The Earth Observer

An EOS Periodical of Timely News and Events

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Inside

Editor's Corner

The European Space Agency (ESA) Council, consisting of Ministers from each ESA member state, met in Granada, Spain in November. At that meeting, the Ministers endorsed the development of two series of ESA satellites: Envisat, to be launched in 1998, and Metop, to be launched two years later. Subsequent to this meeting, Philip Goldsmith, ESA Director of Observation of the Earth and its Environment, in consultation with the Italian Space Agency, wrote to Shelby Tilford to confirm ESA's intent to deliver a MIMR for the EOS PM-1 satellite, in addition to a MIMR for the Metop-1 satellite. With this development, both the U.S. and Europe benefit from having a MIMR fly on Metop-1 in a morning orbit, and on EOS PM-1 in an afternoon orbit.

Last issue I reported that I had begun to restructure the EOS Project Science Office by recommending the appointment of key scientists within the Earth Sciences Directorate at Goddard as Project Scientists of individual EOS spacecraft missions. I am happy to report that Piers Sellers has agreed to be the EOS AM Project Scientist, Chuck McClain the EOS Color Project Scientist, Chet Koblinsky the EOS Altimetry Project Scientist, and Mark Schoeberl the EOS Chemistry Project Scientist. These well-known scientists join Bob Price, Deputy Director of Earth Sciences and EOSDIS Project Scientist, Les Thompson, EOS PM Project Scientist, and Bruce Guenther, EOS Calibration Scientist. I have initiated regular meetings with this Project Science Staff to keep abreast of important science issues affecting each of the

20 Principal Investigator and Facility Instrument Teams as well as EOSDIS. This has proven very beneficial to me, and has enhanced my ability to interact closely with the EOS Project Management at Goddard. In addition to these Project Scientists, I have asked Jay Zwally to be the Deputy Project Scientist for EOS Altimetry, and to work closely with the Altimetry Project Manager and GLAS Instrument Manager on science issues related to laser altimetry.

A Project Manager, Tom Yi, has now been selected for the EOS Color mission. Chuck McClain, Arlene Peterson, Wayne Esaias and I have met on several occasions to discuss issues regarding this 1998 mission, including issues concerning the formation of a Science Team; the design and specifications for a spacecraft and instrument; and the spatial resolution, spectral channel selection, and data policy for the data. Many important science, policy, and schedule concerns have now been raised, resulting in increased attention to this early mission.

The EOS Investigators Working Group (IWG) meeting has now been scheduled for March 29-31 in Greenbelt, Maryland. The primary focus of this meeting is to agree on the definition of at-launch data products for each EOS instrument. This focus necessarily requires prioritizing the at-launch data products for each instrument team, based both on algorithm maturity and the importance of the output data products to scientists within the team, other Principal Investigator and Facility Teams, and Interdisciplinary Investigators. It is essential to finalize the at-launch data products so that EOSDIS and the EOSDIS Core System (ECS) contractor (Hughes Information Technology Company) can have a well-defined and accepted data products list to work toward supporting. The ECS contract, currently under negotiation, should be signed and in place by the time of the IWG. Thus, a secondary objective of the IWG is to inform the scientific community about the conceptual design of the ECS; how it is envisioned to work together with other elements of EOSDIS; and how the scientific community will interact with the ESDIS (EOS Earth Science Data and Information System) Project and the ECS contractor in satisfying the scientific community's data system needs. ■

— ***Michael King***
EOS Senior Project Scientist

Congressional Budget Schedule

Fiscal Year 1994 budget deliberations for NASA and Federal agencies will include the following key steps in the House of Representatives and Senate:

Mid-March	President sends complete budget amendment to Congress
March-April	NASA authorization hearings by the Senate Commerce Committee and the House Science Committee.
April 27-28	Hearings on the NASA budget request are held by the House Subcommittee on VA, HUD, and Independent Agencies.
June	House debate on the VA, HUD, and Independent Agencies Appropriations Bill.
June 10	Deadline for reporting appropriations bills in the House.
June 30	Deadline for passing appropriations bills in the House.
Summer	Senate receives appropriations bills for review by committees, for debate and for conference; voting is usually late in the summer.
September 30	If appropriations bills are not enacted, a continuing resolution must be passed for the fiscal year beginning October 1.

Panel Meeting

EOS Calibration Panel Meeting in San Diego

— Al McKay and Mitch Hobish

The sixth general meeting of the EOS Calibration Panel was held in San Diego, January 28-30. Attendees included the panel chairman, Bruce Guenther, Japanese and U.S. representatives of the ASTER team, and representatives of the CERES, MISR, MODIS, and interdisciplinary investigation teams. Representatives of AIRS, National Institute of Standards and Technology (NIST), and the National Physical Laboratory (NPL) in the United Kingdom were present, and several EOS instrument and data system contractors also attended.

In his introductory remarks, Bruce Guenther pointed out the essential role that data product validation will play in the EOS effort. The first day of the meeting was spent discussing site requirements for data product calibration and validation. Shared use of field facilities may lead to substantial cost savings. Cross-calibration requirements were discussed on the second and third days of the meeting.

Guenther pointed out that we may not be aware of the environmental research programs currently active within the borders of many countries. As EOS needs are defined and documented, requirements can be discussed with the Committee on Earth Observing Satellites (CEOS). CEOS will be helpful in establishing working EOS product validation partnerships with countries which are not currently participating in satellite launches or environmental research.

The U.S.-sponsored Long-Term Ecological Research (LTER) program is identifying global study sites that match standard terrain type definitions, i.e., tundra, boreal forest, desert, etc. At least two or three sites in each category will be selected for long-term monitoring and study. Landsat and other historic records will be examined for the selected sites to help determine global climate change, regional ecology, etc. These are unoccupied test sites, i.e., direct, on-going, on-site ground-based measurements are not required.

Occupied sites require local support infrastructure, including telecommunications. Internet digital communications facilities presently serve a substantial portion of the globe. Moreover, several facilities in areas of the globe not presently served will probably be added by the time of the first EOS launch. Internet may provide the basic digital communications required to access many EOS validation measurements.

By carefully selecting validation sites and cooperating with existing agencies in the countries where validation measurements are required, EOS may be able to utilize existing infrastructure and personnel at these sites and avoid providing its own permanent on-site staff. Kohei Arai from the ASTER team presented an analysis of calibration errors using the ASTER on-board calibration system and also using in-flight observation of selected ground calibration and validation targets. Required ground target characteristics and the measurements that will be needed to determine target characteristics were discussed, and a specific list of candidate sites that meet the requirements was presented. In the course of the presentation, Bruce Guenther noted that EOS instruments will be calibrated relative to physical standards from the U.S., Japan, and Europe (ESA), and that potential differences arising from different standards or calibration methods must be understood and accounted for within EOS and the Mission to Planet Earth. Hugh Kieffer and others expressed the opinion that differences in national standards would be small compared to other calibration errors, but all agreed that factual verification of consistency among international standards was mandatory.

Definitions of instrument calibration and product validation were discussed. Hugh Kieffer offered these definitions: calibration is the process of establishing instrument responsivity (photometric, spatial, spectral, temporal) to the physical quantity it measures directly (radiances, EM fields). Validation is the process of establishing reliability, accuracy, and precision for derived (Level-2) products that are not measured directly. In some circumstances, physically unrealistic Level-2 products may reflect an instrument calibration (Level-1) problem. Bruce Guenther noted that derived products likely will be validated only under a small subset of the global conditions under which the associated retrieval algorithm will be applied because of cost constraints.

Anne Kahle presented a preliminary list of calibration and validation test sites for ASTER. For each of twenty-four sites, the list includes location (name and lat/long), salient features, measurement objective, required field equipment, products affected, and a list of responsible PIs. The information presented was preliminary, since negotiations between U.S. and Japanese investigators are still underway. The list includes two geometric calibration sites: one that uses cross-cutting roads in Iowa and one that uses the Golden Gate and Bay Bridges in San Francisco. Many of the ASTER investigators would like to see more Project interaction with other instruments and investigations. Validation sites include volcano and glacier sites for evaluation of volcanic and glacier products, as well as a number of geologic sites for evaluation of geologic products, reflectance, emissivity, and thermal inertia. Coincident aircraft observation of clouds may be used to jointly validate ASTER, MODIS, and MISR cloud products. Robert Lee (LaRC) reported that plans for CERES product validation are not yet complete and that Richard Green will make a presentation on CERES product validation at the next meeting of the Calibration Panel. Lee then presented a quick overview of ERBE product validation. Areas used for validation include the Sahara Desert (for cloud conditions) and the Southern Pacific. Significant modeling of bidirectional variance for each scene and surface type was required. For CERES, integrated wide-band radiances depend on the spectral character of the scene, i.e., errors in spectral signatures lead to errors in radiance values. A scene must be tracked to determine if its spectral shape has changed. Other sensors, e.g., AVHRR, were used to weight the scenes for clouds, vegetation, ocean/land/coastline, etc. MODIS products will be used for this activity for CERES.

Carol Bruegge presented a list of approximately 100 MISR test sites that will be observed in the MISR local mode (275 m resolution) to support calibration and validation, biogeochemical cycle studies, biosphere-atmosphere interaction studies, land surface climatology studies, ecosystem dynamics studies, and studies of aerosols and clouds. The specific sites were selected based on inputs from MISR team members, EOS interdisciplinary PIs, and ASTER and MODIS team members. MISR observations are generally made in a data-averaging mode in which inputs from several local-mode pixels are averaged at the instrument to reduce platform-to-Earth data transmission requirements. Test sites will be observed in a full-resolution or non-averaging mode. Selected field activities and flight instrument consistency checks also will be used for MISR calibration and validation. MISR will work with a number of other instrument teams and investigators to obtain required instrument calibration and product checks.

Stuart Bigger (U.Az.) discussed ASTER and MODIS calibration site requirements. The University of Arizona team will use two ground calibration sites: the alkali flats area at the White Sands Missile Range and the Rogers Dry Lake at Edwards Air Force Base. No geophysical properties are being studied at these sites; the reflectance of the ground and atmospheric parameters such as optical depth will be measured. Commercial radiometers and other equipment have been purchased to support some of the required measurements; other measurements require special instrumentation that is currently being designed and constructed at the University.

Al Fleig reported that MODIS product validation basically will continue to rely on the measurement programs that were used to support initial algorithm development. Because of limited funds, MODIS algorithm development and product validation measurements will not be done in independent efforts; MODIS team members will join other investigators in previously-existing or independently- defined programs to share costs and increase efficiency.

The MODIS land team will make extensive use of results from the LTER program and the land Pathfinder data effort at the EROS Data Center. Thematic Mapper (TM) data and some field measurements also will be used for selected sites.

The MODIS ocean team expects to share in other efforts; ocean measurements that require ship or aircraft support can be very expensive and costs will be shared. Some of the required measurements are keyed to the launch of SeaWiFS; the program has one dedicated buoy and several sun photometers. Wayne Esaias will announce 60 or 70 study site locations in March.

The MODIS atmospheric team is cooperating with other programs and efforts. The MODIS Airborne Simulator (MAS) is a ten-channel MODIS precursor instrument that is already providing atmospheric data. The atmospheric team also is active in the FIRE, ASTEX, and TOGA/COARE programs. Yoram Kaufmann will provide additional information by the time of the March MODIS Science Team meeting. Because of differing interests and priorities, cooperation between EOS product development and validation teams and other programs is not simple. Partners must agree on the site characteristics that get measured.

Bruce Guenther presented information on FLINN (Fiducial Laboratories for an INternational Network), a global network supporting Crustal Dynamics Test Sites. Sites are generally plentiful in North America, Europe, and the lower portions of Asia but are generally sparse in central Africa, central Asia, the Pacific rim, and South America. New sites are being added to FLINN in the former Soviet Union and other under-represented regions. EOS validation support activities could be introduced at appropriately selected existing or future sites.

The Department of Energy (DOE) is implementing the ARM program, which will measure Earth surface and atmospheric characteristics at 5-10 ecological observation sites. The study will focus especially on carbon dioxide and the effects of fossil fuel burning. A mid-continent observation site has been completed at La Monte, Oklahoma. The next DOE study site built may be an ocean observation station. EOS validation programs requiring on-site support might share personnel and facilities with the ARM program. Al Fleig noted that MODIS algorithm development and product validation may rely heavily on data collected during special measurement campaigns which do not require continuous, on-site support. Bruce Guenther replied that remote sites such as those being discussed could nevertheless serve as data collection and integration sites during the data collection campaigns, and could provide data transmission services to central data collection facilities.

Information on FLINN and ARM sites is currently available in an electronic catalog maintained at Goddard Space Flight Center by the Crustal Dynamics Project. To facilitate sharing of existing field measurement support structures (buildings, electric power facilities, etc.), the EOS Science Processing Support Office may provide an electronic version of this catalog with expanded ecological and geological information for reference by EOS science team members who must select calibration and validation sites. The panel was uncertain that the desirable information (radiometric parameters, vegetation, temperature, water vapor, soil chemistry, etc.) is regularly collected or available at the sites. Several panel members suggested that even a list of site references from the scientific literature and a list of contact persons associated with each site would be helpful.

Several panel members asked if the EOS round-robin calibration would extend to secondary standards used in field measurements, e.g., aircraft campaigns. The panel confirmed that round-robin calibration support for instruments to be used in field measurements is necessary and cost-effective.

Second Day of the Meeting

To begin the second day of the meeting, Carol Johnson (NIST) and Nigel Fox (NPL, UK) were asked to make short presentations on the calibration support activities available from their respective organizations.

Carol stated that NIST provides a calibration baseline for government and industry by:

1. providing artifacts (Standard Reference Materials) for sale. Standard Reference Materials available from NIST are available for a fixed price listed in the NIST catalog;

2. providing fixed calibration services, also available at a fixed price from the NIST catalog; and

3. providing specific services for specific needs as defined by the customer and agreed to by NIST.

By Congressional mandate, prices for these NIST services are based on actual costs incurred. For example, NIST has a contract with GSFC to attend calibration meetings and support EOS planning for calibration activities such as round-robins, etc. NIST has a similar contract with SeaWiFS.

Nigel Fox noted that the NPL provides many services similar to those of NIST, but some differences in emphasis and specific capabilities of the two organizations do exist. Because of preexisting capabilities, in some cases NPL could provide services that complement those of NIST at very low cost. NPL could be especially cost-effective in some areas where NIST does not currently have coverage, e.g., NPL can currently determine aperture sizes to 0.01% uncertainty in area. NPL has a huge carousel facility for radiometric calibration in vacuum. They have component characterization service for space instruments and could provide EOS filter characteristics in the 0.3 - 30 µm range using swept laser radiation.

As an introduction to cross-calibration among EOS instruments, Bruce Guenther presented a calibration policy statement developed for the Polar Platform in the early days of the EOS program. Calibration Preliminary Design Reviews and Critical Design Reviews are to include "peer review" by science-calibration experts. Calibration fixture designs, procedures, and analysis documentation are to be delivered with the instrument and an individual responsible for achieving calibration goals is to be clearly identified. Required elements of the calibration/validation program include: "realistic pre-launch calibration and characterization tests with procedures that represent the manner in which the instrument will operate in orbit; mathematical (analytic) models of behavior of various critical components of the instrument design; calibration in terms of physical standards and standard processes; cross-calibration and comparison of sensors before launch and in-orbit; exploitation of numerous calibration and data product validation approaches for each sensor; and use of ground sites and additional research measurements to verify derived data products."

Fumihiro Sakuma (NRLM, Japan) discussed the pre-launch (laboratory) cross-calibration of ASTER, MODIS, and MISR in the visible, near infrared, and shortwave infrared regions. Cross-calibration procedures will involve the use of a transfer radiometer, a transfer integrating sphere and fixed-point and variable-temperature blackbody furnaces. Required equipment characteristics are being defined and compared with corresponding parameters measured for commercial equipment, and some equipment items are being specially built to support cross-calibration. Stuart Biggar reported on the effort to design and construct a set of custom transfer radiometers at the University of Arizona. Four distinct detector materials are required to achieve the needed spectral coverage. The first instrument will be built using silicon detectors (0.4 - 0.9 µm). The radiometers will support cross-calibration among the ASTER, MODIS, and MISR instruments. The radiometers are not suitable for use with CERES and MOPITT because of the different wavelength domains and operating principles used in these instruments.

John Barker reported on planned cross-calibration activities between the MODIS and SeaWiFS instruments. Solar diffuser outputs will be compared for eight bands (0.4 - 0.9 µm) on SeaWiFS I, SeaWiFS II, and MODIS. Average lunar output for SeaWiFS will be compared with output of the Kieffer lunar model, lunar output through the MODIS spaceport, and direct lunar output from MODIS, MISR, and ASTER. Laboratory responses of the instruments also will be compared for common calibration sources/radiometers in the pre-launch era, and, in the post-launch era, instrument responses will be compared at ground calibration sites.

Jim Mueller of the Center for Hydro-Optics and Remote Sensing, San Diego State University (CHORS), discussed some lessons learned from the Coastal Zone Color Scanner (CZCS) instrument. Experience with on-orbit degradation in the CZCS instrument has demonstrated that even 5% absolute radiometric accuracy is very difficult to achieve. In the initial series of round-robin comparisons begun for SeaWiFS last July, 5% absolute accuracy was not achieved even in the laboratory. Inconsistencies seem to have arisen at the SBRC/GSFC standards interface; the precise source of the errors is still being investigated.

H.H. (George) Aumann (JPL) discussed the ground and in-flight calibration of the AIRS instrument. He emphasized the view that EOS cross-calibration activities should respond to well-defined data customer needs. Error sources for the multi-instrument data user include radiometric shifts in the instruments, spectral uncertainty, beam misalignment, slant path effects, and time-of-observation effects.

Carol Bruegge (JPL) reviewed equipment needs and present equipment status for MISR calibration. A large aperture integrating sphere and high quantum efficiency (HQE) detectors are being acquired. BRDF tests of solar calibration panels are planned, and a diffuser panel that circulates among EOS instruments would permit comparisons of absolute BRDFs among instruments. MISR is acquiring precision apertures that may be useful to MODIS and other instruments. Also component life tests and accelerated aging tests planned for MISR may be useful in the general EOS community. Robert Lee (LaRC) reviewed CERES calibration plans including the use of a Fourier transform interferometer to achieve spectral characterization at wavelengths greater than 150 μm. The instrument builder (TRW) is responsible for CERES instrument design, fabrication, and calibration.

This concluded the formal presentation segment of the Calibration Panel meeting. After a break, the Panel reconvened to receive writing assignments and begin preparation of a draft of an EOS Cross-Calibration Proposal. The proposal will support cross-calibration planning and resource allocation.

Third and Final Day of the Meeting

After an initial discussion of word and phrasing specifics in the completed initial draft of the document, the Panel turned to the larger questions regarding the utility and priority of proposed calibration activities. After a lengthy discussion, the Panel arrived at the consensus that EOS instrument calibration should be done in the following priority order:

1. individual instrument calibration as planned by the individual instrument teams;

2. in-flight radiometric and geometric cross-calibration using suitable Earth targets; and round-robin cross-calibration activities done in the laboratory before the instruments are integrated at the platform builder's site; and

3. cross-calibration done at the platform integrator's site.

The Panel agreed that assigning the lowest priority to cross-calibration at the platform integrator's site is not intended to convey the message that end-to-end testing at the integrator's site is unimportant, but rather that it should be done only if resources are available, and that such activities do not adversely affect the preceding two items. ■

Science Team Meetings

ASTER Science Team

— *D. Nichols, Anne Kahle and Y. Yamaguchi*

The fifth meeting of the ASTER Science Team was held February 2-5, 1993, in Las Vegas, Nevada. The approximately 65 meeting attendees included Japanese and U.S. members of the Science Team and representatives of ERSDAC, JAROS, MELCO, Fujitsu, and NEC in Japan, NASA Headquarters, the EOS Project at GSFC, and the ASTER Science Project at JPL.

This very successful four-day meeting comprised plenary, individual, and joint Working Group sessions. The focus of the meeting primarily was on data products; including both Level 1 and geophysical data products. The Team Working Group structure was reorganized to better address the data product issues.

G. Asrar, EOS Program Scientist, placed the action on the Science Team to prepare their final list of standard data products for review by the EOS IWG in March. The list is to include only data products that will be ready at launch, and it will provide descriptions of each of the products, including their readiness, their science application, and their sensitivity to instrument measurement performance. The sensitivity characteristics are required to understand the impacts of any potential rescoping activity. The new Higher Level Data Products Working Group distributed assignments to the various Science Team Working Groups to develop the necessary support information for each of the standard data products. The final list of standard data products will be incorporated in the EOS Project Science Plan and will be used as one criterion to judge the success of the Project. The ASTER instrument will produce a unique, high resolution, registered, multi-spectral data set. The current list of standard ASTER science data products to be proposed to the IWG is:

- Priority one (essential at launch):
  - Calibrated instrument data
    - Radiance at the sensor with the bands within and between each telescope co-registered
  - Basic physical parameters without atmospheric correction
    - Brightness Temperature at the Sensor
    - Relative Spectral Emissivity
    - Relative Spectral Reflectance
  - Basic physical parameters at the Earth's surface with atmospheric correction
    - Surface Radiance
    - Surface Brightness Temperature
    - Surface Kinetic Temperature
    - Surface Emissivity
    - Surface Reflectance
  - Scene Classification
  - Digital Elevation
- Priority two (highly desired at launch):
  - Soil index
  - Vegetation Index - PVI
  - Vegetation Index - NDVI
  - Relative Spectral Emissivity - Thermal Log
  - Relative Spectral Reflectance - Log Residual

Polar Outflow Glacier Velocity
Temperature Glacier Extent
Cloud Emissivity
Cloud Fractional Area
Cloud Optical Thickness
Cloud Phase
Cloud Top Height
Cloud Base Height
Cloud Top Temperature
Cloud Effective Particle Size
Sea-Ice Fractional Area
Lead Fractional Area
Meltpond Fractional Area
Sea Ice Albedo
Polar Sea Ice Temperature
Polar Sea Surface Temperature
Sea Surface Temperature - split window
Cloud Liquid Water Content
Cloud Thickness

In addition to the standard products, several special products in planning include:

- Interpreted physical parameter products
  - Evapo-transpiration
  - Soil/mineral/vegetation indices
- Products mapped to standard, uniform space-time grids and products resulting from analysis of lower level data. These products include:
  - Thermal Inertia
  - Volcanic Age Maps
  - Directional Land Surface Reflection
  - Coral Reef Maps
  - Geologic Maps
  - Mineral Maps

An auxiliary product will be a comprehensive spectral library.

In the past few months the Japanese have significantly increased their level of activity with respect to the ground data system. At this meeting, they proposed to provide the U.S. with Level 1A data along with radiometric and geometric calibration coefficients.

Matt Schwaller, representing the ESDIS Project, requested that the Science Team provide recommendations to GSFC regarding the data acquisition request process. Inputs will be factored into the activity between the U.S. and Japan in developing the ASTER Project Implementation Plan (PIP). Schwaller also asked for Science Team requirements for "quick-look" data in preparation for the planned June ECS System Requirements Review.

Another key issue discussed during the meeting was geometric and geopositioning requirements for data registration and DEM accuracies. A significant problem that must be addressed is the need for an extensive library of ground control points (GCPs) to support the mapping effort.

The Japan Resources Observation System (JAROS) organization and its instrument subcontractors reviewed the continuing development of the instrument and its individual telescope subsystems. Substantial progress was reported.

GSFC reported that it had decided to commit entirely to the use of a solid state recorder (SSR) on AM-1 in place of the originally planned tape recorders. The state-of-the-art recorders are limited in capacity and will require special operations considerations for observations longer than 13 minutes. Over the coming year, Goddard will study the option of an SSR with higher capacity.

The issue of direct downlink (DDL) of ASTER data was discussed by the Operations and Mission Planning WG. There were supportive opinions for DDL operation at the meeting. The merits of DDL that were raised included: (1) the SSR likely would not have adequate capacity to store all ASTER data; (2) ASTER data acquisition (EOS) opportunities might be limited by a low TDRSS contact priority; (3) DDL operation no longer precludes direct broadcast (DB) capability; and (4) the opportunity for utilizing both ASTER and Landsat 7 data would be enhanced by DDL.

Other topics of importance addressed at the meeting include data calibration and validation test sites, joint U.S.-Japanese algorithm development, and MODIS and MISR coordination.

The Science Team wishes to express its appreciation to the Desert Research Institute and to J. Taranik, DRI President, who hosted several Working Group sessions at the new DRI building on the edge of the UNLV campus. ■

AIRS Science Team

— *George Aumann*

The AIRS (Atmospheric Infrared Sounder) Science Team met January 26-29, 1993 in Pasadena, CA.

The AIRS instrument has been successfully redesigned. This design covers the 3.7 - 15.4 µm region with spectral resolution of 1200 with a single spectrometer (instead of two spectrometers in the old design). The field of view is still 14 km at nadir from 705 km altitude. The 3.4-3.7 µm, 4.6 - 6.2 µm and 8.2 - 8.8 µm regions of the spectrum are no longer covered. System sensitivity predictions (NEΔT) look great. Design requirements are bested by a factor of four in the key 4.2 µm regions. The optics have become simpler with the 1 spectrometer design, with the elimination of 12 mirrors, 16 optical filters, 1 grating, 1 dewar and 1 field-flattening lens. The AIRS visible bands have been decreased from six to four at 0.40-0.44, 0.58-0.68, 0.71-0.98, and 0.40-1.0 µm, with spatial resolution of 2.4 km at nadir. The 1.6 µm band, used to discriminate low clouds from snow, is not a NOAA requirement and has been dropped to save cost. The visible channels will aid the coregistration of AIRS and MODIS (Moderate Resolution Imaging Spectroradiometer) and give the team members access to information obtainable from the lost channels.

The redesigned instrument is more compact, uses less power and is easier to assemble and calibrate. The design accommodates 60% of the original spectral channels. Most of the missing coverage is between 4.6 - 6.2 µm, in the short wavelength side of the 6 µm water band. The four algorithm development teams have evaluated the impact of the reduced spectral coverage using physical retrievals, matrix inversion, neural network algorithm, and simulated data provided by JPL. All teams concur that the AIRS performance requirement of one degree rms accuracy in one km thick layers in the troposphere is only slightly degraded (less than 0.1 °C). The impact on research products is more negative, but has not been fully evaluated. For example, accuracy for the carbon monoxide sounding may be degraded by a factor of two. This is more than adequate for monitoring regional patterns, but climate trends will be lost.

The next AIRS Team Meeting will be held the week of May 25-27, 1993. The tentative location is the World Weather Building in Camp Springs, Maryland. ■

CERES Science Team

— *Bruce Wielicki*

The seventh CERES Science Team Meeting was held at NASA Langley Research Center in Hampton, VA, October 21-23, 1992. CERES (Clouds and the Earth's Radiant Energy System) is an experiment designed to provide a climate data set suitable for examining the role of clouds in the radiative heat balance of the climate system. This data set will provide estimates of cloud physical and radiative properties, as well as estimates of radiative fluxes at the surface, within the atmosphere, and at the top of the atmosphere. The CERES experiment includes an instrument development (similar to ERBE), science team, and data management team. The science team blends expertise in broadband radiometry, cloud and radiation remote sensing, and climate modeling.

The meeting began with a summary of the EOS and EOSDIS project status. The descope of EOS and Payload Panel recommendations were discussed, including an expected 25% reduction in the budgets for science and data management. The effect on the CERES instrument and other EOS instruments is to reduce contingency, and thereby increase risk, especially to the initial copies of each instrument. Consistent with this "level of effort" EOS strategy, the CERES Science Team was asked in January 1993 to evaluate several CERES descope options to help with funding problems in the FY1993 and FY1994 budgets. Several descopes are being considered, including:

1. Delaying delivery of the first CERES scanner to the TRMM spacecraft (while still maintaining a TRMM launch in August 1997).
2. Refurbishing TRMM ground support equipment for EOS-PM.
3. Reducing documentation of the CERES ground support software and combining Software Development Benches for all three missions.
4. Refurbishing the CERES Functional Test Model (FTM) into the first flight copy.
5. Reducing the stringency of electronic parts selection from Class "S" parts
6. Reducing environmental testing on the ground
7. Reducing the scope of the life test plan
8. Eliminating one of the scanners on EOS-PM
9. Eliminating the TRMM scanner

The Team responded to the descopes, and they are listed in the order of desirability from most desirable at the top (number 1) to least desirable at the bottom (number 9). All of the Science Team members accepted items 1-4. Most of the Team members accepted items 5 and 6, although several warned to "remember Hubble." Item 7 was rejected by most Team members, and items 8 and 9 were rejected strongly by all Team members. Team members were especially critical of removing the TRMM scanner, in view of the importance of gaining a simultaneous view of the latent heat (related to precipitation) and the radiative heat components which dominate the tropical heat budget.

CERES Instrument Status

The meeting continued with a summary of the CERES instrument status. Calibration of the CERES radiometric test model (RTM) in the TRW calibration chamber (done in vacuum) revealed that the sensors' zero radiance offsets varied with scan angle. TRW used continuous process improvements (CPI) techniques to define solutions to the problems. Unlike ERBE, the CERES offsets were not caused by electronic noise, but rather by the coupling of mechanical strain through the detector mounting plate to the thermistor bolometer sensors causing them to respond like strain gauges. The solution to these problems included an improved alignment between the motor and the sensor elevation drive axis, as well as the use of a more rigid cantilevered sensor mount design. Initial tests of the new design show that scan-position-dependent offsets are reduced to 0.5% or less. Final estimates will await calibration tests of the Functional Test Model (FTM) scheduled for this summer. While the RTM included tests of the CERES elevation drive and total channel, the FTM will add the remaining two channels (longwave 8 to 12 μm, and shortwave 0.3 - 4 μm) as well as the azimuth rotation drive.

Next, issues concerning scan measurement sampling patterns and frequency were presented to the CERES Science Team for action. To prevent possible damage to the sensors and to prevent solar-driven thermal variations from affecting the data accuracy, the Science Team agreed that the sensors should not scan closer than 20 degrees to the Sun. This restriction affects only the bi-axial scan mode, and not the normal cross-track scan mode. For the TRMM experiment, the Science Team approved a repetitive three-day duty cycle in which the CERES instrument operates in the cross-track scan for two consecutive days and in the bi-axial scan mode on the third day. Several Science Team members, however, felt that the bi-axial scan mode should not be used until the 2 CERES scanner system planned for the TRMM follow-on mission would allow determination of the full set of angular models appropriate for the inclined orbit. Most Science Team members wanted an initial test of the bi-axial scan mode using the TRMM instrument.

At the September 14-17, 1992, Third Annual Space Dynamics Laboratory/Utah State University Symposium on Infrared Radiometric Sensor Calibration in Logan, Utah, TRW and the Science Team participated in an EOS Calibration Panel longwave peer review of the CERES calibration approaches and results. The metrology and radiometry community participated in the review. The CERES shortwave calibration plan was briefly reviewed at the September 25, 1992, EOS Calibration Panel peer review; which was held at the Santa Barbara Research Center, California. At the October 5- 7, New Developments and Advances in Absolute Radiometry Meeting, TRW and the Science Team presented papers on the CERES ground calibrations and CERES-like flight shortwave internal calibration source (SWICS), respectively. The CERES-like solar calibration system is described in a November 1992 *Applied Optics* article.

CERES Data Management Design

The major data management item discussed was the data product catalog and the contents of the data products. CERES has three major elements in its data products:

- ERBE-like data products
- Instantaneous cloud-radiation products
- Averaged cloud-radiation products

The ERBE-like data products to be produced by CERES will use the same algorithms we used on the Earth Radiation Budget Experiment (ERBE). These algorithms have been validated and will be unchanged for CERES. These products are intended to give a reliable answer to questions related to trends in the radiation budget and in cloud forcing since the ERBE observations. In addition, since the algorithms will be maintained with the same angular distribution models, scene identification algorithms, and time interpolation procedures, these products minimize the "algorithm shock" and the time required for validation. Within the ERBE-like products that CERES will produce, there are three different time scales and spatial organizations that we will have:

ES8 This product contains the individual pixels of CERES data, with calibrated radiances, Earth locations (at the top of the atmosphere), scene identifications, and shortwave and longwave instantaneous fluxes.

ES9 This product contains 2.5 degree regional average fluxes at one-hour time resolution. Both clear-sky and other ERBE scene types are included in these regional averages.

ES4 This product contains 2.5 degree regional average fluxes at monthly time resolution. Again, both clear-sky and total-sky ERBE fluxes are included in these regional averages.

The CERES instantaneous cloud-radiation products are intended to provide data needed to improve our understanding of the climatology of cloud properties and their correlation with highly accurate, broadband fluxes. Because cloud and radiative properties are highly variable even on relatively small space and time scales, the fundamental data product will provide cloud and radiative fluxes for each CERES pixel (about 20 km scale). Because of the large volume of these data and because modelers need more aggregated ways of viewing cloud properties, CERES also will combine observations to produce regional average cloud and radiation properties. Our intent is to use algorithms that produce a data set that is as independent of the satellite imager characteristics as possible, and then to aggregate the several satellite data streams together into a single product. This part of the CERES processing system will produce the following major products:

CRS Each CERES pixel, containing MODIS (or VIRS) cloud properties, such as cloud cover, top height, visible optical depth, infrared optical depth, particle radius, and cloud water path. Because of the importance of cloud overlap, the analysis will allow for four conditions within each CERES pixel: clear, cloud layer 1, cloud layer 2, and overlapped cloud. In addition to the cloud properties, radiative fluxes at the surface, in the atmosphere, and at the top of the atmosphere will be estimated for each CERES pixel.

FSW Gridded single satellite cloud and radiative fluxes. In this case, we would aggregate the data into 1.25 degree latitude and longitude regions for ease of comparison with model results at high temporal resolution.

SFC Surface shortwave and longwave net radiation fluxes determined primarily through observations with the CERES scanners.

The final group of CERES data products are intended to yield data sets that have been reduced in volume through space and time averaging. One advantage of these data sets is that such averages are easier to handle for intercomparisons between models and data. The second major advantage is that these averages represent the interactions between clouds and radiation on time and space scales that correspond to those we believe represent the appropriate scales for climate interactions. The major scientific products for this part of the CERES processing include:

SRBAVG
Surface shortwave and longwave monthly averages at 1.25 degree latitude and longitude resolution based primarily on CERES radiation observations.

SYN Synoptic "images" of longwave and shortwave fluxes and cloud properties at 1.25 degree latitude and longitude resolution, with a time resolution of three hours. These synoptic images should provide the EOS community the opportunity to study the evolution of major storms and cloud systems, both in cloud properties (which contain the results of water vapor convergence and divergence) and in radiative fluxes at the Earth's surface, at the top of the atmosphere, and at levels within the atmosphere, including cloud top and bottom.

AVG Monthly averaged cloud and radiation fields at a spatial resolution of 1.25 degree, and with a vertical resolution corresponding to the standard meteorological pressure levels. This product is likely to be particularly important for an observational understanding of the climatology of the atmospheric energy budget at regional scales, as well as the relatively slow variations in the surface energy budget associated with monthly and longer term variations in solar irradiance and the response of the cloud systems to these variations.

Following the plenary sessions, the Science Team convened in working group sessions including: cloud properties/top of atmosphere radiation budget, surface and atmospheric radiation budget, and time interpolation and spatial averaging. These working groups represent the algorithm development for CERES, as well as data users interested in climate processes or in extended-range weather forecasting.

Joint Cloud and Inversion (i.e. TOA fluxes) Working Group

The Cloud Working Group began with progress reports on algorithm development efforts by Science Team members. Jim Coakley reported on a generalized version of the spatial coherence algorithm that allows non-black clouds. His AVHRR results for the Pacific ocean boundary layer cloud showed average 11 µm emissivities of 0.7 to 0.8, giving a daytime bias in spatial coherence cloud cover of 0.18, consistent with the prediction of Bruce Wielicki using high-resolution Landsat data. There appears to be growing evidence of the non-black nature of boundary layer clouds over ocean.

Larry Stowe reported on his AVHRR-based aerosol retrieval for the Mt. Pinatubo eruption. His aerosol optical depths agreed well with the ERBE broadband data from the nonscanning instruments. The team discussed the need for Larry to provide aerosol retrieval of optical depth and size parameters using the visible and 1.6 µm channels on the TRMM VIRS cloud imager. This algorithm will be developed first for the AVHRR K/L/M series expected to have a 1.6 µm channel beginning in 1996, a year before TRMM. Larry Stowe also reported on progress of the CLAVR cloud screening algorithm being used for the AVHRR pathfinder effort.

Pat Minnis reported on his parameterization of adding doubling calculations for clouds intended to provide rapid retrieval of visible cloud optical depth and infrared cloud emittance. These parameterizations extend the results of ISCCP to include nonspherical ice particle scattering, as well as scattering effects in the thermal infrared. Accuracies appeared to be better than 5% for a wide range of viewing angles, solar zenith angles, cloud optical depths, and surface reflectances. Minnis's algorithm will be used in the first version of the CERES cloud algorithm and also is being incorporated into the next ISCCP analysis as well as the AVHRR Pathfinder. Pat Minnis also showed an initial examination of cloud particle size retrieval using the AVHRR 3.7 µm channel.

Ron Welch showed success using the AVHRR spectral and texture measures for cloud identification in polar regions by applying efficient neural networks. Ron also indicated that Quingyan Han was extending his retrieval of water droplet radius using the AVHRR 3.7 µm channel to the case of hexagonal cirrus ice crystals. Bruce Wielicki showed the results of more extended Landsat examinations of the effect of particle size on cloud cover retrieval. An examination of 45 boundary layer cloud cases gave results very similar to those found in his recent JGR paper. Wielicki also showed retrievals of effective particle radius for cirrus clouds in the tropics, finding typical values of 30 - 60 µm radius, similar to previous midlatitude cases.

Finally, Brian Baum presented an initial analysis of multi-layered cloud cases (cirrus over stratus) using combined HIRS and AVHRR data.

Following these presentations, the Cloud Working Group discussed the planned CERES cloud data products, and approved a set of data product changes. The group decided that the cloud algorithm work was sufficiently developed to define a version 1 CERES cloud algorithm for test on global AVHRR and HIRS data. The group debated initial time periods to analyze and settled on the month of October 1986 for NOAA 9 ERBE/AVHRR/HIRS data, followed by NOAA 9 and NOAA 10 AVHRR/HIRS/ERBE for December 15, 1986 to January 15, 1987. The AVHRR/HIRS cloud analysis will be performed for each ERBE pixel, and then used by the other working groups to provide TOA, surface, and atmospheric radiative flux estimates.

Surface and Atmosphere Radiation Budget (SARB) Working Group

The CERES Surface and Atmospheric Radiation Budget (SARB) Working Group (WG) is responsible for retrieving the full vertical profile of longwave (LW) and shortwave (SW) radiative fluxes through the atmosphere and at the surface. The SARB WG will apply the unique CERES broadband top of the atmosphere (TOA) fluxes, the CERES cloud retrievals, radiative transfer calculations, empirical relationships, and meteorological data for this task. At this Science Team meeting, SARB investigators reported on: (1) the testing of retrievals of the net surface SW based on ERBE data, (2) the development of techniques for retrieving the surface LW and the greenhouse parameter with simulated CERES data, (3) a comparison of the greenhouse parameter in a GCM with ERBE, (4) a comparison of the LW SARB as computed with two radiative transfer codes, (5) the sensitivity of the SW and LW surface radiation budget (SRB) to different input data (ECMWF, NMC, and TOVS), and (6) a comparison of a preliminary LW SARB budget with ERBE and the estimation of the atmospheric LW radiative damping time.

Robert D. Cess tested the Li et al. scheme for retrieving the net SW SRB under various sky conditions. Using TOA ERBE data as an input, the scheme produced a net SW flux at the surface that was remarkably consistent with special radiometric tower measurements at Boulder, Colorado, and Saskatoon, Canada. V. Ramanathan reported on the development of an algorithm that would use CERES broadband LW data, the unique CERES 8-12 μm window channel, sea surface temperature (SST), and humidity information to retrieve the surface LW downwelling flux.

Ramanathan also described progress in the application of ERBE data to the measurement of the LW greenhouse trapping of the atmosphere. David R. Randall compared greenhouse relationships that were simulated by the CSU GCM with inferences based on ERBE data. The advances reported by Cess, Ramanathan, and Randall were especially heartening in that they demonstrated how TOA broadband flux measurements could be used to accurately determine fundamental surface radiative parameters.

Shi-Keng Yang and Alvin J. Miller compared LW fluxes calculated with the Fels-Schwarzkopf and Harshvardhan-Corsetti radiative transfer codes. Relative differences for cooling rates were generally larger than for TOA and surface fluxes.

Wayne L. Darnell used temperature and humidity data from three sources (ECMWF, NMC and TOVS) and noted their effects on the calculated SRB. Darnell found regional SW SRB differences of 20 W/m^2 in some cases. The spread of the calculated LW SRB was considerably larger, indicating that the prospects for retrieving a more accurate SRB depend heavily on obtaining improved meteorological data.

Thomas P. Charlock reported on calculations of the full vertical profile of LW fluxes using ISCCP clouds and TOVS (and alternately ECMWF) sounding data as inputs for the Harshvardhan-Corsetti code. Comparisons with ERBE data revealed that ISCCP clouds have a consistent bias with satellite viewing angle. Charlock also computed LW fluctuation damping times and found the strongest radiative effects in the lower tropical troposphere.

Time Interpolation and Spatial Averaging (TISA) Working Group

Ed Harrison reported that the TISA Working Group focused on three areas: (1) algorithm development, (2) sampling studies to evaluate proposed satellite systems and the need for auxiliary data, and (3) interfaces with the Cloud and SARB Working Groups.

Initial algorithm development is underway to provide algorithms for time interpolation of the top-of-atmosphere (TOA) flux. These algorithms will make maximum use of existing ERBE code and averaging methods. The next phase involves development of improved TOA algorithms based on higher-resolution CERES measurements, data from the cloud imager, and routines to incorporate rotating azimuth scanner data. New TISA improvements being researched include using linear interpolation, climatological (e.g., half sine) methods, or more complicated techniques involving the use of auxiliary data (e.g., ISCCP) to better account for the variations between observations.

Simulation studies were conducted to determine how various single and multiple satellite systems sample the radiation fields of Earth and to evaluate the uncertainties in deriving daily and monthly average radiative parameters from the satellite measurements. Sampling studies were conducted for the EOS-AM and EOS-PM orbits individually and together as well as for various TRMM orbits alone and in combination with either one or two sun-synchronous EOS satellites. In all cases, the multiple satellites reduced rms errors in the monthly mean by a factor of 2 to 3. Based on the sampled data sets, the TISA group also evaluated the impact of using ISCCP cloud or radiance data to improve diurnal sampling and, consequently, monthly averages of radiation and cloud parameters. Compared to the ERBE averaging method, the use of ISCCP diurnal shapes reduced the rms errors in the single satellite monthly mean shortwave and longwave by 20% and 35% respectively, and the diurnal range of error by 50%. For consistency with the efforts of the Cloud and SARB groups, the TISA group proposed using standard data months for the simulations. Toward this end all Working Groups (TISA, Clouds, SARB, and Inversion) will use the same data sets for simulations and algorithm development: October 1986 ERBE, AVHRR, and HIRS (NOAA-9) and ISCCP cloud and radiance data; December 15, 1986 - January 15, 1987 ERBE (ERBS, NOAA-9, and NOAA-10), AVHRR and HIRS (NOAA-9), and ISCCP data; and November 1992 VAS (GOES) and ceilometer data for cloud base.

For each CERES pixel, the Cloud Group will provide derived cloud properties such as cloud top and bottom altitude, optical depth, emittance and effective particle size on up to three layers of clouds. The SARB group then will use this cloud information along with ancillary atmospheric sounding data to derive a radiative profile for each pixel consistent with the observed CERES TOA fluxes. The first responsibility of the TISA group will be to average the cloud and radiative parameters onto a specified Earth-based grid. Once on a grid, the data will then be temporally interpolated to produce 3-hourly synoptic images. It has been recognized that because of the highly non-linear quality of the radiative fields, it would be difficult to retain internally consistent radiation fields while interpolating to times without measurements. The current plan is that TISA will interpolate only the TOA fluxes, the meteorological data, the cloud properties, and possibly the surface fluxes to synoptic times. Several candidate techniques for performing the cloud property interpolation are being studied. The SARB group would next recalculate the radiative profile using the TISA-produced synoptic fields as constraints. Monthly means will then be produced by averaging the synoptic fields. ■

AGU FELLOWS

From EOS News

The American Geophysical Union (AGU) has selected 29 distinguished scientists as 1993 AGU Fellows based on their acknowledged eminence in a branch of geophysics. The number of fellows selected each year is limited to 1 in 1000 of the AGU membership. Listed below are the honored scientists who are contributing to the Earth Observing System through their work and leadership on EOS Interdisciplinary Science Investigations (IDS) and Instrument Science Teams.

Eric J. Barron	Principal Investigator for the IDS titled: Global Water Cycle: Extension Across the Earth Sciences.
Bruce R. Douglas	Member of the Altimeter Science Team
James E. Hansen	Principal Investigator for the IDS titled: Interannual Variability of the Global Carbon, Energy, and Hydrologic Cycles
Peter V. Hobbs	Co-Investigator on the SAGE III Science Team
Eric F. Wood	Co-Investigator for the IDS titled: Global Hydrologic Processes and Climate

LAWS Science Team

— *Wayman E. Baker*

The LAWS Science Team met February 2-4, 1993, in Clearwater, Florida. The meeting was attended by 10 science team members, one associate team member, and 30 other people from NASA Headquarters, the NASA/Marshall Space Flight Center, the NASA/Langley Research Center, the Department of Energy, France, the United Kingdom, and private industry.

Considerable time was spent discussing the objectives of a possible joint NASA/DOE "Quick LAWS" mission. The possibility of obtaining lidar wind measurements from space several years earlier than with the presently envisioned LAWS mission was considered to be an exciting opportunity. Although the instrument under discussion for a possible Quick LAWS mission has a much reduced capability (e.g., ~200 mJ laser) compared to that under consideration for the LAWS mission (5 J laser), in order to reduce cost, some wind measurements would still be obtained. This reduced data set would include accurate wind measurements for algorithm development and testing in data assimilation systems. Cloud drift wind validation studies would be conducted and cirrus cloud statistics compiled. Information on atmospheric backscatter coefficients for clouds and clear-air aerosols would aid the design of the more ambitious LAWS instrument. In addition, the assignment of marine planetary boundary layer heights would be checked and comparisons with scatterometer- derived fluxes undertaken.

To provide a preliminary assessment of the impact of winds expected from a Quick LAWS mission, R. Atlas (NASA/GSFC) and D. Emmitt (Simpson Weather Associates) conducted an observing system simulation experiment for a 200 mJ lidar. The assimilated wind field with the 200 mJ lidar was much weaker than with the 5 J lidar but was still measurable in the southern hemisphere.

Efforts to increase NOAA participation in the LAWS program were discussed. A NOAA administrator's discretionary fund request for LAWS Science Team support and a proposed addition to an FY 95 NOAA initiative to support science team activities and instrument studies were described.

Discussions were also held on possible NASA/CNES Doppler lidar science collaborations with R. Sadourny and P. Flamant, French representatives at the Science Team meeting. It was tentatively agreed that the French would host the next Science Team meeting in Paris, July 26-28, 1993, following the Coherent Laser Radar Conference. ■

International SeaWiFS Science Team

Sets Sail in Annapolis, MD

January 19-22, 1993

— *Jim Acker*
(Report prepared in collaboration with the SeaWiFS Project Science staff)

The SeaWiFS Science Team, compared of 56 scientists, will explore the research applications of the first orbiting global ocean color sensor since the 1978-1986 Coastal Zone Color Scanner mission. The first meeting of the full team convened in Annapolis, MD, January 19-22, 1993. The goals of the meeting were to inform the Science Team and invited guests about the current status of the SeaWiFS Project, to discuss and evaluate research plans to be conducted with SeaWiFS data, and to improve the coordination of research activities in the U.S. and with international partnerships. U.S. scientists met with investigators from Canada, Mexico, France, Brazil, the U.K., the Netherlands, Japan, Russia, Ukraine, Germany, Italy, and South Africa for four informative days, which led to 60 specific recommendations for the SeaWiFS Project.

On the first day, the plenary session heard from Dixon Butler and Frank Muller-Karger of NASA HQ, who discussed the current funding status for SeaWiFS. Vince Salomonson described SeaWiFS from the Goddard Space Flight Center perspective, and SeaWiFS Project ties to EOS and MODIS.

Bob Kirk, SeaWiFS Project Manager, provided an introduction to the Project, highlighting several areas: the SeaWiFS sensor is completed and currently undergoing testing; engineering development units have been tested and flight units for the spacecraft are started, but are behind schedule; the SeaWiFS launch involves the use of the STRETCH Pegasus, an L-1011 carrier aircraft, and Vandenberg AFB facilities, all firsts for Orbital Sciences Corporation (OSC), the prime contractor; OSC's ground control system design is complete and under construction, with the decryption box under development; and the GSFC system is on schedule, anticipating a March end-to-end system test. Kirk's remarks were followed by an introduction from SeaWiFS Project Scientist Wayne Esaias.

Representatives from OSC briefed the meeting on the current launch status of the SeaStar spacecraft, which will carry the SeaWiFS instrument. The launch date is now expected to be mid-October. The nearly-completed instrument and initial calibration efforts were described by Richard Roberts and Alan Holmes from Hughes Santa Barbara Research Center. SBRC is subcontracted by OSC to build the SeaWiFS sensor.

Following lunch, representatives from the Oceanographer of the Navy, the National Science Foundation (NSF), the National Oceanic and Atmospheric Administration, the Office of Naval Research, and the Department of Energy (DOE) discussed how SeaWiFS fits into their research goals. Each agency speaker provided a different view of what SeaWiFS will do for his/her agency programs, from detailed observations of coastal regions in support of military operations (Navy) to accurate quantification of carbon cycling in the oceans (NSF), and the role of coastal margins in the carbon cycle (DOE).

The Science Team subsequently commenced an evalution of current SeaWiFS Project baselines. Project staff and MODIS team members provided overviews of the many topics affecting the SeaWiFS mission. The various elements of the Project discussed their designated areas of responsibility and the activities they have designed to meet the requirements of the SeaWiFS mission.

Several presentations underscored the linkage between SeaWiFS and the Oceans discipline of the EOS MODIS project. MODIS Science Team members are involved in the development and validation of algorithms for SeaWiFS data product generation. The SeaWiFS algorithm set will be evolved during the SeaWiFS mission, providing tested prelaunch MODIS ocean science algorithms.

Watson Gregg discussed the Project's daily mission operations. Satellite power limitations could affect coverage of the Southern Ocean during austral summer. Sun glint near the equator will affect observations of equatorial waters, but the sensor's "tilt" capability will help to limit this problem. The goal of Mission Ops is to make the five-year data set as complete as possible, while maintaining the operating health of the satellite. Howard Gordon (MODIS Science Team) presented his improved atmospheric correction algorithms, using different models for marine aerosols. Due to the importance of atmospheric correction, a working group on this topic was formed later in the meeting.

Dennis Clark and Ken Carder (MODIS Science Team) presented their work on algorithms for determining pigment and chlorophyll concentrations in Case I ("open ocean/blue- water") and Case II ("coastal/turbid") waters, respectively. Clark also discussed the development of a marine optical buoy (MOBY) which will help monitor the long-term stability of the sensor. The initial deployment site for MOBY will be off of Lanai, Hawaii. Carder's work has focused on removing the influence of bottom reflection and dissolved humic material in turbid and shallow waters.

A related topic, the schedule and design of field validation cruises, was presented by Deputy Project Scientist Stan Hooker. He noted that the slip of the launch date from mid-August to mid-October is covered in the field verification plans. The difficulties of coordinating at-sea field verification studies with satellite observations were evident in the number of alternate strategies presented for the completion of the at-sea verification requirements.

Gene Feldman laid out the design of the SeaWiFS data processing system, emphasizing that it will be capable of reprocessing the entire data set while also processing new data. The system is currently being tested vigorously and challenged to its operating limits. Chuck Vermilion discussed how the data gets from the satellite to the ground station and then to the data processing system (otherwise known as Data Acquisition). The final destination of the SeaWiFS data set, the Goddard Distributed Active Archive Center (DAAC), was described by Dot Zukor. Her presentation showed how the "browse and order" user interface would appear and function.

Other topics presented to the Science Team included sensor calibration (Bill Barnes and Bob Barnes); collaborative round-robin radiometric calibration between research groups (Jim Mueller); and the calibration and validation baseline and data quality control (Chuck McClain).

During the afternoon of the second day, Science Team members provided short presentations on their research plans, which covered a wide range of spatial scales. There were several relatively small-scale regional investigations, including studies in the North Sea, Japan Sea, Gulf of California, the southern Atlantic near Brazil, turbid waters near the outlets of the Chesapeake Bay and Mississippi River, and the Benguela-Agulhas current regions off of South Africa. Increasingly wider scope was seen in studies of the California coast, the Arabian Sea, the equatorial Pacific, the southwest Pacific, and three regions of the Southern Ocean with varying ice cover conditions. The largest scope of study concerned examination of the global carbon dioxide cycle and multi-year global estimates of primary productivity.

Other team members will devote their efforts to optical studies of pigment fluorescence, spectral characterization, nutrient effects on primary productivity, physical oceanographic forcing of oceanic biology, and accurate sensor characterization methods.

The third day was devoted to focused discussions of Project concerns. Discussion of data archive and access policies of HRPT stations (which are capable of receiving 1 km resolution LAC data) was lively. The Project and the DAAC are considering several alternatives for access to the LAC data, subject to budgetary and time constraints. Other active topics in the data discussion concerned pricing policy, and the capability of the DAAC to provide regional subsets of data. DAAC representatives went home from the meeting with a full cargo of objectives.

An evening session of the meeting concerned plans for the EOS Color mission, a SeaWiFS-type mission which falls in the early EOS era. The continuing scientific need for EOS Color and preliminary planning in the coming year were discussed, with one clear objective of providing a continuing global 1 km resolution data set. This data set would merge with the MODIS data set from the AM and PM platforms. Cross-calibration plans for satellite ocean color sensors with overlapping mission periods was seen as a high priority, especially for field validation efforts.

The morning of the last day was devoted to formalizing the recommendations of the working groups, and organizing several Science Team subgroups for continued prelaunch work. In the afternoon, some participants traveled to OSC corporate headquarters to see space hardware, while others journeyed to GSFC to view demonstrations of data tools, including HDF and SEAPAK. SEAPAK is being developed for distribution to allow processing of SeaWiFS data in a UNIX environment. Gene Feldman demonstrated the "practice" processing of CZCS data by the SeaWiFS data processing system.

The full SeaWiFS Science Team planned to convene approximately five months after the launch of SeaWiFS, subsequent to the initial characterization and validation of SeaWiFS data. All hands anticipated a successful maiden voyage for the SeaWiFS "eye on the ocean."

[The proceedings of the first SeaWiFS Science Team meeting will be Volume 8 in the SeaWiFS Technical Report Series. Anyone desiring a copy or wishing to be added to the SeaWiFS distribution list should contact Elaine Firestone (301-286-4553 or elaine@manono.span).] ■

From EOS News

TDRS Flight 6 Launched

The sixth NASA Tracking and Data Relay Satellite (TDRS) was launched from the space shuttle Endeavor on January 13. The TDRS system of communications satellites will be the primary link to EOS satellites for command uplink and data capture. The system has been functional since 1983, and presently allows contact with the White Sands Complex, New Mexico for at least 85% of each orbit. Two TDRS were fully operational, two are only partially operational, and one was lost in the Challenger accident. This TDRS was boosted to its geosynchronous orbit as an operational spare to maintain the TDRS system.

The Earth Observer

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New EOSDIS Bulletin Board — gsfc.eos

As many people have discovered, using electronic bulletin boards to communicate with others in their community has proven to be an effective means of sharing ideas and information. A new bulletin board, gsfc.eos, has been created for the EOSDIS community to share EOS-related information, questions, and ideas.

If you wish to publicize an upcoming meeting, share an informative article, or share information regarding a recent EOS news event, the gsfc.eos bulletin board provides you with a means to pass this information along to a wide audience. You can also use gsfc.eos to solicit opinions, discuss timely issues, voice concerns, and learn from the experiences of your colleagues.

The EOSDIS bulletin board currently contains on-line newsletters such as "The Processor" and "The Earth Observer," and news articles such as "EOS News" and "ESDIS Weekly." In addition, information on data sets and services provided by the EOSDIS Distributed Active Archive Centers (DAACs) will be posted to the bulletin board.

The EOSDIS Version 0 Network Office will provide you with an account on "ALF," a VAX 3900 located at Goddard Space Flight Center. We will provide you with instructions on how to access ALF, and how to read, post, and save articles from the gsfc.eos bulletin board using the VNEWS newsreader. A help desk telephone number will be provided if you need assistance while using the gsfc.eos bulletin board.

We would like to encourage you to post newsletters, articles, meeting announcements, meeting minutes, the availability of new data sets, and any other EOSDIS-related materials to gsfc.eos.

If you have any questions or comments regarding the EOSDIS Bulletin Board Service, or need instructions on how to access gsfc.eos, please contact me by e-mail at: posinski@boa.gsfc.nasa.gov, or by phone at: (301) 286-1074, and I'll be happy to answer any questions.

—Cindy Posinski
EOSDIS Version 0 Network User Support Office

EOSAT Releases Landsat MSS Data to Public Domain Distribution

After two years of assisting commercial Landsat customers in transitioning from Multispectral Scanner (MSS) data to Thematic Mapper data, EOSAT last week turned all MSS production and distribution functions over to the EROS Data Center in Sioux Falls, S.D.

EOSAT and the Department of Commerce/NOAA reached a mutual decision to cease receiving new MSS data and to return all processing operations back to the Federal Government. This was scheduled to occur after the Landsat 6 launch this summer, but the transition was completed last week because of a failure in certain old ground processing equipment which led to termination of the MSS collection via TDRSS or at Norman, Okla.

In response to a decreasing market for MSS data and in anticipation of launching Landsat 6, which will carry the Enhanced Thematic Mapper (ETM) sensor, EOSAT assisted its remaining MSS clients in upgrading their processing capabilities and phasing out MSS use. The conversion to updated processing streams will allow all EOSAT customers to take full advantage of the state-of-the-art Landsat 6 sensing capabilities.

The U.S. Department of Agriculture, among the largest buyers of Landsat data in the world, was also the final major MSS user until last year. EOSAT developed a Thematic Mapper "Swath Product" that is fully compatible with the processing equipment USDA used for MSS data. USDA, which relies on Landsat data to assess the health and expected yield of crops around the globe, was able to convert from MSS use without a major investment in new equipment.

All orders for archived MSS data will be received and fulfilled through EROS Data Center. There will be no interruption in the low MSS data prices introduced by EOSAT in 1990, which dropped the price of older MSS data from $1,000 down to $200 per full scene. All MSS data regardless of age will now be available at that price.

Further information on MSS products is available from EROS Data Center Customer Services: (605) 594-6151.

EOSAT Reduces Price oF Archived Landsat Data

EOSAT has reduced the price of previously processed Thematic Mapper (TM) data currently in the U.S. Government archive in South Dakota. The special offer drops the price of more than 8,000 Thematic Mapper scenes from the current price of $4,400 down to $1,500 per scene.

"These extremely low prices on archived Landsat data will bring many first-time remote sensing users into the marketplace," said Steven Cox, EOSAT's Executive Director of Marketing and Sales. "We want to broaden the Landsat market in anticipation of the new Landsat 6 data that will be available later this year."

"Another reason for putting older Landsat data on sale is to promote the benefits of using archived data for detecting change," said Cox. "Change detection studies in environmental monitoring and urban planning have become popular applications of Landsat data."

EOSAT announced a 65% price reduction on archived Landsat data.

Detecting and measuring physical change on the Earth's surface are accomplished on computer-based image processing systems that digitally compare older Landsat images with new ones of the same area. Landsat has become the preferred remote sensing data set for change detection studies because of its extensive archive.

The special prices apply to more than 8,000 processed scenes stored at the EROS Data Center in Sioux Falls, S.D. Only full scenes are available in system-corrected, LTWG-quad format on 6250 bpi nine-track tapes. Most of the scenes were acquired by Landsats 4 and 5 between 1985 and 1989. The scenes are available for immediate shipping.

EOSAT is preparing a catalog that lists the available scenes and their acquisition dates. This catalog is available upon request. Contact EOSAT Customer Services at (800) 344-9933.

EOS Science Calendar

March 22-23	MISR Team Meeting, GSFC, MD. Contact David Diner at (818) 354-6319.
March 24-26	MODIS Science Team Meeting, Lanham (Near GSFC), MD. Contact Dave Herring at (301) 286-9515.
March 29-31	Investigators Working Group Meeting, Greenbelt, MD. Contact G. Asrar at (202) 358-0258 or M. King at (301) 286-8228.
April 27-29	TES Science Team Meeting, Langley Research Center, VA. Contact Reinhard Beer at (818) 354-4748.
May 25-27	AIRS Science Team Meeting, Camp Springs, MD. Contact George Aumann at (818) 397-9534.
June 7	CERES Science Team Meeting, Langley Research Center, VA. Contact Bruce Barkstrom at (804) 864-5676.
July 13-15	U.S. ASTER Science Team Meeting, Pasadena, CA. Contact Dave Nichols at (818) 354-8912.
July 26-28	LAWS Science Team Meeting, Paris. Contact Wayman Baker at (301) 763-8005.
November 8-12	ASTER Japanese Science Team Meeting, location TBD, Contact Dave Nichols at (818) 354-8912.

Global Change Calendar

April 19-23	Call for Papers, First Thematic Conference, International Symposium "Operationalization of Remote Sensing". ITC, Enschede, The Netherlands. Contact: Prof. J.L. Van Genderen, ITC, P.O. Box 6, 7500 AA Enschede, The Netherlands, phone: 31-53-874-254, FAX: 31-53-874-436, telex: 44525 ITC NL.
May 18	"U.S. Global Change Policy Symposium," National Press Club in Washington, D.C. For more information, contact: Mike Kiernan, 1516 West Lake Street, Suite 102, Minneapolis, MN 55408, phone: (612) 822-9600, FAX: (612) 822-9647.
June 8-11	The GIS/LIS '93 Hungary Conference and Exhibition will be held in Budapest. For further information, call +36(1) 202-2887 or FAX +36(1) 155-4171d.
June 10-11	The Third Biennial HITRAN Conference will be held at the Science Center of the US Air Force Geophysics Directorate, Hanscom AFB, MA 01731-3010. For information, contact Dr. Laurence S. Rothman, phone: (617) 377-2336, E-mail: ROTHMAN@PL9000.PLH.AF.MIL, or Dr. Robert L. Hawkins, phone: (617) 377-8664.
June 21-25	Third International GPS/GIS Conference and Training Program, Seattle, Washington. For registration or exhibitor information, contact: GPS/GIS '93 Conference Coordinator, c/o GeoResearch, Inc., 115 North Broadway, Billings, Montana 59101, phone: (406) 248-6771, FAX: (406) 248-6770.
June 30-July 1	Call for Papers. The Defense Landsat Program Office Workshop on Atmospheric Correction of Landsat Imagery, Los Angeles, CA. Abstracts should be 250-500 words in length. Authors will be notified by 22 May 1993. For further information contact: Jo Ann Robinson at (310) 320-2300/Fax: (310) 320-4735, Internet address: brockman@geodyn.comm, or write to: Landsat Atmospheric Corrections Workshop, Geodynamics Corp. 21171 Western Ave., Suite 100, Torrance, CA 90501.
July 13-15	Call for Papers. IAMAP/IAHS Joint Symposium on Advanced Observing Techniques in the Atmosphere and Hydrosphere at the Joint International Meeting of the International Association of Meteorology and Atmospheric Physics and the International Association of Hydrological Sciences, Yokohama, Japan. Abstract forms are due January 31, 1993. Contact George Ohring, phone: (301) 763-8078, FAX: (301) 763-8108.
July 26-30	A Gordon Research Conference on The Impact of Volcanism on Climate, New England College, Henniker, NH. Also see announcement in *Science*, November, 1992 issue. For information, contact Lou Walter, Chairperson, at NASA/Goddard Space Flight Center, phone: (301) 286-2538, or O. B. Toon, Co-Chairperson, at Ames Research Center, phone: (415) 604-5971.
August 24-26	"Land Information From Space-Based Systems," Twelfth William T. Pecora Remote Sensing Symposium, Sioux Falls, South Dakota. Sponsored by the U.S. Geological Survey in cooperation with other Federal agencies. Contact: Dr. Robert Haas, Symposium Chairman, phone (605) 594-6007, or Dr. James W. Merchant, Program Chairman, (402) 472-7531, FAX: (402) 472-2410.
September 8-10	International Exhibition & Conference, "MARIGLOBE 93," International Forum in Bremen, Germany. Subject of the conference: 1) Global Change and the Oceans; 2) Use of the Oceans and Marine Measurement Technology; 3) Aerospace Support for Monitoring of the Marine Environment; 4) Environmentally Safe Ocean Transport. For more information contact: Frank Reimers and Peter Grazé, phone: 0421-36 66 219 or 36-66-216.
September 14-15	TERRA-2 conference at Chester College under the title of: "Understanding the Terrestrial Environment: Data Systems and Networks." Further details can be obtained from: Prof. P.M. Mather, Department of Geography, The University Nottingham NG7 2RD, United Kingdom., phone: 0602 515430, FAX: 0602 515428, E-mail: mather@uk.nott.vax