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Editor's Corner

The EOS Investigators Working Group meeting was held on March 29-31 in Greenbelt, Maryland, followed by a half-day preliminary Payload Advisory Panel meeting. The primary focus of the IWG was to agree on the definition of at-launch data products for each EOS instrument (see IWG report elsewhere in this issue). Since the IWG, I have been working with a small team of support contractors and EOSDIS personnel to synthesize the desired data products list for each instrument and the recommended high-priority products from the Atmosphere, Ocean, Land-Biosphere, and Solid Earth Panels. The outgrowth of this process is a data product list that is larger than that proposed at the outset of the IWG. As a consequence, I am in the process of evaluating the prioritization within each instrument team, and of separately identifying data products and parameters. This differentiation recognizes the clear distinction made by Science Teams with heritage in producing data products, such as the Geophysical Data Record recommended by the NSCAT and SSALT/DORIS/TMR teams.

By early June, Ghassem Asrar and I will forward a letter to each Team Leader or Principal Investigator that contains the complete list of at-launch parameters proposed by each Science Team and endorsed by the various Panels, together with a detailed breakdown of products with their corresponding parameters for that Team. At that time we will request confirmation of this prioritization, as well as validation of some of the information we are assuming for these parameters, such as storage volume, floating point operations per second, accuracy, etc. This information will be used to allow EOSDIS and the EOSDIS Core System (ECS) contractor (Hughes Applied Information Systems) to design and support this system. The ECS contract was signed on March 30.

Last issue, I reported the appointment of key scientists within the Earth Sciences Directorate as Project Scientists of individual EOS spacecraft missions. I am happy to report that Dr. Claire Parkinson has agreed to be the EOS PM Project Scientist, replacing Les Thompson, who is moving to a new role as EOS Instrument Scientist. This move recognizes Thompson's strong

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engineering background and experience that should prove especially helpful to Piers Sellers (AM Project Scientist) and Claire Parkinson.

During the preliminary Payload Advisory Panel meeting on April 1, a clear scientific rationale for splitting the EOS Altimeter spacecraft into separate radar and laser altimeter components was articulated. The arguments for separating the GLAS and SSALT/DORIS/TMR instrument components centered on the following scientific considerations: (1) GLAS requires high inclination ($i \approx 94°$) to enable the West Antarctic ice sheet to be studied, whereas radar altimetry prefers an orbit with a lower inclination ($i \approx 65$-$75°$); (2) GLAS requires a non-repeating retrograde orbit, whereas radar altimetry requires an exact repeat prograde orbit to reduce tidal-errors and high frequency geoid errors; and (3) GLAS prefers the 705 km orbit of the AM and PM spacecraft to facilitate cloud intercomparisons with MODIS, whereas radar altimetry prefers a higher orbit ($h \approx 1200$ km). The Payload Advisory Panel recognized the scientific arguments for splitting these two instrument packages considering the cost-constrained nature of the EOS program, and recommended that Goddard proceed with a pre-phase A study of a GLAS-only mission. This recommendation to conduct a feasibility study of a GLAS-only mission has now been accepted by NASA. A comparable feasibility study for radar altimetry will fold EOS requirements into the Topex/Poseidon Follow-On study.

In anticipation of release of a phase C/D contract to build a common spacecraft for the PM-1, AM-2, and Chemistry spacecraft, the EOS Chemistry and Special Flights Project and the Project Science Office have begun to look into further defining the Chemistry and AM-2 payload. The Atmosphere Panel has been charged with convening a working group to assess the value of ACRIM to the Chemistry payload. In addition, the EOS Chemistry Project Scientist, Mark Schoeberl, has initiated a study to assess the scientific value to the global change objectives of EOS for the high-spectral-resolution ultraviolet component of SOLSTICE II. Finally, each PI on the Chemistry platform is being queried to provide input to specific questions on their desired orbit-crossing time. NASA Headquarters is beginning to enter negotiations with NASDA to provide a Chemistry instrument that would complement the EOS Chemistry payload commensurate with the spacecraft resources available for such an instrument. ■

Michael King
EOS Senior Project Scientist

Union Session — Fall 1993 AGU Meeting

Observing Earth from Space: Recent Contributions and Upcoming Challenges

Remote sensing has changed our ability to observe the Earth system by making enormous quantities of spatially distributed data available on oceans, the atmosphere, vegetation, the hydrologic cycle, land-use, geology, and other land-surface processes.

Present and future satellite missions to planet Earth are a central part of the U.S. Global Change Research Program. The largest, NASA's Earth Observing System (EOS), is an integrated program involving: 1) satellite and supporting ground-based observations; 2) processing, archiving, and distributing of data; and 3) interdisciplinary research to use the data to address important questions in Earth system science.

Various contributions of remote sensing to the U.S. Global Change Research Program will be highlighted in a keynote session, followed by oral and poster presentations. Papers are solicited on any aspect of research under the U.S. Global Change Research Program that involves remote sensing. Forward-looking presentations describing how missions or instruments in the design stage will contribute to important questions are also welcome. This session is intended to be an interdisciplinary forum to present an update on recent and expected near-term contributions of programs such as EOS that use remote sensing to address critical questions in global change and Earth system science.

Questions can be directed to any of the co-organizers: Roger Bales (roger@hwr.arizona.edu), Ghassem Asrar (gasrar@sedsparc.ossa.hq.nasa.gov), Eric Barron (eric@essc.psu.edu), or Jeff Dozier (dozier@crseo.ucsb.edu). Contributors should send a copy of their abstract to Roger Bales, Department of Hydrology and Water Resources, University of Arizona, Tucson, AZ 85721 (FAX: 602 621-1422) at the same time that they send a copy to AGU. AGU's deadline for receipt of abstracts will be around September 10, 1993; watch for the call for papers in AGU's *EOS*.

Investigators Working Group Meeting

—By **William Bandeen**

The EOS Investigators Working Group (IWG) met in the Greenbelt Marriott Hotel, Greenbelt, Maryland March 29-31, 1993, and the Payload Advisory Panel met briefly in the same place the following morning, April 1, 1993. Proceedings of the meetings will be available in June, and will be sent routinely to those on the attendance list. Others may write to Ms. Hannelore Parrish at the address shown in "The Earth Observer Staff" (page 26) for a copy of the Proceedings.

The Primary Meeting Focus—Data Products

Ghassem Asrar, the EOS Program Scientist, set the tone by saying that he wanted to focus on reviewing the data products proposed for distribution by the EOS Data and Information System (EOSDIS) immediately after launch of the measuring instruments. These "standard" data products will be used in the following ways: 1) to develop a science plan for EOS; 2) to help estimate the required size of EOSDIS; 3) and to produce quantitative goals against which EOS can be measured. Last fall, the data product list was reduced from 650 to less than 200 entries. From this starting point, data lists were introduced by each instrument team. Then the disciplinary panels (Atmosphere, Land/Biosphere-Biogeochemical Cycling, Ocean, and Solid Earth) discussed the appropriate products and reported their findings to the IWG. Panel reports will be integrated for use by EOSDIS developers and EOS Project and Program personnel. Among the panel recommendations were the following: 1) Determine the mechanism by which new data products can be added to the list; 2) Request each instrument team to produce first-order flow diagrams that show ties among related data products; 3) Study standard gridding and averaging for EOS level 3 data products; 4) Provide the needed attention to certain multisensor products (e.g., surface radiative fluxes); and 5) Define/improve agreements for data access and processing for EOS instruments on foreign satellites and for non-EOS instruments.

NASA Headquarters Reorganization

Shelby Tilford reported that the Office of Mission to Planet Earth (MTPE), Code Y, has been approved formally at NASA Headquarters. Shelby Tilford has been named Acting Associate Administrator and William Townsend has been named Deputy Associate Administrator for MTPE. The office consists of three divisions, i.e., the Flight Systems Division, headed by Michael Luther; the Operations, Data, and Information Division, headed by Dixon Butler; and the Science Division, headed by Robert Watson.

EOS Activities at the Goddard Space Flight Center

A Mission to Planet Earth (MTPE) Office has been established in the office of the Center Director at Goddard, paralleling the reorganization at NASA Headquarters. Bob Price, the newly-named Director of the MTPE Office, presented the detailed functions and responsibilities of the Office, which include overall program management over the EOS flight and data projects, and overall science coordination across all missions. Price remarked upon the many new members of Congress who do not know much about MTPE or EOS and said that, beginning on April 2, congressional staff members will come to Goddard on ten successive Fridays for briefings on the program.

Michael King, the new EOS Senior Project Scientist, discussed progress since the last IWG. The Project Science Office has been reorganized with separate Project Scientists named for each of the EOS flight projects. The Hughes Applied Information Systems (HAIC) was chosen for negotiating a contract for the EOSDIS Core System (ECS). (Actually, the ECS contract was signed on the day following King's presentation.) Congress has established an $8 billion cap on the program for the period FY1991-FY2000. The High-Resolution Imaging Spectrometer (HIRIS) was eliminated from the EOS complement of instruments, but the science investigation continues with a possible flight on Landsat-8 or an Earth Probe. The Microwave Limb Sounder (MLS) was selected for the EOS-CHEM mission. Good progress is being made on the development of the EOS-AM spacecraft and instrument complement. King stated that he would like to accomplish the following six items in the next 12 months: 1) develop a Science Plan; 2) form a COLOR Science Team; 3) rescope the GLAS Science Team; 4) form a SSALT/DORIS/TMR Science Team; 5) resolve the SSALT/DORIS/TMR and GLAS mission definition; and 6) initiate a review process for Instrument PI's and TM's.

John Dalton, Manager of the Earth Science Data and Information System (ESDIS) Project, reported on the status of the Project. Among the highlights were the following: the ECS negotiations were completed, the EOS Data and Operations System (EDOS) Request for Proposal (RFP) was released with proposals due March 29, and the Independent Verification and Validation (IV&V) RFP will be released at the end of March. John then introduced three members of the Hughes ECS Project Organization—Saul Volansky, Project Manager; Bob Curran, Project Scientist; and Bill Dahl, Science Data Processing Segment Manager—who discussed their approach to the ECS contract. They stressed openness, teamwork, and an evolutionary system in developing the ECS, and said that they were eager to open up lines of communication now that the long procurement blackout is over.

Later, John Dalton stressed that, with the start of the ECS contract, now is a critical time to understand data product costs. Two objectives stemming from the data product list are to maintain the best possible projections of cost and to match commitments with the budget. Dalton listed the following three steps requiring immediate attention: 1) get the best definition of products now, at the start of the ECS contract; 2) ask each investigator to look at projected MFLOPS and GBYTES for his/her products, and update them if necessary; and 3) submit this information to Michael King. King said that he would send out a letter specifically requesting what is needed from each Instrument PI, IDS PI, and Team Leader.

Preliminary Payload Advisory Panel Meeting

On April 1, Berrien Moore chaired a Preliminary Payload Advisory Panel meeting. He stated that the purpose of the half-day session was to prepare for the next full-blown meeting, possibly in Europe.

Chet Koblinsky, the EOS-ALT Project Scientist, said that science objectives would be seriously compromised by flying the radar and laser altimeters on the same spacecraft. The EOS-ALT Project is ready to pursue Phase A and B studies over the next year, but it is constrained by Level 1 requirements to develop a single spacecraft with both instruments. Preliminary studies of radar altimeter-only and laser altimeter-only spacecraft will be carried out at Goddard. This approach appears to be cost-competitive with a single spacecraft carrying both instruments. Following discussions of SSALT performance, DORIS performance, GPS performance, and GLAS orbit considerations by Lee-Lueng Fu, Byron Tapley, Tom Yunck, and Bob Schutz, respectively, the following characteristics of a split mission emerged: 1) a laser-only (GLAS) mission, with a capability to observe high-latitude Antarctic ice streams—having an orbital inclination of 94° and height of 705 km; and 2) a radar altimeter-only (SSALT/DORIS/TMR) mission, optimized for ocean observations—having an orbital inclination of 66°-75° and height of 800-1400 km. As a result of these presentations, the Payload Advisory Panel recommended that the feasibility of using two separate spacecraft for the EOS-ALT mission be studied.

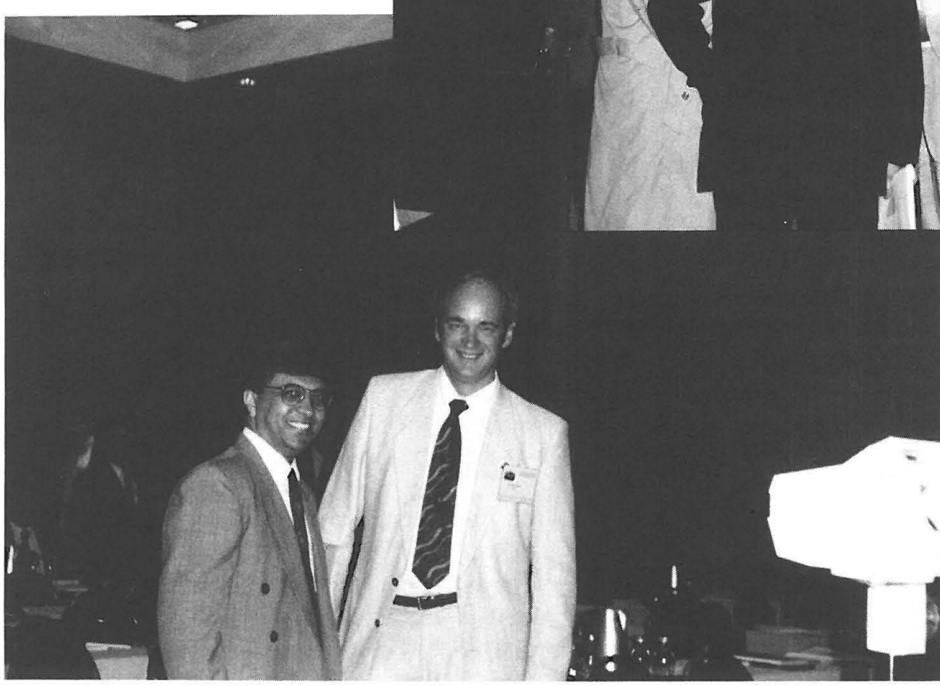
Mark Abbott discussed the objectives of SeaWiFS and EOS-COLOR, recommended improvements of EOS-COLOR over SeaWiFS, and presented a number of considerations/issues regarding EOS-COLOR. Abbott reiterated the need for an EOS-COLOR Science Team, and he brought up the question of data integration with international partners, e.g., data from ADEOS/OCTS and POEM-ENVISAT/MERIS. Berrien Moore said that this question would be addressed at the next meeting.

Mark Schoeberl discussed EOS-CHEM issues. SAFIRE was deselected after it was determined that MLS could provide OH measurements. The addition of SAGE III will provide precise aerosol measurements not made by HIRDLS or MLS. There will be a Japanese instrument on EOS-CHEM in exchange for NSCAT II on ADEOS II. Mark Schoeberl stated that if the Japanese were to provide a TOMS-like instrument, tropospheric ozone could be estimated using the Fishman method.

Gary Rottman discussed SOLSTICE II vs SOLSTICE on EOS-CHEM. SOLSTICE II would measure the full solar disk irradiance from 115 to 400 nm with two spectral resolutions, 1.0 nm and 0.001nm, whereas the descoped SOLSTICE (UARS-type), which is the baseline instrument within the scope of the Project budget, measures only at 1.0 nm. Rottman said that the high-resolution capability would greatly increase our spectral knowledge of the solar UV irradiance and how it interacts with the Earth's atmosphere. However, SOLSTICE II is twice as large as SOLSTICE, and more expensive.

At the end of the morning, Bill Townsend, NASA Deputy Associate Administrator for MTPE, discussed the "Convergence" of EOS-PM2; NOAA-O, P, Q; DMSP; and POEM-METOP. Townsend said that for some time, NOAA and ESA/EUMETSAT have planned to combine their programs and to share sensors and data, with NOAA providing the afternoon spacecraft, and EUMETSAT the morning spacecraft. Last year, NASA and NOAA began to look at the possibility of convergence of the EOS-PM and the operational NOAA polar-orbiting missions into one system that would save the U.S. money. This convergence was planned to begin with the launch of EOS-PM 2 in 2005. Recently, Congressman George Brown, Chairman of the House Science, Space, and Technology Committee, requested that the convergence study include the Defense Meteorological Satellite Program (DMSP), as well as EOS-PM and NOAA spacecraft. This study is now underway.

Dr. Bob Price, Dr. Michael King, and Dr. Shelby Tilford (back to camera)

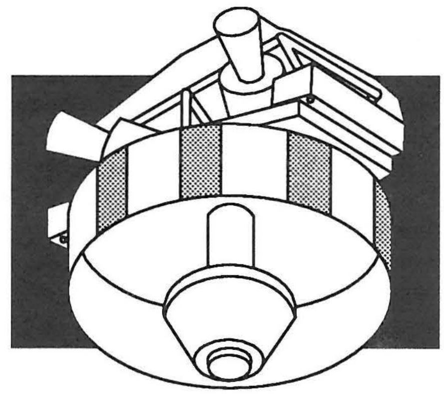


Dr. Ghassem Asrar, EOS Program Scientist, and Dr. Michael King, EOS Sr. Project Scientist, prepare for the first session of the IWG meeting.

Science Team Meetings

Geoscience Laser Altimeter System (GLAS) TEAM

March 4-5, 1993, at NASA/Goddard Space Flight Center
—by **B. Schutz**, GLAS Team Leader



The primary topics of the meeting were focused on preparation for the IWG meeting at the end of March, including a review and assessment of the GLAS orbit requirements and data products. In addition, the meeting examined the progress of the Engineering Team, and the status of the flowdown of science into engineering requirements. The status of summer 1993 airborne activities and 1994 spaceborne activities were presented and Team member tasks, along with Team structure, were discussed.

The ground-track characteristics of various orbit inclinations were reviewed. In particular, C. Bentley and R. Thomas reviewed the areas of Antarctica that would not be covered by various inclinations. The primary inclination consideration is adequate coverage of the Greenland and Antarctic ice sheets. Because of the lack of adequate crossovers with a 90 degree inclination, an inclination that is several degrees away from the poles is desired. Since any inclination that is not exactly 90 degrees will result in a coverage hole, various compromises were considered. It was noted that an inclination of 94 degrees (retrograde) or 86 degrees (posigrade) would provide coverage of all major ice streams in the Antarctic. Since three of the major streams lie between 82 degrees and 85.5 degrees, and because of the nature of these streams (one is hyperactive, one is stagnant), this area is one of the most likely parts of the West Antarctic ice sheet to develop unstable change. As a consequence, the recommended inclination for GLAS is 94 degrees or 86 degrees, with a preference toward 94 degrees. J. Zwally noted the importance of the altimeter crossovers in the analysis, and the more favorable geometry associated with the retrograde orbit.

B. Schutz reviewed the orbit-altitude considerations. It was noted that an orbit period near the EOS-AM or EOS-PM platform would enable near-simultaneous measurements of the GLAS lidar with MODIS at two opportunities on each revolution, a particularly desirable characteristic that was discussed by J. Spinhirne. Simultaneous (within ten minutes) laser and passive visible and IR observations would be essential to determining any bias to passive retrievals of multi-layered and thin clouds. With these considerations, twice-per-revolution near-simultaneous measurements between GLAS and MODIS can be obtained with an orbit altitude of 705 km, the MODIS altitude. The recommended GLAS altitude is 705 km.

The advantages of both repeating ground-tracks and crossovers were reviewed. Zwally reviewed the higher spatial density of crossovers in a non-repeating orbit (or very long repeat period). The opportunities for direct comparisons of repeating tracks were reviewed by Thomas. Since there are distinct advantages to each approach, the Team recommends that three or four cycles of a 10-to-16-day (approximate) repeating ground track be conducted twice a year (summer and winter seasons), but that nonrepeating tracks be used for the remaining periods. The repeat requirement is plus/minus 1 km over the ice sheets.

B. Schutz reviewed the options for achieving the required orbit accuracy. The GLAS error budget currently allows 5 cm radial (rms) orbit error over the ice sheets. The experience with the different tracking systems on TOPEX/POSEIDON was reviewed. Current analyses are suggesting that radial orbit accuracies of better than 10 cm are being achieved. Based on a variety of considerations, GPS is recommended as the primary tracking system, with ground-based satellite laser ranging providing calibration and backup.

The GLAS data products were reviewed in detail. Updates to the product list were prepared for distribution at the IWG meeting.

R. Thomas and W. Krabill reviewed plans for aircraft experiments over the Greenland ice sheet this summer. Plans are proceeding to modify the laser altimeter on the aircraft to emulate the characteristics of GLAS, particularly the 70-meter laser footprint. The data from this experiment will be used to support algorithm development. Other Greenland experiments were reviewed by J. B. Minster. These experiments were conducted along ERS-1 altimeter tracks in summer 1992 in collaboration with the Naval Research Laboratory. In both the 1992 experiments and in the planned 1993 experiments, GPS provides high-accuracy differential navigation.

J. Bufton reviewed the progress of the spaceborne laser altimeter experiment planned for a Shuttle Getaway Special in 1994. This experiment is being constructed using MOLA spare parts. The data collected from the experiment will aid in GLAS algorithm and data system development.

J. Abshire summarized the Engineering Team status, including preliminary study of spacecraft options. The on-going studies include investigation of laser design and component lifetime (R. Afzal); development of a laser-pointing system that can be used for in-flight calibration (R. Follas and L. Ramos-Izquierdo); breadboarding of critical detector and receiver electronics (X. Sun); and review of mass and power estimates (J. Smith). J. McGarry reviewed recent developments in the GLAS software simulator, which will be merged into simulations performed by the science team.

Since the GLAS is a descoped version of the Geoscience Laser Ranging System, considerable discussion took place on the impact of descoping on investigations that proposed to use the ranging mode. With the elimination of the ranging mode, one team member has resigned. The team structure will be reviewed over the next several months.

The next GLAS meeting is planned for the September-October period.

AMS Fellows

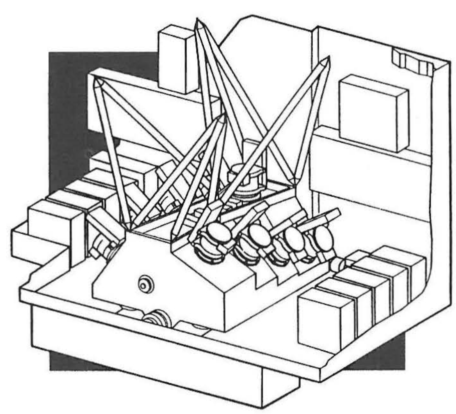
From EOS.News Bulletin Board—Wednesday, March 24, 1993

The American Meteorological Society (AMS) has selected 22 distinguished scientists as 1993 AMS Fellows. Listed below are the honored scientists who are contributing to EOS through their work and leadership on EOS Interdisciplinary Science Investigations (IDS) and Instrument Science Teams.

Wilfried Brutsaert	Co-Investigator for the IDS Investigation entitled *Global Hydrologic Processes,* and Climate Co-Investigator on the STIKSCAT Science Team.
David Halpern	Co-Investigator for the IDS Investigation entitled *The Development and Use of a Four-Dimensional Atmospheric-Ocean-Land Data Assimilation System for EOS.*
Ralph Alvin Petersen	Member of the AIRS Science Team.
Susan Solomon	Co-Investigator for the IDS Investigation entitled *Observational and Modeling Studies of Radiative, Chemical, and Dynamical Interactions in the Earth Atmosphere.*

Multi-Angle Imaging Spectroradiometer (MISR)

March 22-23, 1993, in Greenbelt, MD
—by **Daniel Wenkert**, MISR Science Coordinator, Jet Propulsion Laboratory



All members of the MISR Science Team, along with science and software support personnel from JPL, met for two days in March at the Goddard Space Flight Center (GSFC). This meeting had two important goals: The first was to finalize science requirements and specifications for MISR's standard Level 1 data products. The second goal was to determine, in some detail, requirements and specifications for MISR's standard Level 2 data products.

Level 1 Data Products and Related Issues

Dave Diner, MISR Principal Investigator, presented the current status of the MISR Project and the instrument development. He then discussed MISR image geolocation and registration requirements and their consequences regarding EOS-AM position and pointing knowledge in light of the data system team's desire to use "dead-reckoning" navigation. Information provided by GSFC and Martin Marietta Aerospace (formerly GE) suggest that the spacecraft has a good chance of meeting MISR's requirements, provided that sufficient TDRSS contacts are obtained to improve the platform position determination, and static pointing errors are removed using in-flight geometric calibration. However, there are no guarantees that the performance required to use dead-reckoning navigation will be achieved, in which case, it will be necessary to perform continuous optical navigation of most MISR data in order to meet the science requirements.

Ken Jones of the JPL MISR Data System Team discussed map projections and resampling of MISR Level 1B data. MISR data come from nine separate cameras looking at the same locations on the Earth at slightly different times (spread over a seven-minute window). Thus, in order to analyze the data for retrieval of geophysical properties, data from MISR's 36 separate channels (four spectral bands in each of nine cameras) need to be co-registered. To make geophysical retrievals computationally practical, these data need to be resampled onto some common grid.

Most MISR Level 2 data products will be retrieved with a sample spacing of 2.2 km. However, Alan Strahler (Boston University) of the MODIS Science Team indicated that the MODIS land group would like MISR to retrieve land surface properties with 1.1-km sampling. This would provide compatibility between MISR BRDF's and MODIS/AVHRR footprints. In addition, acquisition of data with 1.1-km sampling would yield better quality data for the 2.2-km products, as a consequence of the Nyquist sampling theorem. It was decided that MISR would use the 4x4 onboard averaging mode to measure radiances at 1.1-km sampling. Since this is a change from previous plans to use 8x8 averaging (for 2.2-km sampling), it was decided that data rate would be conserved by giving up some measurements at the full, unaveraged 275-m resolution of the MISR instrument. These unaveraged data would have provided some extra cloud identification and screening information, but enough unaveraged MISR data will be acquired that most MISR team members felt that the trade-off was justified. In later discussions that Diner had at the MODIS Science Team meeting that followed the MISR meeting, as well as at the IWG the following week, other non-MISR EOS investigators also recommended that MISR acquire data at 1.1-km sampling, in order to generate land-surface products with a smaller fraction of mixed pixels than would occur at coarser resolution.

Ken Jones presented several options for how MISR data might be resampled during Level 1B2 processing. After discussion, the following scenario was adopted:

(1) All resampling would be performed on grids (such as the Space Oblique Mercator projection) having the EOS-AM orbit plane as the "equator," rather than using a fixed Earth-oriented grid (like the standard Mercator projection). This minimizes the amount of distortion introduced into the data during the resampling process.

(2) To simplify the retrieval of tropospheric aerosol and surface properties, data would be resampled with topographic corrections applied. This is necessary because when looking off-nadir, a target's position can shift by several kilometers (depending on its altitude) relative to where it would appear if it were located at sea level.

(3) To simplify the retrieval of top-of-the-atmosphere and cloud properties, data also would be resampled without topographic corrections. Since the altitudes of clouds are unknown a priori, resampling should be kept to a minimum until cloud-top altitudes are known (during Level 2 processing). Moreover, the retrieval of cloud properties depends on high-resolution data as input; therefore, data acquired at 275-m resolution will be resampled onto grids at both 1.1-km and 275-m resolutions, without topographic correction.

Thus, all MISR data will be resampled with 1.1-km sample spacing onto two orbit-based grids, one with topographic correction and one without. In addition, those MISR data which are acquired at the full 275-m resolution will be resampled onto a similar grid, with 275-m sample spacing and without topographic correction. For global observing, the consensus of the meeting was to acquire 275-m resolution data in all four spectral bands of the nadir camera, as well as in a single band (probably the red band) of the eight off-nadir cameras.

Peter Muller (MISR Co-Investigator from University College of London) had gathered information on the quality and availability of global digital elevation models, which he presented at the meeting. Based on this information, the resampling strategy outlined above was felt to be reasonable.

Bob Murphy, the MISR Program Scientist at NASA Headquarters, spoke to the team. He indicated his availability to address any programmatic concerns that team members may have.

MISR Level 2 Data Product

Graham Bothwell, who leads the MISR Science Data System Team at JPL, presented a strawman description of MISR's standard Level 2 data products, as well as open issues associated with them. All geophysical parameters retrieved at Level 2 from MISR data would be grouped into three data products. Since there is a variety of ancillary data which are necessary to make use of any one of these parameters, and because it is not yet known (in some cases) which of these data can be retrieved and which will have to be assumed from models, all such linked data would constitute separate elements of the same product. The three Level 2 products are described below.

Level 2 Top-of-the-Atmosphere (TOA) and Cloud Data Product

The team agreed that the at-launch variables to be included in this product include TOA albedos at coarse (35.2-km) sampling, referenced to 30-km altitude in the atmosphere; and fine (2.2-km) sampling, referenced to the altitude of the local reflecting layer, which is defined to be the surface for clear scenes, and cloud-top altitude for cloudy scenes. In addition, this product will contain TOA bidirectional reflectance factors at 2.2-km sampling and at the reflecting layer altitude. Statistical information about the distribution of reflectances observed within each 2.2-km sample also will be derived from the 275-m resolution data and reported.

MISR Co-Investigators Tom Ackerman (Pennsylvania State University), Roger Davies (McGill University), and Peter Muller, along with Eugene Clothiaux (Penn State) and Larry Di Girolamo (McGill), presented the results of their research on cloud masks and cloud property retrieval and their suggestions for cloud retrieval algorithms.

It was generally agreed that in order to retrieve TOA reflectance properties at the level of the cloud tops (or surface, in clear regions), accurate cloud heights would be required. Although algorithms already have been developed for retrieving cloud height from stereo imagery, and Peter Muller has proven one on existing

ATSR data from the ERS-1 satellite, it is not clear whether such software can run at reasonable cost within EOSDIS. Thus, the MISR Team adopted a two-pronged strategy. MISR-specific stereo cloud-top height retrieval algorithms will continue to be developed. At the same time, the MISR Team will encourage the MODIS Team to retrieve cloud-top height with a 1-km (or 2-km) sample spacing (rather than the 5-km sample spacing currently planned).

Several techniques for cloud recognition were presented, based on image texture, spectral signature, angular variations in both of these, and cloud-top altitude. It was agreed that MISR would employ multiple techniques in one algorithm to retrieve the probability of cloud presence at the resolution of the TOA and cloud data product (2.2-km). Furthermore, identification of the presence of cirrus clouds, using the angular shape of the difference in reflectance between MISR's near-IR and blue bands, has been proposed by Larry Di Girolamo and Roger Davies of McGill. The team felt that cirrus fractional coverage would be potentially deliverable from MISR. However, since the algorithms that will be used for these product elements still are under development, it was agreed that the MISR Team will not promise that they will be available at EOS-AM launch, though they should be included in sizing the Level 2 product.

Level 2 Surface Data Product

John Martonchik (JPL MISR Co-Investigator) discussed the results of his research on the retrieval of land-surface bidirectional reflectance properties using multi-angle data. He is using data taken by the ASAS instrument, supplied by Jim Irons (GSFC), to test his algorithm. Martonchik suggested several improvements he plans to make to his algorithm, based on discussions with Michel Verstraete of the Joint Research Centre in Italy.

Martonchik, Diner, Strahler, Sig Gerstl (MISR Co-Investigator from Los Alamos National Laboratory), and Chris Borel (LANL) discussed the effects of surface slopes on the retrieval of surface reflectance properties, and possible techniques for dealing with these effects.

John Martonchik summed up the results of the surface-property discussions, and presented an initial product specification for the MISR Level 2 Surface data product. The at-launch product elements will include, for clear skies at 1.1-km sampling over land, atmospherically corrected reflectance factors and albedos, as well as the downwelling direct-plus-diffuse irradiance at the surface. The reflectance factors and albedos will be provided for both direct beam illumination only, which is needed for surface structural modelling, and for direct plus diffuse illumination, which is needed for field validation and input to climate models. It was decided, based on advice from Howard Gordon (MISR Co-Investigator from the University of Miami), that the only surface product element retrieved over oceans would be bidirectional reflectance factors in the four MISR spectral bands, at MISR's three near-nadir viewing angles, with 2.2-km resolution, in low-latitude regions only. These data would be useful to the MODIS Team in supplementing MODIS ocean data that would be contaminated by sun-glint caused by the sensor geometry.

Jim Irons discussed improvements made to the Advanced Solid-state Array Spectro-radiometer (ASAS), an instrument flown on NASA's C-130 aircraft. ASAS soon will be capable of observing the surface at all of the MISR viewing angles when flown on NASA's P-3 aircraft. Many MISR Team members will be using ASAS data to develop and validate algorithms for retrieving surface and aerosol properties. In order to use ASAS data to develop algorithms related to cloud properties, the instrument would have to be flown at a higher altitude than the C-130 and P-3 fly. Irons indicated that the instrument would need some modification (e.g., automation) to fly on an ER-2. It generally was agreed that ASAS can provide the MISR Team with critically useful pre-launch data for developing and validating geophysical retrieval algorithms. However, funding for the instrument and related activity at GSFC is tight.

Michel Verstraete discussed the physical surface models for calculating or retrieving bidirectional reflectance which he has developed in conjunction with Bernard Pinty of the Laboratoire de Meteorologie Physique, France. The results presented related specifically to the BRDF of panels made of Spectralon (from Labsphere, Inc.). Such panels will be used for onboard calibration of MISR, MODIS, and MERIS (on ESA's Envisat spacecraft).

Level 2 Aerosol Data Product

MISR Co-Investigators Tom Ackerman, John Martonchik, and Howard Gordon, along with Bob West (JPL), presented the results of their research into aerosol properties and their retrieval. The discussions associated with these presentations involved many other people, including Dave Diner, Ralph Kahn (JPL), and Yoram Kaufman (GSFC).

Gordon presented his latest techniques for using multiple view angles and at least two spectral bands to retrieve aerosol properties over the ocean. The brightness of the ocean at the shorter two MISR spectral bands will be variable enough (due to variations in phytoplankton) to limit their usefulness for aerosol retrievals. The two variables that seem to be directly retrievable from MISR data are the aerosol particle phase function, and the product of aerosol optical-depth and single-scattering albedo.

Bob West discussed the status of his modelling effort for determining the phase function of non-spherical particles from theory. It was generally agreed that the use of such phase functions would be critical for aerosol retrievals, since such a large fraction of tropospheric aerosols deviate significantly from sphericity (and therefore Mie scattering theory does not apply).

Tom Ackerman discussed the question of what sort of retrieval process would be used. Many MISR investigators would prefer to retrieve optical depths of several aerosol types, each specified beforehand by phase function, single-scattering albedo, and unimodal size distribution (separate size modes being classified as separate aerosol types). Such a scheme would require the development of a data base of such parameters, along with the distribution in space and time of the different aerosol types (i.e., a climatology). Other investigators would prefer to retrieve a set of aerosol parameters (including optical depth) that represent an ensemble (albeit non-linear) average of these parameters. No firm consensus was reached; however, for the time being, the MISR Team plans to investigate both approaches.

Tsutomu Takashima (Meteorological Research Institute, Japan), of the ASTER Team, presented the results of his work on atmospheric correction of ASTER data. Several effects are important to the retrieval of surface reflectance properties. In addition to the effects of atmospheric path radiance and atmospheric absorption, ASTER has to deal with two other effects. First, since ASTER resolves regions that are small (~30 m) compared to the depth of the boundary layer, aerosol scattering can spatially blur variations in surface brightness through the adjacency effect. Second, the ASTER Team wants to retrieve surface properties over as much of each ASTER image as possible, including areas close to clouds. Thus, one must correct for the effects of light reflected off of the sides of clouds onto the surface and aerosols.
John Martonchik summed up the results of the aerosol discussions and presented an initial product specification for the MISR Level 2 aerosol data product. It was agreed that the guaranteed at-launch product elements would include optical depths over both land and ocean, as well as phase function over ocean. Additional variables, including single-scattering albedo, phase function over land, and particle size distribution, are anticipated in the post-launch era. Ancillary variables, such as stratospheric ozone and aerosol opacity, boundary layer humidity, and surface pressure, from sources such as SAGE, MODIS, and synoptic weather analyses, will be incorporated in the retrieval process and reported as part of the data product.

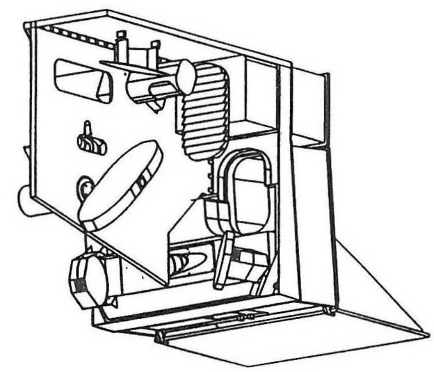
Other Issues

At the end of the Level 2 product discussions, Dave Diner summed up the team consensus on what would constitute the MISR Level 2 products. This was followed by presentations by Graham Bothwell and Daniel Wenkert on algorithm development plans, in which the schedule required to deliver working software before EOS-AM launch was emphasized. Jim Conel (MISR Validation Scientist from JPL) and Carol Bruegge (MISR Co-Investigator and Calibration Scientist from JPL) then discussed validation of MISR retrieval algorithms before launch and validation of MISR data products after launch.

Finally, Alan Strahler and Piers Sellers discussed topics of mutual interest to multiple EOS-AM instrument science teams.

Moderate-Resolution Imaging Spectroradiometer (MODIS)

March 24-26, 1993, in Lanham, MD.
—by **David Herring**/MAST Technical Manager/SSAI



The MODIS Science Team met in three plenary sessions and four discipline group sessions—Atmosphere, Calibration, Land, and Oceans—March 24-26, 1993, in Lanham, MD.

DAY 1 PLENARY SESSION

Introduction

The meeting began with a discussion of important issues currently facing the MODIS Science Team: MODIS data products, their accuracies, and validation plans, the EOSDIS Core System (ECS), and MODIS calibration. At the previous MODIS Science Team Meeting a number of descope options were discussed and have since been successfully applied. At this meeting there were no further descopes planned. Also since the last meeting, the ground calibration approach has been simplified and improvements in testing have been made at Santa Barbara Research Center (SBRC). Additionally, the detector yield has significantly improved. The MODIS Preliminary Design Review (PDR) Team has acknowledged the necessity of having onboard calibrators. The PDR Team is also pleased with the electronics of the instrument.

MODIS Processing Requirements

There has been some discussion as to the processing capacity required for MODIS products. Initial estimates being used by the EOSDIS Project are clearly too low. The MODIS Science Data Support Team (SDST) is developing new and more accurate estimates to submit to the EOSDIS Project.

Test Sites

Bruce Guenther summarized the MODIS Calibration Panel's activities. The Panel is currently reviewing activities at different agencies that are collecting remote sensing data in areas of interest to MODIS. Guenther will compile a list of ongoing test site efforts and report to the Team on what georeferenced databases are available.

SBRC Report

Tom Pagano, of SBRC, discussed the latest engineering developments and current design issues facing MODIS. The mainframe drawings of the instrument are complete, as is the design for the scan mirror assembly and the optical bench. SBRC has finalized the detector mask configuration. Contrary to what was decided at the last MODIS Science Team Meeting, they found that using subpixels in the detector masks was not necessary. Pagano reported that SBRC accommodated the requested changes in bands 21 and 26. (Band 26 was changed to 1.38 μm and Band 21 was changed to 3.96 μm.) The engineering model of the FPA (focal plane assembly) will be complete by August '93.

Pagano reported that MODIS' scan mirror allows views of multiple calibration sources: the Spectroradiometric Calibration Assembly (SRCA), Solar Diffuser Stability Monitor (SDSM), solar diffuser, the Sun, the Earth, deep space, and the blackbody. Based on thermal analysis results, SBRC can detect a temperature gradient of the blackbody to within 0.1°K.

MODIS Data Products

Team Leader, Vince Salomonson, discussed the MODIS Data Products flow diagrams for each discipline group. He tasked each group to review these diagrams and to produce an at-launch data products list that details each product name and accuracy. Additionally, NASA HQ has mandated that each instrument team must tie its data products to instrument specifications. Salomonson also tasked Science Team members with generating an Algorithm Theoretical Basis Document (ATBD) to describe the physics, mathematics, and computer program considerations behind the algorithms for which they are responsible. Team members may incorporate all of their algorithms into one document. ATBDs are due on or about July 30, 1993.

MCST Report

John Barker explained how the MODIS Characterization Support Team (MCST) intends to explore and maintain different calibration methodologies. MCST will characterize calibration precision between two and six months after launch; they will characterize accuracy on a time scale of years after launch; and will validate the math model over the 10- to 15-year lifetime of the EOS mission. Barker asked for inputs from the Science Team on their calibration requirements.

MCST's intent is to build redundancy into the MODIS calibration system to lower risk—they intend to normalize data via cross-calibration and perform ground instrument characterizations, end-to-end performance models, and spacecraft-based geometric characterizations. MCST's intent with the calibration algorithm is to provide some degree of coefficient derivation. The methodology will be organized so that any changes in calibration can be analyzed onboard and in flight. The way the calibration system is operated will depend on what MCST finds when the instrument is in orbit. Barker reported that MCST will release a document describing the calibration methodology in greater detail for peer review by August, 1993. Additionally, MCST will track the calibration history of the instrument. MCST will provide the best coefficients at any time to apply to any previous data. Team members may decide on the significance of the coefficients in determining the advisability of application to their data, or they may defer to MCST's provided recommendations as to which set of coefficients are most applicable to any given data set. In short, MCST intends to provide automatic updates of coefficients every six months based on the best current information. These coefficients will be contained in the Level 1-B algorithms, but there will be pointers to them in the 1-A algorithms.

Cloud/Utility masks are planned as part of the Level 1 calibration process, and are to be available for use in the production of any Level 2 or higher data products. These masks would be available in three 32-bit Level-2A images, one for each of the different 250, 500, and 1000 m MODIS spatial resolutions.

SDST Report

Al Fleig asked the Science Team members to let the Science Data Support Team (SDST) know whom they plan to have validate their output products. At the time of input, SDST will also assemble all validation plans into a single document.

SDST is in the process of updating its estimates of MODIS' processing and storage requirements. Fleig asked Science Team members to report what they really plan to put out for a product; and what do they mean when they say "product"? In short, do the Science Team members have anything SDST can use to scale their processing requirements? In conjunction with MCST, SDST will write a shell for 1A and 1B algorithms. SDST will inquire as to the quality assurance of each product. Science Team members should report to SDST what sort of simulated data they want, and when they want it. SDST plans to assist each member in the development of their software. Team Members should let SDST know whom to contact with questions/concerns regarding software development. Fleig said that if the Team is interested, SDST will put together a seminar to assist Team members in software development. He also offered SDST's help in producing ATBDs. He reminded the Team that they are scheduled to deliver their initial code by January 1, 1994.

For the MODIS Science Computing Facility, SDST plans to use the Product Generating System (PGS) Toolkit, POSIX compliant UNIX, ANSI C and ANSI FORTRAN, and a hierarchical data format. The hosting hardware to the Toolkit will consist of Sun, DEC, Silicon Graphics, Hewlett-Packard, and IBM computers. SDST will use QA/FORTRAN and QA/C as their quality control (QC) tools. Ed Masuoka said that SDST will issue a-Science

Computing Facility (SCF) Plan describing software and data management, software development, and configuration management by the end of June, 1993.

SCAR Experiments

Yoram Kaufman reported on his plans to conduct SCAR (Smoke, Clouds, and Radiation) experiments in 1993 and 1994 to collect data on deforestation and biomass burning. The 1994 experiment will be in Brazil. Kaufman would like to conduct a pre-SCAR experiment in the Eastern United States in July, 1993. SCAR will provide atmospheric science (physical, chemical, and radiative effects of biomass burning on the atmosphere); as well as remote sensing of vegetation, fires, smoke, water vapor, and clouds. The approach will be to conduct remote sensing from aircraft instruments—MODIS Airborne Simulator (MAS), Cloud Absorption Radiometer (CAR), and Advanced Visible/Infrared Imaging Spectrometer (AVIRIS)—in the 0.4- to 14-μm bands; make *in situ* measurements of physical, chemical, and optical properties of trace gases, water vapor, smoke particles, and cloud drops; take ground-based measurements of vegetation, fires, and smoke aerosol; and to use satellite observations from AVHRR, GOES, and Landsat's Thematic Mapper.

DAY 2 PLENARY SESSION

MAST Report

Locke Stuart introduced Janine Harrison and announced that she will become the new MODIS Administrative Support Team (MAST) Manager early this fall. Chris Scolese announced that Piers Sellers is the new EOS-AM Project Scientist.

MISR Report

Dave Diner, MISR Team Leader, said geolocation is a concern to MISR—the EOS Platform is required to provide position accuracies; however, the Project has made no official commitment on this issue. Although Martin Marietta Aerospace (formerly GE) agrees to provide pointing knowledge of ± 90 arc-seconds, MISR would like breakdowns into static and dynamic uncertainties. He feels that MODIS has similar concerns, and invited the MODIS Team to work with MISR to obtain the Project's commitment to make this a contractual requirement for Martin Marietta Aerospace.

EOSDIS Update

H. K. Ramapriyan reported that the EOSDIS Core System (ECS) negotiations have been completed. Ramapriyan explained that the Earth Science Data and Information System (ESDIS) Project is establishing four "focus" teams whose role is to involve the science and DAAC communities in review and guidance of EOSDIS development. The four teams are Data Processing, Data Organization and Access, Science Data Planning and Operations, and Flight and Mission Operations. Chris Justice interjected that having Project personnel serve as chair and co-chairs of these teams will make it harder to get major criticisms through if the systems need to be changed. Gail McConaughy assured the Team that EOSDIS is responsive to complaints and has built-in mechanisms for feedback.

ECS' science software and data management requirements will be defined and refined through meeting with the science software developers and the Data Processing Focus Team. The ECS contractor is responsible for developing the Product Generating System (PGS) Toolkit. The software developers and the DAACs will support the algorithm integration process. The system will then be independently verified and validated. Over the next 12 months, the ESDIS Project has set the following goals for ECS:

- Hughes (ECS contractor) will become familiar with Version 0 DAAC software and the DAAC organization;
- Hughes will establish a development and prototyping facility and demonstrate initial proto-types;
- begin developing an algorithm interface toolkit;
- establish liaison with the DAACs;
- begin analysis of new requirements due to mission changes since the RFP was released;
- conduct reviews of system requirements, system design, and prototype results; and
- establish a system development team to procure the system.

Justice asked what action will be taken to solicit feedback from the instrument teams. He said that as it stands now, the only interface between the instrument teams and EOSDIS seems to be through the DAAC.

McConaughy interjected that EOSDIS will have two mechanisms for receiving feedback: 1) the ECS contractors will provide people to go out and visit team members and principal investigators (PIs) in their environments; and 2) ESDIS Project Science Software managers will talk directly to the instrument teams. McConaughy stated that each instrument team needs to make sure that it has representation among the Focus Groups.

Bob Evans emphasized that there has to be effective, two-way communication between the instrument teams and EOSDIS, which he feels has been missing up to now. He said there have been two meetings to discuss science scenarios and none of the MODIS Science Team members were asked what they have in mind, what algorithms they require, or what they will need to assist them. He is specifically interested in such topics as error handling, portability, error coding, and the PGS Toolkit and its execution environment. Evans voiced a number of concerns; such as: 1) What does the PGS Toolkit support? 2) Is it possible for the Science Teams' algorithms to exist within the PGS environment? 3) Will the PGS Toolkit support a database from which algorithms can select parameters? Evans concluded that the PIs need to make their needs known or EOSDIS could evolve to the point where it is not responsive. Ramapriyan said that it is important to assure appropriate representation in the EOSDIS Focus Teams from all the instrument teams, and the ESDIS Project depends on that mechanism to assure the two-way communication to publicize the Focus Teams more widely. Ramapriyan said he would post information about them on the EOSDIS Bulletin Board. Michael King added that information on accessing the EOSDIS Bulletin Board was published in the January/February issue of *The Earth Observer*.

CERES Report

Bruce Wielicki, CERES Team Leader, said CERES needs to develop algorithms in concert with MODIS' algorithm development. CERES would also like to obtain MODIS' Level 1B radiances. He offered to make CERES cloud algorithms available for MODIS—CERES has a number of people who specialize in cloud remote sensing.

FINAL PLENARY SESSION

Calibration Group Report

At the Final Plenary Session, Phil Slater reported the following Action Items for the Calibration Group:

- review the preflight solar-based calibration of SeaWiFS and the implications for MODIS;
- review MCST's plans for MODIS calibration;
- offer some preliminary suggestions for combining multiple data sets; and
- analyze the stability of the SRCA for a duty cycle of greater than 20 percent.

Slater is concerned that too great an emphasis is being placed on image-based analyses and insufficient emphasis is being placed on the development of sensor models. He said we need a greater understanding of model sensor instabilities. We also need to provide smooth transition, not step functions, in calibration coefficients as a consequence of sensor models. Additionally, Slater stated MCST needs to provide comprehensive error budgets. Slater suggested using an integrated approach to calibration. He recommended implementing peer review of Level 1 MODIS calibration algorithms.

Atmosphere Group Report

Michael King began his report with a discussion of the three MODIS channels currently not meeting specs. The Atmosphere Group feels that it is okay to relax the specs on Bands 27 and 29; however, Band 36 is more sensitive to SNR and he wants to make sure that there is no "roll off" on the dichroic beamsplitters.

It was determined that currently no further funding is available from HQ to support Kaufman's proposed SCAR and pre-SCAR experiments. Moreover, HQ wants Kaufman to secure all of the necessary funding before beginning negotiations on the international agreement with Brazil. King announced that there will be a planning workshop on April 27-28 for the SCAR and pre-SCAR experiments. Regarding the masking utility algorithm, King stated that MODIS will need greater use of the 1.38-μm and thermal IR channels in cloud screening. He said the Atmosphere Group will work more closely with CERES to provide cloud masking. King said that it is necessary to generate a global MODIS simulation data set in close consultation with the entire team.

Oceans Group Report

Wayne Esaias announced that the launch of SeaWiFS will probably be moved from October 15 of this year to sometime in March or April of next year. Esaias raised the possibility of merging EOS COLOR and MODIS ocean products. He stated that the Oceans Group needs access to OCTS (Japan's Ocean Color Temperature Scanner) Level 2 and 3 chlorophyll (and other) products (OCTS is a sensor on the ADEOS satellite). Esaias stated that the FY94 budget is a concern—if the Oceans budget is reduced to as much as 75 percent of expected funding levels, it will impact SeaWiFS' algorithm development in support of MODIS. Of particular concern to Esaias are validation and delivery of algorithms and products for MODIS. Regarding EOSDIS, Esaias feels that Science Team members are highly significant users of the DAAC and should have more participation in the Focus Groups other than just adjusting data products. He said that it is a good idea to have test sites at the EOS level and feels optical test sites in the southern oceans are needed.

Algorithm Theoretical Basis Documents

Vince Salomonson reminded the Team members to tie their data products to instrument characteristics. In their ATBDs, Team members are to state how their products relate to MODIS' bands, specs, etc.; ATBDs should also include error analyses. They do not, however, have to cover requirements for processing. ATBDs are due by the end of July.

Land Group Report

Chris Justice reported that the Land Group had a productive discussion with Martin Marietta Aerospace on pointing knowledge and is satisfied that it is recognized as a critical issue. He feels that Martin Marietta Aerospace will do better than spec. He suggested establishing a platform-level focus group—put together by Michael King and Piers Sellers—to improve communication between Martin Marietta Aerospace and the Science Team. Justice said he is concerned about access to TDRSS (Tracking & Data Relay Satellite System). This is an EOS issue, not just MODIS. He also feels there is a need to discuss the specs for the EOS-PM platform. Alan Strahler said that there's an incorrect perception that there's no need to worry about pointing accuracy if ASTER does not fly on that platform. On the contrary, MODIS also has stringent pointing accuracy requirements.

Justice said that the saturation levels of Bands 31 and 32 need to be higher than AVHRR. Weber interjected that a bilinear gain on MODIS is highly unlikely to be implemented now; it was never a requirement and to make it so now would raise the cost too much. Pagano added that dual gain was difficult to implement. Justice responded that this is a critical issue.

Regarding ancillary data requirements, Justice stated that more communication is needed between MODIS and the other instruments, as well as IDS teams. He noted that pre-launch global 1-km AVHRR data are currently being collected by EDC (EROS Data Center) as part of the DAAC activity. However, it is not clear how the data will be accessible to the Team. ■

ERBE Results Show Volcanic Effect

From EOS News Bulletin Board—Tuesday, April 6, 1993

Data from the Earth Radiation Budget Experiment (ERBE) have been used to confirm significant radiative climate forcing following the eruption of Mt. Pinatubo in 1991 (Minnis et al. 1993 *Science* 259:1411). ERBE detected a 3.8 percent increase in sunlight reflected from the atmosphere for several months following the eruption, presumably due to increased reflection by volcanic aerosols. The ERBE observations are the first direct evidence that a volcanic eruption can lead to a significant change in the global radiation balance. EOS will include ERBE-type measurements with flights of the Clouds and the Earth's Radiant Energy System (CERES) instrument on TRMM, EOS-AM and EOS-PM Satellites.

EOSDIS Testbed System

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Introduction

The EOSDIS Testbed System grew out of the early discussions of the EOSDIS program. The three principal investigators are all members of the EOSDIS Science Data Advisory Panel (better known as the Data Panel), which spent a considerable amount of time discussing the creation, evolution, and character of the EOSDIS. The proposed system was a mini-DIS that would use existing satellite data, computer systems and networks to try out some of the EOSDIS concepts. The testbed system would make it possible to test some of the social interaction aspects of the future data system. Our knowledge of just how such a data system would function to satisfy the needs of a wide variety of people is very limited. Prototype systems of this type allow us to gather valuable information and experience as to how users respond to the availability of satellite data.

The subject data for this testbed system were operational weather satellite data from both the Advanced Very High Resolution Radiometer (AVHRR) on the polar orbiting weather satellites of the National Oceanic and Atmospheric Administration (NOAA), and infrared imagery from the Geostationary Operational Environmental Satellite (GOES). Direct readout stations for both GOES and AVHRR imagery are operated by the Colorado Center for Astrodynamics Research (CCAR) at the University of Colorado in Boulder. The primary storage system for the data to be handled by the testbed data system is the mass storage system at the National Center for Atmospheric Research (NCAR), also in Boulder. Network connections use "Internet" which has a backbone node located at NCAR.

The Initial Testbed Data System

The original goal of the proposed testbed was to provide AVHRR imagery of an eight-State region centered on Colorado. These image data were extracted from the full passes of AVHRR data received at CCAR. The data then were navigated using a new software package (Baldwin and Emery, 1993), and stored on the NCAR mass store. A new interface was written that used a dedicated workstation as the data system computer and outside users were given logons to be able to come into the system over Internet, query the inventory, and order the image data. Because the eight-State file sizes were relatively small, it was easiest just to let people pull the full data files over the network. This task was accomplished by the having the "order" system put the images selected in a named file to be acquired by anonymous FTP. The order interface listed the images in terms of date, time, and AVHRR channel. Since all images were for the same geographic area, no browse or preview image was provided.

One of the first changes introduced was the provision for image browse. Since many users were either interested in clouds or interested in cloud-free images, providing a browse capability would greatly reduce the amount of data ordered over the network. Without the browse capability, users were merely ordering everything and selecting the "good" images and discarding the rest later. Our first approach to image browse was to compute small, subsampled versions of the full images that then could be acquired by FTP, much as the full image data, but at a much smaller volume. We then learned that it was possible to provide online browse for machines that were running under x-windows. The introduction of this realtime browse capability greatly changed the use of the testbed system.

As can be seen by the reduction in volume of data shipped in the spring and summer of 1992 (Fig. 1), browse led people to select and order only those images that would be useful to them as judged by their review of the online browse image.

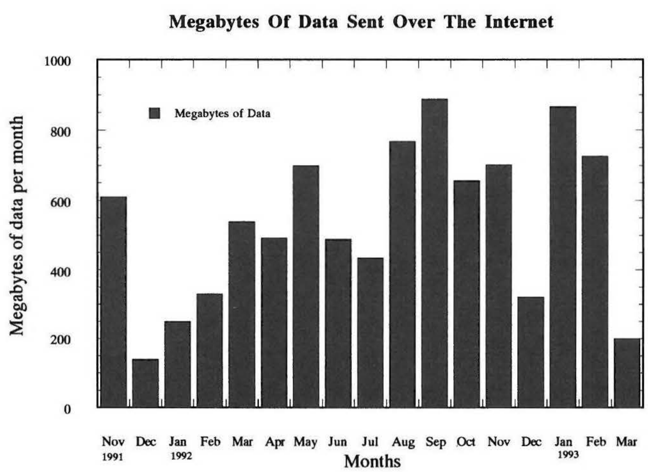

Figure 1.

The First Major Change

One of the basic concepts of the EOSDIS system is that it will evolve as system uses change along with the emergence of new system hardware. It was interesting in the testbed to see how these evolutionary changes took place. Since this is an experiment in the use of the data system, we insisted that users give us information about their use of the system and the data they were getting. All of this was done using computer mail (although there were a lot of phone calls in the early months). As a consequence, we found that many people wanted data that were not in the eight-State region that we had on the system. We kept getting requests for other parts of the AVHRR passes, some farther east and others farther west. We responded by changing the overall image size and providing a much larger portion of the imagery received at our antenna. With the introduction of these larger images, the demands on the network traffic increased. The spikes in Fig. 1 indicate the increase in volume of data shipped as these larger images were introduced. This required a new set of browse images that were even more subsampled than before. The much smaller browse images were then used to select those images to be ordered over the network.

We were amazed at the variety of people that were using the system. As described by Fig. 2, this mix of users includes university users, government researchers, U.S. companies, high schools, junior high schools, and foreign users. While the U.S. universities are the largest users, most of the recent system growth has been in the secondary school users and private industry. It was also clear to us that these users all had very specific applications in mind and really didn't need all of the large images that they were pulling over the network. It was suggested that we develop a system to send out only that portion of the image that was needed by the user.

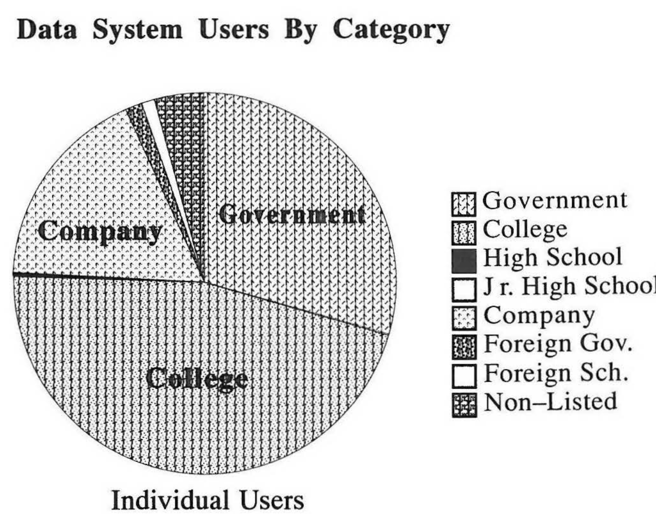

Figure 2.

Nav-order Becomes Navigate

To develop such a system required a fundamental change in the way data were selected and ordered. Up to now we had been doing all of the processing on the extracted portions of the images and just storing and shipping those images. For browse, a subsampled version of one infrared channel (to give us day and night coverage) was put on the system for each image in the archive. For this new approach, it will be necessary to store all of the raw AVHRR data on the mass store. Then, a new interface must be developed that would allow the users to select that portion of the image they were interested in, process/navigate only that portion of the image, and create an FTP file of that image portion. Since the image navigation was the central processing step, this procedure became known as "nav-order" to replace the earlier system called "order."

A number of fundamental changes must be made for this new system. Since the processing would take some computer resources for the image navigation, it was necessary to formulate a routine that would select a network computer at the NCAR cluster that was the least busy at the moment, and to compute the navigation on it. The data then were passed back to the testbed node computer (called "sanddunes") for placement in the anonymous FTP partition. Also, the browse image must be changed to represent the entire AVHRR satellite pass, from which the user could order the region of interest.

It was hoped to use a "rubber-band" window for this selection, but the problem of supporting a variety of map projections made that impossible. Instead, the browse image was formulated as a highly subsampled version of the raw AVHRR pass, the user then would select the center of the desired image portion using the mouse. Finally, in the dialogue box the user would indicate the x,y range of the region of interest. The user also must specify the channels desired, and whether any additional supporting information was required. This supporting information consisted of map data from a digital data base and topographic elevations for the U.S. Also selected by the user is the map projection to be used by the image navigation routine. A total of 12 different projections is supported by the testbed interface software.

With the introduction of nav-order, the use of the system again changed dramatically. The drop-off of data sent (Fig. 1) in the fall of '92 reflects more than just the Christmas holiday (serious drop in Dec.), but also reflects the initial shift to the nav-order system. Once in place, the orders and data shipped increased as shown in Jan. and Feb. of 1993. The apparent drop in March is due to the fact that these statistics were formulated very early in Mar., 1993, and the numbers are not complete for that month. This also is reflected in the raw data orders in Fig. 3. The ups and downs in the plot reflect the volatility in this testbed data system and users employing the system. Again, the summer months are seen as a slight drop, while Christmas is a dramatic drop. The Christmas of '91 was not as dramatic because the system was just getting started at that time. Peak orders are in fall and spring and nearly reach 900 orders per month. Such activity is considerable for a limited data system.

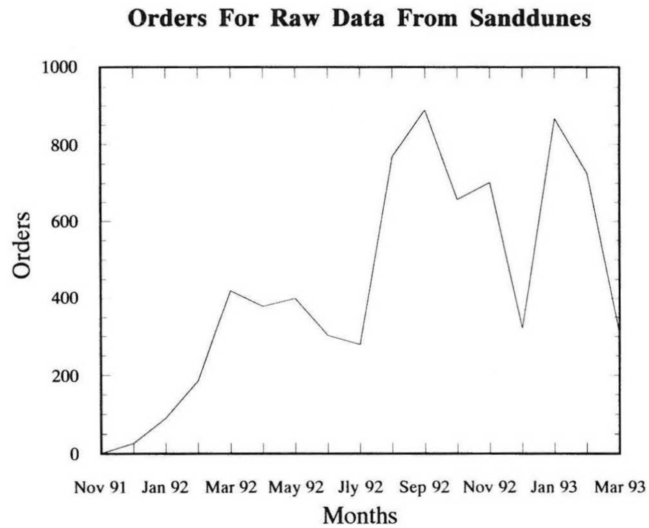

Figure 3.

Another change that was introduced under the nav-order system was the availability of the infrared GOES data to the system. We were not archiving the GOES imagery as we were the AVHRR, but a gigabyte hard disk was installed on the GOES computer that made it possible to store a number of GOES infrared and water vapor images. These images are then transferred up to a drive on sanddunes for access through the system. Nav-order users are allowed to come in, preview the GOES images via browse, and then order any one of the GOES images presently on the disk. Only a finite number of images can be held on this disk, and thus after two days the infrared and water vapor images are lost as they are replaced by new GOES data. This new system opened more opportunities for people to acquire both GOES and AVHRR data. To make things simpler, the "nav-order" title was changed simply to "navigate."

System Growth

The two curves that are essentially monotonic are the "total megabytes delivered by the system" (Fig. 4) and the overall number of logins to sanddunes (Fig. 5). The logins start at just above 0 since a number of the initial users were students at the Univ. of Colorado. The system grew gradually until early '92 when the system changed to accommodate the new, larger images. System growth accelerated again in late '92, as the nav-order system was introduced, and has continued on a fairly steep growth profile ever since. At well over 2,000 logins, the system has a fairly large number of users for such a simple testbed.

The total data delivered shown in Fig. 4 is a line with almost a constant slope. Thus, in spite of system changes and month-to-month variations in system use, the total data shipped to users has been increasing constantly over the life of the testbed. This number would have been much greater if the new navigate system had not been introduced. Even with this new efficiency in keeping the file size down, the overall data volume continues to increase.

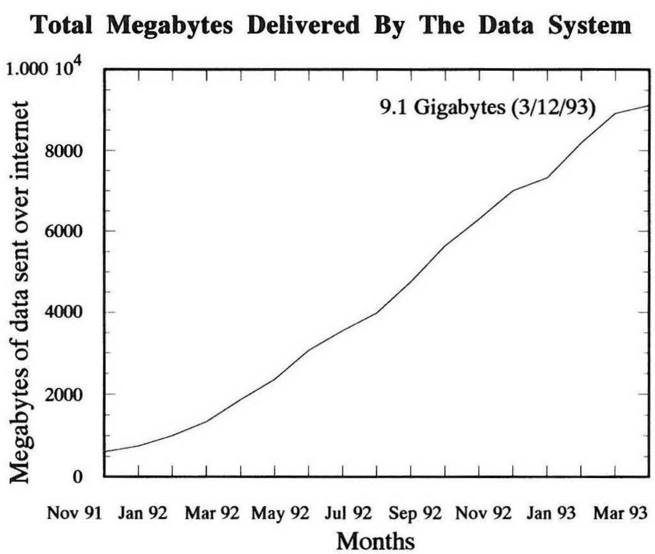

Figure 4.

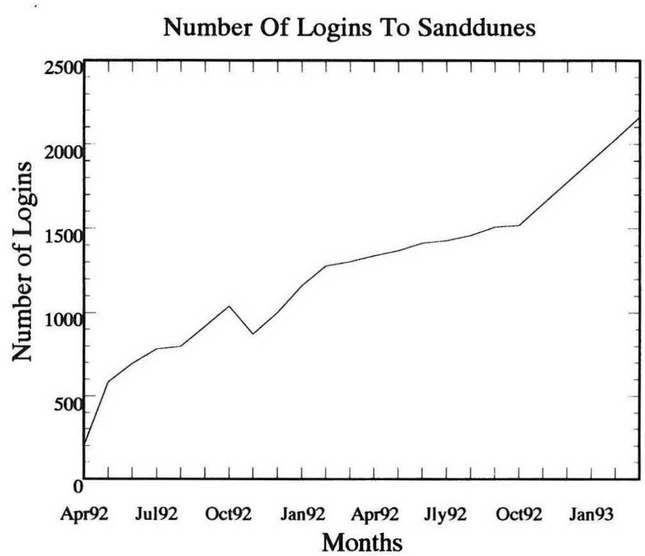

Figure 5.

Software Availability

When the testbed was created, we felt it was necessary to make software available to users of the system that needed the ability to work with the data provided by the system. Thus, we made available display software for UNIX workstations and for Macintosh computers. All of this software was written at CCAR and is distributed commonly at no cost to science users. In addition, we added software to composite, cloud-free portions of images; computed the Normalized Difference Vegetation Index (NDVI); and made snow cover estimates from AVHRR data. All of this software was accessible over the network via anonymous FTP from the program directory. In the early phases of the data system, many users were logging on only to acquire the software. Later, this use changed as people increased in capability to work with the satellite data and their primary interest shifted to the satellite images themselves.

The Testbed as a Learning Experience

The real benefit of this type of prototype data system is the opportunity to learn how people actually would use such a system. The evolutionary nature of the future EOSDIS was demonstrated clearly by the different phases of the testbed system. In response to user requests, the system experienced two major changes, each requiring major revisions of the system itself. Each change dictated a different type of interaction between user and system, and each change also added increased demands on the system capabilities. We learned that it is possible to use computer power to efficiently provide both data and services to users.

Another important "lesson learned" is that data distribution over the network is not only possible, but that it is very efficient. The creation and maintenance of the overall testbed system was performed by one person. This was possible only since the hands-on tasks of shipping tapes, etc. were eliminated, and only network access to the data was provided. As the system evolved, we learned to widen user access by implementing the browse and order systems on Macintosh, and later PC computers, running some version of x-windows. We also found that the user community was willing to provide both data and software to be distributed by the system. One company asked if we supported image display on a PC, and we said no. They then offered to put some software of their own on the system that could be used to display images on a PC. Other users have volunteered data for the system that would extend the historical AVHRR record back into the past.

We are collecting not only statistics but also anecdotes from users to get a better idea of how the system is being used and why. We hope that this valuable information on the societal aspects of a data system can be used in the continuing development of EOSDIS and other data systems. We are encouraged by the variety of use and users of this testbed and feel that the user community is ready to see such services expand in size and capability. Only in this way will it be possible to overcome the barriers to the efficient use of Earth sensing satellite data.

How to Access the System

Anybody interested in getting on and using this system should send internet mail to info@sanddunes.scd.ucar.edu, putting "AVHRR" in the subject and "help" in the body of the text. The mail server automatically will send information on how to access the system both for data and software. Any other questions should be addressed to kelley@sanddunes.scd.ucar.edu. Tim Kelley can be reached by phone at 303-497-1221 or 303-492-8868. Please leave messages if he is not readily available at either location.

We hear that . . . .

EOSAT Company has announced that customers now may browse for Landsat imagery on their home or office computers before they make a purchase.

EOSAT, along with Core Software Technology, and Digital Equipment Corporation have developed an on-line database that for the first time allows users of remotely sensed data to see snapshot samples of Landsat Thematic Mapper (TM) scenes on their computer screens before placing an order.

This "browsing system" is a major step in improving the commercial availability of EOSAT data. With the "Browse," users now have an easy and convenient way to identify the best data available for their project needs, saving precious decision-making time. The system allows users to see a clear visual representation of the area they seek before they order the data.

The archive search and preview system initially will contain more than 30,000 images that have been acquired since 1991 by Landsat satellites. Index information for the entire Thematic Mapper archive dating back to 1982 will be accessible immediately. The remaining preview images, dating back to 1984, will be added to the database within the next year. Landsat-6 preview data also will be added later this year as they are acquired.

Clients who subscribe to the service will gain access to the system by direct-dial computer hookup. They will be guided through the menu-driven program and asked to respond to a series of questions pertaining to their specific request. When prompted, the system will download and display low-resolution or "subsample" images and index information that meet the user's search criteria. Compressed higher-resolution preview images also may be downloaded, analyzed on-screen, or printed for hard-copy assessment.

The subscription service will be made available through Core Software Technology of Pasadena, Calif. Digital Equipment Corporation built and will maintain the database and communication system. EOSAT has provided index and subsampled image data and will provide data updates as new Landsat data are acquired.

Core Software Technology is the developer and distributor of The CORE™, an image display, manipulation, and processing system, which has been enhanced to support the image archive search and preview application. Subscribers with access to a UNIX-based host computer will receive The CORE™ and associated application software as a part of their subscription package. PC users with no local access to a UNIX host will receive X Server software enabling them to access the application remotely.

For CORE subscription information, call Core Software Technology at (818) 796-9155.

FIFE CD-ROM

—by **James McManus, Blanche Meeson, Don Strebel, Dave Landis** and **Patrick Agbu**

FIFE Volume 2, 3 & 4 CD-ROMs Now Available

The Volume 2, 3, and 4 CD-ROMs are now available for the First ISLSCP (International Satellite Land Surface Climatology Project) Field Experiment (FIFE). FIFE collected data on and around the Konza Prairie Research Natural Area near Manhattan, Kansas during 1987-1989. FIFE was one of the most complex interdisciplinary research efforts undertaken in Earth science.

The data collection efforts were split into two phases, monitoring, and Intensive Field Campaigns. Monitoring data were obtained from January of 1987 through October of 1989, including satellite imagery, micrometeorological observations, atmospheric conditions, surface biophysical and hydrological measurements. The five periods of intensive field observations with aircraft and ground-based instruments, totaling 80 days, were dedicated to collecting the detailed, coincident data necessary for exact comparison of satellite observations with surface and atmospheric processes.

FIFE Volume 2 CD-ROM

The Volume 2 CD-ROM contains LAC imagery (707 images) from the AVHRR instruments on the NOAA polar orbiter satellites, and browse imagery (degraded from full resolution) from the Landsat Thematic Mapper (14 images), and the SPOT HRV instruments (42 multispectral images and three panchromatic images). These images were collected as part of the monitoring program throughout the three-year duration of the experiment.

The Landsat TM and SPOT Multispectral and Panchromatic image data are browse products derived from the original proprietary data. Each pixel value is a two by two pixel average derived from the original FIFE "Level-1" image.

FIFE Volume 3 CD-ROM

Volume 3 of the FIFE CD-ROM series contains Thematic Mapper Simulator (TMS) imagery from the NS001 instrument flown on-board the NASA C-130 aircraft. This imagery was collected as part of the Coordinated Mission Plans during the five Intensive Field Campaigns (IFCs).

The NS001 instrument collects radiance measurements in the seven Landsat-4 and -5 Thematic Mapper (TM) bands plus a band from 1000 to 1300 nm. Therefore, when reflected or emitted radiation from surface features of the Earth are measured from the C-130 aircraft, inferences can be made about Landsat satellite measurements.

FIFE Volume 4 CD-ROM

The Volume 4 CD-ROM of the FIFE series contains Advanced Solid-State Array Spectroradiometer (ASAS) imagery and soil moisture imagery from the Push Broom Microwave Radiometer (PBMR), which were flown on-board the NASA C-130 aircraft. This imagery also was collected as part of the Coordinated Mission Plans during the five IFCs.

The ASAS instrument was designed to point off-nadir for the purpose of remotely observing directional anisotropy of solar radiance reflected from terrestrial surfaces. The first-generation ASAS sensor (this includes the data acquired during FIFE) was able to track and image a target site through a discrete sequence of fore-to-aft view directions. This allowed off-nadir pointing from 45 degrees forward to 45 degrees aft, typically recording observations at every 15-degree increment as the platform aircraft approached and passed over a site. For each view angle, ASAS acquired data for 29 spectral bands in the visible and near-infrared portions of the spectrum, with a spectral resolution of 15 nm.

The PBMR instrument is an L-band microwave radiometer, operating at the 21-cm (1.413 GHz) hydrogen line protected band (i.e. the band is protected from use in communications to minimize interference), with a planar phased array antenna made of eight by eight dipole elements, which are combined to form four beams. Its purpose in FIFE was to provide brightness temperature, which could be used to derive soil moisture data for soils studies.

FIFE CD-ROM Software

All three CD-ROMs contain user interface software, image display software, and image decompression software. The interface software is designed for IBM and compatible machines. A Macintosh interface is under development and will be distributed separately. There is no commitment to support the interface on other platforms at this time. However, the contents of the CD-ROM are accessible using normal operating system software and applications programs on all machines with a suitable CD-ROM reader.

The image display software is IMDISP, which was developed at the Jet Propulsion Laboratory by the Planetary Data System and distributed for use in a number of NASA projects. Documentation is supplied with this software on the CD-ROMs. This software allows the display of image data on PC's equipped with EGA or VGA cards and monitors. The FIFE images may be viewed with this software after they are decompressed onto your hard disk.

The decompression software is written in C language and accompanied by text files containing a Users Guide and Installation Instructions. A compiled executable file for an MS-DOS system is on the CD-ROM, along with the source code. The source has been compiled and tested successfully on PC's, Macintoshes, VAX's, and a variety of workstations (IRIS, HP, SUN3, SPARC).

Extensive documentation on each data product, as well as general information on FIFE, also is provided on each of the CD-ROMs.

On-Line Data

Ground data collected for FIFE is available on-line. For further information on the FIFE CD-ROM series and on-line data, please contact James McManus at the GODDARD DAAC/Land FIFE user support office, phone: (301) 286-3135, email address: mcmanus@pldsg3.gsfc.nasa.gov.

Acknowledgement

The FIFE team cooperatively collected and processed the data presented on these CD-ROMs. The requested form of acknowledgement is given in the documentation for each data set, and should be honored. These CD-ROMs should be cited as published volumes:

Strebel, D.E., D.R. Landis, J.A. Newcomer, D. van Elburg-Obler, B.W., Meeson and P.A. Agbu. 1992. Collected Data of The First ISLSCP Field Experiment, Volume 2: Satellite Imagery. NASA Goddard Space Flight Center, Greenbelt, Maryland.

Strebel, D.E., D.R. Landis, J.A. Newcomer, S.J. Goetz, B.W. Meeson, P.A. Agbu, and J.M.P. McManus. 1992. Collected Data of The First ISLSCP Field Experiment, Volume 3: NS001 Imagery 1987 & 1989. NASA Goddard Space Flight Center, Greenbelt, Maryland.

Strebel, D.E., D.R. Landis, J.A. Newcomer, B.W. Meeson, P.A. Agbu, and J.M.P. McManus. 1992. Collected Data of The First ISLSCP Field Experiment, Volume 4 : ASAS & PBMR Imagery 1987 & 1989. NASA Goddard Space Flight Center, Greenbelt, Maryland.

The support of NASA Headquarters, Earth Sciences and Applications Division, Biogeochemistry and Geophysics Branch, is acknowledged gratefully.

Appendix

The following FIFE CD-ROMs currently are available:
- Volume 2: Satellite Image Data (NOAA-AVHRR, SPOT-HRV and Landsat_TM)
- Volume 3: NS001-TMS Data.
- Volume 4: ASAS and PBMR Data.

The following FIFE CD-ROMs will be available in the near future:
- Volume 1: FIFE Ground Data (although this is Volume 1, it will be the last CD-ROM produced in this series, and is expected to be published in late summer 1993).
- Volume 5: FIFE Level 2 Products (NDVI, GIS...) is expected to be published in early summer 1993.

DAAC FOCUS:

Jet Propulsion Laboratory DAAC Begins TOPEX Data Distribution

—by **J. Robert Benada**, Jet Propulsion Laboratory DAAC

The Jet Propulsion Laboratory (JPL) DAAC began distributing TOPEX data to NASA Principal Investigators (PIs) on October 12, 1992. This culminates two years of planning and preparation to archive, inventory, and distribute data from the TOPEX/POSEIDON project.

TOPEX/POSEIDON is a collaboration between NASA and the French space agency, CNES. The purpose of the project is to repeatedly m easure the height of the sea surface all over the Earth to a precision of less than 10 centimeters. The data will be used to study ocean currents, other ocean surface changes, and even the shape of the sea floor.

The satellite, launched in August, carries two altimeters: a NASA dual frequency altimeter similar to GEOSAT, and a proof-of-concept French solid-state altimeter. They cannot collect data simultaneously as they share the same antenna. For the present, JPL DAAC distributes only the data from the NASA altimeter, but will ultimately distribute a merged product.

Currently, the TOPEX project is nearing the end of a six-month Verification Phase, an intense period of examining the accuracy of the data and preparing changes to the processing algorithms and constants. The primary responsibility of JPL DAAC during this phase is to distribute the NASA Interim Geophysical Data Record (IGDR) on tape to the 23 Project PIs so they can participate in the data verification. The data is "interim" because the orbit accuracy is too coarse to do the ocean research planned for the following phase. The data is about two weeks old when the PIs receive it. During the Verification Phase, JPL DAAC is only authorized to send data to the project PIs.

The TOPEX Project asked JPL DAAC to provide a means to get IGDR data to their Verification Team as quickly as possible. We have set up a "Quick-Look Bulletin Board" on an operations VAX, enabling team members to log-in or FTP and retrieve the data. Software is included to read the data. The Quick-Look Bulletin Board has been used by 12 groups of team members with great success. The IGDR data is copied directly from the TOPEX production computer within 12 hours of being processed. Verification Team members have the data within five days from the time it was collected from the satellite.

The Observation Phase began in March 1993. During this phase, the NASA Geophysical Data Records (GDR) will be produced with a high precision orbit, In addition to distributing this data to the NASA PIs, JPL DAAC will be able to distribute products to the science community.

The JPL DAAC will produce a "merged" GDR beginning in June 1993, which will contain high precision data from both the NASA and CNES altimeters. This will give the most complete coverage of Earth's oceans, seas, and large lakes. The data will be published on a CD-ROM in a single format very similar to the current NASA format. This is the form we plan to use to ship the data to the scientists requesting a full set of data. There will be 16 CDs produced per year.

Anyone interested in more information on the TOPEX/POSEIDON project or other activities at the JPL DAAC may contact Robert Benada at (818) 354-2901 or via e-mail at j.benada/OMNET, rbenada@muffin.jpl.nasa.gov (Internet), or SHRIMP::JRB (Span).

$ *Special Book Price to Earth Observer Subscriber* $

The EOS Project Science Office has been able to negotiate a special price for readers of *The Earth Observer* on the book titled *Proceedings of The International School of Physics, <Enrico Fermi> The Use of EOS for Studies of Atmospheric Physics* published by North-Holland Publishing Company, 1992. Course CXV, edited by J. C. Gille and G. Visconti, Directors of the Course—Varenna On Lake Como, Villa Monastero, 26 June-6 July, 1990.

Anyone who wishes to obtain a copy of the book (ISBN 0-444-89896-4) may purchase it through Ms. Barbara Forrest at Elsevier Science Publishing Company, Inc., 655 Avenue of the Americas, New York, N.Y. 10010, USA, (212) 633-3805, at a cost of $171.50 each which is 25% off the regular price of $228.75 each. The special price applies to *Earth Observer* subscribers only, and will expire on September 30, 1993.

This book contains the following subjects:

OVERVIEW

R. G. Prinn	Earth System Science.
J. Dozier	The EOS Data and Information System (EOSDIS).
R. G. Prinn	Tropospheric Chemical Models.
J. R. Drummond	Measurements of Pollution in the Troposphere (MOPITT).
R. Beer	The Tropospheric Emission Spectrometer (TES) for the Earth Observing System (EOS).
L. Marelli	The Use of EOS for Studies of Atmospheric Physics.

THE TROPOSPHERE

G. P. Brasseur and R. G. Prinn	Biogenic and Anthropogenic Trace Gases in the Atmosphere.
F. Molteni	Atmospheric Low-Frequency Variability and the Role of Diabatic Processes.
C. Gautier	Air-Sea Interactions and Precipitation over the Tropical Oceans.
R. Rizzi and M. M. Bonzagni	Principles of Remote Sensing of Atmospheric Parameters from Space: Application to the Atmospheric Infrared Sounder (AIRS).

THE CLIMATE

R. D. Cess	Global Climate
A. Slingo	Satellite Observations of Clouds for Climate Studies.
M. R. Marinucci and F. Giorgi	Regional Climate Modeling
M. D. King	Remote Sensing of Cloud, Aerosol and Water Vapor Properties from the Moderate Resolution Imaging Spectrometer (MODIS).
J. Dozier	HIRIS—NASA's High-Resolution Imaging Spectrometer for the Earth Observing System.
Y. Yamaguchi, I. Sato and H. Tsu	ITIR Design Concept and Science Missions.

THE MIDDLE ATMOSPHERE

M. E. McIntyre	Atmospheric Dynamics: Some Fundamentals, with Observational Implications.
J. R. Holton	Dynamics of the Middle Atmosphere: Its Role in Transport and Troposphere-Stratosphere Coupling.
G. Visconti, F. Sassi and G. Pitari	Transport in the Middle Atmosphere from Satellite Data.
M. R. Schoeberl and L. R. Lait	Conservative-Coordinate Transformations for Atmospheric Measurements
J. C. Gille and J. J. Barnett	The High Resolution Dynamics Limb Sounder (HIRDLS). An Instrument for the Study of Global Change
D. J. McCleese	The Stratospheric Wind Infrared Limb Sounder: Investigation of Atmospheric Dynamics and Transport from EOS.
I. S. A. Isaksen	Stratospheric Chemistry with Emphasis on the Lower Stratosphere.
J. M. Russell III	The Spectroscopy of the Atmosphere Using Far-Infrared Emission Experiment (SAFIRE)
J. W. Waters	Submillimeter Heterodyne Spectroscopy and Remote Sensing of the Upper Atmosphere.

EOS Science Calendar

July 13-15	U.S. ASTER Science Team Meeting, Pasadena, CA. Contact Dave Nichols at (818) 354-8912.
Sept./Oct. TBD	GLAS Science Team Meeting. Contact Bob Schutz at (512) 471-1356.
September 28	MODIS Calibration Working Group Meeting, location TBD. Contact David Herring (301) 286-9515.
Sept. 29-Oct. 1	MODIS Science Team Meeting, location TBD. Contact David Herring (301) 286-9515.
November 8-12	ASTER U.S. and Japanese Joint Science Team Meeting, Japan, Contact Dave Nichols at (818) 354-8912.

AM PROJECT MEETING

From EOS News Bulletin Board — Friday, April 23, 1993

The second semi-annual EOS AM Project Development Meeting was held April 19-23 at NASA/GSFC in Greenbelt, MD. The spacecraft contractor, Martin Marietta Aerospace (formerly GE) reviewed their progress, including presentations on pointing/jitter studies and the Operations and Science Instrument Support (OASIS) software. Highlights of the presentations were: 1) spacecraft pointing and jitter capabilities are approaching the values requested by the instrument teams; and 2) the Solid State Recording Device has been sized at 140 Gbits (ca. 1.1 orbit of data from all on-board instruments). Instrument investigators reported the status of instrument designs, software development, and operational plans. The first meeting of SWAMP (Science Working Group, AM Project) reviewed status and identified subgroups to study critical issues in pointing, data product definition, gridding and geolocation, digital elevation maps, derivation of merged (multi-instrument) data products, algorithm documentation, and calibration/validation plans. Workshops were also held on power and electromagnetic compatibility. The AM Project announced that the Spacecraft Preliminary Design Review was rescheduled from September to November 1993 in order to accommodate the MOPITT development schedule.

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) 286-3884. Correspondence may be directed to Charlotte Griner at the above address. Articles, contributions to the meeting calendar, and suggestions are welcomed. Contributions to the meeting calendar should contain location, person to contact, and telephone number. To subscribe to *The Earth Observer*, or to change your mailing address, please call Hannelore Parrish at (301) 513-1613, or send message to Internet address: hparrish@ltpsun.gsfc.nasa.gov, or write to the address above.

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Assistant Editor: Mary Odell
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Distribution: Hannelore Parrish

Correction

The report of the February 2-5, 1993 ASTER Science Team Meeting, published on pp. 8-9 of the January/February 1993 issue of *The Earth Observer*, was written by A.D. Morrison of JPL, not by D. Nichols, Anne Kahle, and Y. Yamaguchi, whose names were listed by mistake. The staff of *The Earth Observer* sincerely regrets this error.

Global Change Calendar

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 29-July 1	The Defense Landsat Program Office Workshop on Atmospheric Correction of Landsat Imagery, Los Angeles, CA. 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	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. 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. 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 9	Tenth Thematic Conference on Geologic Remote Sensing. Contact ERIM, phone: (313) 994-1200, ext. 3234; FAX: (313) 994-5123.
September 14-15	TERRA-2 Conference at Chester College: "Understanding the Terrestrial Environment: Data Systems and Networks." Further details can be obtained from: Prof. P.M. Mather, Department of Geography, The University of Nottingham, NG7 2RD, United Kingdom., phone: 0602 515430; FAX: 0602 515428; E-mail: mather@uk.nott.vax
October 18-21	Call for papers. Thirty-Second Hanford Symposium on Health and the Environment, Regional Impacts of Global Climate Change: Assessing Change and Response at the Scales that Matter. Send abstracts and inquiries to Ray Baalman, Planning and Communications, MSIN: K1-50, Life Sciences Center, Battelle, Pacific Northwest Laboratories, Richland, WA 99352, phone: (509) 375-3665; FAX: (509) 375-3686.
October 27-28	Fourth Conference on Earth Observations & Global Change Decision Making: A National Partnership. Theme: "Global Change: A New Direction for Decision Making, " National Press Club, Washington, D.C. Sponsored by NASA, NOAA, and ERIM. Contact Robert Rogers, ERIM , phone: (313) 994-1200, ext. 3382; FAX: (313) 994-5123.

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