The Earth Observer

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EDITOR'S CORNER

On October 1, 1990, I replaced Dr. Gerald Soffen as EOS Project Scientist. Jerry has taken on another important job at NASA Goddard Space Flight Center, heading the University Affairs office. We wish him well in this important undertaking and thank him for his service to the EOS Project. We all know that the quality and quantity of future generations of Earth scientists are crucial to the success of EOS, and we expect that Jerry can help us find, recruit, and support those who will carry on when we have retired or otherwise grown beyond the stage where we do useful work.

I have agreed to serve as the Project Scientist for not less than two years. I told Shelby Tilford that I wouldn't quit earlier, no matter how difficult I find the job. I am on leave from my position at the University of California, Santa Barbara, and am employed at Goddard by the Universities Space Research Association. Here I will try to guide the interaction between scientific investigations, data systems, and instruments. I expect to have a major role in guiding the development of EOSDIS, in helping to integrate the interdisciplinary and instrument investigations, and in articulating and defending scientific questions and measurement and modeling strategies for a wide array of disciplines.

I will need your help. Congress, the President, and the NASA Administrator support the Mission to Planet Earth, but tight budgets will continue. Before the November IWG meeting, for example, we had expected that the payload selection for the EOS-A platform would be known, and we apologize for the state of uncertainty. However, Dr. Lennard Fisk, Associate Administrator of the Office of Space Science and Applications, must wait until budgets for the years 1992 through 1996 are negotiated with the Office of Management & Budget and the NASA Administrator.

We must not get into the mold that currently plagues Space Station Freedom, whereby the scope and purpose of the mission are continually questioned, reviewed, and re-budgeted. EOS investigators, EOS management, Congress, and the Administration must agree on what EOS should be, on the priorities for instruments, on the recommendations for the A-series and B-series payloads, and then establish a reasonable schedule and funding profile. During the next three months, we will work to provide each EOS investigator with a likely funding profile from which we can negotiate the scope of work during the next decade.

I look forward to working with all of you to accomplish the goals of EOS, the most important of which is to develop the capability to predict or assess plausible environmental changes, both natural and human-induced, that will occur in the future. Meeting this challenge for the next decade to century requires the integration of knowledge from the traditional disciplines and information from many different sources into a coherent view of the Earth system. EOS is the largest project in the history of NASA and arguably the most important national and international scientific mission of the next two decades.

Jeff Dozier
EOS Project Scientist

MODIS Science Team Meets

A MODIS Science Team meeting was held at the Goddard Space Flight Center on September 24-26, 1990. All members or their representatives were present. The first day was spent largely in reports of the status of MODIS-N and -T, EOS, EOSDIS, funding expectations, and calibration and processing plans. The second and third days were spent in discipline group discussions, with a final summary session which addressed major concerns/issues. Substantial points of discussion are outlined below.

MODIS-N RFP: The MODIS-N Phase C/D Request for Proposals (RFP) was reported to be close to release. Since the meeting, the RFP has been released. Bidder proposals are due December 10, and a midsummer 1991 award (June - July) is expected.

MODIS-T Status: MODIS-T was reported to have satisfactorily passed the Conceptual Design and Cost Review, has received satisfactory evaluations, and has been presented to NASA Headquarters. It currently awaits selection by Dr. Fisk, Associate Administrator for Space Science and Applications.

MODIS Level-1 Processing System Design: An overview was presented, which concentrated on input data requirements, required platform ancillary data, geolocation error sources, and Levels-1A and -1B functions and data. Of particular concern was Earth location accuracy between control points, and without inclusion of topographic correction data. It was determined that an error less than 10 meters would be difficult to achieve.

The number of Level-1B products was also discussed. Current plans call for the production of only one set of products. Some team members felt that different sets of calibration coefficients would need to be applied (for land, oceans, and atmosphere products, respectively) in order to achieve sufficiently high accuracies. The issues will be further addressed in future meetings.

MODIS Characterization/Calibration: Priorities in performing characterization/calibration were defined:

- instrument-related system characterization/calibration;
- discipline-related product sensitivity to calibration; and
- development of utility products.

Other MODIS-T Calibration Concerns: Concerns were expressed about MODIS-T double-sphere calibration (versus single-sphere) and the choice of solar diffuser plate material. The scan mechanism for MODIS-T was also discussed, wherein a "barrel roll" (inclined scan mirror) scanner (as is used for NOAA AVHRR scanners) was compared to a "paddle wheel" (surface normal to the detectors) configuration. Since the meeting, it has been learned that the "barrel roll" scanner causes severe misregistration when used in conjunction with an array of detectors, as is the case for MODIS. Bandpass filter frequency accuracy, and between-band registration — particularly registering the 250 meter bands to the 1000 meter bands — are issues worth consideration. The specified 2.3% polarization level for all bands was of some concern. It has since been learned that the actual value for polarization will be considerably below specification.

Ocean Discipline Report: The Ocean Discipline Group discussed, to a substantial degree, the requirement for their own computing facility. It was determined that such a facility would be absolutely necessary for algorithm development, to evaluate new and existing algorithms using *in situ* ship cruise and mooring data, to compute and track MODIS calibration, and to provide a computing platform for radiative simulations. It will be entirely consistent with EOSDIS goals and operational concerns.

Land Discipline Issues: The Land Discipline Group held extensive discussions, some in conjunction with the Ocean Group, on the use of MODIS-T for bidirectional reflectance distribution function (BRDF) studies. The MODIS-T tilt capability makes its use ideal. Further studies will be conducted to define the land areas which may be covered without interfering with the routine global ocean coverage. The Land Group was also concerned about product nomenclature (at-launch vs. post-launch; official vs. core; standard vs. special), and felt a keen need for simulation data, discussed several possible sources, and entered into serious discussion with the Atmosphere Group on the development of a MODIS simulator.

Atmosphere Group - MODIS Simulator: The Atmosphere Discipline Group concentrated their efforts on developing a scenario for a MODIS airborne simulator. In conjunction with the Land Group, spectral channels, resolution, swath width, scan rate, and the data system were discussed. Complementary use with other simulators was addressed. As a result, the Atmosphere Group will actively pursue the development of the simulator, and hope to have it ready for use by the summer of 1992.

Action items for the next meeting: The Team Leader, Dr. Vincent Salomonson, requested that each discipline group outline and sketch a geophysical parameters validation plan, describing plans for ground, sea, and aircraft measurements, and algorithm development and peer review. A calibration pre-launch management plan was also called for, and should show substantial development prior to the next meeting, which is tentatively scheduled for February 20 - 22, 1991.

Locke Stuart
MODIS Administrative Support Leader

Clouds and the Earth's Radiant Energy System Instrument

CERES and Global Change

Mankind is engaged in a great and uncontrolled alteration of his global habitat. Fossil fuel burning and release of other trace gases and aerosols are expected to have long-term consequences. Agriculture and deforestation alter the Earth's surface in ways that are expected to change the climate. In these and many other examples, we understand some of the immediate impacts of man's activities, yet we cannot predict the long-term consequences.

One of the major sources of uncertainty lies in the impact of clouds upon the radiative energy flow through the Earth-atmosphere system. For example, a recent intercomparison of 14 climate GCMs (Cess et al., Science, 4 Aug. 1989) shows a factor of 3-4 variation in the modeled sensitivity of the Earth's climate. The source of this variation was traced to the different parameterizations of clouds in the GCMs. In some models, clouds acted as a strong positive feedback mechanism, in others as a strong negative feedback mechanism. The reason for such large uncertainties is the primitive state of cloud modeling in climate models. GCM climate models are limited to horizontal spatial scales of hundreds of kilometers, while most cloud physical processes operate on much smaller scales (down to 100 meters).

In recent years, the Earth Radiation Budget Experiment (ERBE) has measured the flow of radiation at the top of the atmosphere (TOA), not just as an undifferentiated field, but with a separation between clear-sky fluxes and cloudy ones. These clear-sky fluxes begin an observational baseline for assessing the impact of changes on the Earth's surface. Cloud radiative forcing (i.e. total scene radiation minus clear-sky radiation), determines the effect of clouds on the radiation budget. For example, in the current climate system, the longwave (LW) cloud-radiative forcing of tropical thunderstorms nearly offsets the shortwave (SW) cloud forcing. Midlatitude storm systems are found to dominate the radiative impact of clouds at the TOA.

Beyond measuring the TOA fluxes, we need to develop the ability to measure the entire radiative energy flow within the Earth-atmosphere system consistently with a simultaneous quantification of the clouds. This ability would provide the atmospheric radiative flux divergence, which enters directly into physically based, extended-range weather and climate forecasting. Recent GCM modeling studies (Randall et al., Journal of the Atmospheric Sciences, 1989) indicate that while TOA cloud-radiative forcing may be near zero in the tropics, the cloud-radiative forcing within the atmosphere is large and plays a critical role in driving the Hadley cell circulation. Knowledge of clouds and radiation would also provide the surface radiation budget, which is critical to studies of atmospheric energetics, air-sea energy transfer, and biological productivity.

CERES Origins

The CERES experiment is an extension of previous attempts to measure the Earth's radiation budget from satellites. Flat-plate radiometers on Nimbus 6 and 7 provided a very coarse spatial and temporal resolution data record. Higher spatial-resolution scanning instruments on Nimbus 3, Nimbus 7 and most recently ERBE have obtained global measurements of outgoing broadband shortwave and longwave radiation at the TOA. Each of these instruments provided successively higher spatial resolution, increased accuracy, and longer time records of this critical climate variable. Analysis of the most recent ERBE data has confirmed the critical role played by clouds in controlling the regional and global radiation budget of the Earth. This recent analysis, along with experience of the CERES science team members in international and national projects such as the ISCCP (International Satellite Cloud Climatology Project), FIRE (First ISCCP Regional Experiment), and SRB (Surface Radiation Budget) supplied the impetus and direction for the CERES proposals submitted to the EOS Announcement of Opportunity. As proposed, CERES will estimate not only TOA radiative fluxes, but also more complete cloud properties, which will allow determination of radiative fluxes within the atmosphere and at the surface. The CERES science team has met three times during the EOS definition phase study. The science team directs two EOS proposals, an instrument P.I. proposal for the CERES instrument, algorithms, and data system and an interdisciplinary science proposal to study the CERES data in conjunction with other EOS data sets and climate models (CERES-IDS). Dr. Bruce Wielicki is P.I. of the CERES-IDS interdisciplinary proposal.

Instrument Concept

The CERES instruments are scanning broadband radiometers which use thermistor bolometers to achieve radiometric measurements with high accuracy and stability. The instruments are based on the ERBE design with several improvements. Advances in the time response of thermistor bolometers will allow the CERES field of view to be reduced to 25 km, about a factor of two smaller than that for ERBE. Improvements in electronic design will allow both a longer instrument lifetime and reduced electronic noise in the measured radiances. Because the objective of CERES includes surface and atmospheric radiative fluxes (as well as TOA fluxes), one of the three ERBE spectral channels will be changed to measure the thermal radiation emitted from the Earth's surface in the 8-12 µm "window." The remaining two spectral bands measure shortwave and total broadband radiation. Broadband longwave radiation is estimated as total minus shortwave. The 8-12 µm window channel was proposed by Dr. V. Ramanathan of the CERES science team. This concept, along with the instrument field-of-view size, were studied during the definition phase.

Recent analysis of the ERBE data has indicated that there are three primary sources of error in estimates of the Earth's radiation budget. The first source of error is instrument calibration and stability. The ERBE scanners have demonstrated stability and internal consistency at the 1% level over a period of five years.

The second source of error is insufficient sampling of the angular variation of radiation. The cross-track scanning pattern required for good spatial sampling over the globe gives limited and biased sampling of angular space. Ideally, observations of radiation are required from all viewing angles of a target on the Earth. For this reason, CERES will include two scanners. One scanner will operate in cross-track scan mode optimizing spatial sampling and obtaining global coverage. A second scanner will scan using a rotating azimuth plane, thereby sampling the full range of viewing angles (when composited over time). Data from the second scanner will be used to generate greatly improved models of the angular variation of radiation. These models are in turn expected to reduce errors in the radiation budget data by factors of from 2 to 4 for both bias and rms errors of SW and LW fluxes.

The third source of error is the requirement to adequately sample the large variation of solar and earth radiation over the course of each day/night cycle. Validation studies using GOES hourly data indicate that this error is as large as the error from angular sampling, and requires 6 samples per day (i.e., 3 spacecraft) to reduce time-sampling errors in regional monthly average net radiative flux to 3 Wm-2 (1σ). Time-sampling errors vary systematically from region to region depending on the type of cloud and surface diurnal cycles present. The sampling error for regional daily average fluxes is 8 Wm-2. Using the entire GOES view of the Earth as a surrogate, the global average diurnal sampling error is estimated to be 1 Wm-2. Given accurately calibrated radiometers (1% or better), the angular sampling and diurnal sampling error sources will dominate the CERES regional error budget, while the instrument calibration error will dominate the global average error. The improved angular and temporal sampling of the CERES experiment will improve the accuracy of the data relative to ERBE by about a factor of 2. Similarly, ERBE achieved improvements of about a factor of 2 over the accuracy achieved by the Nimbus 7 ERB. Table 1 gives an estimate of the CERES error budget for TOA net radiative flux monthly averaged over a 1° latitude/longitude region of the Earth.

Table 1. CERES Error Budget: TOA net flux, 1° latitude/longitude regions

Source of Error	Monthly Average Global Bias	Monthly Average Regional 1σ	Daily Average Regional 1σ
Angular Sampling	1	4	8
Time Sampling	1	3	8
Inst. Calibration	3	3	3
Total	3	6	12

Errors given in units of (Wm^{-2})

A final question of interest is the ability of the CERES data to detect long-term trends. In this case the question is not one of absolute accuracy but of relative stability and noise level. Consider the case of a 2.5 degree latitude/longitude "box" for which TOA fluxes have been obtained for the month of July in a sequence of 10 years. At what level can trends in the radiation budget at the TOA be detected by the planned CERES measurements? The angular and time-sampling errors given in Table 1 are primarily systematic for a given place on the Earth with a given climatology. Since the satellite orbit sampling in time and viewing angle is the same from year to year, the resulting Time and Space Averaging (TSA) and Angular Distribution Model (ADM) errors are stable and should have little effect on the comparison of different years for the same region. They will have the largest effect on spatial patterns within a given month. Detecting long-term trends will then depend primarily on spatial sampling noise (random with no trend) and on long-term instrument drift.

Spatial sampling noise for regional monthly means is estimated for a 3-satellite system at about 1 Wm-2. Instrument drift from the ERBE experience is estimated at less than 1/2% for longwave and 1% for shortwave flux over a given year period. We would then expect that changes from one year to the next year would be detected at the level of 1 Wm-2 (limited by spatial sampling noise). Changes over a given year period would also be detected at the level of 1 Wm-2 (limited by instrument drift). Trend analysis for any spatial scale larger than 2.5 degrees would be limited by instrument drift for all time periods.

Measurement Objectives

Given the discussion above, there are five major measurement objectives for CERES:

1. Top of Atmosphere Radiative Fluxes (SW, LW, up)
2. Atmosphere Radiative Divergence (SW, LW)
3. Surface Radiative Fluxes (SW, LW, up, down, net)
4. Cloud Properties (amount, height, thickness, SW and LW optical depth, particle size, liquid water path, up to 2 layers)
5. ADMs of solar and thermal infrared radiation (SW, LW, vary with surface and cloud condition)

TOA fluxes and angular dependence models will be measured by the CERES instrument. Cloud information will be produced by the CERES team using EOS imaging and sounding instruments. Items 4 and 5 are required to produce items 1 through 3.

INSTRUMENT	SPACECRAFT	CERES REQUIREMENT
MODIS	EOS-A	Global simultaneous cloud properties
TRISS	Space Station	Global simultaneous cloud properties
AVHRR + HIRS	EPOP	Global simultaneous cloud properties
MIMR	EOS-A	Global cloud water content, Precip
AIRS/AMSU	EOS-A	Global temperature and water vapor profiles
HIRS	EPOP	Global temperature and water vapor profiles
EOSP/MODIS	EOS-A	Global aerosol properties
HIRIS, ITIR	EOS-A	Regional validation of cloud cover, particle size
LAWS, GLRS	JPOP, EOS-B	Regional validation of cloud height
MISR	EOS-A	Regional validation of bidirectional reflectance models, and aerosols

Synergism with other EOS Instruments and Interdisciplinary Science

While ERBE-like estimates of TOA fluxes can be made using the CERES instrument alone, advances in estimating surface radiation budget and atmospheric radiative divergence will require synergistic measurements from several EOS instruments. Data from these instruments will be used to derive the data products mentioned above, as well as to validate critical cloud and radiation parameter estimates.

Measurements from the cloud imagers and sounders (MODIS, TRIS, and AVHRR + HIRS) simultaneously with the CERES radiation budget measurements are especially critical to the success of the CERES experiment. Synergism of spacecraft platforms is also required to properly sample the diurnal variation of radiation. Requirements are for two sun-synchronous platforms (one morning, one afternoon) plus one inclined orbit (varying time of day).

The above instruments are those required to measure the Earth's radiant energy system. For studies of the complete energy cycle, measurements of vertical and horizontal transfer of latent and sensible heat by the atmosphere and ocean are also required. Key measurements for these studies include:

- Precipitation: Active radar and passive microwave measurements from TRMM on Earth Probe, TRAMAR on Space Station and MIMR on EOS-A
- Temp/Humidity: AIRS/AMSU on EOS-A, HIRS/AMSU on EPOP
- Surface Wind: Scatterometers on EOS-A and EPOP

Current plans are for the CERES radiation measurements to be included on the space platforms making these other key measurements of heat transport.

Finally, the CERES radiation budget data will be used in a wide range of EOS interdisciplinary science investigations including those led by principal investigators Abbott, Barron, Batista/Richey, Brewer, Hansen, Hartmann, Kerr, McNutt, Moore, Murakami, Rothrock, Schoeberl, Sellers, Srokosz, and Wielicki.

Bruce R. Barkstrom
Principal Investigator

LAWS STATUS REPORT

The Laser Atmospheric Wind Sounder (LAWS) is an EOS facility instrument baselined for launch on the first Japanese Earth Observing Platform in the late 1990's. LAWS is a Doppler lidar system for direct tropospheric wind measurements. The global wind profiles from LAWS will be fundamental to advancing our understanding and prediction of the total Earth system. The key EOS objectives that LAWS data will help to meet are: 1) determining what factors control the hydrologic cycle (specifically, a more accurate estimate of the horizontal transport of water vapor can be determined, and, through the incorporation of LAWS winds in global models using four-dimensional data assimilation, the depiction of vertical motion and precipitation will be improved), 2) quantifying the global distribution and transport of tropospheric gases and aerosols, 3) determining the relationship between large- scale, low-frequency atmospheric variability and variability of sea surface temperature, 4) improving the accuracy of deterministic weather forecasting and extending the useful forecast period, and 5) determining the global heat, mass, and momentum coupling between the ocean and atmosphere.

Fluxes of momentum, heat, moisture, CO_2, and other constituents are important to a majority of the EOS interdisciplinary studies. Under cloud-free conditions, and perhaps under some cloudy conditions, LAWS winds will uniquely contribute to the study of low-level tropospheric dynamics. The lowest level LAWS winds will be averaged over a height of only a few hundred meters in the planetary boundary layer. This mean velocity can be used in traditional parameterizations of air-surface fluxes, which are crucial to studies of the energetics of storms, regional weather analyses, and global climate modelling.

In addition to profiles of the horizontal vector wind, LAWS will provide the distribution of aerosols (sampled at 9.11 µm wavelength) and cirrus clouds, and the height of cirrus and stratiform clouds. These measurements will be extremely important for a variety of climate studies (e.g., cloud-radiation interaction). A summary of the LAWS data products and their expected resolution and accuracy is provided below. A number of events significant to the LAWS effort have transpired recently. They were reviewed and discussed at the LAWS Science Team Meeting in Boulder, August 1-3, 1990. The highlights are briefly mentioned below:

- A second, highly successful Global Backscatter Experiment (GLOBE) survey mission was conducted in the Spring of 1990. Among the preliminary results were: 1) clear-air backscatter returns were found most of the time, 2) water vapor concentration was well

LAWS Data Products, Expected Resolution and Accuracy		
Product	Expected Resolution	Expected Accuracy
Horizontal Vector Wind Profiles	100 km - Horiz.; 1 km - Vert. (0.5 km in high aerosol regions (e.g., PBL) or cirrus)	±1 to 5 ms^{-1} depending on aerosol amount with quality flags
Line of Sight Wind Profiles	100 km - Horiz.; 1 km - Vert. (0.5 km in high aerosol regions (e.g., PBL) or cirrus)	±1 to 5 ms^{-1} depending on aerosol amount with quality flags
Aerosol[A] Distribution	100 km - Horiz.; 1 km - Vert. (0.5 km in high aerosol regions (e.g., PBL). Temporally averaged (e.g., a few days)	TBD
Cirrus[B] Distribution	100 km - Horiz.; 0.5 km - Vert. Temporally averaged (e.g., daily)	TBD
Cirrus Cloud Top Height	50 km - Horiz.	±20 - 50 m[c]
Stratiform Cloud Top Height	50 km - Horiz.	±50 m

NOTES: A. Wavelength dependent (currently 9.11μm)
B. Cirrus not detectable by passive techniques (i.e., sub-visible)
C. Height determination for thin cirrus will be significantly more accurate with LAWS than current passive techniques

correlated with aerosol backscatter, and 3) lidar returns were obtained through deep cirrus layers and multiple layers.

- A new phase of LAWS observing system simulation experiments (OSSE's) has been initiated involving NASA/GSFC, Florida State University, and the European Centre for Medium Range Weather Forecasts (ECMWF) utilizing updated aerosol and cloud information. The results of these studies will be provided to the Japanese as input to their decision-making process with respect to the final orbital configuration of the Japanese platform.

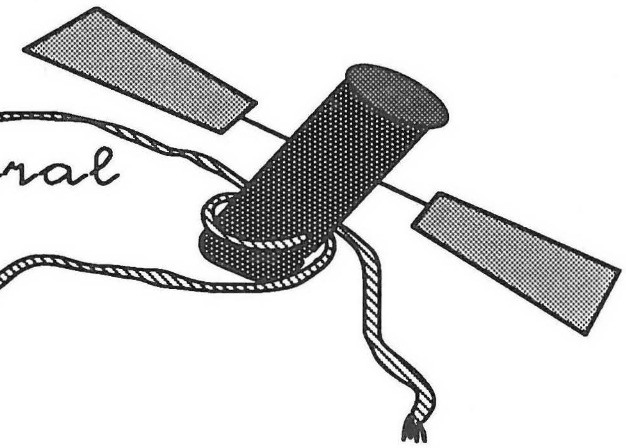
- In recognition of the importance of LAWS data and a precipitation radar (such as to be flown with the Tropical Rainfall Measuring Mission - TRMM) for climate research, a World Climate Research Program (WCRP) Planning Meeting on Earth Observing System for Climate Research was held at ECMWF in Reading, U.K. July 2-3, 1990. The discussion focused on mission and instrument trade-offs for a Doppler wind lidar such as LAWS and a precipitation radar which could be flown on the first Japanese Earth observing platform.

- The dual-breadboard laser (laboratory model of the lidar system) approach, reflecting the different instrument characteristics presented by the two contractor teams, was affirmed at a recent Non-Advocacy Review, organized by NASA Headquarters, Code R. The breadboard versions of the LAWS instrument will be constructed as part of the 21-month Phase B design effort, which was recently initiated.

Excellent progress has been made in defining a space-based wind-measuring instrument, which, together with ground-based systems and complementary GOES cloud-motion winds and aircraft measurements, will satisfy the EOS requirements for tropospheric winds. The primary emphasis of the near-term Science Team activities and the contractor Phase-B design studies will be to: 1) address the 10^9 shot (three year) lifetime requirement for LAWS, 2) minimize power and weight, and 3) provide quantitative assessments, through OSSE's, of the potential impact on LAWS science returns of various platform orbital configurations (i.e., polar, sun-synchronous orbit at 705 km vs. a 55°, non-sun-synchronous orbit at 705 km or at 450 km).

Wayman E. Baker
LAWS Science Team Leader

EOS at the OK Corral
"After the Shootout"



Tombstone, Arizona, site of the OK Corral gun battle, witnessed "Monsoon 90", a major NASA-Agricultural Research Service (ARS), EOS interdisciplinary field campaign this past summer. The campaign was conducted over the USDA-ARS Walnut Gulch Experimental Watershed near Tombstone. A previous article in *The Earth Observer* (Goodrich, Vol. 2, No. 5, June, 1990) described experiment objectives of Kustas et al. (1988) in more detail and a summary of the field work is presented below.

Baseline measurements, over uniformly dry soil (approximately 5%), in which the vegetation was senescent, were obtained in a preliminary field campaign on June 5, 1990. This data coincided with simultaneous overpasses of SPOT-1 and Landsat-5 satellites. Day-and-night NOAA-11 AVHRR scenes were also collected. The satellite data was supported by ground and aircraft spectral measurements in addition to soil moisture and meteorological data.

The majority of field activities were carried out during the July 23 - August 13 time frame. This period typically coincides with the summer monsoon season in the Southwestern United States. It is characterized by increased moisture flow into the region, resulting in air mass thunderstorm activity from convective heating. Analysis of past rainfall records from Walnut Gulch indicated that the probability of occurrence of rainfall events greater than 6mm was maximized during this period of time.

Pre-experiment tension was high as 1989 rainfall amounts for the same period were well below average. However, raindancing practice was cancelled as nature smiled upon us with early and significant rainfall. The vigorous vegetation growth prompted by the early July rainfall produced plant and soil conditions which contrasted greatly from the dry June 5th conditions.

The rain didn't let up for the field campaign as several large, runoff producing, rainfall events occurred with all field personnel in place. The timing enabled very good pre- and post-storm watershed characterization by aircraft remote sensing and ground-based measurements. Three aircraft took part in the experiment, including the NASA C-130, which deployed the Thermal Imaging Spectrometer (TIMS), Push Broom Microwave Radiometer (PBMR) and NS-001 instruments. Numerous additional measurements, outlined in the previous *Earth Observer* article, were also successfully collected.

As a bonus, an additional set of measurements, not outlined in the previous write up, were provided by colleagues of the Institute for Radioengineering and Electronics (IRE) of the Academy of Science of the USSR, working in conjunction with Tom Jackson of ARS. The IRE supplied a multifrequency radiometer system with wavelengths of 2.25, 21, and 27 cm. This instrument affords the unique feature of providing data in two frequencies of the L band portion of the microwave spectrum. There are no aircraft-based systems in the U.S. with this feature.

With low, multifrequency information provided by the instrument, IRE scientists have developed algorithms to predict soil moisture, profile soil moisture, soil salinity, vegetation biomass, and depth to shallow groundwater under ideal conditions. A primary goal of their work is the evaluation of the IRE algorithms under field conditions with ground truth data and concurrent NASA PBMR overflights.

Preliminary reports from the various investigators are very positive. A wide variety of conditions, including several wet up and dry down periods, were observed. The vast majority of ground and aircraft instrumentation operated well throughout the experiment. The only real casualty[1] of this summer's scientific shootout in Tombstone was the lack of clear conditions to obtain satellite imagery, due to the persistence of rain and cloud cover.

However, the resulting data set, once fully processed, should provide valuable insights for a more thorough understanding of semi-arid hydrology and energy balances. This experiment will serve as a solid foundation for the planned interdisciplinary EOS investigation of Kerr and Sorooshian (1990). This investigation will continue to collect data and conduct analyses at larger scales both within and beyond the Walnut Gulch watershed and in sub-Sahara Africa.

David C. Goodrich
USDA-ARS -- Tucson, Arizona

1 Another near casualty was averted when the Principal Investigator, Bill Justas of ARS, escaped a false trial and hanging with minor rope burns. It seems the Tombstone Vigilantes, a local Old West reenactment group, didn't care for all of those planes and scientists buzzing around Tombstone. Bill was released on a technicality, but our Russian colleagues really appreciated seeing a slice of the old American West and Tombstone scientific justice as served up by the Vigilantes (with the assistance of several participating scientists)!

References

Kustas, W. P., L. E. Hipps, R.D. Jackson, and D.A. Woolhiser, 1988. *Water and Energy Balance of a Semiarid Rangeland During the Summer "Monsoon" Season.* NASA proposal submitted in response to NRA-88-OSSA-11, 35 p.

Kerr, Y. H. and S. Sorooshian, 1990. *Utilization of EOS Data in Quantifying the Processes Controlling the Hydrologic Cycle in Arid/Semi-Arid Regions.* NASA proposal submitted in Response to A.O. No. OSSA-1/88, 107 p.

CESDIS Workshop Addresses Role of CS in Mission to Planet Earth

The Center of Excellence in Space Data and Information (CESDIS) at GSFC held a workshop on October 17-19, titled *The Role of Computer Science Research in the Mission to Planet Earth.* The workshop was attended by some 246 people over the three-day period. Opening remarks were to have been presented by John Klineberg, Director of GSFC, but time constraints precluded his presentation. In his place, Gerald Soffen provided an enthusiastic welcome, which was followed by other opening remarks by Ray Miller, CESDIS Director, and other representatives of appropriate NASA divisions.

The stage for the technical sessions was set first by Dixon Butler, NASA HQ, with an overview presentation on EOS and the Mission to Planet Earth, followed by Jeff Dozier's (EOS Project Scientist, GSFC) discussion of the data and computing challenges brought forth by EOS and the Mission to Planet Earth.

The first session, *Visualization Applications in Mission to Planet Earth,* demonstrated the necessity for using new and to-be-developed computing tools to allow researchers to deal with the vast volumes of data that are expected to be made available by the instrumentation that will be placed in orbit, as well as from ground truth investigations. Turning the data into visual representations will be the key to allowing comprehension of the data as information.

The second session dealt with *Data Compression Applications.* The consensus was clear that reliable compression algorithms must be available and implemented throughout the program, not only for raw data as transmitted from satellite-based instruments, but for image analysis and transmission as well.

The ability of scientists to access data was addressed in Session III, Data Access and Interfaces for Mission to Planet Earth. The speakers in this session presented some possibilities for facilitating this process, and addressed themselves to the need for suitable browsing and spatial data management tools.

Day two opened with an address by Vince Salomonson, Director of the Earth Sciences Directorate at GSFC. He spoke on computational challenges provided by EOS, with specific reference to the way one instrument, MODIS, would provide data into the EOS Data and Information System (EOSDIS). This was followed with a "crystal ball" look at the future of science and education by Jerry Soffen. The possible role(s) of industry in the EOS era was provided by Abdur Rahim Choudhary, of Ford Aerospace (now part of Loral).

The first session of the second day dealt with Physical Modeling, and the problems that result from the use of numerical models. The highlight of this session was a presentation by Warren Wiscombe of GSFC on the *Numerical Modeling of Physical Processes: The Ideal vs. the Dismal Reality.* In a short, incisive, and well-organized presentation, he demonstrated great understanding of the problems that arise in the use of numerical models, especially as implemented by researchers who have little or no feeling for the requirements of suitable programming. Because one is a(n) (Earth) scientist does not automatically make one an expert programmer or numerical modeler. Other presentations amply demonstrated the complexities of dealing with real-world data sets, particularly as derived from Earth systems research.

The afternoon was spent in a "practicum" mode, with demonstrations of several of the tools, algorithms, and approaches that had been discussed on a more theoretical basis during the preceding day and a half. The individuals responsible for these demonstrations managed to convey the incredible enthusiasm they feel for their topics, as well as the complexities of the tasks before them in attempting to deal with Mission to Planet Earth-era data sets and volumes.

The third day opened with a session on the *Extraction of Information from Data*. This process is perhaps the most vital in the utilization of the data provided by the Mission, in that useful information is the basis for making conclusions about the Earth system.

In support of the data-to-information process, Session VI discussed the problems that stem from the size of the data sets that will be available. Ephraim Feig, of the Thomas J. Watson Research Center of IBM, presented some basic (and often overlooked) aspects of what suitable browse capabilities should be, and challenged the researchers who will be doing such browsing to give something in return for these tools. He asks that a suitable annotation capability be built into browse tools, so that a knowledgeable researcher could call attention to a specific data series, or indicate that there might have been something wrong with the instrument or data stream at a given point. Even more important, he asks researchers to take the time to do such annotating, and thereby facilitate the give-and-take process that will be necessary for good science.

The last session was handled as a panel discussion on *Potential Collaboration Among Earth Scientists and Computer and Computational Scientists*. This session elicited some heat from panel members as well as the audience, as it became clear that a great deal of work is necessary to facilitate conversation and collaboration between computer and Earth scientists.

The upshot of the meeting was agreement concerning the incredible amount of work that is going to be required to provide scientists with the tools necessary to access, assimilate, process, and visualize data. To develop these tools, computer scientists must become familiar with the requirements of the Earth sciences research community; similarly, Earth scientists must develop increased familiarity with what computer scientists can do for them. New linguistic paradigms may be required to allow these conversations to take place. As a result of the development of these interfaces and the tools which will result, we may see the onset of new paradigms for the use of computers and the way researchers interact with them.

Mitchell K. Hobish
Research and Data Systems Corporation

Global Decision-Making Symposium Held in D.C.

Earth Observations & Global Change Decision Making: A National Partnership was the title of a conference held in Washington, D.C., on October 23 and 24 at the National Press Club. The conference was attended by some 450 representatives of industry, government, and academia, from the U.S. and from abroad. The conference was sponsored by NASA, NOAA, and ERIM (Environmental Research Institute of Michigan).

The stated purpose of the conference was to help build a national partnership for Earth observations and global change decision making by: (1) facilitating dialogue between the various communities involved in global change research and policy; (2) communicating the Federal research strategy (including Mission to Planet Earth); (3)identifying and discussing issues not addressed by Federal initiatives; and (4) discussing how the national agenda fits into the evolving international program.

To facilitate this process, panel sessions were organized to address National Partners, International Partners, U.S. Initiatives, Data Policy and Availability, Economics of Global Environmental Change, Policy Response to Global Environmental Change, and Building a National Partnership. High-ranking elected officials, senior-level administrators, and private-sector representatives formed the panels. NASA representatives included Len Fisk, Shelby Tilford, and Dixon Butler. The format of all panels allowed a short statement by individuals on the panel, followed by a submitted question-and-answer session.

The issues of the conference were further addressed by keynote speakers at the opening of each day's sessions, and during lunch. President Bush was slated to address the conference, but was unable to attend. Dr. D. Allan Bromley, Assistant to the President for Science and Technology, spoke in his place. The text of his talk indicated the emphasis that the Bush administration places on the topic of global change. The luncheon speaker on the first day was Albert Gore, Jr., member of the U.S. Senate, who made some strong statements about his view of the administration's priorities with respect to global change. He emphasized the position that we must do more than research; that *action* is required if we are to reverse some disturbing trends, and that such action must begin now.

The keynote address on the second day was given by Governor Madeline Kunin of Vermont, who has helped put into place in her state some stringent environmental legislation in an effort to curb pollution and waste. Her remarks were greeted with enthusiasm by the audience. The luncheon speaker was to have been Representative Robert Traxler (D-MI), who was unable to attend. In his place, the Honorable Bill Green (R-NY) spoke on the importance of Congress emphasizing global change issues, and the support the committee of which he is a member (House Subcommittee on VA, HUD, and Independent Agencies, Committee on Appropriations) gives to missions such as the Mission to Planet Earth.

The meeting did an excellent job of making the issues clear to individuals and organizations who have concerns in the areas addressed. With missions the size of the Global Change Research Program, Mission to Planet Earth, and EOS, it is necessary to keep everyone as up-to-date and involved as possible. Failure to do this could lead to political wrangling and ultimate disassembly of these vital initiatives. Conferences such as this help to ensure that the issues and the activities necessary to implement the programs discussed are kept in the public eye, and to foster communication between the numerous agencies and governments that are necessary to a successful outcome.

Mitchell K. Hobish
Research and Data Systems Corporation

Aspen Global Change Institute

Concern over the changes that are taking place on a global scale in terms of climate, environment, population and other sensitive areas has led to the foundation of the Aspen Global Change Institute (AGCI). July 29 through August 19, 1990 marked the inaugural session of the AGCI in Aspen, Colorado. The Institute was established as an intensive forum for the interdisciplinary study of Earth systems and the ways in which human activities affect them. A primary goal of AGCI is to create an educational bridge linking scientific knowledge to the arena of policy and governmental decision making. Planetary management of global change factors is seen as a necessity for the sustainable management of the environment. The Institute hopes to provide the scientific information and implementation strategies needed to influence policy designed to first mitigate and then reduce negative impacts on the global environment.

The opening meetings brought together educators and scientists from four countries to assess the state of knowledge on global change and to address the issues of dissemination of this information. Scientists who attended the Institute are leaders in an impressive array of disciplines dealing with global change. Topics covered included: climatology, ozone depletion, atmospheric chemistry, hydrology, radiation, glaciology, aquatic biology, modeling and population dynamics.

As part of their efforts to make information on global change readily available, especially to educational programs and curriculum, AGCI anticipates the preparation of audio and video presentations and the development of interactive computer learning programs. Through the expertise of the assembled educators, plans were initiated for textbooks on global change and innovative programs to actively involve students with scientists in the collection of data and the monitoring of various environmental factors. This summer's outreach programs also included a series of free, public lectures by scientific participants on topics from the global warming debate, to the interaction of population and water supply with global change.

AGCI is the unique result of a coalition of public, private and non-profit organizations whose partners include: Amway Corporation, as the founding corporate sponsor; NASA; the United Nations Environmental Programme (UNEP); the National Wildlife Federation; and Windstar Foundation. Notable participants included: John Denver, whose environmental initiatives led to the founding of Windstar; and Richard Johnson of the University Space Research Association who served as Science Advisor to President Reagan. The United Nations was represented at the Aspen meetings by Dr. Noel Brown, the North American director for UNEP, who spoke on the importance of the international community's efforts to share knowledge on global change and to reach accords to sustain the environment for the common good.

To find out more about the AGCI, the address is 100 East Francis, Aspen, Colorado, 81611 or you may call directly at (303) 925-7376. *[Article printed with permission by the Director of the AGIC, John Katzenberger.]*

The Earth Observer is a monthly publication of the EOS Project Science Office, Code 900, NASA/Goddard Space Flight Center, Greenbelt, MD 20771, telephone (301) 286-3411, FAX (301) 286-3884. Correspondence may be directed to Charlotte Griner at the above address. Articles, contributions to the meeting calendar, and suggestions are welcomed. Contributions to the meeting calendar should contain location, person to contact, and telephone number. Deadline for all submissions is the 20th of each month.

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Global Change Meetings

Jan. 13-18	71st Annual Meeting - American Meteorological Society, New Orleans, Louisiana. Featuring the 2nd Symposium on Global Change Studies; 7th Symposium on Meteorological Observations and Instrumentation; 7th Joint Conference on Applications of Air pollution Meteorology with AWMA; 7th International Conference on Interactive Information and Processing Systems for Meteorology, Oceanography and Hydrology; 1st International Winter Storm Symposium; and a Special Session on Laser Atmospheric Studies. Contact Evelyn Mazur at (617) 227-2425.
Jan. 29-Feb.1	4th Airborne Geoscience Workshop, *Techniques, Results, and Future Needs*, LaJolla, California. Contact Debby Critchfield at (202) 479-0360, or FAX (202) 479-2743.
March 20-22	Remote Sensing Society Conference, TERRA-1, *Understanding the Terrestrial Environment: The Role of Earth Observations from Space*, The Guildhall, Winchester, England. Contact Prof P.M. Mather, Geography Department, The University, Nottingham, NG7 2RD, England. Telephone: 0602 484848 Ext. 3040.
March 28-30	*Squeezed States and Uncertainty Relations Workshop*, University of Maryland, College Park, Maryland. For information contact D. Han, NASA/GSFC, (301) 286-9414.

Future EOS Science Meetings

Jan. 14	SEC Meeting, New Orleans, Louisiana. Debby Critchfield, (202) 479-0360.
Feb. 4-6	LAWS Science Team, Clearwater, Florida. Wayman Baker, (301) 763-8005.
Feb. 20-22	MODIS Science Team, NASA/GSFC, Greenbelt, Maryland. Barbara Conboy, (301) 286-5411.
Feb. 26-28	Payload Advisory Panel, Easton, Maryland. Berrien Moore, (603) 862-1766.
March 12-13	EOS SAR Meeting, Pasadena, California. JoBea Way, (818) 354-8225.
March 26-28	TES Science Team, University of Denver, Colorado. Reinhard Beer, (818) 354-4748.
May 29-31	EOS SAR Meeting, Bergen, Norway. JoBea Way, (818) 354-8225.