The Earth Observer

An EOS Periodical of Timely News and Events

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EDITOR'S CORNER

"Money makes the world go around, the world go around, the world go around...," so goes the refrain from *Cabaret*.

We are entering into a period just prior to the initiation of Phase C/D when the Project Approval gets committed. NASA believes that it understands how to carry out the EOS missions, and their price tag. The two polar platforms with the complement of instruments, the multiple flight units of each spacecraft to assure a decadal observation period, the complex ground segment of the Information System, the International responsibilities, and the support of several hundred selected scientists -- all of these are costly items. When the money becomes available, we will *always* be in a financial pinch!

How do we assemble the "production," balance the various needs and make the appointed launch date? Slipping the schedule is the road to disaster, and "*back to the well for more money*" is unacceptable. The hardest part is figuring out what to sacrifice.

We are now developing a *cost containment plan*. We recommend that everyone on the Project understand their priorities in context with the whole scheme of things. You will be asked many times to defend your needs.

Jerry Soffen
Senior EOS Project Scientist

AGU ON EOS

[This article is reprinted, with permission, from **EOS Transactions**, The Weekly Newspaper of Geophysics, American Geophysical Union, April 17, 1990.]

Planning for a space-based Earth Observing System (EOS) began about a decade ago by the National Aeronautics and Space Administration. Various working groups were established and, as would be expected, the majority of the 20-member EOS Science and Mission Requirements Working Group were AGU members. The first report of this working group was published in 1984 and outlined the scientific imperatives and requirements for EOS. Subsequent study activities by NASA in consultation with members of the scientific community have resulted in the current definition of the EOS program that is being proposed for initiation in President Bush's Fiscal Year 1991 budget. This budget is now being considered by Congress.

The EOS program proposed the launch, starting in 1998, of six Titan-IV-launched, polar-orbiting, Sun-synchronous satellites with instruments to observe Earth over a 15-year period. The primary focus of the program is global change, and with a projected budget of over $17 billion, it is planned to make the majority of such U.S. observations over its duration. EOS will be the largest space science project in NASA's history.

Because of the potential impact EOS will have on many areas of geophysics, AGU established a panel to review the scientific aspects of EOS as now defined. The AGU Council has adopted a formal position, which has been communicated to appropriate agency and congressional people, and its active support by AGU members is now both appropriate and solicited.

AGU Panel on EOS: W. G. Ernst, T. E. Graedel, C. B. Leovy, J. L. Smith, R. H. Stewart, W. R. Thatcher (Chair), and M. J. Walt.

AGU Position on EOS Program

Global observations of the Earth from space are a central part of the Global Change Program and of the total program needed to understand Earth as a planet. Both these programs have been endorsed by AGU as scientifically important. In accord with these positions, we strongly endorse the goal of EOS to better understand our planet by acquisition and interpretation of integrated Earth observations over a period of 15 years or more. A strong component of ground-based science is an essential ingredient of EOS and we endorse the development of the EOS data system, the support of interdisciplinary research teams, and the commitment to train a new generation of students dedicated to the study of the Earth and Earth processes.

The planning of EOS to date has been responsive to inputs from the scientific community and we fully expect this responsiveness to continue in order to maximize the advances made by EOS. In a number of ways, this program represents a major departure from NASA's traditional Earth sciences program. Consequently, we would like to call particular attention to the following aspects of the program.

1. Although EOS is proposed as a key element of the Global Change Program, we see the need for defining the specific objectives of EOS within that larger program. Key trade-off decisions depend on careful translation of specific scientific goals into instrument, spacecraft, and data system requirements. The efforts that are currently underway to establish these requirements in a judicious and balanced fashion should continue to be energetically pursued.

2. The planned 40% to 60% balance between resources devoted to spacecraft and instrument development on the one hand, and data system development and data analysis on the other, over the first decade of the EOS program is unique in space program history and is strongly endorsed. A vital aspect of EOS is the planned evolutionary development of the EOS data system (EOSDIS) and particularly the target of 1994 for having EOSDIS operational using existing data sets. The proposed allocation of specific resources to support students is praiseworthy since the value of the EOS program ultimately depends on the availability of well-trained scientists and engineers to use the data effectively. In view of the broad long-term and interdisciplinary scientific goals of EOS, the 40/60 balance is required and needs to be protected.

3. The usefulness of many of the EOS space measurements is critically dependent on well-planned validation and data intercomparison activities. We note that provision for such activities lies outside of EOS in other NASA Earth Sciences programs and in the programs of other agencies, both in the U.S. and abroad. It is imperative that these *in situ* measurements and process studies be implemented and that they be carefully planned and coordinated by the EOS program.

4. Effective use of the EOS data will require major new computational facilities for interdisciplinary model development, model validation, and model use. EOS should either provide such facilities or assure that they are provided by others.

5. It is extremely important that EOS be launched as scheduled by 1998 since delays will (i) seriously perturb the coordinated strategy for international Earth observation programs, (ii) postpone the time by which needed information on human global impacts is available, (iii) adversely affect the timely match of missions to scientific issues and technological capabilities, and most importantly, (iv) not provide the required continuity of EOS data with existing geophysical data sets. Continuity is critical and flights of priority instruments on Earth Probes and other satellites should be scheduled if there is any appreciable slip in the 1998 launch date.

6. Because it is not possible to cover the entire globe at all times of day with EOS, effective coordination with other agencies and with other countries that deploy Earth-observing operational and research satellites is necessary. This coordination is particularly important for achieving diurnal global coverage that is required to understand Earth and should be an EOS responsibility.

7. In some cases, the free exchange of data that is essential for the achievement of Global Change and EOS science goals is inhibited by existing statutes. For example, NOAA and USGS are now required to charge user fees for data for scientific use outside of the agencies. The same type problem arises for users of Landsat and Spot images. The administration and Congress should be made aware of the impact of such limitations on understanding our Earth so that remedies can be sought, through new legislation if necessary.

8. While continuous measurement of Earth system variables over the 15-year lifetime of EOS is a vital aspect of understanding Earth, EOS must have the flexibility to respond to new scientific questions and technological advances. A strong Earth Probes

program is needed to maintain overall flexibility within the Earth Sciences as well as being a key link between EOS and pre-EOS space-observing systems. An important component of flexibility involves scientific participation. Provision should be made in EOS for a strong competitive research grant program, for rotating membership on science teams, and especially for bringing new investigators into the program in a timely way. The flexibility achievable by selecting instruments for flight one payload at a time is also strongly recommended.

9. The EOS program should be treated as an augmentation to, not a competitor with, the existing NASA Space Science and Applications program. For example, it is important that the level of the existing Earth Science and Applications program not be decreased if EOS is initialized.

In summary, EOS has the potential of being a truly major step in the understanding of Earth.

1990 Global Backscatter Experiment (GLOBE)

In May 1990, the GLOBE mission will repeat a series of Pacific basin aerosol-backscatter survey flights following up those previously flown in November 1989 to provide data needed to develop the EOS/LAWS satellite instrument. Data obtained during these two time periods will provide the seasonal variation of aerosol concentration. Data will be obtained as far north as 75 degrees and as far south as 65 degrees, as well as in remote oceanic areas of the tropical Pacific. The suite of payload instruments will directly measure aerosol backscatter at infrared lidar wavelengths, with concurrent measurements of optical, physical, and chemical properties of the aerosol in the marine-free troposphere.

There are seven related experiments for vertical column and *in situ* aerosol definition. The lead instrument is the JPL pulsed CO_2 lidar, closely supported by the GSFC pulsed Nd:YAG lidar and two CW CO_2 lidars from MSFC. Backscatter measurements from these instruments are augmented by using mounted optical particle counters, a filter/impacter system, a preconditioned particle counter, and an integrating nephelometer.

[This article was previously published in the ***Airborne Geoscience Newsletter*** and was reprinted by permission.]

Letters to the Editor...

Dear Editor:

When I was in the US last August I picked up Volumes 1, 2, 3 and 4 of ***The Earth Observer***. As a scientist working in an out-of-the-way location I find the updates in ***The Earth Observer*** particularly valuable. Please add me to your mailing list.

Following a recent phone call with Dixon Butler I appreciate that some uncertainties exist with respect to EOS funding definition and access to the EOS data stream via direct readout (e.g., X-band ground station). For the last decade we have built an archive of the NOAA polar orbiter data via an HRPT direct readout facility. We are formulating plans to integrate our activities with EOS and to focus research on the eastern Indian Ocean region and its impact on the Western Australian land mass. Given the above, I would encourage you to include materials in ***The Earth Observer*** which review information relating to interested international users of EOS data. For example, *International User Real-Time Access to the EOS Data Stream -- Requirements, Restrictions, Obligations.*

It might also be the case that many interested international users, who are not attached to EOS Instrument Teams, are unsure as to how to become involved in EOS. For example, if one plans *in situ* measurements to support local research using EOS data, it is very likely that such *in situ* data sets might be of interest to EOS P.I.'s or EOSDIS. Are there any such plans to be put in place? Accordingly, articles on a theme *International Support for EOS In Situ Measurements -- Requirements and Plans.*

Keep up the good work!

Sincerely,

Mervyn J. Lynch

[Ed. Note: Mervyn Lynch is Associate Professor of Physics at Curtin University of Technology in Perth, Western Australia. We are planning the *in situ* program supporting EOS that the writer asked about. Contact the EOS Project Science Office at (301) 286-3411. We appreciate our foreign correspondents and would like to institute a new section titled "Notes from Abroad."]

Panel Reports

EOS LAND BIOSPHERE PANEL

The EOS Land Biosphere Panel held a one-day meeting during the EOS IWG in March, 1990. Topics discussed by the group included:

- Purview of the Panel
- Science Interests and Science Products
- Scientific Approvals and Measurement Needs
- Diurnal Variation of Clouds and Interference with Satellite Imagery
- Platform Altitude
- Other Needs
- Discussion of Previous Panel Report on HIRIS

Purview of the Panel

The group concluded that a range of processes connected to the Physical Climate System (PCS) and Biogeochemical Cycles (BGC) were relevant to the scientific investigations covered by group members. Figure 1 shows how five principal areas of interest are closely connected to both the PCS and BGC.

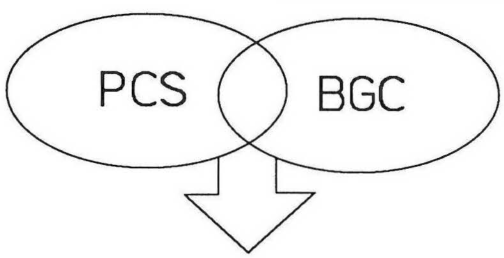

Figure 1. Purview of EOS Land Biosphere Panel

Science Interests and Science Products

The group is primarily focused on using models and satellite data to calculate the following global fields:

- Surface radiation (absorbed/reflected/emitted)
- Surface fluxes: heat, H_2O, CO_2
- Soil moisture and runoff
- Photosynthesis; respiration
- Vegetation cover and successional stage, change

Scientific Approaches and Measurement Needs

In order to calculate the fluxes of energy, heat and mass between the land biosphere and the atmosphere it is necessary to provide or calculate:

- Semi-continuous atmospheric forcings: T, q, u, S, L_w, P. The diurnal cycle must be resolved to provide these.

- Surface boundary conditions: Photosynthetic capacity, P_c*, surface conductance to water vapor, g_c*, soil moisture.

  These fields change relatively slowly but should be updated by observations or inference every 5-10 days.

Figure 2 shows the proposed methodology for satisfying these needs.

- Two polar orbiters, with crossing times spaced a few (3-6) hours apart, should provide fields of temperature and humidity and, if possible, winds, using atmospheric sounders.

- Imagers on the two platforms obtain information on the slowly-varying surface boundary conditions. An optimal configuration would have the 'best' imaging combination observing in the late morning (approx. 1030) with a reduced imaging configuration observing in the afternoon (approx. 1400) to obtain cloud fields and thermal data.

- The current proposal for the 'best' EOS imaging suite to observe at 1330 is non-optimal -- ABL clouds will greatly reduce the amount of usable data in the humid continental regions during the growing season. (See Figure 2 and the following information.)

Diurnal Variation of Clouds

Some literature on the diurnal variation of clouds was discussed. The normal, mid-continent, growing season scenario is for the ABL to rise in the morning, producing popcorn cumulus clouds, and then as convection continues through the afternoon, to produce thicker clouds or even stratocumulus decks, depending on the moisture availability.

Some specific examples are cited below:

- FIFE-87 growing season: NOAA-10 (1000) provided 20 clear images within a May-October growing season as compared with 10 clear images provided by NOAA-9 (1430).
- Minnis and Harrison (1986), Saunders (1985), Duvel and Kandel (1985) published information showing how summer cloudiness usually increased from a near-minimum at 1000 to afternoon maximum values over the humid continental regions.
- Tucker (1990, personal communication): 3 months' worth of daily AVHRR data were required to assemble a clear-view composite of the Amazon basin using the 1430 NOAA platform.

Further investigations into the diurnal cloudiness issue will be carried out prior to the next IWG.

Platform Altitude: 705 km vs. 824 km

The group could see no compelling argument for moving the platform to 824 km. There would be gains in terms of cloud coverage using MODIS-N, but losses in terms of HIRIS and other sensor resolution and MODIS-T coverage.

Other Needs

There were concerns about some potential weak spots in the developing science research effort.

- Models: Better models are needed to translate surface radiances (BRDF) into surface parameters. This concern covers remote sensing science over the whole electromagnetic spectrum. Processes over heterogeneous surfaces need particular attention.
- Data Processing Interfaces: Interfaces between models, GIS packages and data streams need to be more accessible to science.

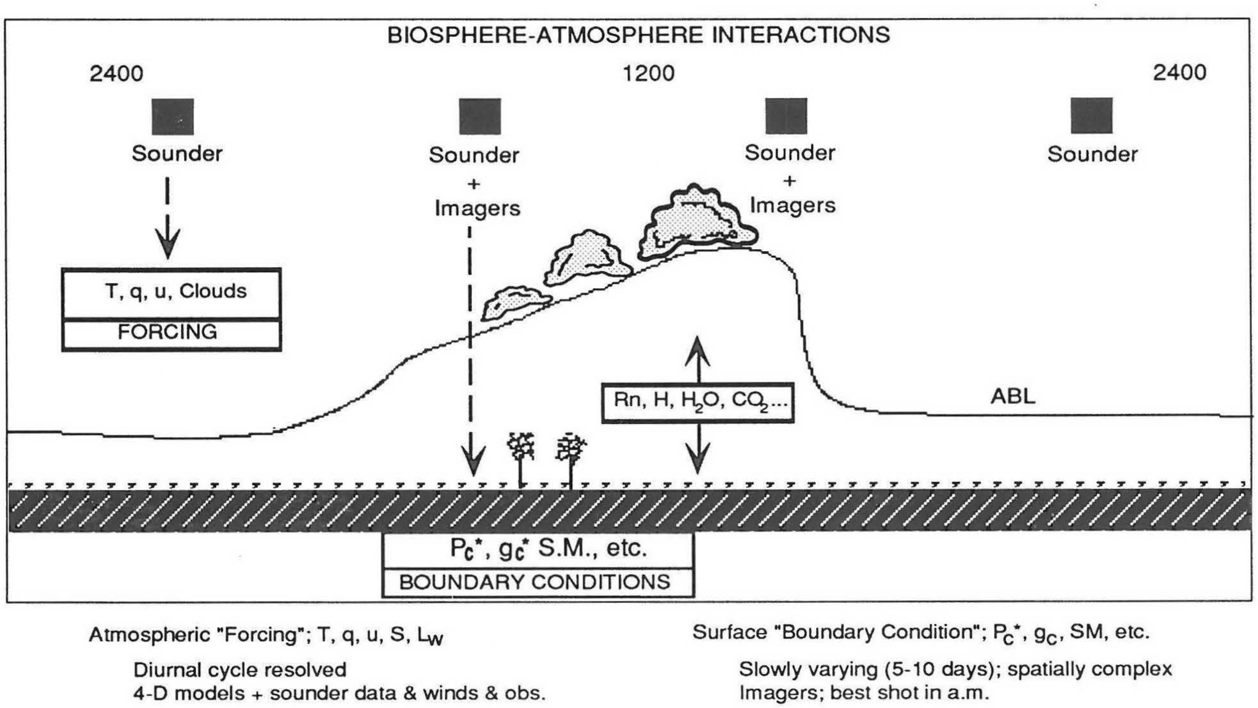

Figure 2. Platform Overpass Times.

- Field Experiments: Experiments to test hypotheses and algorithms are needed before and after launch. The current line-up of equipment and resources will be inadequate for the developing demand. Some changes and additions are desirable for instrumented aircraft, instrument simulators, field experiment support, portable spectrometers, and long-term commitments to experimental efforts.

- Other Data: The need for other data to be bound into EOSDIS was reiterated. These data include operational meteorological observations and soundings, surface and airborne fluxes, atmospheric diversity observations, surface states, and atmospheric optical properties.

HIRIS Review

HIRIS was reviewed in the context of the Land Biosphere Panel needs in an earlier meeting. A report follows this article.

Summary

The central concern of the panel focused on the surface imaging problem with respect to cloud contamination.

There is a strong need for a surface imager of the MODIS-N class to operate on a morning overpass platform. It should have the following characteristics:

- Spatial resolution adequate to detect ABL clouds, 200 m
- Reasonable spectral resolution/coverage
- Dynamic range configured for land

Piers Sellers, Chairperson

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 entries is the 20th of each month.

Land Biosphere Group HIRIS Meeting

Role of HIRIS

Within the context of land biosphere science investigations, it is anticipated that HIRIS will make contributions to the study of:

- Spatial integration/extrapolation techniques to scales appropriate to coarser resolution instruments

- Impacts of environmental change on terrestrial biota

- Biophysical, biogeochemical and ecological processes

Figure 3 shows how the role of HIRIS might relate to that of other sensors on the EOS-A Platform. Generally speaking, the surface parameters most suited to study by HIRIS are characterized by moderate to slow time rate of change and fine spatial resolution.

The first characteristic is predicated by the revisit/coverage attributes of the instrument, the second by its design specification. This means that the instrument should not be assessed in terms of a possible direct contribution to global-scale monitoring (e.g., like MODIS), but rather in terms of its ability to provide greater understanding of processes over a range of sample sites embedded within the global-scale monitoring effort. The (land biosphere) parameters that may be trackable to the instruments include: landscape pattern; vegetation cover, i.e. snow, etc.; vegetation canopy structure; and vegetation canopy chemistry. Other useful parameters include: cloud cover, atmosphere (total column) moisture content, and geologic/pedologic information.

Spatial Resolution Requirements

HIRIS will provide the spatial resolution necessary to translate our understanding of surface processes, observations of changes in surface condition, and one-dimensional radiometric inversion models from the local scale (a few meters) to scales appropriate to global coverage.

Previous research has investigated the effect of coarsening spatial resolution on surface feature extraction or model inversion fidelity. For example:

- Large Area Crop Inventory Experiment (LACIE): 30 m pixels were used to classify agricultural land use. In the central U.S., only half of these pixels fell into 'pure' cover types.

- First ISLSCP Field Experiment (FIFE): (1) Linear features associated with biological productivity and differences in biogeochemical cycling could be resolved best using a 10 m resolution and were lost at between 30 and 50 m resolution, and (2) topographic covariances could be resolved at 30-50 m resolution.

It appears that the spatial resolution of HIRIS (30 m) is just adequate for discriminating different landscape components.

Spectral Resolution and Coverage Requirements

It should be noted that the high spectral resolution characteristics of the proposed HIRIS configuration would be virtually worthless at coarser spatial resolutions.

The use of high spectral resolution data for surface biogeochemical studies is at an early stage. Potential applications of the data might include: canopy chemistry associated with biogeochemical cycling and trace gas emission; snow mapping; inland water and associated BGC; geology/pedology; landscape classification; cloud masking, and total atmospheric water content.

For canopy chemistry applications, it appears that the spectral features are typically 30 nm to 100 nm broad, requiring a 10 nm spectral resolution for effective detection. At this stage, it is difficult to specify which regions of the range 0.4-2.5 μm could be 'dropped' if it were desirable to descope the instrument's spectral coverage. However, it would be preferable to do this rather than substantially coarsen either the spectral or spatial resolution of the instrument.

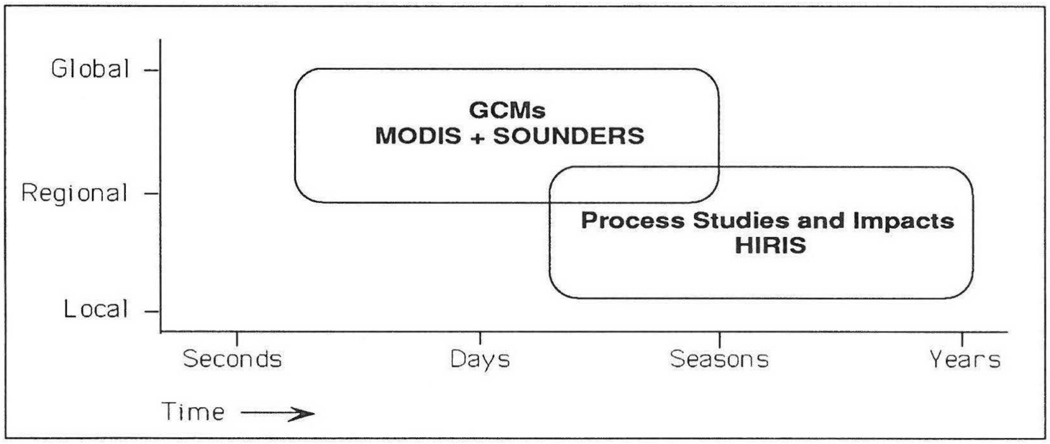

Figure 1. The Role of HIRIS as Related to Other Sensors on the EOS Platform

Next Steps

A number of activities should be initiated to provide a knowledge base for HIRIS applications:

- Field Experiments: Airborne ASAS and AVIRIS data should be acquired in conjunction with surface measurements.

- Modeling: Radiative transfer models should be developed to investigate the links between canopy/soil density and the spectral properties of reflected radiation; sensitivity studies are essential.

- Empirical Work: Laboratory and plot-scale validation work should be done with manipulative experiments on plants combined with spectrometry.

- Atmospheric Corrections: The detailed effects of atmospheric constituents on the upwelling spectral radiances should be investigated by models and experiments.

Summary

HIRIS can make a unique and valuable contribution to the EOS-A payload, particularly in the areas of spatial integration/extrapolation techniques to coarser scales, observing the impact of environmental change on terrestrial biota, and biophysical, biogeochemical and ecological process studies.

The following are recommended, in order of priority:

1. The spatial resolution of the instrument be maintained at around 30 m.

2. The spectral resolution of the instrument be maintained at around 10 nm.

3. The spectral coverage be maintained continuously over 0.4 - 2.5 µm.

Piers Sellers, Chairperson,
Biogeochemical Panel

EOS Altimeter Team

The EOS Altimeter (ALT) Team met at the EOS IWG meeting held in New Carrollton, Maryland in March 1990. Lee Fu, ALT Team Leader, chaired the meeting. There were three major items on the agenda:

1. Review of the science requirements and instrument package.

2. Project status.

3. The issue of repeat track requirement and payload selection.

Science Requirements

The ALT science requirements were closely examined for redundancy and ambiguity. The following have been adopted as the baseline requirements, which shall form the basis for the upcoming Conceptual Design and Cost Review (CDCR):

- ALT height over the ocean shall be measured with a precision of 3 cm at 1/sec data rate.

- The radial orbit height, defined as the height of the ALT zero reference location above the geocenter, shall be determined with an accuracy of 10 cm, to which the contribution from geographically correlated errors shall be less than 5 cm.

- ALT height error due to water vapor shall be less than 2 cm (rms).

- ALT height error due to ionospheric electrons shall be less than 2 cm (rms).

- ALT height error due to sea state effects shall be less than 2 cm (rms) for H1/3 < 2 m and wave skewness < 0.2.

- ALT shall operate with a 100% duty cycle.

- ALT GDR shall be available at a rate of 1 rec/sec with 20 ALT heights/sec.

- Subsatellite ground track drift shall be less than 1 km from averaged track location.

- Orbit repeat period shall be between 10 and 20 days.

- ALT GDR shall contain information on ocean and solid earth tides.

- ALT GDR shall contain information on sea surface air pressure.

- ALT waveform data shall be available at a rate of 20 waveforms/sec.

- Significant wave height shall be measured with an accuracy of 0.5 m or 10% (rms), whichever is greater.

- Wind speed shall be measured with an accuracy of 2 m/sec (rms).

- Wind speed, wave height, and preliminary sea level data (with operational orbit instead of precision orbit) shall be delivered to operational users (e.g., NOAA, Navy) to influence ocean predictions.

Support Instrument Package

Lee Fu reviewed the requirement for support instrument package — the laser retroreflection array (LRA) and the water vapor radiometer (WVR). If ALT is not to be flown with GLRS, then LRA is required for calibration purposes. However, the use of a transponder in altimeter calibration might be well developed in the EOS time. If ALT is not to be flown with either AMSR or HIMSS, then a dedicated WVR is required for wet tropospheric correction. Neither LRA nor WVR are included in the current baseline ALT design. These requirements need to be reexamined when the payload configuration for the platform for ALT is determined.

Project Status

Larry Rossi of GSFC presented the status of the ALT Project. A strawman ALT instrument team has been established within GSFC. A Definition Phase schedule has been defined and a Conceptual Design Task was initiated at APL. Tasks for the near future include the completion of the Conceptual Design, the preparation for the CDCR (in July), completion of the ALT Implementation Plan, and the initiation of the APL Contract (Jan 91).

Sue Lee of APL presented the design differences between TOPEX and EOS ALT. The main difference lies in the interface with the spacecraft: new mechanical, thermal, and power interfaces; new digital command, telemetry, and time interfaces; new reference frequency; difference in lifetime, and orbit. The feasibility of adding rain measurement capability was studied. The conclusion is that it is not possible with the current TOPEX design.

Repeat Track Requirement

C. K. Shum of the University of Texas at Austin presented the results of an assessment of the impact of atmospheric drag on EOS orbit repeat accuracy (a study jointly conducted with J. Lundberg and S. Nerem). They concluded the following: During a solar maximum (the next will occur in the year 2002), it will require an orbit maneuver every 5-6 days to maintain a +/- 1 km orbit. This situation may last for up to a year. During the rest of the time the maneuver frequency is expected to be 35-70 days. This result is in agreement with the analysis made by McDonnell Douglas for the EOS Project.

An issue of the choice of the EOS orbit altitude was also raised. If the orbit altitude is raised to 800-824 km, the average atmospheric density will decrease by up to an order of magnitude, thus greatly reducing the orbit maneuver frequency.

Questions Raised By the Payload Advisory Panel

Lee Fu led the discussion of the three questions posed in Berrien Moore's letter to Fisk (version 6, 3/14/90) regarding ALT:

1. Is the platform stability adequate for ocean altimeter measurement?
2. What are the requirements for repeat-track and what platform control issues flow from these requirements?
3. Are there issues of synergism that require ALT to be on the A-Observatory?

Based on the analysis of the EOS pointing error budget made by McDonnell Douglas for the EOS Project, the expected EOS pointing accuracy and stability performance can meet the ALT requirements. Therefore the answer to the first question is yes. Regarding the third question, ALT requires either AMSR or HIMSS on the A-Observatory to make the critical correction for the effects of atmospheric water vapor and rain.

Regarding the second question, S. Nerem and C. K. Shum took an action item to investigate the percentage of data return (defined as the data collected within 1 km from the nominal ground track) as a function of maneuver frequency, assuming that no yaw-steering (the most difficult maneuver) will be made. The result of the study is expected to form the basis for the Team to assess the extent to which the +/-1 km repeat track requirement can be relaxed.

Lee-Lueng Fu, Team Leader

Fourth Airborne Geoscience Workshop

The Interagency Steering Group on Airborne Geoscience will hold their Fourth Airborne Geoscience Workshop in La Jolla, California January 29 through February 1, 1991. Global Change will be the central theme of the workshop. Panel sessions will include: Agency Thrusts in Airborne Geoscience; Major Field Projects; Development Plan - Instruments and Measurement Techniques; University-Agency Interactions; and Facility Manager-User Forum.

Letters of invitation were mailed with details on the meeting site, accommodations, and key dates for registration, abstracts, and the like. Mark your calendars now. For further information, contact Debby Critchfield, Earth Science Support Office, 600 Maryland Avenue, S.W., Suite 455, Washington, D.C. 20024, telephone (202) 479-0360, FAX (202) 479-2743.

Possible Arctic Ozone Loss

Chemical processes that lead to ozone depletion in the Antarctic are present in the far Northern Hemisphere, and some regions of the Arctic stratosphere may have suffered ozone losses up to 17 percent during the winter of 1988-89, results of the 1989 Airborne Arctic Stratospheric Expedition (AASE) indicate.

At the conclusion of the mission in February, AASE scientists released a statement that "no unequivocal signature of photochemical loss of Arctic ozone was identified before the end of this mission. However, by the end of this mission a considerable portion of the vortex air was primed for destruction."

After almost a year of analysis had refined that conclusion, several investigators, using different analytical methods, reported the Arctic ozone losses. For example, a team led by Dr. Edward Browell of NASA's Langley Research Center, Hampton, Virginia, used a laser-based technique similar to radar to measure ozone distribution and observed depletions of up to 17 percent at some altitudes.

A group led by Dr. Mark Schoeberl of GSFC, inferred average photochemical ozone losses of 0.44 percent per day over the mission at altitudes above approximately 12 miles.

[Reprinted from ***NASA Activities***]

Global Change Meetings

June 4-8	Nonlinear Phenomena in Atmospheric and Oceanic Sciences, Minneapolis, Minn. Call (612) 624-6066.
June 6-13	USRA/GSFC Graduate Student Summer Program in the Earth System Sciences. Contact Claudette Sharps (301) 286-4118.
June 11-15	International Conference on the Role of the Polar Regions in Global Change, Fairbanks, Alaska. Contact Cindy Wilson (907) 474-7954.
June 13-15	AGU Chapman Conference on Hydrologic Aspects of Global Climate Change, Lake Chelan, Wash. Call (202) 462-6900.
June 18-21	Global Environmental Hydrology and Hydrogeology, Leningrad, Russia. Call (612) 579-1030.
June 19-23	4th CERES Science Team Meeting (tentative). Contact Jim Youngblood (804) 864-4509.
July 10-12	Northern Hydrology Symposium, Saskatoon, Saskatchewan. Contact Scientific Information Division, National Hydrology Research Institute, (306) 975-5737
July 15-19	Twelfth International ICSU Committee on Data for Science and Technology Conference, Data for Discovery, Columbus, Ohio. Call (614) 442-6522.
July 16-20	Earth System Science Center Workshop on Atmospheric Oxygen Variation Through Geologic Time, Penn State University. Contact Eric Barron (814) 865-1073.
July 16-20	International TOGA Scientific Conference, Honolulu, Hawaii. Contact Dr. Klaus Wyrtki, (808) 948-7037.
July 9-13	International Symposium on Assimilation of Observations in Meteorology and Oceanography, Clermont-Ferrant, France. Call 45 29 12 25.

Future EOS Science Meetings

Sept. 11-13	Calibration Advisory Panel Meeting, University of Arizona, Tucson, Arizona
Nov. 6-9	IWG, Langley Research Center, Virginia

EOS Science Meetings - 1990

Month	Monday	Tuesday	Wednesday	Thursday	Friday	Sat/Sun
JUNE					1	2 3
	4	5 ← SAR Team Meeting, JPL → ← MISR CDCR GSFC →	6 ← HIRIS Mtg. JPL → → ← GGI CDCR GSFC →	7 STIKSCAT CDCR ← GSFC →	8 SCANSCAT CDCR ← GSFC →	9 10
	11 ← ESA Meeting on MIMR and CIIS, Noordwijk →	12 → ← Physical Climate and Hydrology Meeting - Lake Chelan, Washington →	13 → →	14 → →	15 →	16 17
	18	19 CERES CDCR ← GSFC →	20 TRACER CDCR ← GSFC → ← ICWG Meeting - Frascati, Italy →	21 SAGE III CDCR ← GSFC → →	22 →	23 24
	25	26	27	28 EOSP CDCR ← GSFC →	29	30 1
JULY	2	3	4	5	6	7 8
	9	10	11	12 ← EOSDIS Mtg. Snowmass, CO → ← HIRDLS CDCR →	13 → →	14 15
	16	17 ← SAFIRE TEAM MEETING → ← HIRIS CDCR →	18 → →	19 →	20 →	21 22
	23	24 MODIS-N ← CDCR → (Science & Data Only)	25 MODIS-T ← CDCR →	26 ← AIRS CDCR →	27 →	28 29
	30	31	1 ← LAWS Mtg., Boulder, CO →	2 →	3 →	4 5
AUGUST	6	7	8	9 ← POEMS CDCR →	10	11 12
	13	14 LIS ← CDCR →	15	16	17	18 19
	20	21	22	23	24	25 26
	27	28 ← Payload Advisory Panel and SEC Meetings, Durham, New Hampshire →	29 →	30 →	31 →	

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