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Editor's Corner

Much of the activity during the past few months has centered around the efforts of Goddard Space Flight Center, NASA Headquarters, and the EOS investigators to rebaseline the EOS Program following a $758.5 M reduction in EOS funding through fiscal year 2000. As reported in the last issue of *The Earth Observer*, this activity basically began when Dr. John Klineberg, Director of Goddard Space Flight Center, established 3 teams to independently examine the requirements and implementation approaches currently contained within the EOS program. Following a careful assessment and costing of various elements of this program that could potentially be eliminated, reduced, or deferred, the Mission to Planet Earth Office, together with key individuals from two of the review teams, presented a summary of these deliberations at the recent Payload Panel meeting held in Landover, MD (July 19-21).

This meeting was a unique one in that it was the first time that a Payload Panel meeting was open to a wide participation consisting of EOS investigators, DAAC representatives, and contractors, and because budget planning numbers were made available to the investigators in order to help prioritize EOS mission elements. Following initial exposure to the 26 items that the independent teams had identified for potential elimination or modification, there was open discussion,

facilitated by the cognizant Project and Program Scientists. This enabled all interested parties to discuss the science impacts and priorities of various scenarios.

Following a 2-day plenary session, Prof. Berrien Moore, chairman of the Payload Panel , formed 4 independent teams of EOS investigators, randomly selected, to look at ways to fit the high-priority mission elements into the funding profile as well as the total budget that is available. There was considerable overlap in the prioritization of the EOS mission elements, from which a unified Payload Panel report is currently being formulated. The recommendations of this report, once approved by the Associate Administrator of the Office of Mission to Planet Earth, will be the basis for a rebaselined EOS Program. I anticipate that the full Payload Panel Report will appear in the next issue of *The Earth Observer*.

An EOS Science Executive Committee (SEC) meeting was held on the evening of July 19. The chairman of the SEC, Prof. Eric Barron, announced the election of chairs for the following panels and working groups: David Glover (EOSDIS), Soroosh Sorooshian (Climate and Hydrology), Peter Mouginis-Mark (Communication and Outreach), and Barry Goodison (Cryosphere Working Group). In addition, the SEC discussed the dates, location, and agenda for the next Investigators Working Group (IWG) meeting. The first half-day will consist of a review of the Payload Panel recommendations of the rebaselined EOS Program, and Dr. Kennel's description of actions taken by NASA Headquarters in implementing these recommendations. The bulk of the meeting, however, will be devoted to presentations and discussions of significant science results that highlight and promote broad EOS knowledge of accomplishments obtained thus far, following a format used at the last IWG meeting in San Antonio.

I have recently received the report of the visiting committee that examined 42 algorithm theoretical basis documents (ATBD) prepared by the CERES, MODIS, and MISR Science Teams. The oral portion of this review followed a written review consisting of approximately 5 written reviews of each document. Among the high-level recommendations of this committee were: (i) that more attention be paid to well-defined pre- and post-launch validation strategies, including a need for detailed error and uncertainty estimates, (ii) that stringent tests and product validation be conducted post-launch, and that the 90-day shake-down period currently baselined is too short to adequately carry out these assessments, (iii) that reliance on 'targets of opportunity' for validation opportunities is not appropriate for a mission of this magnitude, (iv) to make the ATBDs widely and electronically available to the entire community, and (v) that mechanisms be put in place to allow for changes and restructuring of science teams as needs arise, including augmenting science teams where gaps in capability are clearly identified.

Much progress has been made in augmenting the World Wide Web site that the Project Science Office has recently established (Unique Resource Locator: http://spso2.gsfc.nasa.gov/spso_homepage.html). Recent additions include the EOS Reference Handbook, NASA Facts (educational leaflets concerning Mission to Planet Earth), Airborne and Spaceflight Information and Schedules, and many EOS-related Servers (most of the DAACs, Science Teams, Interdisciplinary Investigations, etc.). I encourage you to take a look at this information service, accessible using Mosaic, for accurate and up-to-date information on EOS. The airborne and spaceflight schedules, included within this issue of *The Earth Observer*, will be updated annually.

Finally, as the popularity and distribution of *The Earth Observer* continue to grow, the number and length of our many article submissions continue to grow. Given the widespread distribution of this newsletter, I ask that article submissions be brief (preferably limited to 3 pages), and that all acronyms be spelled out, or avoided, wherever possible.

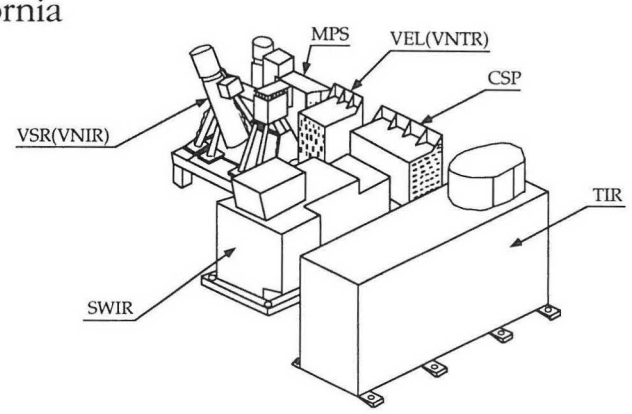
—Michael King
EOS Senior Project Scientist

Science Team Meetings

Minutes of the Seventh Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Science Team Meeting

May 24-27, 1994, Pasadena, California

—**Andrew Morrison**, andy@lithos.jpl.nasa.gov
Jet Propulsion Laboratory



Plenary Session I

Approximately 80 participants representing the ASTER Science Team, NASA/Goddard Space Flight Center (GSFC), the ASTER Science Project at Jet Propulsion Laboratory (JPL), the Japan Resources Observation System (JAROS) organization, and the Earth Resources Satellite Data Analysis Center (ERSDAC) met at the Ritz Carlton Hotel in Pasadena, California for the 7th ASTER Science Team meeting. The four-day meeting was composed of two plenary and several individual Working Group meetings. The objectives of the meeting were to continue technical and programmatic discussions and to resolve outstanding issues.

A. Kahle, U.S. Science Team Leader and meeting Co-Chair, opened the Plenary Session. H. Tsu, overall ASTER Science Team Leader and meeting Co-Chair, thanked the U.S. Team and A. Kahle for arranging the meeting. He said that the key topics for the meeting should be algorithm development and exchange of information. A. Kahle reported that the previous day's Project Implementation Agreement meeting went well and that things are progressing as they should.

H. Koyama of JAROS updated the status of the ASTER instrument and subsystem development. He also presented the schedule for the ASTER CDR and for other upcoming reviews and meetings. He said that there is still disagreement between the GSFC analysis of the effect of shortwave infrared (SWIR) Stirling cycle cooler vibration on boresight jitter and the direct measurement data from JAROS. He also said that analysis of the effect of adding lunar calibrations to the operation plan (currently being considered, but not in the baseline) would add a requirement for thermal redesign of the instrument. This could result in schedule stretchout and power dissipation increases. He said that JAROS doesn't want to redesign the instrument, and he asked for help to avoid this requirement. (This problem appears to be a function of pointing and duration—see the Level-1 Geometrical Working Group meeting notes below.)

K. Ogikubo of JAROS reviewed the status of their preflight test plan and schedule. He confirmed that the test data will not be available until 5 months after the Critical Design Review (CDR). H. Kieffer expressed his concern with the test plan and schedule for the instrument. He gave examples of complicated spacecraft in which hardware problems that were not detected prior to flight were causing serious

problems in processing the data. He argued that engineering model test data from the instrument builders should be supplied as soon as possible to the scientists to allow them to uncover problems in time to allow the manufacturers to correct them. H. Fujisada said that they are also concerned, based on their experience from JERS-1, and therefore they would like to continue discussions and arrangements.

M. Pniel and K. Yoshida presented updates on the ASTER Product Generating System and the Ground Data System, respectively. M. Pniel said that they require simulated MODIS and MISR data by the middle to the end of 1995 to support unit testing, and they require logical and physical interface information sooner. He expects to deliver additional software: Versions 2.1 (March 31, 1998 delivery to DAAC), 2.5 (June 30, 1999 delivery to DAAC), and 3 (June 30, 2000 delivery to DAAC). K. Yoshida said that the announcement of the RFP was issued May 10, 1994 in the *Official Gazette* of Japan, but release depends on approval of the 1994 budget by the Diet; no other information can be released until RFP issuance.

H. Fujisada and H. Watanabe presented an overview of the Level 1 Algorithm Theoretical Basis Document (ATBD) which had been very well received at the ATBD Review. The presentation included the responses to questions submitted by the ATBD reviewers.

A. Kahle reviewed the results of the March 1994 ASTER meetings. A new meeting format that included splinter meetings from the Working Group meetings was very successful—several issues were resolved that might not have been possible to resolve in the larger meetings. On the subject of prioritization of observation requests, she said that the responsibility for developing a scheme for prioritizing data acquisition requests is on the shoulders of the ASTER Science Team—with final review and approval by the AM1 and EOS Project Scientists. The Mission Planning splinter of the Operations and Mission Planning Working Group (OMPWG) agreed that requests for observations would be divided into categories (engineering, emergency, regional monitoring, etc.) and that priorities would be assigned within each category. This scheme will insure that all requests for observations will have a reasonable chance for scheduling. The plan, when completed, will be documented in the Long Term Instrument Plan (LTIP). Requests for observations will include Engineering Test Requests (ETRs), Data Acquisition Requests (DARs), and Science Team Acquisition Requests (STARs). STARs are special cases of DARs in which the requirement for observation assets for one request is sufficiently high as to require Science Team review and approval. Regional monitoring and global mapping requests will be submitted as STARs. Targets of opportunity (TOOs), requests for observations submitted for ephemeral events, will also be treated as special cases of DARs. A. Kahle also presented a proposed success criterion for the global mapping data set.

Y. Yamaguchi presented examples of global maps for specific science objectives—natural resources, volcanoes, etc. As a member of both the Geology Working Group and the OMPWG, he is looking forward to receiving similar maps from each of the other Science Working Groups.

A. Kahle reviewed the results of the ASTER ATBD Peer Review. She said that the review board was concerned with having DEMs as Standard Products and with the "thinness" of the calibration plan. The board did respond favorably to a proposal by H. Kieffer to consider glacial monitoring as a Standard Product. She said that the next versions of the ATBDs will require concentration on validation and on estimates of error.

Plenary Session II

Plenary Session II followed two-and-one-half days of Science Working Group meetings. The Working Group meetings were summarized in this session.

P. Slater, Calibration Working Group, reviewed the steps the Group is taking to prepare for the Calibration Plan Peer Review in Japan later this year. He and A. Kahle stated that they believe that a separate detailed Calibration Plan Document is needed, not simply an expanded ATBD. K. Arai said that the Japanese side will write a Geometric Calibration Plan, a "sister document" to the Radiometric Calibration Plan written by A. Ono. This will be a part of the Japanese Observation Performance Report.

H. Lang, Digital Elevation Model (DEM) Working Group, said that although the DEM is a Standard Product, no money has been allocated to support its

development and implementation within EOS. He said that EOS had declared this an oversight, but at the ATBD Review it was pointed out that a question remained about keeping the DEM as a Standard Product. H. Lang also presented minor revisions made to the Working Group charter. The Action Item list included a suggestion that an ASTER position paper be prepared stating ASTER pre-launch DEM requirements.

H. Kieffer reported that the Level 1 Geometrical Working Group had assigned an Action Item to Scott Lambros, EOS Instrument Manager, to verify that lunar calibrations can be done rapidly, e.g., 12 minutes to pitch 150 degrees, 2 minutes dwell on moon, and 12 minutes to pitch back to nadir. The main concern seems to be thermal impact. Cutting the length of time during which the maneuver is conducted, may allow the ASTER lens to remain within operating conditions. Another Action Item assigned to Lambros was to determine if jitter can be measured at spacecraft integration.

T. Takashima, Atmospheric Correction Working Group, said that the atmospheric correction problem is too difficult to yield to only one algorithm. In addition, it may change with time increasing the need for more than one algorithm. He feels that ultimately there will be two algorithms from which users will choose.

J. Schieldge, Ecosystem and Land Surface Climatology Working Group, presented the Japanese list of prioritized sites. He said the U.S. side has as its objective to produce a similar list by the next Team Meeting.

G. Geller, Level 1 (L1) Architecture, said that the Working Group needs to know whether the Science Team requires user-selected map projections. They said that this is an important issue in defining the requirements on the system. Another unresolved issue is the Ground Control Point (GCP) capability requirement in the L1 system. The Working Group will continue to address these issues.

D. Nichols reviewed the list of meeting topics and the results of discussions in the Operations and Mission Planning Working Group meeting and splinter meeting. The main topics of the meeting included command timing, cloud study, Instrument Support Terminal development, DAR trade study, and Quick-Look processing. M. Schwaller will identify an operational cloud data source (the critical path). An operations concept is to be developed for cloud prediction use by August, with the schedule being driven by the EOSDIS Core System Preliminary Design Review. A DAR trade study will be conducted to provide pros and cons of approaches for specifying areas of interest and repetition, examining impacts on user input utility, science return, Information Management System (IMS), and scheduling system. A white paper will be produced by the end of June. A Japanese prototype operations software package titled Mission Operations Support Tool (MOST) was demonstrated at JPL. The package is installed and operational at JPL. H. Watanabe said that he expects to have a draft of the User Requirements and ASTER Operations Concept document completed this summer.

M. Abrams introduced the new name of the Oceanography, Limnology, Lake and Sea Ice Working Group and presented their new charter. He said that T. Matsunaga had reported on a new sea surface temperature model and some initial results obtained using the model. The Japanese have already begun to assemble their regional mapping requirements. The U.S. needs to follow suit. M. Abrams said that this will require an education effort with groups that are unaware of remote sensing, let alone ASTER. The working group handed the science topic of snow cover over to the Geology Working Group.

Y. Yamaguchi reviewed the listing of science-topic-based regional-mapping desires prepared by the U.S. and Japanese working group members. One-to-two-page white papers will be prepared on each regional-monitoring science-based topic. The white papers will describe the applicability of ASTER data to support studies in each field.

T. Kawakami invited the meeting participants to the next ASTER Science Team meeting, which will be held November 14-17 in Kagoshima-city, Japan. Kagoshima-city is on the volcanically-active island of Kyushu. The meeting will be followed by a one-day workshop on Geothermal, Volcanics, and Ecosystems presented by ERSDAC and the Remote Sensing Team of Kagoshima University.

In closing, H. Tsu said that it was clear from the meeting that we are making progress—that both sides

are doing their best to reach success despite our strained budgets. A. Kahle said that she felt that the Team had made considerable progress on the topics of an algorithm selection process, DEMs, and a Calibration Plan. Looking ahead, she said that the Project has asked people to scour the science communities to have a good start on regional priorities from all groups by the next meeting. She asked the attendees to be prepared to address test sites, validation plans, and coordinated validation activities. The team has made lots of progress and they are looking forward to the next meeting. ■

4-D TIMESERIES DATASET

—**Jim Closs,** closs@nssdca.gsfc.nasa.gov

The Distributed Active Archive Center at GSFC is now distributing the 4-D Assimilated Data Set produced by the Goddard Laboratory for Atmosphere's Data Assimilation Office (DAO). This multi-year gridded global atmospheric data set provides a comprehensive description of the Earth's climate. The spatial resolution of the data is 2 degrees by 2.5 degrees over the entire globe. At present, the model has a complete five-year dataset from March 1985 to February 1990, although there are plans to extend it. Some parameters are reported as frequently as every three hours at 18 vertical levels. Parameters include surface temperature, wetness, pressure, etc., both longwave and shortwave radiative fluxes, atmospheric temperature, turbulence and wind, water vapor, clouds, and many others.

This dataset was produced by blending actual observations with a state-of-the-art Atmospheric General Circulation Model (AGCM). The assimilation of high-quality observations constrains the model to a degree of accuracy that would not be possible by model parameterization alone. Likewise, the model provides a global three-dimensional perspective that is impossible to achieve through observation. The quality of the model and its high spatial and temporal resolution combined with the multi-year duration of its output make this dataset among the best available for the study of the Earth's climate.

This and other data sets are accessible through the Goddard DAAC's online Information Management System. This menu-driven interactive data system is open to the public, but access to certain restricted data products requires special authorization. For more information or to access the 4-D Assimilated Data Set, contact the GSFC DAAC User Services Office at (301) 286-3209, or via Internet at daacuso@daac.gsfc.nasa.gov.

From *EOS.News*

ECS SYSTEM DESIGN REVIEW

The EOSDIS Core System (ECS) System Design Review (SDR) was held at NASA/GSFC June 27-29. The initial reaction to the review was very positive. Plans for the Landsat ground system were included in the SDR presentations. The Review Board chaired by Robert Price will prepare a list of issues for the ECS contractor (Hughes). Review Item Discrepancies will be collected from individuals until July 8. As a follow-on to the SDR, a separate cost review was held on June 30.

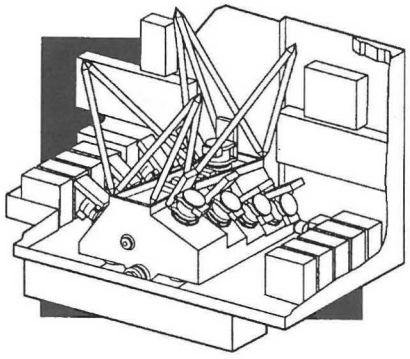
PATHFINDER UPDATE

A one-day sample of all the Pathfinder Data Products is available through the Mosaic Home Page for the Pathfinder Equinox Sampler (http://pathfinder.arc.nasa.gov). A viewer program for displaying, navigating, analyzing, and remapping large HDF files called MERLIN, developed for Pathfinder by the University of Wisconsin is available from the same server. The Implementation Team for the EOS Pathfinder project responsible for data from the TIROS Operational Vertical Sounder (TOVS) met May 25-27 at NASA/GSFC. Data set production for the Pathfinder Benchmark Period (April 1987 to November 1988) is due to be completed in July. Several validation efforts are in progress both here and in France to obtain quantitative error estimates. The TOVS data sets include atmospheric layer mean temperatures, specific humidity, total precipitable water, skin temperature and sea surface temperature, surface emissivity, cloud fraction, cloud-top temperature and pressure, total ozone, and polar environmental parameters. TOVS data for one day are between 1 and 2 gigabytes. Thus, the total volume for the whole Benchmark Period TOVS data is over a terabyte (ca. one day of EOS data). Global browse images will be stored and can be viewed individually or in movie sequences for quick search of the data. The TOVS browse images can be viewed with a program developed by JPL called VISTAS.

Multi-Angle Imaging Spectroradiometer Science Team Meeting (MISR)

March 30 - April 1, 1994, in Pasadena, CA

—**Daniel Wenkert**, MISR Science Coordinator, Jet Propulsion Laboratory



Members of the Multi-angle Imaging Spectroradiometer (MISR) Science Team, along with science and software-support personnel from JPL, several scientific colleagues, and representatives of the ESDIS Project and the Langley Research Center DAAC met at JPL for the annual MISR Science Team Meeting. The meeting lasted three days, two days in open session and one in executive session. The meeting began with the Principal Investigator, David Diner, welcoming the participants and describing the meeting's objectives. Diner spoke about recent work on MISR's Algorithm Theoretical Basis Documents (ATBD) and our continuing need to deliver documents and software on a timely basis.

MISR Instrument and Related Issues

Status reports on the MISR project and instrument were presented early Wednesday morning (March 30), beginning with a report by MISR Project Manager, Terrence Reilly, who discussed the engineering model (EM), which will contain 2 cameras and one of each type of calibration photodiode. The EM will undergo extensive testing this year.

Reilly spoke about progress made in the design and fabrication of MISR CCDs, filters, hybrid circuits, field-programmable gate arrays, and optical bench. Later, MISR Instrument Scientist, Carol Bruegge, gave a brief overview of the MISR instrument and spoke about recent design changes. MISR will no longer have any on-board data editing, and data averaging is now available at 1x4 pixels (but not at 8x8). Bruegge reported that we are currently meeting our signal-to-noise-ratio specifications, even for end-of-mission life.

Data System Issues

Graham Bothwell, MISR Science Data System Manager, then spoke about development of algorithms and related software. The MISR algorithms and their processing loads are much better understood than a year ago. Much of this progress is due to finishing the ATBD for each major algorithm. However, original sizing estimates resulted in our being declared a "tall pole."

The plan for algorithm and software development has changed as a result of a year's experience. MISR is now looking at the "evolving prototype" model, where the investigators and the Science Data System Team (SDST) work closely together at all stages. This is already happening with the Level 1B2 software, and is beginning to happen with the Level 2 Aerosol algorithms.

Bothwell then spoke about the "tall pole" issue. The figures for MISR's processing load decreased by a factor of three from July 1993 to December 1993. One example of how this is done is to use one-time preprocessing at the MISR Science Computing Facility (SCF) to decrease the processing load at the DAAC. Improved figures on the processing load will be generated regularly.

Larry Fishtahler, from the ESDIS Project, spoke about the recent EOSDIS developments and future milestones. He expressed surprise at the overall growth in EOSDIS data processing, I/O, and storage requirements. Fishtahler said he was pleased with the relationship with MISR in working through "tall pole" issues.

Level 1 Data Products and Related Issues

Next, Carol Bruegge described Level 1B1 product generation. Level 1A data are converted to radiances, and a clear-sky mask is produced. In addition to radiometric scaling, MISR Level 1B1 processing will include dead-pixel fill, coherent noise filtering, and detector non-uniformity correction.

Scott Lewicki and Veljko Jovanovic described MISR Level 1B2 product generation, in which radiance data are projected onto Space Oblique Mercator grids. Two major concepts, embodied in the algorithm that will run at the DAAC, were described. The first one is an adaptive image-matching scheme, to improve knowledge of pixel location on the Earth. The second algorithm is backward projection, to resample all MISR data (from 9 cameras, in 4 spectral bands). If EOS AM1 performs at the specification (90 arcsec), image matching will fine-tune the projection parameters so that images are registered to our requirements. If EOS AM1 performs as forecast (30 arcsec), navigation will automatically provide the registration we need. A clear-sky mask (part of the 1B1 product) will indicate where image-matching will and will not be performed, to avoid clouds.

MISRSIM, the MISR simulation program, was then described by Mike Smyth. No current dataset accurately simulates the oblique views of MISR. MISRSIM generates simulated Level 1B1 data, using Landsat and digital elevation model data as input. In developing MISRSIM, software from the Digital Image Animation Laboratory, such as that developed for *LA: The Movie*, was used.

Level 2 Cloud and TOA Radiation Products and Related Issues

The rest of Wednesday afternoon (March 30) and the earliest part of Thursday morning (March 31) were occupied discussing progress in developing MISR's Level 2 Top-of-the-Atmosphere (TOA)/Cloud Product-Generation algorithms and related software. The discussion began with Daniel Wenkert, the MISR Science Coordinator, describing the product elements. He then gave quick overviews of processing flow at the DAAC for the Reflecting-Layer Reference Altitude (RLRA, a product element that in cloudy regions refers to cloud-top height), coarse-resolution TOA albedos, and the other parameters.

Roger Davies then described recent research at McGill University. Especially important is Tamas Varnai's discovery that cloud inhomogeneities at scales <100 m have little effect on bi-directional reflectance (BDR). Davies presented Norman Loeb's results from analyzing one year of ERBE data over the oceans. These showed how plane parallel theory departs from observations, especially as a function of azimuth angle for large solar zenith angles. The most likely cause is cloud side illumination, which must be accounted for in developing the azimuthal coefficients of bidirectional reflectance (an important development activity for MISR).

Davies described the differences between expansive vs. restrictive TOA albedos, (both calculated at 35.2-km horizontal resolution). For the restrictive TOA albedo, TOA upwelling radiation from each 35.2-km square region is assumed to originate from that region alone. For the expansive albedo, one calculates the contributions to the upwelling radiation at the top of the atmosphere (actually 30 km above sea level), from all the surrounding regions, at the appropriate angles. The current movement in the radiation-budget scientific community is to compare albedos in cloudy and clear regions at higher spatial resolution (<100 km). At these resolutions, the differences between expansive and restrictive albedo can be profound.

On Wednesday afternoon and Thursday morning, Larry Di Girolamo of McGill, and Eugene Clothiaux of Pennsylvania State University, described the cloud detection techniques in the TOA/Cloud ATBD. These are largely based on threshold techniques. Clothiaux pointed out the need to get cloud screens in all 9 cameras, relying on existing techniques. Following discussion, the consensus was to devote a small effort to develop preliminary thresholds pre-launch, so that algorithms can be exercised in the first 3 months. There would follow a larger effort to derive thresholds post-launch; this would entail an effort to develop the appropriate threshold-derivation software (for use at the SCFs) during the pre-launch period.

Peter Muller described recent research at University College, London (UCL). He is currently looking at a variety of stereo image-matching software. All software

comparison work has been done on SPOT surface data, AVIRIS simulated stereo pairs, and Along Track Scanning Radiometer (ATSR-1) data (in SWIR spectral bands). Real cloud stereo imagery (like that from ATSR-1) doesn't currently have separately-determined cloud height data. Muller is collaborating with Paul Menzel (on the MODIS team) on comparing retrieved cloud heights from ATSR using stereo, and from GOES-VAS using thermal profiles and CO_2-slicing.

Level 2 Aerosol Products and Related Issues

Most of the rest of Thursday morning (March 31) was occupied discussing progress in developing MISR's Level 2 Aerosol Product-generation algorithms and related software. Ralph Kahn, a member of the MISR Science Staff at JPL, described the Aerosol Product. He also discussed the Aerosol Climatology product, which will be used to constrain the aerosol properties that are retrieved. Kahn suggested reporting optical properties at more than just the four MISR spectral bands, specifically in all the MODIS bands. Kahn then described the Simulated MISR Ancillary Radiative Transfer (SMART) dataset. This dataset consists of the results of forward calculations and will be used in lookup tables at the DAAC, to do aerosol retrievals. To deal with those conditions where there is a large stratospheric aerosol optical depth, it was decided to include stratospheric aerosols explicitly in calculating the SMART dataset. SAGE data, if available, would be used to constrain which models would then be used in the table lookup during aerosol retrieval.

Co-Investigator Howard Gordon then described recent research at the University of Miami on retrieving aerosol properties over water. He discussed the physical basis of a new idea for retrieving aerosol optical thickness. The method consists of solving the radiative transfer equation (RTE) for each component of the size distribution separately and then synthesizing these results to find the solution for the whole distribution.

Co-Investigator John Martonchik described recent research at JPL on retrieving aerosol properties over land. He described several algorithms that isolate the atmospheric path radiance over heterogeneous land targets. Finally, Martonchik discussed additional constraints derived from the Direct-Field aerosol algorithm, developed by David Diner and Susan Paradise. This algorithm works with data from two large view angles and retrieves the differences in optical depth between the MISR blue, green, and red spectral bands.

The Langley Research Center (LaRC) DAAC

Just before lunch on Thursday, Robert Seals made a presentation on the LaRC DAAC, which will be responsible for MISR data. He first described the orientation and purpose of the DAAC, emphasizing that EOSDIS exists now as version 0. Specific disciplines for the LaRC DAAC are radiation budget, clouds, aerosols, and tropospheric chemistry. Currently, data access and distribution are the top priority. Seals described the major data sets at the DAAC and how to get access to them; the DAAC has both high-end and low-end interfaces.

Following Seals' presentation on the high-end (MOTIF) interface into the LaRC DAAC, and the tools needed to support MISR data, he described the LaRC DAAC User Working Group. He described the evolution of the DAAC; interim Release 1, the first to deal with EOS algorithm integration and test, is scheduled for January 1996.

Level 2 Surface Products and Related Issues

The first half of Thursday afternoon (March 31) was occupied discussing progress in developing MISR's Level 2 Surface Product-generation algorithms and related software. John Martonchik began by describing the Level 2 Surface Product. He pointed out what was deleted and added to the product since last year. He stepped through the equations for the surface retrieval. Only a few iterations of the relevant equation are needed, resulting in errors of only ~2-3 percent. These errors are dominated by errors in the assumed aerosol model (retrieved in the Level 2 aerosol retrieval).

Co-Investigator Sig Gerstl introduced his associate Chris Borel, who then described recent research at Los Alamos National Laboratory. Borel first talked about terrain corrections for height and slope. He showed the effects of reflections from adjacent terrain, which are important only for regions with slope >10 degrees, the MISR topographic screen; in fact Borel's results indicate that we can use surface slopes up to ~30 degrees.

Borel then discussed retrieval of TOA albedo from MISR data in non-cloudy areas. Roger Davies discussed the use of angular signature and azimuthal anisotropy seen in the MISR data themselves to choose the azimuthal model that produces the most unbiased estimate of albedo.

The Near-Term Development Schedule

Late Thursday afternoon (March 31) Daniel Wenkert gave an overview of tasks to be accomplished over the next year.

Wenkert spoke first about the stereo image-matching algorithm needed to retrieve cloud-top heights; much of the TOA/Cloud Product depends on its successful development. This was followed by a discussion of cloud detection, classification, and screening (DC&S). Task assignments were then presented for the Aerosol algorithms. Developing the first (preliminary) version of the Simulated MISR Ancillary Radiative Transfer (SMART) data set is the highest priority. This development will go hand in hand with sensitivity studies to determine the distinguishability of different aerosol compositional models.

Work on the Surface algorithms has progressed to the point that this activity is not expected to determine the pace of MISR algorithm development anytime soon. In presenting MISR team accomplishments over the last year, Wenkert mentioned the progress made in developing TOA/Cloud algorithms, the major changes to the Aerosol algorithms, and the fact that development of the surface algorithms is substantially complete.

Calibration and Validation

The EOS AM project is considering the possibility of maneuvering the spacecraft to point the instruments at the Moon, for calibration. Carol Bruegge described several possibilities for lunar calibration maneuvers. The purpose for any such maneuver would be to provide some EOS AM instruments with a view of a long-term stable source. Howard Gordon pointed out that SeaWiFS plans to do this once per month as the only way of determining long-term degradation of the instrument. Others were concerned that thermal effects could change MISR's geometric calibration. These effects need analysis.

MISR Validation Scientist Jim Conel concluded the session by describing the work at JPL on plans for validating the Aerosol and Surface Product algorithms. Field instruments include sun photometers, PARABOLA-II, and a shadowband radiometer to support ASAS aircraft overflights. The MISR Team is participating in larger field campaigns, such as Boreal Ecosystem-Atmosphere Study (BOREAS). Most of the work on validating the TOA/Cloud algorithms will be performed by the Co-Investigators who are developing them. In the latter case, Conel would aid in planning the validations and would provide ground support where possible.

Detailed minutes of this meeting are available from the MISR project office at JPL. ■

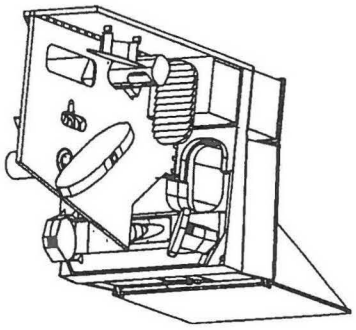
From *EOS.News*

NASA GLOBAL CHANGE FELLOWSHIPS AWARDED

On June 24, 1994, NASA Headquarters awarded 59 new NASA Graduate Student Fellowships in Global Change Research for the 1994-95 academic year, following a peer review of 351 applications. This is the fifth year of this program, and the new students bring the total number of fellowships awarded to 280, with the second large class of about 35 expected to receive the Ph.D. degree this year. The new fellows represent 37 U.S. universities in 25 states; 36% are women, and 24% are foreign students from Brazil, Canada, Germany, India, Italy, Korea, Sierra Leone, United Kingdom, Ukraine, and the former Yugoslavia. The criteria for selection included academic excellence, the quality of the proposed research, and the relevance of the research to NASA's role in the U.S. Global Change Research Program, the Mission to Planet Earth. The awardees will be conducting research in the key areas of Climate & Hydrologic Systems (23), Ecological Systems & Dynamics (12), Biogeochemical Dynamics (10), Solid Earth Processes (4), Human Interactions (3), Data & Information Systems (2), and Solar Influences (1). The purpose of this fellowship program is to train a pool of highly qualified scientists to help analyze and interpret the wealth of data generated prior to and during the Earth Observing System (EOS) era. Global Change Fellows must pursue a Ph.D. degree in Earth Sciences at U.S. universities, for which they will receive a renewable stipend of $20,000, and up to $2,000 to support their research. An announcement for 1995 Global Change Fellowships is planned for the end of this year.

Moderate-Resolution Imaging Spectroradiometer (MODIS) Science Team Meeting

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



MODIS Overview

The MODIS Science Team met May 4-6 at the Greenbelt Marriott. Vincent Salomonson, MODIS Team Leader, welcomed the attendees and began the meeting by reporting that MODIS and the EOS Program are in a turbulent period. Salomonson said one of the objectives of this meeting is to prepare for the ATBD (Algorithm Theoretical Basis Document) review. He reported that the need for a 15-year EOS data set has been questioned at the highest levels. He feels that EOS must provide observations that document global and regional change. This means that all instruments should be well calibrated and characterized so that results can be intercompared over time and space.

Diane Wickland, NASA Headquarters, stated that the MODIS Team needs to begin planning future budgets so that they may respond to possible cuts in a way that is thoughtful and responsive to priorities across the board.

EOSDIS Status Report

H.K. Ramapriyan (Rama) stated that a working prototype of the version 0 processing software for the DAACs will be released in July 1994. Representatives from among all user groups will serve as "tire kickers" for the software. Online documentation is being made available on the World Wide Web (WWW).

Regarding science data processing, Steve Wharton, EOSDIS Project Scientist, stated that the current processing requirements are believed to exceed the current EOSDIS budget for hardware. There is a need to link requirements to cost. He feels that the ATBD review will help identify who will process what data and who will provide ancillary data. A clear understanding is needed to define the EOS products for which EOSDIS will provide interfaces, and which products will be supported at the DAACs. He said there also needs to be a schedule for the phase-in of post-launch products.

MODIS Project Reports

Richard Weber, MODIS Instrument Systems Manager, announced that the EOS AM Project has asked Santa Barbara Research Center (SBRC) to develop a cost reduction and control plan, which they will submit later this month. He announced that in order to save money, SBRC will reuse some of the engineering model (EM) parts on the MODIS prototype. The only OBC (on-board calibrator) on the EM will be the blackbody. SBRC will assemble and test the MODIS EM over the next seven months. Weber noted that the EM will not include the corrections for the ghost image problem—those fixes will be implemented in the protoflight model. Weber announced that the electronics breadboards are complete, as is the beryllium structure.

Weber introduced Tom Pagano, who delivered the SBRC report. Pagano stated that SBRC will not build an SRCA (Spectroradiometric Calibration Assembly), solar diffuser, or SDSM (solar diffuser stability monitor) for the EM because they are not critical to its functionality. These shortcuts will allow SBRC to get test data sooner and begin devising any necessary fixes.

MODIS Science Support Reports

Bruce Guenther, acting head of MCST (MODIS Characterization Support Team), reported that MCST has

rescoped its core Level 1B algorithm for Product Generation System (PGS) processing. MCST will also develop an auxiliary algorithm, that is not part of its Level 1B algorithm for SCF processing, for analyzing the bowtie effect of overlapping pixels. Guenther stated that MCST will not do masking, nor will it resample or replace dead pixels.

Steve Ungar stated that MCST can exploit the bowtie effect in MODIS to determine how well calibration is performed. For example, differences in optical properties of the scan mirror surfaces can be determined, detector-to-detector calibration can be performed within a band, and system misalignments can be examined. Ungar also said that since detector 1 coverage overlaps both detectors 9 and 10, MCST will have the ability to derive the relations between detectors 9 and 10.

Ed Masuoka, Science Data Support Team (SDST) Leader, reported that SDST will deliver beta software to EOSDIS in June 1995. In January of this year, they received heritage code from the Science Team. According to Masuoka, there were some problems with the code; he stated that SDST prefers test data in ASCII format rather than binary. SDST expects to receive "MODIS-like" software from team members in October 1994 that uses a number of MODIS channels. By April 1995, SDST hopes to be able to integrate all MODIS software end-to-end.

Al Fleig presented SDST's perspective on simulated test data. He explained that they will perform both science and code tests on the data. Science tests include testing of both individual algorithms and connected algorithms. Code tests consist of single algorithms, MODIS processing strings, MODIS end-to-end processing, and EOSDIS end-to-end processing. SDST's approach to code testing will involve using real data provided by Science Team members and converting them into a format that will be used by MODIS.

Land Group Science Presentations

Dorothy Hall gave a presentation on her efforts to map the temporal and spatial variability of snow on hemispheric, continental, and large watershed scales. She explained that her product will be a 7-day composite of the maximum snow cover at 1-km resolution. Global-scale snow cover maps are used to extend and improve estimates for climatological studies and as input to GCMs (global climate models). Regional-scale maps are used as input to hydrological models to improve runoff prediction and are useful for predicting water supply and flooding.

Jan-Peter Muller stated that the Land Group needs digital elevation models (DEMs) for all activities to which MODIS products will be applied. He said MODIS needs three-to-five grid points per pixel in order to calculate terrain slopes—a 0.5-km grid is more than sufficient. Muller stated that there is no single-source solution for the supply of a global DEM at the 100-m resolution required for MODIS land processing. There are a number of options which require further investigation of costs and problems of data supply.

Eric Vermote presented an overview of atmospheric correction activities to date. He said their goal is to prepare and validate the MODIS algorithm for atmospheric correction over land. Vermote stated that he plans to work on developing pre-launch aerosol global climatology using AVHRR data.

Atmosphere Group Science Presentations

Liam Gumley gave a presentation on the multi-sensor remote observations of thin cirrus clouds during the FIRE Cirrus II campaign. He explained that thin cirrus clouds have important radiative effects on remote sensing activities, such as performing atmospheric corrections. Gumley concluded that a single instrument is not sufficient for cirrus cloud detection, and that VIS, NIR, and IR information are all useful in tandem. He also encouraged the development of robust detection/classification methods that will allow for the correction of thin cirrus.

Steve Platnick gave a presentation on the uncertainties in the retrieval of optical thickness and droplet radius for liquid water clouds. He explained that optical thickness and effective cloud droplet radius are the major cloud parameters for determining current and future cloud energetics/forcings, processes in cloud development, and parameterizations for general circulation models. He noted that the 1.6-μm band is good for measuring effective radius, as are the 2.2- and 3.7-μm bands.

Yoram Kaufman stated that it is important to characterize aerosol size distribution because that helps scientists understand the magnitude of aerosol radiative forcings, e.g., convection and climate cooling, and how they affect cloud condensation nuclei (CCN), atmospheric chemical reactions (such as ozone depletion), and remote sensing of land and oceans.

Ocean Group Science Presentations

Otis Brown gave a presentation on the role of sea surface temperature (SST) in climate change. SST is the primary mechanism for communicating the ocean upper layer thermal state to the atmosphere, affecting both weather and climate. Today, we can retrieve SST globally to within ±0.5°C. However, we still do not have a long-term global data set.

Bob Evans presented the Ocean Group's method for establishing a processing framework and match-up database for using AVHRR global area coverage data. The goals are to implement a database with satellite, *in situ*, and ancillary data for vicarious sensor calibrations, and to validate algorithm products.

Dennis Clark reported on the initial results of the Marine Optical Buoy (MOBY), which was deployed in February off the west coast of Lanai, HI. The major objectives of the MOBY campaign are to provide a continuous time series of high-spectral-resolution water-leaving radiances for quality assessments of Ocean Color Flight Instruments, and to characterize the bias of the derived pigment fields induced by the observational constraint of a sun-synchronous orbit by optically measuring the temporal variability of the phytoplankton.

Options for Implementing a MODIS Volcano Alarm

Luke Flynn, representing Peter Mouginis-Mark and the volcanology IDS team, discussed options for including a volcano alarm on MODIS, without which scientists will have no operational capability to begin monitoring an eruption in near real time. He hopes to implement a thermal alarm that will enable volcanologists to detect potential eruptions anywhere on Earth. Flynn proposed using the MODIS band at 3.75 μm to detect hot targets during the day, and 1.64 or 2.13 μm at night. He said the only operational commitment needed from the MODIS Team is to implement the volcanology IDS team's small algorithm to see fires; the remaining data processing can be done elsewhere. Adding a volcano alarm will also require turning the 2.1 μm band at night.

Calibration Group Summary Report

Phil Slater gave a summary report of the Calibration Working Group meeting. Regarding the MODIS scattered light problem, he stated that MODIS may not meet the transient response specification because stray light was not originally included as an error source. The sources of stray light are ghosting, optical cross talk, electronic cross talk, and scatter from the scan mirror. This may affect radiometric accuracy in the presence of clouds. Slater stated that the ghosting problem was mostly fixed with the redesign options. He said the crosstalk is marginal.

Slater reported that the Calibration Group is concerned that the testing and validation schedule for both the EM and protoflight model (PFM) of MODIS may be too short. The preflight characterization of the PFM will not be completed until April 1996, which leaves too little time to modify the OBC hardware and/or algorithms should problems arise.

Land Group Summary Report

Chris Justice summarized the proceedings of the May 5 MODIS Land Group (MODLAND) Meeting. MODLAND will participate in the upcoming Boreal Ecosystem-Atmosphere Study (BOREAS) campaign. MODLAND is discussing with Wayne Esaias and Gene Feldman the possibility of using SeaWiFS data as part of its prototyping efforts for producing land products.

Atmosphere Group Summary Report

Michael King reported that the Atmosphere Group met with MODLAND to discuss the upcoming SCAR-C campaign. King announced that everyone from the Atmosphere Group has submitted beta software to SDST.

MODIS Cloud Mask

Paul Menzel reported on his coordinated efforts with the CERES Team and John Barker to develop a MODIS

Cloud Mask. He said he will provide the team with an algorithm from which they may make their own cloud mask. Specifically, Menzel said his mask will indicate whether the FOV has an unobstructed view of the Earth's surface and whether the FOV is affected by clouds.

Ocean Group Summary Report

Wayne Esaias reported that the delivery of software to SDST will be impacted by the slip in the SeaWiFS launch date. According to Esaias, EOS Color will fill a critical role for global coverage frequency. Esaias encourages the use of SeaWiFS observations by other disciplines.

6.13 Conclusions

Vince Salomonson concluded the Science Team Meeting by stating that he has two concerns: 1) ATBD peer reviews and 2) gaining agreement on how to proceed with algorithms for atmospheric corrections, calibration, and cloud masking. The next MODIS Science Team Meeting will be Oct. 12-14 at the Holiday Inn in College Park, Maryland. ■

From *EOS.News*

TOMS UPDATE

On Tuesday, June 21, the TOMS science group at NASA/GSFC presented to the science community a review of their planned version 7 algorithm for Nimbus 7 TOMS. As part of this review, the TOMS investigators summarized planned changes to the algorithm and their impacts on the data. Particular issues included absolute wavelength calibration, detector nonlinearity, effect of rotational Raman scattering (Ring effect), and wavelength dependence of reflectivity. The new algorithm will take all these effects into account, and provide an improved data set for use by the scientific community. It is likely that reprocessing of all 14.5 years of data will begin in August, 1994, and be complete by late fall or early winter. The launch of the next TOMS instrument, TOMS/EP, has been postponed from July 16 following the failed launch of the first L1011/Pegasus XL (which was destroyed while carrying a U.S. Air Force STEP1 satellite on June 27). All Pegasus XL launches are on hold pending the findings of review boards assembled by the Air Force and by Orbital Sciences Corp.

From *EOS.News*

1994 AWARD WINNERS ASSOCIATED WITH EOS

A number of researchers contributing to EOS investigations were recipients of major awards from their peers in the scientific community: Pamela A. Matson (NASA/Ames Research Center), a member of the EOS Interdisciplinary Science (IDS) Team for biosphere-atmosphere interaction studies led by Piers Sellers, was elected to the National Academy of Sciences. Soroosh Sorooshian (University of Arizona), who is the U.S. leader of a joint France-U.S. IDS team studying the hydrology of arid lands, was also elected as a 1994 Fellow of the American Geophysical Union (AGU). Daniel J. Jacob (Harvard University), a member of the science team for the Tropospheric Emission Spectrometer (TES), was honored with the AGU James B. MacElwane Medal in recognition of scientific contributions to the geophysical sciences by a scientist under the age of 35. Dr. Jacob was cited for his contributions to atmospheric chemistry. Finally, three members of the EOS IDS Team for global hydrology studies led by William Lau were honored this year. Wilfried H. Brutsaert (Cornell University) was elected to the National Academy of Engineering. Joanne Simpson (NASA/Goddard Space Flight Center) was honored as a 1994 AGU Fellow. Peter S. Eagleson (MIT), was awarded the AGU William Bowie Medal for his outstanding contributions to fundamental geophysics and for embodying the AGU motto, Unselfish Cooperation in Research. Dr. Eagleson was cited for extending hydrology to regional and global scales and for his instrumental role in redefining hydrology as a rigorous and quantitative element of the Earth Sciences, not merely an engineering subdiscipline.

Data Assimilation for EOS: Mosaic Access to DAO Information

—**Rob Lucchesi**, (rob@pinhead.gsfc.nasa.gov) and **Richard Rood**, Goddard Space Flight Center, Greenbelt, MD

The Data Assimilation Office (DAO) at the Goddard Space Flight Center recently opened a link to the World Wide Web (WWW). This will allow users on the Internet to use the popular Mosaic application to access the latest information about research at the DAO, including the latest information on the Goddard Earth Observing System—Data Assimilation System (GEOS-DAS). In addition to providing general non-technical information to interested Internet users, this service will become a valuable tool allowing the DAO to distribute information about ongoing projects to the Earth-science research community. Any user with an X-Windows display can access documents that integrate text with full-color graphics and links to other servers.

One important function of the DAO's WWW link will be the dissemination of information related to some of the special projects currently underway. One such project is the multi-year assimilation. At this time, the DAO has produced a multi-year (3/85-2/90) gridded global atmospheric data set for use in climate research (Schubert *et al.*, Bull. Amer. Met. Soc., 1993). Information about the availability of these data and links to the distribution site are provided on the DAO mosaic homepage. Some of these data can be obtained from the Goddard Distributed Active Archive Center (DAAC), which also uses a WWW link for communication with the Internet community (see *4-D Timeseries Dataset*, page 6).

In addition, the DAO has been processing a 4x5-degree assimilation of the troposphere and stratosphere for the operational period of the Upper Atmosphere Research Satellite (UARS). This assimilation began in September 1991 and has currently been completed through June 1993. The assimilation uses STRATAN, the stratospheric configuration of the GEOS-DAS, and incorporates 46 model levels and 18 analysis levels (up to 0.4 mb). This is a valuable data set for stratospheric transport studies and other applications.

The DAO has also started a series of assimilation experiments using data from the Tropical Ocean-Global Atmosphere/Coupled-Ocean Atmosphere Response Experiment (TOGA/COARE), which was conducted from November 1, 1992 to March 1, 1993. The DAO has completed a baseline experiment and expects to perform experiments to test the impact of SSM/I total precipitable water, SSM/I winds, and TOGA/COARE observations.

The DAO is also currently involved in supporting the Airborne Southern Hemisphere Ozone Experiment/ Measurements for Assessing the Effects of Stratospheric Aircraft (ASHOE/MAESA) mission. It is designed to study the effect of high-speed aircraft on ozone levels in the lower stratosphere. GEOS-DAS is being used along with products from other meteorological centers for planning the flights of the high-altitude ER-2 aircraft. The mission is based in Christchurch, New Zealand. Participation in this mission has helped to develop an operational capability that demonstrates data flow problems and bottlenecks that must be addressed prior to the EOS AM1 launch. It also provides a good scientific venue in which to experiment with research versions of the system.

At the core of the assimilation system is the GEOS general circulation model (GCM). The description and documentation of version 1 of the GEOS GCM is available on the Mosaic homepage. Also included is a short document entitled Model Requirements for Data Assimilation at Launch (MRDAL). This document describes new collaborative efforts at Goddard to assure a high-quality assimilating model in the 1998 EOS-era system. Highlights include current plans for land-surface modeling and development of cloud water and ice parameterizations.

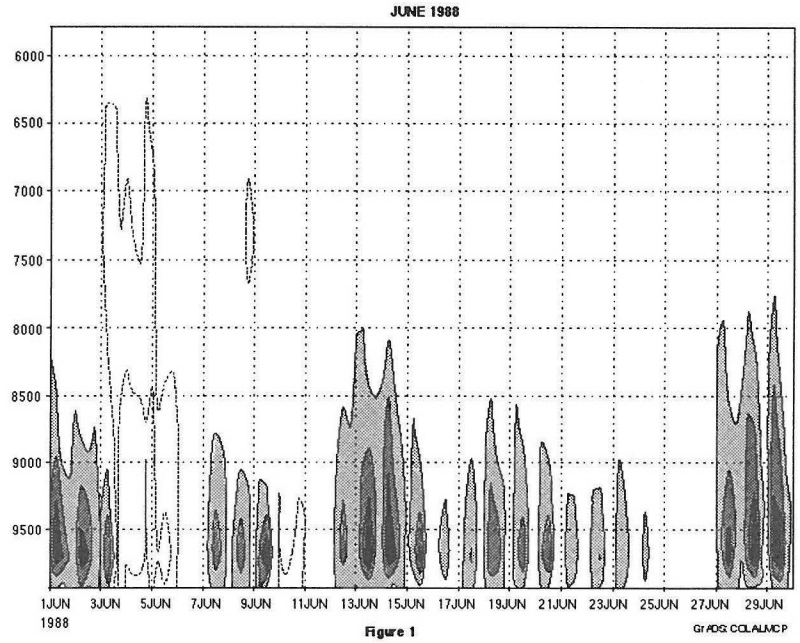
In addition to information about these projects, users of the Mosaic page will be able to browse a directory

containing brief descriptions of specific research topics under investigation at the DAO. Documentation of many components of the GEOS-DAS will be available. Updates on Kalman filter development and the DAO's involvement in the High Performance Computing and Communications Initiative will be online. Any future publications by DAO personnel will be available as well as administrative information about the office.

The Uniform Resource Locator (URL) for the DAO Mosaic home page is: http://dao.gsfc.nasa.gov/dao.home_page.html

Update on Data Availability

The DAO has produced a series of unique data sets. Unfortunately, the distribution of these data sets has been problematic. Recently, the Goddard DAAC has brought a subset of the 5-year data set online. We have tested this facility, and it has worked reliably. The Goddard DAAC has taken the initiative to service the entire data set, but the time scale for this remains on the order of a year. In the near term, left to our own devices, the DAO is trying to enhance our distribution capabilities. Current capabilities are described on the Mosaic homepage. It is crucial for the DAO to get scientific feedback on the DAO product in order to improve it for the 1998 system. These distribution problems, for this rather modest 1 TB data set, highlight and parallel the problems that must be solved by EOSDIS in order to provide a successful data distribution system. ■



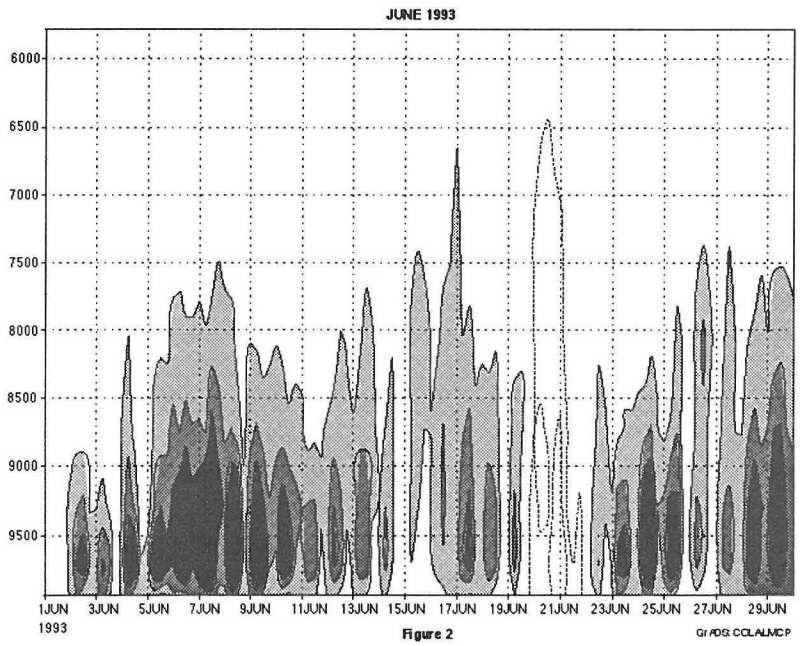


Figure Caption: These two images show the northward moisture flux (g/kg m/s) during the month of June for two different years. The transport of moisture depicted is at a location of 30 degrees North and 100 degrees West, or near the Gulf Coast of Texas. The relatively low values of northward moisture flux in June 1988 (Figure 1) are indicative of the serious drought experienced in the Midwest at that time. Similarly, the high values in June 1993 (Figure 2) are indicative of the record rainfall rates and flooding experienced in that year. These results are products of the DAO's GEOS-DAS multi-year assimilation and can be found on the DAO Mosaic homepage. They show the ability of the assimilation procedure to derive information on diurnal variability to derive from a set of observations that alone under sample the diurnal cycle.

AIRBORNE SCIENCE FLIGHT OPPORTUNITIES

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

The accompanying table was submitted by NASA's Airborne Science Office. The intent is to let investigators know of planned scientific flight opportunities that may offer the possibility of shared resources for Earth observation. Some of the missions shown require deployments that could provide possible "piggyback" opportunities in the areas to be overflown during such "ferry" flights. In some instances, advanced knowledge of the missions will facilitate arrangements for sharing of data.

Entries in the table do not necessarily indicate firm commitments to carry out these missions, but should nevertheless serve as a guide to the possibilities for cooperative airborne research activities.

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

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

AES	Airborne Emission Spectrometer
AIRSAR	Airborne Synthetic Aperture Radar
AOL	Airborne Oceanographic Lidar
ARC	NASA Ames Research Center
ARPA	Advanced Research Projects Agency (DoD, formerly DARPA)
ASAS	Advanced Solid-state Array Sensor
ASHOE	Airborne Southern Hemisphere Ozone Experiment
ASTRO	Astronomy Platform (Shuttle)
ATLAS	Atmospheric Laboratory for Applications and Science
AVIRIS	Airborne Visible & Infrared Imaging Spectrometer
AVIS	Airborne Vegetation Index Sensor
BOREAS	Boreal Ecosystem-Atmosphere Study
ELV	Expendable Launch Vehicle
FAST	Fast Auroral Snapshot Explorer
FIRE	First ISCCP Regional Experiment
FIRARI	Far Infrared Array Radiometric Imager
GEWEX	Global Energy and Water Cycle Experiment
GTE	Global Troposphere Experiment
HARC	Sounding rocket name
HST	Hubble Space Telescope (Repair Mission)
ISCCP	International Satellite Cloud Climatology Project
IML	International Microgravity Laboratory (Shuttle)
JPL	Jet Propulsion Laboratory
LASAL	Large Aperture Scanning Airborne Lidar
LASE	Lidar Atmospheric Sensing Experiment
LEAP	Lightweight Exo-Atmospheric Project (Sounding rocket support)
LIDAR	Light Detection and Ranging
LITE	Lidar In-Space Technology Experiment
MAC	Multiple Aircraft Campaign
MACAWS	Multiagency Airborne Coherent Atmospheric Wind Sounder
MAG	Magnetic, Geo-Magnetic, or Io-Magnetic
MAG-DIP	Magnetic Dip Campaign
MORTIDROP	Airborne Release of "Morti" (name) Instrument (Sounding rocket support)
MSBLS	Microwave Shuttle Beam Landing System
OADS	Optical Air Data System
OAST	Office of Applications and Space Technology (Shuttle)
ORION	Sounding rocket name
PALIS	Polarized Airborne Laser Imaging System
PEM	Pacific Exploratory Mission
POLAR	NASA Solar-Terrestrial Mission (Shuttle)
RADARSAT	Canadian SAR Satellite
ROWS	Radar Ocean Wave Spectrometer
SCAR-A/B/C	Smoke, Clouds, and Radiation, Mission A-C
SAR	Synthetic Aperture Radar
SeaWiFS	Sea-viewing Wide Field-of-view Sensor
SEIDAM	System of Experts for Intelligent Data Management
SFU-RET	Space Flyer Unit-Return (Japan)
SH	Space Habitat module
SIR-C	Shuttle Imaging Radar, Payload-C
SLM	Space Lab Module (Mir)
SLS	Space Life Sciences (Shuttle)
SOHO	Solar and Heliospheric Observatory
SPAS	Shuttle Pallet Satellite
SRL	Shuttle Radar Laboratory Program
STS	Space Transportation System, Space Shuttle
SURFSAT	Synchrotron Ultraviolet Radiation Facility Satellite
SWAS	Sub-millimeter Wave Astronomy Satellite
TDRSS	Tracking and Data Relay Satellite System
TERR	Sounding rocket name
TIMS	Thermal Infrared Multispectral Spectrometer
TOMS	Total Ozone Mapping Spectrometer
UAF	Upper Atmospheric Flash
USGS	United States Geological Survey
USML	U.S. Microgravity Laboratory (Shuttle)
VANDAL	Sounding rocket name
WIMP	Water Impact Payload
WIND	NASA Solar-Terrestrial Mission
WFF	NASA Wallops Flight Facility
X-STORM	Thunderstorm Research Program
XTE	X-ray Timing Explorer

NASA Outyear Airborne Strategy

CY 1994 | CY 1995

FY 1994 | FY 1995

Oct Nov Dec Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec Jan Feb Mar Apr May June July Aug Sept

ELV

- P TOMS
- D WIND
- D POLAR
- P FAST
- D RADARSAT
- D SURFSAT
- P SWAS
- D XTE
- IC SOHO

STS

- Columbia: 58 SLS2; 62 OAST2; 65 IML2; 67 ASTRO2; 73 USML2
- Discovery: 60 SH2; 64 LITE; 63 SH-3; 71 TDRSS
- Atlantis: 66 ATLAS-3; 70 SLM
- Endeavour: 61 HST; 59 SRL-1; 62 SRL-2; 69 SPAS OAST; 72 SFU-RET

DC - 8

- OADS — Dryden
- SRL / SIR-C — 1st Flight
- SRL / SIR-C — 2nd Flight
- ARPA / USGS — Germany, Saudi Arabia
- AIRSAR — Flights
- MACAWS
- JPL / AES
- GTE — V-Tests
- "B" Level Inspect
- GTE / PEM WEST
- BOREAS
- "B" Level Inspect
- MAG-North Ion — Code SS/U.Mass
- Pacific Rim — Under Discussion
- MAC Australia — Proposed
- "C" Level Inspect

ER - 2

- AVIRIS Experiments
- BIOMASS Mission of Opportunity
- AVIRIS Experiments
- BIOMASS Mission of Opportunity
- Puerto Rico
- Ellington Field
- BOREAS
- SEIDAM — Canada
- LASE — WFF
- SCAR-C — ARC
- Antarctic Zone — Christchurch N.Z.
- MAC Australia
- FIRE — Tropical Cirrus
- SCAR-B
- LASE — Winter Validation
- LASE — GEWEX Kansas
- LASE — Summer Storm

ARC 130-B

- TIMS / ASAS Experiments
- TIMS / ASAS Experiments
- BOREAS
- "B" Level Inspect

P - 3B

- AOL — Belize / Ecuador
- AES — WFF
- Atlas / AOL — Greenland
- AOL — SeaWiFS
- ASAS / AOL — MODIS
- LASAL
- LITE Calibration — Chile / Ecuador

L - 188 Electra

- TERRA
- ZERO-T
- LEAP / ORION
- LASE
- LEAP
- Electra Retired from Service
- X-STORM
- VANDAL
- WATER VAPOR

WFF C-130Q

- VANDAL
- LIDAR — Arctic
- Logistics — Brazil
- LITE Calibration — Carib / Brazil / Africa
- MSBLS
- MORTI DROP
- MSBLS — Spain Arctic

T - 39

- ATLAS
- ATLAS
- LASE
- LASE
- ATLAS
- LASE
- HARC
- ROWS
- MAG-DIP — Brazil

UH - 1

- WIMP
- FIRARI
- BOREAS — WFF
- BOREAS — WFF
- BOREAS — Canada
- AVIS
- PALIS
- MORTI DROP

Mission Support Aircraft

- Kansas City (Space Physics) Aero Air Westwind — UAF Lightning
- Kansas City (Space Physics) Aero Air Jet Commander — UAF Lightning
- Kansas City (Space Physics) Aero Air Westwind — UAF Gamma Ray
- Kansas City (Space Physics) Aero Air Jet Commander — UAF Gamma Ray (Proposed)
- ASHOE / Ozone — C-141 Support AC
- FAST Underflight — Alaska / Canada (Space Physics) Aero Air Westwind

P = Pegasus, D = Delta, IC = International Class, LC = Large Class. TDRSS/GOES Not Listed

Science Working Group for the AM Platform (SWAMP)

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

The Science Working Group for the AM Platform (SWAMP) met at Goddard Space Flight Center (GSFC) on May 18, 1994. Representatives of all AM Platform instruments, as well as many Earth Observing System (EOS) and platform scientists and engineers were in attendance. John Klineberg, GSFC Director, provided a thorough "view from the top." The various speakers then described instrument design and development progress, algorithm development status, and EOS Data and Information System (EOSDIS) design and implementation issues. Matters involving overlap between instruments or working groups were stressed. Significant progress continues to be made in all aspects of EOS implementation.

EOS Overview

Klineberg provided an overview of the current state of EOS. The EOS Program, already descoped over the past four years, now faces additional cuts and competition from other space endeavors, and risks becoming financially fragile. Maintaining the current level of EOSDIS, the AM Project, and science funding, and allocating the cuts to later EOS spacecraft runs the hazard of having the project lose its flexibility. This situation could be improved as other agencies, such as the National Oceanic and Atmospheric Administration (NOAA) and the Environmental Protection Agency (EPA), expand their role in this scientific inquiry.

We should differentiate continuity of data from continuity of instruments—technology improves and we should take advantage of technology developments whenever we can. Should EOS downstream plans call for multiple identical instrument copies or should we push the technological envelope with innovations, including those in data capture and processing? We must focus on the original goal of EOS, to provide data for environmental decision makers, and convince Congress of the urgency of this need. An advanced PM spacecraft with new technology may be part of the answer.

The scope of EOS exceeds other projects we have attempted, and breaks ground in many areas. The AM spacecraft is the largest ever delivered by the builder. We are depending on the Air Force to launch the AM spacecraft from an as-yet unbuilt launch pad in California. Can the EOSDIS have all the capabilities we have required? Perhaps every issue from spacecraft size and number to the data distribution system should be reanalyzed, streamlined, and sold to decision makers. We must enlarge the EOS constituency to receive added support.

AM1 Overview

Chris Scolese provided an overview of the AM1 Project. All AM instruments are in the process of being designed and fabricated. Each has its own strengths and critical paths. As development matures, we are now identifying and resolving some engineering conflicts between instruments, as well as capability tradeoffs within each instrument design. Issues of pointing, sunglint, jitter, weight, and electronics require close cooperation among the various instrument designers. There is still adequate funding available, but financial constraints are beginning to appear on the horizon. The next order of business for peer reviews will be to look at higher-level products.

Algorithm Theoretical Basis Document (ATBD) Reviews

Michael King and Forrest Hall addressed the ATBD Review process. The recent round of ATBD reviews was useful, and permitted independent evaluation of the utility and status of the product algorithms while bringing all instrument teams to a consistent level of maturity. Reviewers (280) from all over the world responded and provided their points of view. The visiting committees also provided independent insight. The process pointed out strong and weak areas. Part of the outcome will be a clearer definition of at-launch algorithm status. Piers Sellers suggested that the review

provided two results: it let the Project Science Office see what was going on, and also let the EOS community see what is going on. He suggested repeating the effort in a year or so.

Review committees are assessing the material presented, and will begin to make recommendations shortly. Significant uncertainties still exist in certain classes of product algorithms requiring atmospheric corrections, cloud masking, and redundant calibration. Land system modelling and classification requires more attention, especially in the area of vegetative indices. Forrest Hall questioned the current vegetation index. He is concerned that compositing be done before atmospheric correction so that repeatable look-angle observations are selected. He also suggested that more sophisticated land-cover algorithms exist, and their use should be explored.

Martha Maiden and Brian Bailey pointed to the need for a standardized Topography/Digital Elevation Model (DEM) for product generation, with input desired from the various instrument science teams. Should we avoid redundancy in product development, such as the CERES/MODIS cloud analysis, or can each instrument justify its own set of algorithms? Skip Reber indicated that there is a continued need for peer-reviewed calibration-algorithm development. Anne Kahle reiterated the need for cooperation among science teams, especially in the areas of validation of similar products. An example would be MODIS, ASTER, and MISR providing joint validation of surface temperature and radiance products. Yun-Chi Lu and Ed Chang suggested coordination meetings between data users and suppliers, and the utilization of Science Data Interface Control Documents (ICD), listing required data products for each AM instrument.

Skip Reber also indicated that calibration must continue after launch, to account for changes (e.g., the 1-g shift and the thermal environment of space). As important as absolute calibration is, even more important is relative (long-term) calibration.

Bruce Guenther emphasized two basic conclusions from the calibration peer review: 1) not enough is being done on AM1 dataset calibration for global change products; and 2) there are no Level 2 products that must be produced at launch which are as critical as the Level 1B dataset.

EOS Data and Information System

Steve Wharton assessed the current EOSDIS status. Instruments impact one another in data processing, as well as physically on board the spacecraft. Coordination between instruments is required in the areas of toolkit development, science product quality assurance (QA), data product import/export, reprocessing, and product implementation scheduling. In addition, the EOSDIS design is still fluid, with budget and data processing constraints working to make it less ambitious. We must still get a firm grasp on issues such as metadata requirements, QA, input/output (I/O) requirements and algorithm production processes.

Moderate Resolution Imaging Spectroradiometer (MODIS)

The MODIS presentation was made by Vince Salomonson. MODIS is currently addressing key science-algorithm issues, including reflectance retrieval, cloud masking, treatment of multiple calibration sources, gridding, NDVI, and end-to-end sensitivity analysis. The ghost light problem has been solved. MODIS products are desirable for the production of the science products of other instruments. However, those instruments need to know the degree of accuracy of those products to fully use them. An example is cloud-top radiance. MODIS land-surface data-product algorithms seem to require the most attention at this point.

Paul Menzel presented information concerning the MODIS Cloud Mask. This effort will benefit from previous work including the International Satellite Cloud Climatology Project (ISCCP), NOAA Clouds from AVHRR (CLAVR), and HIRS CO_2 slicing activities. The product will be available with three resolutions: 250 m, 500 m, and 1000 m, with calibrated, navigated MODIS data as input. Incomplete data will result in holes. Simple thresholds offer considerable skill, but there are many conditions (small cumulus, cirrus, etc.) where this characterization is inappropriate. Spatial coherence tests will offer confirmation of scene uniformity. Prelaunch testing will utilize AVHRR/HIRS and the MODIS

Airborne Simulator (MAS) data, and there will be a phased implementation 3 to 6 months after launch.

Multi-Angle Imaging Spectroradiometer (MISR)

Dave Diner addressed the current MISR status. The MISR Critical Design Review (CDR) is scheduled for December 1994. The MISR Engineering Model (EM) is currently in fabrication. The EM cameras, optics train, and dual-drive actuator parts are currently being fabricated. The spectral filters, flight computer, calibration diffuser panels, and charge-coupled devices (CCDs) are complete. The power, weight, and data rate of the instrument remain within allocation. Current design issues include spacecraft jitter resolution, sunglint from nearby instruments, and lunar calibration. The total data processing load has been reduced by a factor of three since the last SWAMP meeting, but is still a concern. However, in many respects, I/O and data volume are more important than simple CPU usage. This issue should be addressed by EOSDIS to ensure proper preparation for data processing capacity.

Clouds and the Earth's Radiant Energy System (CERES)

Ed Harrison addressed the current CERES status. The CERES CDR was successfully held last December. The CDR Panel recommended that flight unit construction begin. Preparation for the Tropical Rainfall Measuring Mission (TRMM) instrument is well underway, including completion of the CERES Flight Design Functional Test Model (FTM), Proto-flight Model (PFM), and TRMM interface test. The TRMM launch is scheduled for June 1997, and the CERES flight on TRMM will precede that on EOS AM. The ATBD reviews were both helpful and encouraging. Additional work is required on a detailed validation plan, including error analysis and simulations, and a tighter schedule. Issues of cloud-analysis overlap with MODIS need to be addressed.

Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)

An ASTER presentation was made by Hiroyuki Fujisada. ASTER is in the EM test phase. The ASTER CDR is scheduled for the fall of 1994, with a calibration peer review in November. An issue remains in the resolution of jitter deriving from the shortwave infrared (SWIR) Stirling cycle cooler. A possible change from capillary loop to heat pipe cooling has significant cost, science, and schedule implications. The issue of lunar calibration and the required spacecraft gyrations are under study. The ASTER Science Team is becoming involved in plans for pre-flight analysis of engineering test data. Anne Kahle added that the ATBD process clarified some thinking and was very helpful to the ASTER team. ASTER has decided to create joint algorithms to be used by both the Japanese and American teams. She was also concerned about the utilization of either standard EOS-wide, or instrument-unique DEMs.

Measurements of Pollution in the Troposphere (MOPITT)

Speaking for MOPITT, Jim Drummond indicated that the instrument Preliminary Design Review (PDR) is complete, with a separate PDR for software early next year. Remaining issues concern meeting the accuracy specifications of the methane channel and defining polarization specifications. A preliminary calibration review was held in March. The MOPITT optical design has been finalized, and progress has been made in the design of the modulator, and the mechanical and thermal components. An instrument calibration facility is under development. The MOPITT CDR is scheduled for December 1994. A MOPITT aircraft experiment is desired, but not yet funded. Remaining issues include ambiguous results from the Capillary cooling experiment on the Space Shuttle, PGS toolkit delivery schedule, and the utility of extended lunar viewing.

Advanced Very High Resolution Radiometer (AVHRR) Pathfinder

Mary James discussed the AVHRR Pathfinder Program. One area of progress is that of gridding and spatial resolution. Any long-term dataset requires standard gridding, and a uniform standard should be set by EOS. Gridding actually includes three issues of data presentation: grid spacing, data binning, and mapping sequence. The resolution of input data should, if possible, conform to that of the products being generated. We must define such mundane concepts as day versus night, map projection, and surface type, and quantify the errors introduced during the transformation from one grid to another. ■

INTERNATIONAL GEOSPHERE-BIOSPHERE PROGRAMME

of the International Council of Scientific Unions (ICSU)

New Executive Director for IGBP

Professor Chris Rapley has been appointed by ICSU as the new Executive Director of the International Geosphere Biosphere Programme (IGBP). He succeeds Professor Thomas Rosswall, who is leaving to become Rector of the Swedish University of Agricultural Sciences, Uppsala. Rosswall has been the IGBP Executive Director since 1986, when the programme was formally established by the International Council of Scientific Unions.

Rapley is a physicist with expertise in Earth observation, high-energy astronomy and solar physics. He is currently Head of Remote Sensing, and Associate Director of the Department of Space and Climate Physics, at the Mullard Space Science Laboratory, University College London. His main research has been the development of new satellite instruments and the exploitation of space-based environmental data, working with the European Space Agency (ESA) and the U.S. National Aeronautics and Space Administration (NASA).

In the period 1974 to 1980, Rapley was involved in instrument development for the NASA Solar Maximum Mission, a spacecraft designed to study solar flares. During several years subsequently spent in the USA, he became interested in the application of remote sensing to global change, especially the use of radar altimetry to study climate-related questions. He and his colleagues have had considerable success in determining the thickness of polar ice-sheets and sea-ice; in measuring changes in inland water levels (rivers, lakes and wetlands); in the topographic mapping of arid land areas; and in the development of novel approaches to the operation of radar altimeters and the processing of their data.

Professor Rapley has been a member of the UK National IGBP Committee and has closely followed the development of the programme, with links primarily through the IGBP Data and Information System (IGBP-DIS). He will take up his duties at the IGBP Secretariat in Stockholm, Sweden on 1 September 1994.

For further information, contact: Prof. Christopher G. Rapley, Mullard Space Science Laboratory, tel: +44 483 274111; fax; +44 483 278312; Dr. Phillip Williamson, Office of SC-IGBP Chairman, UEA Norwich, tel: +44 603 593111; fax: +44 603 507714; Suzanne Nash, Information Officer, IGBP Secretariat, Stockholm, tel: +46 8 166 448; fax: +46 8 166 405. ■

Retrieval of the ENSO Signal from Vegetation Index Data

—**Assaf Anyamba** (aanyamba@vax.clarku.edu), Clark University, Graduate School of Geography, The IDRISI Project, 950 Main St. Worcester, MA. 01610.

Over the last decade systematic measurements of the Earth's surface using the NOAA AVHRR instrument have yielded a large array of data important in monitoring vegetation conditions. A number of studies have revealed and illustrated the use of the Normalized Difference Vegetation Index (NDVI) computed from AVHRR channel 1 and 2 reflectances as a sensitive indicator of variability in the current climate, especially with regard to precipitation regimes. A major component of such annual and interannual climate variability is that set of anomalies termed El Niño Southern Oscillation (ENSO) events. Its recurrence every three to seven years provides a clear signal of climate variability on a global scale. Its land surface manifestations are illustrated by heavy torrential storms on the west coast of South America and droughts in Sahelian Africa, South Africa, Australia, and Eastern Brazil. Since droughts induce moisture stress in vegetation, and NDVI is a good indicator of such stress, NDVI data can reveal components of climate variability that are related to such ENSO events.

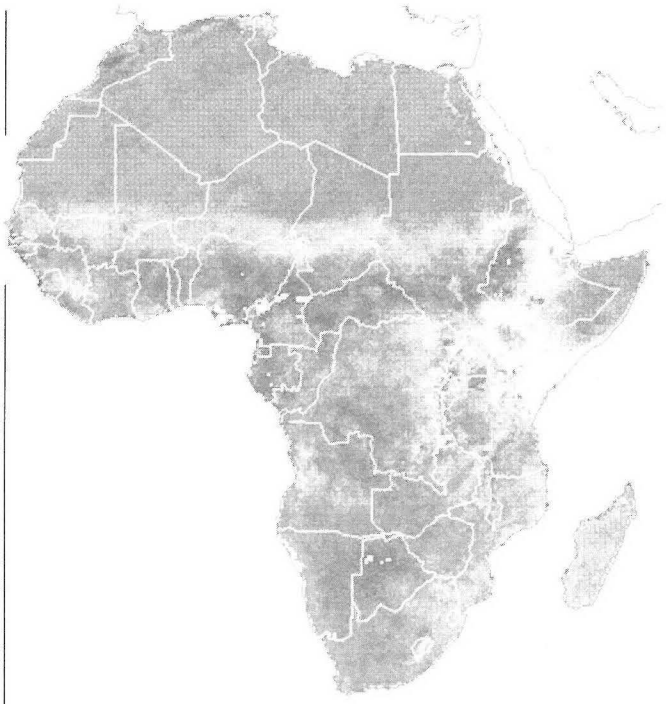


Figure 1a. Spatial pattern of component 7

A large amount of NDVI time series data is now available. However, there is still a need for the development of techniques that will enable us to understand the major underlying factors influencing variability in that data in relation to climate at different time scales. There have been few attempts to link variability in NDVI data with ENSO events and patterns of drought. Most studies

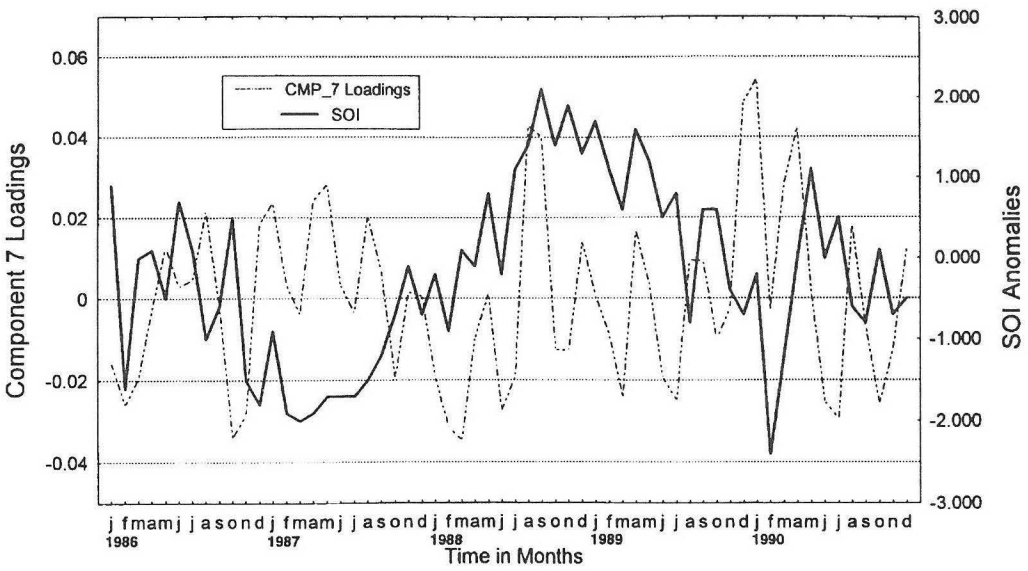


Figure 1b. Time Series 1986-1990: component 7

have used time-profiling techniques, which tend to emphasize the seasonal signal of NDVI at the expense of other signals of variability that have a lifetime of more than one season or have localized spatial effects. Other techniques, such as the principal components transform, traditionally used in reduction of remotely sensed data, have been employed successfully in climatology for space/time analysis. The major advantage of this transform is in the analysis of variance by apportioning the overall variance from a set of time-series measurements to a group of patterns ranked in order of importance. The number of component patterns derived is equal to the number of time slices input. In most cases only a few of these patterns are easily interpretable. We have applied this technique to analyze monthly NDVI data for Africa for the period 1986 to 1990. The results of the transformation are a series of images and graphs of loadings. The loadings show the correlation of each original NDVI image with the new component images. When plotted, these loadings show the temporal evolution of a given pattern, while the corresponding image represents the spatial expression of the pattern. We present partial results from this analysis for components 7 and 8 that indicate a linkage to ENSO events.

The spatial pattern of component 7 is shown in Figure 1a, with an anomaly across the Sahel and Eastern Africa appearing as light gray. Figure 1b is the loadings graph for this component. The pattern retrieved shows positive anomalies for the Sahel-East Africa region for 1986 to mid-1987 and predominantly negative loadings from mid-1987 through 1988 (Figure 1b). The former corresponds to a period of increased precipitation in the region (high NDVI), while the latter corresponds to a period of drought (low NDVI). There is a return to positive loadings in 1990 that correspond well to a change from negative to positive values in the Southern Oscillation Index (SOI). Such positive SOI values correspond to ENSO cold phases and are associated with decreased precipitation, while negative SOI values correspond to ENSO warm phases, which are generally associated with enhanced precipitation in monsoon areas of the world.

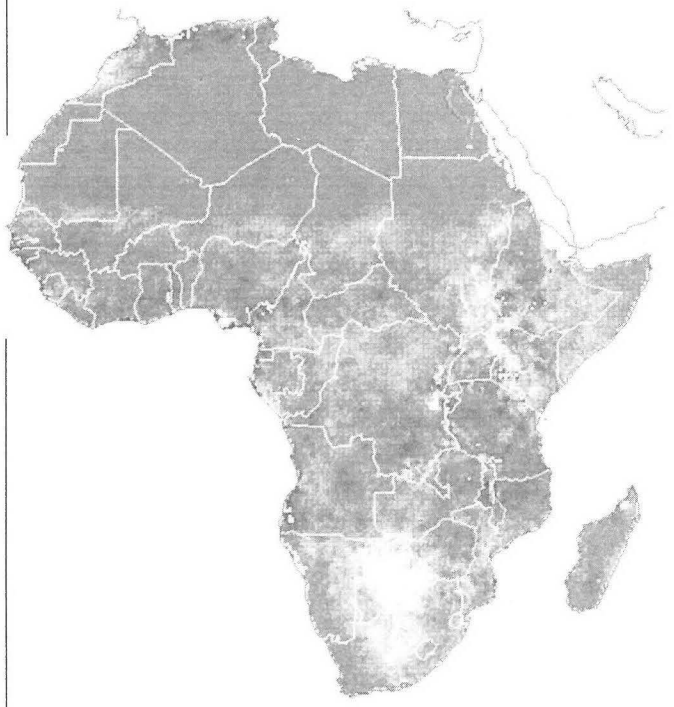


Figure 2a. Spatial pattern of component 8

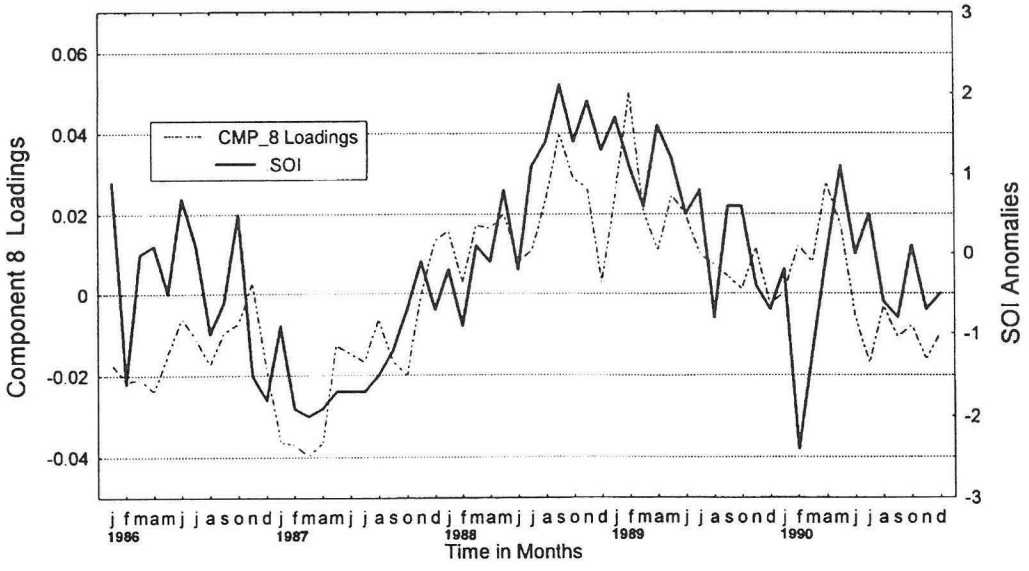


Figure 2b. Time Series 1986-1990: component 8

A comparison of the component 7 loadings with the SOI shows that the two graphs are out of phase during the 1987-1988 ENSO warm event (Figure 1b). The overall correlation between SOI and component 7 loadings for the entire period of analysis is low and negative (r = -0.0890). This may indicate that ENSO warm events (negative SOI) have a tendency to result in wet conditions in Eastern Africa and hence high NDVI values. These results are corroborated by World Meteorological Organization (WMO) reports showing that warm ENSO events are associated with droughts in Southern Africa and enhanced precipitation in East Africa.

Figure 2a is the spatial pattern for component 8 and shows a strong positive anomaly centered in the Southern African country of Botswana (light gray area). The loadings chart (Figure 2b) shows positive loadings in 1986 and August 1988 to September 1990 corresponding to ENSO cold events. The period 1987 to mid 1988 shows a negative loading pattern and corresponds to the period of drought (low NDVI) in this region during the ENSO warm event. A comparison of component 8 loadings and SOI shows that both graphs are well synchronized in their temporal patterns. The correlation between the two is high and positive, r = 0.64745, and illustrates the strong relationship between ENSO events and patterns of variability of vegetation greenness in Southern Africa.

This five-year analysis illustrates that it is possible to retrieve the ENSO signal and its related spatial effects from time-series vegetation-reflectance data using the principal components transform. A comparison of component loadings and SOI shows that there is a high positive correlation between variability in vegetation greenness in Southern Africa and ENSO events, and a weak correlation between vegetation greenness in the Sahel and East Africa with ENSO events. This conclusion agrees with WMO findings regarding SOI and precipitation for the two regions. Eastern equatorial Africa failed to exhibit typical ENSO warm-episode precipitation during the 1986-1988 period (WMO, 1988). It does however, raise the question of whether there are actual hemispheric differences in ENSO effects over Africa or whether there are other sources of climatic variability in the Sahel-East Africa region that may be unrelated to ENSO. These research questions require further investigation, preferably incorporating surface precipitation data from the two regions.

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WMO/UNEP (1991) The Global Climate Systems - Climate System Monitoring, December 1988 - May 1991.

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Further information regarding this research can be obtained from The IDRISI Project, Graduate School of Geography, Clark University, 950 Main St. Worcester, MA. 01610. e-mail: idrisi_res@vax.clarku.edu, Attn.: Assaf Anyamba or Michele Fulk.

Intergovernmental Panel on Climate Change

Article reprinted from: *Global Change Newsletter* March 1994, No.17.
The International Geosphere-Biosphere Programme (IGBP)
of the International Council of Scientific Unions

The Intergovernmental Panel on Climate Change (IPCC) is the body responsible for the scientific and technical assessment underlying the Framework Convention for Climate Change agreed to in Rio de Janeiro in June 1992. The IPCC was created in 1988 by the United Nations Environment Programme and the World Meteorological Organization. It is partly financed by these organizations, and partly by voluntary contributions from various countries.

The Chair of the IPCC is Bert Bolin. Professor Bolin was actively involved in the initial planning and implementation of the IGBP, from the time he chaired the *ad hoc* planning for the IGBP during 1984-1986, and through his terms as Vice-Chair of the Special Committee for the IGBP, and its successor, the Scientific Committee for the IGBP, from 1987 to 1992.

The task of the IPCC is carried out by three Working Groups, of which Working Group I is concerned with the Scientific Assessment of Climate Change. Working Group I published its first assessment in 1990, with an update in 1992. In order to make preparations for its next assessment, due in September 1995, the group met in Shepperton (UK) in early December last year. Several points of relevance to IGBP scientists came out of the discussions.

The structure of the 1995 report will be similar in many respects to the earlier assessments, but obviously updated using the most-recent information. Many IGBP scientists are involved in writing the central chapters covering topics such as *The Carbon Cycle, Trace Gases, Aerosols, Radiative Forcing, Climate Variability and Change, Climate Processes and Models, Sea-level Change*, and *Detection of Climate Change*.

Of particular interest are two chapters on *Responses to Environmental Change*, and *Feedbacks to Climate of the Terrestrial and the Marine Biosphere*. In contrast to the earlier assessments, this time the marine and terrestrial biospheres will have separate chapters, and IGBP scientists will be heavily involved in their preparation. Finally, the chapter called *Narrowing the Uncertainties* in the 1990 report, will now be called Advancing our Understanding, and once again it will be principally authored by the Chairs of the Scientific Committees of the World Climate Research Program (WCRP) and the IGBP.

The Working Group I Support Unit is located at the Meteorological Office, Hadley Climate Centre, Bracknell, UK. It is headed by Bruce Callander.

Working Group II addresses the impacts of climate change and the means for mitigation and adaptation. The Support Unit is located at the Office of the U.S. Global Change Research Program, in Washington, DC, where it is headed by Richard H. Moss. For two years prior to heading the WG II Support Unit, Dr. Moss was Programme Officer at the IGBP Secretariat, ensuring the liaison between the Human Dimensions of Global Environmental Change Programme and the IGBP. ■

Our Changing Planet: The FY 1995 U.S. Global Change Research Program

From the Office of the U.S. Global Change Research Program, 300 D St. S.W., Suite 840, Washington, D.C. 20024

The Subcommittee on Global Change Research, of the United States National Science and Technology Council's Committee on Environment and Natural Resources Research, announces the release of the Annual Supplement to the President's Budget:

The U. S. Global Change Research Program (USGCRP) has released its annual report *Our Changing Planet*, which details the President's Budget Request for FY 1995 for global change research programs, describes some of the key global change issues, and outlines the contributions of the USGCRP to international efforts in global change research. The interagency FY 1995 budget request for the USGCRP totals $1.8 billion. This level of funding would allow the USGCRP to continue to carry out the research needed to underpin sound policy development on global environmental issues. The USGCRP is also developing new programs to link the predictions of future global change to potential socio-economic changes that may be of direct interest to decision makers. These new programs in the social, economic, and policy sciences will enhance the linkages between science research and policy development through the involvement of public and institutional decision makers in program planning and through the development of new integrated assessment and decision-analysis tools.

The USGCRP, along with research programs in many other countries, has helped to provide the world with the policy-relevant scientific insight to underpin key international conventions on the protection of the global environment. One of these is the Vienna Convention for the Protection of the Ozone Layer and its Montreal Protocol and subsequent amendments. These agreements have led to a worldwide phase-out of substances that deplete the ozone layer, including a complete ban of the most harmful chlorofluorocarbons (CFCs). The U.S. is also one of many nations that have signed and ratified the Framework Convention on Climate Change, which is committed to protecting the environment for present and future generations, ensuring a climate conducive to continued availability of the world's food and water supplies, protecting ecosystems and human societies from environmental stress, and promoting economic development in a sustainable manner. On April 21, 1993, President Clinton announced the nation's commitment to reducing U.S. greenhouse gas emissions to 1990 levels by the year 2000. The U.S. Climate Change Action Plan, released in October, 1993, details how to meet this obligation. To provide the basis for considering further actions, USGCRP is developing new tools for assessing policies and options for responding to climate change and to other environmental challenges that could threaten human health, social and economic well-being, the diversity of biological species, and the future of the nation's natural resources.

The USGCRP has been a leading contributor to the international body of scientific knowledge about the climate system and its physical, chemical, biological, ecological, and social and economic interactions. Substantive and useful new findings and information are resulting from USGCRP programs. A sampling of research highlights from *Our Changing Planet* includes the following:

- USGCRP space-based observations and analyses form the best-documented record of global land-use to date. More than 22,000 scenes from Landsat have been collected and archived, and the data are being used to generate products such as global land cover maps and for monitoring global vegetation.

- As an example of the implementation of the U.S. policy, which provides for full and open access for all to U.S. global change data, ozone satellite data have been made available free over the Internet network to the international scientific community and to the general public within 2-3 days of satellite acquisition. Hundreds of requests for these data are received each month from all over the world.

- The USGCRP has demonstrated significant success in forecasting large-scale changes in sea surface temperatures of the tropical Pacific Ocean, especially the onset of the El Niño-Southern Oscillation (ENSO) warming events that can dramatically alter precipitation patterns over much of the Pacific basin, including the southwestern United States. Forecasting of ENSO events can greatly benefit the peoples and the economies of impacted areas. Many of the countries most affected by ENSO events are developing countries with economies that are largely dependent upon their agricultural and fishery sectors for a major source of their food, employment, and foreign exchange. In Ceará, Brazil during the drought of 1991-1992, a systematic effort to organize the timing of seeding, based on climate forecasts, allowed agricultural production to be maintained close to the historical annual mean; whereas in previous El Niño periods, agricultural production had sharply declined. Sustaining production in these regions helps prevent food price fluctuations in other areas, including areas in the U.S.

- By reconstructing worldwide snapshots of past climates, USGCRP scientists are assembling data for testing the effectiveness of climate models by simulating past conditions. Results of these studies lead to model improvements that enhance confidence in predictions of the magnitude and timing of future changes in global climate. Recent results from the analysis of Greenland ice cores have revealed that rapid changes in climate may have occurred over time periods less than a decade, and that these changes are probably associated with "switching" between stable ocean modes, a "switch" possibly caused by changes in sea-ice conditions. Model tests of these changes will help lead to understanding the potential for future climatic surprises.

The consensus of most scientists worldwide is that increasing concentrations of greenhouse gases will lead to significant climate warming, shifts in precipitation patterns, and rising sea levels, although the magnitude, timing, and regional patterns of these changes cannot be accurately predicted at this time. The USGCRP will continue its strong support of national and international scientific research to enhance understanding of the causes and implications of climate change and other global changes. Proposed new USGCRP research will focus on assessing the vulnerabilities of human and ecological systems to both long-term and short-term global changes and contribute to developing response options that will lead to the sustainability of national and global social and economic systems.

Copies of *Our Changing Planet: The FY 1995 U.S. Global Change Research Program* may be obtained by calling or writing to: Global Change Research Information Office, 2250 Pierce Road, University Center, MI 48710. voice: (517) 797-2730; Fax: (517) 797-2622; e-mail: help@gcrio.org; also GCRIO Gopher Information service on the Internet: using telnet: telnet gopher.gcrio.org; using gopher: gopher.gcrio.org ■

Beijing Energy Efficiency Center (BECon)

—Note received from **Zhou Dadi**, Executive Director of BECon, ERI, SPC, China

Beijing Energy Efficiency Center (BECon) is a new organization, formally established last December. BECon is now affiliated with the Energy Research Institute (ERI) of the State Planning Commission. It will ultimately become an independent, non-governmental and non-profit organization, but for now it is part of ERI. The objectives of the Center are to promote energy efficiency and environmental protection activities in China, including policy research, pilot projects, technical transfer, and public education. We also provide consultation services for foreign companies, including market survey, information collection, and project feasibility analysis.

BECon officially opened in December 1993. The Center's purpose is to develop energy-efficiency policies and joint ventures essential for China to make a transition to more-sustainable energy development and use. BECon will help China pursue economic development while minimizing energy-related impacts on the local and global environment.

The Need for Efficiency

China is the world's second largest emitter of greenhouse gases, producing two-to-three times as much carbon dioxide per unit of economic output as is economically efficient. Current emission levels are expected to triple or even quadruple by the year 2025, depending on whether China improves its energy efficiency. Inefficient energy use in China not only heightens the risk of global climate change, but also harms the local environment and hampers economic development. Energy waste leads to power shortages that erode economic productivity and to excessive coal combustion that causes severe air pollution and acid rain.

A New Model for International Cooperation

BECon, like the energy efficiency centers established by Battelle and the World Wildlife Fund (WWF) in Russia and Eastern Europe, is directed and staffed by local energy experts. Zhou Dadi will serve as BECon's executive director. Currently Deputy Director of ERI, he is a leader in Chinese energy-pricing research and climate-change policy negotiations. The center is administratively affiliated with ERI, but its goal is to evolve into an independent institution as the Chinese political system changes.

BECon was founded by Battelle Pacific Northwest Laboratory, World Wildlife Fund (WWF), Lawrence Berkeley Laboratory, and ERI. BECon's board of directors includes the founders and leading Chinese energy policy makers, managers, and researchers. Initial funding is being provided by the U.S. Department of Energy, the U.S. Environmental Protection Agency, and WWF. BECon's goal is to become self-supporting after four years.

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From the Department of the Interior, U.S. Geological Survey, Reston, Virginia 22092

EROS DATA CENTER: BRINGING SPACE DOWN TO EARTH

The scientific revolution begun by using satellites to observe the Earth from space entered a new era on Tuesday, May 31, 1994, when the U.S. Geological Survey (USGS) broke ground for a major new building at the Earth Resources Observation System (EROS) Data Center in Sioux Falls, South Dakota.

"This addition will augment a long-standing partnership between the USGS and the National Aeronautics and Space Administration," Al Watkins, chief of the USGS National Mapping Program, said. "It will house the processing and distribution facilities for data that will be acquired by EOS, the Earth Observing System, the keystone of NASA's Mission to Planet Earth." Construction of the 60,000 square foot addition will begin in early summer, with completion scheduled for early 1996.

The more than two million satellite images of the Earth's surface that have been collected by the EROS Data Center over the last 20 years already make it the world's largest single repository of remote sensing data.

According to Don Lauer, chief of the EROS Data Center, the primary challenge facing researchers during the early years of land-observation satellites was to demonstrate that remote-sensing instruments fulfilled their expectations. "Scientists needed to know if they could assess the condition of crops, for example, by analyzing infrared style images derived from electromagnetic scanning devices orbiting 500 miles overhead," Lauer said. "Today, data from space help guide forest management, wildlife habitat monitoring, snowmelt prediction, crop irrigation assessment, flood mapping and several other critical resource decisions for both government and commercial organizations all over the world.

"In less than one year, NASA's Earth Observing System will transmit more data to EROS than we have received during the past 20," Lauer explained. "This technology brings the next major challenge in Earth observation and analysis–capturing, processing, and distributing vast archives of remotely sensed data." In cooperation with the EROS staff, NASA is designing and funding the purchase of advanced computer systems that will be used in the new building to handle the incoming data stream and rapidly distribute it to scientists and resource managers around the country and throughout the world.

A field site for the USGS National Mapping Program, the EROS Data Center also manages other forms of Earth data, including over 8 million aerial mapping photographs covering the United States. ■

FEDERAL INFORMATION MANAGERS ENCOURAGED BY SPATIAL DATA ORDER

The Executive Order signed recently by President Clinton to develop the National Spatial Data Infrastructure (NSDI) will help coordinate the collection of geospatial data by government agencies and make it more accessible to users, according to the Federal group responsible for the mapping lane of the information highway.

"With this order, the President is requiring Federal agencies to be more cost-effective and efficient in managing spatial information. The NSDI will provide an umbrella for Federal, state, and local government agencies and the private sector to cooperatively develop and share geospatial data, including transportation and hydrologic networks, elevation, administrative boundaries, soils, geology, land cover, and socioeconomic information," Nancy Tosta, Executive Secretary of the Federal Geographic Data Committee (FGDC) said. "Among other things, this will translate into improvements in our ability to manage natural resources, to plan our communities and to monitor the environment," Tosta said. "The goal is for everyone to have access to higher quality, more-current data for decision making on issues ranging from biodiversity to emergency response."

The Executive Order signed April 11, 1994, charged the FGDC, chaired by Secretary of the Interior Bruce Babbitt, with coordinating Federal agency efforts to develop the NSDI. Specifically, the Executive order directs the FGDC to:

- Involve all levels of government and the private sector in developing the NSDI and identify strategies for sharing the costs of data collection.
- Develop a plan for completing a national digital geospatial data framework for the nation, as a foundation for other data collection activities.
- Establish a National Geospatial Data Clearinghouse to facilitate finding and retrieving geospatial data.
- Identify, develop, and promote the use of standards needed to make data sharing easier.

"This Executive Order gives us the opportunity to change the way data-providing and data-using organizations do business," Tosta observed. "All citizens should benefit as the increased availability of geographic information leads to better decisions at all levels of government."

(Note to Editors: Copies of the Executive Order and additional information on the FGDC are available from the FGDC General Secretariat, (703) 648-5725.) ■

From *EOS.News*

ALGORITHM THEORETICAL BASIS DOCUMENTS (ATBD) PANEL REVIEWS

Algorithm Theoretical Basis Documents (ATBD) for the EOS instruments to be launched in 1997-1998 were reviewed publicly before scientific panels convened on May 9-11 and May 16-17 in Landover, Maryland. Individual ATBD presentations were given for each EOS Standard Data product proposed for ASTER, CERES, LIS, MISR, MODIS, MOPITT and SeaWinds. Presentations focused on the theory, empirical evidence, heritage, and outstanding challenges for use of the algorithm being proposed. The instrument science team members presenting each ATBD also responded to the comments received from written peer reviews conducted earlier this year. General comments by the review panels included concern that there was not enough communication between different instrument teams concerning algorithms with similar approaches/problems (e.g., atmospheric correction algorithms) or which measure similar geophysical properties (e.g., cloud masks and certain cloud products from CERES, MODIS, MISR, and ASTER). One general concern expressed in both the individual written reviews and by the panels was that many ATBDs lacked validation plans; however validation plans were not required for the ATBD because they are to be produced and reviewed separately for EOS. This round of reviews engaged over 280 reviewers for EOS science. Current requirements are for these ATBDs to be reviewed annually.

ASTER

ATBDs were presented for data products including: calibrated radiances, scene classification, brightness temperature at sensor, decorrelation stretch, surface radiance/reflectance, surface temperature/emissivity, vegetation indices, soil indices, polar cloud map, and a digital elevation model. Both U.S. and Japan teams have agreed to use the same algorithms in their processing. A common atmospheric correction method for AM-1 visible-infrared instruments (including MODIS, CERES, and MISR) was discussed as a goal, with the recognition that ASTER should have an independent capability to produce surface radiance and reflectance products. In response to panel questions, it was noted that the algorithm for surface temperature/emissivity should be applicable to sea ice and snow. The strategy for producing digital elevation models was criticized for not being explicit enough, particularly in identifying the sources of software (assuming commercial, off-the-shelf software will be available) and the relative roles of the ASTER science team and the EROS Data Center in developing software. Reviewers suggested that algorithms for vegetation and soil indices from ASTER should incorporate the latest modifications developed for similar MODIS data products.

MISR

ATBDs were presented for EOS Standard Data Products including: calibrated and geolocated radiances, top-of-atmosphere (TOA) and cloud products, aerosol products, and surface products. The plan to geolocate by referencing to digital elevation model tie points every 233 orbits (exact repeat) was recognized as sound for land, but the panel suggested that co-registration of MISR cameras will be important over featureless surfaces (e.g. oceans); there was a debate over the computational costs of pixel-by-pixel co-registration in which the panel argued it was feasible using parallel processing methods. The panel pointed out that the five classes in the aerosol product—small, medium, or large and clean or dirty—may be convolved, thus the algorithms need to determine which permutations are distinguishable. They also noted that this was the fifth aerosol-related ATBD they reviewed for EOS, and that the approaches and algorithms should be compared among the MISR and MODIS science teams (in coordination with the SAGE III science team) to ensure a tight coupling of efforts for validation.

LIS

ATBDs were presented for EOS Standard Data Products including: lightning events, flash rate, and time series (80 sec per site). Two special products for the Tropical Rainfall Measuring Mission (TRMM) will be 30-day flash counts at resolutions of 2.5 degrees and 500 km. Reviewers noted that the ability to distinguish cloud-to-ground from intra-cloud lightning would be a plus; the team plans to integrate ground observations in their processing to address this issue.

From *EOS.News*

MODIS

ATBDs were presented for EOS Standard Data Products including: calibrated radiances, albedo/BRDF, surface land temperature, vegetation indices, snow/ice, land cover, fires, leaf area index (LAI) and fractional photosynthetically available radiation (FPAR), land primary production, ocean chlorophyll, photosynthetically active radiation (PAR) over oceans, phycoerythrin, coccoliths, ocean chlorophyll fluorescence, ocean primary production, sea surface temperature, cloud masking, cloud top properties, cloud optical thickness and effective radius, aerosol, precipitable water, and temperature and moisture profiles. The panel pointed out that the science team should address the effect that using different algorithms for atmospheric correction over land and over water will have on their ability to make smooth transitions in coastal or wetland regions. The cloud masking algorithms need to be planned with regard to their use in producing other EOS products and compared with the algorithms being developed by the CERES team. In general, the large number of MODIS data products and channels will require crosswalk charts to see where one product is used by another or may be aliased; the Team has begun this product integration task, and is also planning to study error propagation for cross-effects.

CERES

ATBDs were presented for EOS Standard Data Products including: calibrated radiances, ERBE-like products, shortwave surface flux, longwave (LW) surface flux, cloud masking, cloud height, cloud optical properties, top-of-atmosphere (TOA) fluxes, and the surface and atmospheric radiation budget. Angular distribution models (ADM) for different conditions (e.g., different cloud types, ocean, vegetation, desert, etc.) were discussed in terms of number needed (12 for ERBE-like and ca. 200 for CERES products), the modeling studies used to derive the latter number, and the research plan to develop and assess ADMs and their application. The panel expressed some reservations about the validity of the algorithm for LW surface flux - clear sky when applied over land because of the uncertainty in our knowledge of land surface emissivities. CERES cloud products and masks will use data from cloud imagers (e.g. MODIS, VIRS) to identify and characterize clouds for radiation models. Cloud masking algorithms are being developed in collaboration with those being proposed by MODIS and use a number of techniques, including various artificial intelligence methods. In general, the review committee made the recommendation that there be more coordination of approaches to algorithm development of similar or related data products from CERES and MODIS and, to a lesser extent, MISR and ASTER.

MOPITT

ATBDs were presented for EOS Standard Data Products including carbon monoxide and methane. The algorithms presented will allow for independent MOPITT data processing with input of numerical weather prediction, e.g., National Meteorological Center (NMC), fields for profiles of temperature, pressure, and water vapor. Future developments will include studies on the use of MODIS and ASTER data products for surface radiances, atmospheric profiles, and cloud type, cloud masks, and cloud properties that could improve the accuracy of MOPITT products.

SEAWINDS

ATBDs were presented for EOS Standard Data Products including: backscatter power, sigma-0, and wind vector. The sigma-0 product will carry land/sea and other quality flags, including a precipitation flag derived from the AMSR microwave radiometer also on the ADEOS spacecraft. A maximum-likelihood approach will be used to derive the wind vector product. The panel pointed out that the ability to get ancillary data needed for atmospheric correction (e.g., National Meteorological Center or European Center for Medium Range Weather Forecasting (ECMWF) fields) will limit product delivery schedules; the SeaWinds science team has been looking into the use of forecast data as long as 48 hours ahead of retrievals, and they report promising results. There was also some concern from the panel that the variable view angles (SeaWinds is a scanning pencil-beam design different from the 3 scatterometers flown previously, which received signals only at set view angles) will lead to different accuracies in different parts of the swath; more model testing of these effects was advocated.

CHAPPELL NAMED TO WHITE HOUSE GLOBE PROJECT

Terri Sindelar, Headquarters, Washington, D.C. Phone: 202/358-1977

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June 7, 1994

Dr. Rick Chappell of NASA's Marshall Space Flight Center, Huntsville, Ala., has been named by the White House to serve a one-year assignment as the Deputy Director of the Global Learning and Observations to Benefit the Environment (GLOBE) Program.

Chappell will lead NASA's participation in the GLOBE program and will serve as Special Assistant for Environmental Outreach reporting directly to the NASA Administrator. He will be assigned to the White House and together with the GLOBE Director, Thomas Pyke, Jr., will work on the design and implementation of the GLOBE program for the Vice President.

"The GLOBE program is an innovative environmental education program envisioned by the Vice President. GLOBE will offer students around the world the opportunity to become active stewards of planet Earth," said NASA Administrator Daniel S. Goldin.

"Rick Chappell is an outstanding scientist and manager, who throughout his 20 year career with NASA, has actively created education and outreach programs for the Agency," said Dr. France Cordova, NASA's Chief Scientist. "NASA is pleased to support Dr. Chappell's selection to serve on the GLOBE project."

GLOBE is an environmental education program in which students and teachers from around the world will make environmental observations in their local communities. The environmental data include observations about weather, water and air chemistry and quality, geological measurements, and ecology. These measurements will be transmitted via a combination of ground and satellite networks and will be available to scientists studying global change.

These measurements collected by students worldwide can contribute to NASA's Mission to Planet Earth Program, which together with NOAA's environmental satellites, will be a principal source of data on our changing environment.

Chappell has served as the Chief Scientist for NASA's Marshall Space Flight Center. He has directed research in solar terrestrial physics and he has authored more than 100 papers on the Earth's ionosphere and magnetosphere.

He has held a variety of science management positions and trained as an alternate Payload Specialist for STS-45, the Atlas-1 mission that studied the changing Sun-Earth environment. Chappell is a magna cum laude graduate in physics from Vanderbilt University with a Ph.D. in space science from Rice University.

The White House also today announced that Thomas Pyke, Jr., was named as the Director of the GLOBE program. Pyke currently is the Director of High Performance Computing and Communications for the National Oceanic and Atmospheric Administration. ■

EOS Science Calendar

October 4-6	AIRS Team Meeting, LORAL/LIRIS, Lexington, MA. Contact George Aumann at (818) 354-6865 (hha@airs1.jpl.nasa.gov)
October 12-14	MODIS Science Team Meeting, College Park, MD. Contact Patti Thomas at (301) 220-1701 (swager@gsfcmail.gsfc.nasa.gov)
October 19-21	Investigators Working Group Meeting, Baltimore, MD. Contact Ghassem Asrar at (202) 358-2559, or Michael King at (301) 286-8228.
November 14-17	8th Joint ASTER Science Team Meeting, Japan. Contact Hiroji Tsu at +81-3-3533-9380; FAX: +81-3-3533-9383, or Anne Kahle at (818) 354-7265; (anne@lithos.jpl.nasa.gov).

Global Change Calendar

• 1994 •

September 5-9	Call for Papers for ISPRS Commission III Symposium, Spatial Information from Digital Photogrammetry and Computer Vision, Munich, Germany. Contact Christian Heipke, Secretary, ISPRS Commission III 1992-1996, Chair for Photogrammetry and Remote Sensing, Technical University Munich, Arcisstr. 21, D-80290 Munich, Germany. Phone: +49-89-21052671 (2677), FAX: +49-089-2809573, or e-mail: chris@photo.verm.tu-muenchen.de.
September 12-15	First International Airborne Remote Sensing Conference and Exhibition: *Applications, Technology, and Science*, Strasbourg, France. Contact Robert Rogers, ERIM, Box 134001, Ann Arbor, MI 48113-4001, phone: (313) 994-1200, ext. 3234; FAX: (313) 994-5123.
October 20	*Biogeography In A Changing World*, one-day conference convened by the Royal Geographical Society, Natural Environment Research Council (TIGER Programme) and the Biogeography Research Group of the Institute of British Geographers. For more information contact Alison Glazebrook, Royal Geographical Society, 1 Kensington Gore London SW7 2AR, phone: +71-589-5466, FAX: +71-225-1425.
October 25-27	Second International Conference on Carbon Dioxide Removal, sponsored by Research Institute of Innovative Technology for the Earth (RITE), and New Energy and Industrial Technology Development Organization (NEDO). For further information contact ICCDR-2 Local Secretariat: Ms. Yukiko Morita, c/o Planning and Survey Dept., RITE, 9-2 Kizugawadai, Kizu-cho, Soraku-gun, Kyoto 619-02, Japan. Phone: +81-7747-5-2301; FAX: +81-7747-5-2314.
Oct. 30-Nov. 3	1994 International Snow Science Workshop. Contact Liam Fitzgerald, ISSW '94. Box 49, Snowbird, UT, (801) 521-6040.
November 8-10	Technology 2004 Conference and Laser Tech '94, Washington D.C. Convention Center. For further questions call Leonard Ault at (202) 358-0721 or Michael Hackett at (202) 728-2080.
November 13-16	First IEEE International Conference on Image Processing, Austin Convention Center, Austin, TX. Contact icip@pine.ece.utexas.edu.
November 30	*Geomorphology and Hazards*, one-day conference organized jointly by the British Geomorphological Research Group and the Royal Geographical Society. For more information contact Alison Glazebrook, Royal Geographical Society, 1 Kensington Gore London SW7 2AR, phone: +71-589-5466, FAX: +71-225-1425.

• 1995 •

March 13-17	*Biomass Burning and Global Change*, Williamsburg, Virginia. Abstract deadline is November 23, 1994; preregistration deadline is February 10, 1995. For further information contact AGU Meetings Department, Biomass Burning, 2000 Florida Avenue, N.W., Washington, DC 20009; phone: (202) 462-6900, FAX: (202) 328-0566, e-mail: meetinginfo@kosmos.agu.org.

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