The Earth Observer

An EOS Periodical of Timely News and Events

Vol. 6, No. 1

January/February 1994

Editor's Corner

An EOS Investigators Working Group (IWG) meeting was held January 11-13 in San Antonio, Texas. The meeting focused on (i) learning about the recent progress and exciting accomplishments of various EOS investigators, both instrument as well as interdisciplinary, (ii) introducing plans for calibration and validation of EOS data products, (iii) discussing recent accomplishments in the design and architecture of EOSDIS, including the relative benefits of compute-on-demand vs. routine production and storage, and (iv) hearing the results of a survey conducted by Eric Barron on the policy-relevance of EOS research. A detailed report of the IWG meeting can be found on page 3 in this issue.

During one evening of the IWG, the Science Executive Committee (SEC) held a working dinner to discuss (i) the status of the *Science Strategy for the Earth Observing System*, a document prepared by Jeff Dozier and Ghassem Asrar that will be published by the American Institute of Physics, (ii) the panel structure and membership of the IWG, including updating the charter of the IWG, (iii) orbit preference for the EOS PM mission (ascending vs. descending orbit), and (iv) the need to form an Outreach & Communications Panel, which Peter Mouginis-Mark has agreed to chair. The next SEC meeting is scheduled for early April in Chicago, under the direction of the new chair, Eric Barron.

As reported in the last issue of *The Earth Observer*, the Project Science Office has initiated a written as well as oral review of the theoretical basis behind each algorithm to be developed by the EOS AM, LIS, and SeaWinds Science Teams. The oral portion of this review will be conducted

INSIDE THIS ISSUE

SCIENCE TEAM MEETINGS

ARTICLES

ANNOUNCEMENTS

during the week of May 9 for CERES, MODIS, and MISR, and the week of May 16 for MOPITT, LIS, ASTER, and SeaWinds. These reviews will be held in Landover, Maryland, at the facility of Hughes Applied Information Systems (HAIS), which, as prime contractor for the EOSDIS Core System, has an intense interest in learning about the detailed design of each EOS algorithm. Thus far I have received 29 out of an anticipated 41 algorithm theoretical basis documents (ATBDs) for the first week, and 8 out of 14 products for the second week.

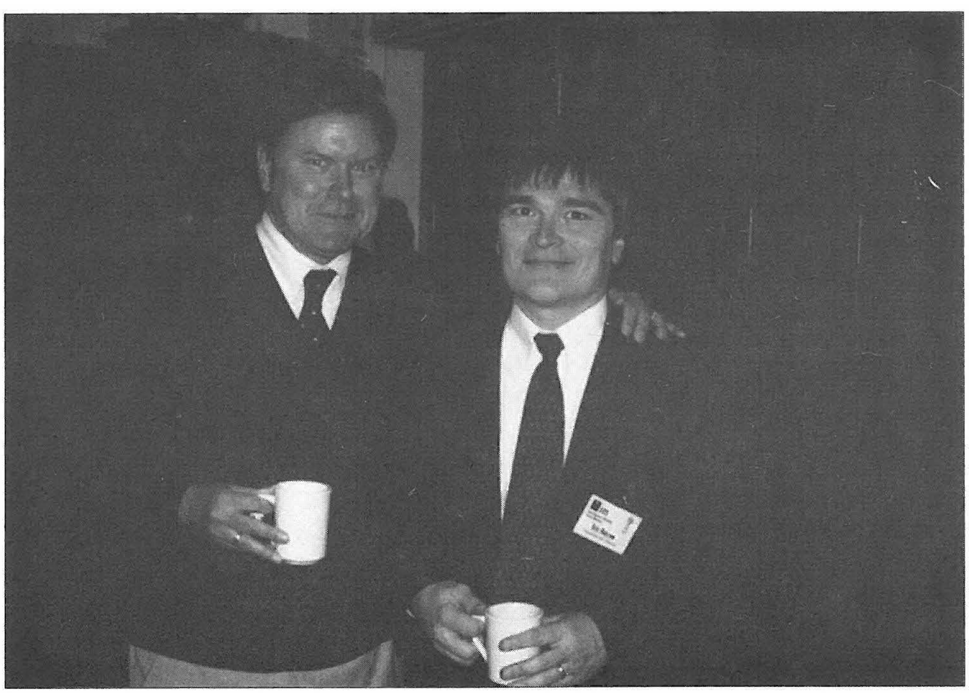
In January, the Clinton Administration submitted its budget request to Congress for FY95 (beginning October 1). The NASA budget submission for the Office of Mission to Planet Earth (MTPE) was $455.1 M for EOS and $284.9 M for EOSDIS, for a total obligation authority of $740 M. This represents an increase of $233 M over FY94 (the current fiscal year). In addition to this submission, the Office of MTPE has agreed to fund the development of Landsat-7 as a NASA program, to be managed as a Flight Project at Goddard Space Flight Center, with collaboration from NOAA on the ground component. The previous arrangement with the Air Force has been severed, such that NASA management has now accepted responsibility for developing Landsat-7 with an Enhanced Thematic Mapper plus (ETM+) sensor. This satellite, of vital importance to many in the Earth Science community, is now once again the responsibility of NASA, but resides outside of the EOS Program.

The extended Phase-B contracts to study the feasibility of using an MELV (Delta-class) launch vehicle for the Common Spacecraft have nearly been completed by four firms: Martin Marietta, Lockheed, TRW, and Fairchild. These contractors are looking at common spacecraft designs for the PM-1, AM-2, and Chemistry-1 platforms. The feasibility studies are expected to be completed by March 1994.

In an effort to enhance EOS communication, we have established an EOS Project Science Office home page accessible via Mosaic, an Internet-based global hypermedia browser and World Wide Web client. This service allows you to discover, retrieve, and display documents and data from all over the Internet. In our case, issues of *The Earth Observer* and the Payload Panel Report are already available. Eventually, ATBDs, the EOS Reference Handbook, the EOS Directory, images from various satellites and airborne instruments, and cross-references to other EOS-related information servers on the Internet will also be available (see article in this issue on page 10 for further details).

Because of the increased effort to make EOS information available in electronic form, we ask that you return the postage-paid card enclosed with this issue of *The Earth Observer* if you wish to remain on our mailing list. **If a response is not received by June 1, your name will be removed from our mailing list.** Your cooperation is greatly appreciated.

—Michael King
EOS Senior Project Scientist



Charles Kennel, Associate Administrator, Office of Mission to Planet Earth, NASA Headquarters.

Eric Barron, Penn State University, new Chairman of the Science Executive Committee of the EOS Investigators Working Group.

The Eighth Meeting of The EOS Investigators Working Group

January 11-13, 1994, San Antonio, Texas

—By **Renny Greenstone** (renny@ltpsun.gsfc.nasa.gov), Hughes STX Corp.

In this two-and-one-half day meeting there was a relatively even balance between Earth science and EOS programmatics. The emotional highlight of the meeting was the farewell to Shelby Tilford, which took place in the final session. Of broad interest were the question of "convergence," the status of EOSDIS, the introduction of Charles Kennel as the new Associate Administrator for NASA's Office of Mission to Planet Earth (MTPE), and the issue of policy-relevant research.

Tuesday, January 11

The first presentation of the morning was given by the EOS Senior Project Scientist, **Michael King**. King said that there is now a prioritized data products list consisting of 222 products, of which 147 are to be ready at launch; and 75 others are to be ready after launch. Of these products, 199 are characterized as being routinely processed, and 14 are characterized as being produced on request (9 "products" are actually software).

King discussed the details of the peer-review process that is soon to be underway. The process is to focus on the algorithms being developed for the data products. Each instrument team is to develop Algorithm Theoretical Basis Documents (ATBDs) for its data products, and these will be the bases for the reviews. The first reviews will be devoted to the products of the instruments that are to fly on the AM platform as well as LIS (TRMM) and SeaWinds (ADEOS-2), and will be held in May of this year. The final step in the review process will be the publication of the algorithms in leading scientific journals, in effect constituting a still-further peer review.

Ghassem Asrar, the EOS Program Scientist, discussed the progress that has been achieved on interdisciplinary science (IDS) investigations. With 24 reviews of the IDS teams now complete, he has found that scientific progress for many of them has been excellent. Still, most teams need to work on documenting their scientific progress, their plans, and the policy relevance of their research to the broader Earth science community. It is significant that the teams have now published 522 articles related to their activities, 57 percent of which have appeared in peer-reviewed journals. Looking to the future years of EOS, Asrar said that there could be changes in the IDS investigations—some might be downsized or possibly eliminated, and new investigations might be added.

Berrien Moore addressed the recommendations of the Payload Advisory Panel that were formulated at the recent meeting in October and then revised in December. A key issue facing the Panel was "convergence" in Earth remote sensing. NASA's PM-1 mission, featuring the AIRS atmospheric sounding instrument, is regarded as a "stepping stone" to convergence with NOAA's operational program of meteorological observations, but there are questions as to whether NOAA has the resources to integrate either AIRS or MODIS into their future NOAA-O,P,Q missions. The Payload Panel has urged that convergence in meteorological missions should begin with DoD and NOAA, with NASA participation to be considered later. The Panel has reviewed possible changes to EOS flight plans: the Tropospheric Emission Spectrometer (TES) might reasonably be added to the Chem-1 mission; and the Active Cavity Radiometer Irradiance Monitor (ACRIM) could fly before Chem-1 in order to avoid a data gap in measurements of solar irradiance.

Commenting on the Payload Panel report, Kennel advised that, while the NASA/NOAA/DoD convergence was definitely on track, NASA/DoD convergence on Landsat was definitely faltering, and, in fact, heading toward divergence.

In a report on EOS calibration activities, **Bruce Guenther**, EOS Calibration Scientist, said that each EOS instrument team is expected to produce a calibration plan that will undergo peer review. The first such reviews will take place this year for the AM-1 instruments. The instruments depending on reflected visible radiation will be the particular focus of review activities because they will benefit most from improved calibration. Tertiary Standards Laboratories traceable to the National Institute of Standards and Technology (NIST) are being planned to calibrate instruments for *in situ* studies.

The "EOS Validation Plan" was described by **Michael King** In response to a request by Mous Chahine and others, the former Calibration/Validation Panel has now been split into separate panels on calibration and validation. As yet there is no chairperson for the newly constituted Validation Panel.

A particular issue would be the timing of release of the EOS data. Will there be an adequate period of time to assure validation prior to general release? There will be a problem with validation in instances where the satellite data may be superior to the field data.

Piers Sellers was the first speaker of the afternoon, discussing the findings of the November meeting of the Science Working Group for the AM Platform (SWAMP). He said that the MODIS "ghosting" problem has been solved; MISR still has a glint problem; and ASTER still has a cooler-generated vibration problem. The spacecraft pointing knowledge may not be adequate for some of the instruments. If angular-displacement sensors are used, they could constitute a major cost element. Image matching will be essential for the geolocation requirements of ASTER. Lunar calibration would be the best stability monitor for the AM instruments and would require just one or two looks per year involving roll maneuvers of the platform, and lasting for just one orbit.

Byron Tapley's talk was on recent global ocean topography results from TOPEX/Poseidon. Post-launch, the error estimate has been found to be 3- to 4-cm RSS absolute as against the original error budget estimate of 13.7-cm RSS absolute. The accuracy of large-scale dynamic topography is estimated to be about 15 cm.

Lee-Leung Fu said that the TOPEX data quality was adequate for the quantitative determination of ocean circulation. TOPEX has provided the first-time-ever global set of ocean altimetry data. Ocean circulation patterns may have a 10-year linkage with El Niño.

The EOS Oceans Panel, as reported by **Chet Koblinsky**, is concerned with the gap between the planned end of the TOPEX mission in 1997 and the initiation of the EOS Altimetry mission in 2002. Possible remedies would be a TOPEX follow-on or a Geosat follow-on. The Payload Panel may be called upon in the Spring to prioritize these ocean measurement requirements relative to current EOS plans.

Minghua Zhang described a SUNY Stony Brook program to analyze cloud-climate interactions in 19 general circulation models. The model findings were compared to ERBE observations of the seasonal cycle of cloud-radiative forcing. The models typically simulate longwave forcing better than shortwave. Errors due to cloud forcing in the different models could be assigned to variations in the treatment of high, middle, or low clouds.

Dave Randall addressed climate model simulations of clouds. He said that cloud amounts in GCMs typically have no physical basis, and he described a new way to put clouds into the GCMs. His new approach gave much better cloud results as shown by comparison with ERBE data and with SSM/I data for liquid water. The threshold for conversion of cloud ice to snow is an adjustable parameter in his model. EOS could contribute to solving several of the modeling problems by determining the distribution of ice mass in the atmosphere, possibly through microwave measurements.

Frank Wentz reviewed the progress of Earth science using SSM/I. What are sometimes called errors in the SSM/I data can be due in part to the large field-of-view of the satellite microwave sensors when compared to point measurements at the surface. Wentz said that it is possible to use the passive microwave data to determine not only wind speeds but also wind directions at the ocean surface. Winds determined in this novel fashion have compared favorably with those from ERS-1 scatterometry.

Pat McCormick presented a detailed survey of the remote sensing accomplishments resulting from SAM II, SAGE I and SAGE II. These instruments have presented long series of data on stratospheric aerosols, ozone, NO_2, and water vapor. The sulfate particles in the stratosphere following the Pinatubo eruption appear to have induced dynamical changes in the stratosphere. The water vapor data seem to contradict the Lindzen hypothesis that greenhouse warming would lead to reduced water vapor in the upper troposphere. SAGE III will provide a quantum jump in capability over SAGE II through improved spectral resolution and the use of lunar occultation to provide more measurement opportunities.

Wednesday, January 12

John Dalton, EOS Project Manager, reported on the current status of EOSDIS, ECS, EDOS, and IV&V. He listed a schedule that is being followed for the review of various EOSDIS elements, and gave the status of support contracts that have been, or soon will be let. He also listed a large number of recommendations that had previously been made by the EOSDIS Advisory Panel and gave the EOSDIS responses to them. Generally, the response was to accept and implement these recommendations.

Dalton said that there has been a very strong growth in requirements for processing speed and storage volume of EOS data to the extent that there will have to be substantial reductions in system costs. Data products may have to be prioritized in case the EOS product generation system (PGS) does not meet current expectations. A possible solution to system cost and capacity problems would be to make a trade between "processing on request" and "routine processing" of data products.

Dave Glover gave the EOSDIS Advisory Panel's recommendations regarding EOSDIS. The Panel had attended the System Requirements Review held in September 1993 and had not been completely pleased with what was presented. Things appeared to be much better at the follow-on review held December 13-14, but the Panel felt that problems still remained. Among these problems were the inadequacy of the system distribution and failure of the system to be evolutionary—a 5-year life cycle for hardware might not be realistic. It could be as little as 18 months.

Steve Wharton spoke as the EOSDIS Project Scientist. He discussed the status of the Pathfinder data effort and then went on to discuss DAAC data support and user services. Following this review, he gave an in-depth discussion of the merits and demerits of routinely generating data products versus generating them on demand.

Ricky Rood gave a progress report on EOS data assimilation activities. The assimilation model is able to incorporate radiances directly, rather than using higher-level products. Also, water vapor is modeled directly. Data from a 5-year model run (March 1985 to March 1990) are now available from the Goddard DAAC. An interesting consequence of using the model has been the determination that the reported TOGA/COARE humidity data were too low. It was noted by Chahine that the model will be a useful source of surface fluxes and soil moisture, which are not available from space borne measurements and will be needed for GEWEX.

Sue Jensen of the EROS Data Center described the status of global Digital Elevation Model (DEM) data sets, noting that MODIS, MISR, and ASTER are the principal EOS instruments requiring DEM data. Also, more than 11 of the IDS investigations require topographic data. ETOPO5 is the only global data set, and it has 10-km resolution. The Digital Terrain Elevation Data (DTED) set has the 90-m resolution needed by MODIS and MISR, but has restricted distribution. Jensen urged that the IWG prepare a letter to the Defense Mapping Agency asking for release of the DTED.

Michael Freilich reported on recent results obtained from analyses of ERS-1 scatterometer data. His group has been able to develop a consistent 21-month-long set of wind velocity data from the ERS-1 observations. The wind velocity data have been used by Robert Brown of the University of Washington to calculate surface atmospheric pressures, which were lower than those derived from the operational analyses and also showed systematic asymmetries in the cyclone structures that were absent from the operational pressure fields. The ERS-1 data have been assimilated into operational numerical weather forecast systems and have had a significant positive impact, particularly in the southern hemisphere.

Mark Schoeberl has been the UARS Project Scientist for the past 5 months. He pointed out that UARS may be regarded as the prototype mission for EOS, although it has many more instruments on its platform than are planned for the EOS spacecraft. There were several reasons why UARS data were slow to appear. Particularly relevant to EOS was the realization that there had been insufficient efforts to develop the algorithms for the instruments prior to launch. The MLS instrument was the only one for which the data were delivered in proper shape directly after launch.

Schoeberl was able to list 10 major scientific accomplishments attributable to UARS. There were several firsts in atmospheric chemistry and in atmospheric dynamics, including the first satellite measurements of winds in the stratosphere. He noted that the strong emphasis on data validation had paid off. It helped speed-up algorithm development and helped to entrain other experimentalists.

Steve Running said that biospheric modeling is still in its early stages—there are just three global dynamic biospheric models now operating. The largest hurdles facing land-biosphere modeling appear to be in classifying vegetation. Running has identified six classes to be applied to the MODIS data products. He has estimated that potential changes in surface temperature could be up to 10° C because of changes in land cover.

Michael King discussed some of his recent activities concerning remote sensing of cloud and surface properties from aircraft. He presented data on cloud characteristics that have been obtained from various aircraft campaigns including FIRE, TOGA/COARE, and Sulfate, Clouds, and Radiation (SCAR-A). Other data included bidirectional reflectance patterns from the Kuwait oil fire smoke and vegetation, as well as images of the flooding of the Mississippi and Missouri rivers last summer.

Dave Skole described Landsat Pathfinder activities related to the effects of tropical deforestation on carbon fluxes. His studies have shown that the rates of deforestation are much lower than previously announced so that the carbon dioxide flux into the atmosphere is much lower than previously believed. His group is now looking at secondary growth as a possible sink for carbon.

Peter Challenor discussed a method of combining altimetry with soundings from ships to derive absolute values for currents. The soundings are made with a conductivity-temperature-depth (CTD) sounder. This technique would be rendered obsolete by a gravity mission.

Thursday, January 13

This last session of the IWG was chaired by **Berrien Moore**, who began with a review of the discussions that had taken place at the Wednesday night dinner meeting of the Science Executive Committee (SEC). The SEC recommended some changes to the IWG panel structure and also recommended that its chairperson should come from the IWG membership. Eric Barron was recommended by the SEC as the first chairperson under the new arrangement [he received the unanimous endorsement of the IWG members].

The new Associate Administrator, **Charles Kennel**, then led a discussion of the Landsat convergence issue, which had been discussed earlier as part of the findings and recommendations of the Payload Advisory Panel. He reiterated that NASA and DoD seem to be fully apart on the issue, and that there would now be a question as to whether NASA would go it alone with the Landsat-7 project. He said that HRMSI would be dropped from Landsat if NASA had to go it alone. Berrien Moore then went over some of the Payload Panel's recommendations regarding Landsat convergence: one of these was the statement that any converged system must accommodate the scientific needs for long-term highly calibrated data; and another was the statement that the programmatic structure for Landsat must provide data for Global Change priorities. Kennel cautioned that the Payload Panel's comments on Landsat need the approval of the full IWG.

The farewell to **Shelby Tilford** began with a presentation by Richard Holdaway, UK Program Director for EOS. Holdaway said that Tilford had been key to effecting the international partnership for Mission to Planet Earth. Next, Michael King presented Tilford with a scrapbook containing viewgraphs based on Mission to Planet Earth as well as signatures and best-wishes from IWG members and other attendees. Berrien Moore then recounted his 16 years of working with Tilford and presented him with a plaque. Tilford responded with a brief farewell speech and was followed by Charles Kennel, his successor, the newly appointed Associate Administrator for Mission to Planet Earth. Kennel said that as a result of Tilford's tenure, Mission to Planet Earth now has the highest priority of all NASA programs.

Kennel contrasted the future of Mission to Planet Earth with the unfortunate history of the Superconducting Super Collider. He was optimistic that Mission to Planet Earth would succeed and accomplish its mission where the Collider had failed to win Congressional support. Mission to Planet Earth is fortunate in that it addresses major societal issues. It is incredibly multidisciplinary. It is not subject to a single point of failure because of its multidisciplinary nature and its multiplicity of instruments and spacecraft. In an aside he noted that he is on a 2-year appointment to NASA.

In the final technical session of the IWG program **Peter Mouginis-Mark** discussed progress being achieved in volcanology and geodynamics using EOS-era radars. He made reference to SIR-C/X-SAR, ERS-1 and -2, RADARSAT, JERS-1, and ENVISAT. He said that radar interferometry allows topography to be determined from space to meter scales and deformations to be determined to sub-centimeter scales. Topographic SAR (TOPSAR) will give 10-m spatial and 2-m vertical accuracies and can produce "slope" maps.

Jim Hansen discussed the relevance of Mission to Planet Earth to the program of the Intergovernmental Panel on Climate Change (IPCC). The IPCC is to have an interim report on radiative forcing due to trace gases. It is difficult to deal with global warming because the gases that contribute to it are pervasive worldwide—it isn't solely the industrial nations that are involved. Also there is a very long delay in the climate response to the introduction of these gases. Hansen's research has demonstrated that there is no simple relation between the amount of trace gases introduced and the resultant surface temperature changes. Both altitude and latitude of trace-gas introduction affect the manner in which the surface temperature changes. (There is a higher sensitivity at higher latitudes.)

The topic discussed by **Jay Zwally** was the global measurements of snow, sea ice, and land-ice/sea-level change. Snow cover modeling by the GCMs is quite satisfactory, but modeling of precipitation over Antarctica is difficult, partly because it is affected by changes in sea-ice concentrations. There is still great uncertainty about the mass balance of ice sheets. Actual sea-level rises have been determined to be about 1.8 mm/year for the period 1880 to the 1970's.

Mark Abbott's talk was concerned with ocean observations and ocean models and their applications to Southern Ocean studies. Abbott's goal is to develop a fully assimilating model of the coupled biophysical processes that are represented by air/sea fluxes of momentum, heat, moisture, and carbon. His research group has found that ocean tides affect satellite altimetric determinations of sea level. Better tidal models are needed to reduce the errors in ocean altimetry.

The concluding programmatic talk was given by **Eric Barron**. He has been conducting a survey among the IWG members to show how EOS is addressing the key policy questions that drive the U.S. Global Change Research Program. (USGCRP). The survey asked the IWG members to indicate the relevance they saw between their research and the five major themes of USGCRP. Suggestions were offered by the attendees as to how the statement of the USGCRP themes might be modified and the IWG statements of relevance should also be improved upon.

This eighth meeting of the EOS IWG closed with a few remarks by Ghassem Asrar concerning meeting frequencies and formats and generally keeping the members informed.

Science Working Group for the AM Platform (SWAMP)
Meeting held in San Antonio, Texas

—By **Philip Ardanuy** (PARDANUY/GSFCMAIL), Research and Data Systems Corp.

An abbreviated meeting of the Science Working Group for the AM Platform (SWAMP) was held January 11 during the EOS Investigators Working Group (IWG) meeting in San Antonio. Topics covered during the meeting included EOS science algorithm peer reviews, progress towards meeting instrument pointing requirements, benefits and risks of lunar nadir views, formulation of a common EOS grid, and attributes of a global soils data base.

Algorithm Peer Review

Piers Sellers reviewed the upcoming set of EOS science data product algorithm peer reviews (key milestones are illustrated in the attached figure). These will be constructive, and not simply "pass-fail." Level-1 and Level-2 products will be reviewed at this go-round, while consideration of Level-3 products will occur in the future and won't be a focus at the upcoming peer reviews. However, if instrument teams have Level-3 algorithms at that time, those will be peer-reviewed as well.

Level-3 products are as critical as the lower-level products: modelers, and anyone who wants to do global science will require Level-3 products (for CERES and certain other instrument products, gridded variables are as important as, or more important than, Level-2). We expect that the subsequent peer review of Level-3 will require a lot more interaction among teams, perhaps in part through SWAMP.

Pointing

Dave Diner reviewed progress made towards selecting navigation methods for data product generation. The definition of *dead-reckoning* is "the use of position and pointing knowledge to geolocate by ray tracing." Platform specifications provide a 231-m dead-reckoning accuracy to 95% confidence. For dead reckoning to support data product generation, the following are needed:

- improve the position error by a factor of three (note that the TDRSS-based navigation [TONS] can improve knowledge by a factor of six), and
- have a period following launch to remove static errors.

Current analytical predictions suggest that dead reckoning is feasible for MODIS and MISR (but *uncertainties* mean this is *not* certain). There is an alternative to dead reckoning: *reference image mapping*. For MODIS and MISR, 233 reference image swaths could be obtained (one for each orbit in the 16-day repeat cycle, taken early in the mission). Using feature or brightness techniques, all subsequent imagery can be registered to the reference library. Elevation data like DTED are critical, and different reference orbits would likely be required for the PM spacecraft. For ASTER, Ground Control Points (GCPs) are a requirement. The prudent approach would be to be prepared to implement image matching.

NASA/LaRC has proposed a jitter experiment (accelerometers) to fly on AM-1. Goddard has talked to LaRC about adding angular displacement sensors (ADS) to the experiment. The instrument budgets are likely to be too tight to afford ADS out of the instrument budget.

Lunar Nadir View

Hugh Keiffer discussed plans to use the moon as a stable calibration source. Potentially, instrument scientists will learn a great deal about their instruments from a single lunar view. The moon changes about $1{:}10^8$ or $1{:}10^9$ per year, while imagers change their characteristics at perhaps 1% per year. No imager has yet been flown with the stability needed to characterize global change over 15 years using only internal calibrators (MODIS will be making the best effort ever).

However, the moon is non-uniform and not an ideal target. From Earth orbit, the moon is circular, with a disc effectively 7 km in diameter. The Arizona photometric model will have an "effective" resolution of 15 m (arc equivalent to a nadir pixel of 15 m). A long observing program will be required to account for the 7° lunar libration. The goal is to get 2% or better absolute radiometry. The shortwave part of the program is underway today, but near-infrared observation requires a more complex technology, and may be 1 to 2 years off. Hugh Kieffer has requested that each EOS instrument team identify a person to act as point of contact.

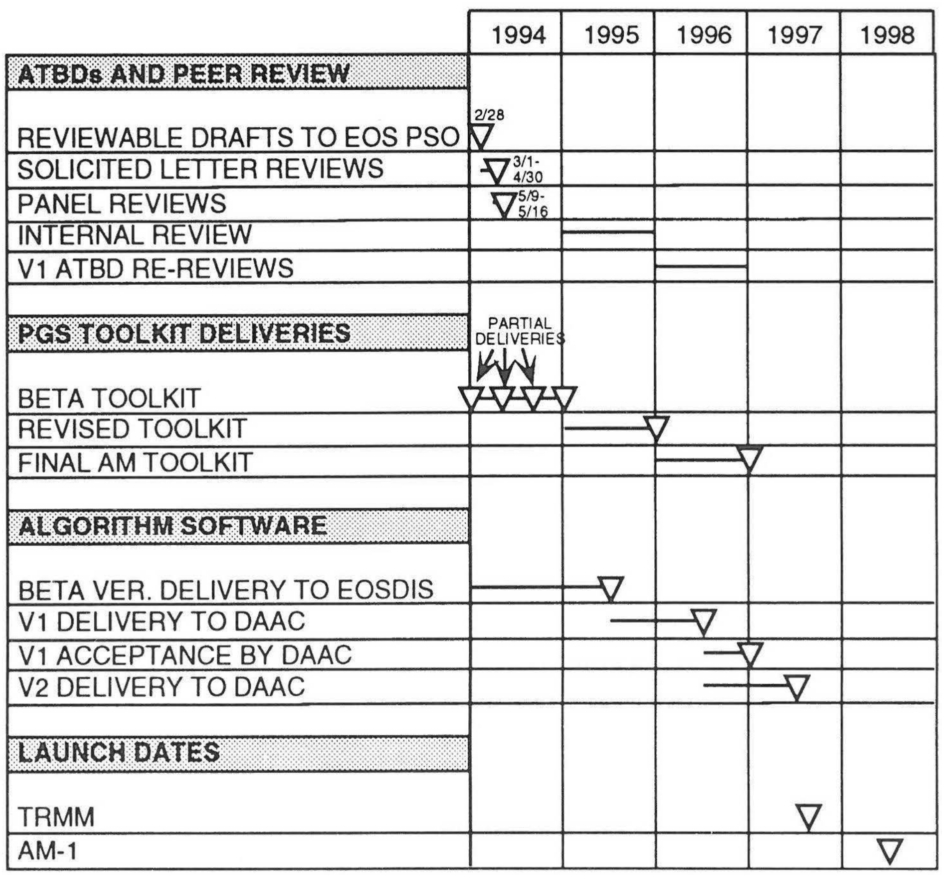
To create greater opportunities for MODIS, MISR, ASTER, and perhaps other instruments to view the moon, spacecraft maneuvers have been suggested. The lunar disk strongly backscatters (the moon is much brighter at full moon near eclipse than at other angles). As a consequence, a maneuver to view the moon through the MODIS nadir scan cavity would view a much brighter moon than through the spaceport. There is a need to do an engineering study and risk assessment—the risk of these maneuvers could be relatively small, and the stability aspect is paramount. The answer to this dilemma hinges on a trade-off of science return and risk/cost. Piers Sellers asked that a small group be formed to study the risks/benefits, with the results to begin to be compiled at the upcoming Calibration Panel meeting. A list of the benefits would come from instrument teams, and a list of risks should come from Paul Westmeyer and Skip Reber. Because this is a general issue that goes beyond the AM spacecraft, this should affect the specifications for the common spacecraft as well.

EOS Standard Grid for EOS AM Platform

Jim Stobie of the Goddard Data Assimilation Office (DAO) recommended a 1° by 1° latitude/longitude grid. Over land, a higher resolution might be required (e.g., 0.5°). Mike Botts of the Pathfinder program/Interuse Experiment found this to be an acceptable initial solution toward meeting interuse requirements. A potential refinement, suggested by Hugh Kieffer, is that adopted by the planetary community: a convention of grid element edges at the integer latitude/longitude lines, with nested resolutions varying by factors of two (4°, 2°, 1°, 0.5°, 0.25°, etc.). While this grid type is excellent for global climate studies, it may not accommodate users who prefer equal-area grids. Data validity, due to data oversampling and undersampling is another concern. The Interuse Experiment teams' belief is that a common intermediate grid based on the 3-D surface of the Earth, along with full and easy access to lower-level ungridded data, may be the best long-term solution.

Soil Types, Textures, and Slopes

Norman Bliss presented details on the global soils database being put together at EDC (1° by 1° with information on slope, texture, and depth). The product will be issued on the ISLSCP CD-ROM in mid-1994.



The EOS Project Science Office Information Server

—By **Yun-Chi Lu** (lu@spso.gsfc.nasa.gov), Code 902, NASA/GSFC, Greenbelt, MD 20771

A World Wide Web (WWW) information server has been installed as a joint effort of the EOS Project Science Office (PSO) and the Science Processing Support Office (SPSO) at Goddard Space Flight Center. The server called the EOS Project Science Office (EPSO) is designed to provide on-line access to EOS-related information and published material, such as *The Earth Observer*, Payload Panel Recommendations, the *EOS Reference Handbook*, Algorithm Theoretical Basis Documents (ATBDs), and other related documents.

The EPSO, a client-server system, was installed on SPSO's Silicon Graphics workstation, using the World Wide Web (WWW) and the Wide Area Information Server (WAIS). WWW provides on-line access to various documents that have been marked up with Hypertext Markup Language (HTML), while WAIS provides free text search capability. To access the EPSO, users are required to have Internet access and client application software, Mosaic, installed on their machines.

Currently, the EPSO offers the last three issues of *The Earth Observer* and the Payload Panel Recommendations dated December 17, 1993. This server will be continually populated with all future issues of *The Earth Observer* and other EOS-related documents, such as the Algorithm Theoretical Basis Documents (ATBDs). The EPSO utilizes the free text search capability of WAIS for keyword search and provides links to other EOS- and NASA-related WWW servers, such as the Office of Mission to Planet Earth, SeaWiFS, CERES, GSFC, and NASA servers.

Required Hardware and Software

To access the EPSO, users are expected to have the following hardware and software:

- X-terminal, Windows capable IBM PC (or compatible), or Macintosh;
- Internet access;
- a client application software, such as Mosaic;
- External Viewer to display images or see PostScript files; and
- software to decompress the downloaded files.

How to Obtain Mosaic and Other Software

All software necessary to access the EPSO, including Mosaic and External Viewer, is in the public domain and available from the National Center for Supercomputing Applications (NCSA) via anonymous FTP:

Host address: ***ftp.ncsa.uiuc.edu***
User ID: ***anonymous***
Password: ***<your e-mail address >***

This will put user in the top level directory and it may be necessary to locate a lower level sub-directory which contains Mosaic and Viewer software before you begin to download them. A subdirectory containing Mosaic and other related software can be found by issuing a "dir" command. Users should select the right version of Mosaic, because three different versions of Mosaic (i.e., X-windows, Microsoft windows, and Macintosh) are available.

Mosaic for X-window System

The easiest way to download Mosaic is to retrieve an executable binary from a subdirectory Mosaic/Mosaic-binary. The following binaries are available:

Mosaic-sun.Z	for Sun 4, SunOS 4.1.x
Mosaic-sun-lresolv.Z	for Sun 4, SunOS 4.1.x, no DNS
Mosaic-sgi.Z	for Silicon Graphics, IRIX 4.x
Mosaic-ibm.Z	for IBM RS/6000, AIX 3.2

Mosaic-dec.Z	for DEC MIPS Ultrix
Mosaic-alpha.Z	for DEC Alpha AXP, OSF/1
Mosaic-hp700.Z	for HP9000/700, HP/UX 9.x

To download a binary:

1. Put your FTP session into binary mode (type ***binary***).
2. Pull down the file (type, e.g., ***get Mosaic-sun.Z***).
3. Quit the FTP session.
4. Uncompress the binary (type, e.g., ***uncompress Mosaic-sun.Z***).
5. Make the binary executable (type, e.g., ***chmod 755 Mosaic-sun***).
6. Execute the binary.

To download a binary from within Mosaic, go to the Mosaic-binaries directory and turn on *Load to Local Disk* using the **Options** menu. Then click on the appropriate filename, and enter a filename into the Save File dialog *Load to Local Disk*. Perform steps 4-6 above. The complete Mosaic source code distribution is located in subdirectory Mosaic-source. The distribution comes as a single compressed tar file, and can be compiled on most Unix systems. Users must have the X11R4 (or later) and Motif 1.1 (or later) header files and libraries on their systems to compile Mosaic.

Mosaic assumes the presence of a number of external viewers—programs that Mosaic can use to allow users to view images, movies, PostScript files, etc., that are retrieved over the network. See the subdirectory Mosaic-viewer for copies of the normal source distributions of some of these viewers. Users should download and install these viewers if the software does not already exist on their system.

Mosaic for Macintosh

Mosaic for Macintosh is located in a subdirectory Mac/Mosaic. To download the file:

1. Put your FTP session into binary mode (type ***binary***).
2. Pull down the file (type, e.g., ***get Mosaic-sun.Z***).
3. Quit the FTP session.
4. Decode and unstuff the file using StuffitExpander or other data compression program.

To run Mosaic on Macintosh, users need to have:

- System 7 or later
- MacTCP 2.0.2 or later
- At least 4 megabytes of disk space

NCSA Mosaic for Macintosh by itself will view the majority of files available. However, to view some images, watch movies, and listen to sounds, users need to install additional software. Mosaic is initially configured to use the following external viewers.

• JPEGView	for GIF/JPEG images
• GIFConverter	for TIFF images
• Simple Player	for Quicktime movies
• Sparkle	for MPEG movies
• SoundMachine	for AU sounds
• Stuffit Expander	for BinHexed files

All except Simple Player are freeware or shareware programs and are available via anonymous ftp from sumex-aim.stanford.edu or mac.archive.unich.edu. Install them using the directions that accompany the software. Simple Player is a Quicktime viewer from Apple that comes packaged with most distributions of Quicktime. It is copyrighted and not in the public domain. It is available from the NCSA anonymous ftp server.

Mosaic for Microsoft Windows

Mosaic for Microsoft Windows is located in a subdirectory PC/Mosaic. The basics for installing Windows Mosaic are:

1. Download and unzip the file. It should contain at least four files:
   - WMOSAIC.EXE
   - WMOSAIC.INI
   - README.TXT
   - FEATURES.WRI
2. Copy the WMOSAIC.INI file to your Windows directory.
3. Read the README.TXT and FEATURES.WRI files.
4. Configure the INI file using ASCII editor. Necessary configuration changes include:
   - Main section
   - Setting section
   - Viewer section
   - Suffix section
   - Annotations section
   - User Menu section
   - Services section

- HotList section
- Font section

5. Make sure you have a WinSock 1.1-compliant sockets DLL functioning.
6. Run WMOSAIC.EXE.

To run Mosaic for Microsoft Windows, users will need a system running Microsoft Windows 3.1 in enhanced mode and a winsock.dll that is 1.1 compliant. Mosaic requires an absolute minimum of an 80386SX-based machine with 4 MB RAM. Recommended configuration is a 33-MHz, or faster, 80486 with at least 8 MB RAM.

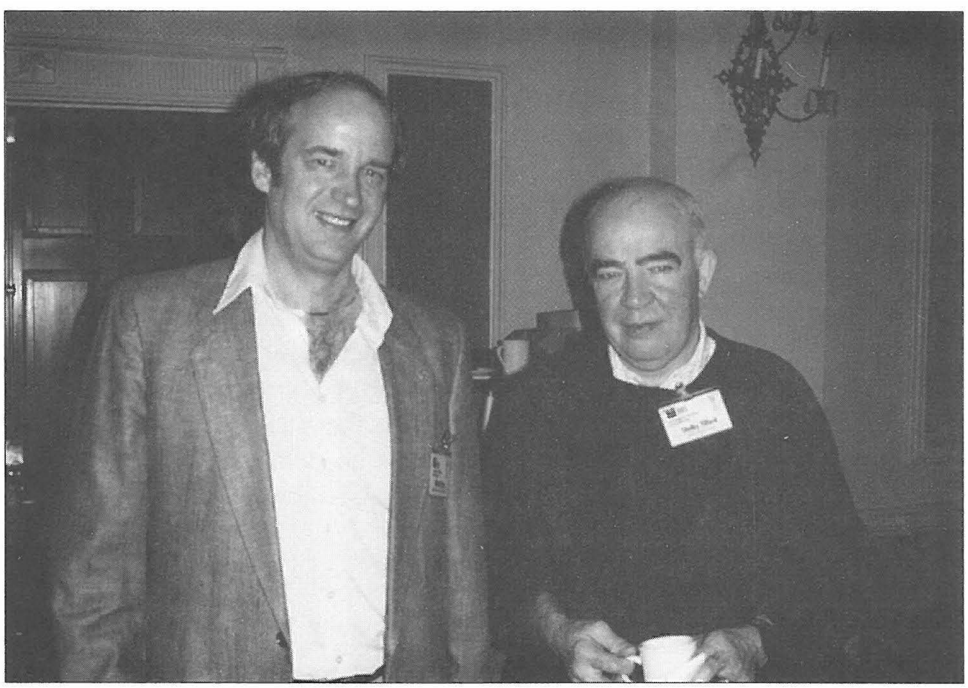
How to Access the EPSO

1. Run Mosaic from your machine.
2. Select "**Open URL** (Uniform Resource Locator)" from your "File" pull-down menu.
3. Type "**http://hypatia.gsfc.nasa.gov/GSFC_homepage.html**"
4. Click "OPEN"

Once the GSFC home page is displayed, users can select the EPSO home page by clicking the corresponding highlighted phrase (in color or underlined) within the Earth Sciences section. This highlighted phrase provides hyperlink to the EPSO server at GSFC. Similarly, hyperlinks to other information resources either on the same server or other servers on the Internet (i.e., SeaWiFS, CERES, Mission to Planet Earth) can be established by clicking highlighted text.

The EPSO server has just been developed and may not be perfect; however, it is ready for testing. We intend to improve and enhance the EPSO server so that it can be of use to the EOS science user community. Please forward your comments or suggestions to:

Yun-Chi Lu
Code 902, NASA/GSFC, Greenbelt, MD 20771
Fax: (301)286-1775
E-mail Address: lu@spso.gsfc.nasa.gov



Michael King (GSFC), EOS Senior Project Scientist

Shelby Tilford, former Associate Administrator, Office of Mission To Planet Earth, NASA Headquarters.

MODARCH: MODIS Documentation Is Now A Keystroke Away

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

In July of 1993, MAST procured an electronic imaging system that allows documents to be archived and retrieved electronically. The MODIS Document Archive, or MODARCH (named for internet address purposes), provides MODIS team members worldwide with access to MODIS-related information from their desktop computers (Macintosh, PC, or UNIX). The system features Excalibur Technologies' unique search and retrieval software—PixTex/EFS—which also comes bundled with Optical Character Recognition (OCR) capability and a flat file database.

Have you ever needed a certain bit of information but couldn't quite remember what it was? Or worse, you couldn't even remember where you read it? Wouldn't it be nice if you didn't have to waste time digging around in file cabinets, but instead you could simply type in a clue on your desktop computer and in seconds it would retrieve the information you need? The MODIS Administrative Support Team (MAST) brought precisely this capability to the MODIS Science Team.

According to Michael Heney, MODARCH System Administrator and contractor with Science Systems and Applications, Inc., MODARCH is flexible in that users may submit documents electronically in a wide variety of formats or in hardcopy form. Moreover, entering documents is fast and easy. "From an operational point of view, the EFS system simplifies the task of maintaining an archive," Heney states. "Because of its auto-index and full-text search capabilities, MAST doesn't need to keyword or otherwise index the documents. We can just scan them in and the software takes care of the rest."

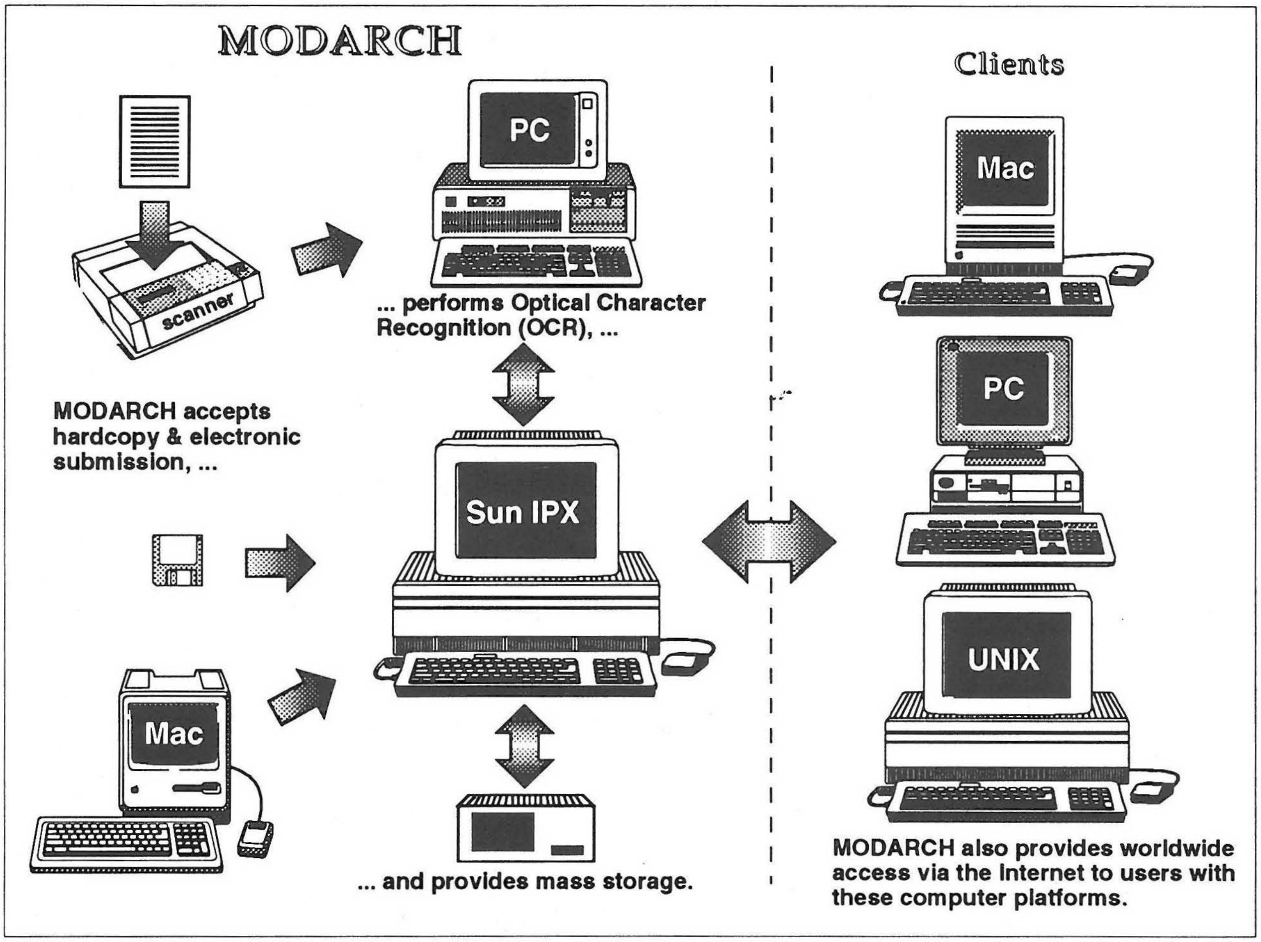
"The rest" is what sets PixTex/EFS apart from other systems. Whereas some archiving applications will not accept hardcopy or documents not formatted to specific standards, MODARCH does not discriminate. PixTex/EFS also stands out above other archiving software, Heney says, because "it has an exceptional search engine. Excalibur started life in the signal processing business, so their pattern recognition algorithms are very good. They transferred this technology to the text-processing arena and developed a very quick and efficient indexing and search engine."

Types of Documents in MODARCH

MODARCH is a repository for any and all documents directly or indirectly related to MODIS. The archive includes, but is not limited to, the MODIS Specifications; minutes from Science, Technical, and Support Team meetings; contract deliverables and technical memoranda; Science Team members' monthly, quarterly, and semi-annual reports; journal articles; and other reports, plans, and presentations (such as ATBDs). MODARCH will also house documents pertaining to NASA's Mission to Planet Earth, EOS, EOSDIS, other instruments within EOS, or the MODIS heritage instruments.

How MODARCH Works

Documents are submitted to MODARCH electronically in a wide variety of formats—Microsoft Word and



WordPerfect are the applications most commonly used—either on disk, by electronic mail, or via file transfer protocol (FTP). But by far the largest volume of incoming documents is in hardcopy form. Since October, 1993 (when the system first began production) approximately 30,000 pages have been entered.

These pages were run through an optical scanner, creating a bit-mapped image of each. The PixTex/EFS OCR software then produces a matching ASCII text version of each scanned page, which is linked to the bit-mapped image so that after conducting a search, users may view or print either the ASCII text or the matching bit-mapped image, or both.

Users will note, however, that because no OCR software is perfect, there are errors in the OCRed ASCII text. PixTex/EFS compensates for OCR errors by employing "fuzzy logic" when conducting searches. If a user is searching for a certain word within a document and that word is misspelled, PixTex/EFS will still find it. PixTex/EFS will find the word even if the user misspells the clue! The ASCII text is used primarily for conducting searches, so if users wish to print an exact copy of a document they should print the matching bit-mapped image.

Once the system became operational, MAST began distributing EFS client software to the team. With the client software on a user's Mac or PC, access to MODARCH is simply a mouse double-click away. Or, users operating on a UNIX platform may access the archive via telnet using X-Windows.

Why Implement an Electronic System?

Paul Baker, of Goddard's Homer Memorial Library, was instrumental in the decision to implement an electronic system. During the summer of 1993, Baker was a NASA Presidential Management Intern (PMI) temporarily employed by MAST to take the lead on researching solutions to the MODIS archiving problems. Baker circulated a survey among MODIS Science and Support Team members and found that the majority of respondents want certain documents available electronically. Based on these findings, Baker set out to scope a "strawman" system, first by defining the basic needs of the archive's users and then by identifying systems commercially or publicly available which actually meet those needs. For example, MAST determined that the MODIS Team uses a variety of computer platforms and word processing applications, so the electronic system selected had to be easily accessible to the entire team.

"Given the variety of environments that various team members work in, we need a system that is flexible, both in terms of computing platform and document formats it will accept," Heney explains. "Also, it must be accessible to Team members widely scattered across the country and overseas. EFS filled these requirements better than any other system. And, the system selected had to be easy to use. Team members can use this system already at their desktops, without having to purchase new equipment or software. EFS has an intuitive user interface and a good online help system, which makes the package easy to use."

Prior to MODARCH, the MODIS Archive was a rapidly burgeoning file cabinet system, with a critical space problem. It consisted of five file cabinets, containing approximately 60,000 pages, spread over at least three different locations at Goddard. MAST determined that the rate of incoming documentation is increasing so that employing a paper system 10 years from now would occupy 85 file cabinets.

Even more critical than solving the physical space issue, PixTex/EFS enables users to search for and retrieve information much faster and with much greater precision without having to leave their desks. A user may type in a "clue," select one of a variety of search strategies, and sort through the contents of every document in the archive in seconds to find precisely the needed information, whether it's a specific phrase or an entire document.

An Output Problem

Whereas MODARCH was initially scoped to serve as only a document archive, Heney has found that users want it to serve a greater function as a document distribution system. "Even though this is an electronic archive, system users want to get their hands on hardcopy," he states. "In the current release of the EFS software, this is a non-trivial task."

Currently, the user must select each page, one at a time, and queue it for printing on a local printer—the user currently cannot print a range of pages or an entire document with a single command. MAST has taken a two-pronged approach to improving this situation. The first approach is to work closely with Excalibur Technologies and emphasize the need for an improved printing capability. Subsequently, MODARCH has become a beta test site for future releases of the software. According to Heney, the next release of PixTex/EFS, due out in May, will allow users with the client software to print multiple pages (including entire documents) easily from their workstations.

Additionally, Heney has developed a set of utilities to allow users with access to UNIX-based print queues to print single pages or entire documents with a single command. Heney used a publicly available set of file translation routines to implement this solution for postscript-based printers. Those interested in setting up a print queue should e-mail Heney to arrange to have their printers established as a print queue from the MODARCH system.

Other Developments

In order to add to the overall functionality of MODARCH, MAST plans to provide a set of utility programs to run outside the PixTex/EFS environment. These will be written and made available as the need is discovered and resources are available to develop them. Since these utilities are not part of the PixTex/EFS system, they cannot be accessed through the client software. Instead, users need to connect to MODARCH via a telnet session to "modarch.gsfc.nasa.gov" and login as "moduser."

One utility Heney developed complements the PixTex/EFS database. "The EFS system allows you to define a database entry for each document in the system," he explains. "However, the built-in database engine is not as robust as we would like. In order to address this, I developed the 'arcinfo' program that allows the user to generate an ASCII representation of the database compatible with Microsoft Excel and other database packages. Arcinfo allows more sophisticated database searching than is possible using the EFS built-in data management system."

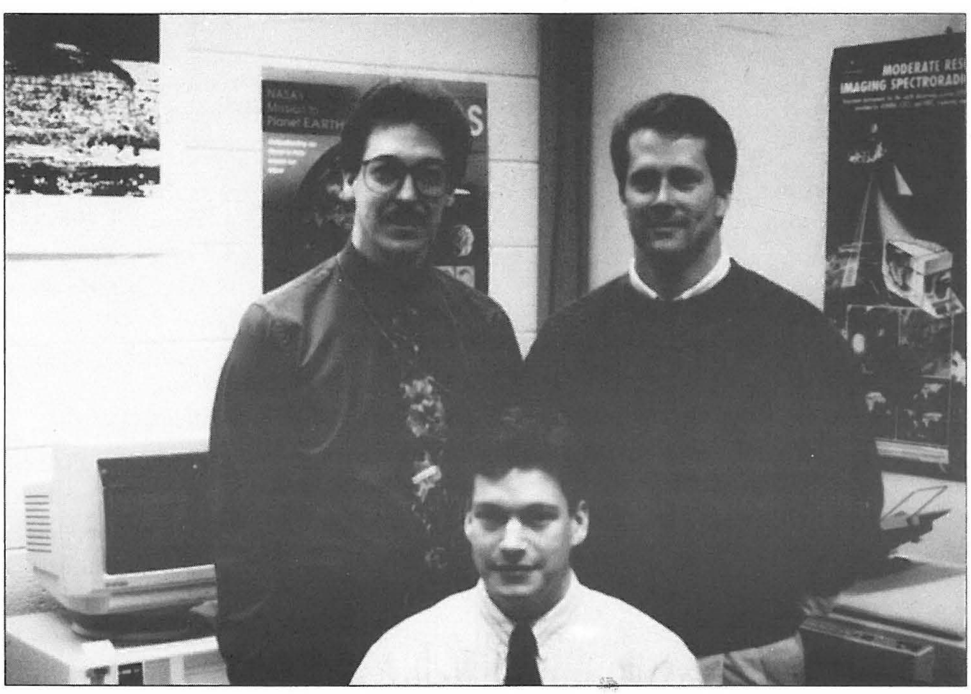
The next version of PixTex/EFS will include a set of Application Program Interfaces (API)—executable files which will allow Heney to create interfaces to other applications. For example, MAST is exploring the possibility of interfacing MODARCH with other information distribution systems. "There is growing interest at Goddard in using other information servers, including World Wide Web, WAIS, Gopher, and Mosaic," Heney observes. "We are examining options for integrating the EFS system and these other servers. We hope to share the data and image files among different information servers, which will make the information even more widely accessible than it already is through EFS."

Additionally, MAST plans to develop an on-line conferencing system with links to MODARCH. This will allow system users to review documents, such as ATBDs, and discuss them on-line in near real time. "In e-mail you get one-on-one or one-to-a-group dialogue; whereas in computer conferencing, all comments are immediately available to an entire group of people, not just a list of recipients or individuals on a mailing list," Heney explains. "The advantage is that each comment is time- and date-stamped so participants can follow the conversational thread. On-line conferencing will probably become possible once we get our hands on the PixTex/EFS APIs."

Down the road, MAST will be prepared if MODARCH is called upon by EOSDIS to serve as a front-end interface for their document archive. According to current plans, EOSDIS will not accept paper copy, whereas the MODARCH system is capable of accepting any document format and can easily reformat or translate its document set into a format usable by EOSDIS.

"This is really a state-of-the-art system," Heney concludes. "It's fun to work with, the interface is fairly intuitive, and it does a good job managing a large volume of paper documents."

Anyone interested in receiving the client software or a copy of the *MODARCH User's Guide* should contact Michael Heney at either his e-mail address (mheney@ltpsun.gsfc.nasa.gov) or at (301) 286-4044.



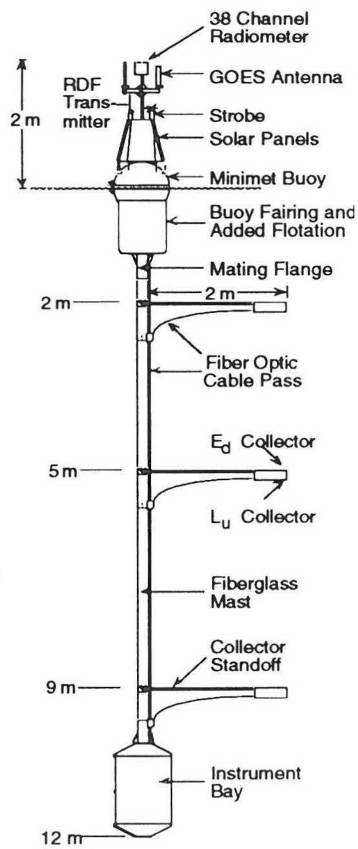
MODARCH System Administrator: Michael Heney (back left), MAST Technical Manager, David Herring (back right), and MAST intern, Dave Shirey (seated in front). Paul Baker (not in the picture), of Goddard's Homer Newell Memorial Library, was vital to the procurement and implementation of MODARCH.

MODIS/SeaWiFS Team Deploys Marine Optical Buoy, Continues Marine Optical Characterization Experiment

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

In support of the Earth Observing System (EOS), a Marine Optical Buoy (MOBY) was deployed off the coast of Lanai, Hawaii on Feb. 21, 1994. Funded jointly by NASA and NOAA, MOBY was developed and deployed under the direction of Dennis Clark, a member of both the MODIS and SeaWiFS science teams. The buoy's primary purpose is to measure visible and near-infrared radiation entering and emanating from the ocean. It is the variations of the visible region-reflected radiation that is referred to as ocean color from which other quantities can be derived, such as the abundance of microscopic marine plants (phytoplankton).

Phytoplankton is critically important to the marine food chain, and it influences the global balance of carbon dioxide within the Earth's atmosphere. It is believed that the abundance of carbon in the atmosphere causes a general increase in global temperature and affects the ocean's productivity. Scientists have learned that the ocean stores vast volumes of carbon from the atmosphere, providing sustenance for phytoplankton. However, researchers don't know whether there will be a corresponding increase in the phytoplankton population to absorb the additional carbon as the volume of carbon dioxide steadily increases in the Earth's atmosphere.



Drawing of the prototype MOBY (courtesy of D. Clark).

In its role of measuring ocean color, MOBY provides a time-series database for bio-optical algorithm development. Because the buoy will acquire data 3-5 times per day at the same site, oceanographers can now monitor the daily fluctuations in biomass concentrations at that site and fine tune their algorithms accordingly. Clark also points out that in addition to the oceanographic applications, MOBY will serve another important function as a calibration reference station for satellite instruments—such as SeaWiFS, EOS COLOR, MODIS, MERIS, and ADEOS OCTS—to assist in maintaining those instruments' accuracies.

"The potential is there for not only calibrating ocean bands, but other low end radiances," Clark explains. "MOBY has science and calibration applications for the atmospheric and land sciences." So MOBY could, for example, support atmospheric correction programs, or radiation budget applications.

"The goal is to produce a site that has high accuracy and high precision radiometry throughout the spectral range from 380 to 900 nm at approximately 2-4 nm spectral resolution," Clark continues. "MOBY serves as one calibration point at specific levels of ocean radiances. Those spectra can then be convolved to match spectral responses of a variety of visible and near-infrared spaceborne sensors." In short, MOBY will provide data for checking the calibration of different sensors at that particular scene and radiance level for any or all EOS optical instruments.

In addition to the deployment, the Team also collected data at the MOBY site for the Marine Optical Characterization Experiment, or MOCE. Also under the direction of Clark, MOCE is a series of field experiments that has been in operation since 1992 parallel to the MOBY campaign. MOCE involves conducting experiments at sea at specific sites to obtain a comprehensive set of bio-optical measurements such as radiometry, pigment analysis, total suspended matter, beam transmittance, and physical properties.

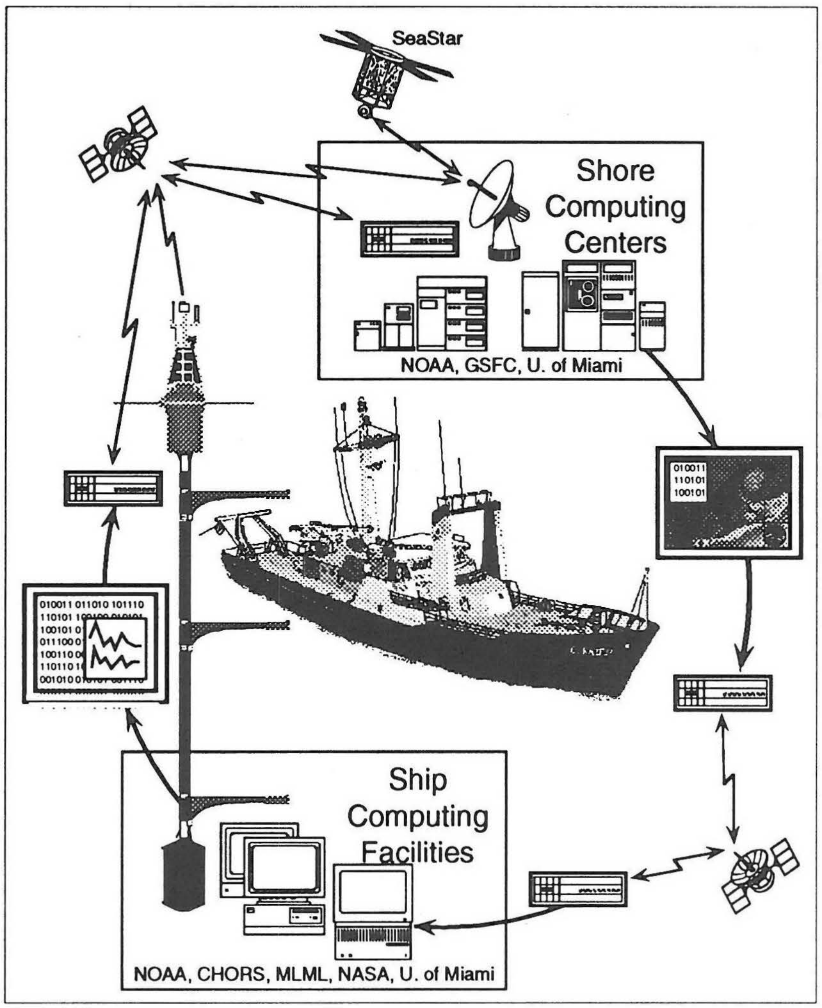


Illustration of the Calibration and Validation Field Program.

MOBY and MOCE are pre- and post-launch campaigns. Prior to launch, these campaigns are being conducted to help in algorithm development. Post launch, these campaigns will serve as a validation and calibration data source. For MOCE, during the post-launch operations, the shipboard operations are timed to be coincident with satellite overpasses, with the ship moving into different oceanic optical regimes. These data are used to check the calibration of satellite-borne ocean color sensors, as well as validate their derived products.

MOBY's Conceptual Design

MOBY's design is the result of a project Clark began in 1986. The buoy consists of six major components which, because the project was not funded initially, had to be purchased and integrated over time. Those components are a new dual spectrograph, the fiber optic multiplexer, the top-end buoy with solar panels and controlling software, a GOES (Geostationary Operational Environmental Satellite) data relay system with data acquisition software, fiber optic radiance and irradiance collectors, and a dichroic water mirror for the dual spectrograph.

The optical system uses two spectrographs with a dichroic ("water") mirror to measure radiometric properties with high spectral resolution and stray light rejection. This "water" mirror is designed to transmit the red (630 to 900 nm) and reflect the blue (380 to 600 nm) portions of the spectrum, making the transition from reflectance to transmittance between 590 and 650 nm. Thus potential for stray light is greatly reduced by splitting the visible spectrum at the beginning of the water absorption region since most of the short wavelength energy is diverted from the entrance slit of the long wavelength spectrograph. The splitting also allows the spectrographs (free spectral range and integration times) to be optimized for the two distinctive spectral domains. Internal calibration and ancillary sensors (temperature, inclination, pressure, etc.) are included.

Approximately 50 feet long, MOBY is the world's largest marine optical device. In the ocean, only its antennae, solar panels, strobe light, and surface buoy (which houses the computer and cellular phone for data transmission) are visible, standing about 7 feet above the waterline. A fiberglass mast extends more than 40 feet directly down beneath the buoy to the instrument bay. At depths of about 6, 16, and 28 feet respectively, 9-foot long booms or "arms" extend outward perpendicular to the mast.

Optical collectors (irradiance and radiance) have been placed at the ends of the arms, as well as on top of the buoy above the surface to collect light coming into the ocean, and then the light reflected back out of the ocean. The reflected portion of the light has been modified by particles such as phytoplankton suspended at various depths, that modifies the signal available to the satellite sensors. Lenses within these collectors focus the light onto fiber optic cables which then transmit the light to a fiber optic multiplexer housed in the instrument bay. The multiplexer relays the light into a dual spectrograph with detectors that measure the spectral radiant energy. These signals are then digitized and relayed by microprocessors and transmitted up to a main computer housed in the surface buoy. This information is then stored on a disk drive, which may be accessed via cellular phone and downloaded for processing back at the MOBY Team facility.

Much of the buoy's hardware and acquisition software was engineered by San Jose State University's Moss Landing Marine Laboratory (MLML) personnel. Mark Yarbrough of MLML was responsible for the final integration of MOBY's components. He also oversees the daily operation of the MOBY Lab sites in Monterey and Honolulu. The acquisition and control software was written by Richard Reaves.

MOBY Funding Sources

The initial MOBY development phases were funded by NASA, NOAA, and the Office of Naval Research (ONR).

A formal MOBY project was originally funded by MODIS to help calibrate and validate the satellite sensor. Fabrication of the buoy was accelerated when in 1991 MOBY received additional funding from SeaWiFS to help in its calibration and validation effort. Charles McClain approached Clark with the idea of using MOBY for two purposes: 1) monitoring the degradation of SeaWiFS over time, and 2) providing a time-series data set.

McClain based the first purpose on his experience with the Nimbus-7 Coastal Zone Color Scanner (CZCS). During its first 18 months in space, the CZCS orbital degradation was well-characterized by the Nimbus experiment team and confirmed by measurements taken aboard ships. After that period, there were no more ship measurements and, subsequently, there was no way of knowing how much error was contained in CZCS data. MOBY's second purpose—providing a time-series data set—will help scientists remove temporal biases from SeaWiFS observations. "Additionally," Clark adds, "MOBY is not constrained by when it takes measurements, so we can observe the response of phytoplankton to different light conditions." Whereas satellites can only view certain sites at certain times, MOBY continually takes data at its site, enabling scientists to interpolate between satellite observations.

MOCE is totally a MODIS-funded endeavor.

How is MOBY Calibrated?

MOBY was calibrated before deployment according to NIST- (National Institute of Standards and Technology) traceable standards. The radiance collectors were calibrated using an Optronix integrating sphere and the irradiance collectors were calibrated using a NIST 1,000-W FEL. The radiance collectors were calibrated using a lamp with a more diffuse light output, because the light reflected back upward through the water column is diffuse.

Also, MOBY contains an internal calibration system. Light from two onboard LED (Light Emitting Diode) lamps (green and red) illuminate a Labsphere Spectralon target that absorbs light at certain wavelengths and reflects all others. The Spectralon target reflects onto an internal mirror (when it is in the calibration position), and the light is then reflected into the relay optics of the dual spectrograph. This allows for calibration checks on the spectral and absolute intensity of the system.

Additionally, every month, divers from MLML and the University of Hawaii will dive at the site with submersible calibration lamps that will be coupled with the collectors in order to monitor system performance.

In order to implement this operational plan, two advanced versions of the MOBY prototype are now being built. Over the course of 5 years these buoys will be swapped out for general maintenance and calibration testing on a quarterly basis. But, before the prototype is removed from the water, both buoys will operate together at the same site for several measurement cycles to establish a crossover calibration between the two instruments to characterize offsets and biases between the two. During this time, both MOBYs will gather concurrent sets of observations to allow the different systems' offsets and biases to be characterized. These observations will allow the Team to characterize or observe the magnitude of biofouling that may be affecting the measurements. (Presently, the biofouling problem is being addressed by coating the collectors with an optically transparent organo-tin compound.)

Contributions to Science

Distinguishing the difference between incoming sunlight and that which is reflected back upward at different depths enables scientists to derive biomass concentrations. Different elements reflect and absorb light in characteristically different ways. For example, scientists have noticed that when there is an abundance of microscopic marine plants, the ocean appears green—phytoplankton absorbs red and blue visible light and reflects green. By measuring this color, scientists can calculate the biomass present.

According to Stanford Hooker, a member of NASA's SeaWiFS Project, MOBY's data will help scientists better understand the effects of atmospheric CO_2 on oceanic biomass concentrations. Hooker says there has been a global increase in atmospheric CO_2, resulting from an increase in fossil fuel burning over the last century. Some of that CO_2 is absorbed into the oceans; however, there is a limit to how much the oceans can store. Scientists don't know what the oceans' saturation limit is, nor do they know how long it will take to reach it.

"Plants consume CO_2 as part of their metabolism," he explains. "But, if you change ocean conditions, will phytoplankton take up more or less CO_2? Some scientists argue that the plants are at their saturation level and cannot adapt." One theory holds that if the marine plant community cannot help absorb the additional CO_2, then the increase of the gas in the atmosphere will accelerate global warming.

MOCE and MOBY operations include taking measurements in three broad categories: optical, biological, and physical. According to Hooker, MOBY's data products include water-leaving radiance and absorption and attenuation parameters that enable the Team to derive the following products: phytoplankton pigments, phytoplankton concentration, total suspended matter, chlorophyll *a*, and fluorescence quantum efficiency.

The Team has also recently deployed another device for collecting *in situ* data to complement MOCE and MOBY observations in order to provide higher quality data sets. A device resembling a delta wing—called a paravane—is lowered to different depths of the ocean and towed alongside the ship. The paravane has been modified to house a pumping system (which collects relatively uncontaminated sea water and pumps it via a hose back up to the ship) and an *in situ* fluorometer. The pumping system delivers sea water to instruments onboard the ship which measure fluorescence, transmissivity, and particle size distribution. These data will be compared to SeaWiFS/MODIS-derived products for validation.

Initially, MOBY data will be processed by MLML and stored by the SeaWiFS Project, an operation that will ultimately be taken over by EOSDIS. The data processing system software—adapted from CZCS processing software—was engineered by Michael Feinholz, of MLML. MOBY data will be cooperatively analyzed by Clark, MOBY Chief Scientist, and Professor William Broenkow, oceanographer at MLML. These data will eventually be made available to researchers worldwide.

Already other investigators are becoming involved with the project. For example, researchers at the University of Hawaii will use MOBY data to aid their efforts. Bob Bedigary is developing oceanic primary productivity models, Tony Clark will use MOBY to study atmospheric aerosols, and Dave Karl is monitoring CO_2 fluxes in the area.

MOBY Deployment Sites

In November of 1992 and 1993 MOBY was temporarily deployed in Monterey Bay, California, for system testing and evaluation. This site was chosen mainly due to its proximity to the lab site where MOBY was fabricated, which is operated by San Jose State University's Moss Landing Marine Laboratories.

The new, permanent deployment site of MOBY is 20°49.0" N Latitude, 157°11.5" W Longitude—or about 11 nautical miles west of Lanai, Hawaii. This site was chosen primarily because it meets the MODIS Ocean Team's calibration/validation criteria. Also, the neighboring islands—Molokai, Lanai, and Maui—provide a lee from the wind so conditions there remain relatively calm. Of course, should typhoon conditions threaten, MLML may quickly retrieve the buoy and then re-deploy it after the storm. Finally, the MOBY site is within range of cellular phone coverage, rendering its data easily accessible.

Hard Work and High Risks

Placing a highly complex scientific instrument in an environment as hostile as the ocean is risky business. MOBY will be exposed to high wind and waves, corrosive salt, and marine organisms—such as barnacles that may grow on its collectors. Then there is the threat of damage from vandalism or accidents from recreational maritime activities. In Hawaii, commercial and sport fishermen like to fish near buoys, called FADs (Fish Aggregation Devices), around which fish often school. The Team fears fishermen may damage MOBY by accidentally bumping it; or, while trawling, they may entangle and drag the buoy. Any of these threats could result in structural or electrical failure, or drifting.

Clark readily admits that there are many ways the buoy can fail. "More buoys have been lost due to mooring failure than probably any other reason," he states. "However, nothing is gained unless you push technology to its limits, and that in itself is a high risk." In an age of dwindling funding, pushing technological limits is a tall order. Because funds were not available in 1986 for beginning and developing a complete system, the incremental development approach was used in which the total system concept was developed and then the individual components were built as funds became available. These components were bought in the mid-80s, so many of the components of the MOBY prototype—such as the linear array detectors—consist of old technology, but the new MOBYs will be state-of-the-art. "Since the beginning of this project, most of our resources have gone into hardware," Clark explains, "forcing us to use a small development team (three people). Given the funding profile of the 1980s, this project could never have come to fruition without using an incremental development approach."

Yet, the integration and testing process greatly accelerated with the infusion of SeaWiFS funds in 1991. "I've never tried to push any system into use as fast as the MOBY system," Yarbrough states. "For economic reasons you want to get things done as fast as possible. Yet for scientific purposes, the longer you use a system, testing it and gaining experience with it, the more reliable it is. It's been a continuous balancing act." The compromise is evident in the Team's work schedule; 14- and 16-hour work days are not uncommon, even on weekends.

Developing and deploying MOBY in a timely manner probably couldn't have been done without a highly resourceful Team dedicated to the project's success. Each MOBY Team member has had to wear many hats, in addition to their individual areas of expertise. Yet, resourcefulness is simply par for the course to Yarbrough. For example, in 1982 he invented a modified CTD (Conductivity, Temperature, and Depth) device that had an immediate impact on the way oceanography is conducted. His resourcefulness has paid off for the MOBY Project too—he has been responsible for the final integration of all the components in the MOBY system.

Although there have been setbacks along the way, the MOBY/MOCE Teams now seem poised to begin enjoying the fruits of their labors. "We're making an effort to provide accurate data and analyses of the biological state of the oceans from an optical standpoint," Clark concludes. "If that database isn't there, you can never formulate analyses which accurately evaluate bio-optical processes or the impact of man's intervention on those processes."

The following is an alphabetical list of the MOBY/MOCE field campaign principal contributors:

James Brown
RSMAS University of Miami

Dennis Clark
NOAA NESDIS

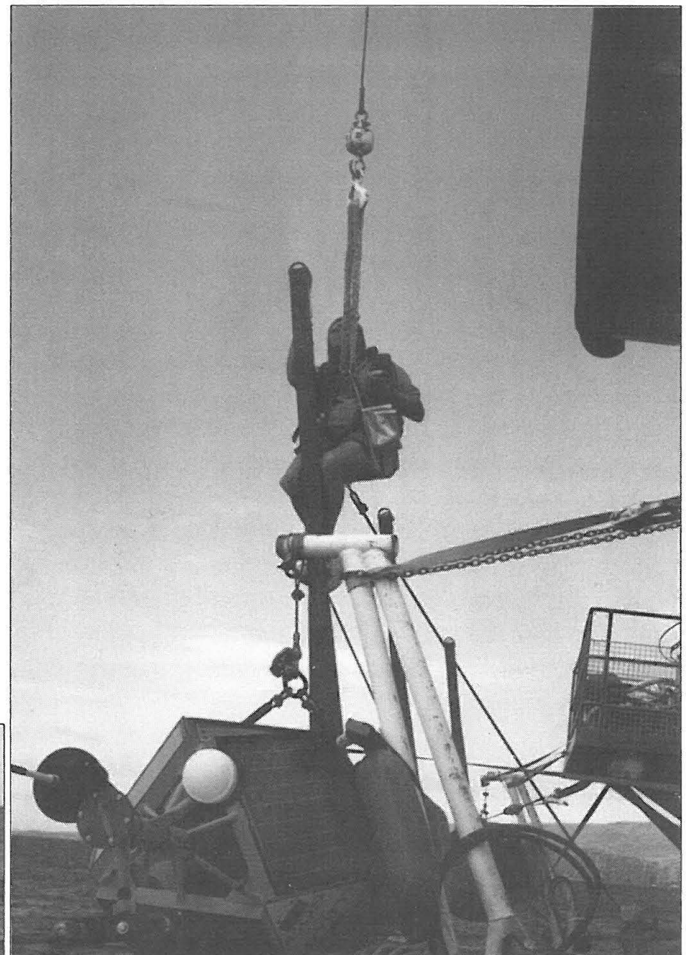
Michael Feinholz
MLML

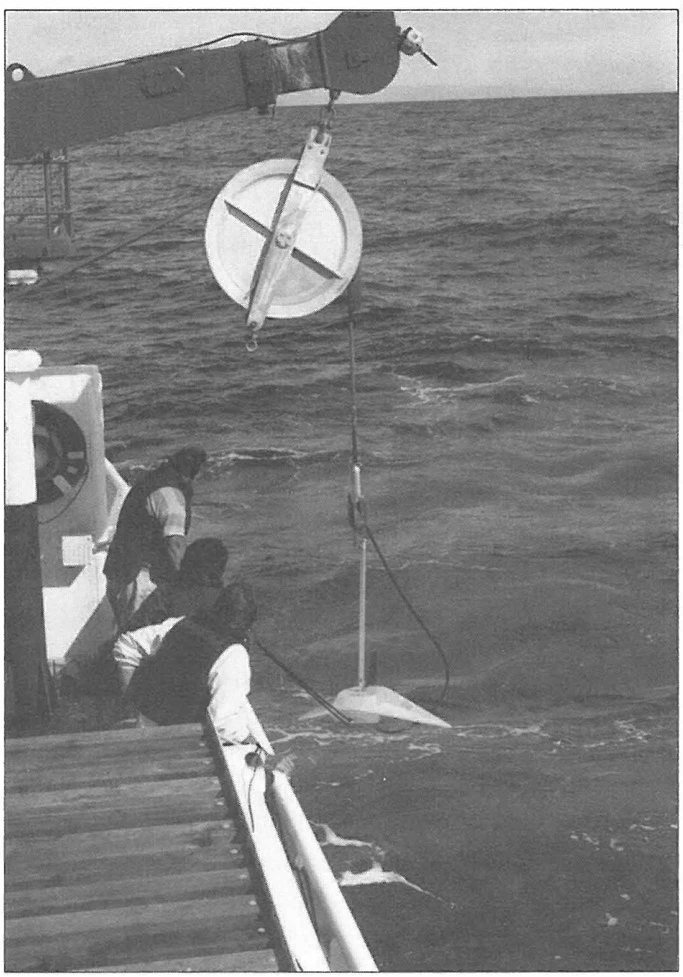
Stanford Hooker
NASA GSFC

Charles Trees
San Diego State University
Center for Hydro-Optics and Remote Sensing

Ken Voss
University of Miami

Mark Yarbrough
MLML





△

(Top Right) MOBY/MOCE Chief Scientist Dennis Clark is shown here applying an anti-foulant around the buoy's lenses just prior to deployment. The anti-foulant is a toxin intended to prevent marine organisms, such as barnacles, from growing on the buoy. Here MOBY is secured to the side of the ship; the southwestern coast of Lanai, Hawaii, can be seen in the background.

◁

(Bottom Left) As part of the MOCE operations, Edward King of NOAA (left), Mark Yarbrough of MLML (center), and Dennis Clark (right) are shown lowering a paravane over the side of the ship. A pump, contained within the paravane, pumps ocean water back up to the ship, from which *in situ* data are taken.

Data Assimilation for EOS: The Stratosphere

—By **Lawrence Coy**/Applied Research Corp., Landover, MD; **Richard B. Rood** (rood@oz.gsfc.nasa.gov)/Data Assimilation Office, Code 910.3, NASA/Goddard Space Flight Center, Greenbelt, MD 20771

The Data Assimilation Office (DAO) at Goddard Space Flight Center is developing an operational assimilation capability for EOS. One focus of this system is assimilation of meteorological data from the stratosphere and application of these meteorological analyses to chemistry and transport problems. Stratospheric assimilation has been performed at Goddard since the late 1980's. The stratospheric assimilation effort has in large part been driven by the needs of researchers working to assess the possible impact of stratospheric aircraft and industrial pollutants on stratospheric ozone. Since the distribution and chemistry of stratospheric ozone are strongly controlled by the winds and temperatures, accurate global wind and temperature fields are a key component of stratospheric ozone research.

The DAO's GEOS-1 (Goddard Earth Observing System-Version 1) assimilation system was discussed in the November/December 1993 issue of *The Earth Observer* (Rood and Ledvina, 1993). The stratospheric version of GEOS-1, STRATAN, includes additional levels in the vertical and extends the top analysis level to 0.4 hPa (about 55 km). Thus, the stratospheric assimilation includes all of the troposphere as well as the stratosphere. A 1-year run beginning from mid-September 1991 has just been completed. The Upper Atmosphere Research Satellite (UARS) was launched in September 1991, and a major use of this data set will be diagnostic studies of UARS data. The UARS assimilation, as well as stratospheric assimilation of data from other time periods, is being used for a number of studies, including the support of aircraft missions, trajectory and transport models of stratosphere-troposphere exchange, and ozone transport and chemistry.

Data assimilation is especially important in the stratosphere because rawinsonde wind measurements are scarce. There are very few wind measurements in the stratosphere and most meteorological information is gathered from temperature sounders on the operational satellites. Without data assimilation, winds in the upper stratosphere are determined indirectly from satellite measurements of the temperatures. Such indirect methods, based on the geostrophic approximation, fail near the equator and can sometimes overemphasize small errors in the satellite temperature analysis. Coy et al. (1994) provides a comparison of winds from the assimilation with conventionally derived stratospheric winds.

An example is shown in Figure 1, which compares the potential vorticity on the 1200 K potential temperature surface (located at an altitude of approximately 50 km) computed from the assimilation's winds and temperatures to that computed from a traditional balanced-wind estimate from the temperature-derived geopotential fields. In the northern hemisphere winter, the undisturbed potential vorticity is highest at the pole and decreases toward the equator. Disturbances throughout the winter distort this pattern. The region of strong potential vorticity gradient, highlighted with the darkest shading, outlines the winter polar vortex. The lighter shading highlights a region of mixing located at the outside edge of the vortex. As can be seen from Figure 1 the assimilation produces a stronger vortex (the dark shading is narrower), and a smoother vortex (the lighter shading does not dip out away from the vortex and break up into blobs). In Figure 1a, air recently pulled off from the vortex edge appears as the broad light-shaded region stretching over the top of the figure. The relatively small-scale structure shown in the light-shaded region in Figure 1b does not correspond to any known wave or instability in the atmosphere and is believed to be an artificial signal produced by the spatial pattern of data generated by the

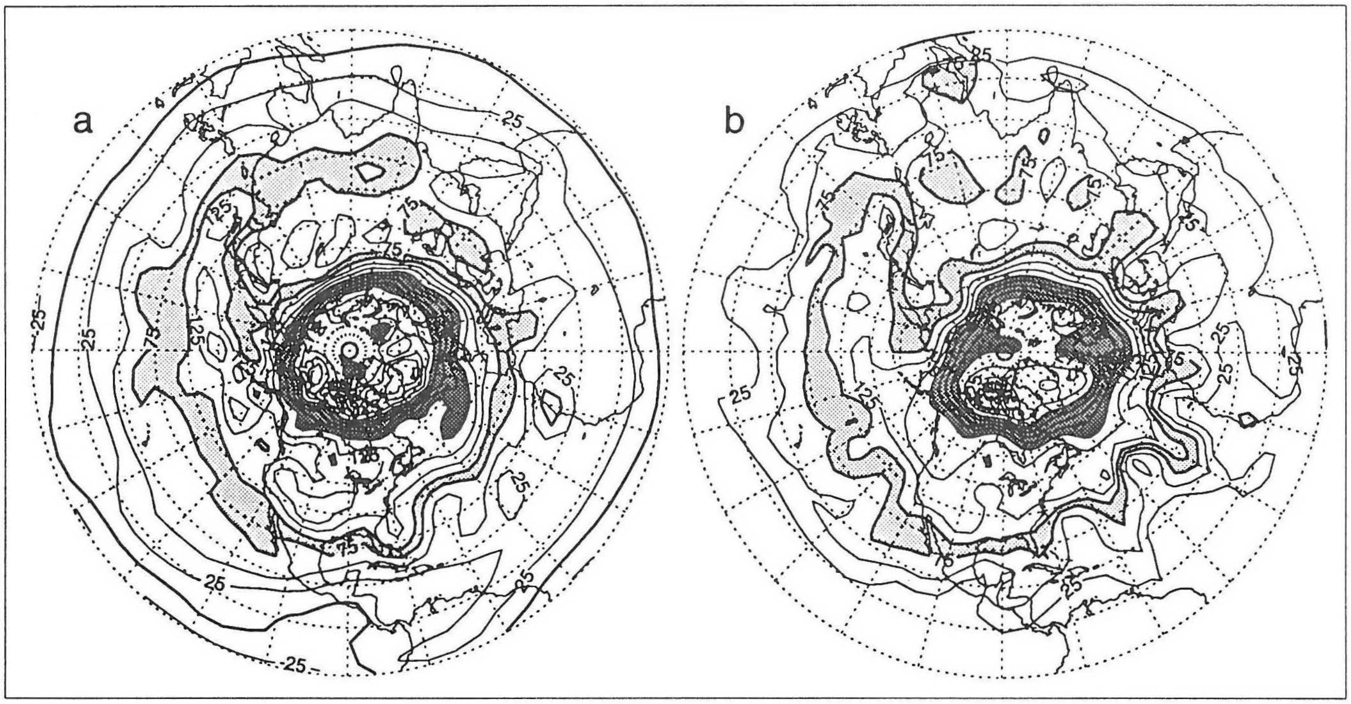


Figure 1. The potential vorticity on a 1200 K potential temperature surface (at an altitude of about 50 km) for January 1, 1992 based on a) the DAO's assimilation products and b) the National Meteorological Centers/Climate Analysis Centers (NMC/CAC) height analysis. The potential vorticity units are scaled by a factor of 10^5.

satellite as it passes over different points of the Earth. This pattern is mainly absent in the potential vorticity produced from the assimilation, Figure 1a. An accurate representation of both the vortex and the mixing region is needed because air from the vortex edge is often stripped off during the winter, and then either returns to the vortex edge or is mixed with air at lower latitudes. This mixing may play a role in mid-latitude ozone changes.

The potential vorticity fields suggest that the assimilated data product provides an improved estimate of stratospheric winds, and one of the main uses for DAO's stratospheric assimilation is to provide transport winds for chemistry models. In these applications, an initial distribution of a chemical constituent or an aerosol (for example ozone or dust from Pinatubo) is transported by the winds from the assimilation. There is no updating of constituent information from observations, and the constituent evolves with the winds and the model chemistry. Figure 2 shows measured total ozone from the Total Ozone Mapping Spectrometer (TOMS, bold line) and calculated total ozone from a transport model driven by the winds from the assimilation (see Rood *et al.*, 1992 and references therein).

The winds capture the variability of the observed ozone field and show that the assimilation gives a good representation of synoptic- and planetary-scale activity. Given that a 1 m/sec error in the wind field translates into a 1-degree-of-latitude error in constituent transport, the transport calculations provide a sensitive test of the quality of the winds. This example shows the power of the assimilation process; the horizontal winds are for the most part provided by the assimilating model transferring indirect information from the observed temperature fields to the motion field. In addition, the transport experiment shows that the vertical wind field, equal to the divergence of the horizontal wind field, is also represented with some quality. Failures in the transport applications also provide information on how to improve the assimilation product as discussed in Weaver *et al.* (1993).

In addition to these applications the DAO developed an operational capability to support NASA's ER-2 aircraft mission, SPADE (Stratospheric Photochemistry, Aerosols and Dynamics Expedition), that took place out of Ames Research Center in spring of 1993. The DAO provided real-time mission support, including forecasts as an aid to flight planning, and assimilation products such as winds and temperatures for in-the-field interpretation of chemical measurements onboard the ER-2. The winds are needed for the correct interpretation of the chemical results because the aircraft can encounter air from different regions of the atmosphere (inside and outside of the vortex, for example), and, hence, air samples with different chemical histories, brought near each other over time. One important tool, developed at Goddard's Atmospheric Chemistry and Dynamics Branch (ACDB), is a back trajectory model that shows where air along the aircraft's flight track originated by using assimilated winds from earlier days. Hence, changes in trace chemical composition can be identified with different air masses. The DAO has also supplied assimilated products for earlier aircraft missions such as the Airborne Arctic Stratosphere Experiment (AASE) and AASE-II, and is currently supporting the 1994 Airborne Southern Hemisphere Ozone Experiment/Measurements for Assessing the Effects of Stratospheric Aircraft (ASHOE/MAESA) ER-2 mission out of Hawaii and Christchurch, New Zealand.

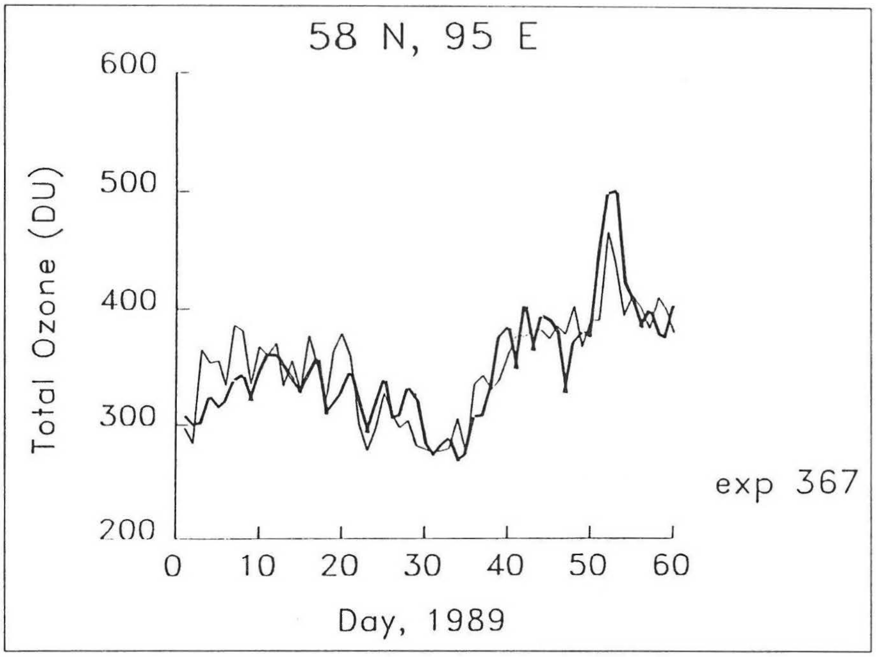


Figure 2. Total ozone comparison at 58 N, 95 E; bold line is measured from TOMS, thin line is the result of a transport model driven by winds from the data assimilation system.

Data assimilation is the best method of using the available data to obtain global fields of measured and unmeasured quantities. It is especially important in the stratosphere where wind measurements are scarce. Winds and temperatures from the assimilation have been shown to be the best way to reduce uncertainties due to the meteorology in chemical assessments. Future applications include tropospheric chemistry, which is more difficult because the effects of convection must be accounted for. The DAO is uniquely committed to providing sufficient diagnostic information for the study of convective transport. For stratospheric assimilation, the DAO plans to start using UARS meteorological data as well as constituent data. An especially exciting possibility is the use of constituent data to retrieve information about the winds through advanced assimilation techniques. If this proves productive, then it will be possible to extend the capability into the upper troposphere using information from the Microwave Limb Sounder (MLS). For more information on data availability send electronic mail to data@dao.gsfc.nasa.gov.

REFERENCES

Coy, L., R.B. Rood, and P.A. Newman, 1994: A comparison of winds from the STRATAN data assimilation system to balanced wind estimates. *J. Atmos. Sci.*, in press.

Rood, R.B., and D.V. Ledvina, 1993: Data Assimilation for EOS: Impact of satellite water vapor data on precipitation estimates. *The Earth Observer* Vol. **5**, No.6, 28-31.

Rood, R.B., J.E. Nielsen, R.S. Stolarski, A.R. Douglass, J.A. Kaye, and D.J. Allen, 1992: Episodic total ozone minima associated effects on heterogeneous chemistry and lower stratospheric transport. *J. Geophys. Res.*, **97**, 7979-7996.

Weaver, C.J., A.R. Douglass, and R.B. Rood, 1993: Thermodynamic balance of three-dimensional stratospheric winds derived from a data assimilation procedure. *J. Atmos. Sci.*, **50**, 2987-2993.

Using Satellite Imagery to Understand the Global Exchange of Carbon Dioxide between the Terrestrial Biosphere and the Atmosphere

—By **Christopher Potter** (chrisp@gaia.arc.nasa.gov), Senior Research Scientist/Johnson Controls World Services, Ecosystem Science and Technology Branch, NASA Ames Research Center.

One of the clearest signals of human impact on a global scale is the rapidly rising concentration of greenhouse gases like carbon dioxide (CO_2) in the atmosphere as a result of combustion of fossil fuels and deforestation. While human-driven changes in the composition of the atmosphere are well documented, interactions and feedbacks between the biosphere (plants, animals, and microbes) and the changing atmospheric composition are not adequately understood.

Hence, as Earth system scientists seek to predict future responses of the planet to global warming, it is critical that they begin with accurate estimates of current patterns of carbon flux and storage. Ecologists are refining our understanding of the seasonal changes in the way climate and soils control exchanges of CO_2 between the land surface and the air. In pre-industrial times, fluxes between the atmosphere, land, and ocean pools were in a relatively steady state. However, when climate and land use change at a rapid pace, the

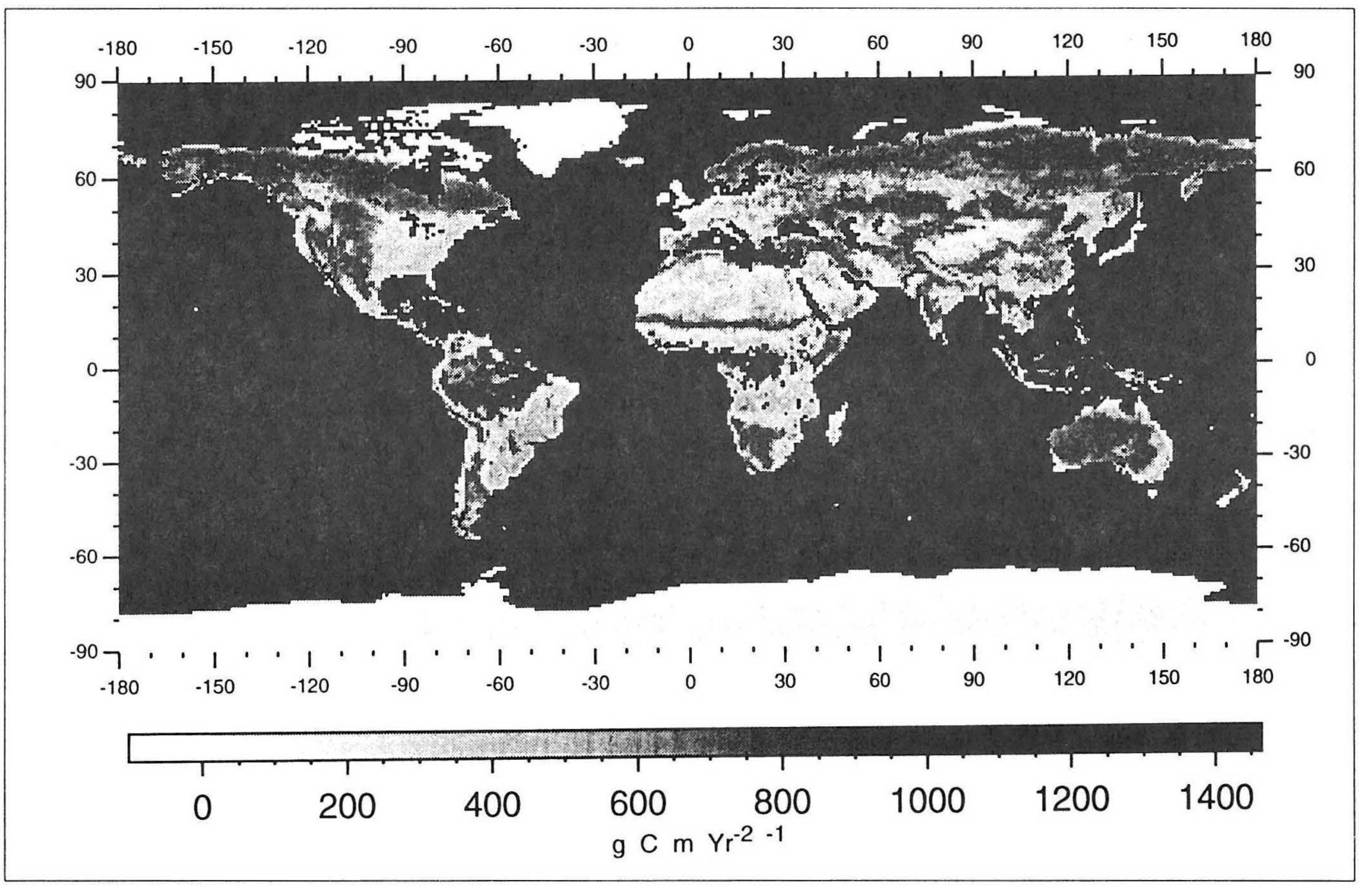


Figure 1. Map of Net Primary Production.

existing patterns of carbon flux and storage them may be dramatically altered.

By the use of recently assembled satellite images of the global land surface, a team of investigators from NASA Ames Research Center, the Carnegie Institution of Washington, and Stanford University have completed a study of the role of terrestrial plants and soils in the cycling of carbon to and from the atmosphere. This research has produced a dynamic picture of the contemporary balance between photosynthetic fixation and microbial respiration of CO_2.

The CASA (Carnegie-Ames Stanford) Biosphere model estimates photosynthetic fixation of CO_2 in terrestrial net primary production (NPP) at 48 Pg (10^{15} grams) C per year. This flux is 10 times the annual fossil fuel emission of CO_2. Our modeling efforts show that 60% of terrestrial NPP occurs at tropical latitudes (Figure 1).

The use of satellite sensor data to estimate NPP captures many of the effects of land cover change (urbanization, deforestation, and cultivation) on the dynamics of the carbon cycle. Human-induced changes in the rate of cycling of carbon in agricultural soils are also included in the model design through increased microbial decomposition rates. We are also investigating the global impacts of fertilizer applications on greenhouse gas fluxes.

In the CASA model, carbon from plant residues stored in the soil and at the surface of forest and grassland soils (called litter) is divided into separate pools, depending on their residence times in the ecosystem. Residence times of litter-soil carbon pools (expressed as the steady-state pool size divided by the sum of annual losses) are generally shortest for ecosystems of the tropics. Both nonwoody (leaves and roots) and woody litter are represented in the model, along with

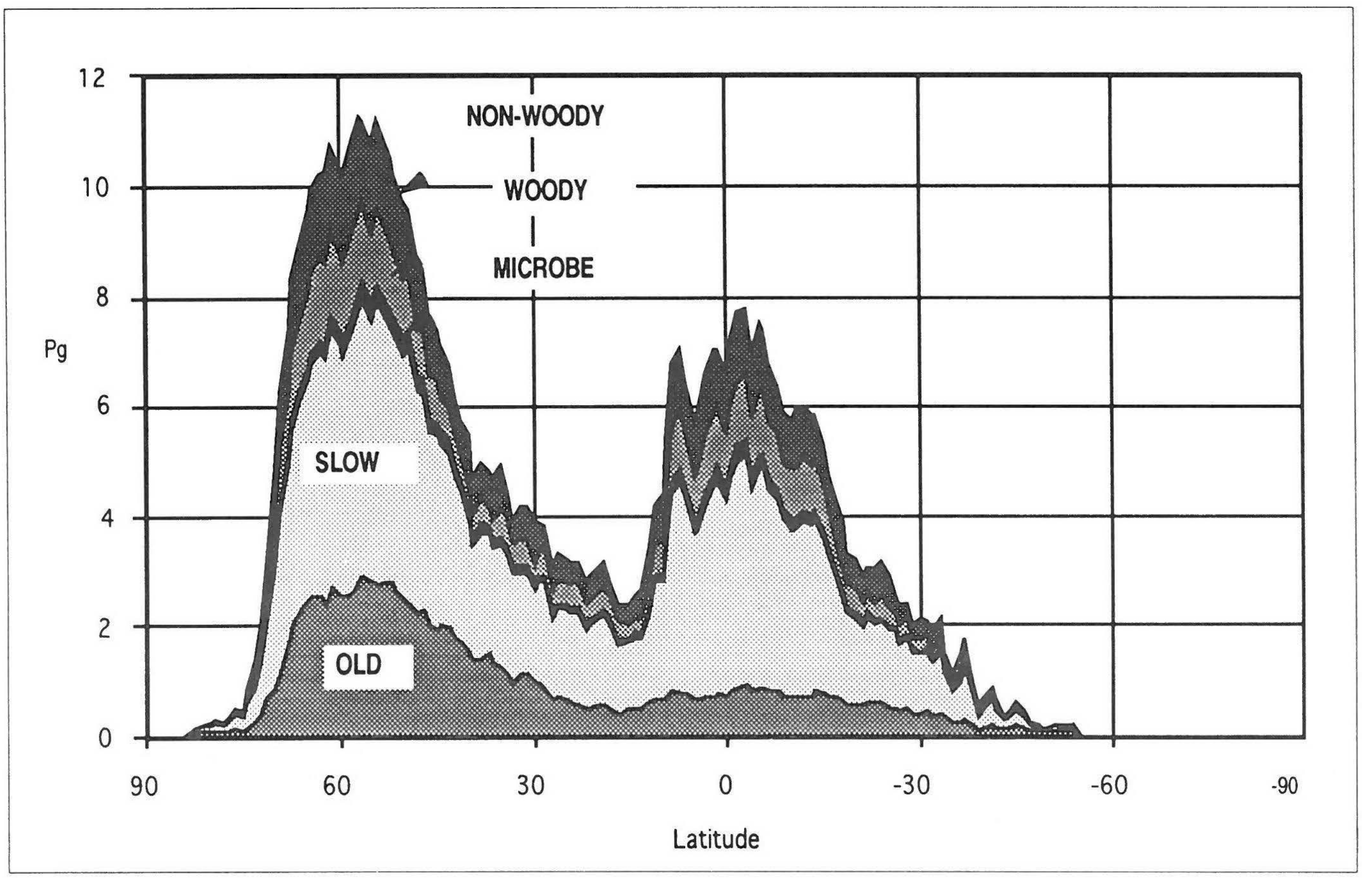


Figure 2. Global distribution of litter and soil carbon pools

soil microbial carbon pools. Soil organic carbon is divided into a SLOW pool (with residence time of 1 to several decades), and an OLD pool (with residence time of 1 to several centuries).

The CASA model shows that SLOW soil carbon makes up the single largest pool in most ecosystems (Figure 2). Steady-state pools of SLOW soil carbon (in the top 30 cm) account for 300 Pg, whereas standing litter represents global storage of around 170 Pg C. The distribution of stored carbon in litter and soil carbon pools varies greatly with latitude. There are large carbon pools in northern boreal/temperate forests and also in tropical ecosystems. With the exception of the OLD carbon component, these large pools have a residence time of less than 70 years. The carbon stored in these pools may be released to the atmosphere at much faster rates if the climate warms significantly. Additionally, deforestation and biomass burning can greatly accelerate losses of soil carbon from these various soil pools.

Global models like the CASA-Biosphere formulation of net ecosystem production can reveal patterns in the functions and interactions of the biosphere-atmosphere system at scales not previously observed before the advent of satellite technology. Continuing research with remote sensing technology is essential to understanding climate change and ecosystem responses to the greenhouse effect.

This research is conducted by the Earth System Science Division at Ames. It was funded by NASA Headquarters' Office of Mission to Planet Earth. Future funding sources are currently being sought.

CASA Reference

Potter, C.S., J.T. Randderson, C.B. Field, P.A. Matson, P.M. Vitousek, H.A. Mooney and S.A. Klooster, 1993; Terrestrial ecosystem production: A process model based on global satellite and surface data. *Global Biogeochemical Cycles.* **7(4)**: 811-841.

From *EOS.News*

SeaWiFS Update

Orbital Sciences Corporation (OSC) informed NASA that the July 1994 launch date for the Sea-Viewing Wide Field Sensor (SeaWiFS) ocean color instrument on the SeaStar satellite will slip 2 months to September 29th. In an unrelated issue, the National Telecommunications and Information Administration (NTIA) of the U.S. Department of Commerce has advised NASA that OSC cannot market the recorded data downlinked by S-band transmission. This includes the Global Area Coverage (GAC, 4 km) and selected Local Area Coverage (LAC, 1 km) data to be stored onboard and downloaded at NASA facilities at Wallops Island. The L-Band transmission of LAC data to stations licensed by OSC is not affected by the ruling.

The SeaWiFS Science Team working group tasked with evaluating algorithms for marine "Primary Productivity" met at Brookhaven National Labs, Long Island, January 23-25. The workshop was convened and chaired by Paul Falkowski and Wayne Esaias. The meeting provided a forum to evaluate the best scientific and practical approaches, as well as for defining requirements for ancillary data (ship or satellite) to productivity models.

News Release—Department of the Interior, Office of The Secretary

Secretary Babbitt Praises The Nomination of Dr. Gordon Eaton To Head The U.S. Geological Survey

Secretary of the Interior Bruce Babbitt today praised President Clinton's selection of Dr. Gordon P. Eaton to be the new Director of the U.S. Geological Survey (USGS).

"I am exceptionally pleased with the President's announcement that he intends to nominate Dr. Eaton to head the USGS," Babbitt said. "Dr. Eaton is the ideal candidate to lead the Nation's premier water and Earth science information agency, at a time when we are facing many critical decisions on the environment. I am confident that he will lead the USGS to an even stronger role in providing us with the scientific information needed for wise policy decisions."

Eaton, 64, is a highly distinguished Earth scientist, administrator and former employee of the USGS. He is currently Director of the Lamont-Doherty Earth Observatory of Columbia University, one of the country's foremost research centers for the Earth sciences. In addition to his 16 years of experience with the USGS, Dr. Eaton has served as President of Iowa State University in Ames, and Provost and Vice President for Academic Affairs at Texas A&M University. He is a Fellow of the Geological Society of America and the American Association for the Advancement of Science.

A native of Ohio, Eaton received his formal training in geology at Wesleyan University (B.A. with high honors and high distinction, 1951) and both M. S. (1953) and Ph.D. (1957) at the California Institute of Technology.

Eaton enjoys broad support and respect throughout the Earth science community for both his scientific credentials and his demonstrated ability to manage a large research institution. He was highly recommended for the nomination by the National Academy of Sciences, which at the request of Secretary Babbitt conducted a nationwide search for candidates qualified to head the USGS.

Upon confirmation by the Senate, Eaton would become the 12th director of the 114-year-old USGS. Headquartered in Reston, Virginia., the USGS has the federal government's largest civilian mapping program, the largest water resources scientific and data program, is responsible for the assessment of energy and mineral resources in the national domain, and conducts basic and applied research into a wide range of Earth science and Earth hazard programs.

Dr. Eaton is married with two grown children.

EOS Science Calendar

Mar. 30-Apr. 1	MISR Science Team Meeting, Pasadena, CA. Contact Dave Diner at (818) 354-6319; (djd@jord.jpl.nasa.gov).
April 13-15	MODIS CDR Calibration Peer Review, NASA/GSFC, Greenbelt, MD. Contact Joan Baden at (301) 286-1378; (baden@highwire.gsfc.nasa.gov).
April 19-20	U.S. ASTER Science Team Meeting, Pasadena, CA. Contact Anne Kahle at (818) 354-7265; (anne@lithos.jpl.nasa.gov).
May 4-6	MODIS Science Team Meeting, Greenbelt, MD. Contact Patti Thomas at (301) 220-1701; (swager@gsfcmail.nasa.gov).
May 9-11	CERES, MODIS, and MISR Peer Review, Landover, MD. Contact Michael King at (301) 286-8228; (king@climate.gsfc.nasa.gov).
May 12-13	CERES Science Team Meeting, Hampton, VA. Contact John Nealy at (804) 864-4412; (nealy@champagne.larc.nasa.gov).
May 16-18	ASTER, LIS, MOPITT, SeaWinds Peer Review, Landover, MD. Contact Michael King at (301) 286-8228; (king@climate.gsfc.nasa.gov).
May 17-19	AIRS Science Team Meeting, World Weather Building, Camp Springs, MD. Contact H. H. Aumann at (818) 354-6865; (hha@airs1.jpl.nasa.gov).
May 23-26	7th Joint International ASTER Science Team Meeting, Pasadena, CA. Contact Anne Kahle at (818) 354-7265; (anne@lithos.jpl.nasa.gov).
May 24-26	International MIMR Meeting, ESTEC, Noordwijk, The Netherlands. Contact Chris Readings at +31-1719-85673, or Roy Spencer at (205) 544-1586 (rspencer@nasamail.nasa.gov).
May 25-26	TES Science Team Meeting, University of Denver, CO. Contact: Reinhard Beer at (818) 354-4748; (beer@atmosmips.jpl.nasa.gov).
November 14-18	8th Joint ASTER Science Team Meeting, Japan. Contact Hiroji Tsu at +81-3-3533-9380; FAX: +81-3-3533-9383, or Anne Kahle at (818) 354-7265; (anne@lithos.jpl.nasa.gov).

The Earth Observer

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

The Earth Observer Staff:
Executive Editor: Charlotte Griner
Technical Editor: Renny Greenstone
Associate Technical Editor: Bill Bandeen
Assistant Editor: Lynn Koert
Design and Production: Winnie Humberson
Distribution: Hannelore Parrish

Global Change Calendar

April 4-8	SPIE's International Symposium on Aerospace Sensing, Orlando, Florida. Sponsor: The International Society for Optical Engineering. Contact SPIE, PO Box 10, Bellingham, WA 98227-0010, phone: (206) 676-3290; FAX: (206) 647-1445; e-mail: spie@mom.spie.org.
April 12-13	U.S. Global Change Policy Symposium, National Press Club. Environmental Researcher/Policy-Maker Forum, Topics include EOS/EOSDIS, Industry Roles and Capabilities, GCDIS, USGCRP, Congressional and White House Policy Directives, interactive data workshops. Contact Shea Marston at (612) 822-3702, FAX (612) 822-9647.
April 12-15	Second Annual Catalog Interoperability/NASA Science Internet Workshop (CI/NSI), Arlington, Virginia. Contact Angelia Bland at (301) 441-4299; Internet: bland@nssdca.gsfc.nasa.gov.
April 26-28	1994 ASPRS/ACSM Annual Convention & Exposition, Reno, Nevada. Contact Denise Cranwell, phone: (301) 493-0200.
May 9-12	Tenth Thematic Conference on Geologic Remote Sensing: Exploration, Environment, and Engineering, San Antonio, Texas. Contact Robert Rogers, ERIM, P.O.Box 134001, Ann Arbor, Michigan 48113-4001, phone: (313) 994-1200, ext. 3382, FAX: (313) 994-5123.
May 12	The State of Earth Science from Space: Past Progress, Future Prospects—A Symposium Sponsored by The Space Policy Institute of The George Washington University's Elliott School for International Affairs in Cooperation with the Office of Mission to Planet Earth of the NASA, The George Washington University, 800 21st Street, NW Washington, DC. Contact Kimberly Carter at (202) 994-1635.
May 16-20	The Third Circumpolar Symposium on Remote Sensing of Arctic Environments, Fairbanks, Alaska. Contact Kenneson Dean, Geophysical Institute, University of Alaska Fairbanks, P.O. Box 757320, Fairbanks, Alaska 99775-7329, phone: (907) 474-7364; FAX: (907) 474-7290; Internet: kdean@dino.gi.alaska.edu.
May 23-27	1994 American Geophysical Union Spring Meeting, Baltimore Convention Center, Baltimore, Maryland. Contact Sherry Washington, 2000 Florida Avenue, N.W., Washington D.C. 20009, phone: (202) 462-6900, FAX: (202) 328-0566.
July 11-21	30th COSPAR Scientific Assembly, Hamburg, Germany. Contact G. Haerendel at Internet: hae%mpe.mpe-garching.mpg.de.
August 8-12	1994 International Geoscience & Remote Sensing Symposium (IGARSS), Pasadena, California. Contact IGARSS Business Office, phone: (713) 291-9222; FAX: (713) 291-9224.
September 5-9	Call for Papers for ISPRS Commission III Symposium, Spatial Information from Digital Photogrammetry and Computer Vision, Munich, Germany. Contact Christian Heipke, Secretary, ISPRS Commission III 1992-1996, Chair for Photogrammetry and Remote Sensing, Technical University Munich, Arcisstr. 21, D-80290 Munich, Germany. Phone: +49-89-21052671 (2677), FAX: +49-089-2809573, or e-mail: chris@photo.verm.tu-muenchen.de.
September 11-15	First International Airborne Remote Sensing Conference and Exhibition: Applications, Technology, and Science, Strasbourg, France. Contact Robert Rogers, ERIM, Box 134001, Ann Arbor, Michigan 48113-4001, phone: (313) 994-1200, ext. 3234; FAX: (313) 994-5123.
October 25-27	Second International Conference on Carbon Dioxide Removal. Sponsored by Research Institute of Innovative Technology for the Earth (RITE), and New Energy and Industrial Technology Development Organization (NEDO). For further information contact ICCDR-2 Local Secretariat: Ms. Yukiko Morita, c/o Planning and Survey Dept., RITE, 9-2 Kizugawadai, Kizu-cho, Soraku-gun, Kyoto 619-02, Japan. Phone: +81-7747-5-2301; FAX: +81-7747-5-2314.
November 13-16	First IEEE International Conference on Image Processing, Austin Convention Center, Austin, Texas. Contact icip@pine.ece.utexas.edu.

Code 900
National Aeronautics and
Space Administration

Goddard Sapce Flight Center
Greenbelt, Maryland 20771

Official Business
Penalty For Private Use $300.00

Postage and Fees Paid
National Aeronautics and
Space Administration
NASA-451

U.S.MAIL