geographers.

Release of Updated EOS Data Product Report

— Yun-Chi Lu (lu@spso.gsfc.nasa.gov), Code 505, NASA Goddard Space Flight Center, Greenbelt, Maryland

The Science Processing Support Office (SPSO) at the Goddard Space Flight Center (GSFC) has released a report entitled *Earth Observing System Output Data Products, Processes, and Input Requirements - Version 4.0.* The SPSO report, consisting of three volumes, is based on the latest input provided by the EOS instrument teams. It provides information on EOS output data products, input requirements and production processes for the EOS instruments. It also provides information on the input and output data products of the Interdisciplinary Science (IDS) investigation teams. All the information presented in the SPSO report is also available from the SPSO Homepage. Its URL is "http://spsosun.gsfc.nasa.gov/spsohomepage.html."

The highlights of this release are:

- revised payload information, reflecting the "reshaped" EOS mission profile, dated January 16, 1996;
- revised product type information based on the ATBD reviews by the EOS Project Science Office;
- revised and expanded process information from the AIRS, GLAS, and SAGE III instruments;
- updated material for ASTER, CERES, DFA, MISR, MODIS, MOPITT, and SWS, as well as for DAS. Non-EOS input requirements have also been updated;
- detailed data file and process information and the interdependencies among data products and processes; and
- material on two NMC datasets relevant to EOS.

The first version of the SPSO report, released in August 1991, listed the data products then expected from EOS. Subsequent versions have followed the evolution of EOS through a variety of program redefinitions. The current version includes the revisions, based on input from instrument teams through the Ad Hoc Working Group on Production (AHWGP) in February 1996, and provides new information such as data files and processes on an instrument-by-instrument basis. The main information in the report is divided into three parts: high-level summary tables for EOSDIS resource requirements, detailed information on EOS data products and processes, and information on input and output products of the EOS IDS teams.

Volume I contains introductory and background material, a discussion of various definitions and conventions, and a paragraph or two describing each appendix in the succeeding two volumes. The first volume also contains several summary tables: daily data volumes in GB per day for each processing level (0 to 4) by instrument and platform; processing loads in MFLOPS, again by level, instrument and platform; and data traffic in GB per day among the DAACs for Level 1B and for Levels 2 and 3 combined.

Volume II consists of detailed data product/parameter and process/file information in a total of eight appendices. Data product material is presented in the first three, for both EOS and related non-EOS data. Peak volume and processing figures are given, along with production center, archival center, product type, production mode, and related descriptive material. Two appendices contain information on the resolution and accuracy of the parameters corresponding to each product, where available. Finally, a set of three interrelated appendices describes the files and processes that underlie the EOS data products: a process appendix that gives the volume per process, the number of process runs per day, the number of operations per process and the processing load; a file appendix, giving file size, time coverage and disposition (archival, permanent, or temporary), along with the processing and archival centers; and an appendix that clearly displays the input and output files for each process. This last appendix allows one to trace out the detailed dependencies among all the EOS products and processes.

Volume III contains information on NMC and IDS products. The first set of appendices, which gives information on two NMC datasets (Model Output and Observational Data), is included because of the importance and popularity of the datasets as input data for EOS investigators. The NMC Observational Data are used as input by the GSFC Data Assimilation Office. The second set of appendices presents the IDS output products, the input requirements, and an analysis of which of those requirements can be met by the projected EOS data products.

The SPSO homepage, developed as the version 4.0 material was being incorporated into the SPSO database, has been specifically tailored to make that material easily accessible. You can search for data products or data production processes using search criteria such as platform, instrument, or processing center, etc. The search will return detailed information on products, parameters, processes, and files. You can also specify a particular process and see a listing of all the input and output files associated with that process. Hypertext links allow you to move among the detailed descriptions, clicking your way from a data product description, for example, to the process that generates that product, then on to the related input/output files for that process. This detailed information can also be accessed through two "quick" routes that allow you to select from a table of possible criteria. There is also a set of high-level summary tables, similar to those in Volume I of the hard copy. In addition, the report itself is also available on-line either for browsing or downloading.

The SPSO Homepage offers an on-line comment capability in case you have any questions or would like to make suggestions. It also offers a set of links to other related EOS homepages, such as those of the EOS Project Science Office and the ESDIS Project. ■

McDonnell Douglas Aerospace Awarded Contract To Provide Med-Lite ELV Services

NASA Headquarters, Washington, DC. Phone: (202) 358-1779
— Ernie J. Shannon, Phone: (301) 286-6256, NASA Goddard Space Flight Center, Greenbelt, Maryland

RELEASE: 96-40
February 27, 1996

NASA has awarded McDonnell Douglas Aerospace, Huntington Beach, CA, a contract to provide fixed-price medium-light (Med-Lite) class expendable launch vehicle services. The Orbital Sciences Corp., Dulles, VA, is a major subcontractor.

The contract has the potential value of approximately $500 million depending on the number of options exercised, vehicle configurations, and mission-unique requirements.

The program, which will be managed by the Goddard Space Flight Center, Greenbelt, MD, is scoped to provide launch capability in the range of 4,400 pounds (1,995 kg) to low Earth orbit. At the time of contract award, three missions have been named as Med-Lite payloads: the Far Ultraviolet Spectroscopy Explorer (FUSE); Mars Surveyor Orbiter-2; and Mars Surveyor Lander-1. FUSE is scheduled for launch in 1998, the Orbiter is scheduled for launch in December 1998, and the Lander is scheduled for launch in January 1999. In addition to the three named missions, two firm unnamed missions are scheduled for flight under the new contract as well as nine optional missions, for a total of 14 launch services.

The contract includes an eight-year ordering period for the optional missions beginning at the time of the signing. McDonnell Douglas proposed a nominal 30-month call-up for each launch service. Launches are planned from both the East and West Coast to support Discovery, Explorer, and Mission to Planet Earth requirements.

McDonnell Douglas is the prime contractor and will provide launch services under the contract with Delta II 7300, Delta-Lite and Taurus vehicles. The Delta Lite will be available under this contract, when developed by McDonnell Douglas. ■

NASA Airborne Sensor Aids Superfund Site Cleanup

— Douglas Isbell, NASA Headquarters, Washington, DC. Phone: (202) 358-1547
Mary Hardin, Jet Propulsion Laboratory, Pasadena, CA. Phone: (818) 354-5011

March 13, 1996
RELEASE: 96-48

Maps produced from a NASA airborne sensor are cutting costs and helping to speed the clean-up of hazardous waste at a Superfund site in Leadville, CO.

Several federal agencies, including the Bureau of Reclamation, the Environmental Protection Agency, and the U.S. Geological Survey (USGS), are using the maps to find sources of acid mine drainage and heavy-metal contamination at the California Gulch Superfund Site. The contamination is the result of more than 130 years of mining activities associated with the Leadville Mining District, according to Felix W. Cook, Sr., director of the Technical Service Center at the Bureau of Reclamation, Denver, CO.

The maps were produced by the USGS using data from NASA's Airborne Visible and Infra-Red Imaging Spectrometer (AVIRIS) which was developed and is managed by the Jet Propulsion Laboratory, (JPL), Pasadena, CA. The AVIRIS instrument flies aboard a NASA ER-2 high-altitude research aircraft.

While being carried 12 miles above sea level at a speed of 450 miles per hour, the instrument can take approximately 7,000 measurements per second. Earth scientists use AVIRIS to make measurements related to global climate and environmental change research in ecology, geology, oceanography, snow hydrology, and cloud and atmospheric studies.

"This technique of imaging spectroscopy represents a fundamental new way of doing remote sensing. We are measuring in detail how light is absorbed or reflected by various materials on the Earth's surface and that gives us an accurate picture of what those materials on the ground are made of. Once we know where the materials are, we can begin to make decisions based on those maps," said Robert Green, the AVIRIS experiment scientist at JPL.

"The imaging spectroscopy mineral mapping has allowed us to identify potential contaminating sources as small as individual mine dumps for evaluation," Cook said. "Based on our recent experience, the Bureau of Reclamation anticipates that many future hazardous clean-up efforts throughout the United States, especially at large sites, should use AVIRIS to produce relatively inexpensive thematic site maps to aid in remediation."

An analysis program that recognizes the spectral signature of the contaminants on the ground has been developed by the USGS to construct mineral maps from the AVIRIS data. "AVIRIS data are like a treasure chest of scripts in an unknown language — totally unreadable to the untrained observer," said Gregg Swayze, a geophysicist at the USGS. "The imaging analysis program is like a Rosetta stone, a key to that language by which the AVIRIS data can be interpreted and profited from."

The mineral maps have helped officials save roughly $500,000 and about a year's time in identifying the areas in need of attention.

"NASA's AVIRIS program has enabled more money to be used for actually cleaning up the hazardous mine waste materials currently contaminating this site," Cook said. "In addition, the speed with which the AVIRIS data can be processed, mapped, and integrated into our system has enabled us to complete the site data development and analysis process about a year ahead of schedule, saving additional money and time."

Reclamation officials believe the AVIRIS data mineral mapping could be used for site investigations on many of the hazardous waste sites now included on the Environmental Protection Agency's National Priorities List.

The AVIRIS instrument is managed by JPL for NASA's Office of Mission to Planet Earth, Washington, DC. ■

JET AIRCRAFT: How Large A Source Of Atmospheric Pollution?

— Don Nolan-Proxmire, NASA Headquarters, Washington, DC. (Phone: 202/358-1983)
Catherine E. Watson, NASA Langley Research Center, Hampton, VA. (Phone: 804/864-6122)

RELEASE: 96-33
February 15, 1996

Every day, thousands of jet aircraft fly through the Earth's atmosphere, but scientists are still uncertain how much pollution is produced. To better understand this relatively unknown source of air pollution, researchers at NASA's Langley Research Center, Hampton, VA, are measuring emissions from the engines of two NASA research jets — Boeing 737 and a Boeing 757.

During a two-week experiment, as part of NASA's Atmospheric Effects of Aviation Project (AEAP), a NASA T-39 jet will fly behind a NASA 737. Instruments aboard the T-39 will measure various gases and small pollutant particles (called aerosols) emitted by the 737's engines. The T-39 data also will be used to study how the 737's engine emissions disperse in the atmosphere, and how rapidly. Jet engine emissions can often be seen in the atmosphere in the form of contrails flowing behind the aircraft.

The NASA 737 also will fly over a ground-based laser system at Langley that can measure the aerosols emitted from the engines. These aerosol measurements can be used as tracers to study how air flows around the jet, dispersing the emissions into the atmosphere. Jet engine emissions have been shown to affect the concentrations of atmospheric water vapor and aerosols, and they may affect how clouds form and the concentrations of atmospheric ozone. Few direct measurements of their effects have been made, however.

In addition to the ground-based laser system and the T-39, researchers from the University of Missouri-Rolla will measure engine emissions from both the 737 and the 757 in ground tests at Langley. Using a probe mounted near the rear of the engine, the University of Missouri researchers will measure the amount of aerosols emitted by each engine and the distribution of the particle sizes.

The data collected during this experiment will provide AEAP scientists with a unique data set to help them better understand how jet aircraft emissions are affecting our atmosphere and how these emissions are dispersed. ■

EOS Science Calendar

April 23-24	AMSR Science Team Meeting, NASA/GSFC, Greenbelt, MD. Contact Elena Lobl, (205) 922-5912, (elena.lobl@msfc.nasa.gov).
May 1-3	MODIS Science Team Meeting, Location (TBD). Contact Barbara Conboy, (301) 286-5411, (barbara.conboy@ltpmail.gsfc.nasa.gov)
May 6-8	Land Processes DAAC Science Advisory Panel Meeting, EROS Data Center. Contact Bryan Bailey, (605) 594-6001, (gbbailey@edcserver1.cr.usgs.gov).
May 8-10	EOS Validation Workshop, NASA/GSFC. Contact Tim Suttles, (301) 441-4028, (suttles@ltpmail.gsfc.nasa.gov).
May 13-15	EOS Investigators Working Group (IWG) Meeting, Greenbelt, MD. Contact Kelly Whetzel, (301) 220-1701, (whetzel@ltpmail.gsfc.nasa.gov).
May 16-18	SWAMP Land Workshop, Conference Center at University of Maryland at College Park. Contact Piers Sellers, (301) 286-4173, (piers@imogen.gsfc.nasa.gov)
Week of June 10	ASTER Science Team Meeting, Pasadena, CA. Contact Anne Kahle, (anne@aster.jpl.nasa.gov) or H. Tsu, (tsu@ersdac.op.jp)

Global Change Science Calendar

April 9-13	AAG Conference, Charlotte, NC. Contact Kevin Fitzpatrick, Tel. (202) 234-1450, FAX: (202) 234-2744, E-mail: GAIA@AAG.ORG
April 22-24	ASPRS/ACSM Annual Convention, Baltimore, MD. Contact Convention Coordinator, 5410 Grosvenor Lane, Suite 100, Bethesda, MD 20814.
May 12-15	ICASSP '96, Atlanta, GA. For information see WWW at http://www.ee.gatech.edu/conferences/icassp96 or E-mail: icassp96-info@eedsp.gatech.edu.
May 27-31	1996 International Geoscience and Remote Sensing Symposium (IGARSS'96), Lincoln, NE. See IGARSS'96 WWW at http://doppler.un1.edu/igarss96, E-mail: stein@harc.edu, Tel. (713) 291-9222, or FAX: (713) 291-9224.
June 4-7	Ninth Annual Towson State University GIS Conference, Baltimore, MD. Contact Jay Morgan, Tel. (410) 830-2964, FAX: (410) 830-3888, E-mail: e7g4mor@toe.towson.edu.
June 10-12	4th International Satellite Direct Broadcast Services Synmposium for NOAA Polar-orbiting Operational Environmental Satellite (POES) Users, Annapolis, MD. Call (301) 345-2000, ext. 135, E-mail: POESUSER@infrmtcs.com.
June 10-14	USRA/GSFC ESS Lecture Series, Global Change and the Americas, Goddard Space Flight Center. Contact Paula Webber, Tel. (301) 805-8396, E-mail: paula@gvsp.usra.edu.
June 16-20	American Society of Limnology and Oceanography Annual Meeting, University of Wisconsin at Milwaukee. Call for Papers. Contact Susan Weiler, FAX: (509) 527-5961, E-mail: weiler@whitman.edu.
June 17-21	Second International Scientific Conference on the Energy and Water Cycle, Washington, D.C. Contact International GEWEX Project Office at (202) 863-0012 (gewex@cais.com) or Judy Cole at FAX: (804) 865-8721 (cole@stcnet.com).
June 24-27	Second International Airborne Remote Sensing Conference and Exhibition: Technology, Measurements, and Analysis, San Francisco, CA. Contact Robert Rogers, ERIM Conferences, Box 134001, Ann Arbor, MI 48113-4001; Tel. (313) 994-1200, ext. 3234, FAX: (313) 994-5123, E-mail: raeder@erim.org. Information available on WWW at http://www.erim.org/CONF/.
July 9-19	International Society for Photogrammetry and Remote Sensing (ISPRS), Vienna, Austria. Contact Lawrence Fritz, Tel. (301) 460-9046, FAX: (301) 460-0021.
August 4-9	SPIE Annual Meeting, Denver, CO. Contact Diane Robinson, Tel. (363) 676-3290 Ext. 357, E-mail: diane@spie.org.
August 20-22	William T. Pecora Memorial Remote Sensing Symposium, Human Interaction with the Environment - Perspectives from Space, Sioux Falls, SD. Contact Gary Johnson, Technical Program Chair, at pecoral13@edcserver1.cr.usgs.gov. Information available on WWW Homepage at http://edcwww.cr.usgs.gov/pecora13.html.
September 14-18	National States Geographic Information Council, 6th Annual Meeting, Doubletree Hotel, Tucson, Arizona. Contact Ammie Collins, Tel. (603) 643-1600, FAX (603) 643-1444, E-mail: NSGIC@AOL.COM.
September 23-27	European Symposium on Satellite Remote Sensing III, and Conference on Sensors, Systems and Next Generation Satellites. Taormina, Italy. Call for Papers. Contact Steve Neeck, Tel. (301) 286-3017, E-mail: Steve_Neeck@ccmail.gsfc.nasa.gov.
November 4-7	ECO-INFORMA '96 — Global Networks for Environmental Information: Bridging the Gap Between Knowledge and Application, Lake Buena Vista, FL. Contact Robert Rogers, Tel. (313) 994-1200, ext. 3234, FAX (313) 994-5123. In Europe, contact Otto Hutzinger, (49) 921 552 245 or 155, FAX: (49) 921 546 26.

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The Earth Observer

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

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