THE EARTH OBSERVER

A Bimonthly EOS Publication

July/August, 1994 Vol. 6, No. 4

INSIDE THIS ISSUE

Editor's Corner

On August 17-18, the House-Senate Appropriations Conference Committee marked up the VA-HUD-Independent Agency (VA-HUD-IA) bill for FY95. The NASA budget submission for the Office of Mission to Planet Earth was \$455.1 M for EOS and \$284.9 M for EOSDIS, for a total obligation authority of \$740 M. The Conference Committee voted to increase the EOS budget by \$25 M and the EOSDIS budget by \$10.1 M, for a combined total of \$775.1 M, with the express purpose of augmenting EOSDIS reserves and enhancing the funding for "secondary payloads," such as SAGE III and EOS Color. This latter recommendation is partly a consequence of the Conference Committee recommendation to delete funding for SAGE III from the attached payloads budget of the International Space Station Alpha.

Prior to the Conference Committee markup, the EOS program was rebaselined in accordance with the budgetary guidelines submitted to the Congress for FY95-FY00, guidelines that resulted in a 9% reduction in the EOS budget approved only one year ago. After considerable effort leading up to the EOS Payload Panel meeting in July (see report on page 4 in this issue), the rebaselined budget allocation for FY95 was \$489.9 M for EOS and \$250.1 M for EOSDIS. How the augmentation to the EOS budget that was recently authorized by the Congress will be allocated between the various components of the EOS program has not yet been decided.

On August 2 the Program Management Council (PMC), consisting of the NASA Associate Administrators and chaired by the Deputy Administrator, met to review the following issues concerning the EOS program: (i) the robustness and soundness of the rebaselined program, (ii) the need for and approval of a change order for the EOSDIS Core System (ECS) contract, and (iii) authorization to release the request for proposals (RFP) for the EOS common spacecraft (PM-1, Chemistry-1, AM-2). The PMC approved the release of the RFP, which was subsequently issued at noon, September 1. The ECS change order will reflect changes to the EOS program that have occurred since the contract was initially written, including multiple spacecraft (AM-1, PM-1, Chemistry-1,...) as opposed to the A1 platform, the addition of two DAACs (Oak Ridge, CIESIN), the advanced launch date for AM-1 (from December 1998 to June 1998), science product generation for CERES and LIS on TRMM, and ECS support for Landsat-7. This change order is expected to be negotiated and awarded in October. The rebaselined program, in addition to the PMC, has been presented to and discussed with the NASA Administrator, the Senate Appropriations Subcommittee on VA-HUD-IA, and the Office of Science and Technology Policy of the White House. It has been widely acknowledged that this process, though painful, was extremely well done and has resulted in a very sound program to support global environmental change research.

The Project Science Office has synthesized the inputs from both the written and oral reviews of the Algorithm Theoretical Basis Documents (ATBDs) prepared by the CERES, MISR, and MODIS science teams. This analysis has included the written reviews, oral reviews, visiting committee summaries, and discussions with some algorithm developers, team leaders, and the EOSDIS Project Scientist. As a consequence of this analysis, the at-launch/post-launch specification for each product has been revised and clarified in greater detail. The importance of the product(s) to EOS priorities, the soundness of the algorithm(s)' approach, and the maturity of the algorithm(s) to date have all been considered in particular detail.

Each ATBD has been categorized into one of four categories, with revised algorithms for all category A and B algorithms (those with a particularly sound basis, extreme relevance to global change research, and either minor or major modifications required) to be delivered electronically to the Project Science Office by November 1 for subsequent posting on World Wide Web. Category C ATBDs, due December 1, entail algorithms that are inappropriate as DAAC standard products at the present time, and algorithms in one or more of the following sub-categories: (i) *validation* product, to be produced and archived for ~6 months, then deleted, (ii) *research* (experimental) product to be produced at the team leader's computing facility or a team member's Science Computing Facility (SCF), or (iii) *internal* product used in the generation of successive products, but inappropriate for distribution to the Earth Science community. Category D algorithms are candidates for deselection, as it is deemed unlikely that an operational product will be produced in the foreseeable future using these algorithms.

In an effort to foster improved communication to the EOS Community, the electronic mail distribution lists, originally established by Jeff Dozier, have been moved to the Project Science Office. Using these new lists (see below), it is possible to rapidly communicate to any of the EOS Panels, the Investigators Working Group (IWG), or the Science Executive Committee (SEC). These new lists include updated membership and e-mail addresses, and include some recently formed panels that did not previously exist (e.g., Cryosphere Working Group, Data Quality Panel). In addition to establishing these new e-mail distribution lists, there has been a parallel effort to update and validate the EOS Directory. This newly revised directory will be sent to the printer in September, and should be available in early October, prior to the IWG meeting in Baltimore.

The *Science Strategy for the Earth Observing System*, by Ghassem Asrar and Jeff Dozier, was recently published by the American Institute of Physics. This document describes the need for an Earth Observing System, coupled subsystem models of the Earth System, the challenge for Earth System Science, and the need for integrated measurements. It proceeds to lay out the science strategy behind each of the seven themes of EOS, including clouds and radiation, oceans, greenhouse gases, land surface processes, ice sheets and polar processes, ozone and stratospheric chemistry, and volcanoes. Finally, the document outlines the rationale for the international EOS program and the need to assess humanity's impact on climate change.

An EOS Science Executive Committee (SEC) meeting was held in Chicago on September 1. The chairman of the SEC, Eric Barron, announced the election of Steve Running as chair of the Land Panel. In addition to discussing the preliminary agenda for the upcoming IWG meeting in Baltimore on October 19-21 (see registration form on page 45), the SEC discussed the purpose, intended audience, and outline of a Science Plan for EOS. This will be refined further in the next month, and discussed at the IWG meeting.

Finally, I would like to take this opportunity to thank Mark Schoeberl, who has served as EOS Chemistry Project Scientist for the past year and a half. He has decided to step down as Chemistry Project Scientist, but to continue his leadership role as principal investigator on his interdisciplinary investigation as well as his duties as UARS Project Scientist. His Deputy during the last few years, Jim Gleason, has now been appointed Chemistry Project Scientist. Congratulations, Jim!

I would also like to announce the appointment of Jay Zwally as Laser Altimetry Project Scientist. Chet Koblinsky remains the Radar Altimetry Project Scientist. This recognizes the split of the Altimetry Mission into separate spacecraft as recommended by the Payload Panel. ❑

—Michael King
EOS Senior Project Scientist

Electronic Mail Distribution Lists

e-mail name	distribution
iwg	Investigators Working Group (all EOS investigators)
iwg-atmospheres	Atmospheres Panel
iwg-biogeochem	Biogeochemical Cycles Panel
iwg-climate_and_hydrology	Physical Climate & Hydrology Panel
iwg-cryo_working_group	Cryosphere Working Group
iwg-data_quality	Data Quality Panel
iwg-eosdis	EOSDIS Panel
iwg-everybody	Combination of everyone listed in all e-mail distribution lists
iwg-land	Land Panel
iwg-management	Management (Headquarters and Goddard Space Flight Center)
iwg-mission	Mission Design Panel
iwg-modeling	Modeling Panel
iwg-oceans	Oceans Panel
iwg-payload	Payload Panel
iwg-sec	Science Executive Committee
iwg-SWAMP	Science Working Group for the AM Platform (SWAMP)

† To distribute a message to one of the lists, use the following format in the To: field of your message: e-mail name@ltpsun.gsfc.nasa.gov (e.g., iwg-sec@ltpsun.gsfc.nasa.gov)

Payload Panel Report

The EOS Payload Panel

July 19-21, 1994

—**Berrien Moore III** (b.moore@unh.edu), Panel Chair, Inst. for the Study of Earth, Oceans, and Space at University of New Hampshire

Responding to the Demand to Reduce the Earth Observing System Budget from $8 to $7.25 Billion: 1990-2000

INTRODUCTION

The reduction in the currently projected 10-year budget for the Earth Observing System (EOS) from $8.0 billion to $7.25 billion was mandated by the Clinton Administration in its budget submission for FY 1995. NASA and the Earth science community have worked together to define a minimum EOS Program that can be accomplished within this new funding constraint, while retaining the basic scientific integrity of the mission and its ability, over time, to meet the needs for environmental information of policy makers concerned with global and regional climate change.

While some of the multi-year reductions may be accomplished without serious effect on the program, it must be stated that the achievement of several essential elements (e.g., continuity of observations for 15 years) of the program are now at *significantly greater risk.*

The items that were identified as part of the recent EOS rebaselining and recommended by the EOS Payload Panel as the structure of the reduction follow:

- Do not slip AM-1 or PM-1; avoid the Space Station syndrome. Assume six-year launch centers. Strive not to slip CHEM-1.

- Accept nine of the ten reductions to the EOSDIS budget that the Project and Program recommended; the Panel does not recommend, at this time, the closing of one or more of the DAACs. The Panel accepts all of the budget recommendations regarding the spacecraft as well as Project and Program administration costs.

- Keep both CERES scanners on PM-1 for now; charge the Atmospheres Panel of the Investigators Working Group to study the value of the second CERES scanner on PM-1. In particular, the Panel should evaluate the value of the second CERES scanner on PM-1 versus moving EOSP from AM-2 to this position and versus simply not flying the second CERES scanner on PM-1 and not moving EOSP from AM-2. The Atmospheres Panel should report on this issue before March 1, 1995. Removing this instrument without this study is too dangerous, and it (the removal of one CERES) is a step that could be taken later without unnecessary cost.

- Request from NOAA the MHS (or a refitted AMSU-B) for flight on PM-1. The MHS would make a valuable, scientific contribution to the mission and flying it with AMSU and AIRS would be important for later achieving operational status for the AIRS/AMSU/MHS package.

- Cancel the combined EOS Radar and Laser Altimeter Mission and rephase them as separate Missions. a) Fly EOS ALT-R as a joint mission with CNES or as a GEOSAT Follow-On-II in 1999. Maintaining the TOPEX/Poseidon data record is essential for ocean circulation determination. There will be important synergism with the altimeter on ENVISAT. b) Slip EOS ALT-L by 12 months. Determination of ice volume is an important long-term challenge to understanding climate change; however, slipping initiation of this measurement is less damaging than other cuts to the program. The Panel remains supportive of this valuable measurement; the delay is, however, damaging to the overall program. c) The Cryosphere and Atmospheres Panels should review the overall mission objectives for EOS ALT-L and give specific attention to the issue of the cloud lidar option of EOS ALT-L and mission lifetime. These Panels should report on this issue before July 1, 1995.

- Move TES to CHEM-1; this enhances the scientific value of CHEM-1 and allows AM-2 to accommodate the land remote sensing instrument planned for Landsat-8 and thereby to save the country and NASA the cost of a launch and spacecraft.

- Remove ACRIM, SAGE III, and SOLSTICE from CHEM-1. This increases the robustness of the mission and allows earlier flight for certain instruments. It also allows CHEM-1 to accommodate TES and remain a Delta II class mission. a) Even in the light of the budget difficulties expressed in the rebaselining, the EOS Payload Panel again recommends to launch SAGE III in a mid-inclination orbit by 1999-2000 and to fly SAGE III in a high-inclination orbit by 2000. Measurement of the profiles of important aerosols, ozone and upper tropospheric water vapor are essential component of a climate change program. SAGE III is particularly appropriate since there is an important long-term record from SAGE II. b) Fly ACRIM on a small satellite by 1998-99. Obtaining a longer record of solar forcing is an essential component of a climate change program. Develop the SOLSTICE-II instrument for a Flight of Opportunity in 2002-03. This instrument makes key measurements in the UV, which are important for atmospheric chemistry.

There is a significant concern since this recommendation makes the high inclination SAGE III and the SOLSTICE-II instrument dependent upon Flights of Opportunity. The mid-inclination flight of SAGE III was already a Flight of Opportunity.

- Use AM-2 to fly an ETM+ type instrument instead of a Landsat-8 mission. This high spatial resolution measurement stream is important to global change and valuable to the nation in many areas. This strategy, as noted, saves the cost of a Landsat-8 launch and a spacecraft.

- Eliminate the cost for a second LIS instrument and rely on the flight spare unit for any follow-on mission (e.g., TRMM-2).

- Cancel EOS Color but seek to fly an ocean color instrument on Landsat-7. Losing ocean color in tropical regions is too risky for a program that must address the global carbon cycle.

- Add the OH-capability to MLS.

- Merge the ASTER and Landsat Science Teams

- Reduce the total cost of Algorithm Development

- Consolidate and phase the implementation of EOSDIS DAACs

- Delay some of the processing and archiving of EOS Standard Products

- Reduce the ASTER Standard Product Demand Assumption

- Slip the CHEM-1 Mission by nine months only if there is no other way to meet the funding profile and the previous recommendations.

In association with these recommendations, the Panel attempted to identify some of the scientific impacts and programmatic risks implicit in these recommendations. *In the revised EOS program both content and schedule are adversely affected; this was unavoidable.*

EOS MISSIONS AND INSTRUMENTS

EOS Common Spacecraft Missions

- Do NOT slip AM-1 or PM-1; the Earth Observing System must avoid the Space Station syndrome.

- Strive NOT to slip the CHEM-1 Mission.

- Fly the AM, PM, CHEM Series Common Spacecraft on six-year centers.

The objective of this latter recommendation is to launch AM, PM, and CHEM on six-year intervals without any concomitant increase in the reliability, maintainability, and availability specifications for the satellites or their instruments.

Viewed in another light, this is a one-year slip of AM-2, PM-2, and CHEM-2 and a two-year delay in AM-3, PM-3, and CHEM-3.

The recommendation to fly the EOS common space-craft missions on six-year centers with five-year design lives introduces risk, but this risk is acceptable if the alternative is to lose critical climate measure-ments.

More specifically, this deferral of the AM-2 launch to 2004 and the deferral of other missions to six-year launch centers increase the risk of data loss and data continuity due to launch or in-orbit failure. *This increase in the chance that there will be significant gaps in parts of the EOS observing record is hard to quantify precisely, but it is not negligible.*

EOS Altimetry Missions

At the October 1993 meeting of the EOS Payload Panel, it was recognized that the science objectives of EOS Land-Ice Altimetry (EOS ALT-L) and EOS Ocean Altimetry (EOS ALT-R) measurements dictate that these sensors be on separate spacecraft. Polar orbits with non-repeating or long-period repetition ground tracks are required for complete ice sheet surface topography, while lower inclination orbits with reasonable values for the mid-latitude and equatorial ground track crossover angles are required to achieve optimal recovery of ocean surface topography. Furthermore, it was felt that separating these missions added budget robustness.

This robustness allows the Panel to respond to the budget pressure of the rebaselining of the EOS Mission. This response is not accomplished easily.

- Deferral of the EOS ALT-Laser (EOS ALT-L) mission by 12 months

At the October 1993 EOS Payload Panel meeting, the Panel recommended that "strategies be explored for advancing the launch data (7/2002) of the Geoscience Laser Altimeter System (GLAS) on the EOS ALT-L Mission." GLAS is the essential instrument for an IPCC key category of scientific uncertainty: polar ice sheets. Commencement of (GLAS) measurements is extremely important to establish a baseline of global ice volume change and obtain essential data for forecasting sea level change.

Unfortunately, in the current budget climate the Panel must reverse itself and recommend a delay by 12 months of the EOS ALT-L Mission.

It is recognized that the recommendation to delay the 2002 launch will further delay reliable assessment of the impact of polar ice sheets on global sea level change. Our current inability to assess accurately either current or future changes in ice mass and sea level is a critical deficiency. Specifically, it is not known whether the polar ice sheets are shrinking in size and contributing to the observed sea level rise, or growing and reducing the amount of global sea level rise that would otherwise be occurring. Changes in the ice mass balance that will be associated with climate warming may also be either positive or negative, and may therefore either amplify or reduce future sea level rise.

This decision is not easy nor without some controversy.

At the $8 billion dollar Program level, the EOS Mission was devoid of nonessential observations; cutting the Program to $7.25 billion does damage and the Panel was forced to establish principles to mini-mize the harm to the Program. One theme was to delay certain observations in lieu of not making an observation or in suffering a damaging gap in existing or on-going time series. The Panel believes that this delay is less damaging than not making other mea-surements such as ocean color or the OH measure-ment.

This results now in a late start of the key measure-ments of ice sheets and mass balance of polar regions which have a direct impact on global sea-level rise. This delay is important and is discussed in more detail in Appendix I.

Finally, the lidar is also likely to be the only convinc-ing way to unambiguously measure polar cloud height and amount, especially for polar night, when clouds dominate the surface energy budget by blocking the atmospheric window. Since sensible and latent heat fluxes are very small during polar night, the longwave flux energy budget at the surface determines the surface temperature. Changes in the polar night surface radiation budget are dominated by changes in cloud properties.

The Cryosphere and Atmospheres Panels should review the overall mission objectives for EOS ALT-L and give specific attention to the issue of measuring polar cloud height and amount by the lidar and the question of the mission lifetime of EOS ALT-L. These Panels should report on this issue before July 1, 1995.

- Increase the dependency on inter-agency or international cooperation for accomplishing the EOS ALT-R Mission

In October 1993, the Panel recognized again the importance of ocean altimetry and challenged the Program and Project to "explore options for ensuring that the important measurements provided by the current TOPEX/Poseidon mission be continued to bridge the gap between the end of TOPEX/Poseidon and the launch of EOS Ocean ALT."

In order to meet the funding constraints, these options must become the EOS Ocean ALT (ALT-R) Mission. Fortunately, the effort initiated in response to the October 1993 recommendation has revealed two possibilities:

a) To conduct the Mission jointly with the Centre National d'Etudes Spatiales (CNES) and NOAA, and

b) To support the second spacecraft, instrument, and launch in the U. S. Navy's Geosat Follow-On (GFO) Series.

Although the identified arrangements are both viable and attractive financially, there is considerable implementation risk associated with each option. In addition, one of the options (discussed later in this Report) for flying SAGE III in a mid- to high- inclination orbit is to utilize the EOS ALT-R Mission. The orbit proposed in the CNES option is suitable for accommodating SAGE III as a Flight of Opportunity with optimum 66-degree inclination orbit; however, the Panel does not know the position of CNES with respect to flight of SAGE III on EOS ALT-R. The orbit for the second GFO option provides a better coverage of polar regions for cryospheric process studies; however, the orbit introduces certain aliasing and is less desirable for SAGE III. The Panel does not know the possibility of shifting the orbit of the second GFO.

The increased risks with these options are balanced by improvements in the chances for observational continuity in ocean circulation measurements using radar altimeters with the accuracy of TOPEX/Poseidon. The external cooperation will enable launch of an EOS Altimeter Radar Mission three years earlier than the original EOS ALT-R Mission but one year later than that recommended by the Panel in October 1993 for the altimetry mission "to bridge the gap between the end of TOPEX/Poseidon and the launch of EOS Ocean ALT." However, this still should enable continuity in the measurements initiated by TOPEX/Poseidon in 1992 provided that TOPEX/Poseidon lasts one year longer than its currently planned extended mission.

The Program and Project should consider carefully the full range of issues and costs associated with each option and work cooperatively with the different Agency partners associated with each option. The Oceans Panel should provide advice on this matter to the Program and Project.

The funding for the selection of an ALT-Radar Science Team must be identified from within the existing EOS Science budget.

EOS Color Mission

In the current context of the rebaselining pressures, the EOS Payload Panel has no alternative but to recommend cancellation of the EOS Color Mission. Obviously, this decision is not taken lightly nor without a full understanding of the ramifications (see Editorial for latest information concerning this mission).

The EOS Color issue is, in a sense, a problem of scientific and financial risk management. There are concerns over the potential lifetime of the SeaStar/SeaWiFS mission, once it attains orbit, and an EOS

Color mission would assure data continuity from SeaWiFS to the MODIS on PM-1. In addition, EOS Color in combination with the MODIS on AM-1 and MERIS on ESA's ENVISAT-1 would significantly enhance the acquisition of ocean color/productivity data in the tropics.

In order to minimize the damage to important scientific activities, such as attempting to understand the global carbon cycle and its relation to climate and climate processes, the Panel has sought alternative methods for obtaining these measurements of oceanic primary production. *The only alternative within the constraints of the rebaselined budget that has an acceptable level of scientific and technical risk is to attempt to use the Landsat-7 spacecraft to fly an ocean color instrument.*

This option results in significant savings (more than $50 M) in early years and avoids the potential data gap between SeaWiFS and a second MODIS instrument on the PM-1 satellite, but there is likely to be considerable complexity and risk in accommodating an EOS Color instrument on Landsat-7.

The Panel is not aware of any scientific or technical reason why the Landsat-7 spacecraft could not be used to fly an ocean color instrument, but we realize that there are serious political and programmatic issues that must be resolved before it would be permitted.

We also do not know whether industry has responded to the announcement of Flight of Opportunity with instrument proposals at no cost to the government that might lead to Landsat follow-on instruments. If such proposals were received, they may have to be of higher priority than a Flight of Opportunity on Landsat-7 for Color. It is clear, however, that flying Color as a free-flyer is not a financially feasible option under the new constraints of the rebaselined budget.

Instrument Deletions

- Possible deletion of one of the CERES instruments on PM-1

The rebaselined budget forces the Panel to consider eliminating the second CERES scanner on PM-1. Our decision for the moment is to keep both CERES scanners on PM-1, and the Panel requests the IWG's Atmospheres Panel study the value of the second CERES scanner on PM-1. Moreover, while considering the value of this scanner, we request that the Atmospheres Panel evaluate the second CERES scanner versus moving EOSP from AM-2 to this position. This study needs, of course, to consider not flying the second CERES scanner on PM-1 and not moving EOSP from AM-2.

While it would be very valuable to get the best possible tropospheric aerosol information as soon as possible, the Panel is concerned that the EOS Mission do the best job possible with the total energy flux measurements from CERES; therefore, the Panel is reluctant even to raise the issue of a swap of these two potentialities prior to getting more firm information about the accuracy issue with CERES. In any case, it seems likely that bringing EOSP forward to PM-1 would result in a significantly larger financial cost in the early years than is saved by eliminating one of the CERES instruments on PM-1, and this coupled with the rebaseline budget restrictions may render the issue of the advancement of EOSP moot.

The Atmospheres Panel should report on this issue before March 1, 1995. Removing one of the CERES scanners without this study is too dangerous, and it (the removal of one CERES) is a step that could be taken later without unnecessary cost.

- Possible loss of the MHS from PM-1

As was noted at the October 1993 meeting of the EOS Payload Panel, accurate humidity profiles are crucial parameters for the study of the energy and hydrology cycle as well as climate modelling and weather prediction.

"The contribution of a Microwave Humidity Sounder (MHS) to the retrieval of accurate humidity profiles, including full overcast conditions, has been well established by the AIRS/AMSU/MHS Team. The sounding system of AIRS/AMSU/MHS will be able to retrieve humidity (and temperature) profiles under all cloud and weather conditions."

"Furthermore, the sounding system on the PM platform is designed to function as a true prototype operational system for NOAA. Although NOAA and NASA can depend on AIRS/AMSU to improve the retrieval capabilities of water vapor, allowing high-quality humidity measurements under most conditions, it will still depend on MHS to provide added sensitivity under overcast conditions. NOAA would likely regard the loss of MHS on the EOS PM-1 as loss of a vital pre-operational demonstration of improved capabilities originally developed by NOAA with 'AMSU B'. The software algorithm currently planned by NOAA integrates data from AIRS/AMSU/MHS as a prototype operational algorithm. The loss of MHS will prevent NOAA from testing the full three-instrument suite as a pre-operational system, and costly modification of the software package would be required." [October 1993 meeting of the EOS Payload Panel]

Under the current constraints of the rebaselined budget, NASA must a) depend upon NOAA to provide either the MHS or an AMSU-B instrument, and b) depend upon the AIRS team to provide integration costs.

The EOS Payload Panel recommends that NASA request from NOAA the MHS or a refitted AMSU-B for flight on PM-1, and, if it is provided, then the Panel recommends that the AIRS Science Team provide the integration cost.

There is a high likelihood that neither the MHS nor an AMSU-B will be available for flight on the PM-1 Mission. The loss of MHS and the associated ability to resolve the role of mid-tropospheric drying due to regional convective systems and their impact on greenhouse warming is a significant loss. This loss is compounded by the failure to fly the full AIRS/AMSU/MHS as a pre-operational system.

- Eliminate the cost for a second LIS instrument

Relying on the flight spare unit for any follow-on mission could restrict the flexibility for obtaining LIS measurements beyond TRMM. The continuity of lightning observations beyond TRMM is at risk.

Restructuring the CHEM-1 Mission

- Add TES to the CHEM-1 Mission and remove ACRIM, SAGE III, SOLSTICE-II from the CHEM-1 Mission.

The EOS Payload Panel reiterates its October 1993 recommendation to move TES from AM-2 to CHEM-1; this enhances not only the scientific value of CHEM-1, but also it allows AM-2 to accommodate the land remote sensing instrument planned for Landsat-8 and thereby saves the country and NASA a launch and spacecraft cost (more than $300 M).

In order to accommodate the move of TES to CHEM-1 and maintain the cost saving associated with a Delta II Common Spacecraft approach to the EOS Mission, the Panel recommends removing ACRIM, SAGE III, and SOLSTICE-II from the CHEM-1 Mission. Flying these instruments on various small spacecraft not only increases budget robustness, but also it could provide for an earlier flight for ACRIM and SAGE III, which is consistent with past recommendations of the EOS Payload Panel.

TES

In order to move TES forward, the Panel not only recommends removing ACRIM, SAGE III, and SOLSTICE-II from the CHEM-1 Mission, but also acknowledges that resource demands of TES must be reduced. The Panel recommends that TES be built to a cost and resources envelope. These constraints need to be quantified by the Project and Program as soon as possible and provided to the TES Team.

SAGE III

Even in the light of the budget difficulties expressed in the rebaselining, the EOS Payload Panel again recommends the launch of SAGE III in a mid-inclination orbit by 1999-2000 and flight of SAGE III in a high-inclination orbit by 2000. Measurement of the profiles of important aerosols, ozone and upper tropospheric water vapor are essential components of a climate change program. SAGE III is particularly important given its long history, simplicity, low risk, low data rate, and its well-calibrated observations.

Three scenarios for flight of SAGE III should be considered, and two of these scenarios exploit International Space Station Alpha (ISSA) funds (see editorial for latest information concerning SAGE III funding):

i) First flight instrument built with ISSA funds but with availability by 1999-2000, and a second copy built with EOS funds and flown on ALT-R. The integration costs for SAGE III on ALT-R need to be identified and supported by EOS. Note: the ALT-R Mission would go in 1999; therefore, this possible opportunity for high-inclination orbit for SAGE III moves the launch slightly forward in time; however, this opportunity does depend on the exact orbit for ALT-R, and whether or not this orbit complements ISSA.

ii) First flight instrument built with ISSA funds but with availability by 1999-2000 (i.e., no EOS funds needed), a second copy built with EOS funds and flown on a Russian spacecraft of opportunity. These (perhaps different) integration costs need to be included.

iii) First and second flight instruments built with EOS funds with Flight of Opportunity determined potentially by flight of ALT-R and Russian spacecraft. Integration costs need to be identified and included. In addition, the issue of complementing orbits needs to be evaluated.

Flight on the International Space Station Alpha is hardly ideal or required, and it may add unnecessary expense to the NASA budget; however, it does put less pressure on the EOS budget. Regrettably, the reliance on the ISSA program to provide funding for development of the first SAGE III instrument is very important in early years (i.e. 1995-97) in the rebaselined budget, and this could add significant risk to the flight of SAGE before 2000.

In any case, flight of SAGE III in both mid-inclination and high-inclination orbit takes precedence over the exact platform. In other words, if the Space Station option or reallocated funds are not available and if the budget pressures do not relax, then additional cuts to the EOS Program will need to be made to accommodate this high-priority recommendation and allow SAGE to be developed solely on EOS funds. Specifically, in the absence of ISSA or other funds, then the EOS program must revisit its priorities to identify the necessary funds to develop the first SAGE III instrument for a Flight of Opportunity (e.g., on a Russian spacecraft and/or the EOS ALT-R).

Where these possible additional cuts to the Program could be made is not obvious to the EOS Payload Panel.

ACRIM

The Panel recommends that ACRIM fly on a small satellite by 1998-99 and continue in the objective to obtain a long-term record of solar forcing, which is an essential component of a climate change program. This mission would become a level-of-effort, continuous-measurement mission (roughly $4 million per year) through the year 2000.

If the rebaselined budget cuts were not so severe, the Panel would reiterate its October 1993 ACRIM recommendation, "The Panel requests that NASA aggressively explore the possibility of refitting the ACRIM ATLAS instrument for early flight (1996-98)..." The risk in waiting until 1999 to deploy the first in the ACRIMSAT series should be further reviewed. Under the recommended rebaselined launch of ACRIMSAT in June 1999, there is an implicit assumption that the VIRGO sensors will be fully operational at this time; moreover, their ability to calibrate sensor degradation is unknown, since this instrumentation has not flown on extended missions previously. Sensor degradation will occur and, based on ACRIM's experiences on SMM and UARS, it could be a significant factor over a 4-5 year period (~500 ppm). The Panel acknowledges that it would be much safer to launch ACRIMSAT in the mid-97 to mid-98 timeframe; however, the budget constraints of the $7.25 billion rebaselined budget make this highly unlikely.

This issue of measuring total solar irradiance is important and, in light of the budget uncertainty, the possibility of an earlier flight of ACRIMSAT is discussed in more detail in Appendix II.

SOLSTICE

The Panel recommends that the SOLSTICE-II instrument be developed for a Flight of Opportunity in 2002-03. This instrument makes key measurements in the UV, which are important for atmospheric chemistry. Unfortunately, in the rebaselined EOS Program, the spacecraft, payload integration, and launch for the SOLSTICE-II instrument must now be provided from an as yet undefined cooperative arrangement (i.e., SOLSTICE-II is now seeking a Flight of Opportunity).

In sum, the solar instruments (ACRIM, SOLSTICE-II) must be flown, and ACRIM must be flown as early as possible in order to have high-precision measurements of the variation in total solar irradiance. These data will be invaluable in assessing any potential solar contribution to changes in the Earth's climate system.

While Space Station would have an acceptable orbit for the SAGE III instrument, there is significant additional cost to the U.S. taxpayers in requiring that SAGE III be a man-rated instrument. The Panel cannot justify a rationale for the country to absorb the additional cost; however, the rebaselined budget does not allow an alternative.

There are risks and losses associated with the CHEM-1 recommendations.

There is an increase in the reliance on Fights of Opportunity for SOLSTICE-II and the SAGE III instruments; there is a likely delay in launch of SOLSTICE-II. This will result in a data gap in UV observations between UARS and EOS, and it will increase the risk in maintaining continuity in SAGE III observations.

- Add the OH measurement to the MLS Baseline Instrument

In October 1993, the EOS Payload Panel stated that it "...continues to endorse the measurement of OH as provided by the enhanced MLS. OH is a key radical controlling ozone loss in the lower stratosphere and is a critical component in the monitoring strategy of EOS CHEM-1."

This remains the position of the Panel.

In addition, the Payload Panel continues to endorse strongly the United Kingdom's contributions to the MLS instrument. The Panel recognizes that UK participation is critical to the scientific success of the MLS instrument and that the UK-provided radiometers will make a fundamental contribution to our understanding of the influence of trace gases on atmospheric chemistry and climate change.

The AM-2 Mission

- Combine Landsat-8 with AM-2

The Landsat-8 issue is extremely important. The continuity of the TM-class data set has always been an assumption of the EOS measurement strategy, and to have an advanced ETM+ capability colocated on the AM-2 platform would have obvious scientific advantages. Moreover, integrating Landsat-8 into the EOS program and accommodating an advanced ETM-type instrument on the AM-2 spacecraft saves NASA and the country the cost of a spacecraft and launch (more than $300 M).

Regardless of the spacecraft chosen for the Landsat-8 measurement capability, there remains an important open issue that the EOS Program must face, namely the cost of the instrument. Absorbing into the EOS program the cost of the follow-on advanced ETM+ instrument could have very serious consequences if additional money is not provided.

Science Teams and Algorithm Development

- Merge ASTER and Landsat Science Teams

In light of the decision to proceed with Landsat-7 as a NASA-led Mission and in keeping with the recommendation of this Panel to accommodate the Landsat-8 observational capabilities, the Office of Mission to Planet Earth (MTPE) should consider combining the activities of the ASTER and Landsat Science Teams through a restructured and refocused means of selecting a new Aster-Landsat Science Team. This should allow not only a direct savings, but also provide cost savings in algorithm development. The Panel notes that the ASTER Team bears a special responsibility to work with their Japanese colleagues to ensure that the ASTER instrument produces measurements that can be calibrated. This goal should be shared for the Landsat-7 instrument as well. Finally, the Panel also recognizes that the ASTER Team bears a special responsibility for mission planning and selecting observing strategies during the operation of the EOS AM-1 Mission.

It is assumed that Japan will cover the full cost of data processing up to Level-1B, as agreed to in a Memorandum of Understanding under discussion, and that there will be limited development of algorithms and data analysis associated with the ASTER instrument per se. Because calibrated land-leaving radiances are an essential and critical feature of ASTER and all the surface imagers, including Landsat-7, development of algorithms for these products are the highest priority Standard Data Products.

Fortunately, the scientific impact of this reduction in cost may be positive through cross-fertilization of the ASTER and Landsat Teams.

- Reduce the total cost of algorithm development

The total cost for algorithm development must be reduced if other parts of the EOS Program are to survive the budget reduction in rebaselining. It is particularly essential to reduce the near-term costs (FY 1995-1997). The Program and Project must accept this challenge using, in part, the May Algorithm Theoretical Basis Document Reviews as a guide for deleting certain Standard Products and for rephasing other Standard Products.

The scientific impacts of this reduction and rephasing are difficult to quantify. Obviously, it will put more responsibility on the Science Computing Facilities (SCFs). The issue needs to be carefully evaluated and monitored by the various Panels of the Investigators Working Group (IWG).

The rephasing and deletions are consistent with other recommended, significant reductions in data processing requirements of the EOS Data and Information System (EOSDIS) and, in particular, reductions in the EOSDIS Core System (ECS), which is discussed in the next Section.

We note that the Panel has not, itself, formally reviewed the Standard Data Products.

EOSDIS Core Data System

Most of the changes in the EOSDIS Core System (ECS) that were considered are contained in the Project and Program recommendations. As noted in the Introduction, nine of the ten recommended changes were accepted by the EOS Payload Panel. The only change not accepted was the elimination of one or more of the DAACs. In this Section, we discuss one of the nine recommended changes, namely the elimination of the "quick look" data products from EOSDIS, since it may be somewhat confusing. We also discuss three additional changes:

—Consolidating and phasing implementation of EOSDIS DAACs,
—Delay in processing and archiving of EOS Standard Products, and
—Reduction in the ASTER Standard Product demand assumption.

These proposed and endorsed changes were developed during the July meeting of the Panel, and consequently, they are not described in the Project and Program original documentation of the proposed EOSDIS rebaselining.

- Elimination of the "quick look" data products from EOSDIS

The purpose of the "quick look" data is to provide rapid access to EOS data for qualitative study of transient Earth system processes in near real-time and to choose the optimum number of observations or scenes for further analysis. In the budget climate imposed by rebaselining targets, it is a requirement that we cannot afford.

Elimination of the "quick look" products will delay availability of some EOS products, and it may increase the overall data processing load by EOSDIS because of uncertainty in selection of the optimum number of observations or scenes to be processed by EOSDIS. It will still be possible to have "quick look" data under certain conditions; however, it will no longer be a requirement.

- Consolidating and phasing implementation of EOSDIS DAACs

All portions of the EOSDIS and ECS must be rebaselined. The Panel knows well the history of concerns associated with an overly centralized EOSDIS. The EOS Program and Project have been very responsive, and the architecture is now both geographically and logically distributed. However, the budget reductions in rebaselining force the Panel to recommend a reduction in the budgets of the Distributed Active Archive Centers (DAACs).

Specifically, during the first two years there will be a general reduction at all DAACs, which will constrain their collective abilities to serve users, but the individual cuts should be small enough as to be tolerable.

This reduction is in addition to any of the reductions implicit or explicit in the Project and Program recommendations. There is also a reaccounting of costs associated with the JPL DAAC and with work on SeaWinds.

These rephasings and reductions will reduce and/or delay the availability of some services and products to the scientists, and thereby challenge their ability to assess the impact of global climate change on environmental policy decisions.

- Delay in processing and archiving of EOS Standard Products

This change delays purchase of both processing and archiving hardware in EOSDIS. The specific change is still being developed; however, the current working assumption or guide is to purchase only 0.5 processing strings at L-24 months, 0.5 at L-17 months, and then purchase two strings at L+24 months. A concomitant delay is made in acquisition of archival hardware, with archives restricted to 25% of a full year's capacity at launch and an additional 25% at L+12 months with full capability provided at L+24 months. These changes will mean that the accuracy, coverage, and/or resolution of standard data products will be resource constrained until two years following element launches.

- Reduction in the ASTER standard product demand assumption

For purposes of the EOSDIS architecture trade-off studies, it was assumed that 100% of all potential Level 1A data acquired by ASTER would be processed to Level 2 products. This resulted in an extraordinarily high estimate for ASTER Product Generation System (PGS) computing requirements. Discussion subsequent to the EOSDIS Core System's System Design Review (ECS SDR) resulted in a more realistic set of assumptions, which can now be used to update the cost model. The proposed (and accepted) estimate assumes that, of the ASTER Level 1B scenes which were able to be scheduled, acquired, and pass the cloud test (which is probably only about 20% of the instrument potential), only 20% would be requested by users for any given on-demand product. Obviously, if this demand model turns out to be low, then processing capabilities at the EDC DAAC could be insufficient.

APPENDIX I

EOS Laser Altimetry Mission: EOS ALT-L

(Text based on material from the GLAS Team Members)

The primary purpose of the EOS Laser Altimetry Mission (EOS ALT-L) and the GLAS instrument is the determination of changes in the ice volume. The paper by van der Veen (1991) is particularly instructive and elucidates the current state of balance of the cryosphere. In it, van der Veen states that "there is an urgent need to greatly improve the current estimates and to monitor the ice sheets continuously for changes in volume and extent."

An area of concern is the West Antarctic ice sheet, the component of Antarctica known to be undergoing the most dynamic changes. Alley and Whillans (1991) reviewed the status of knowledge about the West Antarctic ice sheet and noted that total disintegration of the West Antarctic ice sheet, which consists of about 12% of the Antarctic ice volume, would result in a global sea level rise of 6-7 meters. Even though the East Antarctic ice sheet exhibits less dynamic characteristics, its vastness implies that relatively small changes could have large effects.

In a catastrophic scenario of West Antarctic ice sheet collapse occurring over a 100-year period (consistent with the dynamic response time from Oerlemans 1989), what would be the policy response, both nationally and internationally, to a predicted collapse and the resultant 6 meter sea level rise? Clearly, the response would be directly coupled with the confidence in the prognostic capability of the models and database supporting this. How would the 10,000 miles of U.S. coast respond to such a rise? Could a response plan be formulated and implemented in 100 years, or 500 years?

This issue has a parallel in discussions about severe earthquakes; however, there is a distinct difference in data sets. For earthquake prediction in critical areas like California, there are extensive observational networks and databases; this is not the case for ice sheets.

While a catastrophic disintegration is not imminent or expected, it is also the case that the ice sheets have been inadequately surveyed, and our ability to predict their overall future behavior has been severely impaired by this lack of data. Measurements near the margins of the ice sheets are important and, as noted by van der Veen (1991), "monitoring the margins of ice masses may help in early detection of changes." GLAS is optimized in its design to make measurements over the steep slopes and disturbed ice of the critically important marginal zones of the ice sheets, areas in which radar altimetry cannot make scientifically useful measurements.

With the level of uncertainty that now exists, the capture of epoch measurements against which future measurements will be compared is essential. The difference between initiating the measurements in 2002 or 2004 could be important, especially recognizing the state of uncertainty that now exists, considering also the separation and potential aliasing of periodic changes into our interpretation of long-term/secular changes.

The initial epoch measurements of the ice sheets are particularly important—they may be the most important measurements in the series—because they will be the measurements against which all future measurements will be compared. Comparisons against the epoch measurements will provide us with information about changes that are taking place over time. The GLAS instrument team is well aware of the particular importance of the epoch measurements and has focused upon development of an instrument that will provide the reliable, calibrated, verified, and validated data that will be the basis of all assessments of the cryosphere mass balance. These epoch data will be our legacy.

With the level of uncertainty in our present knowledge and our inability to acquire the essential data by other means, the scientific impact of a two-year slip is difficult to judge. The community should not judge this impact by their own expectations about what the measurements will show—there are too many instances in science where such judgments have been wrong. As stated by van der Veen (1991), "Monitoring global ice volume and establishing quantitative records of changes in it are long overdue and should be a priority among glaciologists and the 'global change' community in general."

The GLAS team judges that the instrument and algorithm development are on track for a 2002 launch. There are no technical "show-stoppers." It is most unfortunate to the effort of providing the country with a balanced, core observational system focused upon climate change, that the cut of the EOS budget from the agreed-upon $8 billion baseline to $7.25 billion forces a significant delay in implementing the EOS-L Altimetry Mission.

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APPENDIX II

Measuring Total Solar Irradiance: ACRIMSAT

In October 1993, the Atmospheres Panel provided a report on measuring long-term trends in total sun irradiance (TSI); this report is included in the EOS Payload Panel's Report on the October 1993 Meeting. The Atmospheres Panel states in Section 3.1 that "The best strategy for measuring long-term trends in total solar irradiance is to continue the sequence of overlapping measurements with instruments specifically designed to measure total solar irradiance with absolute calibration. Because the precision, but not the accuracy, of TSI measurements is sufficient for long-term monitoring, detection of long-term trends requires substantial overlap between succeeding instrument packages so that they can be calibrated against each other and provide a record of TSI deviations. To retain this precision against instrumental degradation, each package requires multiple detectors. With the currently planned schedule for launches of active cavity radiometer (ACR) instruments, a gap in the record will likely occur between the end of UARS/ACRIM measurements and the SOHO/VIRGO measurements sometime in the 1994-96 interval and again between SOHO/VIRGO and the planned launch of the ACRIM on EOS/CHEM in about 2002."

In Section 3.3 on the Future Measurements and the Overlap Strategy, the Atmospheres Panel notes that "The strategy for long-term measurement of total solar irradiance requires overlap between succeeding ACR instruments, so that the biases between instruments can be accounted for, thereby producing an estimate of long-term deviations in TSI that is independent of the uncertainty in absolute accuracy." "...it is likely that the string of overlapping ACR measurements begun with Nimbus-7 ERB will be broken by gaps between the UARS/ACRIM and SOHO/VIRGO instruments in 1994-96 and again between SOHO/VIRGO and the planned EOS CHEM in 2002. Without overlap between past and future instruments, a record of long-term solar irradiance variations cannot be built upon the record available from the current generation of instruments."

In light of these considerations, it must be noted that there are several problems with delaying ACRIMSAT until 1998-99:

1) SOHO/VIRGO [launch in 1995] will likely provide some useful TSI results but neither the PMOD or CROM sensor technology has been flown on extended missions before.

2) It is a gamble to delay the ACRIMSAT launch by more than VIRGO minimum mission (18-24 months) length.

3) There has never been only a single TSI flight experiment in orbit during the modern solar monitoring program. The absence of external standards in this field of measurement make it especially valuable to have more than one TSI experiment operational at a time. Redundancy has saved the database and provided important corroborative evidence of newly discovered solar phenomena in the past.

It is important that the first ACRIMSATs be in orbit six months to a year before the predecessor (SOHO/VIRGO) ceases to function.

The ACRIMSAT Team has proposed two Scenarios that would launch ACRIMSAT earlier than the recommended 1999 launch.

The Optimum Scenario is:

FY:	95	96	97	98	99	2000	Launch
Optimum Scenario:							
	$6 M	$4 M	$4 M	$4 M	$4 M	$4 M	96

The Second Scenario is:

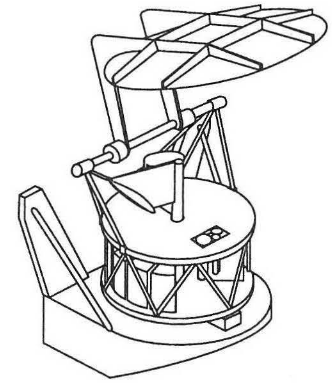
FY:	95	96	97	98	99	2000	Launch
Second Scenario:							
	$2 M	$4 M	$4 M	$4 M	$4 M	$4 M	97

The Second Scenario would provide overlap of ACRIMSAT and VIRGO near the end of the VIRGO minimum mission, optimizing the probability of database continuity; in addition, it would sustain the ACRIM hardware team at JPL.

Unfortunately, in the context of the rebaselined budget, the EOS Payload Panel can only present the advantages of a 1996-97 launch on ACRIMSAT; it can not endorse this launch given the other severe funding difficulties in the rebaselined environment. ❑

Second International MIMR (Multifrequency Imaging Microwave Radiometer) Science Advisory Group Meeting

—**Elena Lobl** (surica@tornado.msfc.nasa.gov), Hughes STX



The second international meeting of the Multifrequency Imaging Microwave Radiometer (MIMR) Science Advisory Group (SAG) was held at the European Space Research and Technology Center (ESTEC), at Noordwijk, The Netherlands, May 25-27, 1994.

Chris Readings (MIMR SAG Coordinator, and Head of the Earth Science Division, ESA) opened the meeting by going over the last meeting minutes. He then presented the meeting agenda and the ultimate objectives of the MIMR SAG: to provide a report that captures all interested disciplines' inputs on the MIMR mission objectives, requirements, and data products, and list any pre-mission necessary scientific studies, experiments, and campaigns.

Yvonne Menard (ESA, MIMR Program Manager) presented the hardware development status in the demonstration phase. The objectives are to develop the critical technologies and the key functions, as well as the two calibration targets, and to demonstrate the instrument integration and test processes. The final discussion was on the trade of scan angle versus swath width/footprint size.

Alberto Tobias (METOP Program Office) briefly presented the MIMR accommodations difficulties on METOP. Paul Hwang (EOS-PM Project Office) discussed NASA's plans for procuring the EOS-PM platform, with a common design for the second AM, PM, and CHEM platforms.

Both Alberto Mugnai (Consiglio Nazionale delle Ricerche, CNR, Institute for Atmospheric Physics, Italy) and Tom Wilheit (Texas A&M University) gave scientific presentations regarding the precipitation algorithm. Mugnai pointed out the problems in precipitation retrieval, such as identification of the precipitation area, deconvolution of the measured brightness temperatures, surface emissivity uncertainty, and the different choices of algorithm structure. Wilheit reviewed new aircraft results impacting the beam-filling problem in pre-cipitation retrieval.

Chris Readings presented the plans for the remainder of the SAG meeting. Two of the four working subgroups, identified at the last meeting, were rearranged: the Atmosphere group and the Oceans group were reorganized into the Precipitation group and the Atmosphere/Ocean group. Johnny Johannessen (ESTEC) reviewed the last meeting's subgroup findings, and suggested a common format for each subgroup report.

The key issues addressed in the subgroup meetings were:

- review of the MIMR mission requirements
  - data requirements (spatial, sampling, etc.)
  - frequency, polarization, and footprint require ments
  - user requirements on accuracy, performance, and sensitivity
- justification of multiple concurrent flights of MIMR
  - multiple radiometers in the morning
  - one morning and one afternoon radiometer
- synergism
  - Advanced Scatterometer (ASCAT)/MIMR
  - MODIS/MIMR
  - AMSU/MIMR
  - other
- working plans
  - scientific studies
  - development of algorithms (operational, climate monitoring, and research)
  - field campaigns

On the last day of the meeting, each group coordinator reported on the agreements and recommendations of the group.

Precipitation Group

The first and most important issue discussed was the data products and the channel requirements to retrieve these products. It was agreed by the group that the Level 2 instantaneous rain rate (over ocean and land), and Level 3 monthly rain totals (over ocean and land), and Level 3 monthly rain totals (over ocean and over land, separately) are the products obtainable from MIMR, with optional byproducts being the Level 2 rain/no-rain flag and Level 2 precipitating cloud liquid water. The required channels for precipitation retrieval are: 10H, 18H, 23H, 2x37H, 2x90H, and 2x90V. (In order to achieve Nyquist sampling at the higher frequencies, two horns are used for the 37 GHz, and four horns are used for the 90 GHz channels. H and V signify horizontal and vertical polarization, respectively.) No specific decision was made as to whether one set of the 90H and V channels can be dropped. The radiometric accuracy and sensitivity are not particularly critical, but the recommendation was to keep both below 1 K.

The group agreed that multiple radiometers, flown on morning and afternoon platforms are necessary for climatological applications and for diurnal cycle determination. Multiple radiometers on AM platforms (staggered by more than 2 hours) would be useful for operational meteorology. The synergism issue was divided between MIMR being the benefactor or the beneficiary: ASCAT, Visible/InfraRed Scanning Radiometer (VIRSR), and MODIS would benefit from MIMR; MHS and MTS would be beneficial to MIMR. Regarding algorithms, it was agreed to draw on the WetNet and Global Precipitation Climatology Project (GPCP) experience, and as a first activity during the development of the rain algorithm, do an intercomparison of the scattering radiative transfer algorithms. There are no MIMR-specific campaigns or scientific studies to be done before MIMR is launched. The recommendation was to participate in the already planned FASTEX (1996) and TRMM (1997) campaigns.

Atmosphere/Ocean Group

The mission requirements were discussed at length. The group revised the appropriate items in the MIMR Products Performance table: the major changes occurred in the sea surface temperature, ocean surface wind speed, and water vapor content accuracies. The group agreed that two 90 GHz horns are sufficient, as long as the resolution becomes similar to that of the 37 GHz data; swath width is more important than resolution, and a one-time cross-calibration with cloud-free IR imager data is necessary for improvement of the absolute accuracies of the SST retrievals. Synergism with AMSU, IR imagers, ASCAT, and SCARAB is highly desirable for enhancing the parameter retrievals. Multiple flight opportunities are also very desirable; they would provide more complete coverage, more frequent sampling, and resolve the diurnal cycle questions.

The two scientific studies that the group felt necessary for improving the MIMR data set were laboratory measurements of the dielectric constant of sea water at temperatures from -2 degrees C to +35 degrees C, and the improvement of the emissivity models as a function of temperature, wind speed, and direction. There were several recommendations made on the atmosphere/ocean algorithm development. The group felt that there should be agreement on a single forward radiative transfer model and the establishment of the algorithm concepts (channels to be used, resampling of different channels, etc.). There was general agreement that there should be a simple consensus operational algorithm, and 'many' scientific, 'off-line' complex algorithms that could be considered for replacement of the operational algorithms after launch.

Land Group

The Land group listed their requirements for an extensive number of parameters (surface temperature, surface roughness, soil moisture, frozen soil, flooding, snow extent, etc.) in a table that rates the importance of the channel, the ideal radiation sensitivity, and an ideal and an adequate spatial resolution. Most of the required sensitivities are 0.2 to 0.5 K; the ideal resolution is 1 to 10 km, but 10 to 50 km is adequate. The group agreed that for optimal diurnal coverage at least two MIMRs are needed: one in the morning and one in the afternoon, with exactly the same type of orbit (e.g., descending in the daytime). Synergism with Scatterometer, VIRSR, and MODIS is needed to do an atmospheric correction over land. Intercalibration of different sensors would also be very beneficial. No specific campaigns are proposed; mostly data analyses from merged data sets and modeling are recommended. The work plan for generating the operational algorithm is: 1) improve the forward model for all relevant parameters and observables, 2) derive robust inverse algorithms, and 3) do an extensive validation program.

Cryosphere Group

This group distinguished between the operational and scientific requirements. Specifically, as far as data retrieval is concerned, the operational side would like to have the Level 0 data in real time and the Level 2 data in less than three hours; the scientific side of the group needs Level 1 data in less than three months and Level 2 data in six months. The two sides mostly agreed on the rest of the parameters: keep all channels with footprints as small as possible, 1 K temperature sensitivity, spatial resolution more important than swath width, and have a MIMR on both a morning and an afternoon platform. The group saw synergism between MIMR and ATSR, AVHRR, MODIS, ASCAT, and AMSU, for surface temperature, ice type, surface roughness and other parameters. A proposed preliminary validation plan includes: A joint NASA/European Aircraft Mission using a MIMR simulator, an IR system, an 8-bit line-scan system, photography and video, and, possibly, a lidar. Other suggestions are: piggyback on other research ships for surface measurements, analyze high-resolution visible/IR/radar data, ASTER, AVHRR, and SAR data concurrently with the aircraft mission, analyze historical aircraft, submarine, and ground data, and develop a radiative transfer program to improve the interpretation of the microwave data. The algorithm development for sea ice will use the conventional technique: the radiative transfer equation with a global ice concentration with open ocean masking, and up to three surface classes for type classification. The scientists will separately use the isoclass/neural network (with different specifications) and a Kalman filter technique (using model and ancillary data).

The next MIMR SAG is planned for November 15-17, 1994 at ESTEC. Some of the topics to be discussed are: UK Met Office (J. Foote), sea ice operational and research activities (R. Ramseier and J. Comiso), downwelling radiation budget from the Passive Microwave Radiometer (PMR) (P. Schlusse), and an EOSDIS review (P. Hwang). ❑

The National Academy of Sciences has announced the election of the following members in recognition of their distinguised and continuing achievements in original research:

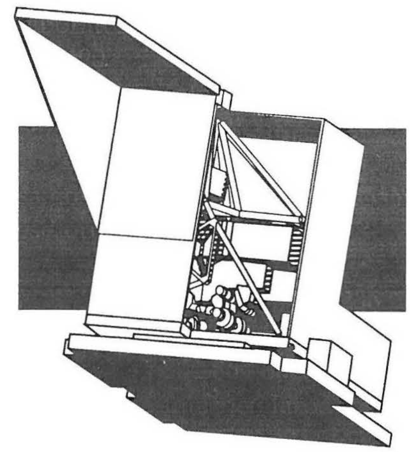
Dr. James R. Holton, Department of Atmospheric Sciences, University of Washington. Dr. Holton is a Co-Investigator for the EOS HIRDLS instrument and a member of the Goddard Space Flight Center Distributed Active Archive Center User Working Group. He also served as a Principal Investigator on UARS.

Dr. Pamela A. Matson, NASA/Ames Research Center. Dr. Matson serves as a Co-Investigator on Piers Sellers' EOS Interdisciplinary Investigation, and is a member of the Biogeochemical Cycling Panel and an advisor for the Global Change Fellowship Program.

Dr. Charles D. Keeling, professor of oceanography, Scripps Institution of Oceanography, La Jolla, CA.

9th TES/AES Science Team

—**Reinhard Beer** (beer@atmosmips.jpl.nasa.gov), Jet Propulsion Laboratory, Pasadena, CA



The 9th Tropospheric Emission Spectrometer (TES)/ Airborne Emission Spectrometer (AES) Science Team Meeting was held at the Ramada Inn, Denver-Midtown on June 9, 1994. As usual, the meeting was preceded by an executive session of the Data Analysis Working Group (DAWG) on June 8.

Data Analysis Working Group (Curt Rinsland, Chair)

The DAWG meeting began with Tony Clough (AER Inc.) describing recent improvements in his retrieval algorithm LBLRTM and in studies of the direct retrieval of tropospheric O_3 from nadir soundings. It appears that, for the case studied (a profile based on a strongly-structured ozonesonde profile from Ascension Island obtained by Jack Fishman of LaRC), some 5 levels can be retrieved in the troposphere with a precision of ~20%, each with an accuracy on the order of ~50% (2% in the column). A less-pathological case should provide even better results. Aaron Goldman (U. Denver) then discussed his efforts to reconcile the band-to-band strengths of HNO_3, which are currently inconsistent among all workers. Clearly, more needs to be done on this very important reservoir/sink species of odd nitrogen. Larry Sparks (JPL) gave an update on the parallelizable retrieval algorithm SEASCRAPE and outlined its future directions (inhomogeneous atmospheres and 3-dimensional viewing geometry, for example). An early version of SEASCRAPE is currently being tested on AES aircraft data. Paul Morris (Oxford U.) announced that they plan to incorporate GENLN2 into a limb-retrieval code. Oxford has undertaken to lead the effort to use TES data for the investigation of troposphere-stratosphere exchange. Tony Clough then discussed his studies of the 15 µm CO_2 bands in the HIS CAMEX spectra (this region is widely used for temperature sounding), which have highlighted the importance of line-coupling in their analysis.

The session continued with Reinhard Beer (JPL) giving the team their first look at the AES data acquired during its first test flights in April 1994. The data were noisy and plagued with electromagnetic-interference spikes (both problems have since been markedly reduced) but clearly show the ability to obtain linewidth-limited radiometric spectra of species important to tropospheric chemistry (O_3, CH_4, CO, N_2O, etc., as well as the to-be-expected CO_2 and H_2O). Finally, the nature of the third code-intercomparison test (to be completed later this year) was discussed. Previous tests had involved intercomparison of forward models. This next test will intercompare trial retrievals.

Plenary Session (Reinhard Beer, Chair)

The plenary session began with an update by Joe McNeal (NASA HQ) on the status of the EOS program (as of that week), with dire warnings of program descopings that are unlikely to end, given the current budget environment. This led to Tom Glavich (JPL) pointing out that a significant fraction of the TES Project Management's time was being spent in responding to the continually-changing requirements from both HQ and the Goddard Project Office. On the other hand, the AES project is fairly healthy and promises to provide a good deal of data to both the Science Team for algorithm development (and, we hope, some good tropospheric science) and also to the software developers who will have real, rather than simulated, data upon which to test their codes. Just as important, AES has already provided major input into the TES detector/signal chain design that will result in significant cost savings to the TES project. Also discussed was the potential move of TES from the AM-2 platform to CHEM. While not yet formally approved, there is a good deal of sentiment that a payload of MLS, HIRDLS, and TES offers a powerful tool for investigations of the atmosphere during the EOS timeframe that will not be duplicated anywhere else.

Reinhard Beer then presented samples of spectra acquired during the first flight operations of AES on the NASA P-3B from the Wallops Flight Facility on the Virginia eastern shore. The flight profiles were 2 degree lat/long legs: N-S a few miles off the coast and N-S and E-W legs over the Great Dismal Swamp on the Virginia-North Carolina border. Also shown was a segment of the video recorded during the flights. The video is of the downlooking scene observed in real time through the AES pointing control system.

Steve Larson (JPL) described how we plan to provide access to AES data. The long-range plan is to archive the results at the Langley DAAC. However, the required HDF format is still inconsistent with our needs, so in the interim the data may be obtained from JPL by calling Larson at (818) 354-0679 or by e-mail: stevel@cascades.jpl.nasa.gov. Note, however, that we are still in the early stages of instrument characterization and the data are not yet suitable for analysis. When they are, a subsequent newsletter will be issued.

Following this, Larson explained the process of converting raw (L0) data to interferograms (L1A), and Helen Worden (JPL) discussed the process of converting the interferograms to L1B spectral radiances and the uncertainties thereby engendered.

Tom Glavich listed the future flight plans for AES. Except for the next flight (see below), these are still tentative and unapproved:

1) A series of DC-8 test flights in July-August 1994 (at this writing, already underway).

2) A Thermal Infrared Multispectral Scanner (TIMS) calibration flight on the C-130. TIMS is an infrared multi-channel imaging radiometer being used as an ASTER precursor. The main calibration target is Castaic Lake just north of Los Angeles, and the intent is to see if AES can be used to provide better atmospheric characterization for TIMS (Fall 1994);

3) A TIMS/AES volcano campaign, again using the C-130. If approved, this coming Winter we shall observe gas-rich volcanos in Hawaii, New Zealand, and (possibly) Antarctica. The EOS Volcanology IDS team will also be heavily involved.

4) In collaboration with NOAA (Aeronomy Laboratory), P-3B flights over the Southern Oxidant Study (SOS) sites in Tennessee. We also hope to overfly the Atmospheric Radiation Measurements (ARM) site at Lamont, Oklahoma (36.61° N, 97.49° W) during this campaign, which is provisionally set for 1995-96.

5) More DC-8 flights over sites to be determined.

Charles Bennett (Lawrence Livermore) gave a briefing on a near-infrared imaging Fourier transform spectrometer (128 x 128 pixels) that they have developed, mainly for slant-viewing of industrial plumes. This system has the potential for being a valuable tool for air-quality investigations of the type that EPA used to do (but appears to have stopped).

Finally, it was agreed that the next team meeting should be held at the Goddard Space Flight Center on Friday, December 16 so that the TES team and the Project Office may become better acquainted. ❑

EOSDIS Panel Assessment of the EOS System Design Review (SDR)

—**David M. Glover** (david@plaid.whoi.edu), Woods Hole Oceanographic Institution

At the IWG in San Antonio, TX (January, 11-13 1994) the EOSDIS Panel presented a number of its concerns about the EOSDIS architecture as it had been presented up to that time. Some of these concerns have been addressed, some still remain and, as much as possible, these remaining concerns have been woven into the fabric of this report.

This article is written from the perspective of the EOSDIS Panel meeting that followed the EOSDIS System Design Review (SDR), June 27-29, 1994. (The Panel met and presented its findings in the course of the EOS Payload Panel meeting in Landover, MD, July 19-21, 1994.) Since the end of June a number of activities by various groups have been undertaken, and some are reported elsewhere in this issue of *The Earth Observer*. To the extent possible, these activities are mentioned in this report too.

The Good News

The EOSDIS System Design Review (SDR) presented an architecture that is a good approximation to the architecture we have been encouraging all along. It is important to remember that architecture is not hardware. Nevertheless, it is clear that Hughes has listened to this Panel and others and has produced a design that is a set of logical functions, is reasonably extensible and robust, and could actually be implemented. Although not totally satisfied with this architecture, the EOSDIS Panel is comfortable with it.

After the System Requirements Review (SRR, September 14-15, 1993) and the December review (December 13-14 , 1993) we were disappointed that the EOSDIS Core System (ECS) contractor (Hughes) was not more aware of important and recent developments in the commercial software market. The SDR showed that the ECS Contractor is now aware of current commercial market directions (DCE, CORBA, etc.), and these new developments may help to cut costs. This renewed effort should place EOSDIS in the mainstream of commercial technology in the near and not-too-distant future. The Object Oriented Programming paradigm, although strange to those unfamiliar with it, is clearly in the scientific computing future. Hughes' embracement of this paradigm clearly demonstrates their willingness to place their efforts in the forefront of the mainstream computer science developments.

The ECS contractor has also expended more energy in getting out to meet with the potential EOSDIS users. After the previous round of reviews, it was identified as a shortcoming that the ECS contractor did not have a better idea of how these potential users thought they were going to use the system. These visits are a good start to rectifying this problem, but the channels of communication between the scientists and contractor/EOSDIS Project must be kept open. In a similar vein, the contractor has tapped into the large experience base of other, operating data centers. We felt that the ECS contractor should try to learn from their mistakes, not repeat them. Finally, the ECS contractor has produced a primitive user model that is of limited use, but is definitely a step in the right direction. It's important to have the correct user model because of the far-reaching ramifications this model has on sizing the system.

The ESDIS Project at GSFC has been more responsive too. So much so, that many of our complaints were being worked on the day this report was presented to the Payload Panel. In particular, now that many contract negotiations are concluded, the Project has been forthcoming in explaining their cost estimates, albeit slowly. They have opened some of their cost-scrubbing exercises to members of this Panel and we wish this line of communication to continue. They are also getting the EOSDIS V0 IMS out to the EOSDIS user community. These users are beginning to see that it works and is of value to them. We feel that V0 is very important to the perceived health of EOSDIS and encourage the Project in its efforts at making this software available.

At the time of this writing, the ECS contractor has funded three independent alternate architecture studies. The funds for these studies come out of the prototyping and analysis budget. Recently, there has been some discussion of saving money in EOSDIS by cutting this budget, severely. We strongly discourage this action for the simple reason that the architecture presented in June is not the only architecture possible. These alternate architecture studies represent a source of fresh ideas that may have substantial cost savings in the out years. The results from these studies are to be presented in September 1994, and we recommend that the Project, Hughes, this Panel, and Headquarters review the final reports and make suggestions as to how these alternates can be worked into the EOSDIS architecture. We also recommend that prototyping activities continue into the future as a constant source of fresh ideas that will help stimulate the evolution of EOSDIS.

The Bad News

After a long period of trying to understand one another, the ECS contractor has presented the EOS science community with an architecture that, apparently, we cannot afford. Why this should be so was something of a mystery to this Panel, and the next section of this report tries to provide a top-level glimpse at where the big costs in EOSDIS are.

At the time of the SDR, 24% of the cost was in the EOSDIS Core System (ECS), and 15% was in data capture and transport. Within the entire EOSDIS project, these two categories represented the two tallest "poles" in the entire EOSDIS budget (based on numbers received from John Dalton in order to help the EOSDIS Panel better understand the cost model). Within the ECS alone, Maintenance and Operations (M&O, 37%) and Development (31%) were the two tallest "poles" (numbers courtesy of Marsh Caplan). Unfortunately, at the time of the SDR the EOS Data and Operations System (EDOS) contract was still in negotiation, and details about the data capture and transport pole were not available. The M&O component of the ECS contract is composed mostly of personnel salaries. The Development component is "lines-of-code" (measured in thousands, KLOC) and the engineering analysis involved in checking out commercial-off-the-shelf (COTS) software.

In studying the numbers and facts provided to us by both the Project and Contractor, two things appear to be driving these tall poles. The first driver is a large and complicated requirements list. It is apparent that the contractor and Project make no critical assessment of these requirements. Instead they treat them all as of equal importance and try to build a system that meets all of them. This leads to stringent RMA (Reliability, Maintainability, Availability) with lots of people and other costs involved. There has been very little, if any, dialog with the science community to prioritize these requirements. The EOS scientists need to look at the science requirements, and then the DIS engineers need to look at the engineering-derived requirements that flow out of this type of dialog. Only then will we be able to make intelligent cuts to stay within budget constraints.

The second driver of these tall poles is the list of data products and production assumptions. It has been obvious that communication of how big the products are, how often they're produced, and what their computational and storage requirements are has needed substantial improvement. To foster this communication, an Ad Hoc Working Group on Production (AHWGP) was formed. The work of this group is described in detail elsewhere in this issue of *The Earth Observer.* Briefly, this working group contains representatives of the investigators, the Project, and Hughes. It will coordinate information passage between the investigators and the system modelers to produce a much better basis for making cost estimates. It is believed that this work will produce a much more visible description of what EOS will produce and when EOS data products will be available to the community.

Currently EOSDIS acts as an amplifier of data products; data products are being produced without any priority and the DIS will host them. This is a direct outcome of the disincentive built into the EOS undertaking as a whole. In order for EOS scientists to be assured of financial support from NASA, they must be producing "standard data products" with the logical assumption that the DIS will host these products. While it is clear that we need to carefully attend to the requirements for the current list of products, we also do not want to discourage experimentation, particularly since the life of EOS is much longer than what we are used to. We clearly need to discover how to accommodate useful new knowledge and new kinds of data within a limited budget.

The EOSDIS Project Scientist has circulated a draft of "Science Operations Concepts for EOSDIS Part I: Data Product Resource Allocation." This document seeks to maximize the science accomplished within any particular data production and operation budget. The components of this document include a phased algorithm implementation ranking, a set of rigorous product evaluation criteria, a data capacity baseline, requirements for data management, and a science advisory process. These components are designed to involve scientists, from project inception, in the production of, and access to, high-quality data sets.

EOSDIS Panel Concerns

The EOSDIS Panel has a number of concerns after the SDR, many of which were being addressed immediately after the SDR. Consequently, some of these items are in a state of flux. In particular, there has been the assertion that there are too many KLOCs, especially for the Flight Operations Segment (FOS). However, the contrary position has been taken by the ECS contractor that the large heritage of FOS code is inappropriate for an object-oriented based system. These positions are being looked into. We are also concerned that subsetting and processing-on-demand are being considered only in predefined cases such as browse products. We feel that more investigation of cost trades needs to be done. In addition, the autonomic nature of the architecture is not being exploited to its full advantage. We think that more reliance on "lights out" operations should be looked into.

A number of members of the Panel are concerned about whether all the Distributed Active Archive Centers (DAACs) are necessary. A less-draconian viewpoint is to consider whether or not we can phase-in their operations rather than have them running full-up at the time of the EOS AM-1 launch. Perhaps there is even some room for considering something that might be called a meta-DAAC. These DAACs would be data access points and archives of higher level products, but would not be processing Level 0 or Level 1 data to higher levels. It is important that the DAACs provide sound scientific, as well as programmatic, justification for their role in EOSDIS and have that role reviewed periodically.

There are other concerns. The Internet is assumed to be the distribution network for most of the data products (at the SDR the split was 80% electronic, 20% physical media). With the announcement that the National Science Foundation (NSF) plans to cease subsidizing the academic community's connection to the Internet, plans are in the works to drastically change that split. Investigation is being done into the cost tradeoffs of ever increasingly expensive physical media (media, people, postage) and the plummeting price of commercial high-speed network connections (telephone companies). There is mounting evidence that the costs of commercial, high-speed network connections are dropping faster than the model employed by the ESDIS Project. Yet the fallback position of the Project seems to be a reliance on shipping physical media due to the belief that network circuits are too expensive now and will remain that way. The network and its costs remain a large unknown in the EOSDIS enterprise.

The EOSDIS Panel is frustrated by the fact that it is difficult to obtain independent information about the cost of the DIS. The "best" numbers come from either the ECS contractor or the Project, and it is difficult to evaluate how objective these numbers are. We feel that there should be an independent audit or review of the cost model being used by both of these parties.

Finally, the Panel is concerned that the Project and ECS contractor seem to show little ingenuity in solving cost problems. This may be unfair, but if the EOSDIS Panel sees little evidence of their efforts at keeping the cost down, then the rest of the EOS community probably sees nothing. This is an unhealthy state of affairs and can lead to "raids" on the funds reserved for EOSDIS by the uninformed.

Recommendations

1) Wait for the alternate architecture studies to be finished and their findings reported to the ECS contractor and Project. Significant cost savings may be accomplished with simple inclusion of some of these ideas.

2) We urge the Project and ECS contractor to seek ways to better utilize the autonomic capabilities of their architecture.

3) We need to go beyond opening a dialog between the EOS science community and the Project/contractor to critically assess the requirements placed on the DIS. We need to set up a mechanism that prioritizes these requirements and has the authority to make it stick. If we can prioritize these requirements, then we will have a better idea of what we can and cannot afford in the current budget climate.

4) Additionally, we recommend that the EOS science community (e.g., AHWGP) and the EOSDIS Project Scientist work together to create a data product priority. This process should be seeking to reduce the tall poles identified in this report and other costs within the EOSDIS project.

5) The disincentive problem can be rectified by continuing to fund scientists researching non-standard data products.

6) Make a full appraisal of currently available FOS code for the ECS.

7) Very careful analysis of network options needs to be done. It is easy to believe that high-speed network technology will solve this problem for us in the future, only to be bankrupted in the cost of the "last mile" of connectivity. There needs to be more communication between the ESDIS Networks Team and the scientific community so that we can all participate in the choice of the mode of data distribution.

In all frankness it should be pointed out that many of these recommendations are already being acted upon by either the Project or ECS contractor or both, but involvement of the EOS scientific community is absolutely essential. It is important to realize that we now have an architecture we can really use; how we use it is up to us. ❑

Landsat Information via the Internet

—Ed Sheffner (esheffne@mtpe.hq.nasa.gov), NASA Headquarters

A folder containing information on the Landsat Program has been established on the Internet. The folder is intended to facilitate the Landsat Advisory Process by serving as a repository for news on the program and a mechanism for gathering comments and recommendations from the Landsat data user community.

To access the Internet folder via Gopher, use the URL: gopher://gopher.usra.edu/11/pub/landsat.

To access the information via ftp, use the URL: ftp://ftp.usra.edu/pub/landsat.

Using a traditional ftp client, ftp to "ftp.usra.edu" and move to the directory "/pub/landsat."

There is currently no WWW (World Wide Web) access to the folder. Interested parties may also direct questions and comments about the Landsat Program to the Internet address landsat@usra.edu.

The EOSDIS Core System's Preliminary Design Review and the Ad Hoc Working Group on Production

—**Bruce R. Barkstrom** (brb@ceres.larc.nasa.gov) and **Mel Banks**, Co-Chairs, Ad Hoc Working Group on Production

In mid-December of this year, the EOSDIS Core System (ECS) will be undergoing its Preliminary Design Review (PDR). Over the last year or two, the ESDIS Project and the ECS contractor have been preparing requirements for ECS. We might interpret these requirements as stating what functions the ECS will have to perform, together with a rough estimate of when these functions need to be in place. Both the Project and the contractor have studied possible implementations and estimated the costs of these possible systems. However, these estimates should be regarded as "back-of-the-envelope" calculations. The PDR is the first time that there will be a working apportionment of functions to hardware, networks, and software.

Getting through PDR on time with an affordable cost is critical to the success of EOSDIS. To achieve this goal will require cooperation and yet more hard work by all the members of the investigation teams. An Ad Hoc Working Group on Production (AHWGP) has been formed to help facilitate this work by easing the translation of the investigator needs into the material the Project must have for reliable design numbers and cost estimates. This note describes what a successful PDR needs from the investigator teams, how that information connects with performance modeling, and the role of the AHWGP in smoothing the information flow.

What a Successful ECS PDR Needs

To come through PDR successfully, many estimates have to be "in place": "What data products will be produced?"; "How big will the data product files be, how frequently will they be transferred, and from which sources to which destinations?"; "How much computer time will it take to produce the data products?"; "How many users will there be and how will they interact with EOSDIS?"; "How much network capacity do we need, what capacity will be available and at what price?"; "What kinds of computers and disks will be available and at what prices?"; and "What software will we buy and what software will the ECS contractor have to develop?". Certainly, the investigator community has provided a lot of information about these items over the course of the last several years.

What the Investigators Need to Provide

Some of the items that the Project and Hughes need are not new. For example, Michael King and Ghassem Asrar have been working over the last several years on providing a list of data products that are scientifically important and within cost. Yun-Chi Lu of the Science Processing Support Office (SPSO) has labored to capture information from the investigator community in a database and to keep that information updated as the investigators have improved their understanding. Perhaps the two most-important fields in this database are the expected rates of data product increase, and an estimate of the computer operations required to build the products—the infamous MFLOPS.

When work started on this database, it was expected that production would be a relatively simple process. A data product would be dominated by one parameter, and there would be one job that produced each product. However, as we have improved our understanding of production, we have outgrown these early assumptions. Most of the data products are collections of many parameters. Most of the processes that create data products use several input data products and create several others. EOS data production is a very complex process.

An additional source of complexity lies in the network connections or media delivery that we require. The current information we have in the database probably does not give a good description of network transfers. Although the

SPSO database maintainers have made a valiant effort to get the community to respond, few of us have supplied sufficiently precise information to allow either Hughes or the Project to put together a model of EOSDIS production that seems reliable. We really need to know which data product files the Interdisciplinary Science (IDS) teams need from the Distributed Active Archive Centers (DAACs). We also need to know how often those files are transferred and whether they should be subsetted before they are sent.

To remedy this situation, those of us in the investigation community will have to provide some new kinds of information, probably in more of a hurry than we would like.

How the Investigator-Supplied Information Connects with Performance Modeling

One of the difficulties with our communication has been clearly relating the information the investigators provide to the performance modeling and cost modeling that the Project has to do. For PDR, Hughes will be using a standard commercial tool that describes production and network file transfers with queuing theory. This tool requires file sizes and rates of file arrival from the ground stations to be available as part of its input. Then, a description of the discrete computer jobs, including CPU loading, bus I/O transfer rates, disk latency, and similar parameters, is used to estimate how many jobs a given computer layout will be able to process. Networks are included in this description, both within facilities (as local area networks, LANs) and for file transfers from one facility to another.

Up to the present, the estimates of performance have been based on a more-continuous picture of data flow. The "back-of-the-envelope" estimates assumed that CPU processing dominated the length of time it took to process a given job. Now, we have a better tool that includes networks in the heart of its computation. However, it needs new information. We are also aware of more factors that influence the rate at which we can create good data.

The Role of the AHWGP in Smoothing the Information Flow

With this need for new kinds of information, it has become apparent that we need to improve communication between the EOS investigators, the ESDIS project, and the ECS contractor regarding the way in which the investigator data production needs are translated into computer sizings and network loading. Some readers may recall the concern that multiple transfers of the MODIS radiances to the LaRC DAAC on the same day would have large impacts on EOSDIS costs. The same concern appeared with the assumption that all standard data products will begin production on the first day after the instruments are checked out. With that need in mind, several of the investigators (Bob Evans, Paul Bailey, and Bruce Barkstrom) met with the individuals at Hughes who are involved with producing the computer sizings (Bill Bass, Bob Howard, Mike Theobald), network loadings (Mary Armstrong), and user production scenarios (Ken Hubbard, Dave Case, Karl Cox). Yun-Chi Lu, who has maintained the Science Processing Support Office's database, and Chris Harris from the Langley DAAC joined us as well. During this meeting, we discussed several of the facets of production of concern, and felt that there was a reasonable understanding between the investigators and the modelers.

On this basis, we contacted a number of additional investigation teams and other individuals in the Project to see if we could expand our understanding. The response was generally positive. Towards the end of July, we had a meeting with the Project and Hughes representatives to see if we could gain an agreement to proceed as a Working Group to improve the communication among all of the parties. The Project agreed very rapidly, and suggested that Mel Banks be recognized as Co-Chair of this Ad Hoc Working Group on Production. Banks is the Contracting Officer's Technical Representative for the ECS contract with Hughes, and so is in a key position to ensure that any understandings we might reach would be expeditiously reflected in the contracting activity.

The Objectives of the Working Group

The objectives of the Working Group are:

1) To provide an interface

between Science Community, Project, and ECS contractor to ensure that we have a sound basis for describing

- data products,
- operational scenarios,
- EOSDIS archival size, computational loading, and network properties, and
- external interfaces for acquiring non-EOS data.

2) To provide mechanisms for building the infrastructure needed to smooth the passage of documentation and other descriptions from the Science Community into the Project, Hughes, and the DAACs. We want to make sure that Hughes receives reliable information on which to build its models of EOSDIS production sizing, data archiving, and network loadings. We also need to respond quickly in providing a firm basis for agreements between the ESDIS Project and other agencies regarding data that we need for production in EOS.

We started the business of the AHWGP with a teleconference from 2:30 p.m. to 4:30 p.m. on Thursday, Aug. 11. We had participants from the investigator teams: ASTER participants included Moshe Pniel and Gary Geller; CERES participants were Carol Tolson and Troy Anselmo; the LIS participant was Steve Goodman; MISR participants were Graham Bothwell, Earl Hansen, Bob Vargo, and Daniel Wenkert; and MODIS participants were Ed Masuoka, Bob Evans, and Al Fleig. Paul Bailey from MOPITT was not able to be with us, but has been an active participant by e-mail. We also had participants from the Project, including Mel Banks as Co-Chair, Steve Wharton, Barbara Putney, Yun-Chi Lu, Skip Reber, and Steve Kempler from the management side, Andy Germain and Dick desJardins for networks, and Matt Schwaller for external data products. We had Hughes representatives for performance modeling (Bill Bass, Bob Howard, and Mike Theobald), for networks (Mary Armstrong), and for user production (Dave Case, Karl Cox, and Mac Macdonald). Finally, we included representatives from several of the DAACs, including Chris Harris (LaRC) and (initially) Greg Hunolt (GSFC).

The critical item of business on which this group reached a consensus was that we can describe processing in terms of data product files, processes (where a process can be a computer program, a network file transfer, or a Q/A activity involving people), and process activations. The Hughes modeling folks will be using this kind of description for estimating processing and network loads as we move to PDR. The details of this kind of model differ from the previous description in the SPSO database. The intention of the SPSO database was to reflect the most-recent understanding of the data products. However, the translations of the user requirements and the retranslation into the model parameters may have had inadvertent side effects. Thus, the consensus achieved in the teleconference marks the beginning of a quite different view of processing from what we have had so far. With this consensus, we can move forward under the assumption that the material we collect from now on will not have to be reworked if there is a change in the way the system is modeled. This view of processing should also reduce errors in transmitting information from the investigators to Hughes.

The second critical item was to reach an understanding of Matt Schwaller's need to collect data product information for tangible external data interface agreements between the ESDIS Project and external agencies providing data needed by the investigators. In putting together the processing description, we will develop a description of what data products the investigators need, how often they need them, and what criticality they place on them. It appears reasonable to group the product needs into continuous delivery, regular but intermittent delivery (e.g., for instrument calibration), and sporadic delivery (e.g., for validation campaigns involving aircraft or ships). Skip Reber suggested that we might categorize the needs in terms of science processing, validation, and scientific studies. Matt Schwaller added that the Project would probably categorize the priority of these needs, with regular production receiving the highest priority. Scientific studies with *in situ* or aircraft data would probably receive lower priority. In the long run, the AHWGP will try to blend these somewhat different perspectives into a more-unified view of data needs.

The final major item of discussion was network expectations. Both the Project and Hughes network specialists made it clear that the investigation teams need to supply very specific information regarding network traffic: which data products need to go from which locations to which other locations, and how often they need to be transmitted. This information is not currently available with sufficient detail and needs to be developed as part of the processing scenarios provided by the investigator teams. Bob Evans had provided a rather interesting and thoughtful discussion of network assumptions to Dick desJardins, and there was a useful clarification of working assumptions as part of this teleconference. Because the technical characteristics of the assumptions are lengthy, we will provide a detailed set of assumptions elsewhere. There are likely to be limitations to data transfer, which we will deal with as expeditiously as possible. Evans concern was that these limitations may mean that some Q/A data will have to be distributed on media, which could result in production running "blind" for as long as a week. We will consider critical connectivity needs as we improve our description of processing.

We also had a substantive discussion concerning making the documentation of operational scenarios (and data products) available through the DAACs. Chris Harris of the LaRC DAAC suggested that a Mosaic connection would be easiest, and this met with general approval.

What we expected from this teleconference was that the investigator teams (which include all of the TRMM and EOS AM-1 investigators) would begin working on providing operational scenarios (with products, processes, and process activation lists). Andy Germain set up a mail server and "anonymous ftp" site on the machine "eos.nasa.gov." Many of the documents we are producing will be found on that machine in the directory "AHWGP." For example, Hughes has provided a preliminary list of the information they need, and Bruce Barkstrom has provided a condensed list, together with a suggestion as to how what Hughes needs can be assembled. The Hughes list has priority. We are working to give Hughes a sound basis for estimating processing and network loads by October 3, with a review of our understanding of external data products in mid-September around the time of the EOSDIS Panel meeting. We will also provide a presentation to the EOS Investigators Working Group in mid-October. If we fulfill this commitment, then we should have a reasonable basis for looking at numbers from the Hughes models about November 1. This schedule will allow us some time to make a reasonable number of tradeoff studies before PDR.

In the ftp site, we also have a document from Paul Bailey describing a MOPITT operational scenario, and a description that Karl Cox provided of Bob Evans' production of products at Miami. Matt Schwaller has provided a set of files in the ftp site that describe NOAA products that may be useful as external (non-EOS) data products for production. We also have a data product availability scenario (sort of a data product schedule) and one-page abstracts for each of the products.

Our schedule is very compressed. One item that we want to work on is understanding contingency. We hope to state the producer requirements in terms of the "investigator working space," rather than in terms that are difficult for producers to interpret. We will need help from the community and cooperation to build the information we need. Certainly, we will report on the progress of this activity at the Investigators Working Group meeting. However, we will also provide more-frequent communications through e-mail to "iwg-everybody" and through *The Earth Observer.*

We hope to begin concentrating on the problem of getting good data to our user community as fast as possible, rather than on the nuts, bolts, and dollars concerns that have so often sapped our energy up to now. ❑

EOSDIS Version 0 is Now Available

—**Greg Hunolt** (gregh@ulabsgi.gsfc.nasa.gov), ESDIS Project

The EOSDIS Version 0 (V0) working prototype is now (August 31, 1994) available for use by the general Earth-science community. The V0 system is the culmination of three years of work by the Earth Science Data and Information System (ESDIS) Project and the EOSDIS Distributed Active Archive Centers (DAACs) to develop data archive, catalog, distribution, and user support capabilities at each DAAC and a working prototype of a cross-DAAC catalog capability. Each DAAC has science data holdings available to users (described in the Science Data Plan to be updated in October, 1994) and provides a choice of data delivery options and active user support. The V0 Information Management Service (IMS) provides a user accessing the system at any DAAC a coherent view of the data holdings of all of the DAACs and the means to identify, in some cases browse, and order combinations of data meeting common search criteria from any combinations of DAACs in which the data reside. The V0 IMS system also provides access to the NOAA/NESDIS Satellite Active Archive.

As a working prototype, the V0 system is intended to provide useful services to users, including the wholly new cross-DAAC catalog capability, while at the same time testing user reaction to prototype implementations of a variety of functions. Information gained from user experience with this prototype will be used in the development of future versions of EOSDIS, to be based on the EOSDIS Core System (ECS) being developed for NASA by Hughes. As would be expected with a prototype, users will encounter some rough edges, both in terms of minor problems with the system and with performance. System response time for the V0 IMS Graphical User Interface (GUI) will be limited by the capacity of the network connection between the user site and the DAAC the user accesses. In the near future, a character user interface (ChUI) will also be available, and it is planned that eventually users will be able to port V0 IMS client software to their own sites to further minimize performance problems.

The ESDIS Project and the DAACs need and solicit user comments, critical or favorable, on the V0 system and the full suite of services available from the DAACs. Information on available data sets and how to gain access to the V0 system is available from DAAC User Support Offices.

Please do not hesitate to contact the DAACs if they can be of service to you.

DAACs—Distributed Active Archive Centers:

ASF DAAC User Services
Alaska SAR Facility
University of Alaska, P.O. Box 757320, Fairbanks, AK 99775-7320
907-474-7487 voice
907-474-7290 fax
Internet: asf@eos.nasa.gov

EDC DAAC User Services
U.S. Geological Survey
EROS Data Center
Sioux Falls, SD 57198
605-594-6116 voice
605-594-6589 fax
Internet: edc@eos.nasa.gov
WWW: http://sun1.cr.usgs.gov/landdaac/landdaac.html

Goddard DAAC User Services
NASA Goddard Space Flight Center, Code 902.2
Greenbelt, MD 20771
301-286-5033 voice
301-286-1775 fax
Internet: gsfc@eos.nasa.gov
WWW: http://daac.gsfc.nasa.gov

JPL DAAC User Services
Jet Propulsion Laboratory
Mail Stop 300-320
4800 Oak Grove Drive

Pasadena, CA 91109
818-354-9890 voice
818-393-2718 fax
Internet: jpl@eos.nasa.gov
WWW: http://seazar.jpl.nasa.gov

Langley DAAC User Services
NASA Langley Research Center
Mail Stop 157B
Hampton, VA 23681-0001
804-864-8656 voice
804-864-8807 fax
Internet: larc@eos.nasa.gov
WWW: http://eosdis.larc.nasa.gov

Marshall DAAC User Services
NASA Marshall Space Flight Center, Building 4492
Huntsville, AL 35812
205-544-6329 voice
205-544-5147 fax
Internet: msfc@eos.nasa.gov
WWW: http://wwwdaac.msfc.nasa.gov

NSIDC DAAC User Services
National Snow and Ice Data Center
CIRES, Campus Box 449
University of Colorado
Boulder, CO 80309-0449
303-492-6199 voice
303-492-2468 fax
Internet: nsidc@eos.nasa.gov
WWW: http://eosims.colorado.edu:1733

ORNL DAAC User Services
Oak Ridge National Laboratory
PO Box 2008, Mail Stop 6490
Oak Ridge, TN 37831-6490
615-241-3952 voice
615-574-4665 fax
Internet: ornl@eos.nasa.gov
WWW: http://arm4.esd.ornl.gov

SEDAC User Services
CIESIN SEDAC
2250 Pierce Road
University Center, MI 48710
517-797-2727 voice
517-797-2622 fax
Internet: ciesin@eos.nasa.gov
WWW: http://www.ciesin.org

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ADEOS UPDATE

On July 1, 1994, the Executive Board of the National Space Development Agency (NASDA) approved the selection of 151 investigations for ADEOS calibration/validation and science from the 200 proposals received. The proposals covered use of data from all ADEOS instruments except POLDER, for which there is a separate CNES-NASDA research announcement (with selection expected in October). The largest numbers of accepted proposals were from Japan (53) and the U.S.A. (46), with an additional 18 countries represented. NASA endorsed 41 of the U.S. investigations. Of the total, 103 investigations were classified as science, and 48 as calibration/validation. Use of multiple instruments will be the focus of 42 investigations, followed by 35 for OCTS, 32 for AVNIR, 12 for IMG, 12 for NSCAT, 7 for ILAS, 6 for RIS, and 5 for TOMS. The first ADEOS Investigators meeting is planned for December 6-9 in Kyoto.

List of Acronyms:

ADEOS	Advanced Earth Observing System
AVNIR	Advanced Visible and Near-Infrared Radiometer
CNES	Centre National d'Etudes Spatiales
ILAS	Improved Limb Atmospheric Spectrometer
IMG	Interferometric Monitor for Greenhouse Gases
NASDA	National Space Development Agency
NSCAT	NASA Scatterometer
OCTS	Ocean Color and Temperature Scanner
POLDER	Polarization and Directionality of Earth's Reflectances
RIS	Retroreflector In Space
TOMS	Total Ozone Mapping Spectrometer

User Recommendations for the EOSDIS Core System

—**Rogard Ross** (rross@eos.hitc.com), Jan Poston (jposton@eos.hitc.com), **Scott Griffith** (sgriffit@eos.hitc.com), EOSDIS Core System Project

The EOSDIS Core System (ECS), which is now in the preliminary design phase, is one of the central components of NASA's Mission to Planet Earth program. ECS will control the EOS spacecraft and instruments, process data from the EOS instruments, and manage and distribute EOS data products and other selected data sets. A goal of the ECS program is to provide an adaptable system that is responsive to the evolving needs of the Earth-science community. Over the system lifetime, ECS will evolve as scientific needs change, new technologies emerge, and the information infrastructure grows. The ECS development is being accomplished in cooperation with the user community, with a shared commitment to the vision of an information system which promotes effective utilization of data across the entire Earth-science community.

To support these goals, ECS created and maintains a Recommended Requirements Database (RRDB). The fundamental goal of the RRDB is to identify user recommendations that can enhance the ECS design and be a benefit to the entire Earth-science community. Since the RRDB's inception in May 1993, more than 600 recommendations have been received, and over two-thirds of these have influenced the ECS design. Over Internet, the RRDB may be accessed to read the recommendations and comments which have previously been entered and/or it may be used to propose requirements.

Once received by the RRDB analysts at ECS, each recommendation is evaluated for its applicability to the Project. Analysts compare the recommendation to existing requirements and perform a cross-check to determine whether the recommendation is already being implemented in ECS design plans. Occasionally, a recommendation can not be evaluated immediately due to an on-going design study and must be deferred for later re-examination. The author of the recommendation is contacted by e-mail to provide feedback on the recommendation's progress through the process and, if necessary, to obtain additional data. The author may also monitor progress via the RRDB.

After this initial analysis phase, the recommendation is reviewed by a Screening Team consisting of representatives of the ECS segments, system engineering and integration office, and science office and of NASA. When a recommendation corresponds to an existing requirement but the design is not yet mature enough to verify that the specific implementation suggested in the recommendation is being incorporated, the item is flagged and provided to the software developers for design consideration. Once a decision on that design feature is made, the recommendation is re-evaluated for closure.

When a recommendation is identified as a new requirement, it is forwarded to the Technical Assessment Panel. This panel, consisting of the Chief Engineers from the ECS segments and the system engineering and integration office, reviews the impact of the recommendation on the technical, cost, and schedule baseline. If there are no obstacles, it is then sent to the appropriate Configuration Control Board(s) where it will be considered for incorporation into the ECS design as a New Requirement.

Instructions for accessing Version 2.0 of the RRDB may be found via the ECS Data Handling System (See *The Earth Observer*, March/April 1994) or it may be accessed directly through a vt100 interface or X-Windows interface as follows:

To log-on to the RRDB via vt100:

- Set your terminal to the vt100 mode.

- To connect to the RRDB host, type telnet 192.150.28.17 at login prompt, type rrdb and press return.
- At the password prompt, type password and press return. The welcome screen will appear.

To log-on to the RRDB via X-Windows:

- Set your terminal to X-Windows mode.
- To enable the server, type xhost + 192.150.28.17.
- To connect to the RRDB host, type telnet 192.150.28.17.
- At login prompt, type rrdb and press return.
- At the password prompt, type password and press return.
- Welcome screen will appear.
- At prompt, type y to verify use of X-Windows.
- Type in your display (Internet) address, for example, you@some.where.com:0 or xxx.xxx.xxx:0 (where the x's denote the numeric Internet address) and press return.

In November, Version 3 of the RRDB will be released providing users with a new GUI interface for adding their contributions and browsing the results of previous recommendations. If you need more information on the RRDB, please contact rrdb@eos.hitc.com. ❑

SPSO Report on EOS Products and Input Requirements

—**Yun-Chi Lu** (lu@spso.gsfc.nasa.gov, fax: (301)286-1775), Code 902, Goddard Space Flight Center

The Science Processing Support Office (SPSO) at GSFC released its interim report document entitled "EOS Output Data Products and Input Requirements-Interim Version." It was distributed to EOS Principal Investigators and Instrument Team Leaders in early August. The interim report covers the updates received during the period November 1993 through June 1994, including the Algorithm Theoretical Basis Documents (ATBDs) from 7 instruments (5 AM-1 instruments, LIS, and SeaWinds). The interim report consists of six tables, as follows:

- **Table 1**—summarizes the recent changes made to the SPSO database since November 1993.

- **Table 2**—lists all at-launch and post-launch data products planned by instrument teams, providing information about DAAC, platform, production mode, data volume, processing load estimates, etc.

- **Table 3** —provides information on the characteristics of each parameter (i.e., units, accuracy, temporal and spatial resolution/coverage, etc.), required input data, and volume and processing load estimates.

- **Table 4** —is the same as Table 3, but listed according to the parameter ID. The purpose of Table 4 is to assist the reader in quickly locating the input parameters listed in the column for "Data Needed for Product Generation."

- **Table 5** —shows daily data volume estimates by processing level and platform for both at-launch and post-launch data products given in GB/day.

- **Table 6** —shows processing requirements by processing level and platform for at-launch and post-launch data products given in millions of floating point operations per second (MFLOPS). All estimates presented in the table were provided by instrument teams or derived from the ATBDs.

The SPSO plans to release version 3.0 of the full report in November 1994 prior to the EOS Core System (ECS) Preliminary Design Review. The version 3.0 report will incorporate changes recommended for the EOS Program Rebaseline by the Payload Panel in July 1994 and data processing information collected by the Ad Hoc Working Group on Production (AHWGP) led by Bruce Barkstrom (CERES Principal Investigator) and Mel Banks of the Earth Science Data and Information System (ESDIS) Project, GSFC. In addition, revision requests received from instrument teams following the release of the interim report will be incorporated. The SPSO is currently setting up an anonymous FTP server on one of its UNIX machines, which will allow users to download the product and parameter information. If you would like to have a copy of the interim report or need further information about the anonymous FTP server, please contact Yun-Chi Lu .

DATA ASSIMILATION FOR EOS: The Value of Assimilated Data, Part 1

—Richard B. Rood, Stephen E. Cohn, Lawrence Coy (coy@arachnid.gsfc.nasa.gov)

Model-assimilated data sets are often called value-added products. Because of the extensive computer and networking requirements and the large manpower resources involved, data assimilation is rightfully perceived as an expensive undertaking. In the increasingly resource-constrained environment of EOS and Mission to Planet Earth (MTPE), it is necessary to consider exactly what value is added by the assimilation procedure. Then it is necessary to determine if this value is worth the cost of the data product. Assimilated data products are Level 4 data products in the parlance of the EOS Project.

Data assimilation is the process of incorporating observations of a dynamical system into a model of the system. In a broad sense, assimilation procedures are at the heart of the scientific process. Models represent our understanding of a physical or chemical system. Observations, with their associated errors, represent our quantitative measurements of the system. As the observational data are fed into the models, the inadequacies of the models are revealed, leading to enhanced scientific understanding and subsequent improvement of the models. As models become more complete and more accurate, a situation evolves whereby the discrepancies between the observations and the underlying values predicted by the model provide new information about the underlying physical system. In this way the total information extracted from the observations is extended beyond that obtained directly from the observations themselves.

A classic example of the assimilation process at work is the evolution of the modern description of the solar system. Equations of motion to define planetary orbits were quickly obtained after the development of Newtonian mechanics and calculus. However, the number of planets and other celestial bodies added sufficient complexity to the problem that it took many years to refine the modern description. Measurements of orbital periodicity and eccentricity helped to refine the equations of motion. Ultimately, sufficient confidence was placed in the model equations, and in the quality of the observations, that the discrepancy between model and observations could not be explained without postulating the existence of unobserved planets or asteroids. The existence of Neptune, for instance, was postulated because of unexplained perturbations in the orbit of Uranus. Ensuing models of Neptune's orbit were sufficiently accurate to lead to observational strategies that ultimately located Neptune within one degree of its predicted position (see Grossner, M., *The Discovery of Neptune*, Harvard Univ. Press, 1962).

The modern mathematical formalism for data assimilation problems, known as estimation theory, in fact traces its roots back to the least-squares method proposed by Gauss in 1795 for determining the orbit of the asteroid Ceres from observations of its motion (Sorenson, *IEEE Spectrum*, 1970; Meditch, *Automatica*, 1973). Thus it is not surprising that the explosive development of estimation theory in the 1960's and 1970's (Sorenson, *Kalman Filtering: Theory and Application*, 1985), which elegantly treats both the dynamic and stochastic aspects of data assimilation, saw some of its earliest applications in orbit-determination problems. Now, however, the orbits were those of spacecraft, and computers were available to implement the theory in real time. For example, during the first manned voyage to the Moon (Apollo 8, December 1968), midcourse corrections and lunar orbit insertion were accomplished through use of a small on-board computer programmed specifically to solve the equations of the

Apollo trajectory dynamics, and to update the solution in real time by means of a Kalman filter driven by navigational observations made by the astronauts (Battin and Levine, *Application of Kalman Filtering Techniques to the Apollo Program*, 1970). Much of the early theoretical and applied work on estimation theory was carried out at the Goddard Space Flight Center (Jazwinski, *Stochastic Processes and Filtering Theory*, 1970), where effort is now directed towards data assimilation for Earth-system science in the MTPE/EOS era.

In Earth-system science the assimilation problem is much more complex and difficult than orbit-determination problems, but the potential impact of data assimilation is tremendous. The impact can be divided into several categories.

1) Data assimilation objectively places a diverse set of observations onto a spatially regular, temporally continuous grid. For input, the assimilation procedure uses observations from Earth-orbiting satellites as well as ground-based, balloon, aircraft, and ship observations (see Stobie and Rood, *The Earth Observer*, March/April, 1994). Through the physical mechanisms of the model, and the objective statistical methods of the analysis system, which updates the model prediction with the observed data, the assimilation procedure assures a high degree of dynamical consistency in the output, the assimilated data product. This attribute of assimilation organizes and complements the raw observations and thereby provides a data product of enhanced usefulness to the community.

2) Data assimilation is also a method for estimating unobserved quantities. For the quantities needed to define the processes and to understand the mechanisms responsible for Earth-system variability, the number and types of direct observations are very limited. Through the assimilating model, estimates of unobserved quantities can be made, allowing the execution of science that would be impossible without assimilation. This attribute of assimilation supplements the information obtained from the observations themselves and will be the primary subject of this article.

3) Data assimilation propagates information from regions where there are plentiful observations to regions where there are few observations. This is closely related to both Items 1 and 2 above, but is distinguished by emphasizing the fluid dynamical character of most components of the Earth system. As an example, the North American weather observations define weather systems as they propagate from west to east into the Atlantic ocean region. Even though the quantitative model description of the weather systems degrades over the ocean, there is still sufficient information propagated so that weather forecasts over Europe are positively impacted by the North American observations.

4) Data assimilation provides a powerful method of data quality control. One of the fundamental products of the assimilating model is an estimate of what the Earth-system is expected to look like at the time of the observations. Comparison of the observations with this estimate allows the identification of potentially spurious data, after which further quality control procedures may be applied as appropriate. By carrying out this comparison repeatedly in time, it is even possible to calibrate instruments as well as to diagnose biases and changes in instrument performance.

5) Finally, data assimilation is the ultimate means of validating and improving the quality of the assimilating Earth-system model. This in turn improves the quality of the assimilated data product. Analogous to our example of inferring the existence of unobserved celestial bodies, by repeatedly confronting the model with data it becomes possible to identify weaknesses in the model such as systematic errors. These errors exist because our models are discrete, because of subgrid-scale processes that can only be parameterized, and ultimately because the Earth system is not a closed system. We must, however, attempt closure at

successively higher levels by adding components to the Earth-system model such as atmospheric trace-constituent transport and chemistry, land-surface processes, and coupled atmosphere-ocean dynamics. As this closure process is carried out, the weakest links in the chain of interactions can be identified, and the relevant parameterizations improved, by means of data assimilation.

These five categories describe some of the major ways in which assimilation can add value to the observations. The remainder of this article will focus on Item 2, the ability of the assimilation system to supplement the observations. This is one of the most important aspects of assimilation for generalized Earth-science applications being pursued by NASA. Future articles will focus on other categories, the differences between data assimilation for numerical weather prediction and data assimilation for broader Earth-science applications, and "yes, Virginia," even some of the shortcomings of data assimilation.

Supplementation of Observations: An Example of Scientific Capabilities Realized Through Use of Data Assimilation

In the field of numerical weather prediction, improved data assimilation methodology has been key in the improvement of forecasting capabilities over the past 10-15 years. Though not designed for more general science applications, the assimilated data sets produced by the numerical weather prediction centers (e. g., National Meteorological Center, European Centre for Medium-Range Weather Forecasts, United Kingdom Meteorological Office), have been widely used to address fundamental problems of the climate system. In the past five years, scientists have tried to expand the utility of assimilated data sets to far-reaching applications. One of the most successful applications has been in stratospheric research.

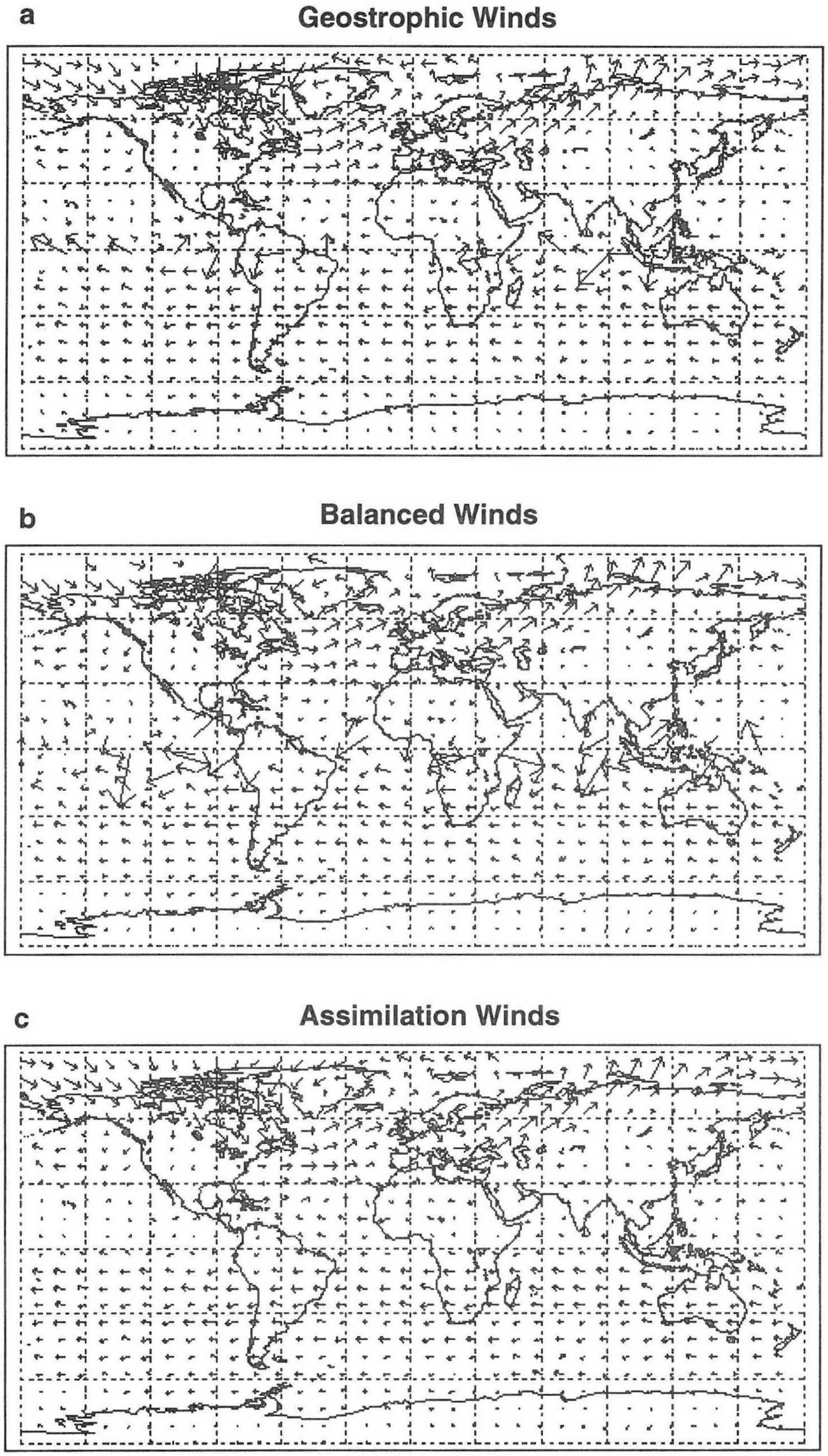
Atmospheric winds are a fundamental quantity needed in many studies of the Earth system. One clear example of the need for wind information is the study of stratospheric ozone. In order to understand chemical processes, dynamical variability must be quantified and removed from the suite of chemical observations. The most-important source of direct wind observations is the radiosonde network. All of the sources of wind information, together, only cover a small part of the domain. In the stratosphere, virtually the entire global wind field, horizontal and vertical, must be derived from temperature observations. Prior to the availability of winds from data assimilation systems, stratospheric winds were estimated from balance conditions derived by scaling the momentum equations (see Randel, W.J., *J. Atmos. Sci.*, **44**, 3097-3120, 1987).

Figure 1 shows the wind field on a longitude-latitude surface derived assuming geostrophy, derived using "balanced" winds, and derived from a data assimilation system. The geostrophic winds (Fig. 1a) have clear disadvantages: namely, they cannot be defined at the equator, and their accuracy decreases substantially in the tropics. Often scientists stop calculating geostrophic estimates 10-20 degrees of latitude from the equator, leaving no wind estimates over a substantial portion of the globe (an area from 30 degrees S to 30 degrees N is equal to half of the Earth's surface). In addition, the geostrophic winds have been shown to be positively biased by as much as 10-20% in the core of the polar night jet (Randel, ibid, 1987). Given that a one meter per second wind error translates to a one degree of latitude per day error in the transport of a constituent, this provides a serious handicap to studying ozone transport and chemistry.

The balanced-wind estimates in Fig. 1b have been shown to be a substantial improvement over the geostrophic estimate and have proven to be very useful in process studies of midlatitude, lower stratospheric ozone chemistry. However, as seen in the subtropics, there are times when the balanced-wind estimate fails. This failure is due to the decrease of the magnitude of the Coriolis force near the equator compared with the accelerating force necessary for curved flow. The balanced winds can then become far from geostrophic as the balanced-wind equations support anomalous flow around highs and lows. As discussed in Coy and Rood, *The Earth Observer*, Jan./Feb. 1994, the balanced-wind estimate also has increasing uncertainty with altitude. Like the geostrophic winds, balanced-wind estimates cannot be used for global studies.

Figure 1:

Wind vectors at 10 mb on January 22, 1992. Wind vectors are scaled so that 60 m/sec equals 10 degrees of latitude. Winds are given on a 4-degree-latitude-by-5-degree-longitude grid. For clarity, only every other latitude and longitude are displayed, so that winds near the equator are shown 2 degrees south and 6 degrees north. The geostrophic and balanced winds were calculated from the DAO STRATAN assimilated height fields. The wind fields shown are: a) geostrophic winds. Often, in practice, the badly behaved winds near the equator are replaced by linearly interpolating between 10 degrees S and 10 degrees N; b) nonlinear balanced winds. The very large amplitude balanced winds, greater than 150 m/sec, near the equator have not been plotted. In practice where the balanced-wind algorithm is unstable, e.g., large vectors in subtropics, the winds are replaced by geostrophic or interpolated from nearby regions; and c) winds from the assimilation system. Note generally well behaved, weak tropical winds. Transport calculations confirm that the general characteristics of the tropical winds from the assimilation are correct.



With tropical middle stratospheric sources, extratropical lower stratospheric reservoirs, as well as links to the mesosphere and troposphere, ozone transport and chemistry is a global problem. Global wind estimates are needed to understand stratospheric ozone. In Rood *et al.* (*J. Atmos. Sci.*, 1989) the application of winds from a data assimilation system to global stratospheric chemistry problems was first discussed. Subsequent research has proven that winds of sufficient quality to represent most of the observed ozone variability can be produced by assimilation procedures. In addition, many research efforts (e. g., Chipperfield *et al.*, 1993; Lefevre *et al.*, 1994) now use winds from assimilation systems because it is the most-effective way to reduce transport-related uncertainties in stratospheric chemistry problems. The realistic representation of dynamic variability also allows much more direct confrontation of satellite constituent observations with model simulations; hence, a much more quantitative utility of the observations.

In summary, in the atmosphere, horizontal winds are observed directly in only a very limited sense. There are no observations of vertical winds. Therefore, assimilation opens up whole new research paths by providing useful, dynamically consistent estimates of unobserved quantities, in this case the three-dimensional, time-varying wind field. The quality of transport applications validates the information content of the wind estimates. This is a tangible example of how assimilation has allowed more information than was directly observed to be extracted from the observations. In the absence of comprehensive global wind observations, it is safe to conclude that any scientific application that requires complete information about atmospheric winds, tropospheric or stratospheric, will require a state-of-the-art assimilation system. Applications such as oceanic and land-surface science, quantification of the hydrological cycle, tropospheric chemistry, stratospheric chemistry, climate-process studies and more will require information from a data assimilation system.

A Free Market Example: UARS and Stratospheric Aircraft Missions

As discussed above, stratospheric chemistry studies have traditionally used winds derived from simple balance conditions. These winds have commonly been derived from mapped geopotential height fields provided by the Climate Analysis Center at the National Meteorological Center; hereafter, NMC/CAC. The NMC/CAC geopotential product is not an assimilated data product; rather it is a map produced through Cressman analysis. Prior to the Upper Atmosphere Research Satellite (UARS) Sept., 1991 launch and the Stratospheric Photochemistry, Aerosols, Dynamics Expedition (SPADE), NMC/CAC balanced winds were the primary source of wind information used to study stratospheric transport.

In the UARS project, routine data assimilation is provided to the science team by the United Kingdom Meteorological Office (UKMO, see O'Neill and Swinbank, 1993). In addition, NMC/CAC balanced-wind estimates are available. The quality of the winds from the UKMO assimilation, even without direct assimilation of high-quality UARS observations, has made them the predominant source of wind information chosen by scientists studying UARS observations (for instance, UARS Special Issue. *J. Atmos. Sci.*, 1994). Papers such as those of Bithell *et al.* (1994) show that without wind information, it is virtually impossible to study the observations of instruments with complex viewing patterns such as the Halogen Occultation Experiment (HALOE).

Similarly, at SPADE in 1993, the Data Assimilation Office (DAO) provided analyses and forecasts to the scientists in the field. By the end of the mission, the assimilation analyses were the product of choice for flight planning and data interpretation. In the current Measurements for Assessing the Effects of Stratospheric Aircraft (MAESA) mission in New Zealand, scientists are using the DAO product, reflecting the scientists' choice of assimilated data products.

Level 4 Products: Far Beyond Mapping

Model assimilated data sets are classified as Level 4 (L4) products by EOS. Geophysical profiles that have been organized by space and time, or mapped, are classified as Level 3 (L3). The previous sections provide an example of the fundamental differences between L3 and

L4 products. The L3 products are composed of information compiled from a single instrument. L4 products provide the best estimate of a geophysical quantity compiled from all sources of information. L4 products are produced directly from L1, radiances, or L2, retrieved, profiles. L3 mapped products are not used as input for L4 products because too much information is lost in the production of L3 products. L3 products cannot easily address the problem of asynoptic mapping, and algorithms to address asynoptic sampling usually strongly smooth the observations. L4 products naturally absorb asynoptic observations into the model, and generally provide a more-faithful representation of the information in the individual observations. Finally, while it is possible to derive a limited set of geophysical parameters from the L3 products (e. g., geostrophic winds), often these derived quantities have very limited utility. L4 products contain a complete description of the modeled system, with data-constrained, model-estimated values of unobserved quantities.

Closing Remarks

This article has highlighted the value added by the ability of assimilation to supplement the observations. It has focused on stratospheric winds. The use of winds from assimilation procedures in stratospheric ozone modeling goes far beyond improving scientific capabilities by actually making quantitative global transport modeling possible. This feeds into policy issues, for instance, by allowing more quantitative research on such problems as the potential impact of aircraft on atmospheric chemistry.

Wind has been used in the example above, but many other quantities are also credibly estimated. These include precipitation; latent heat release; surface heat, momentum, and moisture flux; ocean wind stress; vertical wind velocity; planetary boundary layer depth; and many other quantities, depending on the completeness and accuracy of the model. In addition, useful estimates of diurnal variability of all these quantities are natural byproducts of assimilation. This supplemental information is essential for defining the mechanisms of Earth-system variability. It is crucial to quantify variability in order to measure global change.

Two other aspects of data assimilation are worth mentioning in the context of supplementing observations. The first is that modern assimilation techniques are powerful enough that assimilation can mitigate the loss of information inflicted by scaling back instruments. In the case of stratospheric winds, experiments suggested that the assimilation procedure provided wind products of such quality, that a stratospheric wind instrument would have relatively little additional impact (this was a factor in the deselection of SWIRLS). Implicit in the arguments surrounding the LAWS instrument is the idea that our knowledge of the wind field is good enough that LAWS does not provide a cost-effective improvement. In a very fundamental sense, data assimilation is a cost-effective way to estimate geophysical parameters, and data assimilation becomes more important as instrumentation is scaled back.

The second aspect is the ability to reprocess data already archived. For years weather centers have struggled with the problem that satellite temperature soundings often degrade forecasting capabilities (Andersson *et al.*, *Month. Wea. Rev.*, 1991). Recent improvements in assimilation techniques have shown that in modern systems the satellite observations can have a strong positive impact. This has increased enthusiasm for other types of satellite data such as moisture observations. In addition, it points to how reprocessing archived data sets can extract much more information than we currently have on the causes of variability in the Earth system. Especially exciting are surface winds from SSM/I where research such as that by R. Atlas *et al.* (NASA/Goddard) has shown that accurate speed and directional information can be derived from SSM/I observations. ❑

Information Available From CIESIN

—**Marilyn McCord** (marilyn.mccord@ciesin.org)

What is CIESIN

The Consortium for International Earth Science Information Network (CIESIN, pronounced "season") is a private, non-profit corporation that serves scientific, policy-making, educational, and public access data and information needs. It addresses urgent international concerns, including: 1) global environmental change and sustainable development issues, and 2) the need to promote more efficient access, dissemination, and use of scientific data and information.

CIESIN's 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. To achieve this mission, CIESIN is developing an international alliance of academic, governmental, public, and private organizations interested in understanding global, regional, and local environmental change. In accordance with its mission, CIESIN archives and disseminates data relevant to understanding human interactions with the environment. CIESIN services support interdisciplinary research and applications in key areas including global environmental change and sustainable development.

CIESIN is developing global-scale, time-series, and baseline data and information on the human dimensions of global environmental change. Data identification and acquisition efforts are focused in these areas: industry and energy; agriculture and food security; population dynamics; economic activity; human attitudes, preferences, and behavior; land and fresh water resources; policy and institutions; human and environmental health; and other supporting data sets and regional data collections.

CIESIN is implementing infrastructure and data development programs with the National Aeronautics and Space Administration (NASA), the U.S. Environmental Protection Agency (EPA), the U.S. Department of Agriculture (USDA), the Strategic Environmental Research and Development Program (SERDP), the Office of Science and Technology Policy, and the United Nations Development Program (UNDP) Sustainable Development Network (SDN). CIESIN developed and is operating the Socioeconomic Data and Applications Center (SEDAC), as part of the NASA Earth Observing System Data and Information System (EOSDIS), and operates the U.S. Global Change Research Information Office (GCRIO) for the Executive Office of the President. In addition, CIESIN has organized and maintains access to an expanding Information Cooperative, a distributed global network of data centers and other institutions to provide its users access to relevant data located worldwide.

What is SEDAC?

Operating as a major component of CIESIN, the Socioeconomic Data and Applications Center (SEDAC) is one of nine data centers in the Earth Observing System Data and Information System (EOSDIS) that supports NASA's Mission to Planet Earth program. While the other eight EOSDIS data centers are responsible for archiving natural science data, SEDAC's focus is on human dimensions of global environmental change.

With the aim of translating scientific data and information into tangible benefits to the American people, SEDAC will serve as a two-way information gateway between the socioeconomic and Earth science data and information domains. This will be accomplished in two ways: 1) through the development of new policy-oriented information products that synthesize Earth science and socioeconomic data, and 2) by providing the resulting operational data and information services to the public.

Availability of CIESIN Services and Data Products

CIESIN has just announced that a major element of its information system is now available to the public. The CIESIN WWW server is available at: http://www.ciesin.org. The CIESIN home page provides access to a variety of information resources which support CIESIN's mission of facilitating the understanding of human interactions in the environment.

The home page contains four main sections on:

- Data Access, including information on CIESIN's Catalog Services, Dataset Guides describing CIESIN's data holdings, and the Information Cooperative;
- Information Resources, including Thematic Guides on human interactions in global environmental change, Data Resources, Metadata (data describing data) Directory and Inventory entries, and the CIESIN Kiosk (see below);
- Analysis Services, featuring the Data Exploration Software for the U.S. Census PUMS Data; and
- Education and Outreach Services that provide access to CIESIN's Classroom Earth Bulletin Board System (BBS) and the Human Dimensions Quarterly Calendar of Events.

For Gopher users, CIESIN also maintains a Gopher server with a subset of the features described above, located at: gopher.ciesin.org.

The CIESIN Kiosk

The CIESIN Kiosk is an interactive electronic forum to facilitate information sharing on the human dimensions of global environmental change. The Kiosk encompasses two types of materials: 1) unpublished scholarly papers; and 2) an electronic bookshelf. The CIESIN Kiosk is intended to promote the timely exchange of current information on human dimensions of global change among researchers and policy makers, both within and across disciplinary boundaries. It provides the infrastructure for sharing materials that otherwise might be difficult to locate and access. The unpublished scholarly papers section of the Kiosk, encompasses three types of materials:

- Unpublished scholarly papers for which feedback or comment from scientific colleagues is desired;
- Preliminary working papers;
- Background information or data.

Through the Kiosk, researchers can make their unpublished research materials available to others in the community. Copyright holders retain copyright.

The CIESIN Electronic Bookshelf provides a unique set of information resources to the human dimensions community not readily available through other means. The Electronic Bookshelf provides access to reports, working papers, and other background information from the Human Dimensions of Global Environmental Change Programme (HDP) of the International Social Science Council, the SysTem for Analysis, Research, and Training (START), United Nations Environmental Program (UNEP), International Institute for Environment and Development (IIED), and the Canadian Global Change Program (CGCP). The CIESIN Kiosk provides the infrastructure for sharing these materials that might otherwise be difficult to locate and access.

Accessing the Kiosk

The CIECIN Kiosk materials, which are primarily textual in nature, can be accessed via the Internet through File Transfer Protocol (FTP), gopher, and the World Wide Web. Electronic mail access will be available to users of services such as Omnet, Compuserve, FidoNet, and Bitnet.

If you have questions about accessing the CIESIN Kiosk (or submitting contributions), please send e-mail to kiosk@ciesin.org or contact CIESIN User Services between 8:00 am and 5:00 pm Eastern Time at CIESIN User Service and Training, phone: (517) 797-2727, FAX: (517) 797-2622; E-mail: ciesin.info@ciesin.org. CIESIN User Services will gladly answer your questions about CIESIN's many activities, products, and services. ❑

Climate Change and the Insurance Industry

—**Ann M. Deering** (adeering@pipeline.com), President of Environmental Technology & Telecommunications (ET&T), Ltd.

What follows is taken from a presentation by Frank Nutter, President of the Reinsurance Association of America (September 28,1993, Climate Change & the Insurance Industry: The Next Generation Conference, organized and chaired by Environmental Technology & Telecommunications [ET&T] and co-sponsored by The College of Insurance and Greenpeace.)

We in the insurance industry find that our economic interest is very much intertwined with that of the environment and the climate. It is the threat of natural catastrophes that drives the demand for insurance protection. It's also clear that climate change could bankrupt the industry.

Since 1986, the insurance industry has paid an unprecedented, and unanticipated $60 billion in catastrophe losses (see Figure 1). A catastrophe loss is defined as an event in which at least $500 million was paid by insurers. Nearly 90% of these property losses have been the result of wind-related perils, such as hurricanes, tropical storms, wind storms, cyclones, and tornadoes.

Hurricane Andrew was the real wake-up call to the vulnerability of the insurance industry to natural catastrophes, costing the insurance industry $16 billion for a single event. To date, 1994 is the second worst year on record for loss payments, with $8.58 billion paid between January and June resulting from 18 events. This present trend is projected to continue for the foreseeable future.

We present some reactions of the insurance industry to the potential impacts of climate change.

What Does All of This Have to Do with Climate Change?

According to climatologists and atmospheric scientists, global warming is believed to be a contributing factor in the increased severity and frequency of natural disasters and changing weather patterns. Dr. William Gray, a respected authority on hurricanes, predicts an increase in activity and severity starting in 1995 in the Atlantic region. The 40-year lull of hurricanes in the Atlantic is expected to end. During this lull, coastal construction in the U.S. increased three to fourfold. Since 1940, coastal populations have increased from 44 people per square mile to 140 people. If this population shift continues, 75% of the population will reside within 10 miles of the coast by the year 2000. This migration pattern increases the exposure to the insurance industry to coastal hazards and potential loss of life and property. The estimated present value of insured properties in coastal areas is in excess of $2 trillion.

A recent New York Times article addressed a new analysis of past hurricane behavior and Northeastern development and looked at the likelihood and impact of a Category 3 hurricane hitting New York. The analysis was conducted by Dr. Nicholas Coch, a geologist at Queens College in New York, and author of a publication *Hurricane Hazards Along the Northeastern Atlantic Coast of the United States.* Dr. Coch believes that when the conditions are right, a Category 3 storm with winds of 111-130 miles per hour could get an extra jolt from the Northeast coast and could move up to a severe Category 4 Storm (131-155 miles per hour sustained winds) that could penetrate far inland. Dr. Coch feels that the "big one" will arrive, it's only a question of when.

He is quoted as follows: "The disastrous northeasters of December, 1992 and March, 1993 provide a foretaste of the pattern of damage to be expected from this convergence of factors...but the severity could be much greater....The worst case scenario for the New York metropolitan area would be a Category 3 hurricane that bears inland across central New Jersey on a northwesterly track. In this case, the powerful right side of the hurricane would strike the metropolitan region squarely, producing a storm surge of 20 feet in Raritan Bay and New York Harbor."

The article also quoted Brian Jarvinson, a meteorologist at the National Hurricane Center in Florida, who says a hurricane is expected in this region on the average of every 12 years. This worst-case hurricane could cause $50-$100 billion in damages in the New York area.

In addition to the threat of hurricanes, sea level is rising, and, according to the Intergovernmental Panel on Climate Change (IPCC), is projected to rise as much as 3.3 feet in the next 100 years. 70% of the beaches in the U.S. have reported significant erosion, and half of the U.S. coastline is only 10 feet above sea level. This results in increased exposure to beach communities and to urban populations in coastline cities.

If global warming occurs as predicted, it will have a direct impact on the financial well-being of the global insurance business well into the next century. As a result of the losses paid in the past 5-6 years, many companies became insolvent and did not have the financial reserves to pay claims.

What is the Ability of the Insurance Market to Handle Disasters?

The insurance market is global and a catastrophe in one part of the world impacts insurance markets worldwide. The cumulative world market capacity for insurance to make claim payments in any one year is $160 billion, the size of the insurance industry's financial loss reserves. Imagine if "the big one" hit New York, Los Angeles had a major earthquake, and a tsunami hit Japan all in the same calendar year. The result could be financial devastation to the insurance industry. To put this in perspective, according to Bob Sheets, head of the National Hurricane Center, in meteorologists lingo Hurricane Andrew missed Miami and New Orleans by a "gnat's eyelash," and if it had hit these cities, the insured losses would have been $50-$60 billion. According to insurance industry loss predictions, an 8.0 earthquake in Southern California could cause $60-80 billion in insured damage.

Eugene Lecomte, President of the Insurance Institute for Property Loss Reduction, an organization with 350 member insurance companies, states that two events could conceivably take away $70-$80 billion of the $160 billion in surplus. If that happened, "you'd cripple the industry. It wouldn't be able to take on new risks. It wouldn't have the capacity to underwrite the business of the future. We'd have massive, massive availability problems." (September 28, 1993, *Climate Change & the Insurance Industry: The Next Generation* Conference)

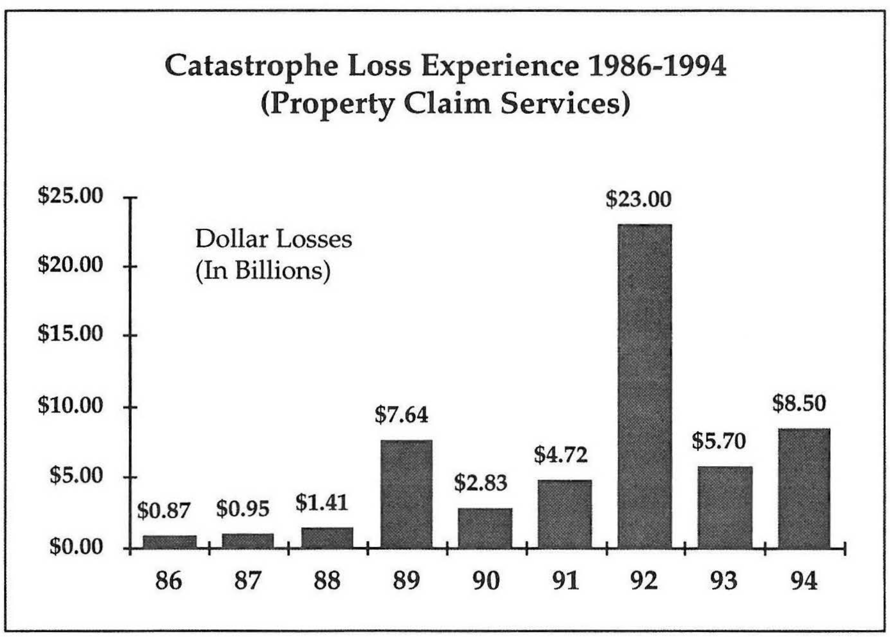


Figure 1. Catastrophe Losses Worldwide

Why is This Important?

The health of the insurance industry is critical to economic development and recovery following a disaster to allow the construction, financing, and sale of new buildings and residences. Following Hurricane Hugo in 1988, insurers paid $5 billion, and subsequently either pulled out of the Caribbean region, or increased rates by six fold, and refused to write new business. New construction came to a halt, lenders requiring insurance protection refused to make loans, and the effects of this one event are still being felt in that region. It is anticipated that it will take Dade County, Florida until the year 2000 to make a full economic recovery from Hurricane Andrew. The impact of this one 3-hour event will be felt for 8 years by insurers, individuals, and businesses.

What is the Insurance Industry to Do to Mitigate Future Catastrophe Losses?

The insurance industry cannot continue on this present course of paying losses and must reevaluate its ways of doing business, assessing and insuring risks, and consider its new options for the future to mitigate disasters.

The present insurance industry risk-assessment modeling methods in determining exposures are inadequate. Exposures were underestimated by a factor of three to four in several disasters by many insurers. The industry needs better information to improve risk assessment methods using a combination of scientific, engineering, and financial analysis techniques. When combined with these three techniques, Earth observation and remote sensing technology can enhance insurers' capability to underwrite property insurance and project future losses.

The insurance industry is doing many things to mitigate exposures, such as encouraging better construction techniques, implementing new technologies and buildings materials, exploring new public/private partnerships as a risk-sharing mechanism, and promoting public education programs on the risks of natural disasters. All of these areas contribute to disaster mitigation, exposure reduction, and potentially fewer insured losses. The industry is now working in all of these areas and has an open ear to new ideas and programs.

The insurance industry has studied the issue of climate change, most recently in a report published by the Chartered Insurance Institute in London, entitled "The Impact of Changing Weather Patterns on Property Insurance." The report recommended that underwriters review their underwriting strategies to make effective use of Geographical Information Systems. It also advised insurance professionals to "individually consider how global warming or changing weather patterns might affect their own job, and become knowledgeable enough to handle these aspects," and stated that investment managers should "modify their investment policy to take account of the potential direct and indirect effects of global warming" and "consider the need for further study groups on climate change to improve knowledge on overseas hazards and to investigate the implications for the life and pensions industries."

NASA can support the insurance industry by better understanding its needs and the potential importance of remote sensing and Earth observation technology to improving disaster management and risk assessment methods.

In order to support the information availability and sharing, ET&T is constructing a Climate Change & Insurance Industry Web Server that identifies articles, reports, and other Internet information resources on global warming, disaster mitigation, risk management, and insurance-related topics. (http://199.222.60.33:1133). The Server should be operational in mid to late October. For further information on this subject, contact Ann Deering, ET&T, 330 E. 38 St., NY, NY 10016 (212) 661-5373/(212) 867-8675 (Fax) or e-mail adeering@pipeline.com. ❑

DISTINGUISHED POSTDOCTORAL FELLOWSHIPS

Program Description

The U.S. Department of Energy (DOE), Office of Health and Environmental Research (OHER), Environmental Sciences Division (ESD), has established the Global Change Distinguished Postdoctoral Fellowships to support research on projects related to the U.S. Global Change Research Program (USGCRP). These fellowships address the nation's global change activities that are carried out by DOE and other federal departments and agencies represented on the Subcommittee on Global Change Research of the Committee on the Environment and Natural Resources. A long-term, multidisciplinary, technological undertaking, the USGCRP encompasses the full range of Earth system changes, including the physical, chemical, biological, geological, economic, and social. Fellowships are tenable at any DOE or other USGCRP-agency laboratory, as well as at any university or private laboratory having a department with annual funding of more than $250,000 from USGCRP agencies. Fellows will conduct research in technical areas related to the strategic priorities of the USGCRP: establishment of a long-term program of observation and data management on a global scale; increasing knowledge of the physical, geological, chemical, biological, economic, and social processes that affect Earth system behavior and impact human health; the development and application of integrated conceptual and predictive Earth system models; and integrated assessments of the state of scientific knowledge and their implications on policy-making decisions. These fellowships will provide DOE and other federal departments and agencies with highly trained and educated individuals for advancing the science of global change.

Sponsor

These fellowships are supported by the U.S. Department of Energy, Office of Health and Environmental Research, and are administered by the Oak Ridge Institute for Science and Education.

Eligibility

Applicants must have received a doctoral degree in an appropriate discipline after March 31, 1992, or must complete all such requirements prior to starting the appointment. The starting date must be between April 1 and September 30, 1995.

A variety of scientific fields is appropriate to these fellowships, but an applicant's background should be related to one or more of the strategic priorities previously listed. Degrees in the life, physical, Earth, environmental, economic, social, and computer sciences, as well as engineering and supporting scientific fields, are appropriate.

The program is open to all qualified U.S. citizens and permanent resident aliens without regard to race, age, gender, religion, color, national origin, mental or physical disability, or status as a disabled veteran or a veteran of the Vietnam era.

Program Provisions

Participants receive an annual stipend of $35,000 the first year and $37,000 the second year. Inbound travel and moving expenses are reimbursed according to the Oak Ridge Institute for Science and Education Travel and Moving Reimbursement Policies. Participants are eligible for limited reimbursements to cover the cost of health insurance. Appointments are for one year, renewable for a second year upon recommendation of the host laboratory, and are subject to the availability of funds.

Application Information

Completed applications and all supporting materials must be received by December 15, 1994. Appointment offers will be made in March 1995.

For more information and application material, contact:

Global Change Distinguished Postdoctoral Fellowships
Science/Engineering Education Division
Oak Ridge Institute for Science and Education
P.O. Box 117
Oak Ridge, Tennessee 37831-0117
(615) 576-9934

EOS IWG Meeting Information and Registration

Please fill out the EOS IWG Registration Form provided below and return to Kelly Whetzel at (301) 220-1701, by fax at (301) 220-1704, or on E-mail at swager@gsfcmail.nasa.gov.

EOS INVESTIGATORS WORKING GROUP (IWG) MEETING
AT MARRIOTT'S HUNT VALLEY INN, HUNT VALLEY, MARYLAND
OCTOBER 19-21, 1994

REGISTRATION FORM

______ Yes, I plan to attend.

______ No, I will not be able to attend. I will be sending a representative. (Please have representative fill out a separate registration form.)

Attendee Name ______________________________

Affiliation ______________________________

Business Address ______________________________

City ______________ State ______________ Zip __________ Country ______________

Telephone ______________ Facsimile ______________

E-mail Address ______________________________

Role in the EOS Project ______________________________

HOTEL INFORMATION

For information purposes only. This does not reserve a hotel room. Attendees should call the hotel directly to make reservations. The Marriott telephone number is (410) 785-7000.

Date and time of Arrival: ______________ Date and time of Departure: ______________

EOS RECEPTION

An EOS Reception will be held on Thursday, October 20, 1994. The cost for the reception will be $30 per person. The reception will include a dinner cruise along the Baltimore Harbor. Meeting attendees need to sign up for this reception in advance to ensure we reserve enough space to accommodate everyone.

______ Yes, I will attend the reception ______ # of Guests

______ No, I will not attend.

From *EOS.News*

PASSIVE MICROWAVE WIND MEASUREMENTS

NASA is supporting the development of low-cost passive microwave technology capable of measuring the sea-surface vector wind field. On April 19, the Physical Oceanography Program sponsored a workshop at JPL entitled *Future Directions of Ocean Wind Remote Sensing using Passive Microwave Radiometers."* The justification and requirements for global wind measurements were discussed by representatives from the Naval Research Laboratory and the Defense Meteorological Satellite Program. Frank Wentz (Remote Sensing Systems) showed SSM/I monthly wind maps, which clearly demonstrated the potential of microwave radiometers to measure wind direction. Simon Yueh (JPL) presented initial results from a 19 GHz polarimetric radiometer (WINDRAD), which was flown on the NASA DC-8 aircraft earlier this year. Preliminary analyses demonstrated a measurable directional-wind signal. The workshop also had presentations by Al Gasiewski (GIT), Calvin Swift (U Mass), and John Bates (NOAA) on other aircraft instruments. Bill Wilson (JPL) presented a concept for a modest space instrument for this wind measurement. General recommendations from the workshop were to (1) conduct an intensive aircraft program to optimize use of the passive radiometric sensors and gather data for a geophysical model, (2) develop a preliminary model relating brightness temperatures to near-surface ocean wind vectors, and (3) develop a design for a spaceborne polarimetric radiometer instrument for global sea-surface wind measurements. The results of the meeting suggest that vector wind data capable of meeting operational as well as global change research requirements could be derived from instruments costing less than $10 M.

Motivated by the recommendations from the workshop and the encouraging initial results from WINDRAD, the instrument was upgraded to include both 19 and 37 GHz frequencies. On July 6 and 8, two flights of the enhanced WINDRAD instrument were conducted over NOAA ocean buoys along the California and Oregon coasts. Wind speeds during the flights ranged between 2 m/s and 10 m/s, allowing instrument verification under a wide range of environmental conditions. Preliminary analysis shows that under the strongest wind conditions, upwind, downwind, and cross-wind directions produced brightness temperature differences of up to 5 K. This is ample signal for detecting wind direction at the higher wind speeds. More-careful analysis of the complete data set is underway to determine the limits of this technology.

Many of these initial results were presented at the IGARSS meeting at JPL on August 12, Copies of the workshop report can be obtained from: Michael Van Woert, Manager, Physical Oceanography Program, NASA HQ, Code YSC, Washington, DC 20546. Phone: (202) 488-5150.

SEAWIFS UPDATE

The launch of SeaStar/SeaWiFS has been postponed by Orbital Sciences Corp. (OSC) from September 30, 1994, to no earlier than March 29, 1995. SeaStar development and integration has been delayed by a decision last year to redesign the flight computer. OSC initially planned to use the same computer for SeaStar as for a sister spacecraft, APEX, but found that it did not have sufficient throughput to process SeaWiFS imaging data. A successful end-to-end data flow test between the engineering model SeaWiFS and the spacecraft avionics has been completed. OSC is conducting a Failure Mode Effects Analysis to assess the effectiveness of the SeaStar radiation hardening system. The APEX spacecraft, carrying the same radiation protection design and many subsystems and components common to SeaStar, was launched on August 3.

On June 27, 1994 the launch vehicle for SeaStar, the Pegasus XL, failed in its first launch attempt and was terminated by range safety with the loss of the Air Force STEP-1 spacecraft. The failure is still under investigation. Based on wind tunnel tests performed at NASA/LaRC, OSC has attributed the Pegasus-XL launch failure to incorrect aerodynamic coefficients in the autopilot model. A test Pegasus-XL launch will not be necessary provided that further wind tunnel testing and aerodynamic analysis confirm the LaRC results. EP-TOMS will most likely be the next Pegasus-XL launch.

On the positive side, the Marine Optical Buoy off Lanai, Hawaii was successfully recovered after more than four months at sea (a month longer than planned). The buoy hardware and software are robust: the system survived hurricane-force winds and correctly responded to a dwindling battery capacity due to damaged solar panels. The buoy is undergoing calibration and refurbishment and the mooring will be replaced in September.

A calibration/validation review at GSFC went very well. The first versions of the Level 2 and Level 3 programs were delivered by Miami, and the I/O programs for the Hierarchical Data Format (HDF) are nearly complete, with all known HDF bugs exterminated. Finally, three training classes for the SeaWiFS Data Analysis System (SeaDAS) software, with a combined enrollment of over 90, were conducted between July 28, and August 5.

EOS Science Calendar

October 12-14	MODIS Science Team Meeting, College Park, MD. Contact Patti Green (swager@gsfcmail.gsfc.nasa.gov), tel. (301) 220-1701.
October 13-14	GLAS Team Meeting, NASA/Goddard Space Flight Center, Greenbelt, MD. Contact Bob Schutz (schutz@utcsr.ae.utexas.edu), tel. (512) 471-4267.
October 19-21	Investigators Working Group Meeting, Baltimore, MD. Contact Michael King (king@climate.gsfc.nasa.gov), tel. (301) 286-8228 or Ghassem Asrar (gasrar@mtpe.hq.nasa.gov), tel. (202) 358-2559.
November 2-4	AIRS Team Meeting, LORAL/LIRIS, Lexington, MA. Contact George Aumann (hha@airs1.jpl.nasa.gov), tel. (818) 354-6865.
November 11-12	ASTER/Calibration Peer Review, TBD (Tokyo or Tsukba), Japan. Contact Skip Reber (reber@cdhf2.gsfc.nasa.gov), tel. (301) 286-6534.
November 14-18	8th Joint ASTER Science Team Meeting, Japan. Contact Hiroji Tsu, tel. +81-3-3533-9380; FAX: +81-3-3533-9383, or Anne Kahle (anne@lithos.jpl.nasa.gov), tel. (818) 354-7265.
Nov. 30-Dec. 2	CERES Science Team Meeting, Hampton, VA. Contact Bruce Wielicki (b.a.wielicki@larc.nasa.gov), tel. (804) 864-5683.
December 16	TES Team Meeting, NASA/Goddard Space Flight Center, Bldg. 21, Greenbelt, MD. Contact Reinhard Beer (beer@atmosmips.jpl.nasa.gov), tel. (818) 354-4748.

Global Change Calendar

• 1994 •

November 8-10	Technology 2004 Conference & Laser Tech '94, Washington D.C. Convention Center. Call Leonard Ault, tel. (202) 358-0721 or Michael Hackett, tel. (202) 728-2080.
November 13-16	First IEEE International Conference on Image Processing, Austin Convention Center, Austin, TX. Contact icip@pine.ece.utexas.edu.
December 5-9	American Geophysical Union Fall Meeting, San Francisco, CA. Contact Karol Snyder, tel. 1-(800) 966-2481, FAX (202) 328-0566.

• 1995 •

January 15-20	75th AMS Annual Meeting, Diamond Anniversary, Dallas, TX. Contact Monica Walters, tel. (202) 466-6070, FAX (202) 466-6073.
February 6-10	Optical Remote Sensing of the Atmosphere, Salt Lake City, Utah. Contact Optical Society of America, 2010 Massachusetts Avenue, N.W., Washington, D.C. 20036-1023. Tel. (202) 223-0920; FAX: (202) 416-6100.
February 16-21	AAAS Annual Meeting and Science Innovation Exposition, Atlanta, GA. Call (202) 326-6450.
Feb. 28-Mar. 2	ACSM/ASPRS '95 Annual Convention, Charlotte, NC. Contact Ann Ryan Tel. (301) 493-0290; FAX (301) 493-0208.
March 6-8	International Symposium on the Expansion of the Remote Sensing Market, Paris, France. Contact Dr. Paul Kamoun, Organizing Committee Chairman, AAAF/EARSC Symposium, 100, Boulevard du Midi, 06322 Cannes-La-Bocca Cedex, France. Telefax: (33) 92.92.30.10 or Claude Frédéric, Symposium Coordinator, AAAF/EARSC Symposium, 6, Rue Galilée, 75782 Paris Cedex 16, France. Telefax: (33) 1.47.23.89.11.
July 10-14	International Geoscience and Remote Sensing Symposium, Congress Center, Firenze, Italy. Contact IEEE Geoscience and Remote Sensing Society, 2610 Lakeway Drive, Seabrook, TX 77586-1587. Tel. (713) 291-9222; FAX: (713) 291-9224; e-mail: stein@harc.edu.
September 18-20	Third Thematic Conference on Remote Sensing for Marine and Coastal Environments: Needs, Solutions, and Applications, Westin Hotel, Seattle, Washington. Sponsors: ERIM, MSRC, EPA. Contact Robert Rogers, tel. (313) 994-1200, ext. 3453; FAX: (313) 994-5123.

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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) 286-1738, and is available on World Wide Web via Mosaic at Universal Resource Locator (URL) http://spso.gsfc.nasa.gov/spso_homepage.html. Correspondence may be directed to Charlotte Griner (cgriner@ltpsun.gsfc.nasa.gov) or mailed to the above address. Articles (**limited to three pages**), contributions to the meeting calendar, and suggestions are welcomed. Contributions to the Global Change meeting calendar should contain location, person to contact, telephone number and e-mail address. To subscribe to *The Earth Observer*, or to change your mailing address, please call Hannelore Parrish at (301) 441-4032; send message to hparrish@ltpsun.gsfc.nasa.gov; or write to the address above.

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