The Earth Observer

An EOS Periodical of Timely News and Events

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Editor's Corner

On December 17, 1992, Shelby Tilford concurred with the recommendations of the Science, Engineering, and Project Team that reviewed MLS and SAFIRE to select MLS for flight on the first EOS Chemistry flight in 2002. This decision was arrived at with great care. The review team was impressed with both instruments and, were more resources available, would have supported the flight of both instruments on the same spacecraft.

The selection of MLS over SAFIRE was based on the following scientific considerations: 1) the ability to obtain accurate vertical profiles of ClO throughout the stratosphere and BrO in the middle stratosphere, key radicals in ozone loss; 2) the ability to measure upper tropospheric water vapor in the presence of clouds, a key variable in climate impact assessments; 3) the ability to measure SO_2 arising from volcanic eruptions, with no degradation from polar stratospheric clouds, ice clouds or aerosols; and 4) a modular design that permits additional radiometers to be added that would extend the measurement capability to include vertical profiles of OH, H_2O, N_2O and other gases throughout the stratosphere. The baseline instrument includes the ability to measure O_3, temperature, and pressure, as does SAFIRE. Both the MLS and SAFIRE teams are to be commended for the very professional and thoughtful development of their respective proposals, and their collaborations with international partners. Finally, the combination of MLS (with OH) and HIRDLS, along with SOLSTICE II and SAGE III meets all of the requirements laid down by the Atmospheres Panel.

The instrument being pursued for flight on Chemistry-1 is the 'focused' MLS, consisting of the 'baseline' MLS (ClO,

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BrO, SO_2, upper tropospheric water vapor) together with the 442 MHz (H_2O, N_2O, CO) and 2.5 THz (OH) radiometers, thereby providing a comprehensive chemistry package. In the event that this instrument cannot be constructed within the cost constraints of the EOS program, the 442 MHz and 2.5 THz radiometers are modular such that they can be added to future Chemistry missions (i.e., Chemistry-2 and Chemistry-3).

I have begun to restructure the EOS Project Science Office in such a way as to appoint key scientists within the Earth Sciences Directorate as Project Scientists of individual EOS spacecraft missions (Altimetry, Color, AM, etc.), as well as EOSDIS. I will be working with these scientists closely, and expect to use their expertise and heed their advice to the maximum extent possible. Once the appointments are firmly in place, I will announce them in a future issue.

At the present time, there is good progress on the development of the EOS AM spacecraft and instrument complement. There is, however, no launch vehicle yet determined. The launch vehicle selection will not occur until the first quarter of FY94, following evaluation of proposals. In November, the high rate tape recorder activity was terminated for the AM spacecraft, to be replaced with solid state recorders. This development should permit higher command and data handling reliability, allow better buffering of instrument data before read-out to ground (thereby simplifying level-0 processing on the ground), and permit data compression on orbit, if benefits can be developed.

Phase-B spacecraft contracts have begun with GE, Hughes, Fairchild, Martin Marietta, TRW, and Lockheed to study the common spacecraft design called for by the recent Red and Blue Teams. These contracts are looking at common spacecraft designs for the PM-1, AM-2 and Chemistry platforms, and are expected to be completed by May 1993. At the recent ESA Ministers meeting, the possibility of flying HIRDLS on the POEM-Envisat spacecraft was discussed and not approved. At the moment HIRDLS remains an important element of the EOS Chemistry payload, and, as such, its accommodation is being studied in the common spacecraft contract. ■

—Michael King
EOS Senior Project Scientist

ANNOUNCEMENT

NASA Graduate Student Fellowships in Global Change Research

NASA announces graduate student training fellowships for persons pursuing a Ph.D. degree in aspects of global change research. These fellowships will be available for the 1993/1994 academic year. The purpose is to ensure a continued supply of high-quality scientists to support rapid growth in the study of Earth as a system. A total of 159 fellowships have been awarded since the inception of the program in 1990. Up to 50 new fellowships will be awarded in 1993, subject to availability of funds.

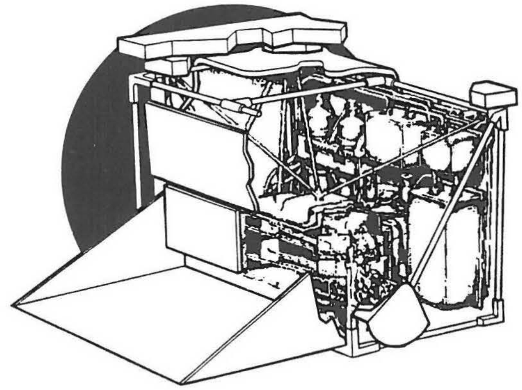
Applications will be considered for research on climate and hydrologic systems, ecological systems and dynamics, biogeochemical dynamics, solid Earth processes, human interactions, solar influences, and data and information systems. Atmospheric chemistry and physics, ocean biology and physics, ecosystem dynamics, hydrology, cryospheric processes, geology, and geophysics are all acceptable areas of research, provided that the specific research topic is relevant to NASA's global change research efforts including the Earth Observing System and the Tropical Rainfall Measuring Mission which are a part of the Mission to Planet Earth. THE DEADLINE FOR SUBMITTING APPLICATIONS IS APRIL 1, 1993.

For further information contact:
Dr. Ghassem Asrar, NASA Headquarters
(202) 358-2559.

Science Team Meetings

AIRS Science Team Meeting

—H. H. Aumann



The AIRS Science Team had a very productive meeting on September 22, 23 and 24, 1992 at Caltech. Dr. Mous Chahine gave an update of the status of EOS and AIRS, including a discussion of the recommendations of the Red/Blue Team and the Payload Panel. The directive issued by NASA headquarters to rescope AIRS and its relationship to the "evolutionary AIRS" for the future NOAA operational platform were the main topics for this AIRS team meeting. The rescope of AIRS has implications for the hardware and the data products.

Fred O'Callaghan gave an update of the project status. Significant progress has been made with the detectors, the detector multiplexers, and the coolers. A large fraction of the current effort of LORAL is spent supporting the rescope effort. The very ambitious goal of this effort is a cost reduction, a power reduction, and a weight reduction, while maintaining the present system NEDT and the 1K retrieval accuracy requirements. These goals drive AIRS from a dual-spectrometer to a single-spectrometer design with a loss of spectral coverage.

Bob Pagano presented the sequence of optical configuration refinement studies which culminated in the Single Spectrometer Concept. The proposed single spectrometer decreases the originally contiguous spectral coverage from 3.4 to 15.5 micrometers to coverage from 3.74-4.61 micrometers, 6.2 to 8.22 micrometers and 8.81 to 15.4 micrometers, with several narrow gaps necessitated by array length limitations. The single spectrometer has a major advantage: a single entrance slit defines the ground footprint for all wavelengths, i.e., there is inherent spatial measurement simultaneity.

The science team was generally supportive of the single spectrometer concept. However, the loss in spectral coverage eliminates a number of research products: CO sounding at 4.7 micrometers, methane and boundary layer water sounding in reflected sunlight in the 3.4 to 3.7 micrometers region (but the 7.7 micrometers methane band was retained) and cloud and surface emissivity measurements in reststrahlen bands in the 8.2-8.8 micrometers region. It was the general team consensus that elimination of the water band between 4.7 and 6.2 micrometers would not jeopardize the ability of AIRS to meet its 1K accuracy in the 1 km layer temperature sounding requirement. This conclusion is retrieval algorithm sensitive and needs to be confirmed in simulated retrievals as part of the algorithm development effort. A file with the official subset of the wavelengths available with the single spectrometer has been distributed to team members involved in the core algorithm development.

Mous Chahine discussed the reduced list of AIRS data products proposed by Ghassem Asrar, the EOS Program Scientist at NASA Headquarters. Asrar's proposal deletes 19 of the 32 AIRS data products originally listed as "ready at launch" data products. There are three major categories of data products:

(1) data products that meet established scientific priorities of EOS and are in a mature state of development, i.e., most validation is based on pre-EOS spacecraft data. These products will be routinely produced by EOSDIS and released within 72 hours after the data are taken;

(2) data products which are more in the research category. A science team member develops the algorithm pre-launch and validates the data product using data obtained during the early part (first year) of the EOS mission. If the validation is successful, the product is thereafter produced and released through routine production at EOSDIS;

(3) data products similar to research data products, but with substantially higher development risk. Production occurs at the science team member's home computing facility. No algorithm is delivered to EOSDIS.

Asrar's reduced data product list included only the first category. Science team members who disagreed with the deletion of one of their data products from the first category had until October 2, 1992 to respond to the team leader with a clear and concise scientific justification.

Five core algorithm development teams presented results of extracting Level-2b data products from the "Write Test" (Level-1b) data . The data for this test (with nominal instrument noise) were posted in February 1992. The test data were generated from 200 profiles of winter mid-latitude ocean night cloud-free conditions. In addition, 100 of the profiles (the "A-set") were posted as a truth table, while the other 100 (the "B-set") were kept secret.

Henry Fleming summarized the results obtained with his five-step approach, developed in collaboration with Mark Tripputi at NOAA NESDIS, using all 3600 spectral samples available with the dual spectrometer configuration.

Al Huang presented the results obtained at the University of Wisconsin using an algorithm concept developed by Bill Smith using all 3600 spectral samples available with the dual spectrometer configuration.

Joel Susskind presented results obtained with collaborator Joanna Joiner at GSFC. The algorithm is a physical retrieval tested on HIRS/MSU data, but expanded to make use of the best of the 3600 AIRS channels (93 for ground surface temperature, 61 for vertical temperature profile, 89 for moisture profile and 4 for ozone retrieval) and all 8 AMSU channels. Climatology was used as the first guess.

Frederique Cheruy used the same physical retrieval code as Joel Susskind, but used the TIGR set for a first guess. The results for the physical retrieval algorithm show that a good first guess leads to a consistent improvement in the retrieval accuracy.

Alain Chedin used a neural network approach using 279 of the 3600 AIRS channels. The algorithm was trained on the TIGR set. Of the five algorithms, it achieved the lowest rms error in the troposphere.

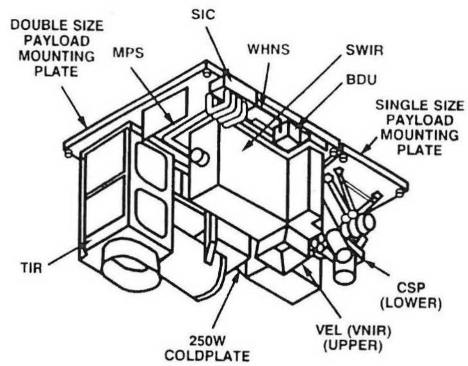
Mous Chahine instructed the algorithm development teams to try their current algorithms using only the subset of channels available with the single spectrometer approach and post the results before the end of October 92.

Every team member was given the opportunity to give a progress report. David Staelin (MIT) presented the write test results obtained by Phil Rosenkranz. In the AIRS/AMSU/MHS concept the microwave channels will be used for cloud clearing and as a potential source for the first guess, but not as a stand-alone temperature sounder. Ralph Petersen (NOAA/NMC) discussed the possibility of using a first guess generated by a general circulation model (GCM). Larry Strow (U. Maryland) reported his progress on the Forward Model and made a plea for retaining channels near 4.7 micrometers to measure CO. Rolando Rizzi (U. Florence) showed results of rapid algorithm transmittance calculations. Larry McMillin (NOAA/NESDIS) presented the cloud-clearing algorithm that is being developed for the joint NASA, NMC, NESDIS interactive retrieval. Joel Susskind (GSFC) noted that his algorithm handles temperature retrieval very well in the presence of up to 75% cloud cover. Bill Smith (U. Wisconsin) discussed an algorithm concept for temperature retrieval and cloud property estimation using the combination of AIRS and MODIS data. Bob Hohlfeld (Boston U.) is collaborating with Jean King (Phillips Lab) to obtain a differential inversion to the AIRS convolution integrals. Lew Kaplan (JPL) showed that methane can be monitored using the strong band near 1300 cm^{-1} and pleaded that the CO measurement capability of AIRS be retained near 2169 cm^{-1}.

The next team meeting was tentatively scheduled for January 26, 27, and 28, 1993 at Caltech. The following meeting will be in late May 1993 at the LORAL facility in Lexington, Mass. The meeting thereafter will be in late September 93, tentatively at the World Weather Building in Camp Springs, MD. ■

U.S. ASTER SCIENCE TEAM MEETING

—**A. D. Morrison**, *Jet Propulsion Laboratory*



The U.S. ASTER Science Team met November 10-12, 1992 at Tucson, Arizona. The thirty-eight meeting attendees included Science Team members, JPL ASTER Science Project personnel, the EOS AM-1 Project Scientist and the EOS Program Scientist. ESDISP, the Land Processes DAAC and the MODIS instrument team were also represented.

This very successful three-day meeting, chaired by Team Leader Anne Kahle, was sandwiched between two other ASTER Science Project meetings held at the same site, a Spectral Libraries meeting, chaired by Jack Salisbury, and an Algorithm Development Workshop, chaired by Charles Voge. Many ASTER Science Team members attended more than one of these meetings. U.S. ASTER Science Team meetings are held twice each year, alternating with twice-yearly joint U.S./Japanese ASTER Science Team meetings.

Dave Nichols, Manager of the JPL ASTER Science Project, reported that the ASTER schedule had been unaffected by the recent NASA rescope, and the instrument is still to fly in June 1998 on EOS AM-1. However, the number of science data products that will be ready by launch has been significantly reduced. He reported progress on the instrument operations scenario and agreements reached with GSFC and the Japanese regarding some operations constraints, a first cut at a standard products list, and completion of the first draft of the algorithm guidelines.

Scott Lambros (AM Project ASTER Instrument Manager) reviewed the EOS AM-1 schedule and the ASTER instrument layout on the platform. Several issues regarding instrument capabilities were raised that need to be resolved as soon as possible. These issues include the possible effect on dynamic range of a proposed use of the SWIR for volcano monitoring; the effects on data collection of the proposed use of direct data down link without on-board recording; and the effect on jitter control characterization of the proposed removal of an angular displacement sensor from the VNIR.

Larry Fishtahler (ESDISP) discussed the Product Generation System (PGS), the environment in which the science product software will run. He said that the tool kit that will be the interface between the algorithm software and the EOS Project is scheduled to be delivered to the Science Team in 1995. The Science Team expressed concern that the tool kit was being delivered so late.

Mike Abrams reported on the Land Processes DAAC Science Advisory Panel meeting. The Panel represents MODIS, HIRIS, EOS SAR, ASTER, plus two IDS investigators. He urged the ASTER Science Team members to identify Test Sites and to request co-registered data sets (with TIMS, AVIRIS, etc.) as soon as possible.

Hugh Kieffer (Registration Working Group) reported little progress on the issue of registration. Both GSFC and the Japanese are conducting analyses of jitter effects. Kieffer called for structural analyses of the platform and instrument as necessary for the pointing geometric analyses and raised the issue of having Level 1 processing capability in the U.S. He pointed out that the U.S. will have little visibility into Level 1 processing if it is done exclusively in Japan; that there will be major cost and logistics problems with transportation of products; and that the Japanese plan to run the Level 1 processing software on proprietary machines. Kieffer said that the current plan would require many resamplings of the data. He said that the fundamental impact is that any artifacts introduced in the Level 1 processing by the Japanese will be there forever in all subsequent data products. His suggestions included:

- continuing the cost estimate of the U.S. building a Level 1 processing capability;
- requesting from the Japanese a detailed description of their radiometric and geometric calibration plans;
- developing close ties to the Japanese Level 1 processing algorithm development;
- determining the extent of U.S. access to detailed Japanese Cal reports;
- detailed Level 1 processing algorithms;
- Level 1 processing code;
- determining the ability to modify Japanese Level 1 processing code during the mission;
- deciding on whether the U.S. will have an independent capability to do Level 1 processing; and
- deciding on whether the geometric transform capability will be developed in the U.S. or Japan.

On the issue of geocentric vs. geodetic coordinates, Kieffer said that the difference between geocentric and geodetic is, at a maximum, 0.193 deg (2 full cycles/orbit) and he concluded that this is not a science issue, but an engineering issue. Regarding ground controlled scenes, he said that no significant amount of ground control exists except in the U.S. and, perhaps, France.

Frank Palluconi (Atmospheric Correction Working Group) presented an introduction to the effect of correction for ozone. The error that can be expected from a mis-estimate of ozone levels is 0.002-0.004 deg C per Dobson Unit. To do the correction, an as yet unspecified climatological model will be used. Occasional MODIS measurements will be used to test the model and insure that the error is minimized.

Alan Gillespie (Temperature-Emissivity Working Group) reviewed the Temperature-Emissivity algorithm options currently under consideration. The Working Group will run a series of tests of the candidate algorithms using a test data set and pare the list down to two options to recommend to the joint Science Team meeting in February. The three leading contenders at this time are the reference channel emissivity, the normalized emissivity and the alpha log residual algorithms.

Dave Nichols (Operations and Mission Planning Working Group) raised the topic of functionality associated with the U.S. Instrument Support Terminal (IST). The issue is the role of the Science Team in the planning and scheduling of data acquisitions. Questions that need to be discussed over the next year include: 1) what will the joint Science Team role be vs. the Japanese ICC role; and 2) what capabilities are needed in the U.S. for input, conflict resolution and interfacing with the Japanese?

Simon Hook, (Airborne Sensor Working Group), reported that the C-130 was down for 1993 but will probably be up again for 1994; that it could be used on a cash-reimbursable basis in 1993; and that there are alternatives to the C-130 (the ER-2s and the Learjet). He said that the TIMS/ MODIS Airborne Simulator flight scheduled for April 1993 would also include the AVIRIS. He also reported on the data taken in 1992.

Jack Salisbury gave a recap of the one-day Spectral Library Meeting held Monday, November 9, just prior to this meeting. He said that he felt that they made a lot of progress. He also talked about other possible users for spectral library data. He said that five other EOS groups have indicated interest in the spectral library products.

Zhengming Wan reviewed the status of calibration for MODIS. He reviewed the NOAA data sources that will be used to help calibrate the IR instrument. Wan said that MODIS has not yet defined its exact data requirements from ASTER. ASTER will need to know MODIS's ground truth plan well in advance to be able to use their ground data to help calibrate ASTER.

Ghassem Asrar (EOS Program Scientist) reviewed the EOS Project chronology since the early 1980's including the 1991 restructuring and the 1992 rescoping. He reviewed the process used to reduce the product list and reiterated his position that the number of data products has to be science driven.

Anne Kahle (U.S. Science Team Leader) lead the discussion on Standard and Special Data Products. The Science Team agreed that digital elevation models (DEMs) should be classified as Standard Data Products and, further, that they should be produced with caveats regarding the need for a ground control net. The members understand that the ASTER Science Team is not taking the responsibility for producing a globally consistent DEM data set. The globally consistent DEM data set will be the responsibility of the Land Processes DAAC. The Team also agreed that the Surface Radiance data product, which requires a DEM, should be produced with an accuracy estimate that would be constrained by the existence or quality of an ASTER DEM, a DAAC DEM, and a ground control net.

Andy Morrison (JPL ASTER Science Project, Science Operations Planning) reviewed the latest version of the ASTER 16-Day Instrument Operations Scenario. He presented the background, current objectives, approach and constraints (both instrument and simulation), and the summary of the results of running the scenario for a representative 16-day cycle.

The next joint ASTER Science Team meeting is scheduled for February 2-5, 1993 in Las Vegas, and the next U.S. ASTER Science Team meeting is tentatively scheduled for June 21-25, 1993.

TRMM WORKSHOP

—From EOS NEWS

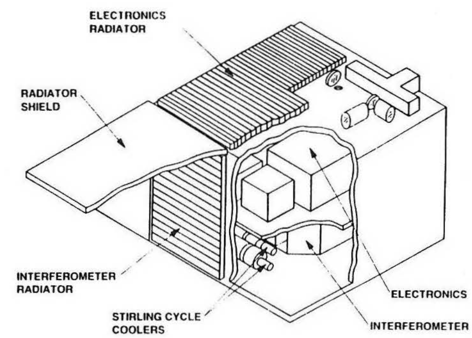
A workshop on the Tropical Rainfall Measuring Mission (TRMM) was held at the NASA/Goddard Space Flight Center on October 5-9. The primary focus of the meeting was to review the status of prospective TRMM algorithms for rain retrieval. K. Okamoto reported that a general outline has been set for the Precipitation Radar (PR) algorithms, and input/output specifications have been determined. J. Weinman gave an update on activities and findings of the TRMM Combined Instrument Team, and noted the possibility that lightning flash data from the Lightning Imaging Sensor (LIS) on TRMM could contribute to the determination of rainfall. R. Adler reported success in combining low-orbit microwave data with geosynchronous infrared data to develop monthly means of precipitation. The TRMM Instrument Systems Manager, R. Lawrence, reported that a 21.3 GHz channel is being added to the TRMM Microwave Imager (TMI) to measure total water vapor, and that the number of spectral channels on the Visible and Infrared Scanner (VIRS) has been reduced from 7 to 5. Science Team members were also given a demonstration of a prototype TRMM Science Data and Information System (TSDIS).

6th TES/AES Science Team Meeting

(Tropospheric Emission Spectrometer/Airborne Emission Spectrometer)

—*Reinhard Beer*

TROPOSPHERIC EMISSION SPECTROMETER



The sixth Science Team Meeting convened at Atmospheric and Environmental Research (AER), Inc. in Cambridge, MA on October 14 and 15, 1992. The Data Analysis Working Group, chaired by Curt Rinsland (LaRC), met on the afternoon of October 13. Representatives of all subgroups were present, except for the University of Denver representatives who were involved in preparations for a balloon flight. In addition, the meeting was attended by representatives from NASA HQ, the Goddard EOS Project Office, and NOAA.

The scope of the meetings has been extended beyond the EOS TES project to include the Airborne Emission Spectrometer (AES), which, while funded independently of TES, has much commonality with it in terms of science and engineering. Furthermore, AES will be operational in 1994—well before TES. Table 1 shows a comparison of TES and AES.

COMPARISON OF TES AND AES

	TES	AES
Sponsor(s)	NASA Goddard Space Flight Center	IC, NASA, HQ, NOAA, EPA
Platform	EOS (AM-2)	Aircraft, Ground
Spectral Range	600-4350 cm^{-1} (2.3-16.7 μm)	650-4250 cm^{-1} (2.4-15.4 μm)
Spectral Coverage	105%	96%
Spectral Resolution	0.1 cm^{-1} downlooking 0.025 cm^{-1} limb-viewing	0.1 cm^{-1}
Operating Temperature	150K (radiative)	Ambient
Focal Plane Arrays	4 x 1 x 32 (MCT PC & PV)	4 x 1 x 4 (MCT PV & PC)
Focal Plane Temperature	65K (Stirling-cycle cooler)	65K (pumped LN_2)
Pointing	Automatic	Interactive
Field of Regard	Limb-to-Limb (45° forward)	30° cone about nadir
Spatial Resolution	2.3 x 23 km limb viewing 0.5 x 5 or 5 x 50 km downlooking	7 x 70 meters

Table 1

Data Analysis Working Group

Tony Clough (AER, Inc.) presented an update on his tropospheric ozone retrieval studies using a Maximum Entropy method. While this work is ongoing because the parameter space to be explored is exceedingly large, it appears that on the basis of downlooking observations alone, the troposphere can be subdivided (resolved) into at least two or three altitude regions with adequate accuracy (20 - 30%). In the future, the improvement to be expected through concatenation of limb and nadir observations will be explored.

Larry Sparks (JPL) discussed the status of the SEASCRAPE[1] parallelizable sequential estimation algorithm, currently undergoing validation against the operational ATMOS[2] algorithm ODS.

1 Sequential Evaluation Algorithm for Simultaneous and Concurrent Retrieval of Atmospheric Parameter Estimates.
2 Atmospheric Trace Molecules Observed by Spectroscopy.

Some discrepancies still remain, but we hope that by the time of the next team meeting in the Spring of 1993 we shall have valid benchmarks for both the AER and the JPL algorithms.

Jim McComb (JPL) presented his conclusions on the types of surface emission and reflection properties to be included in the retrieval scheme (as an input constraint for downlooking observations). Currently, these fall into seven classes that we hope to expand in the future as the necessary databases become available.

Reinhard Beer (JPL) discussed the effect of coupled non-linearity and phase error in Fourier Transform spectrometers. This investigation is based on recent ATMOS/ ATLAS[3] 1 data where a new, very broadband filter generates significant problems of non-linearity in the MCT PC detector. The relevance to TES is that PC detectors (planned for the long-wave bands of both TES and AES) are non-linear at any signal level. While the magnitude of the effect should be much smaller for TES/AES than for ATMOS, it is nevertheless a matter of concern.

John Martonchik (JPL) provided a brief overview of the upgrades to the JPL Emission Spectrum (ES) forward radiative transfer code which is used both for species sensitivity studies and to provide accurate estimates of the signal levels and radiance gradients to be encountered by remote sensors.

Curt Rinsland provided an overview of the LaRc DAAC and suggested that it would be useful to meet with them to ensure that our needs and their requirements were in tune. In particular, Special Products seem to be getting little attention even though it is those products that many team members feel will be the best source of "new" science.

Plenary Sessions

Joe McNeal (NASA HQ) provided an overview of the Red/Blue Team activities and the implications for the EOS Program, and Reinhard Beer gave a short presentation on the September Payload Panel meeting. The latest scenario has TES on the AM-2 platform in 2003, moved from the CHEM payload (now 2002) where it previously resided. The team expressed some concern about the loss of synergism with the stratospheric sensors on CHEM but no action was proposed.

Reinhard Beer and Tom Glavich then discussed their recent visit to the Institute for Meteorology and Climate Research (IMK) in the Karlsruhe Nuclear Science Center, Germany and to the Department of Atmospheric, Oceanic and Planetary Physics at Oxford University.

IMK hosted the 3rd Annual International Workshop on Atmospheric Science from Space using Fourier Transform Spectrometry. This meeting continues to grow in attendance (~60 this time) and importance: this year IMG/ADEOS (Japan), MIPAS[4]/ ENVISAT (ESA), IASI[5]/METOP (France) and TES/EOS (US) were all strongly represented. Of particular interest was a lengthy introduction by Chris Readings of ESA on the recent changes to the POEM platforms and an overview of the entire European space element of their Global Change program. In a later conversation, Readings expressed concern about the "lack of information about the U.S. program!" Since the EOS Payload Panel frequently makes the same comment about the European program, it is evident that some significant communications barriers remain between the programs.

The results of tests of the "breadboard" version of Interferometric Monitor of Greenhouse Gases (IMG) were presented in substantial detail and make it clear that significant problems have arisen in its design: the radiometric calibration is seriously deficient, and the instrument loses its alignment during operations. A major redesign is underway for the engineering model that will incorporate a dynamic alignment system.

A specific issue that arose during the meeting was that of the NASDA policy regarding IMG data use: contrary to U.S. and European practice that vests the copyright of publications in the journal, NASDA requires that it retain the copyright. The impact of this policy is that IMG data can be used but the results cannot be published in the open literature. By the same token, copying and transfering data and data products among users is prohibited. Our Japanese colleagues are as concerned about this as we are, but

[3] Atmospheric Laboratory for Applications and Science.
[4] Michelson Interferometric Passive Atmosphere Sounder.
[5] Infrared Atmospheric Sounding Interferometer.

cannot promise any relief. Clearly, this is an issue that must be decided at an inter- governmental level but it certainly runs counter to the US policy of free data exchange.

Following the trip to Karlsruhe, Reinhard Beer and Tom Glavich went to Oxford where they discussed ways in which Oxford could participate in the TES hardware development, a role which is sought by Oxford in order to strengthen the U.K. commitment to tropospheric science. Since Oxford has developed extensive calibration facilities for ISAMS/UARS and ATSR/ERS 1, it soon became evident that the preflight and inflight calibration of TES was an excellent role for them to undertake. The benefits to us are considerable, since it will avoid the need for JPL/NASA to provide such facilities at a potential cost savings of several million dollars. The concept is currently under review both in the U.S. and the U.K. and we hope to have an agreement "in principle" in place by next Spring.

Tom Glavich followed with an update on TES status and plans. A number of technology study and development contracts have been placed with industry in order to reduce risk in Phase C/D. A major reconfiguration of the TES package was necessitated by the change to the new platform proposed by the Red/Blue Team activity. It now appears that the oft-postponed CDCR will occur next Spring.

The afternoon session was given over entirely to AES—its status, design and operations concept. Chris Grund of NOAA presented his agency's plans for AES usage (uplooking from the ground for cloud studies) and Bill Gunderman of JPL gave a "walk-through" of the AES data processing flow. An issue arose here of the accessibility of the AES data catalog to outside users. The problem is being studied and will be reported on at our next meeting.

The session concluded with an open discussion of the AES Mission Plan. It was agreed that early AES flights should operate in a "survey" mode in order to build up a database of atmospheric signatures so that later, more–focused operations can use them as a starting point for retrievals. The team also strongly urged that AES operate continuously during DC-8 flights and that data editing be performed post-flight. While the volume of tape cartridges that would be generated during a 12–hour flight is not excessive, the cataloging and editing tasks alone may be a significant burden on the Data Analysis Facility (DAF).

The final session began with an update by Daniel Jacob (Harvard) on tropospheric chemistry, particularly focused on the results and plans of the on-going Global Tropospheric Experiment (GTE) program, into which we hope to incorporate AES after 1994.

The final topic was an extensive discussion of the Standard Data Products list that Ghassem Asrar has asked everyone to review. A revised list was generated (see table 2.) that included a new request—that the DAAC flag our Global Mode data for the presence of non-standard molecules. The actual retrieval of these species will be a Special Product but only the DAAC will have the resources to find the data containing these signatures, which are expected in only a very small fraction of the TES spectra.

The final action was to agree that the next TES/AES Team Meeting will be held at the Langley Research Center in Hampton, VA, April 27 - 29, 1993.

TES STANDARD DATA PRODUCTS

Note: For all products, *Type* is S, *Investigator* is Beer, *Instrument* is TES, *Platform* is AM-2, *DAAC* is LaRC, *Timeframe* is AL (At Launch), *Temporal Resolution* is 1/(16 day), *Horizontal Resol :: Domain* is 170 x 53 km :: G (Global)

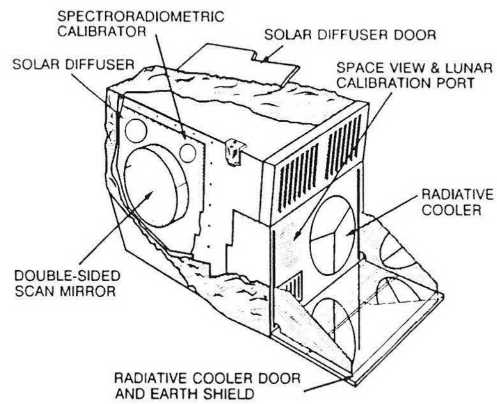
Prod #	Product Name	Units	Accuracy Abs :: Rel	Vertical Resol :: Dom
1616	Temperature Profile	K	2K :: 0.2K	4-6 km :: 0-33 km
1325	O_3 Mixing Ratio	ppbv	:: 3-20 ppbv	2-6 km :: 0-33 km
1129	CO Mixing Ratio	ppbv	:: 3-15 ppbv	2-6 km :: 0-33 km
1089	CH_4 Mixing Ratio	ppbv	:: 14-40 ppbv	2-6 km :: 0-33 km
1842	H_2O/HDO Mixing Ratio	ppmv	:: 0.5-50 ppmv	2-6 km :: 0-33 km
1243	N_2O Mixing Ratio	ppbv	:: 0.01-20 ppbv	2-6 km :: 0-33 km
1268	NO Mixing Ratio	pptv	:: 15-25 pptv	2-3 km :: 4-33 km
1278	NO_2 Mixing Ratio	pptv	:: 500 pptv	2-3 km :: 4-33 km
1206	HNO_3 Mixing Ratio	pptv	:: 3 pptv	2-3 km :: 4-33 km
2455	Land_sfc Brightness Temperature	K	1K :: 0.1K	
2402	Level_1B Radiance, TES			
(none)	Level_2 Detection Flags*			

* Detection Flags will be set for SO_2, NH_3, C_2H_6, C_2H_2, H_2O_2, PAN, HO_2NO_2, HCOH, HCOOH, $(CH_3)_2S$, HCl, HF, Clouds & Aerosols

Table 2

MODIS Science Team Meeting

—**David D. Herring**, *MODIS Airborne Simulator (MAS) Technical Manager, SSAI*



The MODIS Science Team met in three plenary sessions and four discipline group sessions-Atmosphere, Calibration, Land, and Oceans-October 27-29, 1992, in Goleta, CA.

Plenary Sessions

Dr. Vincent Salomonson welcomed the meeting attendees and gave an overview of the agenda in which he introduced the major topics of discussion for the meeting: the recommendation to include the 1.375-µm band in the SWIR/ MWIR focal plane, detector operability, descope options, a software development plan, and MODIS calibration. Salomonson introduced Michael King as the new EOS Senior Project Scientist.

Tony Janetos, MODIS Program Scientist, gave NASA Headquarters' perspective of EOS and traced the funding history of the program, which has most recently been reduced by 30 percent to $8 billion. He cited the loss of HIRIS (High Resolution Imaging Spectroradiometer); the reduction in the number of at-launch science/data products; the loss of contingency funds--which puts instrument development at a much higher risk; and the serious possibility of further descopes as examples of cost constraining measures being taken in light of the budget cuts. Janetos stated that each team must have a plan laid out for descoping if a budgeting worst-case scenario happens; and they must be prepared to show how those descopes impact their science products, other instrument science, and IDS (Interdisciplinary Sciences) investigations.

King noted that MODIS (formerly MODIS-N prior to the deletion of MODIS-T) currently has not been mandated to descope. Regarding the development of the EOS Data and Information System (EOSDIS), King stated that there was a delay in the process of selecting the core system contractor; however, Len Fisk, NASA Associate Administrator for Space Science and Applications, has now selected Hughes Information Technology Company with whom to negotiate the contract.

Chris Scolese, EOS AM Project Manager, discussed the EOS AM-1 Spacecraft milestone schedule. CERES and MODIS have already completed their Preliminary Design Reviews (PDRs), and the other EOS AM instrument PDRs will be held with the next six months. He summarized the EOS Charter that was developed by the Red/Blue Team. Scolese pointed out that the EOS budget is not being cut across the board. Specifically, the instrument budgets were not cut, although instrument contingency was reduced. Other areas of the program, spacecraft, science, and data system were cut, although not necessarily by 30 percent.

Lloyd Candell, MODIS Manager for the Santa Barbara Research Center, spoke on the overall status of MODIS with respect to detector operability, registration, and calibration. He noted that the changing marketplace is affecting contractors' abilities to meet technical requirements in general. Candell introduced Tom Pagano, SBRC's chief systems engineer for MODIS and MODIS Science Team interface. Pagano highlighted some of MODIS' technical capabilities.

SBRC's Descope Options

The spectroradiometric calibration assembly (SRCA), Pagano explained, provides a radiometric calibration check, spectral band calibration, band registration check, and self calibration. He encouraged implementing an SRCA on MODIS. Pagano went on to discuss registration between focal planes, filter modeling, and SBRC's reprioritized list of risk items.

Dick Weber, the MODIS Instrument Manager at Goddard, addressed SBRC's list of risk items, stating that SBRC has spent beyond their original plan on registration, development of filters and detectors, ground support equipment (GSE), and on the MODIS beryllium mainframe. Pagano emphasized that spectral band registration and operability is a challenging task—SNR (signal-to-noise ratio) is driving the task. Currently, SBRC feels that the registration budget can be met, but statistically it is a high risk. He asked the Science Team to prioritize MODIS' bands in terms of required registration accuracy so that SBRC can determine which bands need the most emphasis on re-work. He strongly recommended relaxing the required specification for registration to 0.2 pixel, from 0.1 pixel.

Pagano also proposed reducing the size of the SWIR/MWIR detectors to 1/4 their present width in order to meet producibility yield requirements and to improve the modulation transfer function (MTF). Pagano also presented a descope option that allows failure of one detector element per band, and less than or equal to two detector elements per focal plane (but not both in the same band). He pointed out that this relaxation would also considerably reduce risk.

SDST Status Report

Al Fleig presented a processing flow diagram of MODIS data products. He requested that the Science Team notify the Science Data Support Team (SDST) if they will need a cloud mask for certain products, and that the Science Team make sure that the processing flow is correct for each product. Fleig outlined the MODIS Science Data Management Plan (which requires input from the Science Team members) and Science Computer Facility Plan (which requires Team members to report to SDST all of their plans to purchase computer hardware).

Science Team members are expected to submit code to SDST within one year. According to Fleig, this code need not be the same physics that is expected in the final algorithm, but should be detailed enough to provide a rough estimate of the computing size. It will also enable SDST to run large pieces of code and get experience.

Fleig discussed the MODIS instrument duty cycle, currently defined as "day mode" 40 percent of the time. The requirement is for MODIS to provide continuous monitoring of the thermal bands plus some daytime coverage of the shortwave bands. Fleig noted, however, that 40 percent "day mode" coverage does not allow full daytime coverage. In order to achieve full global daytime coverage only, the instrument must be recording the 19 shortwave bands from 44 percent of the time—at the solstices—to 50 percent of the time—at the equinoxes.

Day 2 Plenary Session

On day two of the plenary session, Scolese defined four problem areas: 1) optical design, 2) mechanical design, 3) ground calibration, and 4) contract rate increase. He stated that MODIS' descope priorities are 1) registration, 2) detector operability, and 3) SRCA/ground calibration. Salomonson instructed the Calibration Group to take the lead in understanding the ground calibration problem and to make a recommendation to the Team. He asked whether the Science Team can make do with either the ground calibrator or the SRCA. Later in the meeting, (regarding parts quality) Salomonson stated that the Science Team would accept Grade 2 parts for MODIS.

MCST Status Report

John Barker presented the MODIS Characterization Support Team (MCST) status report, which included a list of MCST's priorities: 1) instrument-related characterization/calibration, 2) algorithms, software, and hardware for EOC/MCST monitoring of in-orbit data, 3) MODIS cloud-masking utility product, 4) algorithms for simulated MODIS imagery; and 5) discipline-related product sensitivity to calibration, in cooperation with Team members.

Barker showed a list of MODIS Level-1B calibration products, which have been condensed into a single image product—Calibration Product #3646. He also presented the algorithm and ancillary data development schedule. He reported that MCST will have calibration data at Level 1A and 1B for both the AM and PM Platforms, and that the data will include MODIS simulated or real data sets.

Barker gave outlines of the MODIS Mission Calibration Plan, which provides a comprehensive review and integration of all methodologies used to calibrate the MODIS instruments; the MODIS Level-1B Calibration Algorithm Plan, which provides a plan for MCST's algorithm production activities; and the MODIS Science Calibration Handbook, which provides a stand-alone scientific user's guide containing all one needs to know about calibration of MODIS data throughout the lifetime of the EOS mission. The algorithm plan, he noted, will be organized by radiometry, spectral algorithms, and geometric algorithms.

Barker said he is trying to develop an end-to-end model of the system, which he feels is still six months to a year from completion. Salomonson wanted assurance that the Team wants to invest the resources in an end-to-end simulation. He stated that the core job of data calibration comes first.

Direct Broadcast

Ed Chang reported that all direct readout data will come down via X-band. He explained that there are two direct broadcast modes, one is used to broadcast only MODIS data to users with 3-meter antennas; the other is used when simultaneous direct downlink of ASTER data is required. In the latter case, direct broadcast of MODIS data is available only to users with 10-meter antennas.

The 1.375-µm Band

Kaufman presented his proposal to include a 1.375-µm band for identification of cirrus clouds. Kaufman and Bo-Cai Gao wrote a paper explaining that the 1.375-µm band shows cirrus definitively against a black background, which is important for land and ocean temperature measurements; and it is important for remote sensing of reflectance and aerosols. Gao presented AVIRIS data taken over Coffeyville, KS, as an example of how well the algorithm works.

Other Instrument Status Reports

Instrument status reports were given by Moustafa Chahine, AIRS Team Leader; Dave Diner, MISR Principal Investigator; and Anne Kahle, ASTER Team Leader.

Atmosphere Discipline Group

After a brief discussion, the Atmosphere Group decided to recommend including the 1.375-µm band in the SWIR/MWIR focal plane. The Group also concluded that the increased MTF offered by sub-pixel detectors is advantageous—to the Atmosphere as well as to and other discipline groups—because it offers cloud/no cloud detection, and improved characteristics of blending 250-, 500-, and 1000-m bands. They prefer to relax the registration specification from 0.1 pixel to within 0.15 pixel, with a goal of 0.1 pixel, with some optimization of layout on focal planes. The Atmosphere Group also feels strongly that onboard calibrators should be further developed and maintained, with priority over the ground support equipment (GSE) efforts.

Calibration Discipline Group

The Calibration Group examined all aspects of the MODIS preflight and inflight calibration hardware and the proposed preflight tests. With respect to hardware, the group concluded that many of the functions performed by the ground calibrators could potentially be performed by an improved, robust, well tested SRCA.

Additionally, it was concluded that the cooled detectors in the Solar Diffuser Stability Monitor (SDSM) could be eliminated and that the approach to the solar test source should be re-examined. With respect to instrument requirements, the group identified several system-level thermal vacuum tests to be re-examined and proposed an examination of relaxation of the registration requirement. The group agreed that SBRC should construct a strawman report/study with respect to capability and performance characteristics, and should submit this report to GSFC for extensive review.

Land Discipline Group

Zhengming Wan reported on thermal calibration issues—he is concerned that the radiometric accuracy of the MODIS thermal bands (29, 31, and 32) may not meet the required goal. He recommended an evaluation of signal-to-noise levels at lower temperatures than implemented by SBRC. Wan has a high registration accuracy requirement to implement emissivity corrections in heterogeneous areas.

Alfredo Huete reported on MCST activities from an optical perspective. Huete reported that MCST wants additional background information on the land registration accuracy requirements and would like the MODIS Land

Group to study the effects of MTF, radiometric calibration, mis-registration effects, and focal planes, more rigorously.

According to Chris Justice, the Land Group envisions two components to the peer review process, informal and formal. The informal process should consist of regular contacts with IDS groups, other instrument teams, other agencies, and international scientists. The formal process should consist of a series of peer reviewed scientific papers in the open literature.

Justice reported that the Land Group is developing worldwide test sites. The focus for the site selection is land cover. The MODIS Land needs are being integrated with the Landsat Pathfinder test site project.

The Land Group supports the proposed 1.375-µm band and prefers to have all Land bands registered to within 0.1 pixel. The bands within focal planes could be prioritized for maximizing registration precision. The surface temperature bands 29, 31, and 32 should be placed for optimal band-to-band registration. Additionally, the Land bands should be grouped on their focal planes to provide optimal band-to-band registration.

Justice reported that the Land primary products are vegetation indices, snow/ice cover, land cover, albedo, BRDF, surface temperature, leaf area index, net primary productivity, and fire characteristics. All Land products assume certain input parameters such as a radiometrically corrected radiance, atmospheric correction, topographic correction, geometric correction, BRDF correction, hemispherical reflectance conversion, and cloud/snow mask.

Oceans Discipline Group

The Oceans Group decided that products derived from different algorithms should not be assigned under the same name. Regarding descope priorities, they felt that all high resolution bands (first 250 meters, then 500 meters) could be deleted, as could all radiometric calibration except that furnished by the SRCA. Also, relaxation of polarization specifications should not be high on the descope list.

The Oceans Group stated that relaxation of registration to 0.2 pixel is acceptable. They strongly recommend that electronic alignment to alternatively improve registration in certain bands should not be routinely changed in orbit, because such changes are considered detrimental to the interpretation of global data sets. The Group felt that the improved MTF would offset any disadvantages derived from narrowing the detector width. The Oceans Group assumes that choosing the sub-pixel eliminates the need to consider the descope option of two dead detectors per focal plane assembly (FPA).

They support the 1.375-µm band proposal.

Summary of the Meeting

Salomonson summarized the main points of the Science Team meeting. He observed that there has been a subtle shift in philosophy among MODIS Science and Technical Team members from a ground-based to an in-orbit capability of adjusting calibration. Salomonson stated that polarization should be a high priority, but should be kept on the prioritization list because there is now more reliance on the SRCA. He stated that the spec requirement for registration would probably be relaxed to 0.2 pixel, with a goal of 0.1 wherever possible. Bill Barnes added that SBRC will meet the 0.1 pixel goal within focal plane. Regarding detector operability, the Team recommends sub-pixels. The Team unanimously decided to adopt the 1.375-µm band. Salomonson stated that the duty cycle needs to be increased, to enable all shortwave channels to be recorded during the daytime portion of each orbit. He also stated that there seems to be a desire among discipline groups to do their own masking algorithms.

The next MODIS Science Team meeting will be held at the Holiday Inn in Lanham, MD, March 24-26, 1993. The MODIS Critical Design Review (CDR) will be held sometime around October 1993.

LANDSAT 6 LAUNCH WILL BE DELAYED

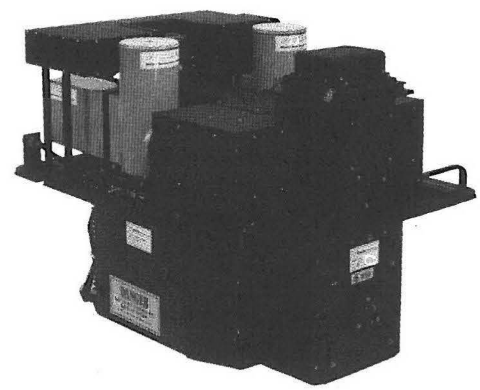
From EOS News

The Landsat 6 launch will be delayed until middle of 1993 due to some problems with its Solar Array Actuator (SAD). Possible problems with SAD bearings, lubricant, and design have caused concern over meeting the 5-year design requirement. Several options are under review by the manufacturer, but none yield a launch date earlier than mid-June 1993.

The MODIS Airborne Simulator (MAS)

–*Michael King*, *EOS Senior Project Scientist, Goddard Space Flight Center*

–*David Herring*, *MODIS Administrative Support Team Technical Manager, SSAI*



Introduction

The MODIS Airborne Simulator (MAS) is a recently developed spectrometer designed to meet the scientific requirements for airborne remote sensing of clouds, aerosols, water vapor and land. During its development, MAS has flown periodically on both national and international campaigns. These missions have provided valuable experimental data to assess the capability and importance of specific narrow bandpass channels in studies of the Earth's atmosphere. These early indications suggest that MAS will successfully fulfill its goal, which is to aid in defining algorithms and in building an understanding of the ability of MODIS to remotely sense atmospheric conditions for assessing global change.

History

Prior to 1991, the MODIS Atmosphere Discipline Group performed atmospheric investigations with data from the Multispectral Cloud Radiometer (MCR) and the Multispectral Atmospheric Mapping Sensor (MAMS). These instruments have both flown on the NASA ER-2, a high-altitude research aircraft based out of Ames Research Center. By 1991 the limited channel capability and problematic performance of the MCR and MAMS could not be altered to fit the needs of the users. A study of the latest scanners was conducted to determine which would be appropriate for conducting MODIS simulations. Funding and design schedules were also considered. Of all the sensors reviewed, the WILDFIRE infrared imaging spectrometer was found to be the most adaptable to the science requirements. It possessed fifty narrow bandwidth channels and a blackbody calibrator system, and was being designed to mount in the rear of either wing pod of the ER-2. It was under development and due to be delivered to Ames in 1991. The principal investigator of WILDFIRE (Jim Brass) and John Arvesen (Branch Chief of the High Altitude Missions Branch at Ames) were amenable to our proposal to modify the instrument immediately after development to meet the schedule for the First ISCCP (International Satellite Cloud Climatology Project) Regional Experiment (FIRE) cirrus campaign, to be conducted near Coffeyville, KS during November, 1991. This was to be the first MAS field deployment. Ames' cooperation was a major factor in the selection and scheduling.

An Overview of WILDFIRE

In 1987, Dædalus Enterprises, Inc., began developing the WILDFIRE infrared imaging spectrometer as a shortwave-infrared, near-infrared and infrared spectrometer to monitor gases carried into the upper atmosphere, nutrient transport phenomena, and the intensity and size of forest fires. The instrument was to be a 50 channel cross-track scanning spectrometer consisting of four spectrometer and detector subassemblies or ports with linear array detectors (InGaAs, InSb, InSb, and HgCdTe). The wavelength range of the WILDFIRE spectrometer was 1.17–12.4 µm. This spectrometer was joined to a scanner subassembly to collect radiometric imaging data with the following characteristics:

1. Spatial resolution of 2.5 mrad, corresponding to a ground resolution of 45 m at nadir from a nominal ER-2 altitude of 18 km,
2. Cross track scan of ±43°, equivalent to a swath width of 34 km with 716 pixels per scan,
3. Scan rate of 375 rpm (6.25 Hz).

A photograph of the WILDFIRE spectrometer mated to the scanner subassembly is shown above. There are up to 16 channel outputs dispersed from each of the four detector assemblies.

With inputs from the MODIS, CERES and FIRE II Science Teams, the opportunity arose to modify this very capable system to more fully meet the needs of the earth science research community.

Converting WILDFIRE into MAS

Converting the WILDFIRE infrared imaging spectrometer into a MODIS Airborne Simulator (MAS) was a gradual metamorphosis. First, there was the FIRE II configuration, focused on cirrus clouds in the central U.S. and the Gulf of Mexico. Less than 6 months after the FIRE cirrus experiment, the upgraded MAS was deployed to the Azores, Portugal as part of the Atlantic Stratocumulus Transition Experiment (ASTEX), where the focus was on marine stratocumulus clouds over the eastern Atlantic Ocean. The MAS is currently deployed to Townsville, Australia as part of the Tropical Oceans-Global Atmosphere Coupled Ocean-Atmosphere Response Experiment (TOGA-COARE), focused on high-altitude cirrus clouds and convective cloud systems of the western Pacific. These changes in WILDFIRE have primarily been driven by the need to increase the performance, reduce the saturation temperature in the thermal infrared, and to extend the wavelength coverage in the visible as well as the thermal infrared for the remote sensing of clouds, aerosols, and water vapor. In addition, there was a further desire to increase the number of bands that have corresponding channels on MODIS. These changes were considered and prioritized in light of available resources and flight schedules, and were conducted between field campaigns so that the MAS was able to complement other sensors (e.g., lidar, infrared sensors) needed to support atmospheric missions.

FIRE Cirrus Configuration

Spectral Channel	λ	$\Delta\lambda$	Bits Recorded
1	0.680	0.010	8
2	1.630	0.050	8
3	1.930	0.050	8
4	2.080	0.050	8
5	2.130	0.050	8
6	3.750	0.150	8
7	4.500	0.150	10
8	4.650	0.150	8
9	8.800	0.400	10
10	10.950	0.500	10
11	11.950	0.500	10

Table 1

The MAS configuration for the FIRE II cirrus campaign differed from the original WILDFIRE configuration in that one SWIR set of channels was replaced with a single 0.68-µm channel and several other spectrometer channels were readjusted. The channels of the MAS for the FIRE II campaign are given in Table 1. Eleven flights were conducted over the FIRE ground site at Coffeyville, KS and/or the Gulf of Mexico. The aircraft data system could only handle a limited number of channels, so eleven of the most significant ones were recorded. Of these, seven channels were recorded at eight bits, while the remaining four channels were recorded at 10 bits. These flights, coordinated with the NCAR Sabreliner, University of North Dakota Citation, and NOAA-11 and Landsat-4 satellites, were all successful. Two thermal infrared channels—3.75 and 4.50 µm—were noisier than desired, thereby limiting their measurement capability. Subsequent development has improved the sensitivity and accuracy in this spectral region.

Paul Menzel (NOAA/NESDIS, University of Wisconsin) examined the engineering flight data and set the gains of the instrument for the first research flights. He subsequently processed the FIRE II data and converted them to the spatial resolution of MODIS. In this way, he was able to reduce the instrument noise as well as to simulate the scene characteristics likely to be obtained using MODIS.

The onboard thermal blackbodies and the ground-based visible and near-infrared calibration obtained by viewing the Goddard integrating hemisphere were used to calibrate the spectrometer. Finally, cold-chamber tests were conducted at Ames Research Center to assess the effect of temperature on the visible and near-infrared calibration coefficients, since the ER-2 flies at a much colder temperature than the surface where the ground-based calibration was performed. All data were processed post-flight by the MODIS Science Data Support Team, thereby providing calibrated MAS radiances for every pixel on every scanline and geolocation data (latitude, longitude, solar zenith angle, zenith and azimuth angles of the observations) for every tenth pixel on every scanline. These output data files also contain the spectral channels that were recorded, as well as the calibration coefficients and navigation data (altitude, heading, etc.), and are available to FIRE/ASTEX investigators in netCDF format on Exabyte 8500 tapes through the NASA Climate Data System (NCDS) at the Goddard DAAC (now known as DAAC/Climate).

Conversion for ASTEX

The MAS was returned to Dædalus Enterprises for further modification in January 1992. At that time the visible and thermal detector/spectrometer ports were to be completed. The single visible silicon (Si) detector was replaced by a nine-element visible and shortwave infrared linear array detector. The thermal (HgCdTe) detector also was replaced. However, due to problems with the detector and the thermal lens, the modifications were incomplete when MAS was delivered for the ASTEX campaign in May. A gain change due to the hostile high altitude environment, which was observed during FIRE II cirrus campaign, and the aircraft 400-Hz interference noise on the thermal detector, were further reduced. The fully-configured MAS for ASTEX was a 50-channel spectrometer with 19 channels having spectral characteristics similar to those of MODIS. Again, the aircraft data system could only handle eleven channels, with the ones selected for this deployment listed in Table 2.

ASTEX Configuration

Spectral Channel	λ	$\Delta\lambda$	Bits Recorded
1	0.665	0.055	8
2	0.875	0.041	8
3	0.945	0.043	8
4	1.623	0.057	8
5	2.142	0.047	8
6	3.725	0.151	8
7	8.563	0.396	10
8	11.002	0.448	10
9	12.032	0.447	10
10	13.186	0.352	10
11	13.952	0.517	8

Table 2

The ASTEX campaign was conducted from Terceira, Azores during June 1-28, and provided many multispectral images of marine stratocumulus in the eastern Atlantic. The instrument with the new thermal and VIS-SWIR detector systems operated nominally. Eleven ER-2 flights were conducted during this campaign. The MAS operated successfully but the data system only recorded nine of these flights. Noise was observed in the newly-installed CO_2 slicing (13.19 and 13.95 µm) channels. These channels were noisy because a thermal lens coating had begun to degrade and the detectors were picking up radio interference noise from the unsheilded ER-2 pod heater-blower motor.

In-Flight Performance

On June 17, the ER-2 flew a coordinated mission in which the NASA ER-2 flew above and the University of Washington C-131A aircraft flew within an extensive marine stratocumulus cloud layer located approximately 1380 km west of Lisbon. This mission also included coordination with the SPOT satellite. Figure 1 illustrates MAS images of reflected solar radiation at two spectral channels (0.665 and 2.142 µm), where the images have been converted from calibrated radiances to reflection function, formed from a ratio of the reflected radiance and the incident solar zenith angle and solar flux. In both of these images, the aircraft was flying from top to bottom down the center of these images with the MAS scanning clockwise. These images represent reflectances over an 85 km x 35 km section of the Atlantic, with a clearly defined demarcation between marine stratocumulus (upper portion of the image) and continental stratocumulus (lower portion). In spite of the great distance from the European mainland, there was a large aerosol outbreak that led to clouds with larger numbers of small droplets in the continental clouds. These images have been used to derive the cloud optical thickness and effective droplet radius (not shown), and will provide many opportunities to

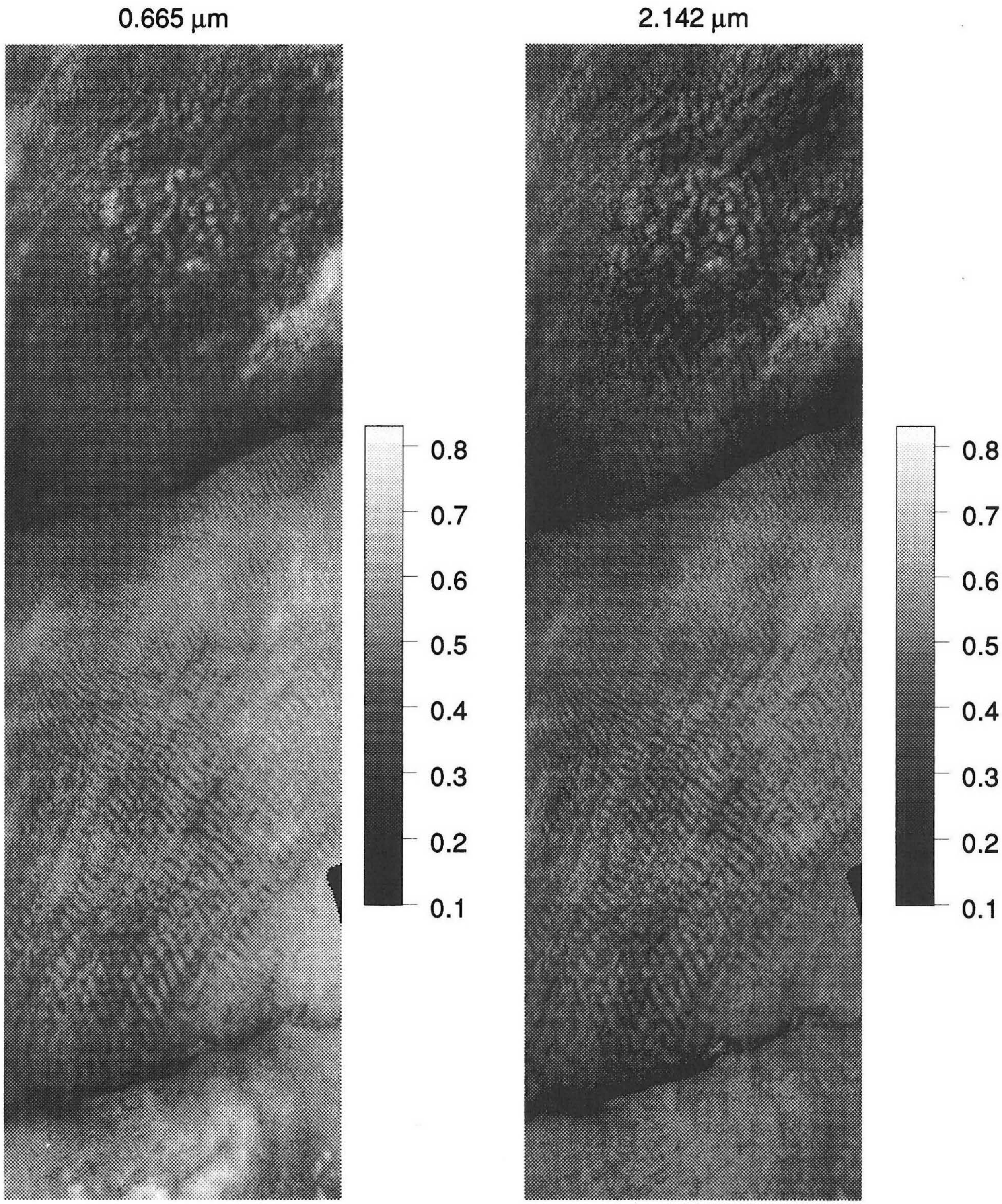


Figure 1. Images of the reflection function of clouds at 0.665 and 2.142 μm, derived from 2600 scan lines of MAS data on June 17, 1992. These data were acquired over marine stratocumulus clouds some 1380 km west of Lisbon, near the Azores.

TOGA-CORE Configuration			
Spectral Channel	λ	Δλ	Bits Recorded
1	0.665	0.055	8
2	0.875	0.041	8
3	1.623	0.057	8
4	1.830	0.05	8
5	2.142	0.047	8
6	3.725	0.151	8
7	8.563	0.396	10
8	11.002	0.448	10
9	12.032	0.447	10
10	13.186	0.352	10
11	13.952	0.517	8

Table 3

test and validate remote sensing algorithms for MODIS, CERES and ASTER.

System Upgrades

The instrument configuration for TOGA-COARE and Central Equatorial Pacific Experiment (CEPEX) campaigns is identical to that of ASTEX, except that a wide-band thermal lens has replaced the lens used previously. This serves to extend the useful spectral range to 14.3 µm. The channels being recorded for TOGA-COARE, shown in Table 3, are somewhat different from those recorded for ASTEX. Replacing the wide bandpass thermal lens and shielding the MAS from the pod heater and blower system has improved the signal-to-noise ratio for the 8.9 — 13.8 µm channels.

The TOGA-COARE and CEPEX campaigns are taking place in January and February from Townsville, Australia, and March from Nadi, Fiji, respectively. Following CEPEX, the CO_2 slicing (13.19–14.30 µm) channels will be modified to increase the radiometric sensitivity. The grating and detector will be modified to improve the transmission and consequently the sensitivity of those channels. Because the original HgCdTe thermal detector has degraded, a more reliable detector was selected as its replacement. The MAS will be returned for the new detector and its discrete cold filter development after these campaigns. The instrument will be completed by the summer of 1993. The cycle of development and field deployments has continuously improved the MAS performance and the resulting data quality.

Future Modifications

A 50 channel, 16-bit data system is currently being developed for the MAS. This system, when completed in the winter of 1993, will enable the MAS to record all 50 channels at 16-bit digitization, thereby allowing 12 bits of noise–free data to be recorded with a dynamic gain adjustment of 16. With these modifications, it is expected that the MAS will meet the needs for atmospheric, land and ocean remote sensing applications. In addition to the CERES and MODIS science teams, MAS will serve a broader science community for many years to come.

Acknowledgments

The development of MAS has been the joint effort of many people at Goddard Space Flight Center (Ken Brown, Liam Gumley, Tom Arnold), Ames Research Center (Pat Grant, Jim Brass, Ted Hildum, John Arvesen), the University of Wisconsin (Paul Menzel, Chris Moeller), and Dædalus Enterprises (Fred Osterwisch, Steve Cech).

LIS SCIENCE TEAM MEETING

From EOS News

The Science Team for the Lightning Imaging Sensor (LIS), to be flown on the USA-Japan Tropical Rainfall Measuring Mission (TRMM) in 1997, met in San Francisco on December 10. Presentations included updates on: instrument development; calibration facilities; data archiving (MSFC-DAAC in EOSDIS), processing and algorithms; satellite simulations; present satellite data sets (Optical Line Scanner) and experiments (CaPE, TOGA/COARE, and Federal Aviation Administration studies); installation of lightning sensor systems at TRMM ground stations; and modeling. Issues discussed included global thermometers based on lightning measurements, experiments to take advantage of upgraded NEXRAD radar in the Gulf of Mexico region, NOAA projects and accommodation of a lightning mapper instrument on a geostationary platform, and the lack of time development observations from the TRMM instrument package.

TWO YEARS AND HUMMING.......... LAND PROCESSES DAAC MOVES AHEAD

—**G. Bryan Bailey**, *Land Processes DAAC Project Scientist*
U.S. Geological Survey, EROS Data Center

In late 1990, the U.S. Geological Survey (USGS) Earth Observation Systems (EROS) Data Center (EDC) was selected by NASA to be the site of the EOS Land Processes Distributed Active Archive Center (LPDAAC), one of eight DAACs that together form a fundamental component of the EOS Data and Information System (EOSDIS). In the two years since, much has happened at the LPDAAC, and exciting things are planned for 1993.

Upon selection as the site for the LPDAAC, EDC established the EOS Data Systems Project Office (EDSPO) to manage and coordinate all EDC activities in support of LPDAAC systems and capabilities development. This office is supported by a growing staff of EDC engineers and scientists who are responsible for the development of LPDAAC systems and capabilities, as part of the EOSDIS Version 0 Program.

Consistent with its data processing and management responsibilities for AM Platform 1 instruments MODIS and ASTER, as well as potential subsequent HIRIS and EOS SAR sensors, and consistent with Version 0 objectives, the LPDAAC initiated a Version 0 Program that emphasizes: (1) enhancing user access to existing land-related data, particularly for use as prototype data sets in developing pre-EOS analysis procedures and standard product algorithms; (2) developing initial product generation, data archive, and information management capabilities to prepare for transition to operational versions of these systems in the EOS time frame; and (3) developing the science support programs required to enhance use of Land Processes DAAC data and products. The LPDAAC Version 0 Program consists both of system-level and DAAC-specific activities, but only the latter are addressed in detail by this article.

System-Level Activities

The LPDAAC's system-level activities are conducted in close coordination with the EOSDIS Project and with the other DAACs, as they deal largely with the development of capabilities and services that impact the full EOSDIS. In 1992, various LPDAAC activities contributed to the development of the Version 0 information management system (IMS), interactive on-line browse capabilities, standard data formats, the science processing library, and coordinated user services.

In 1993, the LPDAAC will expand and enhance the local DAAC interface to the 1992 prototype IMS, which demonstrated inventory interoperability over Internet, develop and incorporate new DAAC data sets in the IMS, and continue to support expansion of graphics capabilities for geographic coverage plotting and image data browse functions in the IMS. In addition, the LPDAAC will continue to participate in the development of data structures to expand the hierarchical data format (HDF), which has been selected as the prototype EOSDIS Version 0 standard data format. Support of EOSDIS efforts to bring consistency and commonality to user services functions among the DAACs will be continued through participation in the EOSDIS Version 0 User Services Working Group.

DAAC-Specific Activities

DAAC-specific activities are those activities which generally are unique to a DAAC's individual efforts to develop its Product Generation System (PGS) and Data and Archive Distribution System (DADS) capabilities, and to enhance near-term science productivity by providing users with improved access to relevant existing data and newly developed data products.

Global Land 1-km AVHRR Data Set

During the past few years, needs for the acquisition and compilation of a global land 1-km resolution multitemporal and multiyear AVHRR data set have been articulated by many Earth and Global Change scientists. Consequently, as one of its Version 0 activities, the LPDAAC has assumed responsibility in cooperation with NASA, NOAA, the European Space Agency, Australia's Commonwealth Scientific and Industrial Research Organization, and a number of non-U.S. AVHRR receiving stations, for coordinating the acquisition, archiving, and management of such a global land 1-km AVHRR data set.

The global land 1-km AVHRR data set is defined as 5-channel, 10-bit, raw AVHRR data with 1.1-km spatial resolution (at nadir) collected for 18 consecutive months beginning April 1, 1992. The data set will include essentially all land surface and coastal zone data acquired during each daily orbital pass of NOAA's TIROS "afternoon" polar-orbiting satellites.

The data acquisition, archiving, and management phase (Phase I) of this effort is well underway. Agreements with participating HRPT station operators to routinely acquire and transfer all afternoon NOAA-11 data to the LPDAAC have been established. NOAA is scheduling the LAC recorders to complement HRPT data received and to ensure that the maximum amount of afternoon land coverage is obtained daily. To date, more than 10,000 AVHRR scenes have been acquired and archived at the LPDAAC. Following extensive software development, digital browse image products and metadata files for all data received are being generated and entered into the IMS. The science community has been surveyed to define requirements for higher level (2-4) products to be generated during Phase II of this effort, and a document outlining procedures for generating such products has been prepared.

In 1993, emphasis will be on continuation and refinement of the ongoing data gathering, archiving, and management activities of Phase I. Approximately 80 observations per day will be acquired by the station operators and NOAA recorders. Browse products and metadata files for each observation will be generated and transferred to the IMS at the time of ingest. A mass storage system to support and test data processing, archiving, and distribution methodologies will be implemented. Phase II activities will include the compilation and the generation of continuous orbital segments of AVHRR data. Also, in Phase II the development and generation of science community-defined higher level products will begin, terrain and atmospheric correction algorithms will be applied, and at least one global composite product will be produced. In addition, an image registration technique will be developed to efficiently provide sub-pixel AVHRR image registration accuracy on a global basis.

Topographic Data

The general lack of digital topographic data at resolutions sufficient to meet many requirements of the EOS and global change science communities is an issue of great concern and increasing importance as the EOS time frame approaches. The issue is important because such data will be vital to the success of many EOS scientific investigations that have strict requirements for accurate atmospheric and radiometric correction and/or geometric registration of remotely sensed data. While full or satisfactory resolution of this issue is not imminent, existing digital topographic data sets and satellite systems capable of acquiring topographic data currently are not being fully utilized. Consequently, the Land Processes DAAC is implementing a variety of activities aimed at improving access to existing digital topographic data, enhancing the utility of those existing data, and generating new digital topographic data sets from airborne and satellite data.

As a USGS facility, EDC archives and distributes a variety of digital elevation models (DEM) and other digital cartographic data. In an effort to expand their offerings, EDC and the LPDAAC have been negotiating with the Defense Mapping Agency (DMA) for the opportunity to distribute DMA Digital Terrain Elevation Data

(DTED). These approximately 100-meter resolution raster elevation data exist for a majority, but not all, of the Earth's land masses.

To enhance the utility of existing digital topographic data, the LPDAAC has developed capabilities to assemble regional- to-continental-sized data sets compiled from various sources. For example, DMA Level 1 DTED data, supplemented with data from Canadian sources, have been processed and merged to create a 0.5-km DEM of the North American continent. A portion of this data set was used in a proof-of-concept hydrologic analysis of the Rio Grande basin. Automated feature extraction software was used to generate stream networks from the merged data set that compare favorably with the same networks as represented on existing maps.

Digital topographic data of the globe, in vector form captured from 1:1,000,000-scale Operational Navigational Charts, are now available on CD-ROM as the DMA's Digital Chart of the World (DCW). For some parts of the world, these elevation data are the best available. Procedures to efficiently generate raster topographic data from DCW vector data have been developed and successfully tested at the LPDAAC.

Another important LPDAAC Version 0 goal is to develop and demonstrate capabilities to generate digital topographic data from stereoscopic remotely sensed data. Workstation and software procurements pursuant to achieving this goal have been initiated.

In 1993, efforts to enhance user access to, and utility of, existing topographic data sets will continue. Specifically, the LPDAAC plans to prepare a document that describes and cross-correlates the topographic data requirements of the EOS science teams, and that provides a current overview of topographic data programs and relevant activities, including current data availability and future satellite data alternatives. Discussions will continue with the DMA for release of non-U.S. DTED data, and production of 0.5-km DEMs from the DCW will begin, with the goal of producing a global data set by 1994. In addition, the LPDAAC will implement an integrated hardware and software capability to generate DEMs from JERS-1, SPOT, and aircraft-acquired stereoscopic data for selected EOS test sites on an experimental basis.

Aircraft Data Sets

Surrogate data with characteristics at least similar to those anticipated from ASTER, HIRIS, and MODIS are required by the LPDAAC to develop data processing and product generation capabilities for these sensors in the pre-EOS time frame. Such precursor data also are needed by EOS investigators for the development of algorithms to generate ASTER, MODIS, and HIRIS standard data products, and they are needed by the global land sciences community to address current global change and other Earth science problems. No existing satellite sensor data meet these requirements and needs, but certain aircraft sensor data do.

The Thermal Infrared Multispectral Scanner (TIMS) is a NASA sensor with characteristics similar to the thermal channels of ASTER, and the NS-001 and other NASA thematic mapper simulator sensors have spectral characteristics similar to the visible, near-IR, and mid-IR channels of ASTER. The Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) is a 220-channel NASA sensor that acquires data very similar to those that may eventually be acquired by HIRIS, and the MODIS Airborne Simulator (MAS) is a 50-channel NASA sensor capable of acquiring data with spectral characteristics similar to MODIS. The LPDAAC is cooperating with the Jet Propulsion Laboratory (JPL) and the Ames Research Center (ARC) to transfer from those centers to the DAAC certain TIMS, NS-001, and AVIRIS data archiving, processing, product generation, and distribution responsibilities. Current discussions with the Stennis Space Center (SSC) may lead to the transfer of SSC-archived TIMS and other aircraft sensor data to the LPDAAC, as well. Similar responsibilities, if any, for the LPDAAC with respect to MAS data are yet to be defined.

Initial efforts will include the reproduction and transfer to the LPDAAC of the JPL and ARC historical TIMS, NS-001, and AVIRIS data archives and the development of capabilities to process those data to Level 1 products for distribution to science users. Appropriate metadata and browse image products also will be generated. After these capabilities are implemented and tested, the LPDAAC will assume responsibility for the processing and distribution of historical TIMS, NS-001, and AVIRIS data. The LPDAAC expects to produce and offer, on a selective basis, merged aircraft data sets as simulated ASTER data sets.

In 1992, requirements for the transcription of the TIMS and NS-001 data sets (e.g., archived data formats and media, metadata descriptions, and browse images) were defined, software was developed to perform the transcription task, and the necessary hardware platforms were procured.

In 1993, ARC TIMS and NS-001 data sets will be transcribed and transferred to the LPDAAC, metadata and browse images will be generated and entered in the IMS, and procedures for Level 1 product generation and distribution will be established. In addition, requirements for Version 0 AVIRIS data processing and data handling will be defined, as will AVIRIS browse products and metadata. System to generate AVIRIS browse products and metadata will be implemented, and population of the IMS with these metadata and browse products will begin.

Synthetic Aperture Radar

LPDAAC Version 0 activities related to SAR were initiated to enhance DAAC experience and expertise in processing radar data, particularly in the area of geometric rectification, as necessary steps in the development of SAR PGS and DADS capabilities to meet land processes requirements. Enhancing user access to existing SAR data sets is another important objective of LPDAAC SAR activities.

In 1992, SAR spacecraft models were created for Seasat and ERS-1, and an automated procedure to generate terrain-corrected and map-projected SAR images was developed. The procedure was used to produce a high-quality, 21-scene ERS-1 SAR mosaic of the Tanana River valley in Alaska.

In 1993 the LPDAAC will develop and begin to implement, in cooperation with JPL, plans to establish the DAAC as a long-term archive and distributor of SAR data. In addition, development and documentation of prototype software for generating higher-level SAR products will continue. Specifically, a prototype Version 0 IMS interface to the JPL SAR Data Catalog System will be developed and implemented, in advance of the 1994 transfer of JPL-archived SEASAT, SIR-B and AIRSAR data to the LPDAAC for archive and distribution. ERS-1 terrain correction, map projection, and mosaicking software will be optimized, documented, and made available to interested users; the SAR spacecraft model will be modified to include the JERS-1 SAR; and procedures to generate DEMs using ERS-1 interferometry will be investigated.

Science Support

Basic to LPDAAC Version 0 Program philosophy is the recognition that all LPDAAC EOSDIS systems and capabilities must be developed and implemented to maximize their ultimate benefit to the EOS and global change science communities. To that end, the DAAC is engaged in numerous activities to ensure that science community influence is incorporated, to the maximum possible extent, in the LPDAAC program planning, development, and implementation process.

The Land Processes DAAC Science Advisory Panel, with broad EOS and non-EOS science community representation, was established as the primary formal mechanism through which the DAAC receives guidance and recommendations from the science community. This panel met at the DAAC twice during 1992, and it provided important recommendations that were used in preparing the DAAC's FY 1993 Version 0 Proposal to the EOSDIS Project. The Science Advisory Panel will continue to meet regularly and provide guidance to the DAAC throughout its involvement in the EOS Program. Activities and recommendations of the panel will be reported in future issues of *The Earth Observer*.

The LPDAAC also has established liaison with, and participates regularly in meetings of, the MODIS, ASTER, HIRIS, and EOSSAR Instrument Teams, as well as the EOS Investigators Working Group and the EOSDIS Advisory Panel. Interaction with these groups will continue and increase in the future, and special efforts will be made in 1993 to develop similar relationships with individual IDS teams whose investigations have substantial requirements for LPDAAC data.

In 1992, the DAAC developed a preliminary plan for a comprehensive LPDAAC Science Support Program. Based on EOS science requirements definition and input from the science community, the plan will be finalized in 1993, and implementation of specific program elements will begin, particularly as relate to support of high-order product algorithm development and prototype product generation.

The past two years have been exciting and busy times for the Land Processes DAAC. Much has been accomplished, but even greater challenges lie ahead. Plans are moving forward for construction of additional facilities to house the LPDAAC's growing systems and staff, and efforts have been initiated to ensure that participation by the new EOS Core System contractor in the development results in maximum productivity with minimum disruption to ongoing activities. Clearly, things will continue to "hum" as the LPDAAC moves ahead!

From EOS News

EOS PATHFINDERS

The AVHRR Atmosphere Pathfinder Science Working Group met on December 9 and the Landsat Pathfinder Science Working Group met on December 15-16. The AVHRR-Atmosphere group affirmed an algorithm for producing cloud maps from 5-channel afternoon-series data. The group also changed the gridding scheme for Level-3 products from equal angle to equal area to further global analysis and use of this data product. Processing of the AVHRR atmospheric Pathfinder products will be done at NOAA NESDIS. The Landsat group reviewed a draft science plan for their Pathfinder activities. Part of the new Landsat NASA Research Announcement will be devoted to requests for pilot studies with Pathfinder data sets, which will be reviewed by the Landsat Pathfinder Science Working Group.

COMMITTEE ON EARTH OBSERVING SATELLITES

The Committee on Earth Observing Satellites (CEOS) held a plenary meeting on December 11 in London. The group admitted the Russian Space Agency and Hydromet as members and conditionally approved membership of two Chinese agencies. A secretariat composed of members from the USA (NASA/NOAA), Japan (STA/NASDA) and Europe (ESA) was approved to maintain continuity and perform administrative duties. A draft was released of a compilation of all ground segment activities supporting Earth observing satellite programs, including standard data products, locations of archives, etc. This report should be available in early 1993.

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 write to the address above.

The Earth Observer Staff:
Executive Editor: **Charlotte Griner**
Technical Editor: **Renny Greenstone**
Associate Technical Editor: **Bill Bandeen**
Assistant Editor: **Mary Reed**
Production: **Winnie Humberson**
Distribution: **Hannelore Parrish**

EOS IWG Meeting Information and Registration

As announced in the last EOS Science Calendar, the next EOS Investigators Working Group (IWG) meeting is scheduled for March 29-31, 1993 at the Greenbelt Marriott Hotel in Greenbelt, Maryland. Because of overlapping schedules, the Clouds Topical Science Workshop will not convene during this week in March. New meeting dates will be announced at a later date.

Lodging Accommodations

Travel and lodging reservations and payments are the responsibility of each individual attendee. A block of sleeping rooms has been reserved at:

The Greenbelt Marriott Hotel
6400 Ivy Lane
Greenbelt, Maryland 20770
Toll-free Telephone (800) 831-4004
Telephone (301) 441-3700
FAX (301) 474-9178

B&D has blocked 50 rooms at the government rate of $101.20/single or double per day, tax inclusive. Government per diem in the Washington area is $110.00/lodging and $34.00/meals (total of $144.00). Non-smoking and handicapped assessible sleeping rooms are available upon request. Hotel check-in is 4:00 p.m.; check-out time is 12:00 noon.

To make a reservation at the hotel, call the Reservations Department at (800) 831-4004 or (301) 441-3700 and identify yourself as part of the EOS IWG Meeting. The cut-off day for room reservations is Friday, March 12, 1993. After this date, rooms and government rates are subject to availability. March is a busy month in the Washington, D.C area! Please make your hotel reservations early!

Science Executive Committee Meeting

A working dinner is planned for the SEC. Specific details will be provided at a later date.

Payload Advisory Panel Meeting

There will not be a Payload Advisory Panel meeting during this week. Rather, plans will be made for a separate meeting later this summer.

Social

To date, a social has not been scheduled during this meeting. We will advise you if this changes.

Registration

Registration for the IWG meeting will be held in the lobby of the Greenbelt Marriott from 5:00 to 7:00 p.m. on Sunday, March 28, and from 8:00 to 10:00 a.m. on Monday, March 29. Advance registration should be made by sending the registration form below to:

Theresa Watts
Birch & Davis Associates, Inc.
Earth Science Support Office
300 D Street, SW, Suite 840
Washington, DC 20024
FAX: (202) 479-0360 or (202) 863-3995

☞

At this time, no registration fee is required. All registration forms must be received by March 1, 1993. Please return the form even if you do not plan to attend the meetings.

Additional information will be sent to you in a follow-up logistics package from B&D. Information will include: detailed maps, support services available, information on transportation to the hotel, and more details about hotel accommodations, registration, and the social. In the meantime, if you have any questions, please do not hesitate to call Theresa Watts or Debby Critchfield at (202) 479-0360, fax: (202) 479-2743, or E-mail:

Internet: twatts@se.hq.nasa.gov
Internet: dcritchf@se.hq.nasa.gov
Omnet: D.CRITCHFIELD
Telemail: DCRITCHFIELD/GSFCMAIL

NASA/EOS IWG Meeting
Registration Form

March 29 - 31 1993
Greenbelt, Maryland

Please print clearly.

Attendee Name ______________________

Affiliation ______________________

Business Address ______________________

____

City ____________ State ____________ Zip ____________

Telephone ____________ Facsimile ____________

☐ I plan to attend the IWG Meeting
☐ I do not plan to attend the IWG Meeting

Please return advance registration by March 1, 1993 to:

NASA EOS IWG Meeting
Attn: Theresa Watts
Birch & Davis Associates, Inc
Earth Science Support Office
300 D Street, SW, Suite 840
Washington, DC 20024
FAX: (202) 479-0360 or (202) 863-3995

Global Change Calendar

• 1993 •

February 8-11	Ninth Thematic Conference on Geologic Remote Sensing: *Exploration, Environment, and Engineering*, Pasadena, California. Contact: Robert Rogers, ERIM, Box 134001, Ann Arbor, MI 48113-4001 USA, phone (313) 994-1200, ext. 3234, FAX (313) 994-5123, telex: 4940991 ERIMARB.
March 24-27	Sixth Annual Geographic Information Systems Conference (TSU/GIS '93). Contact: Dr. John M. Morgan, III, Department of Geography and Environmental Planning, Towson State University, Baltimore, Maryland 21204-7079, phone (410) 830-2964, FAX (410) 830-3482.
April 4-8	25th International Symposium on Remote Sensing and Global Environmental Change, Graz, Austria. Sponsored by CIESIN (Consortium for International Earth Science Information Network), ERIM (Environmental Research Institute of Michigan), and Joanneum Research. Contact: Nancy Wallman, ERIM, P.O. Box 134001, Ann Arbor, MI 48113-4001, phone: (313) 994-1200, ext. 3234, FAX: (313) 994-5123.
April 19-23	Call for Papers, First Thematic Conference, International Symposium "Operationalization of Remote Sensing." ITC, Enschede, The Netherlands. Contact: Prof. J.L. Van Genderen, ITC, P.O. Box 6, 7500 AA Enschede, The Netherlands, phone: 31-53-874-254, FAX: 31-53-874-436, telex: 44525 ITC NL.
June 21-25	Third International GPS/GIS Conference and Training Program. Seattle, Washington. Contact: GPS/GIS '93 Conference Coordinator, c/o GeoResearch, Inc., 115 North Broadway, Billings, Montana 59101, phone: (406) 248-6771, FAX: (406) 248-6770.
July 13-15	Call for Papers. IAMAP/IAHS Joint Symposium on Advanced Observing Techniques in the Atmosphere and Hydrosphere at the Joint International Meeting of the International Association of Meteorology and Atmospheric Physics and the International Association of Hydrological Sciences, Yokohama, Japan. Abstract forms are due January 31, 1993. Contact: George Ohring, phone: (301) 763-8078, FAX: (301) 763-8108.
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 14-15	TERRA-2 Conference at Chester College "Understanding the Terrestrial Environment: Data Systems and Networks". Contact: Prof. P.M. Mather, Department of Geography, The University NOTTINGHAM NG7 2RD, United Kingdom, phone: 0602 515430, FAX: 0602 515428, email: mather@uk.nott.vax.

EOS Science Calendar

• 1993 •

January 26-28	AIRS Team Meeting, Pasadena, California. Contact G. Aumann at (818)397-9534
January 28-30	EOS Calibration Meeting, San Diego, California. Contact B. Guenther at (301) 286-5205
February 2-5	Joint ASTER Science Meeting, Las Vegas, Nevada. Contact Dave Nichols at (818) 354-8912
February 2-4	LAWS Team Meeting, Clearwater, Florida. Contact W. Baker at (813) 763-8005
March 2-4	EOS Validation Meeting, Pasadena, California. Contact D. Vane at (818) 354-3708
March 24-26	MODIS Science Team Meeting, GSFC/Greenbelt, Maryland. Contact D. Herring at (301) 286-9515
March 29-31	IWG Meeting, Greenbelt, Maryland. Contact G. Asrar at (202) 358-0258 or M. King at (301) 286-8228
April 27-29	TES Team Meeting, Langley Research Center. Contact Reinhard Beer at (818) 354-4748
June 21-25	U.S. ASTER Science Team Meeting, Location TBD. Contact Dave Nichols at (818) 354-8912

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