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INSIDE THIS ISSUE

Editor's Corner

On June 23, Ghassem Asrar and I sent a letter to each Instrument Team Leader, Instrument Principal Investigator, and Interdisciplinary PI that contained a complete list of at-launch and post-launch data products, based largely on recommendations of the Investigators Working Group and the Atmosphere, Ocean, Land-Biosphere, and Solid Earth Panels. We solicited confirmation of this prioritization, as well as validation of information on these products, such as a detailed listing of all parameters within each data product, storage volume, floating point operations per second, accuracy, etc. This comprehensive process of updating, validating, and prioritizing data products to be produced by EOS has been both time-consuming and extremely valuable. It has enabled the EOS investigators and the ESDIS Project to narrow their focus and to prioritize what can realistically be produced by EOS in a timely manner. We now have received detailed responses from all 18 Instrument Science Teams as well as from Richard Rood's Interdisciplinary Investigation. The responses separately accounted for routine, on-request, and software products, that are summarized in the following table.

Of primary importance in this exercise is the prioritization of the at-launch data products and the updating of processing load and storage volume estimates. We are currently analyzing the comprehensive responses provided by the investigators, but preliminary indications are that the processing load estimates for the EOS AM platform alone increased by a factor of about 5 and the data storage requirements increased by a factor of about 2.5.

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In addition to aiding in the sizing and management of EOSDIS and the EOSDIS Core System, the highest-priority data products for each instrument are essential for setting the Level-1 requirements in the EOS Execution Phase Project Plan. This important document has now been approved by Dr. Shelby Tilford, Acting Associate Administrator of the Office of Mission to Planet Earth, and Dr. John Klineberg, Director of Goddard Space Flight Center. The Level-1 requirements listed in the Project Plan are a subset of the at-launch data products to be provided by each Instrument Team, and include not only the data product name but also the accuracy and resolution to be provided. These data products are preliminary, pending negotiation of the Statements of Work with the responsible EOS investigators. The Project Plan does not list the parameters within a given product; instead, parameters will be cross-referenced to the Science Plan that will be developed in the next year. The distinction between Level-1 requirements contained in the Project Plan and the additional level-2 requirements to be contained in the Science Plan is the level of configuration control. A modification to the Level-1 requirements will require approval by the Associate Administrator and the Director of Goddard Space Flight Center.

The EOS Payload Advisory Panel meeting has now been scheduled for October 4-6 in Herndon, Virginia. The primary focus of this meeting will be on coordination and convergence of EOS with other programs, such as (i) EOS Chemistry in light of ESA's plans for Envisat in 1998, involving discussions on the preferred orbit and instrument complement for EOS Chemistry, (ii) EOS PM in light of ESA's plans for Metop-1 as well as NOAA's plans for NOAA-O, P, Q and the Department of Defense's plans for DMSP, (iii) Landsat, SPOT, and HIRIS-2, and (iv) TOPEX/Poseidon follow-on in light of plans for Geosat follow-on and EOS Altimetry/Radar. A secondary objective of the Payload Advisory Panel meeting is to update the EOS Principal Investigators on progress on the management and operation of EOS Color and on the status of EOS Altimetry/Laser (GLAS).

—Michael King
EOS Senior Project Scientist

Table 1.

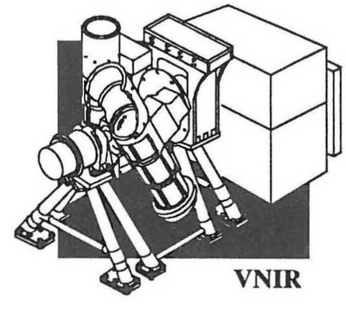
Instrument Name	At- Launch Products				Post-Launch Products				Grand Total
	Routine	On-request	Software	Total	Routine	On-request	Software	Total	
ACRIM	1	0	0	1	0	0	0	0	1
AIRS/AMSU/MHS	10	0	1	11	3	0	0	3	14
ASTER	4	10	0	14	0	0	0	0	14
CERES	3	0	0	3	7	0	0	7	10
EOSP	4	0	0	4	0	1	0	1	5
GLAS	10	0	0	10	1	0	0	1	11
HIRDLS	15	0	0	15	14	0	0	14	29
LIS	3	0	0	3	1	0	0	1	4
MIMR	8	0	0	8	7	0	8	15	23
MISR	5	0	0	5	6	0	0	6	11
MLS	3	0	0	3	15	0	0	15	18
MODIS	29	2	0	31	3	0	0	3	34
MOPITT	7	0	0	7	0	0	0	0	7
SAGE III	10	0	0	10	0	0	0	0	10
SeaWinds†	2	0	0	2	1	1	0	2	3
SOLSTICE	3	0	0	3	2	0	0	2	4
SSALT/TMR/DORIS	3	0	0	3	0	0	0	0	5
TES	12	0	0	12	8	0	0	8	20
Total	132	12	1	145	68	2	8	78	223

† Note: NSCAT II has been renamed SeaWinds.

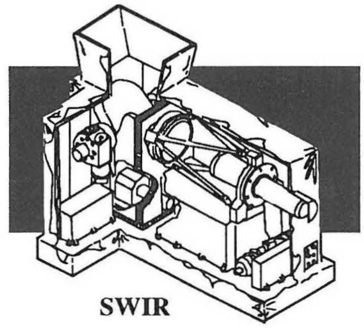
U.S. ASTER Science Team

July 14-16, 1993

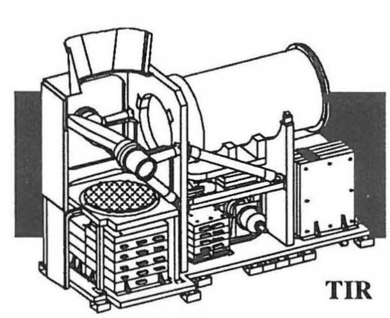
— **Andy Morrison**, Jet Propulsion Laboratory



VNIR



SWIR



TIR

The U.S. ASTER Science Team met at the Jet Propulsion Laboratory, Pasadena, California, 14-16 July 1993. There were 47 meeting participants, including representatives of the ASTER Science Team, ASTER Science Projects, the EOS Projects at Goddard Space Flight Center, and the EOSDIS Core System. The purpose of the meeting was to update Team members on the status of the EOS AM and ASTER Projects, address Project issues that impact science, and review the status of the Team members' ASTER-related research and development activities.

Anne Kahle, the U.S. Team Leader, opened the meeting and presented the status of the science data products. She noted that a "Polar Regions Cloud/Sea Ice Extent" product has been added to the list of Standard Data Products.

Gary Geller reported that the Japanese have proposed a Level 1 processing arrangement in which:

- Japan produces scene-specific geometric and radiometric calibration coefficients;
- these coefficients are sent to the U.S. along with the sensor data; and
- the U.S. applies coefficients to the L1A data to produce L1B

To date, the Japanese proposal seems to be informally accepted, although some issues still need to be worked out. Geller presented a processing flow concept that indicated architectural options for filters to remove clouded scenes from the processing stream. Science Team members felt strongly that no data should be filtered out before Level 1B processing.

Piers Sellers, the EOS AM Project Scientist, said that the current plan is to have about 60 calibration test sites for radiometric and geometric calibration worldwide. These test sites will be available for all the instruments.

Sellers also said that the National Meteorological Center's 48-hour forecasts are extremely good as predictors of cloud cover. For example, it can predict the times that the Amazon is cloud-free 48 hours in advance. This strongly suggests that ASTER can obtain more cloud-free data if revised schedules can be uplinked to the spacecraft 24 to 48 hours before acquisition, rather than one week in advance as is now planned.

Bryan Bailey reported that the Land Processes DAAC (LPDAAC) photogrammetric workstation is in place, and they are now producing Data Elevation Models (DEMs) using various data sources. Simon Hook urged that the workstation be used to produce DEMs of all the ASTER test sites. As LPDAAC Science Advisory Panel Co-Chairman, Mike Abrams urged Team members to make more use of the DAAC to support their work.

It was noted that although the current EOSDIS plan does not include production of hard copy data, many users will require hard copies. Bryan Bailey said that the LPDAAC has the facilities to produce hard copy products. Matt Schwaller said that although the EOSDIS will be a producer of digital rather than analog products, it may act as a broker between the requesters and hard copy vendors.

The Science Team members and ASTER Discipline Working Groups reported on their recent activities, current status, and plans. The presentation highlights included:

- Phil Christensen, Arizona State University, reported that their spectral library now includes data for 170 minerals. Their ultimate objective is to combine the data with the Roger Smith and Jack Salisbury data to obtain a comprehensive library.

- Jack Salisbury has put together a set of standard spectral samples and he is distributing them to interested labs to use to calibrate their instruments. He will assemble a data base of results from the 'round robin.' He also performed a spectral analysis of snow. His results showed a considerable difference between measured reflectance as a function of particle size vs calculated reflectance (particle size grows as a function of the age of the snow). His results argue that the radiation models used in global change models may need to be modified.

- Tom Schmugge said that, despite concerns that the AM platform data would be inferior to PM data for studying the rate of change of ground surface temperature, his modeling and measurements now indicate that the signal-to-noise ratio will be better, due to the cooler air temperature in the AM.

- Phil Slater reported improved characterization of atmospheric effects by refinements to measurements, data reduction and thus inputs to the radiative transfer code, construction of ultra-stable radiometers for cross-comparison purposes, and the development of new calibration methods including a ratioing radiometer for use with solar diffusers. Slater emphasized the need for the Japanese to process their data using the same calibration coefficients that the U.S. uses, in the same way.

- Stuart Biggar discussed cross-calibration activities, including the design for a new silicon "trap" detector, and post-launch calibration activities and plans.

- Frank Palluconi presented a summary of the ASTER Calibration Peer Review held March 8-10 in Tsukuba. A preliminary Review report containing the information requests written at the Review (and also containing many vendor responses) has been written. Palluconi expressed concerns about: a) lack of a single document for geometric requirements; b) need for additional pre-launch calibration measurements; c) no rapid space-look in the thermal vacuum calibration of the TIR subsystem; d) out-of-band spectral response measurement procedure; e) small area of illumination of SWIR aperture by the calibration lamp; f) need for a plan to send pre-launch calibration data to the Science Team; g) need for TIR data map information; and h) need for SWIR temperature measurement uncertainty estimates

The status of the development of algorithms for the Standard Data Products was reported by each cognizant investigator:

- Dave Pieri presented a process flow plan for the volcanoes thermal change algorithm. He found the algorithm for hot spot monitoring to be much more complex than first anticipated. Such things as obscuration and self-obscuration, differences between different volcanoes, and changes of any volcano with time were not anticipated. Still, he expects to deliver the algorithm on schedule.

- Ron Alley predicted that the beta version of the decorrelation stretch would be delivered on schedule July 23. The source code will be in Fortran.

- Phil Slater, presenting for Kurt Thome, said that their data flow study is nearly complete, coding will begin in August, test data will be developed concurrently with the coding work, and they expect to deliver the algorithm on schedule in October.

- Ron Welch noted that his products have not been formally approved yet. For his algorithms, he will use a fuzzy logic approach written entirely in C. He estimates delivery of his initial product in August 1994.

- Alan Gillespie reported on the status of several algorithms under development. The Scene Classification browse product algorithm is in process and will be delivered before November 1, 1993. He said that data are required from all three telescopes for his classification scheme to operate optimally. The Temperature-Emissivity Working Group has selected the Alpha log residual and the normalized emissivity approaches as the final candidates for the T-E algorithm. Both algorithms will be provided in the beta version, with a switch provided. The switch may be disabled for the final version. The Perpendicular Vegetation Index and the Soil Brightness Index (PVI-SBI) algorithms are also in process. They will be delivered by October 1, 1993. The Normalized Difference Vegetation Index (NDVI) algorithm is up and running and currently being tested. It will be submitted by October 1, 1993.

- Frank Palluconi, Atmospheric Correction Working Group, reported that at this time the U.S. and Japan are pursuing separate algorithm development paths. A common algorithm will be selected later. Palluconi described the core components of the TIR atmospheric correction algorithm and predicted that the beta version would be delivered by November 1, 1993.

There was considerable discussion in the meeting about the process and criteria for assigning priorities to science classifications and to individual observations to enable conflict-free scheduling. It was noted that: a) it will be necessary to agree on a single set of U.S./Japanese ASTER Science Team Goals and Objectives to produce the Long-Term Instrument Plan; b) other instruments may provide data equivalent to some ASTER data, and the overlap should be taken into consideration; c) prioritization will not be based solely on climate change or on non-renewable resources, but will reflect the diversity of the user community. Larry Rowan, Geology Working Group Co-Chair, presented a possible set of criteria for prioritization of target areas. They were: seismicity, volcanic activity, resources (non-renewable), population (risk), coastal erosion, and the presence or absence of vegetation cover. He also presented a preliminary version of the best possible targets for obtaining lithologic information, using exposure as a criterion.

Piers Sellers proposed the concept of providing ASTER users with a currency (funny money) that could be used at the investigators' discretion to bid for the use of ASTER resources. Scientific prioritization might then become a part of the currency allocation process and not part of the DAR evaluation process. He also said that he thought that EOS investigators should have a higher priority than other categories of users.

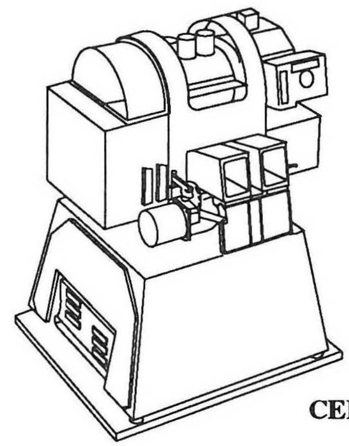
The Science Team discussed the issue of Ground Control Points (GCPs) for DEM generation. Harold Lang stated that a far more complete system of GCPs than presently exists is critical for EOS in general and ASTER in particular. He pointed out that ASTER DEMs based on GCPs or their equivalent, such as GCP-constrained SPOT DEMs, would be needed to register MISR and MODIS data. He also pointed out that investigators doing land change studies or any time-series studies need geocoded data, which all require GCPs. Radiometric correction of ASTER SWIR data requires slope knowledge to within 5 degrees, which requires DEMs with at least 15-30 meter resolution. Lang is seeking assurance that there is a commitment somewhere that there will be sufficient GCPs available to produce the DEM and other geocoded data required of EOS.

Roy Welch said that geocoding and rectification of ASTER-type data usually requires 5-10 GCPs per 60 km square scene. He noted that: a) more and better ground control will be needed than currently exists; b) data processing to systematically produce DEMs will be challenging; c) DEM generation is very labor intensive. He estimates that a 60X60 km scene would require one skilled person-day to produce a DEM. Several Team members will pursue the GCP/DEM issue between this and the next meeting.

The next Joint U.S./Japan Science Team meeting will be held in Japan in November, 1993. The next U.S. Science Team meeting will be held in the Spring of 1994, the specific time and place to be determined.

CERES Science Team Meeting and Calibration Review Parameters and Data Products

— **Bruce R. Barkstrom**, Atmospheric Sciences Division, NASA Langley Research Center, Hampton, VA



CERES

The CERES Science Team met in Williamsburg, VA on June 9-11 following a Headquarters and Project Peer Review of the CERES Interdisciplinary Investigation. The primary business of the meeting was to discuss revisions to the proposed CERES Data Products that were presented to the EOS Investigators Working Group. There were four major scientific issues driving this discussion:

- How can we expeditiously produce surface radiation budget fluxes derived from the broadband scanner measurements with the traditional top-of-atmosphere radiation fluxes?
- What are the appropriate parameters we need to describe clouds and their vertical structure?
- How do we provide retrievals of the vertical structure of radiative fluxes in the atmosphere?
- How do we deal with time-averaging of cloud and radiation properties to ensure consistency?

Readers may recall that the proposed CERES data products presented at the EOS IWG meeting were based on the Data Flow Diagram shown in Figure 1. In this figure, instrument data arrives at the upper left corner of the diagram. The process (shown as a "bubble") labeled "1" deals with the instrument calibration and Earth location. Two kinds of data products come from this process. The first product is CERES instrument Bidirectional Scans (labeled BDS), and contains 24 hours of raw counts, filtered radiances, and Earth geolocations (at the top of the atmosphere). The second product consists of CERES Instrument Earth Scans (labeled IES). A single IES product contains one hour of filtered and Earth-located radiances, arranged in as regular a scan pattern as possible. This spatial organization will improve the efficiency with which we can merge the CERES pixels with data from the cloud imagers (VIRS on TRMM, MODIS on EOS-AM and EOS-PM).

As we move horizontally across the top of the data flow diagram, the CERES data is processed with the ERBE algorithms to produce total-sky fluxes and clear-sky fluxes of reflected sunlight and emitted terrestrial radiation. The ES8 data product contains one day of Earth-located fluxes, with their associated scene identifications. This data is tied to the scanner pixel organization. The ES9 and ES4 products are monthly, regional average fluxes. Our original intent was to keep the algorithms and coefficients in this part of the processing identical with the processing in ERBE. Thus, this data would be useful in looking for climate changes from the baseline established by the previous ERBE measurements.

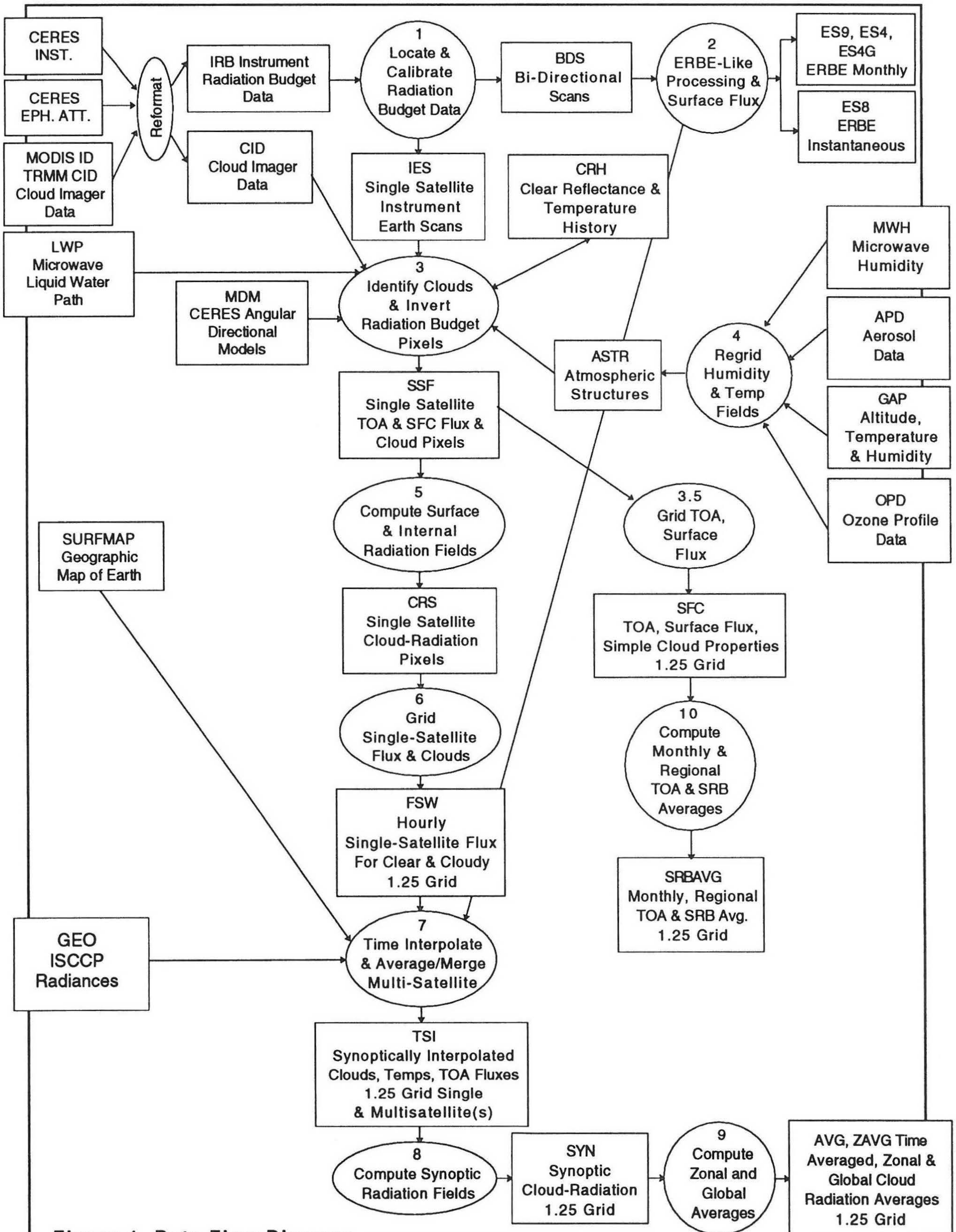


Figure 1. Data Flow Diagram

As we move vertically down the left side of the data flow diagram, the CERES radiances and cloud imager data are merged together into one-hour swaths of data along the orbital subtrack. Process 3 produces the cloud properties and adjusts the atmospheric structure to produce consistency between the CERES radiances and the cloud property influences on those radiances. After this process, the original expectation was that the data would flow as a single-hour swath of CERES pixel-related radiant fluxes and cloud properties. The next process averages the pixel values into geographic averages, and then merges the results from as many satellites as were observing at one time.

The final steps in the CERES processing are expected to involve time averaging. On ERBE, the time interpolation of the top-of-the-atmosphere fluxes used linear interpolation for longwave fluxes over the oceans, a partial sinusoidal fit to the time variation of geostationary observations over deserts and land regions, and more complex interpolation for shortwave fluxes. For CERES, we will extend this interpolation philosophy in dealing with both top-of-atmosphere fluxes, as well as cloud properties and radiation fluxes at other points in the atmosphere.

We can see in the data flow diagram the influence of recent developments in extending the ERBE data. An algorithm by Li and Leighton allows us to accurately estimate the net shortwave flux at the surface from the net flux at the top of the atmosphere, using a relatively minor correction for column atmospheric water vapor. There is also additional work on computing an observational determination of the greenhouse effect at the Earth's surface based on well-calibrated observations with a spectrally flat filter that covers the atmospheric window. From this determination, we expect to be able to derive useful monthly estimates of the clear-sky longwave flux at the Earth's surface.

With this perspective, the CERES Science Team discussed the four issues we raised above. On the first issue, we can see that it would probably be useful to combine the new types of surface radiation budget information into data products that contain fluxes derived from the ERBE algorithms and from the new approach suggested in the last paragraph. The Science Team felt that the most appropriate move was likely to be simply using the existing, validated algorithms to develop intermediate data products. Then, the new surface radiation measurements could be appended with only a small amount of additional work, producing a slightly altered set of "ERBE-like" data products.

The appropriate kinds of cloud properties and their vertical overlap generated considerable discussion. Two members of the MODIS Team attended the CERES Science Team meeting to contribute their ideas toward building a consensus on how to resolve this issue. Most members of the Cloud Working Group have contributed algorithms and case studies to the literature, so there are strong ideas on what is likely to be successful and what is not. The general experience of the members of this Working Group is that no single method succeeds in accurate cloud retrieval at all times and for all places. The consensus of the group appears to be to use a hierarchical processing, in which statistical properties of large groups of pixels provide a context within which we can categorize pixels at finer spatial resolution.

The third major issue facing the Science Team is related to the appropriate description of cloud properties and the vertical structure of the cloud fields. We know that over a large fraction of the Earth where there are clouds, the layered structure familiar to our everyday experience includes broken and patchy cloudiness with many spatial scales. One of the more difficult problems in retrieving cloud properties has always been understanding how clouds are distributed within different layers. The radiation field within the atmosphere is strongly influenced by this layering. The question is "how do we represent that vertical structure so that it is preserves the true atmospheric data while still being useful to the atmospheric modelling community?". On the one hand, the clouds in the atmosphere have little knowledge of the standard vertical levels we use in modelling the atmospheric circulation. Yet, at the same time, the models are limited for the foreseeable future to finite vertical resolution with a small number of vertical layers. In the proposal to the EOS IWG, we had included many vertical layers in order to capture as much of the retrieved cloud structure as possible. However, this proposal has large data volumes and possible overinterpretation of the data. Thus, the Science Team consensus is to calculate radiation fluxes at many levels in the atmosphere, but to record the results of these calculations only at the top of the atmosphere, at the tropopause, at the Earth's surface, at the tops of the retrieved cloud layers, and at the 500 hPa level. Several years after launch, and after a suitable period of intensive validation of the cloud properties and fluxes, we may revise the data products so they contain additional vertical levels.

The final major issue has to do with time interpolation of cloud properties and radiation fluxes. Because the cloud properties influence the radiation fields nonlinearly, it appears likely that data users will have to be careful in interpreting the relationship between time-averaged cloud properties and radiation. The time average of the radiation fluxes may not be well modeled by using a radiative transfer calculation with time-averaged cloud properties. The Cloud Working Group agreed to consider this matter further at a Working Group meeting in Denver in mid-September. We should also note that a significant portion of the user community represented on the CERES Science Team felt that radiation and cloud properties interpolated to standard synoptic times of the day were essential and had considerable use in the meteorological community.

Following the meeting, the CERES Science Team and the CERES Data Management Team worked on refining their estimates of data product sizes and contents.

At the meeting, the Science Team also discussed development of the CERES instruments, which continues to make good progress. Following the meeting, members of the CERES Instrument Working Group visited TRW, Inc., to conduct a review of the proposed ground calibration procedures and the algorithms to be used for reducing that data. The Instrument Working Group considered it important to understand calibration at this time because the CERES Flight Test Model will be undergoing calibration later this year in preparation for the CERES Critical Design Review in mid-December. Although an initial agenda for the calibration review covered nearly a week, the Instrument Working Group found that it was effective to present their understanding of the procedures and algorithms to the contractor, who could then correct any misunderstandings. Before the meeting, the Principal Investigator had prepared a preliminary paper describing his understanding of the data reduction, and distributed that to members of the Working Group and to the individuals at TRW and other parts of the Project with an interest in the ground calibration. This way of reviewing the ground calibration proved to be extremely efficient and cost effective because it minimized the preparation time by the instrument contractor and also made it easier to have a constructive dialogue on the calibration. Instead of taking a week, the calibration review lasted only two days, and resulted in a much improved understanding of the calibration.

LAWS Science Team

— **Wayman E. Baker**, National Meteological Center, Camp Springs, MD

The Laser Atmospheric Wind Sounder (LAWS) Science Team met July 26-28, 1993, in Paris, France at CNES Headquarters. The meeting was attended by eight science team members, one associate team member, one adjunct team member, and 31 other people from NASA Headquarters, NASA/Marshall Space Flight Center, NASA/Goddard Space Flight Center, the Department of Defense, CNES, ESA, France, the United Kingdom, and private industry.

Considerable time was spent discussing possible NASA/CNES proposals for a joint Doppler wind lidar mission. A joint NASA/CNES mission definition document was finalized at the meeting.

Also discussed was the status of the NASA/DOE "Quick LAWS" efforts. In addition, the status of the NOAA/NESDIS-funded LAWS Technology Readiness Assessment Study, underway at MIT/Lincoln Laboratory, was summarized.

A manuscript highlighting the importance of Doppler lidar wind measurements for weather and climate prediction was reviewed at the meeting and will soon be submitted to the *Bulletin of the American Meteorological Society*.

Finally, it was noted that this was the first formal LAWS Science Team Meeting in France. Both U.S. and French participants expressed their strong desire that this meeting will inaugurate a long and successful collaboration on Doppler wind lidar.

Topical Science Workshop on Remote Sensing of Aerosols and Atmospheric Corrections from MODIS/EOS

May 17-18, 1993, in Greenbelt, Maryland

—**Yoram Kaufman**, Goddard Space Flight Center

CHARTER AND OBJECTIVES OF THE WORKSHOP

The workshop was initiated by the MODIS Science Team members who are associated both with remote sensing of aerosols and with atmospheric corrections. The decision to conduct the workshop resulted from the need for closer communication and collaboration among scientists developing methods for corrections of atmospheric effects over the oceans and land, as well as methods for remote sensing of aerosols above the oceans and land. A closer communication with the outside scientific community was also recognized as being needed. Scientists working on AVHRR, MISR, POLDER, EOSP, and Japanese sensors were also invited to review the MODIS activity and report on their own developments that could be relevant to MODIS algorithm development. Specific objectives of the Workshop were:

- To *review* and *critique* current algorithm concepts for analysis of MODIS data for remote sensing of aerosols and for atmospheric corrections.

- To compare and generate a stronger *link* between the algorithms for correction of atmospheric effects over the *oceans* and correction over the *land*.

- To review *new methods* for remote sensing of *aerosols over the oceans* and to compare them with by-products of atmospheric correction over the oceans.

- To review the algorithms and products anticipated from *other sensors* available simultaneously with MODIS in order to consider their use in the MODIS activity.

- To review the main *unresolved scientific issues* regarding remote sensing of aerosols and atmospheric corrections.

- To review the planned activity for *validation* of the MODIS aerosol products.

During the review of the algorithms, several scientific issues that require further consideration and research focus were identified. The issues were identified as part of the presentations or as part of the vigorous discussion that followed.

Atmospheric Correction Over the Oceans

The additional near-IR channels on MODIS designed for atmospheric corrections over the oceans introduce new opportunities and new challenges. Howard Gordon reviewed the use of these channels in the algorithms and the results of a sensitivity study that reveals the errors possible in extrapolation of the atmospheric path radiance from the near-IR to the visible channels for purpose of atmospheric corrections. Gordon and Wang developed a correction algorithm that is based on the utilization of nine aerosol models. This was necessary because it was found from simulations that the effects of multiple scattering, which must be included in order to meet the accuracy requirements of SeaWiFS and MODIS, depended significantly on the aerosol model. For the aerosol models similar to those that were used in the analysis (maritime, tropospheric, and coastal), the errors in simulated retrievals were acceptable, i.e., the uncertainty in the surface reflectance was approximately 0.001. However, when an urban model was used as the real aerosol to produce SeaWiFS-simulated data, the errors were significantly larger because the urban model has considerably more absorption than the models on which the correction is based. This type of aerosol is less likely to be present over the oceans except for outbreaks of pollution off the coast of industrial regions, but it shows some of the uncertainties associated with the algorithm. Gordon believes that one of the main uncertainties in utilizing this algorithm is our lack of knowledge regarding the validity of the aerosol models.

There are other problems that must be faced for either atmospheric correction over the oceans or for aerosol retrievals. One problem is the presence of whitecaps on the sea surface. Whitecaps can easily have reflectances of about 0.005, which is a significant fraction of the reflectance due to aerosols in the near-IR. The whitecaps depend on the wind speed and the atmospheric stability in a way that is only poorly known. Another problem is the calibration of the sensor itself. The water-leaving radiance over the oceans is generally so small that its retrieval requires excellent sensor calibration. Most agree that the necessary calibration accuracy can only be achieved by recalibration of the sensors in-flight. Such vicarious calibration requires precise knowledge of the columnar aerosol optical properties coincident with the satellite overpass.

Aerosol Models

Aerosol models used in simulations of remote sensing and atmospheric corrections over the land and oceans are based on limited information about the aerosol particles. This information is based mainly on measurements from the ground and may not represent the vertical column. The optical properties of the aerosol particles in the models are calculated using Mie theory, which assumes perfectly spherical and homogeneous aerosol particles with fixed refractive indexes as a function of particle size. There is a need to evaluate these models against optical aerosol measurements and remote sensing cases, in order to judge their applicability for MODIS and EOS science.

The sparse information available today is conflicting. While some measurements show differences in the modeled and actual optical properties of dust of 30% to 300% (Koepke and Hess; Nakajima et al.), Tanré et al. showed good agreement between remotely retrieved dust properties and ground truth using a dust model. Fraser et al. obtained good agreement between satellite-derived aerosol optical thickness and ground-based measurements over the Eastern U.S. using these models. Ground-based remote sensing of aerosols by Kaufman et al. shows that the scattering phase function (a main parameter affecting remote sensing) computed from Mie theory is only 20%±15% different from the actual phase function. These measurements were made in various climatic regions: desert transition zone, industrial pollution in Europe, mixed California air, smoke in Brazil, etc. Several groups are working on forming networks to perform such measurements on a regular basis: Teruyuki Nakajima in Japan and China, Didier Tanré in France, Howard Gordon over the ocean, Brent Holben in Brazil, Chris Justice at Long Term Ecological Research (LTER) sites in the Eastern U.S., Robert Frouin in California, Yoram Kaufman over U.S., Europe, middle East, and other targets of opportunity, and Larry Stowe and Sasha Ignatov over the Clemente-Colon Islands and ships of opportunity. This review of the status of models and aerosol properties resulted in the main recommendation from the workshop (see below).

Remote Sensing of Aerosols Over the Oceans

Aerosol properties are a by-product of Howard Gordon's atmospheric correction scheme. However, the MODIS channels provide additional near-IR channels that can enhance the retrieved aerosol information. Two techniques have recently been suggested for taking advantage of this capability. Both techniques are based on ocean properties derived by Gordon's correction scheme. Didier Tanré and Yoram Kaufman suggested basing their technique on a look-up table of log-normal size distributions with a two-step correction for multiple scattering and the use of a principal-component-analysis technique that can speed and stabilize the inversion process. Terry Nakajima suggested a direct inversion scheme similar to the inversion of skylight developed by him. Work on both methods has just begun.

Using the 0.55 μm to 2.15 μm range, it is anticipated that 3-to-4 independent pieces of information on the size distribution can be obtained from the data. The success of the remote sensing technique will strongly depend on the calibration precision between the spectral bands. Assuming that stratospheric aerosol (if present) will be accounted for using SAGE III and the 1.375 μm channel on MODIS, these four pieces of information can be used for tropospheric aerosol. Optically, it should be possible to infer the accumulation and coarse-particle modes of the aerosol size distribution. Candidate size distribution characteristics to be inferred are the central radius of each mode, the ratio between the volume of particles in the two modes, and the width of the accumulation mode. The last parameter is likely to be less well determined, though possible, since backscattering light to space is sensitive to small particles. This parameter may be very important due to the recent suggestion (Hoppel et al.) of the presence of two accumulation modes, one resulting from coagulation of smaller particles around a radius of 0.1 μm and a second resulting from particle growth in cloud processes. The width and location of the accumulation mode observed from space may be used to determine the frequency of occurrence of these two modes.

The NOAA AVHRR Experience

Larry Stowe and Sasha Ignatov showed the success of the NOAA oceanic aerosol product in revealing the location, frequency, duration, and magnitude of the main aerosol outbreaks. The influence of pollution from industrial regions, biomass burning, and dust is clearly present. The data were also used to track the stratospheric aerosol resulting from the eruptions of Mount Pinatubo. Their presentations also showed the importance of sunphotometer validation to assess the effects of errors introduced by satellite calibration, surface reflectance, aerosol size distribution, and single scattering albedo. Many more such studies are required to fully validate the NOAA aerosol optical thickness product. Two- and three-channel (NOAA-K, L, M, AVHRR) retrieval algorithms are under development to reduce the influence of, and to detect, particle size.

Remote Sensing of Aerosols Over the Land and Atmospheric Correction

Yoram Kaufman and Didier Tanré discussed this topic with help from Eric Vermote, Lorraine Remer, and Bo-Cai Gao. For remote sensing of tropospheric aerosols, Kaufman's group is studying the use of the 2.15 and 3.75 μm channels of MODIS to find dark pixels. Due to the relation between the surface reflection properties in the mid-IR and the visible part of the spectrum, these pixels will also be dark in the visible. Most aerosol particles are small and transparent to mid-IR radiation. Therefore, these pixels can be determined in the mid-IR with minimal atmospheric interference. To develop this technique, data from the AVIRIS and MAS airborne sensors and the Landsat TM spaceborne sensors are being used.

Collaboration with MISR

On the EOS-AM platform, MODIS will share the view with MISR. MISR has a smaller spatial coverage than MODIS as well as a narrower spectral range, but views a given spot from nine simultaneous view directions. This viewing geometry should prove highly advantageous for remote sensing of aerosol properties. One possible scenario is that over the ocean and over vegetation, MISR-derived optical thicknesses will be compared with those derived from MODIS. Discrepancies can be used to learn about the capability of these sensors and about specific optical properties of aerosol that may affect remote sensing from these sensors differently. Over dry land masses, MISR can be used to derive the aerosol optical thickness every 4-9 days, and the contrast-reduction technique of Didier Tanré, applied to MODIS, can then be used to retrieve values for the rest of the days, using the MISR data as an anchor. The surface bidirectional properties have to be handled correctly to succeed in this process.

The POLDER Surprise

Pierre Deschamps and Didier Tanré discussed the capability of the POLDER instrument, to be flown as part of the Japanese ADEOS Satellite System. This is an experimental sensor, with calibration based on inflight comparison with surface and atmospheric targets. It has, however, some new and interesting capabilities. The main one is the use of polarization. Recent polarization images acquired from an airborne version of POLDER over a land area covered by mixed vegetation and soils showed that in the visible channels the polarization signal from aerosols is much stronger than that from the underlying vegetation. Quantitative analysis of the information content of aerosol properties using polarization measurements has not yet been performed and demonstrated.

Cirrus Clouds

MODIS will have a new capability to observe cirrus clouds without interference from the Earth's surface, clouds, and aerosol in the lowest 6 km (provided the precipitable water vapor [in cm] exceeds 0.5 cos θ_o where θ_o is the solar zenith angle). There is a need to develop correction schemes for the effect of cirrus clouds on remote sensing of the surface. Preliminary results were presented by Yoram Kaufman and Bo-Cai Gao.

MAIN RECOMMENDATIONS

1. Further development of the algorithms for remote sensing of aerosols and atmospheric correction requires a better understanding of the actual optical properties of aerosols and their relation to the aerosol type and atmospheric processes. These properties should be integrated throughout the vertical column, distinguishing between tropospheric and stratospheric aerosol. These properties are also important for understanding the direct and indirect aerosol effect on the Earth's radiation balance. It is recommended that networks of sunphotometers/radiometers be established such as the ones being developed by Tanré and Holben at CNRS/NASA; by Prospero, Voss, and Gordon at the University of Miami; and by Nakajima at the University of Tokyo. These networks should be sited so as to measure the properties of major aerosol types as a function of the distance from the sources, in order to observe the effect of atmospheric conditions on the aerosol properties. These instruments, which measure the solar radiance and the angular distribution of sky radiation, can provide the aerosol optical thickness, the size distribution, and the scattering phase function. It is important to note that measurements of the aerosol optical thickness alone are not sufficient to characterize the aerosol for remote sensing purposes. Some algorithms are also being developed to derive the single scattering albedo (a measure of aerosol absorption) from these data (Wang and Gordon) or from comparisons with satellite measurements (Nakajima, Stowe, and Ignatov). The network should be supplemented occasionally with instruments to measure the downward fluxes and with instruments to measure the solar and sky radiance out to 2.15 μm.

2. It is recommended that within a year or two a follow-up Workshop be convened on remote sensing of aerosols from EOS and on atmospheric corrections, with a broader charter than that of the first Workshop. The Workshop should represent all EOS sensors with aerosol capability and the user community, e.g., investigators involved in climate and atmospheric chemistry.

From *EOS News*

Upper Atmospheric Research Satellite

On September 17, the Upper Atmosphere Research Satellite (UARS) performed a forward to reverse yaw maneuver during which the solar array drive experienced some unexpected slippage. The array stopped and software turned off all instruments except the low power MLS (Microwave Limb Sounder) and parked the array. Software has been implemented to automatically engage the array at 2 times normal rate if it falls more than 15 degrees behind. This approach is working successfully, but is required on nearly every orbit. The incident indicates further degradation of the solar array drive clutch on the 2-year old satellite. Batteries are not at risk. Presently, all instruments except HALOE (Halogen Occultation Experiment) are off. Alternatives for resuming normal operations are being studied, and include 1) relying on the current software fix, and 2) driving the array using the second drive motor and clutch.

ACTS Launched

The Advanced Communications Technology Satellite (ACTS) was successfully launched from Space Shuttle Columbia on September 12. ACTS provides for the development and flight test of high-risk, advanced communications satellite technology such as: Ka-band (30/20 GHz) operations, where there is 2.5 GHz of spectrum available (5 times that available at lower frequency bands); very high-gain, multiple hopping beam antenna systems which permit smaller aperture Earth stations; on-board baseband switching which permits interconnectivity between users at an individual circuit level; and a microwave switch matrix which enables gigabit per second communication. Compared to conventional satellites, these technologies provide for up to 3 times the communications capacity per weight, 20 times higher communication rates between users, greater networking flexibility and on-demand digital services not currently available. ACTS technologies will potentially lower the cost or technical thresholds so that such new services such as inter-connection of supercomputers will be feasible. ACTS is in a geostationary orbit over the equator at 100 degrees west and experiments by industry, university, and government science teams will begin in December. The satellite is designed for a minimum life of 2 years but has enough fuel to last over 4 years.

Surface Processes Airborne Research Management and Operations Working Group

— **Lee F. Johnson**, Johnson Controls World Services, NASA/ARC

The Surface Processes Airborne Research Management and Operations Working Group (SPARMOWG) is a technical operations working group which provides operational support to the Earth surface processes remote sensing component of NASA's airborne science program. The SPARMOWG evolved from the former Land Airborne Science MOWG in June 1992.

The Group reviews and provides guidance options for those program elements within the NASA Office of Mission to Planet Earth (MTPE) which utilize research aircraft and remote sensing instruments to acquire data for Earth system process studies. The Group serves as a forum for discussion by the surface process science community regarding the utilization of aircraft and remote sensing instruments, and the storage and retrieval of airborne remotely sensed data. The SPARMOWG represents the interests of the surface processes remote sensing user community to the NASA airborne science program by staying abreast of the community's needs for aircraft, sensors, and data. The SPARMOWG continuously reviews the surface processes airborne science program with regard to its effectiveness and quality, to identify strengths and weaknesses in the program, to identify problems and issues to be addressed, and to recommend possible solutions. Finally, the Group raises issues with respect to potential new scientific opportunities for the aircraft program, and responds to requests for assessment of new opportunities raised by NASA/MTPE.

Members of the SPARMOWG are nominated by Branch Chiefs and Program Managers within the MTPE program elements. Members serve nominal 3-year terms. The Group is composed of approximately 20 formal members, representing a balance of Earth scientists, remote sensing instrument experts, and aircraft mission operations managers and is currently chaired by James Lawless (NASA/ARC).

The SPARMOWG meets twice each year. The most recent meeting was held at the University of Wisconsin on June 22-23. At that meeting, Ed Sheffner (USRA) announced that an initial version of a bibiography of Global Change Airborne Science has been compiled and is available for internal (SPARMOWG) review. The bibliography (currently containing 1000+ citations from the years '85-'92) is accessible by End-Note software in either the Macintosh or PC environments. It is intended for eventual use as a research tool for the general community. Jeff Simmonds and Jakob van Zyl (both JPL) announced that they are establishing an electronic bulletin board which will list the archived AVIRIS and AIRSAR datasets.

Simmonds presented a survey of Calibration Facilities resident at JPL, ARC, and GSFC, and also presented ideas on future remote sensing instruments for the visible, NIR, and MIR (0.3-5 micrometer) regions which could be built from "off-the-shelf" components. Concerns were raised that the MODIS Airborne Simulator, which is considered by many to be a facility instrument, lacks adequate engineering and calibration oversight. Similar concerns were also raised for the TIMS instrument. Recommendations are being formulated for presentation to Headquarters.

Guest speaker Phil Russell (NASA/ARC) presented an updated status report on remotely piloted vehicles (RPV's), both high altitude and nap-of-earth. Russell discussed the Enviromental Research Aircraft and Sensor Technology program, which will provide funds for both platform and sensor development. To-date, most advocacy for RPVs has come from the atmospheric research community. Diane Wickland (NASA/HQ) will take the lead in arranging an adjunct session at an upcoming symposium for the discussion of advanced aircraft and sensor requirements of the Earth Science community.

The next SPARMOWG meeting is scheduled for January 11-12, 1994, at the Jet Propulsion Laboratory.

Workshop on Data Assimilation for EOS

May 3-5, 1993 at NASA/Goddard Space Flight Center

— by **R. Errico**, National Center for Atmospheric Research, Boulder, Colorado

The purpose of the workshop was to discuss data assimilation requirements and proposed methods for EOS. Invitations were sent to each interdisciplinary science team Principal Investigator (PI) requesting a representative from his group. Approximately 60 people attended, primarily from the EOS data assimilation community. The workshop organizers were R. Errico (National Center for Atmospheric Research, NCAR), W. Higgins (NASA), T. Vukicevic (NCAR), and J. Derber (National Meteorological Center).

Session Summaries

Welcoming remarks were given by F. Einaudi, Chief of NASA's Goddard Laboratory for Atmospheres (GLA), R. Rood, Head of GLA's Data Assimilation Office (DAO), and R. Errico, Co-PI of the interdisciplinary EOS project at NCAR. G. Asrar, EOS Program Scientist, began with a summary of the current status of the EOS project and platforms. He stated that EOS particularly needs data assimilation to provide temporal continuity (especially diurnally) and important fields that will still be inadequately observed, including wind, precipitation, and soil moisture.

R. Rood described the DAO and its plans through the beginning of the EOS era. The goal of the DAO is to "produce research-quality data sets for generalized Earth-science applications, with a particular emphasis on EOS." Its current plan is to systematically develop a data assimilation system starting from current optimal interpolation algorithms and heading towards fixed-lag Kalman smoothing. Substantial model development is required, particularly for physical parameterization schemes, as is development and testing of algorithms with simplifying assumptions for practical implementation of Kalman smoothing. The accomplishment of these goals requires extensive coordination (particularly sharing of information and expertise) with the operational numerical weather prediction (NWP) centers and the research community, as well as feedback from users of the DAO products. What the DAO produces will be limited by time and resources (both manpower and computer hardware).

The first two speakers in the afternoon were representatives from two operational NWP centers. P. Courtier of the Data Assimilation Branch, European Centre for Medium-Range Weather Forecasts (ECMWF), described the 4-dimensional variational data assimilation system using adjoints that is currently being developed at ECMWF with expected operational implementation sometime next year. Its feasibility has already been demonstrated on one case, with very encouraging results. Courtier also discussed the cooperation between the European Space Agency (ESA) and ECMWF regarding correction of algorithms used by ESA for processing of ERS-1 scatterometer data: essentially, discrepancies between the ESA retrievals and the ECMWF background analyses indicated the existence of errors in the former. J. Derber, National Meteorological Center (NMC), outlined ambitious plans at NMC for including new fields (as either input or output) for their data assimilation system. He described how the accuracy of satellite-derived temperature retrievals has been substantially improved recently by utilizing information provided by output from the NMC data assimilation system.

J.N. Paegle (U. Utah) concluded the first afternoon by presenting an example of the current uncertainty in characterization of the atmospheric hydrological cycle. She described a comparison of monthly mean fluxes through walls in various locations in both hemispheres computed using analyses produced at different centers, and demonstrated that the combination of insufficient wind observations and the current difficulty of modeling the circulation in regions of steep terrain create relative uncertainties in the moisture flux divergence of order 1 within the important region of the Amazon Basin.

The second morning was occupied by presentations by S. Cohn and R. Todling of the DAO. Cohn began with a tutorial on the basics of estimation theory and finished with a description of how the DAO plans to implement fixed-lag Kalman smoothing. He made clear the necessity of testing potential approximations to the theoretical formulations, due to the computational magnitude of the problems posed. This requires some trial and error with a hierarchical system, since it is difficult to *a priori* estimate the degree of sub-optimality introduced by such assumptions until the data assimilation community has greater experience with them. Todling described a hierarchical series of experiments using a simple model to demonstrate the improvement of optimal interpolation by systematic relaxation of its simplifying assumptions.

On the second afternoon, D. Salstein (Atmospheric and Environmental Research, Cambridge, MA) described the general agreement between calculations of the length of day using either astronomical or atmospheric wind measurements (the latter by invoking the approximate conservation of angular momentum between the solid Earth and atmosphere). He suggested that if we had more accurate wind information we might be able to infer some characteristics of the motions within the Earth as well.

Also during the second afternoon, S. Schubert (DAO) and M. Kanamitsu (NMC) described the reanalysis efforts at their respective centers. The data assimilation systems at all the centers which regularly produce global data sets have undergone significant changes frequently in the past. As a result, the greatest changes to climatic statistics derived from these data sets are a result of changes in analysis method (or model) or observing system network rather than a likely result of true climate change. The goal of these reanalysis efforts is to produce a 5-year benchmark (at DAO) and a longer data set (at NMC) based on an unaltering assimilation system. Comparison of the analyses will highlight some uncertainties in the existing systems, and a more temporally consistent system will make detection of significant climate change more possible. Schubert also described some experiments highlighting the uncertainty of the analysis due to uncertainty of model parameters.

J. Pfaendtner presented an overview of the DAO GEOS-1 data assimilation system (DAS). He focused on a discussion of the conventional data assimilation cycle in the GEOS-1 DAS including a discussion of the Incremental Analysis Update (IAU). In the IAU procedure, standard OI analysis increments are computed at the analysis times (0, 6, 12, 18Z). The increments are then inserted gradually into the GEOS GCM by rerunning the forecast and adding a fraction of the increment at each model time step. The assimilation thus effectively consists of a continuous GCM forecast with heat, momentum, moisture, and mass source terms updated every 6 hours from observations. Pfaendtner illustrated the quality of the balance achieved when using IAU.

The third morning began with J.-N. Thepaut (ECMWF) describing the interactions between dynamics and satellite observations in a 4-dimensional variational data assimilation system. He compared the flow-dependent interpolation structure determined by the variational scheme with those specified by the currently operational (optimal interpolation) scheme. The former spreads information much further. He then showed some effects of TOVS radiances on the new system. Additionally, SSM/I precipitable water observations were shown to significantly impact the wind analyses through consideration of the advective dynamics. ERS-1 scatterometer observations also had substantial impact on the analyses in several locations.

Akira Kasahara (NCAR) described attempts to produce more accurate and mutually consistent analyses of wind, temperature, atmospheric moisture, and precipitation. This is intended to reduce model spin-up problems (regarding moist physical processes). His method combines several balance conditions (including diabatic nonlinear normal mode initializations) and variational fitting of observations with constraints based on model parameterization schemes for convection. Arthur Mizzi (NCAR) followed this with a description of estimation of daily tropical precipitation rates from satellite-measured OLR and cloud albedo using regression techniques.

S.-K. Yang (in work done with A. Miller, representing the CERES Science Team) presented data assimilation requirements for optimal retrievals from the CERES instrument. Most useful will be cloud top pressures, but also important are accurate temperature (<1° K error) and relative humidity (<10% error) on a 1.25° grid with better than 25-mb vertical resolution below 700 mb (particularly in regions of marine stratus and inversions) at 3 hour intervals. Winds and SSTs also are required. The error characteristics of the assimilated products must be provided.

L. Walstad (Oregon State U.) presented a list of assimilation products required for oceanic climatological studies. Foremost was surface wind stress followed by the sensible heat and radiative fluxes at the surface, as well as the salt flux (the difference between evaporation and precipitation). Wind on a scale of 200 km may be sufficient for many purposes, so that wind curl on a scale of 400 km may be determined, except near coasts where gradients of many quantities within the ocean are much steeper. The diurnal cycles of heat exchanges are also important.

The final afternoon was filled with discussion regarding several key issues raised during the previous days. These included: (1) the need for data assimilation for achievement of EOS goals; (2) the need for greater resources (computational and personnel); and (3) the need for more effective use of existing resources. The consensus of this discussion appears in the conclusions and recommendations to follow.

Conclusions

Data assimilation using an NWP-type model is critical to the success of EOS. This criticality should not be underestimated: (1) The use of ECMWF products to enhance and correct satellite-derived products provided by ESA and the use of NMC products to enhance those provided by NESDIS have already demonstrated the great importance of data assimilation for accurate and quality-monitored data retrieval from satellites. (2) Only a data assimilation system can produce statistically optimal and dynamically and physically consistent global synoptic fields. Without such a system, most EOS analyses will be limited to calculations of some simple statistics of a few "directly" observed fields. (3) In particular, with no wind observing system planned for EOS, process studies will be extremely limited since advection, both horizontally and vertically, is such a dominant mechanism.

Great strides have been made in data assimilation during the past few years. Resolutions of the atmospheric models used in data assimilation systems have increased (the ECMWF grid has approximately 60-km resolution outside the tropics) and the analysis techniques have improved. During most of the last decade, the analysis improvements consisted primarily of finer tuning of parameters, but last year NMC made some significant changes and even more significant changes are being planned for next year at ECMWF. The DAO has even more ambitious plans. These new systems are being designed with fewer assumptions based on computational requirements alone and instead will produce data sets more consistent with our knowledge of true atmospheric dynamics and statistics. Analyses produced by them will likely be a quantum step over those of the last decade, as the current ones are over those of the decade before. These new systems are not just theoretical, but at some centers are close to operational implementation.

Development of the data assimilation systems envisioned for the last half of this decade requires a significant commitment of computational and personnel resources. The computational resources for the most statistically optimal application of estimation theory will likely be unavailable throughout the EOS era. This implies that good sub-optimal systems must be developed instead. A community of developers must accumulate experience regarding which approximations produce the most accurate results for an acceptable computational cost. Further development of quality control algorithms and model physical parameterization schemes are also required. It is clear that the EOS program alone, even augmented by other NASA programs, cannot provide the necessary personnel. Only through enhanced cooperation, including stimulation and entrainment of the university research community, can these goals be met.

An additional requirement for successful development of a data assimilation system for EOS is a contingent of investigators using and monitoring products produced by the DAO. Once investigators recognize the need for data assimilation products such as wind fields, there will of course be large numbers of such users. It is important, however, that monitors also be involved during some of the development phases. It is also important that users interact with developers to ensure that the most appropriate decisions are made regarding which fields are produced and at which resolutions.

Recommendations

To the data assimilation community, it still appears that many EOS investigators do not appreciate what data assimilation can provide to enhance their studies or even how critical its products may be for their research. For this reason, part of a future IWG meeting should be devoted to educating the EOS community about the critical importance and exciting prospects of data assimilation.

Some time next year a second workshop on data assimilation for EOS should be convened. The primary purpose of this second workshop would be to continue coordination of data assimilation development and research between the DAO, NMC, NCAR, and others, as well as to perhaps entrain others within the research community. It is important that users and potential users of the assimilated data be encouraged to attend.

LAWS or a similar wind sounder may not be flown on an EOS satellite or any other satellite during the EOS era. If estimates of wind are critical to many of the EOS problems, however, some other source of wind information must be available. Furthermore, even if wind analyses are not actually critical to the general success of EOS, the usefulness of the EOS data will be greatly enhanced if concurrent wind information is available. The only dynamically consistent, temporally frequent, globally covered, and statistically optimal source of wind information will be a data assimilation system. These facts should be considered when budgets and resource allocations are determined.

DAAC FOCUS Goddard Space Flight Center

— **Paul Chan**, Goddard DAAC

The Goddard DAAC (GDAAC) is responsible for archiving and distributing data related to the upper atmosphere, atmospheric dynamics, global biosphere, and geophysics. Geophysics data are currently being supported by the Crustal Dynamics Data and Information System (CDDIS), a separately funded data system at GSFC.

One challenge of the GDAAC is that the development is carried out in parallel to the day-to-day operation. For the past twelve months, it has been very active in acquiring new data sets, developing local GDAAC software, and providing user services. The GDAAC has also done thorough planning and preparation to ingest, archive, inventory, and distribute data from the UARS and SeaWiFS projects.

The GDAAC currently provides access to and information about a wide variety of data sets in climatology (ISCCP, FIRE, GEDEX, and FIFE) and global biosphere (AVHRR Land Pathfinder, CZCS, TM, MSS, and SMMR VegIndex). The GDAAC will begin distributing UARS data to the science community in October, 1993. The distribution of SeaWiFS data to authorized users will begin shortly after satellite launch in June 1994. These two data sets culminate many months of planning and working together with the UARS and SeaWiFS projects. The SeaWiFS data set will be the first up-to-date ocean color data set since the days of the CZCS and is expected to be one of the most sought after data sets archived in the GDAAC.

The GDAAC has also committed substantial resources in planning and preparing to archive, inventory, and distribute the Pathfinder data sets including the AVHRR and TOVS Pathfinders. The following list shows when new data sets will be available from the GDAAC in FY94.

UARS Level 3a	Oct 93
TOMS2 Level 3	Oct 93
TOVS Benchmark Data	Nov 93
TOGA-COARE Field Data	Jan 94
SeaWiFS Data (for June 94 launch)	Aug 94

In order to automate data distribution, the GDAAC has made a significant effort in developing the Version 0 system. The latest release of the software includes automated data ingest and archive, an on-line tutorial, on-line search of metadata and ordering of data, and Hierarchical Data Format (HDF) implementation. It has also acquired substantial computing resources to build up the infrastructure to prepare for the influx of new data sets during the next year. The DAAC is providing incremental operational support as we head towards July, 1994, when the version 0 system will be completed.

The GDAAC is collaborating with the Goddard Laboratory for Terrestrial Physics in publishing five CD-ROMs of data from the First ISLSCP (International Satellite Land Surface Climatology Project) Field Experiment (FIFE), and is planning to publish the data formerly available through the NASA Climate Data System on CD-ROMs. It is also collaborating with the ISLSCP to publish two CD-ROMs that will provide data for the modeling of global water-energy-carbon cycles, carbon and biogeochemical cycles, and ecosystems.

In the near future, data will be available through both the GDAAC's on-line Information Management System (IMS) and its User Support Office. Initial IMS support includes all functions necessary to order data: generic metadata search, on-line help, and product request. As the IMS evolves towards the operational July 1994 release, additional functions will be added, including a distributed browse facility and coincident data search support.

For the twelve month period ending June 1993, the GDAAC received about 3500 inquiries about its existing archived data, and distributed over 2600 data sets using magnetic tape media, CD-ROMs, or electronic file transfer. By the third quarter of 1994, as a result of the addition of new equipment, the GDAAC will be able to distribute 60 Gigabytes of data per day via electronic file transfer and various magnetic and optical media.

Anyone interested in more information on the GDAAC data holdings may contact the GDAAC User Support Office at (301) 286-3209 or via e-mail at daacuso @eosdata.gsfc.nasa.gov.

DAAC FOCUS
CIESIN: Broadening User Access to the EOSDIS

— by **Robert J. Coullahan** and **Carroll A. Hood**, Consortium for International Earth Science Information Network (CIESIN), Washington Operations

CIESIN and the USGCRP: Understanding the Focus

The Consortium for International Earth Science Information Network (CIESIN) is a non-profit consortium of universities and research institutes that was created in 1989 to respond to an initiative of the U.S. Congress. This initiative sought to ensure the widest possible access to, as well as the coordination and integration among, the results of other federally funded investments in Earth and environmental monitoring and parallel international efforts. Special emphasis was placed on the generation of policy-relevant information to enable informed decision-making about the environment. In the three years since its inception, this mandate has manifested itself in a number of federal and international activities.

The apparent diversity in the scope of CIESIN activities and user base can often be a source of confusion without an understanding of the context within which CIESIN was created. It is important to note that in 1992, the National Research Council, Committee on the Human Dimensions of Global Change reported that:

> "An information network should be designed for global change research (including the human dimensions) that will make catalogues, data bases, data transformation, documentation, scientific literature, and other public information more widely and inexpensively available. As part of the network, we recommend that the federal government should seriously consider establishing a national data center on the human dimensions of global change parallel to the existing national centers for data on climate, oceans, geophysics, and space science."

The CIESIN mission is "to provide access to and enhance the use of information worldwide, advancing understanding of human interactions in the environment and serving the needs of science and public and private decision making." For NASA, the mission and capabilities are very focused, directed toward: a) enabling broad access to the EOSDIS for non-traditional users of Earth science information, and b) providing an integrated data resource in the interdisciplinary domains supporting the investigation of the human dimensions of global change research.

Despite the breadth of our mandate, references to CIESIN, especially within the NASA community, are typically associated with socioeconomic data and the human dimensions of global environmental change. This perception is consistent with our responsibility for developing and operating a Socioeconomic Data and Application Center (SEDAC), which is an integral part of EOSDIS. It is also consistent with many of our international activities and with the data acquisition and development framework of our Information Cooperative (i.e., to create a distributed virtual archive of data and information that are relevant to the human dimensions of global environmental change.) The reasons for this strong correlation are twofold:

- Within the last year, a review of the guiding strategic principles of the U.S. Global Change Research Program has embraced the notion that the assessment of the social, economic, and human responses to global environmental change is as fundamental to the overall Program goals as is an understanding of the underlying physical processes. Such assessments are also required to ensure that sound and prudent policy decisions are made with respect to the environment.

- CIESIN, given its close ties to the physical science, social science, public health, and policy communities, is in a unique position to fill this niche. No other single organization, agency, or entity has the charter, the organizational flexibility (i.e., consortium), or the experience base to undertake this responsibility.

Thus, we recognize that the human dimensions of global environmental change is and will continue to be our area of greatest emphasis. At the same time, however, we remain committed to the intent of our broader original charter.

We firmly believe that the combination of our agency-neutral perspective, our national and international contacts and cooperative agreements, experience, and our state-of-the-art information systems expertise will enable CIESIN to play a leading role in improving the management of and access to a diverse set of Earth and environmental data and information worldwide — thereby extending the reach and effectiveness of the EOSDIS in meeting international objectives in improving the understanding of Earth as an integrated system in tandem with the societal impacts of global change.

Focus of the FY 1993 Program

Understanding human interactions with the environment unveils other pressing global change issues such as explosive population growth, sustainable agriculture, and the availability of fresh water resources. The U.S. Government, with the leadership of NASA defining the need, recognized that EOS was vital because the causes and effects of environmental change could not be understood through a retrospective analysis of extant data alone. A national commitment and a major investment in the development of instruments such as EOS was essential. The same rationale and analysis apply in the case of human dimensions factors. Extant resources, though invaluable, are often not properly configured to enable their immediate integration with physical data, and in fact require conditioning even to be utilized with other socioeconomic and public health data.

Establishing priorities before commensurate investment of resources was a first step taken by the U.S. prior to the initiation of EOS. CIESIN has commissioned an international study team specifically to guide the long-range planning process from the point of view of vital socio-economic data. The international commission is chaired by Sir Claus Moser of Oxford University, former Chairman of the United Nations Statistical Advisory Committee. In addition to social scientists and statisticians, the committee will include physical and biological scientists in order to ensure that there will be integration of data needs and understanding of human interactions in processes of global change. The current CIESIN SEDAC Science Data Plan is organized around eight data categories: 1) Population Dynamics; 2) Human and Environmental Health; 3) Agricultural Metabolism; 4) Social and Political Structures and Institutions; 5) Industrial Metabolism; 6) Land Use; 7) Economic Activity; and 8) Human Attitudes, Preferences, and Behavior.

SEDAC, CIESIN's Contribution to EOSDIS

The Statement of Work for SEDAC development (written by NASA) succinctly describes the role of the SEDAC in EOSDIS: The ultimate goal of the MTPE program is to see the fruits of the Earth science research program translated into tangible benefits to the American people . . . by way of improved public policy making. For this to be possible, Earth science research results . . . must be used in combination with socioeconomic data and information to analyze the ongoing and/or forecast effects of changing environmental conditions on human activities such as agriculture, energy consumption, urban planning, etc. . . In turn, this requires research into the development of information products that synthesize Earth science and socioeconomic data and into ways of making Earth science, socioeconomic, and synthesized combinations of . . . such data useful to policy makers. . . The research effort and resulting operational services must be supported by a suite of data and information services that, guided by priorities driven by the science objectives of the research program, identify sources of socioeconomic data, make available descriptions of these data to the research community, provide access to these data to the research community either through cooperative arrangements with the data sources or, when necessary by establishing a new capability to do this, provide the socioeconomic community with access to MTPE Earth science data and information, and provide information products and services to the policy-making community.

In order to provide these services, CIESIN has designed the SEDAC with the following systems:

1) The Data and Information Access System (DIAS) will allow users to locate, view, and order data and information of interest that are located within the main CIESIN archives in Saginaw, MI and other resource centers associated with CIESIN. These additional resources include, but are not limited to selected data holdings of CIESIN's Information Cooperative partners, data and information available through the Global Change Master Directory and NASA's EOSDIS system, and other resource servers publicly available on the Internet. (Corresponds to portions of an EOSDIS IMS node.)

2) The Data Archive and Distribution System (DADS) will provide archive management for all of CIESIN's

holdings in Saginaw, MI, process orders for user-selected data and software, deliver data and software to users, and ingest data and software into the archive for archival or product generation. The entire physical archive will be managed as three logical groups of information - Metadata (all directory, guide, and inventory descriptions), Inventory (primary orderable data and software), and Service/Customer Information. (Corresponds to an EOSDIS DADS.)

3) The Data Processing and Analysis System (DPAS) will provide computational tools and support for product generation, scientific analysis, application and tool development, and human science - physical science integration studies. (Corresponds to an EOSDIS PGS plus the functionality of a SCF.)

4) The User Services System (USS) will provide on-line (e.g., forums, bulletin boards) and traditional (i.e., via phone, mail, e-mail, fax, telex) assistance in data access, ordering, and analysis. (Corresponds to portions of an EOSDIS IMS node plus DAAC-specific customer service resources.)

5) The Operations Management System (OMS) is responsible for the coordination of activities between SEDAC system elements; supporting system and network engineering tasks related to resource allocation, system maintenance and evolution (i.e., change control and configuration management); providing system security; and assisting in resource adjudication. (Corresponds to portions of an EOSDIS SMC/LSM.)

Access to CIESIN's SEDAC systems is provided through a common user interface called the "SEDAC Pathway" (Figure 1). System compatibility will be provided for X-Windows, MS-Windows, Macintosh, or ASCII interface standards.

CIESIN is working closely with the EOSDIS Core System contract team to ensure architectural compatibility of the SEDAC and the other DAACs. CIESIN is contributing to the ECS User Demographics Study, which is evaluating ECS user profiles and data demands, in preparation for the System Requirements Review. Recently, CIESIN participated in a GSFC Workshop on "Human Dimensions of Global Environmental Change: Links Between EOS and Social Science Variables." The CIESIN team is dedicated to successful implementation of the EOSDIS and is privileged to be making a contribution to Mission to Planet Earth by enabling enhanced user access and improved resources for the investigation of the human dimensions of global environmental change.

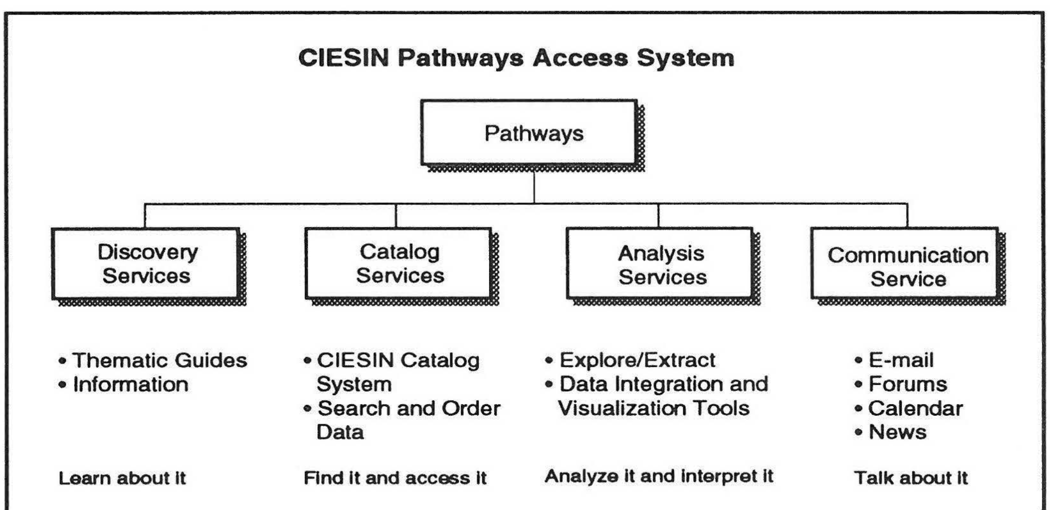


Figure 1: Pathways: Access to CIESIN Products and Services

SCAR-A

Sulfates, Clouds, and Radiation

— **David Herring** and **Janine Harrison**, MODIS Administrative Support Team, Goddard Space Flight Center

A team of scientists gathered in July at Wallops Flight Facility to participate in SCAR-A, an experiment which will enable scientists to study how sulfates, clouds, and radiation interact to affect climate. The primary objective of SCAR-A is to help scientists characterize the relationship between sulfate particles and clouds, thereby gaining a better understanding of how sulfates affect clouds' reflective properties.

Yoram Kaufman (GSFC), together with the entire MODIS Atmosphere Discipline Group, initiated the SCAR-A effort. Kaufman explains, "The interactions of aerosol particles—such as sulfate particles and smoke from biomass burning—with clouds and climate remain one of the greatest elements of uncertainty in predicting global climate change." Sulfate particles are believed to affect the size distribution and density of cloud droplets; however, the interaction between these aerosols and clouds is very complex and not well understood. Sulfate particles can come from both man-made sources such as fossil fuel burning, and natural sources such as volcanic eruptions and oceanic phytoplankton.

According to Lorraine Remer, a SCAR-A scientist, sulfate aerosols are thought to provide more CCN (cloud condensation nuclei) causing the water in polluted clouds to condense into smaller, more numerous droplets than in non-polluted clouds, thereby increasing the cloud's albedo and, subsequently, having a net cooling effect on the climate.

A secondary objective of SCAR-A was to provide a data set for simulating MODIS (Moderate-resolution Imaging Spectroradiometer), the keystone instrument for EOS. Specifically, the MODIS Atmosphere Discipline Group plans to use these data to help develop and test their algorithms for remote sensing of aerosols and clouds, as well as for atmospheric corrections of land surface images.

SCAR-A ("A" stands for America) is the first in a series of experiments; it will be followed by SCAR-C (for California) in 1994 and by SCAR-B (for Brazil) in 1995. However, SCAR-B will have a slightly different focus: *smoke*, clouds, and radiation. "Biomass burning in the tropics generates large quantities of trace gases and particles that affect atmospheric chemistry and physics, which may affect regional and global climates," Kaufman states. "Fires in tropical ecosystems consume as much as 80 percent of the total biomass burned on a global basis. Even though regulations are designed to reduce deforestation in Brazil, the rate of deforestation on a global annual basis has increased from 11 million hectares per year in the early 1980s to over 15 million in 1991. The effects of smoke from these fires are poorly understood, and research is needed to characterize their direct and indirect radiative effects."

There were several advantages to conducting SCAR-A first: 1) to enable scientists to compare and contrast the effects of sulfates and smoke particles from biomass burning on clouds; 2) to test the

The image shown was acquired on July 16, 1993 by the MODIS Airborne Simulator (MAS), a scanning visible/near-infrared/infrared spectrometer that flies on a NASA ER-2 aircraft. The direction of flight is from the top down. Nadir is along a line down the center of the image. The image has been resampled so that the spacing between pixel center is 64 meters in the along-track and cross-track directions. At the top left the city of Norfolk, VA is visible. The uniformly darker area at lower left with a lake in the center is the Great Dismal Swamp. This area is of interest because it provides a uniform vegetation surface whose bidirectional reflectance characteristics may be easily derived, and can serve as a reference surface for atmospheric corrections and visible/near-IR calibration intercomparison purposes. Multiple flight lines with different headings, atmospheric conditions, and solar zenith angles were acquired over this region.

Image courtesy of Liam Gumley (Climate and Radiation Branch) and Michael King (Earth Sciences Directorate), NASA Goddard Space Flight Center.

logistics and methodology of using multiple aircraft and instruments in parallel; and 3) to give Brazilian atmospheric scientists the opportunity to observe a SCAR experiment before hosting one. "We wanted to show Brazilian scientists that we don't only want to measure pollution generated from biomass burning in the Amazon, we also want to measure the pollution generated in the United States," Kaufman explained.

Overall, the objectives for the combined SCAR missions are: to advance our knowledge of how the physical, chemical, and radiative processes in our atmosphere are affected by sulfate aerosol and smoke from biomass burning; to improve our expertise at remotely sensing smoke, water vapor, clouds, vegetation and fires; and to assess the effects of deforestation and biomass burning on tropical landscapes. SCAR scientists hope to gain a better understanding of the following:

- rate of emissions of trace gases and particulates from biomass burning and the influence of atmospheric processes on the emission products;

- radiative properties of smoke particles (size distribution, scattering phase function, and single scattering albedo);

- interaction of smoke particles, water vapor, and clouds (effects of the particles on the cloud microphysics and of the clouds on the particle sizes and concentrations);

- effect of biomass burning on surface vegetation properties and their remote sensing from space in the presence of smoke;

- relation between fire temperature and strength and the emission factors;

- radiative forcing by smoke aerosol; and

- remote sensing by MODIS of fires, smoke, clouds, water vapor, vegetation, and radiation.

The SCAR experiments are collaborative efforts involving scientists and engineers from NASA Goddard Space Flight Center, the University of Wisconsin-Madison, the University of Washington, the Jet Propulsion Laboratory, and NASA Ames Research Center. The SCAR team employs a variety of instruments operated both on the ground and aboard two aircraft.

In the SCAR-A experiment, a network of five sunphotometers provided ground-based data on the physical and radiative properties of the aerosol particles that also serve as a ground truth for the aircraft and satellite remote sensing. The University of Washington's C-131A aircraft flew through clouds gathering *in-situ* data, while NASA's ER-2 aircraft flew at high altitude (20 km, 65,000 ft) gathering remote sensing data. The ER-2's instruments included MAS (MODIS Airborne Simulator) and AVIRIS (Airborne Visible and Infrared Imaging Spectrometer), which collected valuable data on the radiative properties of clouds, aerosols, and water vapor.

MAS is a scanning visible/near-infrared/infrared spectrometer that flies mounted in one of the ER-2's wing pods. It can record 12 of the 50 available spectral channels at 8-bit digitization with a spectral range comparable to that of MODIS. MAS is used primarily for remote sensing of clouds, water vapor, and aerosols; however, in future missions it may be used to gather data over land surfaces. (For more information on MAS, see the November/December 1992 issue of *The Earth Observer*.)

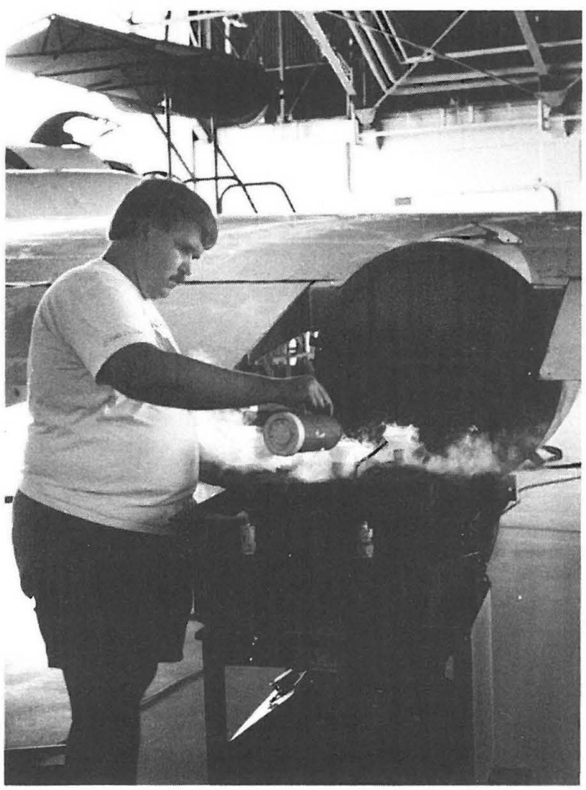
AVIRIS, mounted in the Q-bay of the ER-2's body, gathers data on upwelling ground radiance from 400 to 2500 nm through 220 contiguous channels. This instrument was originally designed to simulate HIRIS (High-Resolution Imaging Spectrometer). Although HIRIS was recently deselected from EOS, AVIRIS continues to gather data used for geology, hydrology, and vegetation studies.

The Goddard-developed CAR (Cloud Absorption Radiometer) mounted in the nose of the C-131A, measures the angular distribution of scattered radiation within clouds as well as radiation reflected from the ocean and land surface. Finally, images were obtained from the Landsat 5 Thematic Mapper and NOAA-AVHRR (Advanced Very High Resolution Radiometer) satellite sensors overlooking the same regions at the same time and location as the aircraft.

The MAS and CAR data are currently being analyzed by Michael King (GSFC), Si-Chee Tsay (USRA) and Liam Gumley (RDC); Robert Green (JPL) is analyzing the AVIRIS data; Dean Hegg (University of Washington) is analyzing data from the C-131A instruments; and Kaufman (GSFC), Remer (SSAI), and Brent Holben (GSFC) are analyzing data from the sunphotometers.

Thumbs Up! NASA ER-2 pilot Doyle Krumrey of Lockheed signals success after a SCAR flight mission.

Eric Vermote (left) of the Univ. of MD - College Park shows Chris Moeller (right) of the Univ. of WI-Madison the sun-photometer site at Wallops Flight Facility.



John Bush of NASA Ames pours liquid nitrogen into the dewars on the MAS (MODIS Airborne Simulator) to keep the detectors cold.

Tim Suttles of NASA Headquarters and Lorraine Remer of SSAI discuss the next mission during a flight planning meeting.

Spacecraft Interface Simulator:

One Design For Multiple Instruments and Missions

—**Carl Schueler**, Hughes Santa Barbara Research Center

Most NASA spacecraft require that all instrument developers conform to a common interface specification that calls out the electrical and data connections between the instrument and the spacecraft. On EOS, this is the General Instrument Interface Specification (GIIS) that requires each instrument developer to provide a common set of instrument-to-spacecraft interfaces. The common signal and power interface that exists between the EOS spacecraft and the EOS instruments suggests that independent of instrument functionality differences, major elements of the instrument ground support equipment (GSE) are common and that a single test equipment design approach may be adapted to all EOS instruments. This offers the possibility for significant risk and cost reductions.

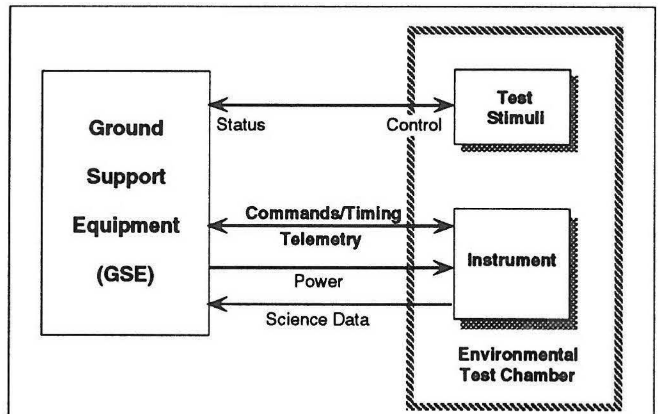


Figure 1. EOS Instrument Testing Concept

On the EOS spacecraft, a common instrument interface is provided. The instrument ground support equipment (GSE) that each instrument developer must build to test the instrument before delivery for integration with the spacecraft must electrically simulate the spacecraft interface to ensure that the instrument will perform correctly on the spacecraft. Signals that the instrument generates are transmitted through the spacecraft interface simulator to the GSE, and signals generated by the GSE (simulated spacecraft signals) are transmitted to the instrument through the spacecraft interface simulator.

Figure 1 illustrates a generic GSE-to-instrument interface arrangement necessary to test an instrument. The GSE on the left is used to provide instrument power, telemetry, and data interfaces during instrument assembly, testing, and calibration at the instrument developer's facilities. The spacecraft interface simulator portion of the GSE provides the discrete command/telemetry and timing interface.

Santa Barbara Research Center has developed the Remote Telemetry Interface Unit (RTIU), shown in Figure 2, which will be used as the spacecraft interface simulator for the Moderate Resolution Imaging Spectroradiometer (MODIS) program. Figure 2 illustrates how the RTIU participates in the instrument ground testing process. The RTIU provides the command, telemetry, and timing interface between the GSE and the instrument. It also provides master clock synchronization, instrument power on/off and primary/redundant channel switching, parameter measurements such as temperature, resistance, voltage, contact closure, and other measurements. Altogether, it provides a robust link between the GSE and the instrument, and within the instrument thermal vacuum chamber.

For MODIS testing, the RTIU is connected to a part of the overall MODIS GSE called the Payload Interface Controller (PIC). The PIC is mounted in a standard 19" rack located outside the instrument environmental test chamber. Because the RTIU itself is inside the chamber, sensitive analog signals travel over very short cables before being converted to noise-immune digital data for transmission out of the chamber over a standard RS-232 serial interface to the PIC.

Although not required by MODIS, the RTIU incorporates all the GIIS-specified discrete connections, so that any EOS-compatible instrument can be tested through the RTIU. Full primary and redundant channels are provided, as required by the GIIS. In addition, the RTIU has a

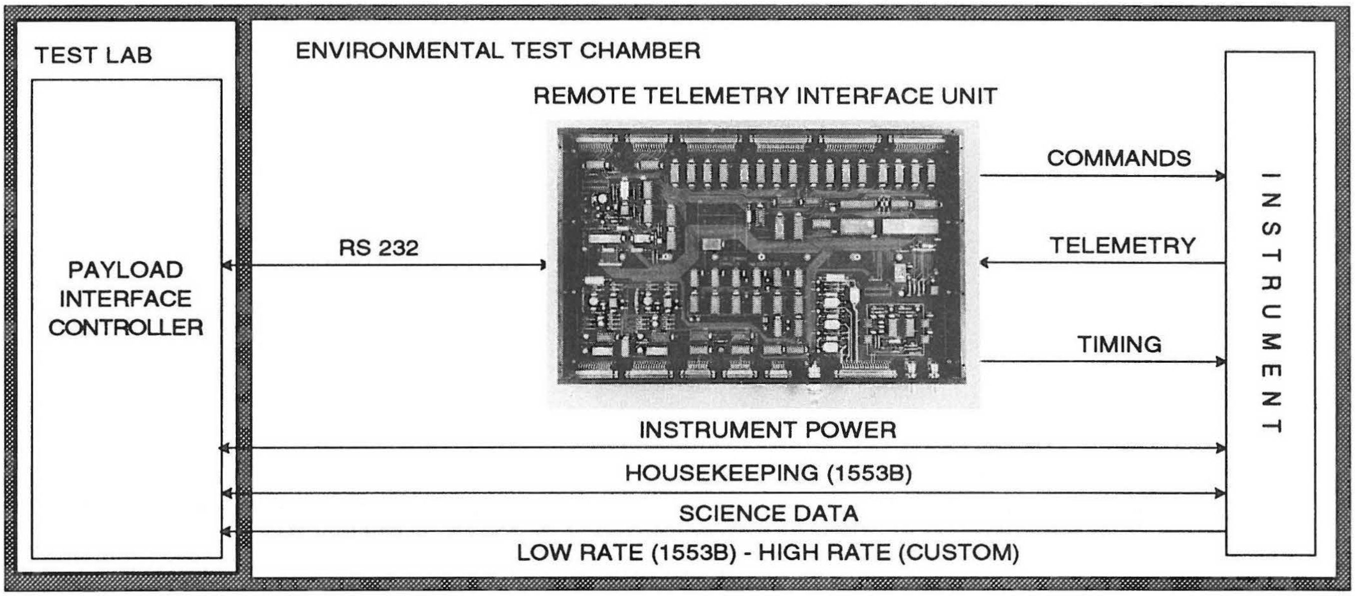


Figure 2. EOS Remote Telemetry Interface Unit operates with the instrument in the Environmental Test Chamber.

number of features that the EOS Project Office and the instrument teams indicated would be useful. Environmental test chamber compatibility, including on-board temperature sensors to monitor heat rise, allows close proximity to the instrument for analog signals. Moreover, the RTIU has very low power consumption of less than one watt. The RS 232 serial digital interface to the GSE outside the environmental test chamber offers electrical isolation to ease restrictions on GSE placement. Simplicity and compactness allow ease of use, with a simple user interface to either a computer or a "dumb" terminal, rack compatibility (17 x 10.6 x 2.1 inches, 42.5 x 26.5 x 5.3 cm) and light weight (7.5 pounds, 3.4 kg). Software is downloadable to Electrically Erasable Programmable Read Only Memory (EEPROM) to accommodate potential GIIS changes or to allow changes to accommodate non-EOS interface requirements.

In fact, SBRC is using the RTIU to support the Tropical Rain Measuring Mission (TRMM) Visible and IR Scanner (VIRS) program. On this program the RTIU simulates the TRMM spacecraft interface, which is somewhat different from the EOS interface. As indicated in Table 1, the RTIU has sufficient flexibility to handle these interface variations with little modification.

Thus far, SBRC has built five RTIUs: a non-environmentally qualified prototype, two environmentally-qualified units for MODIS, and two units for the TRMM VIRS program. The RTIU design could readily be used with other EOS instruments.

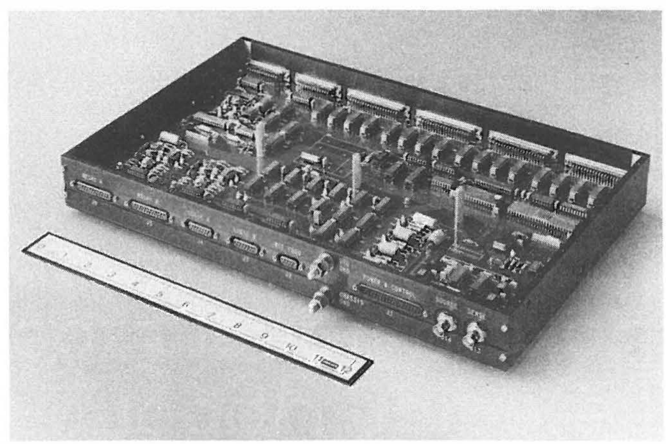


Figure 3. Remote Telemetry Interface Unit is compact and environmentally qualified.

Table 1. SBRC RTIU Supports MODIS and TRMM VIRS

RTIU Parameters	MODIS per GIIS	TRMM VIRS per TRMM ICD	RTIU Flexibility
S/C clock frequency	1 MHz	N/A	DC to 20 MHz
Time Mark Period	1.024 sec	1 sec	msecs to seconds
Logic Output	82 ohms	N/A	Variable Resistance
Logic Commands	50 msec pulse	2 sec pulse	Programmable
Relay Driver Rise Time	1 msec	0.5 msec	0.1 msec - 5 msec
Relay Driver Source Resistor	10 ohms	20 ohms	1 - 100 ohms
Current Source Compliance	10 volts	5.1 volts	1 - 12 volts

Development of the RTIU was supported by SBRC and is a proprietary design.

Summer Storms Provide Abundant Research Opportunities For The North Dakota Tracer Experiment

— **Jeffrey Stith**, University of North Dakota, and **John Scala**, NASA Goddard Space Flight Center

The record-breaking wet weather that hit the Midwest this summer provided a bonanza for the North Dakota Tracer Experiment (NDTE), a cooperative study of convective storms. This project used new tracer techniques to measure the movement of air and hydrometeors by the storms in combination with traditional measurements using Doppler radars and instrumented aircraft. The data collection was centered near Bismarck, North Dakota from June 21 through July 30, 1993.

A major goal of the program is to better understand the mechanisms responsible for the development of rain and hail during the growing season. North Dakota is a major wheat producing state and traditionally suffers from inadequate moisture and crop losses from hail, especially in the western part of the state. It is hoped that the improved understanding will lead to better forecasts and a means to evaluate the potential for rain augmentation or hail suppression efforts.

To follow the fate of air ingested by the storms, radar chaff and sulfur hexafluoride (SF_6) tracers were released at various locations in the storms. The chaff was followed using a circular-polarized X-band Doppler radar from the NOAA Wave Propagation Laboratory (WPL). The circular depolarization ratio from the chaff is much greater than from hydrometeors and allows the return from chaff to be distinguished from the return due to the storm. The SF_6 was sampled *in situ* using analyzers on two of the research aircraft. Fluorescent beads were also released in regions thought to be sources of hail embryos. Hail samples were collected by storm chase teams and analyzed to detect the presence of the beads. A second C-band Doppler radar from the University of North Dakota (UND) was used for documenting the storms and for dual Doppler analysis.

Research aircraft included the UND Citation fanjet, the South Dakota School of Mines and Technology (SDSMT) armored T-28, and a Beechcraft Duke from WMI, Inc. The first two were used for measuring cloud microphysics, air motion, and SF_6. The third aircraft was used for tracer releases.

Numerical cloud models, including the South Dakota two-dimensional time-dependent cloud model and the NASA Goddard Cumulus Ensemble Model (GCE), were used daily to forecast the cloud and precipitation characteristics. Objectives of the program include comparing the results from these models with the measurements and observations of the storms and evaluating the usefulness of these types of cloud models for operational forecasting.

On July 1 a severe hailstorm struck Bismarck causing millions of dollars in damage. This storm was extensively studied by the NDTE aircraft and radars. Figure 1 shows the forecast cloud structure as predicted on the morning of July 1 by the NASA GCE and the observed structure of the storm by the UND radar. The simulation contained a rear inflow circulation that descended beneath a predicted hailshaft due to the generation of negative buoyancy near the hailshaft. This helped maintain an outward propagating gust front that displaced regions of high equivalent potential temperature and generated new convection. This circulation helped to maintain the storm. Convective elements of the storm were tagged with chaff and SF_6, and followed with the NOAA radar and UND Citation (Figure 2). Future analysis will focus on determining the factors that improve the simulation by comparison of the model results with the field data. In addition, the trajectories of the chaff and SF_6 will be compared with trajectories computed from the models to better understand how air is transported and mixed by these types of storms.

The primary sponsors for the project are the NOAA Federal-State Cooperative Program in Atmospheric Modification Research, the National Science Foundation, and the North Dakota Atmospheric Resource Board

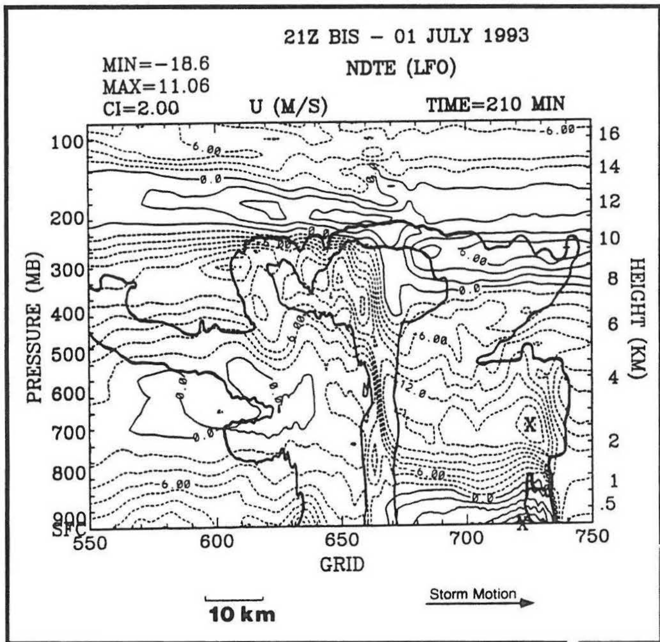
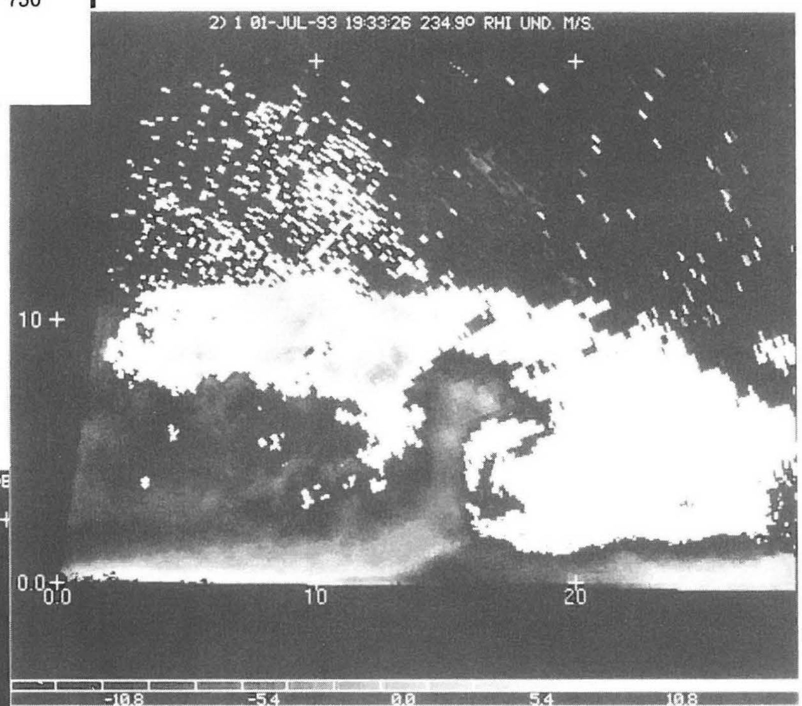
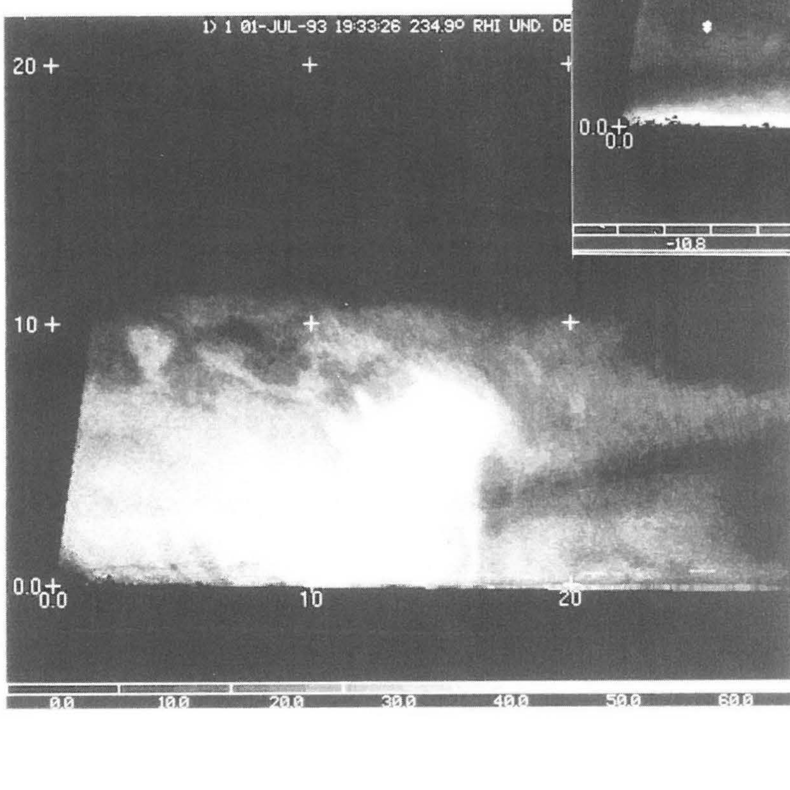


Figure 1. Forecast simulation of the July 1 hailstorm by the NASA Goddard Cumulus Ensemble model at 210 min into the simulation. The top diagram shows contours of storm relative horizontal wind velocity (the model was run in a two-dimensional mode). The cloud outline is superimposed on the horizontal velocity contours. The inner outline is the 0.75 g/kg condensate contour, which is included to show the high reflectivity region of the simulation. The lower diagrams show range-height displays from the UND radar of the radial velocity (middle right) and the observed storm reflectivity (lower left) on July 1 (courtesy Alan Borho, UND). The vertical and horizontal scale is labeled in kilometers. The main hail region is visible in the mushroom-shaped pattern that contains regions of high reflectivity and air with slower radial velocity, due to its origin from lower in the storm.



Radial velocity



Observed storm reflectivity

(ARB). Additional support is provided by the National Center for Atmospheric Research (NCAR), the National Severe Storms Laboratory (NSSL), NASA, the National Weather Service (NWS), and the Canadian Atmospheric Environment Service (AES). A list of the NDTE facilities is given in Table 1. The data from the project will be made available to the scientific community. For more information contact the North Dakota Atmospheric Resources Board, State Water Commission, 900 East Boulevard Avenue, Bismarck, ND 58505.

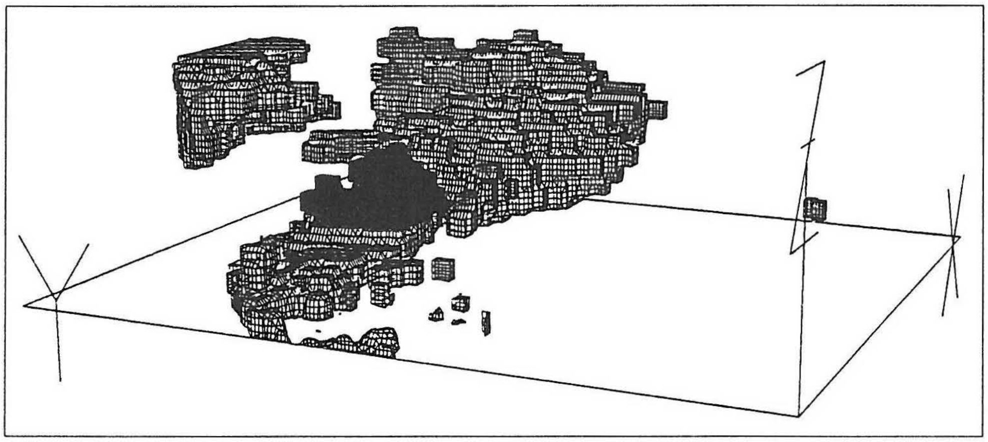


Figure 2. Three-dimensional depiction of the reflectivity from the NOAA radar during a period when one of the cloud turrets was tagged with chaff and SF_6 at the cloud base. The chaff region that was carried aloft by the turret is darkened. (Courtesy Brad Orr, NOAA-WPL.)

Table 1. List of NDTE Facilities

Facility	Role	Operating Agency	Principal Scientist
NOAA-C Doppler Radar (X-band)	Chaff tracking surveillance	NOAA/WPL	Martner, Reinking
UND C-band Doppler	Surveillance	UND	Rinehart, Brown, Hjelmfelt
Mobile CLASS	Soundings	NCAR	Hjelmfelt
UND Citation	Cloud physics tracer	UND	Stith
SDSMT T-28	Cloud physics tracer	SDSMT	Detwiler
Duke	Tracer release	WMI, Inc.	Grainger
Storm Intercept	Hail samples photography	SDSMT	Orville, Knight
SDSMT 2D Cloud model	Cloud forecasts	SDSMT	Kopp
GCE Model	Cloud forecasts	NASA/Goddard	Scala
Aerosol Sampling	Nuclei measurements	CSU	Demott
McIDAS and NLDN*	GOES imagery and lightning detection	ARB	Schultz, Scarlett
Eta Model	Regional forecasting	AES/NWS	Dudley, McCarthy

* National Lightning Detection Network

Fleet Restructuring at NCAR†

— **Paul Spyers-Duran**, National Center for Atmospheric Research, Research Aviation Facility, Boulder, CO

Currently the Research Aviation Facility (RAF) at NCAR is in a transitional period while undergoing fleet restructuring. The current fleet consists of an Electra L-188C, a King Air B200T, and a recently acquired EC-130Q aircraft. The King Air will be removed from the NSF-supported base as of FY94, and support will be provided on an as-needed, cost recovery basis. The EC-130Q aircraft was added to the fleet to provide long-range, heavy lift capability for research support over the remote oceans and continents for chemistry, clouds, and land/ocean/atmosphere interaction experiments. This aircraft will be undergoing modifications to accept a large array of instrumentation, with the expected completion date to provide research support by August-September 1994. The RAF is in the process of acquiring a WB-57F aircraft. This aircraft, with its high-altitude capability, will be able to support a significant range of geosciences research in the stratosphere.

The RAF aircraft support observational research studies in areas such as atmospheric chemistry, cloud physics, mesoscale meteorology, boundary-layer dynamics, air-sea interactions, oceanography, and other fields within the atmospheric sciences. The NCAR fleet is equipped to measure atmospheric state parameters, turbulent fluxes up to 10 Hz equivalent wavelength, cloud physics parameters, and atmospheric trace gases. Radiometers (short/longwave and ultraviolet) remote radiometric surface temperature sensors, and video cameras are available. The aircraft are also equipped for drop-windsonde and oceanographic dropsonde dispensing and acquisition. Various active remote sensing systems (Doppler lidar, Doppler radar) are either available or under development. In addition to RAF-supplied instrumentation, user-supplied instruments can be mounted on the aircraft under RAF supervision.

The aircraft are equipped with a sophisticated, networked data system, which furnishes real-time data display and recording in a variety of user-selectable formats. Data tapes generated during flights are processed by RAF for all the measured and derived parameters. Detailed documentation, including quality assessment of the data, is provided to our users. During the field phase, in addition to the onboard real-time data availability, quick-look analysis and planning for future missions can be done on site, using RAF hardware and software.

RAF can advise and, in some instances, assist users in the aeronautical, chemical, and electrical engineering design and fabrication of special equipment. Guidance in sampling and measurements can also be provided. In addition, RAF can help project scientists with experimental design and with flight planning.

For further information, and for procedures to request support from RAF, contact Paul Spyers-Duran, Facility Liaison for Field Support at (303) 497-1036 or e-mail: paul@chinook.atd.ucar.edu.

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† The National Center for Atmospheric Research (NCAR) is operated by the University Corporation for Atmospheric Research (UCAR) under the sponsorship of the National Science Foundation (NSF).

NASA Study Refines Estimates of Amazon Deforestation

by **Allen Kenitzer**, Reprint from *Goddard News*, July 1993 Vol. 40 No. 7

Tropical deforestation and adverse effects on tropical forest habitat have increased in the Brazilian Amazon Basin since the late 1970s, a NASA-University of New Hampshire study has revealed.

Data from the Landsat-4 and -5 satellites covering 1978-88 indicate that although the extent of deforestation is less than expected, it has increased substantially and created adverse "edge effects" that pose a threat to the habitat of plant and animal species.

Results of the study conducted at Goddard and the University of New Hampshire, Durham, were published in the June 25 issue of *Science*.

"We are seeing less deforestation than expected," said David Skole, a research assistant professor with the Institute for the Study of Earth, Oceans and Space at the University of New Hampshire. Skole is the lead author of the paper in Science. "Our study helps clarify actual greenhouse gas emissions, such as carbon dioxide, resulting from tropical deforestation."

"Although we found lower deforestation than previously estimated, the effect upon biological diversity is greater, " said Compton Tucker, a research scientist in the Laboratory for Terrestrial Physics at Goddard Space Flight Center. Tucker was co-author on the *Science* paper.

Skole and Tucker studied more than 200 Landsat satellite images, covering the entire forested portion of the Brazilian Amazon Basin. Using Landsat images and a computerized geographic information system, they made specific measurements of deforestation, fragmented forest, and edge effects.

A fragmented forest is forest surrounded by deforested area. "Edge effects" are the destruction or degradation of the natural habitat that occur on the fringes of fragmented forests. These effects include greater exposure to wind, weather, foraging livestock, other non-forest animals, and humans. Tropical deforestation increases atmospheric carbon dioxide and has profound implications for biological diversity through destruction of habitat. The conversion of forests to cropland and pasture increases atmospheric carbon dioxide because the carbon in forests is higher than in agricultural areas which replace them.

This is a thematic mapper composite image from southern Rodonia, Brazil, acquired using the Landsat-4 and -5 satellites on June 5, 1988. Areas of tropical forest, deforestation, regrowth and isolated forest are labeled on the imagery. The size of the area identified as isolated forest is nearly 2 by 9 miles (3 by 15 kilometers).

Greenhouse gases, such as carbon dioxide, cause the "greenhouse effect," which is the warming of climate, resulting when the atmosphere traps heat radiating from Earth toward space. Certain gases in the atmosphere resemble glass in a greenhouse, allowing sunlight to pass into the "greenhouse," but blocking Earth's heat from escaping into space.

While occupying less than 7 percent of the Earth's surface, tropical forests are the home to more than half of all plant and animal species. Deforestation is leading to massive extinction of species, including—for the first time—large numbers of vascular plant species, such as trees.

"The primary cause of Brazilian deforestation in the last two decades can be attributed primarily to agricultural expansion," Tucker said.

The Brazilian Amazon is the largest continuous tropical forest region in the world. Estimates of tropical deforestation in the Brazilian Amazon range as high as 20,000 square miles (50,000 square kilometers) per year to 32,000 square miles (80,000 square kilometers) in the late 1980s.

The *Science* paper reports that the 1978 to 1988 rate of deforestation for the Brazilian Amazon was 6,000 square miles (15,000 square kilometers) per year.

The Amazon Basin of Brazil includes all or part of eight Brazilian states, covering 2 million square miles (5 million square kilometers). In that region, 1.6 million square miles (4 million square kilometers) are forested 330,000 square miles (850,000 square kilometers) are tropical savanna, and 35,000 square miles (90,000 square kilometers) are water.

By using satellite data and the geographic information system, scientists are able to individually map or "stratify" different categories of Earth's geographic features such as forests, and grasslands, thereby providing a means to compare deforestation results from other studies.

EOS Science Calendar

September 28	MODIS Calibration Working Group Meeting, NASA/GSFC. Contact David Herring at (301) 286-9515.
Sept. 29-Oct. 1	MODIS Science Team Meeting, NASA/GSFC. Contact David Herring at (301) 286-9515.
October 4-6	EOS Payload Panel Meeting, Herndon, VA. Contact Berrien Moore at (603) 862-1766.
October 12-14	AIRS Science Team Meeting, U. of Wisconsin, Madison, WI. Contact George Aumann at (818) 397-9534.
October 19-21	TES Science Team Meeting, JPL, Pasadena, CA. Contact Reinhard Beer at (818) 354-4748.
November 8-12	ASTER U.S. and Japanese Joint Science Team Meeting, Japan. Contact Dave Nichols at (818) 354-8912, or Anne Kahle at (818) 354-7265.
November TBD	GLAS Science Team Meeting, location TBD. Contact Bob Schutz at (512) 471-4267.
November 16-18	1st International MIMR Science Team Meeting, ESTEC, Netherlands. Contact Roy Spencer at (205) 544-1686, or Cris Readings, (ESTEC) +31-1719-85674.
Jan. 11-13, 1994	Investigators Working Group (IWG) Meeting, San Antonio, TX. Contact Ghassem Asrar at (202) 358-0259, or Michael King at (301) 286-8228.

From *EOS News*

ANNOUNCEMENT OF OPPORTUNITY ADEOS

NASDA, the National Space Development Agency of Japan, and the Japan Environmental Agency (EA) are planning to release a RESEARCH ANNOUNCEMENT (JRA) soliciting letters of intent to submit proposals for the utilization of multiple or individual sensor data installed on ADEOS.

The JRA solicitation is open to all categories of Japanese and foreign investigators. Investigators whose proposals are accepted under the JRA will be appointed as members of the ADEOS Sensor and/or Science Teams (TBD).

The ADEOS satellite is planned for launch in early 1996. ADEOS is a polar-orbiting platform carrying eight sensors:

- OCTS: Ocean Color and Temperature Scanner
- AVNIR: Advanced Visible and Near Infrared Radiometer
- ILAS: Improved Limb Atmospheric Spectrometer
- RIS: Retroreflector In Space
- IMG: Interferometric Monitor for Greenhouse Gases
- NSCAT: NASA Scatterometer
- TOMS: Total Ozone Mapping Spectrometer
- POLDER: Polarization and Directionality of the Earth's Reflectance

NOTE: the JRA will address all sensors except POLDER and IMG. Announcements for these instruments will be released separately to complement this JRA.

JRA deadlines are still being defined. The following dates should be considered tentative, and are provided here so that you may plan in advance of the official release of the JRA. The first JRA requests letters of intent to propose by September 30, 1993. Full packages of the ADEOS JRA will be mailed to respondents starting October 1 to allow them to complete proposals. Proposals will be due by December 24, 1993. The selection is expected to be concluded by the end of March, 1994.

Brief information on research goals and objectives of the JRA are provided in the "First Opportunity for Research Announcement" document (JRA-93-001). For a copy of this document, please send your request to:

Masanobu Shimada
JRA office in charge of ADEOS RA
Earth Observation Center, NASDA
1401 Numanoue
Ohashi, Hatoyama-machi, Hiki-gun, Saitama-ken, JAPAN
350-03 tel. 81-492-98-1215, FAX. 81-492-98-1001.

NASA Headquarters requests courtesy copies from all U.S. respondents and requires that U.S. respondents planning to request NASA funds submit copies of all materials and inquiries, including the letters of intent, to:

Dr. Ramesh Kakar
Code YS
NASA Headquarters
300 E Street, SW
Washington, DC 20546.

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

The Earth Observer Staff:
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Distribution: Hannelore Parrish

Global Change Calendar

• 1993 •

October 18-21	Call for papers. Thirty-Second Hanford Symposium on Health and the Environment, "Regional Impacts of Global Climate Change: Assessing Change and Response at the Scales that Matter." Send abstracts and inquiries to Ray Baalman, Planning and Communications, MSIN: K1-50, Life Sciences Center, Battelle Pacific Northwest Laboratories, Richland, WA 99352, phone: (509) 375-3665; FAX: (509) 375-3686.
October 27-28	Fourth Conference on Earth Observations & Global Change Decision Making: A National Partnership. Theme: "Global Change: A New Direction for Decision Making, " National Press Club, Washington, D.C. Sponsored by NASA, NOAA, and ERIM. Contact Robert Rogers, ERIM, phone: (313) 994-1200, ext. 3382; FAX: (313) 994-5123.
November 3-4	The Federal Committee on Earth and Environmental Sciences, Private Enterprise-Government Interactions Working Group, in partnership with the Geosat Committee, announces the first annual "Roundtable Conference", at the Key Bridge Marriott Hotel in Arlington, Virginia. Contact Linda Greczy or Julia Jones,USDA Global Change Program Office, 1621 N. Kent St., Room 60LL, Arlington, Virginia 22209, phone: (703) 235-9018; FAX: (703) 235-9046.
December 6-10	American Geophysical Union Fall Meeting, San Francisco, California. Contact Kristan Hanson, 1630 Connecticut Ave., N. W., Washington D.C 20009, phone: (202) 462-6910, FAX: (202) 328-0566.

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January 23-28	74th Annual Meeting of The American Meteorological Society, Nashville, Tennessee. Contact Yale Schiffman, 1701 K Street, N.W., Suite 300, Washington, D.C. 20006-1509, phone: (202) 466-6070; FAX: (202) 466-6073.
Jan. 31-Feb. 2	Second Thematic Conference on Remote Sensing for Marine and Coastal Environments: Needs, Solutions, and Applications, New Orleans, Louisiana. Contact Robert Rogers, ERIM, P.O. Box 134001, Ann Arbor, MI 48113-4001, phone: (313) 994-1200, ext. 3382, FAX: (313) 994-5123.
March 1-4	7th Australasian Remote Sensing Conference, Melbourne, Australia. The Conference will be held in conjunction with: 1.) The Inter-Congress Symposium of Commission 5 of the International Society for Photogrammetry and Remote Sensing (ISPRS), 2.) The second Australian Photogrammetric Conference, and 3.) The Pacific Ocean Remote Sensing Conference (PORSEC 94). Contact: Michael McLean/Secretary to the Organizing Committee, 7th ARSC Conference Secretariat, P.O. Box 29, Parkville, Victoria 3052 Australia, phone: (03) 387 9955, FAX: (03) 387 3120.
March 8-11	Oceanology International 94, Brighton, UK. The theme of the conference is *The Global Ocean: from Ocean Understanding to Sustainable Development* and the programe will emphasize the international dimension of the marine environment, the need to understand it and the need for the protection and sustainable development of its resources. Also on this occasion the first conference of the International OTEC/DOWA Association will be held within OI94. Contact Lesley Ann Sandback, Spearhead Exhibitions Ltd, Rowe House, 55-59 Fife Road, Kingston upon Thames, Surrey KT1 1TA, UK, phone: 081 549 5831 (International: +44 81) FAX: 081 541 5016 or 081 541 5016 (International: +44 81).
March 29-April 2	Association of American Geographers 1994 Annual Meeting, San Francisco, California. Contact Ronald Abler, 1710 16th St. N.W., Washington, DC 20009-3198, phone: (202) 234-1450; FAX: (202) 234-2744, Internet: AAG@GWUVM.GWU.EDU; Bitnet: AAG@GWUVM.
May 9-12	Tenth Thematic Conference on Geologic Remote Sensing: Exploration, Environment, and Engineering, San Antonio, Texas. Contact Robert Rogers, ERIM, P.O.Box 134001, Ann Arbor, MI 48113-4001, phone: (313) 994-1200, ext. 3382, FAX: (313) 994-5123.
May 23-27	1994 American Geophysical Union Spring Meeting, Baltimore Convention Center, Baltimore, MD. Contact Sherry Washington, 2000 Florida Avenue, N. W., Washington D.C 20009, phone: (202) 462-6900, FAX: (202) 328-0566.

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