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INSIDE THIS ISSUE

Editor's Corner

I recently received the report of the visiting committee that examined 13 algorithm theoretical basis documents (ATBDs) prepared by the ASTER, LIS, MOPITT, and SeaWinds Science Teams. The oral portion of this review followed a written review consisting of approximately 5 written reviews of each document. The Project Science Office has synthesized the inputs from both the written and oral reviews, visiting committee summaries, and discussion with some algorithm developers, team leaders, and the AM Project Scientist (Piers Sellers). As a consequence of this analysis, the at-launch/post-launch specifications for each product have been revised and clarified in greater detail. An overall indication of both the importance of the product(s) and the maturity of the algorithm(s) to date has been determined, with particular attention paid to the following categories addressed by the external reviewers: (i) degree to which product meets Mission to Planet Earth (MTPE) priorities, (ii) soundness (feasibility/practicality) of the algorithm's approach, and (iii) the planned schedule for generating useful at-launch products.

As done previously with the ATBD report and analysis for the MODIS, CERES and MISR Science Teams, each ATBD was placed into one of four categories. Revised algorithms for all category A and B ATBDs (those with a particularly sound basis, extreme relevance to global change research, and either minor or major modifi-

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cations required) are to be delivered electronically to the Project Science Office by February 1 for subsequent posting on World Wide Web. Category C ATBDs, due March 1, entail algorithms that are inappropriate as DAAC standard products at the present time, and fit one or more of the following subcategories: (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 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 deemed unlikely to produce an operational product in the foreseeable future and, therefore, are candidates for deselection.

Many ATBDs are now available for anonymous file transfer protocol (FTP) from the World Wide Web site that the Project Science Office has established (URL http://spso.gsfc.nasa.gov/spso_homepage.html). Most of the ATBDs can be downloaded as a single postscript file, with embedded equations and graphics, while others are available in separate postscript files for text and graphics. The table of contents for each ATBD, together with a Readme file, are also available for easy browsing on the Web, prior to downloading the full file(s). This Readme file gives appropriate instructions for an individual ATBD, and may also give the location of the original document as well (Microsoft Word, Framemaker, WordPerfect, etc.).

On November 29, Dr. Charles Kennel, Associate Administrator of the Office of Mission to Planet Earth, confirmed the Stratospheric Aerosol and Gas Experiment (SAGE) III investigation for flight on the Russian Space Agency's METEOR 3M-1 spacecraft in August 1998. In addition, the flight of SAGE III on the International Space Station Alpha (currently planned for 2001) was confirmed, as well as the completion of a third instrument for a flight of opportunity. These modifications to the EOS Mission Profile have already been made in the World Wide Web site maintained by the Project Science Office. Congratulations to the SAGE III Science Team on being confirmed for execution phase development of the SAGE III instruments as well as Science Team algorithm development.

Finally, I would like to take this opportunity to thank Bruce Guenther, who has served for the past two years as EOS Calibration Scientist (and previously as AM Project Scientist), for his efforts in promoting calibration issues across EOS instruments and platforms. He is stepping down as Calibration Scientist to focus more on his responsibilities for MODIS calibration and to devote more time to running the Sensor Development and Characterization Branch at Goddard.

Guenther will be succeeded by Jim Butler, who is a laboratory calibration expert with a Ph.D. in physical chemistry from the University of North Carolina. Over ten years ago he spent two years as a post-doc at the National Institute of Standards and Technology (NIST), with which he still maintains a close working relationship. The duties and responsibilities of the EOS Calibration Scientist will include working closely with NIST to formulate a clear plan for developing transfer radiometers and conducting round-robin calibrations of EOS sensors. This position will also entail interaction with a lunar calibration and characterization investigation being conducted by Hugh Kieffer (U.S. Geological Survey) and Bob Wildey (Northern Arizona University). This long-term ground-based observation program will enable EOS instrument teams to take greater advantage of periodic observations of the moon when the EOS spacecraft is commanded to view the moon. This will help ensure that a long-term, well-characterized and calibrated set of EOS observations is obtained to ensure maximum accuracy from space-based observations. Jim Butler will also coordinate his activities with the EOS community through his participation in the recently formed Data Quality Panel, chaired by Michael Freilich.

—Michael King
EOS Senior Project Scientist

—Letter to the Editor

The article by Rood *et al.* (1994) in the July/August issue of *The Earth Observer* entitled "Data Assimilation for EOS: The Value of Assimilated Data, Part 1" prompted me to write this letter. The authors make a compelling case for the importance of data assimilation for the success of the EOS mission. No other tool is available to the Earth science community that is as effective in combining the advances that have been made in modeling the Earth system with the environmental observations that will be collected.

However, while no one questions the advances afforded by data assimilation in producing a proxy wind field from temperature observations compared to simply estimating them from, say, balance conditions (see Fig. 1 in Rood *et al.*), I believe Rood *et al.* have overstated the case for the data assimilation in suggesting that "modern assimilation techniques are powerful enough that assimilation can mitigate the loss of information inflicted by scaling back instruments." (Note: "Scaling back" was taken to mean de-selection not just de-scoping.) Probably one or more examples can be cited to support this statement, but left unchallenged, I believe it sends the wrong message to the non-specialists who are constantly looking for soft spots in the Earth science budget. As a case in point, Rood *et al.* cited the Laser Atmospheric Wind Sounder (LAWS) as an example of an instrument whose tropospheric wind measurements could be adequately proxied by data assimilation. Evidence supports the contrary. For example, Table 1, reproduced from Wang *et al.* (1992), illustrates the uncertainty in estimating the moisture flux divergence, an important quantity in advancing our understanding of the hydrologic cycle and an important EOS objective. In the Wang *et al.* study, the wind and moisture fields from two modern data assimilation systems were utilized — the European Centre for Medium-Range Weather Forecasts (ECMWF) and the National Meteorological Center (NMC). As may be seen in Table 1, the differences between the ECMWF and NMC analyses in the wind field *alone* (3.0 m/sec) result in an uncertainty in the moisture flux divergence calculation (4.9 cm/mon) for a region over South America. This exceeds the signal in the rainfall (4.0 cm/mon) obtained from general circulation model experiments conducted to simulate the impact on rainfall of Amazonian deforestation. Note that the moisture flux divergence uncertainty is much less for a similar region over North America (2.1 cm/mon), where accurate wind data are plentiful. Furthermore, realistic observing system simulation experiments have demonstrated a very significant potential for space-based wind lidar data to improve global analyses, even with the assimilation of very accurate satellite temperature soundings (see Atlas, R. and G. D. Emmitt, Preprints: "Second Symposium on Global Change Studies," New Orleans, Amer. Meteor. Soc., 28-32, 1991).

Another unsubstantiated point made by Rood *et al.* is contained in the statement "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." Preliminary results from a cost-benefit analysis for an operational wind lidar being conducted by

Table 1. Sensitivity of the moisture flux divergence to uncertainties in tropospheric wind analyses, contrasted with the effect of Amazonian deforestation (rain forest replaced with grassland)* on rainfall (based on findings of Wang *et al.* 1992**).

Region	Current Wind Analysis Uncertainties	Resulting Uncertainties in Moisture Flux Divergence (For Precipitable Water)
North America	2.3 m/sec	2.1 cm/mon
South America	3.0 m/sec	4.9 cm/mon
Effect on Amazonian Rainfall		≈4.0 cm/mon (~20% - 25% Reduction)

* Lean, J. and D. A. Warrilow, *Nature*, **342**, 411-413, 1989.

* Shukla, J., C. Nobre and P. J. Sellers, *Science*, **247**, 1322-1325, 1990.

** Wang, M., J. Paegle and J. N. Paegle, "Proceedings of the Sixth Conference on Mountain Meteorology." *Amer. Meteor. Soc.*, 1-5, 1992.

the Department of Economics at George Washington University refute this statement.

In conclusion, I agree with Rood *et al.* that data assimilation is an important tool for Earth science researchers, but the extent to which it might offset the loss of various instruments needs to be carefully examined. Furthermore, in an era of ever-increasing budget pressure, the economics of new sensors is an increasingly important consideration. Cost-benefit analyses can help quantify what is to be gained economically just as observing system simulation experiments have done from a scientific perspective.

—**Wayman Baker**
Chairperson, NOAA Working Group on Space-Based Lidar Winds

USRA/GSFC GRADUATE STUDENT SUMMER PROGRAM IN THE EARTH SYSTEM SCIENCES — SUMMER 1995

—**Paula L. Webber**, Student Programs Coordinator (paula@gvsp.usra.edu)

The Universities Space Research Association (USRA), in collaboration with the Goddard Space Flight Center's (GSFC) Earth Sciences Directorate, is offering a limited number of graduate student research opportunities for the summer of 1995. The Program is scheduled for June 12 to August 18, 1995. Now in its fifth year, the Program is designed to spur interest in interdisciplinary studies within the Earth system sciences and will enable selected students to pursue specially-tailored research projects in conjunction with Goddard scientific mentors. In addition, during the first week, all students and the general public will be invited to attend a concentrated 5-day public lecture series entitled "Understanding the Earth as a Coupled System: The ENSO Experience."

Students will work at GSFC conducting an intensive research project for the majority of the Program period. Each student will be given significant latitude to choose from a pool of research projects and mentors. Project topics will be developed and implemented in conjunction with scientists within the three Earth Science laboratories at Goddard: The Laboratory for Atmospheres, The Laboratory for Terrestrial Physics, and the Laboratory for Hydrospheric Processes.

The initial public lecture series is designed to provide a comprehensive introduction to the science and techniques of remote sensing and satellite observations. Well-known experts from Goddard and the scientific community will present lectures on remote sensing and atmospheric, oceanographic, biological, and societal impact aspects of the El Niño Southern Oscillation phenomenon (ENSO).

The lecture series is an annual event sponsored by USRA and NASA/GSFC and is open to the general public. However, off-site attendees must register prior to June 3 in order to guarantee admittance to the Goddard Space Flight Center. There is no registration fee.

The Program is open to students enrolled in or accepted by an accredited graduate program in the physical or biological sciences, mathematics, computer science, or engineering. Students will be selected on the basis of academic record, demonstrated motivation and qualification to pursue interdisciplinary or multidisciplinary research related to Earth sciences, clarity and relevance of research interests to the NASA programs, and letters of recommendation. Minorities and women are encouraged to apply. Students must commit for the full ten-week period (June 12 - August 18, 1995). Application information must be received by February 13, 1995. Selection announcements are planned by March 27, 1995.

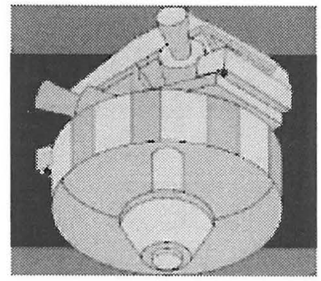
Students selected for the Program will receive a stipend of $8.50 per hour for the 10-week period. In addition, USRA will reimburse reasonable domestic travel expenses for participants needing to relocate to the Greenbelt, MD area. Students requiring accommodations will be housed at The University of Maryland at USRA's expense. Accommodations outside the university will not be provided.

To receive an application for the Graduate Student Summer Program or information on the lecture series contact: Paula L. Webber, Program Coordinator, USRA/GSSP, 7501 Forbes Boulevard, Suite 206, Seabrook, MD 20706, telephone (301) 805-8396, FAX (301) 805-8466, E-Mail: paula@gvsp.usra.edu.

Atmospheres Panel Report

The Scientific Importance of GLAS (Geoscience Laser Altimeter System) Atmospheric Measurements

—**Dennis Hartmann**, Chair, Atmospheres Panel, (dennis@atmos.washington.edu)



Introduction and Recommendation

The Atmospheres Panel considered the potential scientific utility of the atmospheric measurements proposed as part of the Geoscience Laser Altimeter System (GLAS) at its October 21, 1994 meeting in Hunt Valley, Maryland. At that meeting the panel heard from Dr. James Spinhirne about the potential capabilities of the atmospheric portion of the experiment. The Panel requested that the GLAS team provide a written description of its proposed atmospheric capabilities, including descriptions of the physical variables to be determined and their accuracies. This description is included below, following this introduction section and our recommendation.

GLAS is a nadir-pointed active laser altimeter. A 1.064 μm pulse is used for surface height measurements, and a 0.532 μm pulse can be used for cloud and aerosol measurements. Although sampling is limited to the nadir trace of the orbit, the active laser sounding technique provides unique measurements that are important and complementary to those derived from passive techniques. We understand that the atmospheric measurement capability can be included for a modest fraction of the total GLAS cost. We, therefore, recommend that the GLAS capabilities for measuring cloud and aerosols in the atmosphere be implemented.

The proposed atmospheric capabilities of the GLAS instrument are outlined in more detail below, but several key measurement capabilities can be listed to illustrate its potential importance for global change research. First of all, it is capable of providing accurate measurements of the altitude and thickness of thin clouds with optical depths less than 2 or 3, such as thin tropical cirrus clouds, which are known to be climatically important, but which are very difficult to measure accurately with passive techniques. These thin clouds have a direct effect on the outgoing

Spatial Resolution	Threshold Optical Depth for Detection	Cloud Height Accuracy	Optical Depth Accuracy	Vertical Profile of Cross-Section Accuracy
175 m	0.05	150-300 m	—	—
2 km	0.01	150-300 m	30%	—
20 km	0.005	150-300 m	20%	30%

Table 1: GLAS Measurement Capabilities for Optically Thin Clouds (τ <2-3)

longwave radiation, and are also probably very important in determining the relative humidity of the upper troposphere in the tropics.

For optically thick clouds with cloud top scattering cross sections greater than 10^{-3} m^{-1}, the cloud top height can be measured to an accuracy of 75 meters and a horizontal resolution of 175 meters along the orbit track. These data will be of direct scientific utility and will also serve as important validation data for estimates of cloud height based on passive techniques. The detection and characterization of clouds described above will also be possible for low clouds in polar darkness and above snow cover, where passive techniques become inaccurate or fail completely. These low clouds are important for the heat budget of the polar regions.

Detection and vertical profiling of aerosols in the lower troposphere with GLAS may also be very important. The 150 meter vertical accuracy for 10 km horizontal resolution will be useful for characterizing boundary layer depth, which is, among other things, very important for understanding the maintenance of boundary layer clouds over the oceans.

A more complete description of GLAS capabilities, prepared by the GLAS team, is given below.

GLAS ATMOSPHERIC MEASUREMENTS

Acquisition of the atmospheric signal from the Geoscience Laser Altimeter System (GLAS) will have important applications for cloud, aerosols, and planetary boundary layer investigations. The GLAS atmospheric measurements have a unique capability for direct and unambiguous profiling of the cloud and aerosol vertical structure of the atmosphere. The specific atmospheric parameters to be measured by GLAS and their importance are given below.

1. Optically Thin Clouds

The laser measurement will provide very sensitive detection of thin scattering layers such as sub-visible cirrus. In addition, clouds will be profiled and the cloud base determined up to an optical thickness limit of approximately 3.

Direct measurements:

a. Detection and coverage.
The measurement sensitivity is a function of horizontal resolution. For a 2 km horizontal resolution, cloud layers will be detected to a 0.01 minimum optical thickness for thin cirrus of typical vertical thickness. At 20 km resolution, an estimated 0.005 optically thick layer will be detected and layers of 0.05 thickness would be resolved in most cases at the full 175 m resolution.

b. Height and vertical thickness
The basic accuracy of height measurements is 75 m. The practical accuracy will be 150 to 300 m due to signal effects. The cloud vertical thickness and cloud base height will be determined with similar accuracy up to an optical thickness of approximately 2 for a 2 km horizontal resolution and up to 3 for a 20 km resolution.

Derived measurements:

Cloud visible and infrared radiation parameters may be derived from laser profiles when combined with thermal radiance measurements.

c. Optical thickness
The optical thickness of cirrus and other thin clouds will be derived with a 30% relative accuracy for a 2 km horizontal resolution and an optical thickness of up to 2 and 20% relative accuracy for a 20 km horizontal resolution and cloud optical thickness up to 3.

d. Vertical profile of cross sections
An infrared absorption cross section and the visible backscatter cross section are derived in the standard analysis. The profile of the cross section will be obtained with a 30% or better relative accuracy to an optical thickness of 3 for 20 km horizontal resolution.

2. Dense Clouds

a. Cloud height
For clouds with a cloud top total scattering cross section of greater than approximately 10^{-3} m^{-1} the

cloud top height may be determined with 75 meter vertical resolution at 175 m horizontal resolution.

b. Cloud base and LCL height
For broken, optically thick clouds, cloud base height will be derived from the distribution of cloud height. For convective boundary layer clouds, the lifting condensation level (LCL) is indicated by the cloud base height. For typical conditions, convective cloud base height observations at 60 km horizontal resolution is possible.

3. Multiple Cloud Layers and Cloud Structure

The laser measurements will define multiple cloud layers and image cloud structure. Multiple optically thin cloud layers and dense clouds under thin clouds will be detected up to an overlying optical thickness of 3 at a 2 km horizontal resolution. The relative profile of the observed scattering will be obtained up to the optical thickness limit with better than 30% accuracy.

4. Aerosol Scattering

The laser measurements will define the vertical profile of aerosol loading.

Direct Measurements:

a. PBL aerosol profile
The relative profile for aerosol scattering in the planetary boundary layer (PBL) will be acquired at 20 km or better horizontal resolution with 20% accuracy for typical conditions.

b. Elevated haze layers
The laser measurements will detect and profile elevated haze layers such as volcanic haze layers in the stratosphere and upper troposphere. Layers of optical thickness greater than 0.002 will be detected for a 200 km horizontal resolution and aerosol scattering down to a level of 10^{-6} m^{-1} observed with 20% signal accuracy. The vertical accuracy would be 150 m or better.

Derived Measurements:

c. The aerosol optical thickness may be obtained from the lidar measurements with a procedure that employs the coincident surface signal and background radiance. The expected accuracies of the optical thickness measurement will be approximately 20-30% of the value.

d. The vertical resolved aerosol total scattering cross section will be obtained with expected accuracies on the order of 20-30% for cross sections greater than 10^{-5} m^{-1}

5. PBL Height

In many cases, especially for marine atmospheres, the PBL height may be derived from the structure of the aerosol scattering profile. Analysis and field studies indicate that over large fractions of the ocean and many land areas the GLAS measurements would define the PBL height with 150 m vertical accuracy and a horizontal resolution of 10 km or better.

IMPORTANCE OF GLAS ATMOSPHERIC MEASUREMENTS

The GLAS atmospheric measurements will both provide important global observations that are fundamentally unique to active sounding and observations that are an important adjunct and validation to EOS passive sensors.

1. Cloud Vertical Profiling

Active cloud profiling is needed to validate and to supplement the limitations of passive cloud retrievals. A main deficiency for parameterization of clouds is our lack of knowledge of the vertical distribution of clouds. Existing and planned passive measurements, while providing top-of-the-atmosphere radiation information, do not adequately provide the essential vertical profiles of clouds and the resultant heating. The prospect of adding active measurements will significantly add to progress on determining the 4-D distribution of cloud optical properties and the relationships between these properties and cloud liquid water, ice mass, and water vapor. The progress will come through validation studies of the infrared and microwave techniques which are designed to determine cloud vertical profiles and also through the establishment of an independent data set of direct profile measurements. For the validation of EOS cloud retrievals, the science return of the GLAS cloud lidar channel would be very cost effective. The projected cost of the GLAS cloud lidar channel is on the order of a single aircraft field program to validate cloud algorithms and other EOS objectives.

2. Detection of Optically Thin Cirrus

Optically thin, or sub-visible, cirrus is potentially a significant greenhouse component of the atmosphere. In particular, aircraft and solar occultation measurements indicate that typically over half of the west Pacific warm pool region is covered by a sub-visible layer of cirrus at the tropopause. The optical thickness of this persistent layer is small. However, the net radiative impact over the entire region is estimated to be potentially significant. Such optically thin cirrus is not reliably detected by passive sensing other than limited sampling by solar and lunar occultation observations. Laser measurements will provide a very sensitive measure of the presence, height, and thickness of tenuous cirrus layers. The science enabled by observations from space is process studies on the formation and influence of thin cirrus.

3. Polar Clouds

GLAS cloud observations will have significant value for polar cloud studies. The interpretation of satellite-based cloud imaging and retrievals in polar regions has major problems due to factors such as darkness and extreme low temperatures. Satellite radiometers operate at or beyond the limit of their response. Current polar cloud retrievals are considered in large part unreliable. GLAS would obtain a very good coverage at the poles and would unambiguously define cloud type and fraction. Clouds and haze are important for the processes of Arctic atmospheres. Cloud cover defines the net radiation balance of the Arctic regions and strongly affects dynamics. In the cold half of the year in Arctic regions, hazes of small ice crystals occur in the lower troposphere giving rise to large reductions in visibility. The crystals are thought to be an important factor in the radiation transfer which determines the vertical temperature and humidity structure of the winter Arctic atmosphere. Cloudless ice-crystal precipitation is believed to be the dominant source of precipitation in large areas of Antarctica. Only active laser sensing has the potential to reliably detect ice-crystal precipitation.

4. Multi-layer Clouds

Typical cloud structure is multiple layered and broken. Observations of the structure of multiple layered clouds is problematic for passive remote sensing techniques. The data set of laser measurements of cloud multiple layering would be unique and important for understanding the interpretation of passive cloud observations and would directly relate to all applications for cloud vertical profiling.

5. Cloud Base Height and LCL

For a significant fraction of cloud cover, laser measurements will determine cloud base height. The measurements are direct and unambiguous. Surface radiation budget is a critical factor for climate. Cloud effects on surface warming are related to the cloud component of the downward atmospheric flux. The determining factor of the cloud flux component is largely the distribution of cloud base height. Cloud base height measurements are generally not possible from passive satellite measurements. For clouds forming in the PBL, the cloud base indicates the LCL. The LCL is a significant variable for boundary layer dynamics. Over the tropical and subtropical oceans, the LCL together with remotely-sensed SST can provide a measure of average water vapor content within the PBL.

6. Cloud Morphology

The laser measurements image the vertical structure, or morphology, of cloud systems. The morphology information has applications for process studies of cloud and storm formation. As an example, recent studies indicate that many thick cirrus clouds form primarily from precipitation from very thin generating layers. Such layers may be clearly identified from the structure revealed by the laser imaging, and the height is precisely determined. The correlation of generating layer with temperature and humidity fields would aid the parameterization of cirrus formation. Other examples may be given.

7. Elevated Aerosol Layers and Long Range Transport

Aerosol profiles provided by the GLAS instrument will provide information on episodic aerosol events such as volcanic emissions, ablated desert soils, continental particulates, and Arctic haze. Vertically elevated layers of particulates are transported over long ranges and have been linked to air quality degradation and ocean nutrients. The laser measurements uniquely define the vertical aerosol structure throughout the troposphere. The active laser sounding is highly synergistic with, and will support the interpretation of, passive radiometric measurements and images when aerosol optical thickness becomes appreciable. Current satellite aerosol loading retrievals are based on reflected radiation and are daytime only. The laser measurements will give full diurnal coverage. Ground-based laser radar measurements have long been a standard for monitoring volcanic aerosol layers in the stratosphere. The GLAS measurements would give global coverage for such events. Dense volcanic plumes have been known to be a hazard for aircraft transport. The laser observations would aid in the early detection and altitude definition of such layers, especially in conditions of darkness, and thus serve in a hazard avoidance function.

When coupled with wind direction and speed information, the vertical distribution of aerosol trace materials also provides information on aerosol mass transport. Long-range transport of trace gases and aerosols is a dominating factor in the global chemical balance. Accurate aerosol vertical profile information is necessary.

8. PBL Height

In many cases the GLAS observations will determine the height of the mixed layer from the aerosol scattering structure and in all cases, at high accuracy, the height for a cloud-capped boundary layer. The planetary boundary layer height is a basic parameter linking the surface to atmosphere dynamics, especially over oceans. Measurement of the PBL height is unique to the active laser measurements.

9. Cloud Filtering for GLAS Surface Altimetry

The stated principal goal for the GLAS instrument is precise surface altimetry for polar ice sheets. Clouds and haze will obscure the surface for many laser returns. For conditions of partial transmission through clouds, multiple scattering will affect transmitted pulse shape and thus possibly range accuracy. Scattering for cirrus clouds in particular is highly forward peaked, and the effective transmission may involve a large fraction of scattered photons. Pulse spreading to a degree larger than the desired surface altimetry accuracy is possible. The identification of cloud influenced surface returns will be greatly aided by measurement of the GLAS atmospheric return. A GLAS atmospheric channel is highly recommended for this function.

Pathfinder Program WWW Site Now Available

Information about the NASA Pathfinder Program and the various Pathfinder projects is now available via WWW from the Pathfinder Program home page (http://xtreme.gsfc.nasa.gov/pathfinder/). This page provides access to:

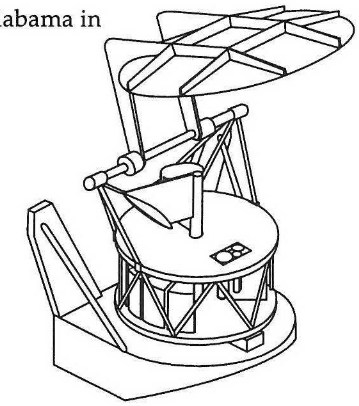
- various Pathfinder data sets;
- meeting minutes and notes;
- Pathfinder reports and articles;
- Pathfinder team listings.

Among the reports available is the recently released Pathfinder Lessons Learned Report. This report is a compilation of the reports from subgroups that met at the Inter-Pathfinder Conference in March and April 1994. This report covers several topics including Science Software Implementation, Operational Processing, HDF Use, Product Validation, Archive and Distribution, and Data Interuse.

For additional information or assistance, contact the Pathfinder Home Page curator, Dave Wolf at dw137@umail.umd.edu, or the Pathfinder Program Manager, Martha Maiden at mmaiden@mtpe.hq.nasa.gov.

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

—**Elena Lobl** (elena.lobl@msfc.nasa.gov), Earth System Science Laboratory, University of Alabama in Huntsville



The third 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, November 15-17, 1994.

Chris Readings (MIMR SAG Coordinator, and Head of the Earth Science Division, ESA) opened the meeting by going over the minutes of the last meeting. He then announced the possibility that ESA might not provide a MIMR instrument to NASA to fly on the PM platform; the final decision will hopefully be made in the European ministerial meeting March 27-29, 1995.

The agenda for the SAG meeting listed several presentations to be made to the entire audience before the subgroups would start work on refining Draft 0 of the MIMR Interim Report. On the last day all subgroups came together to discuss their recommendations and to present the reasons that a MIMR is necessary on the PM platform.

Yvon Menard (ESA, MIMR Program Manager) presented an update of the hardware status. Development of the MIMR demonstrator began in June 94, and a PDR will take place in January 95. The Demonstrator Radiometric Test (only 3 out of the 6 frequencies) is scheduled for early 96 with the final review in May 96. The present schedule shows the METOP (Meteorological Operational Program) Phase C/D kick-off in the first quarter of 96 with an instrument delivery to the spacecraft in mid-1999. (METOP launch is scheduled for December 2000). Menard showed a tentative schedule for the MIMR delivery to the PM platform at the end of 1998. The final discussion was on polarimetry: Should it be implemented on MIMR? A series of open items, such as the relative priorities of polarimetry and high spatial resolution, the degree of interest in polarimetry by all specialties (both for research and operational applications), and the maturity of the polarimetry concept for PMRs (Passive Microwave Radiometers), were presented for the subgroup discussion.

The presentations continued with Paul Hwang (EOS PM Project Office) and Eva Oriol-Pibernat (METOP Mission Manager) showing the data products being generated and archived for the two respective missions. There were many commonalities between the two systems. Hwang also presented the Ground system planned for EOS. Oriol-Pibernat asked the subgroups to complete a table with each specialty's requirements for data products. The table will become part of the MIMR Report.

The last five presentations were on the research being conducted by some of the MIMR SAG members. John Foote (UK Met Office) showed the difference between their forecast model when both wind speed and direction are included versus when only wind speed is used. The difference was significant mostly in the southern hemisphere predictions, the wind direction reducing the prediction errors for long-term forecasts.

Joey Comiso (Goddard Space Flight Center, Laboratory for Hydrospheric Processes) discussed his research in producing the most-accurate ice concentration algorithm, and showed good agreement between his algorithm results and 'ground truth' data. Rene Ramseier (Microwave Group-Ottawa River, Canada) showed ice operations needs and described the 'egg' code used in ship navigation. Peter Schluessel (University of Hamburg-Meteorological Institute, Germany) presented some of his research results on the retrieval of the longwave radiative net flux at the sea surface obtained from SSM/I and AVHRR measurements. The satellite-derived net fluxes were successfully tested against *in situ* measurements taken during the TOGA/COARE and CEPEX (Central Equatorial Pacific Experiment) field campaigns. Paolo Pampaloni (Consiglio Nazionale delle Ricerche, Italy) showed his results in using microwave radiometry for recognizing the different signatures from various types of vegetation.

The main topics discussed by the subgroups were: the addition of polarimetric capability, the Level 2b products (complete a products table that Oriol-Pibernat generated) and the workplan for the generation and validation of algorithms. For details on each subgroup work, interested persons can contact the subgroup's leaders: Precipitation - Tom Wilheit (Texas A&M, Department of Meteorology, College Station, Texas, USA, wilheit@ariel.tamu.edu); Oceans and Marine Atmosphere - Peter Schluessel (University of Hamburg, Meteorological Institute, Hamburg, Germany, schluessel@dkrz.d400.de); Cryosphere - Joey Comiso (NASA-GSFC, Laboratory for Hydrospheric Processes, Greenbelt, Maryland, USA, comiso@joey.gsfc.nasa.gov); Land - C. Matzler (University of Bern, Institute of Applied Physics, Bern, Switzerland, FAX 41-31-631-3765).

On the topic of polarimetric capability there were differing opinions: the Oceans and Maritime Atmosphere subgroup (renamed from Oceans/Atmosphere subgroup) was a big proponent of the addition and its products; the other subgroups needed more information to understand the trade (between oversampling of H and V and getting the H, V, H+V and H-V). Frank Wentz (Remote Sensing Systems, Santa Rosa, Ca.) showed an easy implementation and explanation of the products. The action items generated were to have F. Wentz and J. Noll (ESTEC) collaborate in providing the theoretical understanding of the problem; and to have E. Attema (ESTEC) provide the understanding of the aliasing that would exist with no oversampling.

The last topic discussed by the SAG was the justification for the need of a MIMR on an afternoon satellite (assuming there is one on a morning satellite). Roy Spencer (MIMR SAG U.S. Team Leader, MSFC) summarized the discussions: 1) need to understand the diurnal variability of the atmosphere, specifically, heating of the clouds, absorption; 2) sampling of rapidly changing parameters, such as precipitation; and 3) instrument synergy for process studies.

The next meeting will take place at the European Space Research INstitute (ESRIN), Frascati, Italy, July 5-7, 1995. Topics for short presentations will be: algorithm validation (L. Eymard), review of three ESA studies (wind speed need, operational use of MIMR data, sea surface temperature and synergy with AVHRR) and an in-depth presentation of ESA ground stations (Oriol-Pibernat), emissivities on land (C. Matzler), MIMR simulator (M. Hallikainen), and PM mission update (P. Hwang). ■

NSIDC Distributed Active Archive Center

The National Snow and Ice Data Center (NSIDC), located at the University of Colorado, Boulder, is in the third year of collaboration with NASA participating as one of nine Distributed Active Archive Centers (DAACs) in the Earth Observing System Data and Information System Project (EOSDIS).

— **Ronald Weaver** (weaver@kryos.colorado.edu); **Vince Troisi** (troisi@kryos.colorado.edu) and other members of the NSIDC DAAC Staff

The discipline focus of the NSIDC DAAC is on snow and ice processes, especially interactions between snow and ice and the atmosphere and ocean. The primary areas in which the DAAC supports research are global change detection, Earth system model validation, and process model development and validation relating to the cryosphere, (Barry *et al.* 1994).

This report gives a brief overview of the data sets held and distributed by the NSIDC DAAC. It also provides information about current development efforts in data and information delivery systems and new datasets. The NSIDC DAAC is particularly well sited at the University of Colorado. For example, recently NSIDC has collaborated with scientists from the Cooperative Institute for Research in Environmental Sciences (CIRES), our University host institute, and from the Nansen Environmental and Remote Sensing Center, Bergen, Norway who have developed areal estimates of sea ice coverage derived from the SMMR and SSM/I time series. Figure 1 shows the globe's sea ice extent, while Figure 2 shows just the Northern Hemisphere. Of particular note is the slight downward trend in the SSM/I years (1987-1991), with 1990 exhibiting the most pronounced summer reduction. Results of on-going research into the causes for this reduction will be presented at the Polar Meteorology Conference of the American Meteorological Society in January 1995.

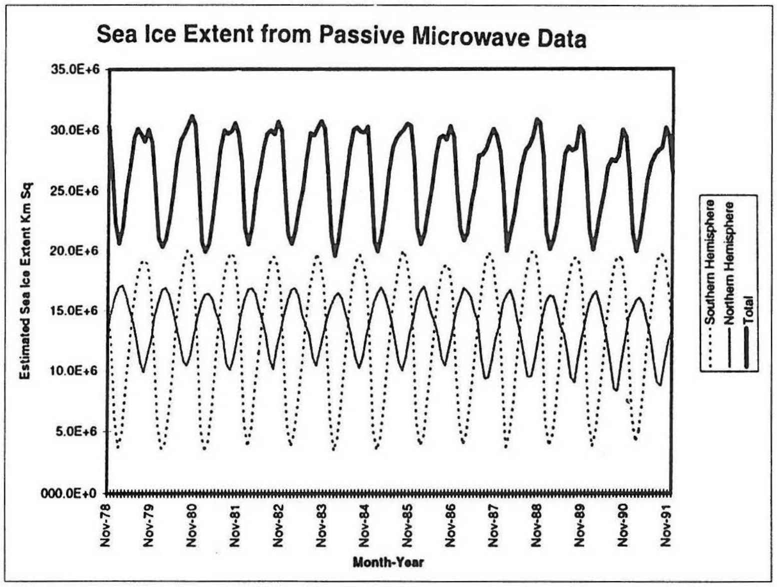


Figure 1.

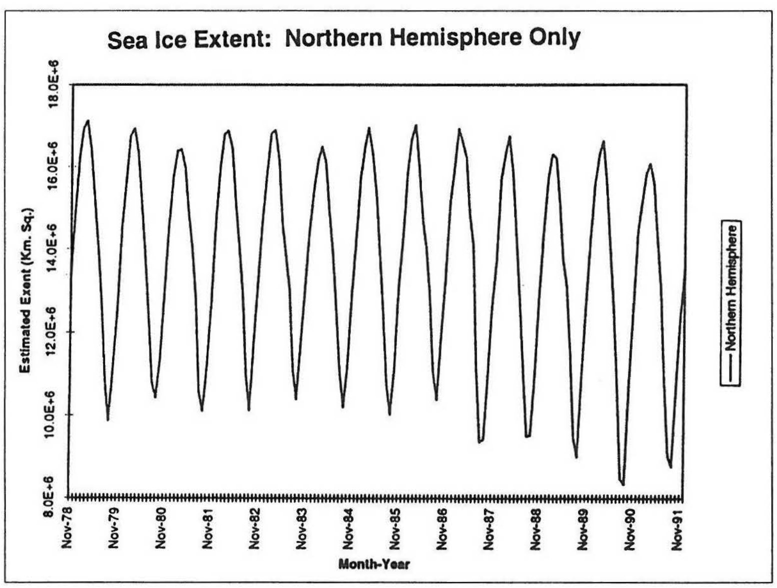


Figure 2.

Data Sets

Currently, snow and ice products are generated from DMSP SSM/I data. Non-satellite data, such as meteorological fields, station data, and buoy measurements, are archived for comparison to satellite information and for input into sea-ice and climate models. The NSIDC DAAC supports the development of products to monitor ice-surface temperature and motion by providing access to 1 km AVHRR, and TOVS satellite data*. Satellite altimetry data are being archived and distributed to support ice-sheet topography studies.

As of FY94, data sets held by the DAAC include those of the heritage NSIDC Cryospheric Data Management System (CDMS). The suite of DAAC holdings is summarized in Table 1, with additional information provided in the following discussion.

Data Type	Volume (GB)	Remarks
DMSP SSM/I	70	Level-1.5 and Level-3 brightness temperatures; Level-3 ice extent and concentration (daily) and ice concentration (monthly)
Nimbus-7 SMMR	7	Level-3 brightness temperatures and sea-ice concentration
Geosat and Seasat altimetry data	15	Gridded elevations, height profiles, and waveforms for Greenland and Antarctica
Nimbus-5 ESMR	3	Level-1.5 and Level-3 monthly and 3-day brightness temperatures and sea-ice concentration products (monthly)
AVHRR: Polar Subsets	120	Level-0 and swath data
LEADS: ARI	20	Level-3 AVHRR scenes
In situ data	1.9	Multiple source and data types

Table 1. NSIDC DAAC - Summary of Data Holdings as of July 1994

DMSP SSM/I Data

NSIDC DAAC processes the SSM/I data into gridded, full global, and polar data products. All products are available on CD-ROM. Orbital data from the SSM/I instrument are held by NOAA Satellite Data Services Division (SDSD). Within the EOSDIS DAAC structure, the Marshall Space Flight Center (MSFC) DAAC is designated as the Level-1.5 data archive. Products generated at the NSIDC DAAC from SSM/I data include gridded sea-ice concentration and brightness temperature. Currently, a polar stereographic projection covering the polar regions is employed. The Equal Area SSM/I Grid (EASE-Grid) will be produced in parallel with the polar stereographic products to provide improved radiometric fidelity, temporal resolution, and coverage. A loose-leaf User's Guide containing complete documentation is part of the package. Sea-ice concentration data, and F 11 brightness temperature data are distributed in Hierarchical Data Format (HDF) and can be displayed and manipulated using software from the National Center for Supercomputing Applications (NCSA) or commercial packages such as IDL.

Nimbus-7 SMMR Data

The SMMR on Nimbus-7 operated from 1978 to 1987. Current DAAC products include gridded SMMR brightness temperatures and sea-ice concentration in the SSM/I polar-grid format, which were generated by Dr. Per Gloersen of Goddard Space Flight Center in conjunction with the NSIDC DAAC. The complete time series has been published on CD-ROMs. Version 1 of the User's Guide for Nimbus-7 SMMR Polar Radiances CD-ROMs has been distributed. This document was in an extended development and review process in order to provide the proper amount of information in a format that would be helpful to users. The User's Guide supplements the SMMR Atlas (Gloersen *et al.* 1992).

* NSIDC through its NOAA affiliation also provides access to digital DMSP Operational Line Scan imagery, SSM/T2, and orbital SSM/I data. These data are distributed independently of the DAAC through a cooperative arrangement with the National Geophysical Data Center, NOAA/NESDIS.

Dr. Eni Njoku at the Jet Propulsion Laboratory (JPL) has completed recalibration of the SMMR time series. It is our understanding that the recalibration performed by Dr. Njoku closely follows techniques used by Dr. Per Gloersen and, therefore, may not greatly change the sea-ice-concentration product already in distribution. There will be two SMMR Pathfinder products of interest to the snow and ice community, each containing 10 channels (5 frequencies, 2 polarizations) of brightness temperature data. The first consists of recalibrated SMMR level-1B data in swath (orbital) format, with spatial resolution varying from 21x 33 km for the 37 GHz channels to 105 x 160 km for the 6.6 GHz data. The Marshall Space Flight Center DAAC will archive the complete set of swath data. The second Level-2 product will contain SMMR data mapped to NSIDC's 25-km EASE-Grid format. Production of this data set is being considered for FY95.

Gridded sea-ice-concentration estimates from both the SMMR and SSM/I data have been issued on CD-ROM, covering 1978 to 1991. This combined data set is one of the longest satellite-era measurements of a cryospheric parameter.

AVHRR Data

Recent polar AVHRR data of both polar regions, at 1.1 km resolution (LAC and HRPT data types), are available from NSIDC. The Polar AVHRR 1-km data set at NSIDC consists of Antarctic scenes acquired since April 1992, and Arctic scenes acquired since August 1993. All five bands of the AVHRR sensor (primarily from the NOAA-11 satellite) are archived in orbit swath format, in uncalibrated sensor units. Several derived data products, such as sea-ice motion and ice-surface temperature, are under development in conjunction with the polar science community.

Radar Altimetry Data

NSIDC DAAC distributes a data set derived from the Geosat and Seasat radar altimeters that contains georeferenced and corrected data collected over Greenland and Antarctica. The data are available as either point elevations or interpolated onto a 20 km grid. NSIDC has arranged with NASA's GSFC to provide data distribution from its archive of Seasat and Geosat data (supervised by Dr. Jay Zwally of GSFC). Gridded digital elevations, height profiles, and waveform data are available for both missions. For requests for data over limited areas, NSIDC will select the data from the archive and deliver them (floppy diskette, tape, or ftp transfer). The entire data set, with browse and retrieval software, will be available on CD-ROM and will be distributed by both NASA GSFC and NSIDC.

Nimbus-5 ESMR Data

ESMR monthly and 3-day brightness temperatures and monthly sea-ice-concentration grids for 1973 to 1976 for Arctic and Antarctic regions are distributed on 9-track tape. Ancillary data include surface air temperature and pressure mapped to the same grid as the ESMR products. These data are currently being moved from 9-track tape to magneto-optical media, with documentation improvements scheduled in early FY95.

In Situ Data

The following summarizes the more important *in situ* data available from the NSIDC DAAC. A more complete list can be obtained from the NSIDC DAAC User Services Office.

<u>Drifting Buoy Data</u> —Arctic Ocean drifting buoy data (1979 to present) collected by the Polar Science Center (PSC), University of Washington, are archived at NSIDC DAAC. This set of pressure, temperature, and interpolated ice-velocity values is derived from an average of about 10 Argos buoys per day. A related data set is the historical drifter data, also assembled by PSC and archived at NSIDC, containing 2-day interpolated velocities for 34 polar tracks spanning 1893 to 1973.

<u>Arctic SoundingData</u>—The Historical Arctic Rawinsonde Archive (HARA) of Arctic temperature soundings above 65° N from the beginning of record through 1991 is archived at NSIDC DAAC. Approximately 1.2 million soundings are contained in the archive, representing nearly 100 land stations. For most stations the record begins in 1958; a few begin in 1947 or 1948. The data are one file per year per station. Coverage is relatively uniform, except in the

interior of Greenland. Typically 20-40 levels are available in each sounding. Documentation is provided on the CD-ROM volumes, and in hard copy (Serreze *et al.*, 1992). Software (Fortran and C) is provided on the CD-ROM volumes to retrieve a subset of the sounding data. Sounding data were obtained from the National Center for Atmospheric Research (NCAR), Boulder, Colorado, and the National Climatic Data Center (NCDC) of NOAA in Asheville, North Carolina. The HARA CD-ROM set is being distributed at no charge as an NSIDC DAAC product. The daily sounding data base is available on three CD-ROMs.

Additional Data

NSIDC archives and supports polar subsets of satellite data that have primary archives at other DAACs or affiliated data centers, as well as cryospherically relevant *in situ* data. This section presents the current status of these data sets.

AIDJEX—During the 1970s, the Arctic Ice Dynamics Joint Experiment (AIDJEX) generated data sets relating the response of sea ice to its environment. NSIDC holds three track-lines of sonar data collected in April 1976, containing a 777-nautical-mile profile of the sea ice. Wind, current, and position data from four manned camps on ice floes are also held for April-October 1975. The location of most of the AIDJEX data sets is unknown at this time. NSIDC continues to seek out information that may lead to the recovery of these data.

MIZEX—The Marginal Ice Zone Experiment (MIZEX), which was conducted in the Fram Strait and Greenland Sea in June to July 1983, May to July 1984, and March to April 1987, and in the Bering Sea in February 1983, provided data from shipborne platforms on processes in the marginal ice zone. Supporting data sets on meteorology, oceanography, sea-ice conditions, and biology are archived at NSIDC. Meteorology data are distributed on the CEAREX CD-ROM Vol. 1.

CEAREX—Coordinated Eastern Arctic Experiment (CEAREX), carried out in the East Greenland Sea west of Svalbard from September 1988-June 1989, used satellite, ship, aircraft , helicopter, and ice-floe-based sensors. Surface platforms provided meteorological, oceanographic, biological, acoustic, and sea-ice data. NSIDC is the designated archive for the CEAREX datasets, and was funded by ONR to generate a CD-ROM series containing CEAREX and other important eastern Arctic data. This was released in November 1991.

Birdseye Data—NSIDC holds over 11,000 ice observations from U.S. Navy "Birdseye" and other ice reconnaissance operations spanning 1964 to 1975. Airborne sensors flown during MIZEX and CEAREX also generated SAR and SLAR data; microwave, infrared, and visible imagery; radar altimetry; and boundary-layer meteorological information. If funding becomes available, these data sets will be prepared for incorporation in the eastern Arctic CD-ROM series. They are an invaluable resource for better understanding the meso- to small-scale processes in the exchange of momentum, heat, and biomass within ocean eddies, internal waves, and the ocean/atmosphere boundary layer.

NSIDC DAAC Systems Development Activities

The NSIDC DAAC system consists of the following elements: Product Generation System (PGS), Data Archive and Distribution System (DADS), Information Management System (IMS) and User Services Office. Each of these elements was officially deemed operational in August 1994 when the NASA Project Office announced that the EOSDIS Version 0 was available for use by the Earth Science research community.

Major systems components, both software and hardware, are described in the following paragraphs. The DAAC computing environment continues to evolve, generally guided by the movement towards mid-range workstations tied together with ethernet and FDDI LAN hardware.

Product Generation System (PGS)

During 1994 NSIDC acquired an SGI Challenge-L multiprocessing system to support the SSM/I product generation and AVHRR 1 km polar subset ingest and archive activities. The SSM/I processing environment was transferred to the Challenge. The Land Analysis

System (LAS), acquired from EROS Data Center was installed on the Challenge. The LAS software is used to generate subsampled browse images and level 1B products.

Data Archive and Distribution System (DADS)

The DADS is configured with a Cygnet WORM jukebox subsystem. Software has been developed to provide archive storage and archival management of the data residing on WORM platters residing in the jukebox. Data residing on 1600/6250 bpi magnetic tapes are being transferred to the optical media. Copies of the WORM volumes are being made on 8 mm cartridge tape media and will be transferred to NGDC for off-site storage. A 10-cartridge 4 mm DAT auto changer was added to the DADS configuration. The DAT autochanger was acquired to support archive and distribution activities associated with the AVHRR 1km polar subset.

Information Management System (IMS)
Cryospheric Information Management System (CIMS)

The NASA EOSDIS Version 0 IMS is based on the distributed client/server model. Each DAAC manages a server which services requests for metadata, browse, or data products from remote clients. NSIDC continues to populate its local IMS server (CIMS) data base with metadata as well as maintain a data dictionary which describes the information architecture of the metadata. Another component of the IMS is a GUIDE subsystem. The GUIDE is an electronic document handling system which uses the WWW and WAIS technologies to organize documents on-line. Documents can be accessed using MOSAIC-like interfaces. During 1994, NSIDC populated a variety of dataset-related documents into the NSIDC GUIDE server. Documents were formatted using HTML and include links to graphics and images.

NSIDC has been very impressed with the way the WWW and WAIS technologies organize and service textual and graphical information over the network, and the Data Center is in the process of developing an on-line information system using the WWW and WAIS protocols. Services include access to the following: 1) Data Announcements, 2) New Accessions Lists, 3) *NSIDC Notes* (a quarterly newsletter published by NSIDC), 4) general news, 5) a gallery of images, and 6) a calendar of events.

SSM/I Quality Control Using Artificial Intelligence Techniques

Under a one-year DAAC supplemental grant, NSIDC designed a system to apply knowledge-based methods to automate and improve quality-control testing within the SSM/I data processing stream. This processing stream involves the conversion of orbital-format brightness temperatures into gridded, averaged brightness-temperature products, and subsequently to geophysical products such as sea-ice concentrations and snow depths. A variety of quality control checks are possible within this processing stream, but these steps typically require some human intervention that can be time-consuming, and may require expert knowledge beyond that offered by most operations staffs. Our objective was to test the use of artificial intelligence methods to minimize the need for manual QC and to apply high-level skills within the processing stream.

NSIDC developed software to apply QC decision rules at the gridding stage of the processing stream. We developed rules coded in 'C' and the CLIPS rule-based language to check data ranges, to determine general conditions of the data, and to compare the brightness temperatures to other ancillary information such as surface temperatures and masks. We stored the results of these checks as metadata, and summarized this metadata using a weighting scheme to determine whether a particular orbit scan should be flagged as suitable for gridding. We successfully tested the system to determine its ability to read in, process, and write out SSM/I data in a form compatible with the current operational processing software. In its current form, the software offers a range of possible extensions, additions, and enhancements that could be applied to the SSM/I processing stream. Similar techniques could be used for other data sets, and offer a variety of potential applications for algorithm selection and tuning.

Future EOS Data Sets

In future years of the EOS era, NSIDC will be involved with numerous new data sets . Table 2 summarizes them, with discussion following.

Product ID	Platform	Instrument	Data Set Name	Product Level	Data Producer
GLA07	ALT-L	GLAS	Ice Sheet Elevation	2	NSIDC
GLA08	ALT-L	GLAS	Ice Sheet Roughness (R)	2	NSIDC
MIM07	PM	MIMR	Snow Depth	2	NSIDC
MIM08	PM	MIMR	Snow Water Equivalent	2	NSIDC
MIM11	PM	MIMR	Sea Ice Concentration	2	NSIDC
MIM12	PM	MIMR	Sea Ice Type	2	NSIDC
MIM18	PM	MIMR	Gridded Snow Depth	3	NSIDC
MIM19	PM	MIMR	Gridded Snow Water Equivalent	3	NSIDC
MIM22	PM	MIMR	Gridded Sea Ice Concentration	3	NSIDC
MIM23	PM	MIMR	Gridded Sea Ice Type	3	NSIDC
MOD10	AM, PM	MODIS	Snow Cover Extent	2	GSFC
MOD29	AM, PM	MODIS	Sea_Ice Max Extent	2	GSFC
MOD33	AM, PM	MODIS	Gridded Snow Cover Extent	3	NSIDC
AST16	AM	ASTER	Glacier Extent, Temperate	4	EDC
AST17	AM	ASTER	Glacier Velocity, Polar Outflow	4	EDC
AST18	AM	ASTER	Sea_Ice Albedo	2	EDC

Table 2. Summary of EOS Mission data sets with which NSIDC will be involved

AM-1 (1988 Launch)

Moderate Resolution Imaging Spectroradiometer (MODIS)—NSIDC is responsible for snow-cover and sea-ice-related products from MODIS on AM-1. These products will be generated either at NSIDC or at GSFC pending review of resources available at the two DAACs. Exact interface requirements for this processing must be decided between GSFC and NSIDC in FY 95. In addition, NSIDC will be monitoring the MODIS Instrument Team development of these products.

Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)—NSIDC is collaborating with the EROS Data Center (EDC)-DAAC on glacier-related products derived from ASTER. We are discussing with EDC how glacier products will be distributed.

PM-1

MODIS—Similar snow and ice products will be derived from MODIS on PM-1 as on AM-1. Discussion above under AM-1 apply to PM-1 MODIS as well.

Multifrequency Imaging Microwave Radiometer (MIMR)—NSIDC will produce and distribute snow cover and sea-ice products derived from MIMR. MIMR instrument development and its availability for PM-1 are in a state of flux. We are uncertain which of several options will be employed to acquire passive microwave data.

ALT (Laser)

Geoscience Laser Altimeter System (GLAS) (2003 Launch—NSIDC plays an important role in the processing of GLAS products. The primary mission of GLAS is the monitoring of ice-sheet elevation. NSIDC will produce the products derived from the Level 1 data stream for ice-sheet elevation. Other products derived from the GLAS data stream include determination of aerosols, polar cloud composition, as well as various vegetation-related products. NSIDC will interface with the GLAS instrument team to aid the development of the ice-sheet and other cryosphere-related products. NSIDC has proposed the relocation of the GLAS low-level archive from GSFC to NSIDC since the primary mission and most of the products are polar related.

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Next Generation EOSDIS—The Evaluation Packages

—**Thomas Dopplick** (tom@eos.hitc.com), ECS Science Office and **George Percivall** (gperciva@eos.hitc.com), ECS Evaluation Package Manager, Landover, MD

Introduction

The next generation of EOSDIS, beyond Version 0, must provide end-to-end services across the broad range of EOS mission operations, from EOS instrument data collection to science data processing to full access to EOS and other Earth science data holdings. Next generation EOSDIS must accommodate high throughput and storage on a scale not seen before by NASA data centers in order to ingest, process, archive, and distribute the high data rates from EOS instruments. EOSDIS' infrastructure, the EOSDIS Core System (ECS), will give EOS and other U.S. and international scientists access to a broad range of services provided by the Distributed Active Archive Centers (DAACs) as well as other data providers who rehost and adapt reusable ECS components. The ECS infrastructure will also support exchange of data and research results within the science community, across multiple agencies, and internationally.

Multi-Track Development

The ECS Team is developing ECS using a multi-track development approach that includes: 1) development of a portion of ECS on an incremental track, and 2) parallel development of the remainder of ECS on a formal track using the traditional waterfall development methodology. The two primary drivers for development on the incremental track are volatility of user-sensitive requirements and commercial-off-the-shelf (COTS) intensive integration. To accelerate and accommodate early user feedback, a delivery mechanism called an Evaluation Package (EP) was devised to put incremental developments and selected prototypes in the hands of distributed users for evaluation and design iteration significantly in advance of formal track releases. Another purpose of the Evaluation Package is early integration of COTS hardware and software in order to evaluate advertised capabilities of commercial vendors.

The Evaluation Package Challenge

The key to successful development on the incremental track is to provide structure without creating an administration overload that removes the freedom to react to objectives and design changes dictated by emerging circumstances, such as programmatic changes or technology evolution. To meet this challenge, we have adopted an Evaluation Package life cycle that merges selected practices from more traditional engineering methods with rapid prototyping methodology. For example, an objectives review is held with ESDIS and science community representatives at the beginning of each Evaluation Package to establish common understanding of design and evaluation goals. Other reviews with ESDIS and science community representatives include design, test readiness, consent to ship, and final readiness reviews. At each review, status and lessons learned are discussed and changes incorporated based on feedback by review attendees. Mockups, early prototyping, and in-process demonstrations give reviewers progressively better insight into the planned Evaluation Package functionality.

After final integration and testing, the Evaluation Package software is then distributed to the DAACs and other evaluator sites for a multi-week evaluation. Also, science community representatives are invited to participate in structured usability testing at the ECS development facility in Landover, MD. Usability testing is an efficient and low-cost method of testing and quantifying ease of use. Experience to date indicates that the minimum time to produce meaningful content in an Evaluation Package is about 6 months, and that evaluation will require an additional 2 months including time for data analysis and results sharing. Details can be found in the Evaluation Package Strategic Plan White Paper, which is readily available on WWW using Mosaic from the ECS Data Handling System (EDHS) home page, URL: http://

edhs1.gsfc.nasa.gov/. The EDHS provides a catalog listing and full text search. Documents of interest can be retrieved in four commonly used formats from simple ASCII text to full-figured Postscript.

Prior Evaluation Packages

Evaluation Packages 1 through 3 were focused primarily on establishing a distributed testbed environment that interconnected ECS workstations at each DAAC and the ECS development facility in Landover, MD. The testbed environment is built upon an emerging communications technology, Open System Foundation's (OSF) Distributed Communications Environment (DCE). Evaluation Package 3 also introduced mockups of early concepts for the ECS Client.

Current Evaluation Package

Evaluation Package 4 explores new concepts for the ECS Client based on the revised architecture presented at the ECS System Design Review in June 1994 (Figure 1). In particular, Evaluation Package 4 focuses on the Scientist Workbench; search and traversal of advertisements available from the Advertising Service; continued development of EOSView, an ECS tool for viewing Hierarchical Data Format (HDF) data; and continued development of selected communications infrastructure components. The ECS Client now consists of a Scientist Workbench, which contains various tools, and desktop support for organizing user interface objects and setting interface preferences. Note that most of the communications infrastructure is not directly visible to end users but is, nevertheless, critical to developing an extensible and open core system as strongly recommended by the science community and the National Research Council.

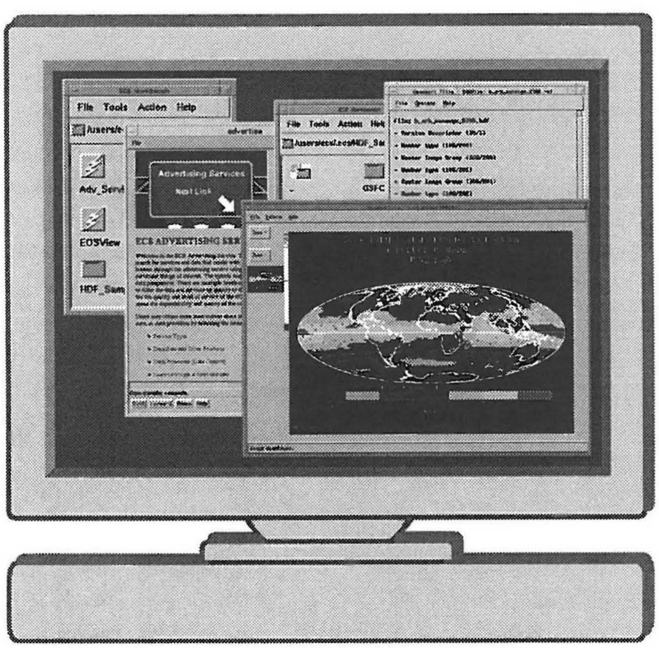

Figure 1. Evaluation Package 4 explores new concepts for the ECS Client

Scientist Workbench

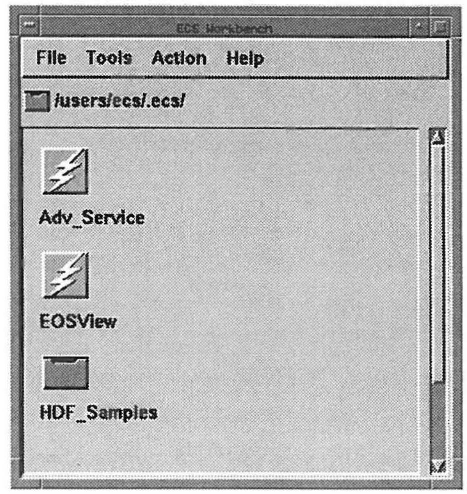

Figure 2. ECS Scientist Workbench is a window to ECS services.

The Scientist Workbench is the desktop portion of the ECS Client and allows access to ECS applications and data. The Prototype in Evaluation Package 4 will refine desktop requirements for launching and installing ECS applications. The present prototype uses screens similar to those presented at the ECS System Design Review. The Evaluation Package 4 version of the Scientist Workbench is implemented using native X and Motif. Alternate desktop paradigms for implementing the Scientist Workbench will be incorporated when they are available on more platforms.

The ECS Scientist Workbench (Figure 2) is the primary interface for working with ECS. Displayed on the Evaluation Package 4 Scientist Workbench are two applications: the "Adv_Service" (Advertising Service) and "EOSView" (HDF viewing tool). Also displayed is a "HDF_Samples" folder that contains sample HDF data files from each DAAC for use in evaluating EOSView. In a fully functioning ECS, data files would

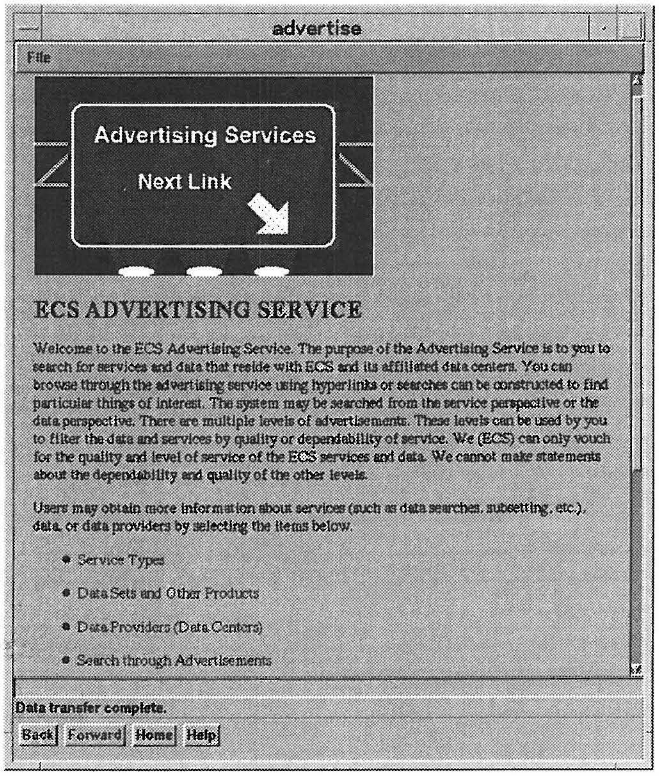

Figure 3. The ECS Advertising Service supports browsing and searching of data and service advertisements.

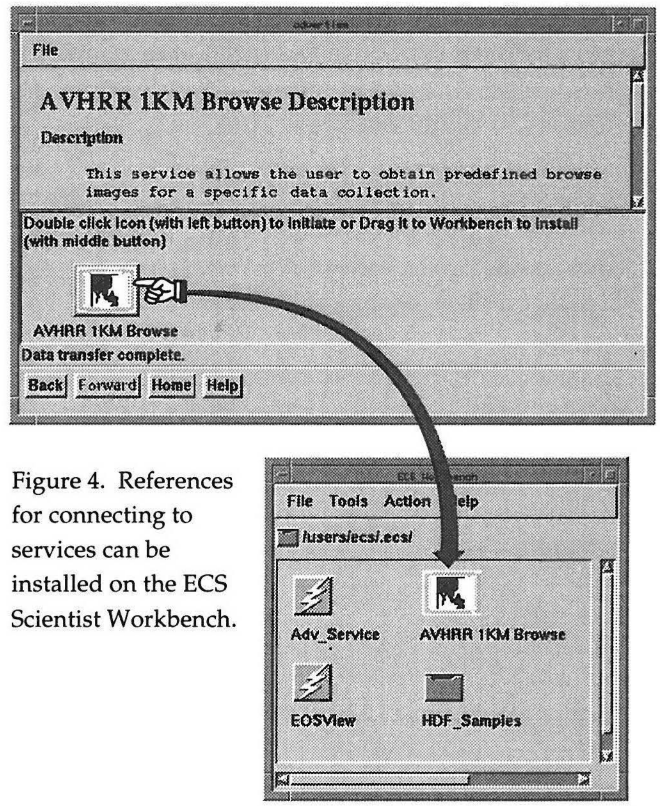

Figure 4. References for connecting to services can be installed on the ECS Scientist Workbench.

be present as the result of previous searches and data retrievals. Desktop pull-down menus contain other tools and aids to assist the user of the Scientist Workbench. An on-line survey is also available so users can enter their numerical evaluation and free text comments.

Advertising Service

The Advertising Service provides the interfaces needed to support the Client browsing and searching of data and service advertisements. The directory function is subsumed by the advertising service. The Prototype in Evaluation Package 4 will flush out search/traversal requirements and interface requirements with the Trader Service (see below). Also, the prototype will be used to determine the level of information that is needed to build useful service advertisements.

The Advertising Service is built using a modified Mosaic interface and should be familiar to those who have used Mosaic or Netscape. Users can "surf" through advertisements for services, data sets, and data providers, or users can submit queries that search through advertisements to find data and services of interest (Figure 3).

Figure 4 shows an example of finding a hypothetical "AVHRR 1 KM Browse" service. When located, the description of the AVHRR 1KM Browse service and reference icon are presented to the requester. The browse service can be immediately invoked by double clicking on the reference icon or the user can install the reference icon, using drag-and-drop, onto the Scientist Workbench for launching at the user's convenience. A future Evaluation Package will provide the actual browse services. Query forms (not shown here) are also available for finding services of interest.

Trader Service

The Trader Service, although not directly visible to the user, plays an important role by accepting general

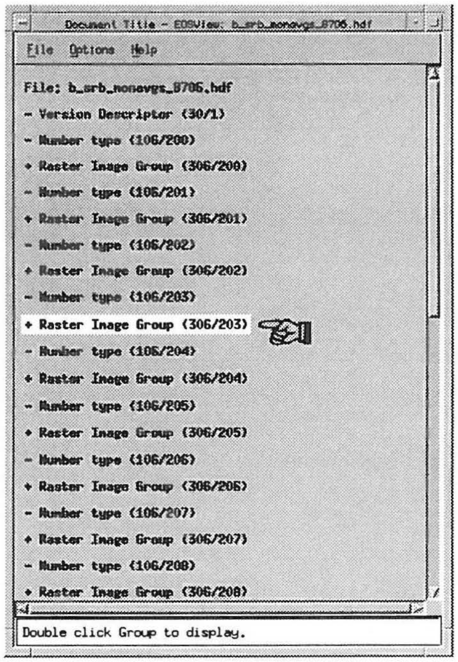

Figure 5. EOSView displays the internal structure of a HDF data file.

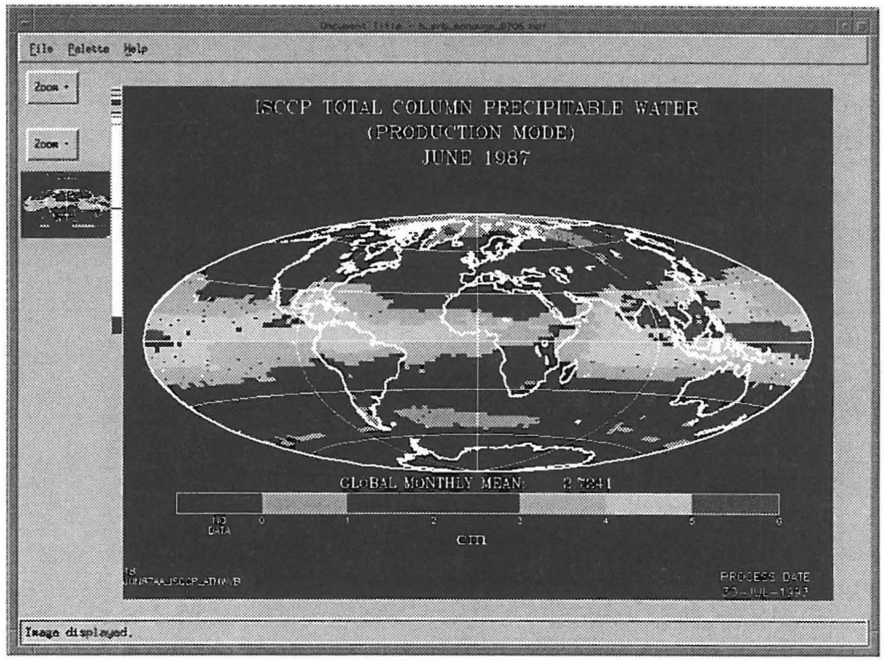

Figure 6. EOSView displays raster images for use in data verification.

service queries from the advertising service and returning objects that match the characteristics of the queries. This service also matches EOSDIS user requests to ECS servers. The prototype for Evaluation Package 4 is a static trader developed using HP's (Hewlett-Packard's) Object Oriented Distributed Computing Environment to allow object passing over the Distributed Communications Environment.

EOSView

This HDF viewing tool will make it easy for anyone, even non-EOS users, to read and understand HDF-EOS data files. EOSView will be widely available, both in terms of physical locations and in terms of supported platforms. Visualization in EOSView will be for the purpose of data verification only. Analysis and presentation of data is best left to commercial applications. The incremental development of EOSView for Evaluation Package 4 will have the following features: display HDF file structures, including raster and 2D arrays, pseudo color window, preliminary scripting language and simple animations. A DAAC sampler is available in Evaluation Package 4 with sample HDF files from each DAAC. Users can examine and, where appropriate, visualize samples of current DAAC products with EOSView provided in Evaluation Package 4.

There are several ways to activate EOSView: a) double clicking the EOSView icon, b) drag-and-drop of a HDF data file onto the EOSView icon, or c) double clicking a HDF data file. Each method will result in a display similar to Figure 5 which lets a user view the internal structure of the HDF data file.

Those sections of a HDF data file delineated by a "+" sign contain further levels of information or image data. Double clicking a Raster Image Group will activate the image display capability of EOSView as shown in Figure 6.

Communications

Evaluation Package 4 continues development and integration of communications infrastructure components with the focus on system security, network management and system management. In addition to Open System Foundation's (OSF) Distributed Computing Environment (DCE), HP's OPENVIEW is also being evaluated for use in the core communications infrastructure.

Current Status

A 2-month evaluation period will begin in January, 1995 after distribution of Evaluation Package 4 software to the DAACs and other evaluator sites. Feedback will be documented through an on-line survey that solicits numerical evaluation and free text comments. In parallel, structured usability testing will be conducted at Landover, MD with science community representatives. Results from the on-line survey and usability testing will be analyzed and a report published in March 1995.

Future

Evaluation Package 5 will be completed in April 1995 but will focus completely on communications infrastructure components needed for Interim Release 1 that supports early interface testing with TRMM and EOS missions. On the horizon, however, is a prototype workshop scheduled for May, 1995 to present prototype concepts to the science community for user interfaces to data search and access services. The results of this prototype workshop will be incorporated in Evaluation Package 6 that will be completed in November, 1995. Evaluation Package 6 will allow users to evaluate the following services: advertising, data dictionary, data search and access, browse, and ECS to V0 interoperability. A second prototype workshop will be held in December 1995 to present prototype concepts for product access, processing requests, and request/results status.

OTA Congressional Fellowship Program 1995-96

The Office of Technology Assessment (OTA) is seeking outstanding candidates from academia, business and industry, and the public sector for its Congressional Fellowship Program. Up to six Fellows will be selected for a one-year appointment in Washington, DC, usually beginning in September 1995. The program provides an opportunity for individuals of proven ability to assist Congress in its deliberations of science and technology issues affecting public policy and to gain a better understanding of the ways in which Congress establishes national policy related to these issues.

The Fellowship honors former Congressman, Morris K. Udall, of Arizona, who retired in 1991 after a long, distinguished career of public service. Mr. Udall was one of the founders of OTA and has served on OTA's Technology Assessment Board since 1973, including several terms as Chairman.

OTA provides congressional committees with comprehensive analyses of emerging, complex, and often highly controversial issues involving science and technology; helps Congress resolve uncertainties and conflicting claims; identifies alternative policy options; and provides early alert to new developments that could have important implications for future federal policy and the society at large.

The assessments are conducted in areas such as economic competitiveness, international security, energy, infrastructure, space, agriculture, health

(Continued on next page)

care technologies, renewable resources, telecommunications, environment, education and transportation.

Qualifications

The program is open to individuals who have demonstrated exceptional ability in such areas as the physical or biological sciences, engineering, law, economics, public health, environmental and social sciences, and public policy. Candidates must have extensive experience in science and technology issues or have completed research at the doctoral level. OTA encourages applicants with diverse backgrounds and work experiences to apply.

Applicants must be prepared to perform balanced, comprehensive analyses, to work cooperatively in an interdisciplinary team setting, and to present reports in clear, concise language.

Applicants are considered on the basis of their records of achievement and their potential for contributing individual expertise to one or more of OTA's studies.

Salary

The salary range is from $35,000 to $70,000 per year, based on the Fellow's current salary and/or training and experience. In some instances, a Fellow may accept a salary supplement from his or her parent organization. Such instances are addressed on a case-by-case basis.

Application

Applicants for the fellowships are required to submit the following:

- a resume limited to two pages, including education, experience, and area(s) of special interest

- a one-page listing of their most recent published works;

- three letters of reference, including telephone numbers, from individuals who know the applicant well enough to write about his or her professional competence (sent directly to the address below before the application deadline);

- a statement of up to 1,000 words that either:

  - evaluates an issue with technical and public policy content and why it is of interest to you, or
  - summarizes the public policy findings of work you have done; and

- a brief statement of up to 250 words explaining how OTA and the Fellowship fit into your career objectives.

Application Deadline

Applications and letters of reference must be received by February 1, 1995. Personal interviews of the finalists will be conducted March 28-29, 1995. Awards will be announced by April 7.

Send applications and letters of reference to:

Morris K. Udall Fellowships
Personnel Office
Office of Technology Assessment
600 Pennsylvania Ave., SE
Washington, DC 20003

Precision Farming: Farming by The Inch

— **Chris J. Johannsen (johannsn@ecn.purdue.edu),** Laboratory for Applications of Remote Sensing (LARS), Purdue University

Introduction

"Precision Farming" is a current buzz word among agricultural circles. The term "precision farming" means carefully tailoring soil and crop management to fit the different conditions found in each field. Precision farming is sometimes called "prescription farming," "site specific farming," or "variable rate technology." It has caused a focus on the use of three technologies that are very central to the LARS programs—remote sensing, geographic information systems (GIS) and global positioning systems (GPS).

We have literally taken "agriculture into the space age." Farmers have services available that involve satellites collecting data, transmitting locational information, or providing data from a variety of sources. Farmers can analyze this satellite information or they can rely on companies to do this service for them for a fee.

Some farmers have already received benefits from satellite remote sensing data. Satellite images from Landsat and SPOT have been used to distinguish crop species and locate stress conditions. The cost of obtaining the images has been the biggest deterrent in regular use of such data. A typical farm manager of 2,500 acres in the Midwest is not going to spend $3,500 every 2 weeks to monitor conditions in his field. It is believed that future satellite programs such as the TRW Small Satellite, World View Imaging, Eyeglass International and Space Imaging will be competing for the agricultural market, and lowered prices will encourage the farmers to participate.

More recently, farmers have gained access to site-specific technology through Global Positioning Systems (GPS). GPS makes use of a series of military satellites that identify the location of farm equipment within a meter of an actual site in the field. The value of knowing a precise location within inches is that: 1) locations of soil samples and the laboratory results can be compared to a soil map; 2) fertilizer and pesticides can be prescribed to fit soil properties (clay and organic matter content) and soil conditions (relief and drainage); 3) tillage adjustments can be made as one finds various conditions across the field; and 4) one can monitor and record yield data as one goes across the field.

The real value for the farmer is that he can adjust seeding rates, plan more-accurate crop protection programs, perform more-timely tillage, and know the yield variation within a field. These benefits will enhance the overall cost effectiveness of his crop production.

Seeding

Hybrid seeds perform best when placed at spacings that allow the plants to obtain such benefits as maximum sunlight and moisture. This is best accomplished by varying the seeding rate according to the soil conditions such as texture, organic matter, and available soil moisture. One would plant fewer seeds in sandy soil as compared to silt loam soils because of less available moisture. The lower seed population usually has larger heads (ears) of harvested seeds providing for a maximum yield. Since soils vary even across an individual farm field, the ability to change seeding rates as one goes across the field allows the farmer to maximize this seeding rate according to the soil conditions. A computerized soil map of a specific field on a computer fitted on the tractor along with a GPS can tell the farmer where he is in the field allowing the opportunity to adjust seeding rates as he goes across the field.

Crop Protection

The application of chemicals and fertilizers in proper proportions are of environmental and economic concern to the farmers. Environmental regulations are calling for the discontinuance of certain pesticide applications within 100 feet of a stream, waterbody or well, or within 60 feet of an intermittent stream. Using a GPS along with a digital drainage map, the farmer is able to apply these pesticides in a safer manner. In fact, the spraying equipment can be preprogrammed to automatically turn off when it reaches the distance limitation or zone of the drainage feature. Additionally, the farmer can preprogram the rate of pesticide or fertilizer to be applied so that only the amount needed is applied as determined by the soil condition, varying this rate from one area of the field to another. This saves money and allows for safer use of these materials.

Tillage

The ability to vary the depth of tillage along with soil conditions is very important to proper seedbed preparation, control of weeds, and fuel consumption (and therefore cost) to the farmer. Most farmers are using conservation tillage, which means leaving residues on the soil surface for erosion control. The use of GPS in making equipment adjustments as one goes across the different soil types would mean higher yields and safer production at lower cost.

Harvesting

The proof in the use of variable rate technology (adjusting seed, pesticide, fertilizer, and tillage) as one goes across the field is in knowing the precise yields. Combines and other harvesting equipment can be equipped with weighing devices that are coupled to a GPS. One can literally measure yield as one goes across the field. With appropriate software, a yield map is produced showing the yield variation throughout the field. This allows the farmer to inspect the precise location of the highest and the lowest yielding areas of the field and determine what caused the yield difference. It allows one to program cost and yield to determine the most-profitable practices and rates that apply to each field location.

Conclusions

Where do GIS and remote sensing fit with Precision Farming? Several companies are starting to market GIS record-keeping systems so the farmer can record all of the field operations such as planting, spraying, cultivation and harvest (along with specific information such as type of equipment used, rates, weather information, time of day performed, etc.). Additionally, the farmer is able to record observations throughout the growing season such as weed growth, unusual plant stress or coloring, and growth conditions. Data collected by the GPS operations can be automatically recorded with the GIS program.

Remotely sensed data can be analyzed and added to the GIS using soil maps, digital terrain, and field operations information as ground truth. This can be used to guide further field operations like spraying, fertilizing, and irrigating, plus it is part of the permanent record.

Precision farming will make a strong impact on the way farmers manage their farm operations in the future. We will see a steady growth of the remote sensing, GIS and GPS technologies as a result of this method of "farming by the inch."

CORRECTION

In our September/October 1994 issue we carried an article entitled "JPL Physical Oceanography DAAC Reprocesses Ten Years of Sea Surface Temperature Measurements from NOAA AVHRR." Principal author, Jorge Vazquez (Jet Propulsion Laboratory), has asked us to add Elizabeth Smith (Old Dominion University) to the list of authors. Her name had been included in the list of authors for the original article, which had previously appeared in the *Science Information System Newsletter* and was inadvertently omitted from the version we printed. We are always happy to give credit where it is clearly due.

—Editor—

Calibration of BUV Satellite Ozone Data - An Example for Detecting Environmental Trends

—**E. Hilsenrath** (hilsenrath@ssbuv.gsfc.nasa.gov), **P.K. Bhartia** (bhartia@chapman.gsfc.nasa.gov), Laboratory for Atmospheres (Goddard Space Flight Center), **R. P. Cebula** (cebula@ssbuv.gsfc.nasa.gov), Hughes STX Corporation

Introduction

The environmental and economic implications of ozone depletion were just emerging when the Nimbus-7 satellite was launched in 1978. This marked the beginning of ozone monitoring with observations from the Solar Backscatter Ultraviolet (SBUV) and Total Ozone Mapping Spectrometer (TOMS) instruments. Since that time a National Plan for Stratospheric Monitoring (1989) was put into place. Its keystone was the continuation of ozone observations on the NOAA polar orbiting satellite series with the SBUV/2 instrument. In parallel to this plan, NASA is flying a series of improved TOMS instruments on the US Earth Probe and Russian and Japanese environmental satellites. Both the NOAA and NASA series of instruments will operate into the next century. A version of TOMS, supplied by the Japanese, may also fly on the EOS Chemistry platform. An advanced instrument using SBUV principles, called the Global Ozone Monitoring Experiment (GOME), will be launched by the European Space Agency in 1995 on the ERS-2 satellite. This instrument will measure several important atmospheric constituents as well as ozone.

A combination of satellite- and ground-based observations has now verified that global ozone depletion has occurred. Measurements of photochemically active gases in the stratosphere and model calculations indicate that this depletion is most likely the result of anthropogenic gases reaching the stratosphere (WMO, 1991). Because atmospheric ozone blocks harmful ultraviolet radiation from reaching the Earth's surface, a global policy was established to phase out certain gases, such as chlorofluorocarbons, known to be harmful to the ozone layer. With this phase out, ozone is predicted to recover to levels existing prior to 1980 about the year 2030 (WMO, 1991). Nevertheless, it remains clear that global-scale ozone monitoring should be continued to verify model predictions and to monitor for possible unpredicted events such as the Antarctic ozone hole and the recent accelerated ozone depletion in the Northern mid-latitudes attributed to Mt. Pinatubo aerosols (Gleason *et al.* 1993).

Global total ozone has decreased by approximately 2-3% (Stolarski *et al.* 1992; Bojkov *et al.* 1990) while upper stratospheric ozone has decreased by about 5-8% (Hood *et al.* 1993) since 1978. These trends, derived from both satellite- and ground-based data, are consistent with model predictions (WMO, 1991). Detecting and verifying these trends has been a major challenge to the scientific community. As part of an international effort, the Ozone Processing Team (OPT) at the Goddard Space Flight Center has been committed for over 15 years to refining and validating ozone data from SBUV, SBUV/2, and TOMS (collectively called BUV) instruments flying on the NASA, NOAA, and Russian satellites. This task is being realized through algorithm improvements and comprehensive studies of the various instruments' pre- and post-launch calibrations. The purpose of this article is to review how the BUV instrument performance has been assessed and to describe some of the tools employed to correct pre- and post-launch calibrations. An example will be given that demonstrates the suitability of corrected and combined ozone data sets from two satellites for climatological and trend studies.

Satellite Instrument and Data

The SBUV instruments which view in the nadir, measure both column amounts of ozone and ozone profiles from roughly 25 to 55 km with an IFOV of 200 km square. The TOMS instruments measure only total column ozone. Employing a cross-track scanner TOMS can map, with 50 km square resolution at the nadir, the entire daylight portion of the globe in about 24 hours. SBUV and TOMS instruments operate on similar principles and employ a common algorithm based on measurements of the Earth's geometrical albedo in the wavelength range where ozone absorbs ultraviolet radiation (250-340 nm). Measurement of the geometrical albedo (proportional to the ratio of Earth's backscattered radiance to the incoming solar irradiance) has a distinct advantage among remote sensors and has been critical for accurately detecting long-term changes. In principle, the albedo measurement allows a canceling of nearly all time-dependent instrument changes that are common to both the radiance and irradiance measurement. For BUV measurements, the most critical component that does not cancel is the reflectivity of a diffuser which is deployed only for the solar irradiance measurements. The accuracy of the ozone measurement depends on the accuracy of the pre-launch albedo calibration and the uncertainty of the solar diffuser time-dependent changes. There are other non-cancelling parameters, such as instrument linearity, that must also be tracked carefully over time. The BUV instruments and their operating periods studied by the OPT are listed in Table 1.

Instrument	Period
BUV (Nimbus-4)	1970-1975
SBUV (Nimbus -7)	1979-1990
SBUV/2 (NOAA-9)	1984-present
SBUV/2 (NOAA-11)	1989-present
SSBUV (Shuttle)	7 flights since 1989
TOMS (Nimbus-7)	1979-1992
TOMS (Meteor-3)	1991-1994

Table 1. BUV Satellite Instruments Studied by OPT

The NOAA-14 SBUV/2, Earth Probe TOMS, and ERS-2 GOME are scheduled to be launched over the period December 1994 - June 1995. The data from these new instruments will represent the continuation of the long-term record started by Nimbus-7. The challenge, therefore, is expanded not only to track precisely each instrument's performance over time, but also to assure consistency among measurements, since each instrument will likely have different calibration biases and a unique observing geometry.

Pre-Launch Calibration

Consistent pre-launch calibration of an instrument of one type is essential for traceability when successive instruments of one type are flown. However, accurate absolute calibrations are essential for understanding differences among instruments which employ different observational techniques. Calibration of BUV instruments requires standards and measurements provided by the National Institute of Standards and Technology (NIST). The primary standard for irradiance is the well established FEL lamp, a 1000 watt tungsten filament lamp with a quartz envelope. These lamps have been reliable and have long demonstrated consistency and stability of the order of 0.5%. FEL lamps have a two-fold purpose in BUV albedo calibrations. First, they are used for the irradiance calibration and second, they illuminate a laboratory diffuser target for the radiance calibration. The target's bidirectional reflectance distribution function (BRDF) must be known in order to compute its radiance. In the past, NIST has provided these BRDF measurements, but recently they have not been able to meet all the NASA and NOAA requirements for BRDF measurements. As a result, NASA has established a facility at GSFC to measure BRDF of targets used for the BUV and other satellite-borne environmental observing instruments.

Recently an integrating sphere has been successfully employed to calibrate the radiance sensitivity of BUV instruments (Heath *et al.* 1993). The technique involves transferring the irradiance of a standard FEL lamp to the sphere. The sphere radiance is computed from its irradiance through a geometrical expression. The integrating sphere has now been used to calibrate the SBUV/2, SSBUV, TOMS, and GOME instruments. These instruments have also been calibrated using targets whose BRDFs have been measured in the GSFC facility. Comparison of the integrating sphere and diffuser calibrations has shown agreement of about 1% (Janz *et al.* 1994) for SSBUV, SBUV/2, and

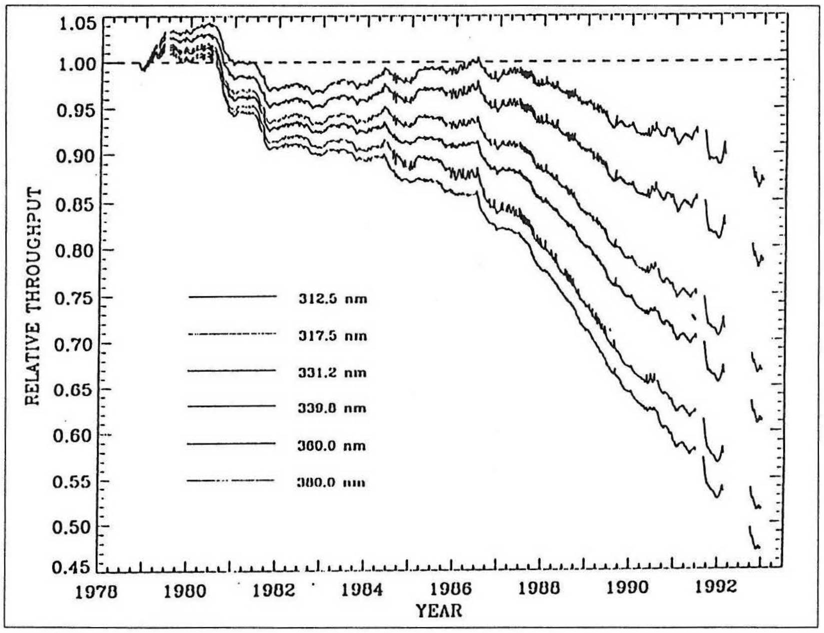

Figure 1. TOMS total instrument throughput degradation over time relative to first day. The shorter wavelengths degrade the most.

GOME. For TOMS the agreement ranged from 1-3%. The NOAA-14 SBUV/2, which was launched December 30, 1994, and the Earth Probe TOMS and ERS-2 GOME to be launched in 1995 will, therefore, have had common and consistent pre-launch calibrations. Overlap of these instruments with the presently operating instruments (Table 1) is not guaranteed. However, a Shuttle SBUV (SSBUV) instrument flight, planned for November 1995, will provide a link from the old to the new instruments. The SSBUV will be discussed below.

Post-Launch Calibration

An accurate description of an instrument's time-dependent characteristics is fundamental to detecting trends in most of the Earth's environmental parameters from space. This critical issue has been recognized by the EOS community, and, therefore, instrument stability has been a major consideration in specifying performance on the EOS platforms. Figure 1 illustrates the total output change experienced by the Nimbus-7 TOMS instrument during 14 years in orbit. The changes shown here include changes to both the solar diffuser's reflectance and drift in the instrument optics throughput. For most of this period, the decrease in output is dominated by diffuser degradation. The Nimbus-7 SBUV/TOMS instrument did not include an on-board calibration system. Therefore, indirect methods were developed to assess diffuser change based on the observation that the diffuser degraded approximately exponentially with solar exposure (Cebula *et al.* 1988). Although the model worked well for the first six years of the mission, by the mid-1980's it was clear that the model was under-predicting the amount of diffuser degradation based on comparisons of the satellite data with ground-based ozone monitoring stations. This underestimate was probably due to diffuser degradation occurring even when the diffuser was not exposed to the sun.

Figure 2 summarizes diffuser degradation experienced by several BUV type instruments. For each

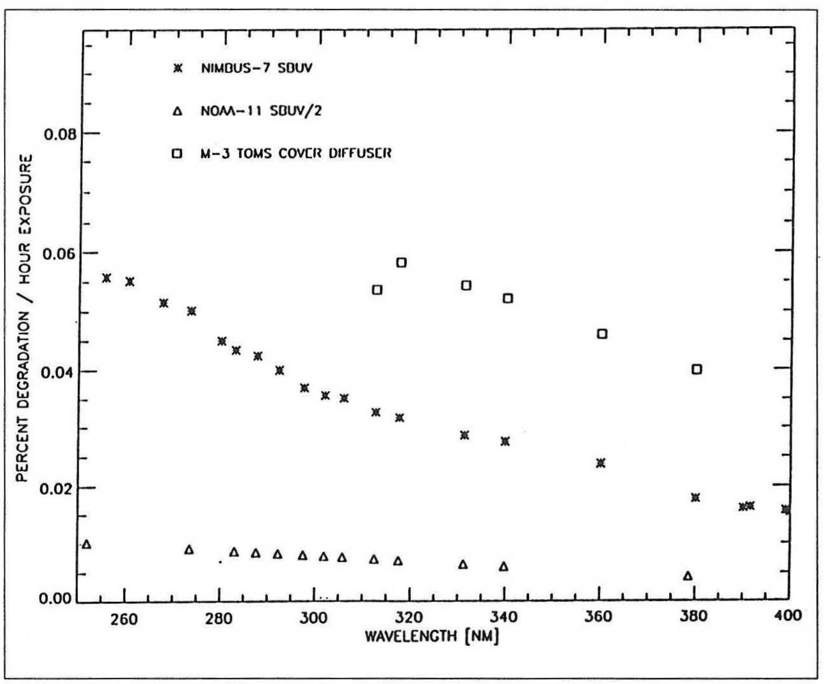

Figure 2. Solar diffuser degradation rate for three BUV instruments.

instrument the diffuser degradation rate increases with decreasing wavelength. However, the exact rate (percent change in diffuser reflectance per unit solar exposure) as well as the spectral dependence varies greatly from one instrument to another. These degradations are thought to result from polymerization of contaminants due to exposure to the solar UV and, therefore could vary from one instrument and spacecraft to the next. Like the Nimbus-7 SBUV and TOMS, both the Nimbus-4 BUV (not shown) and the Meteor-3 TOMS instruments also experienced diffuser degradation that was approximately exponential with solar exposure. In contrast, however, the diffuser degradation experienced by the NOAA-11 SBUV/2 instrument over the period 1988-1993 is approximately linear with solar exposure for the small amount of diffuser degradation observed during this period. These observations indicate only a few of the complexities encountered in characterizing diffuser temporal and spectral behavior.

In order to overcome this problem, several techniques have been employed by the OPT to characterize and correct diffuser degradation. Not all of these can be discussed here because of space limitations in this article. The following is a review of three of these techniques: (1) spectral discrimination method, (2) on-board systems, and (3) inter-satellite comparisons. Other techniques, not discussed here, take advantage of steady scenes such as the Antarctic and Greenland ice caps and clear sky ocean reflectivity.

Spectral Discrimination Method

As an alternative to adjusting the Nimbus-7 satellite SBUV/TOMS data to the ground-based data, it was necessary to develop internal calibration methods to more accurately describe the diffuser degradation in the absence of a direct measurement. One of these methods is called the "Spectral Discrimination Method." It takes advantage of the fact that the observed albedo response to diffuser degradation is roughly linear with wavelength in the 305-400 nm region (Figure 1), while the effect of a real decrease in atmospheric ozone would produce an exponential change with wavelength of the measured albedos. Given a sufficient number of wavelengths, these two spectral features can be easily separated. A simplified version of this method that used only selected pairs of wavelengths (called the Pair Justification Method) was used to correct total ozone measurements from the SBUV/TOMS instrument (Herman *et al.*, 1991). This method could be improved further by using continuous spectral data. Although the SBUV has a limited amount of spectral data, the GOME instrument has been designed to take full advantage of this technique.

Unfortunately, this method is limited to wavelengths longer than 305 nm. At shorter wavelengths, ozone changes produce linear rather than exponential change in radiance with wavelength that cannot be readily separated from diffuser degradation. For shorter wavelengths a different technique was developed, inspired by the so-called Langley Plot method, long used for the calibration of ground-based ozone instruments. This method compares the ozone values derived from measurements made at different solar zenith angles. Ozone can be observed under these conditions when the polar region is in perpetual sunlight and the same latitude band is observed twice; once during the ascending portion of the orbit and again during the descending portion. Since the solar zenith angles for these two sets of measurements are different, the Langley Plot method can be applied to these data. The actual application of this method to BUV measurements is complex (Bhartia *et al.* 1995), and subject to uncertainty from the diurnal variation of ozone in the upper stratosphere. Nevertheless, this method worked quite well based on ground and satellite intercomparisons. The uncertainty in estimating the 274 nm albedo is about ±3%. This translates to uncertainty in ozone at 2 mb of about ±5% over the 12-year life of the SBUV instrument, during which the diffuser itself suffered a degradation of about 40% at this wavelength.

On-Board Calibration Systems

To overcome the difficulty experienced with the Nimbus-7 diffuser degradation, the NOAA SBUV/2 instruments carry an on-board system to measure diffuser reflectivity change. This system consists of a low-pressure-discharge mercury lamp, which is viewed by the instrument directly and then is viewed by the instrument via the diffuser. This system failed on the NOAA-9 instrument but worked satisfactorily on NOAA-11. The diffuser reflectivity is determined

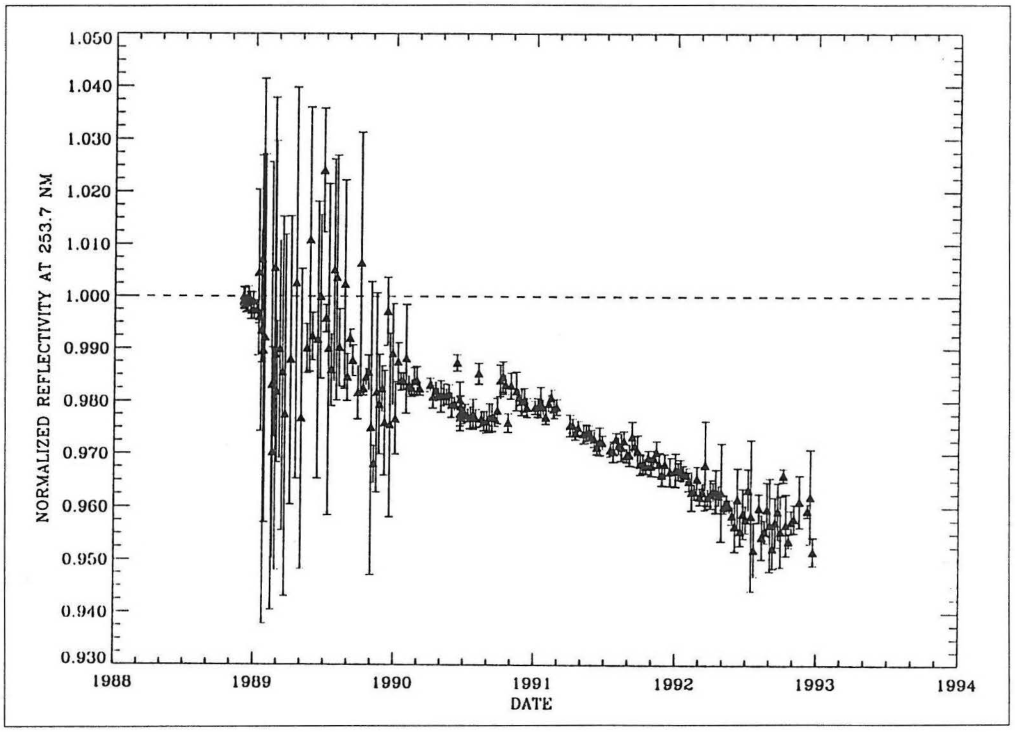

Figure 3. SBUV/2 solar diffuser degradation as measured using the on-board system. Noise appearing in the first year was due to grating drive errors.

from weekly measurements of six strong lines of the mercury lamp. Figure 3 illustrates the diffuser reflectivity change at the 253.7 nm line of the lamp (noise in the data during the first year was caused by some imprecision in the grating drive). With this and similar data at other mercury lines, a linear fit over time and then over wavelength was derived. This yielded time-dependent correction coefficients at all wavelengths covered by the SBUV/2 measurements through January 1993. (Since that time NOAA has employed an extrapolation of those coefficients for operational processing). Other time-dependent factors including temperature, gain, and instrument goniometry (which was sensitive to the NOAA satellite drifting orbit) were all corrected for in the most recent reprocessing of the NOAA-11 SBUV/2 data (Hilsenrath *et al.* 1995).

The Meteor and subsequent TOMS instruments incorporate further refinements to minimize and measure diffuser degradation. These instrument diffusers consist of three surfaces in a carousel configuration. The first surface is a cover and exposed to space most of the time. The second surface is the working diffuser and exposed to the sun about one hour per year. Finally, the third surface is used as a reference and only exposed less than one third hour per year (Jaross *et al.* 1994). The upcoming TOMS, to be flown on the U.S. Earth Probe and on the Japanese ADEOS 1, will incorporate both the carousel and an on-board system to measure diffuser reflectivity.

Inter-satellite Comparison

Another method to evaluate and calibrate an aging satellite instruments' sensitivity is to compare its data with data taken from a freshly launched instrument. In accordance with this concept, the National Plan (1989) called for regular flights of an SBUV instrument (called the SSBUV) on the Space Shuttle as additional assurance that the drift in the NOAA SBUV/2 instruments would be accurately corrected. The strategy for employing SSBUV to check the calibration of the NOAA instruments was described by Frederick et al. (1990). Accurate flight-to-flight SSBUV calibrations are critical to achieving this goal and are checked regularly. Calibration precision has been tracked with a precision of 1% (Cebula *et al.* 1989, Hilsenrath *et al.* 1993). SSBUV has flown seven times since 1989 and has conducted near simultaneous observations with all of the instruments listed in Table 1 except for the Nimbus-4 BUV.

The NOAA-11 SBUV/2 data were corrected using the on-board system discussed above as a first step. Its calibration was then further checked using nearly coincident SSBUV observations in the following way. From a coincident data set (approximately 60 coincidences per mission), an Albedo Normalization Factor, (ANF) was computed from the difference in the measured albedos between the two instruments with a further correction factor to account for the fact that the measurements from the two instruments are not taken under identical conditions. The correction to measured albedo difference is calculated from a radiative transfer code which accurately predicts the albedos for a given solar zenith angle, surface reflectivity, wavelength (ozone cross section) and ozone amount (measured from one of the two instruments). The ANF values were computed for three SSBUV flights covering the period 1989 to 1991 and then used to correct the NOAA-11 SBUV/2 pre-launch calibration and to verify the time-dependent corrections derived from the on-board systems (Hilsenrath *et al.* 1995). Table 2 summarizes those results and lists percent ozone corrections to the NOAA-11 operational (uncorrected) data set for the period January 1989 to April 1993. In principle, an ANF correction could be used between any number of BUV instruments in orbit after selecting one as the standard and then defining coincidence criteria between the two.

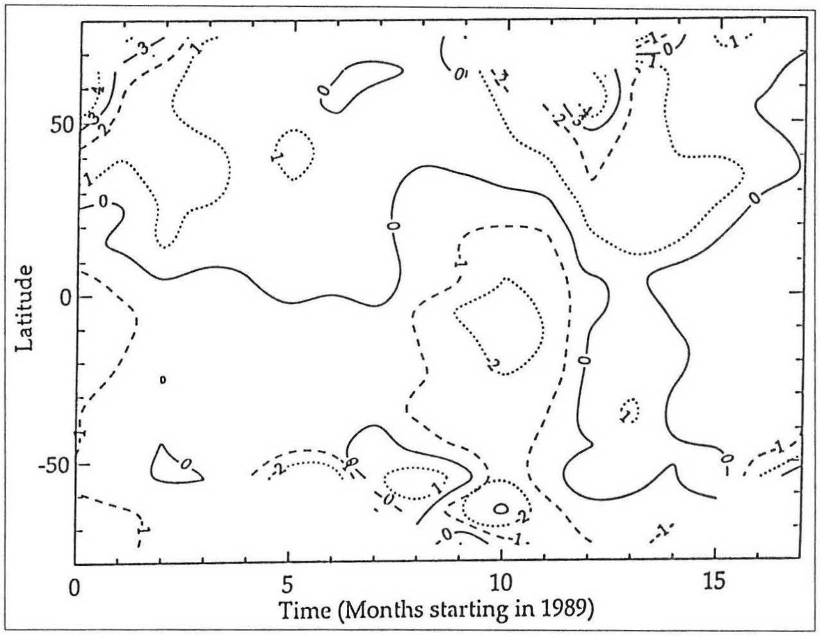

Figure 4. Comparison of SBUV and SBUV/2 total ozone for the period when the two measurements overlap as a function of latitude and time. Contours are ((SBUV- SBUV/2)/SBUV)x100.

	Pre-launch	Time Dependent (per year)	Total (after 4 years)
Total ozone	1	0.4	2.5
Ozone at 15 mb	0	0.8	3.2
Ozone at 1 mb	5	3.0	16.0

Table 2. Percent Corrections for NOAA-11 SBUV/2 Data

The NOAA-11 SBUV/2 data, reprocessed with an improved algorithm and the calibration corrections discussed here, have been reported by Planet et al. (1994) to describe the effect of Mt. Pinatubo aerosols on the recent trends in Northern Hemisphere ozone global amounts. SSBUV data, using a refinement of the process described above, are now being employed to verify the calibration of Nimbus-7 and Meteor-3 TOMS with promising results. However, correction of the TOMS data is much more complex because of large scene variability. Larger scene variations occur with TOMS comparisons because of its higher spatial resolution and because observations are made at wavelengths (>300 nm) that are reflected from the Earth's surface.

Results

With these corrections, the NOAA-11 SBUV/2 data can now be compared to overlapping data from the Nimbus-7 SBUV. These data, which overlap for about 18 months starting in 1989, are compared in Figures 4 and 5. Figure 4 illustrates the difference in total ozone between the two instruments as a function of latitude and time. The differences are on the order of 1% except at high-latitude winters where they differ by as much as 4%. This most likely results from the fact that the measurements from the two instruments are made at different solar zenith angles at the same latitude. This solar zenith angle effect most likely results from residual calibration errors in one or both of the instruments. Figure 5 illustrates a time series of ozone centered at 3 mb, over Southern Hemisphere mid latitudes, for both SBUV and SBUV/2. This is the altitude most sensitive to ozone destruction by anthropogenic chlorine via homogeneous chemical

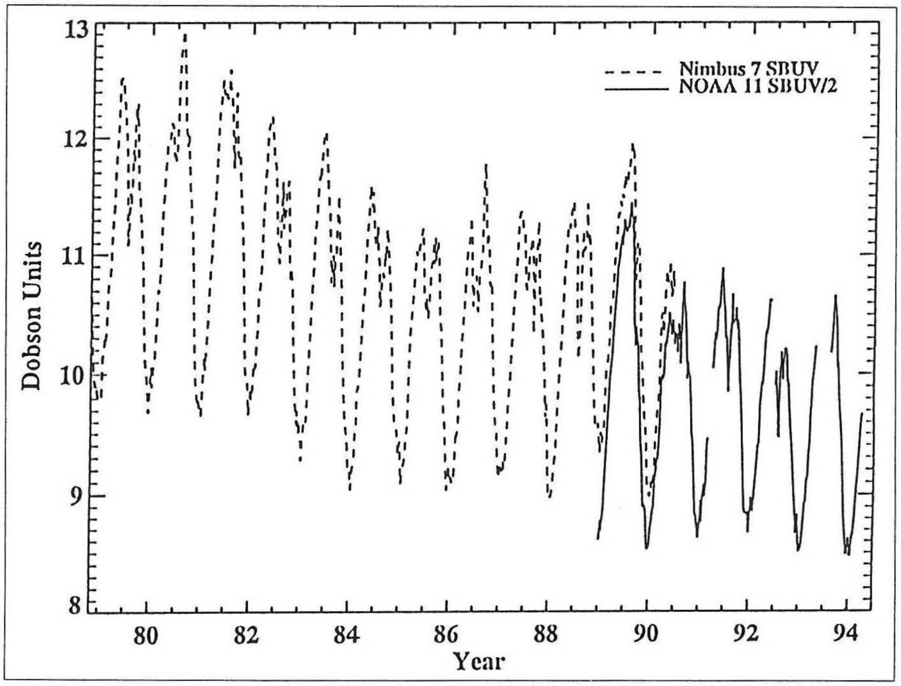

Figure 5. Time series of ozone in a layer 2-4 mb zonally averaged over 30 S to 50 S. Nimbus-7 SBUV data are dashed and NOAA-11 SBUV/2 data are solid lines.

catalytic processes. The corrected SBUV/2 data match the SBUV data fairly well. The annual cycles and the long-term trend in ozone superimposed on the 11-year solar cycle are also clear. The differences in ozone are about 6% which translates into an albedo difference of only 3% for the corresponding wavelength. This is a remarkable result considering the history of the two data sets. Several studies are now underway to combine these data sets to derive ozone trends as a function of latitude and altitude for the period 1979 to 1993.

Conclusion

We have discussed some of the tools that the Goddard Ozone Processing Team has used over the years to create a trend-quality ozone data set from the BUV instruments. Development of these techniques has required close collaboration between instrument and algorithm scientists and data users. In addition, a long-term project with stable personnel has been critical to the success of these efforts. We have discovered that creating high-quality satellite data sets is a highly iterative process. One starts with an incomplete understanding of how the Earth's atmosphere and surface affect the radiances measured by the satellite instrument. Uncertainties in both pre- and post-launch calibration of the instrument add to this uncertainty. For climate research, where one is dealing with small changes embedded in large short-term variability, these uncertainties make it difficult to separate between "true" change and those that are caused by small systematic errors in calibration and the algorithm. However, as the length of the data record builds and multiple instruments of the same type are launched, identification of various sources of errors becomes increasingly precise.

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The News from the Langley DAAC

—**Lise D. Maring** (l.d.maring@larc.nasa.gov, Langley DAAC)

The Langley Distributed Active Archive Center (DAAC), located at the NASA Langley Research Center in Hampton, Virginia, officially opened its doors in January of 1992 with the completion of its local IMS (Information Management System), which allowed users to search through the DAAC's inventory of available data products and to place an order. Since then, "business" has increased steadily with each new data product being made available to the scientific community.

The Langley DAAC is responsible for archiving and distributing remote sensing data in the areas of radiation budget, clouds, aerosols, and tropospheric chemistry. Some of its main holdings include data products from the Earth Radiation Budget Experiment (ERBE), the Stratospheric Aerosol and Gas Experiment (SAGE), the Surface Radiation Budget (SRB), the International Satellite Cloud Climatology Project (ISCCP), the First ISCCP Regional Experiment (FIRE), and the Global Tropospheric Experiment (GTE). The SRB data and the ISCCP C2 data are available on CD-ROM. Many of the data products are also available via ftp.

The Langley DAAC is currently preparing to receive the ISCCP D1 and DX products from NASA/GISS for archiving, along with some newly available ISCCP B3 data (July 1991 through June 1992). Work is continuing on the SAGE II, FIRE, and GTE products, and some of the ERBE products, such as S7, S4N, and S4GN (these data products utilize nonscanner data only). The SAGE II Nitrogen Dioxide Concentration Profiles will soon be ready for distribution.

The Langley DAAC works closely with its User Working Group to assure that prospective data products will be relevant to the scientific community, and that available DAAC resources will be utilized in the most efficient manner to archive higher priority data sets. The data ingest team includes members of the User Services staff, programmer/analysts proficient in working with remote sensing data and Hierarchical Data Format (HDF), members of the IMS group, and graduate students from the William and Mary Department of Atmospheric Sciences. The team works closely with the data providers to assure accuracy and quality of the data products prepared for archiving at the DAAC. The on-line guides are written primarily by the data providers and reviewed by the DAAC team. Wherever possible, accompanying software and user's guides are also developed and made available to the user community.

This team is currently working diligently to archive existing heritage data sets and to prepare for the EOS missions in the future. The data ingest team has shared with the EOSDIS Core System (ECS) contractor, Hughes Applied Information Systems, some of the lessons learned in archiving a number of data products and in working with a variety of data formats. The team recently assisted Hughes in their task to formulate a data archival cost model by filling out data set archival surveys and by participating in several telecons.

Future missions to be supported by the Langley DAAC include the Clouds and the Earth's Radiant Energy System (CERES). CERES, due to be launched on TRMM (Tropical Rainfall Measuring Mission, a joint U.S.- Japanese venture) in 1997 and followed by a launch on the Earth Observing System EOS AM satellite in 1998 and the EOS PM satellite in 2000, will be the DAAC's first EOS data set to be processed at the DAAC utilizing hardware and software systems put in place by the ECS contractor. This mission will measure the Earth's radiation budget and atmospheric radiation from the top of the atmosphere to the surface and will permit retrieval of cloud parameters in terms of measured areal coverage, altitude, liquid water content, and shortwave and longwave optical depths.

The Langley DAAC is working closely with the ECS contractor in order to be ready for the TRMM launch in 1997. Langley will be one of the recipients of an earlier release of the EOSDIS Core System being developed by Hughes to replace the V0 System-Level IMS. Although this release will not have the full range of capabilities the V1 Release is scheduled to have, it will need to have the necessary tools to ingest and archive the large volumes of CERES L0 data as it is received from the Sensor Data Processing Facility. The DAAC and Hughes are currently working on defining the interface requirements for being able to meet the 1997 launch date.

For more information about the Langley DAAC and available data products, please access the Langley DAAC Home Page using Mosaic at URL http://eosdis.larc.nasa.gov.

Users can also contact the Langley DAAC User Services staff at the following e-mail address or telephone number (804) 864-8656. For instructions on how to access the local IMS or the V0 System Level IMS at the Langley DAAC: llarc@eos.nasa.gov

LIS SCIENCE TEAM MEETING

Feb. 20-22, 1995

Contact: Steven J. Goodman (205) 922-5891 (steven.goodman@msfc.nasa.gov)

The next LIS science team meeting will be held at the Global Hydrology and Climate Center (GHCC), 977 Explorer Blvd, Huntsville, AL 35806 during the period Feb. 20-22 in Room D101 (1st floor conference room). The main emphasis of this meeting will be on cloud/electrification model activities, progress and plans and status of TRMM Combined algorithm input (Tall Vector Approach). (Similar to the last LIS science meeting held in Boulder, CO).

The list of hotels and map can be found on the Mosaic Homepage at URL http://rimeice.msfc.nasa.gov:5678/

A Visit to the Boreal Ecosystem-Atmosphere Study (BOREAS)

— **David Herring** (herring@ltpsun.gsfc.nasa.gov), MODIS Administrative Support, Science Systems & Applications, Inc.

In 1994, scientists from NASA/GSFC—along with some 85 science teams from universities, governments, and industry worldwide—made five trips to midwestern Canadian provinces to study the relationships between the boreal forest and the Earth's atmosphere. Part of the Boreal Ecosystem-Atmosphere Study, or BOREAS, these intensive field campaigns (IFCs) are the largest of their kind ever conducted. The objective is to improve our understanding of the exchanges of radiative energy, heat, water, carbon dioxide, and trace gases between the boreal forest and the lower atmosphere. Using data from myriad satellite, aircraft, and ground-based platforms—from both remote sensing and *in situ* measurements—scientists will develop computer simulation models of boreal ecosystems that will enable them to visualize the dynamics of those systems and, hopefully, predict how they affect and will be affected by global climate change.

NASA/GSFC's Code 923 provided much of the leadership and all of the operations and data system management for BOREAS. Drs. Piers Sellers and Forrest Hall headed up the effort within NASA/GSFC. According to Sellers, the idea for BOREAS came as a natural progression from the FIFE (First ISLSCP Field Experiment) and ABLE (Atmospheric Boundary Layer Experiment) campaigns. Sellers and Hall played lead roles in both FIFE efforts in 1987 and '89.

Hall says that BOREAS had two main goals: "First, to generally understand how the land's vegetated surface couples with the Earth's lower atmosphere to influence weather in the short term and climate in the long term. There are a lot of specific questions that arise from that goal. For instance, where is the missing carbon in the boreal ecosystem and how might the carbon balance change if there are climate changes?

"The other goal," Hall continues, "is learning how to better use satellites on a global scale to monitor change and provide information concerning global change." Lessons learned on BOREAS will directly benefit EOS.

Science Background and Objectives

Throughout history there have been many natural changes in the Earth's climate. Today, there is strong scientific evidence that human activities are contributing to the recent global warming trend. "Currently, we do not have adequate models to predict the future course of global warming," Sellers states. "But BOREAS will provide much needed data that will help us refine our models and validate them."

Stated simply, the problem lies in observing and measuring trends in global processing and dynamics for a sustained period of time, quantifying significant anthropogenic effects on local and global ecosystems, and then somehow differentiating between the two to characterize how the global ecology works naturally. However, BOREAS itself is not a long-term endeavor. Rather, the idea is to test a number of key hypotheses concerning the fundamental physical, biological, and chemical processes inherent in boreal ecosystems, then use these hypotheses in computer simulation models to predict what changes might occur under certain conditions.

Theoretically, significantly increased concentrations of greenhouse gases—such as carbon dioxide and methane—in the atmosphere serve to trap longwave radiation in the Earth's atmosphere, resulting in temperature increases. We do not know to what degree the relationship between greenhouse gas and temperature increase is proportional. Nor do we fully understand how a global increase in greenhouse gas concentrations, and a corresponding rise in temperature, will affect other parts of the Earth system—some of which could feedback to exacerbate the temperature or greenhouse gas problem. We do know that terrestrial ecosystems are a significant source and sink for carbon dioxide, second only to the oceans (Asrar and Dozier 1994). Scientists estimate that global terrestrial ecosystems take up to 1 to 2 gigatons per year of anthropogenic carbon dioxide (Asrar and Dozier 1994).

Boreal forests are estimated to store a sixth of the land's organic carbon (Hall *et al.* 1993). Typically, boreal forests are characterized as being located in cold, northern latitudes; containing any combination of the following species of trees: aspen/birch, larch, jack pine, black/white spruce; and containing bogs and fen complexes. Scientists hypothesize that as global temperature rises, the bogs/fen complexes of the mid-continental forests will begin to dry up (Hall *et al.* 1993). As drying occurs, the southern boundaries of the boreal forests could slowly shift northward, succeeded by other grassland species better suited for warmer, drier climates (Sellers *et al.* 1995). Theoretically, the northern boundaries will also slowly retreat, succeeded by conifers (Sellers *et al.* 1995). These changes are likely to be associated with changes in the carbon dynamics of the area; it is possible that the region may become a net source rather than a net sink for carbon.

Scientists have found that better understanding the interchange of energy (heat and light) and moisture between the forest and the lower atmosphere is an important piece of the puzzle. We know that much of the sunlight absorbed by the surface is used to evaporate water and release sensible heat. This process serves to cool the surface and heat the atmosphere, leading to increased cloud formation.

A Day in the Life of BOREAS

A typical day in the life of the BOREAS campaign actually begins the night before. Science investigators, flight crew, meteorologists, and other support staff assemble—either physically at the operations center or remotely, linked via conference call and speaker phones—to report on the day's work just done, to review the next day's weather forecasts, and then to plan the next day's work.

Work typically starts around 3 a.m. with the first meteorological updates. These are used to start committing aircraft to their respective flight patterns. This information is especially critical in planning ER-2 sorties because it typically flies long routes. Then, later in the morning, air crews are updated on the weather forecasts and planned surface operations. As the day progresses, the aircraft are fed into the sites.

"There were sometimes eight aircraft at one time operating within a rather small air space," Sellers states. "But most days we didn't get that far—usually due to bad weather, sometimes equipment failures." While operations were in progress, the teams were in constant touch with one another, sending and receiving updates on their progress. Then, at the end of the day, the teams reassembled to begin the cycle again.

Logistically, in its day-to-day proceedings, BOREAS was a step up in complexity over FIFE, largely due to lessons learned from FIFE. "We learned we needed a good radio telecommunications system between researchers in the field, researchers in aircraft, and the mission operations centers in order to implement real time changes in our [data collection] strategy," Hall explains. "In BOREAS, the operations center could talk to investigators at sites 300 miles away, or researchers at different sites could talk to one another." Effective communications enabled the teams to respond quickly to technical problems (e.g., dead batteries in instrumentation) and adapt quickly to changing weather conditions.

"In BOREAS, we had to learn how to operate in very inaccessible environments," Hall continues. "Where some BOREAS sites are miles from telephone lines, roads, and electrical power, we worked for years prior to the campaign to establish the needed infrastructure."

Experiment Design and Project Organization

BOREAS provides EOS with a rare opportunity to intercompare high quality data from a variety of platforms and instruments. The BOREAS Team used a nested, multiscale measurement strategy to integrate observations and process models over a defined range of spatial scales (Sellers *et al.* 1995). At the regional scale, satellites and aircraft were used to collect remote sensing and flux measurements, as well as to provide meteorological observations and modeling. These data provide an overview of the dynamics involved in the exchanges of energy, water, and carbon between the land surface and the lower atmosphere.

Satellite data include those of AVHRR, ERS-1, GOES, LANDSAT, SPOT, and SSM/I (DMSP). Eleven aircraft—including an Aerocommander, C-130, Chieftain, CV-580, DC-8, ER-2, Helo, LongEZ, Twin Otter, Electra and King Air—were used to gather remote sensing and flux data. Among the aircraft instrumentation used, two were developed by Goddard principal investigators: the MODIS Airborne Simulator (MAS) and the Advanced Solid State Array Spectrometer (ASAS). Additionally, some retrospective meteorological satellite and *in situ* data dating back to 1974 are being collated.

From late 1993 to 1994, over a 13-month period, BOREAS researchers gathered data across a 1,000 km by 1,000 km region covering most of Saskatchewan and Manitoba, Canada. During this time, some 300 scientists and support crew conducted five intensive field campaigns (IFCs) lasting for a total of 123 days.

Within the BOREAS region, two study areas—one (8,000 km^2) toward the northern and one (11,170 km^2) toward the southern boundaries of the boreal forest—were chosen as foci for the satellite and airborne remote sensing studies, airborne flux measurements, and mesoscale modeling. Within the study areas, ten towers were erected at specific sites to measure the fluxes of radiation, sensible heat, water and carbon dioxide, and some meteorological variables (e.g., temperature, pressure, humidity, wind speed, etc.) at the boundary layer between the forest canopy and the lower atmosphere. Additionally, about 80 auxiliary and process study sites were established for gathering *in situ* ground data to complement remote sensing data.

A mesometeorological network was put in place between and around the two study areas to coordinate the ground-based process studies with remote sensing investigations conducted using satellite, airborne, and surface-based instruments. This network is comprised of a number of atmospheric profiling/sounding rigs and surface meteorological stations which were arranged to enable the team to understand the relative importance of horizontal transport of heat and moisture with respect to surface-atmosphere transfers.

The BOREAS data collection strategy provides an excellent springboard for parameterizing EOS models and modifying remote sensing algorithms.

BOREAS Modeling Team

Parallel to the data collection efforts, a team of computer modelers was established. The modelers' objective was to synthesize all of the BOREAS data into a collective, holistic look at the boreal forest.

"Our goal is to extrapolate in space and time beyond the direct measurement campaign," Dr. Steve Running, of the University of Montana, explains. "For example, if you want to know the carbon flux [for the boreal forest] for a whole year, yet only have measurements during IFCs at a couple of tower sites, you will need to extrapolate the missing information. Modeling gives continuous fluctuations and spatial representations across the boreal ecosystem that measurements could never do. You can't take data all of the time everywhere."

So now that the BOREAS campaign is over, the bulk of the modelers' work lies ahead. But they, too, got a head start on their efforts—they held workshops in February and July 1994.

"Our effort in July was to give everyone practice in parameterizing their models to represent the basic boreal biome types," Running states, "and to perform initial test simulations for the tower flux sites. Now, as actual field data are coming in, and 1994 climate data are coming in, we can begin doing real simulations of the boreal ecosystem through 1994 to include all IFCs, field data, and aircraft and satellite data."

Computer models will allow investigators to explore the system mechanisms behind some of the flux data.

"The towers measure carbon dioxide flux as a final aggregate number. But the models allow us to separate the carbon dioxide flux into its separate components: photosynthesis, autotrophic respiration, decomposition, and soil respiration." In short, models allow differential calculations of boreal-atmospheric interactions and activities in ways that aircraft instruments cannot.

BOREAS Information System (BORIS)

A BOREAS Information System (BORIS) was begun in 1990 at GSFC to electronically store and distribute data from the campaigns. Patterned after the FIFE Information System, BORIS is a data processing, management, and dissemination system that assists investigators in documenting submitted data sets, checks the quality of submitted data for internal consistency, and facilitates intercomparison of related data sets. All BOREAS investigators are linked to BORIS (a micro VAX system), facilitating quick access to data as they are ingested.

"There are a lot of data already online and accessible to BOREAS investigators," states Jeffrey Newcomer, BORIS Manager. "So far there is good consensus among team members as to what the data are showing." Newcomer projects that BORIS' data holdings will reach 0.5 terabytes.

"For now, BOREAS data are available only to BOREAS team members," Newcomer points out. "Until the data are deemed distributable to the outside community, outside users do not have access to BORIS."

But eventually BOREAS data will become available to outside researchers. Newcomer is currently working with EOSDIS and the Oak Ridge DAAC to develop a Memorandum of Understanding for data distribution.

Early Findings or Results

Although it could take years to fully examine the data and develop a clear picture of boreal ecosystem dynamics, there are already some surprising preliminary results from the BOREAS campaigns. BOREAS investigators report that in May and June of 1994—early in the growing season—"the boreal forest was releasing very little water vapor to the atmosphere with the result that the atmospheric boundary layer, pumped by large amounts of surface sensible heat flux, often reached 3,000 meters in depth." This is partly because the soil/water layers between 30-100 cm in depth—the root zone of most boreal trees—was still frozen (Sellers *et al.* 1995).

BOREAS investigators observe that in terms of its water and energy balance, the Canadian boreal ecosystem often behaves like an arid landscape, particularly early in the growing season. "Even though the moss layer is wet for most of the summer, the poor soils and harsh climatic conditions lead to low photosynthetic rates, which in turn lead to low evapotranspiration rates," they explain in their summary report. "A large fraction of the precipitation simply penetrates through the moss and sand to the underlying impervious layer and runs off." (Sellers *et al.* 1995).

Most incoming sunlight is intercepted by the boreal vegetation canopies, which therefore control water loss from the moist underlying moss/soil forest floor. Consequently, much of the available surface energy is dissipated as sensible heat, which leads to the development of the aforementioned deep and turbulent atmospheric boundary layer. So, contrary to early characterizations, the boreal ecosystem is not a freely evaporating surface (Sellers *et al.* 1995).

"The important variables controlling photosynthesis and evaporation appear to be soil temperature in the spring, and atmospheric relative humidity and air temperature in the summer and fall," BOREAS investigators state in their report. "This new understanding of controls on regional evaporation rates is relevant to the issue of whether the boreal ecosystem is a sink or source of carbon, but until the analysis is further along this question will remain unresolved. As far as we know, all current climate and numerical weather prediction models grossly overestimate evapotranspiration from the region." (Sellers *et al.* 1995).

Suggested Future Studies

As they are beginning to find answers, BOREAS investigators are also asking more questions. "Certainly there's already a desire to get funding to go back and supplement the BOREAS data set in 1995," Newcomer states. "Plans are afoot already."

What about tropical systems? According to Hall, tropical systems appear to be neither a sink nor a source of carbon; rather, they somehow roughly maintain a balance between the biosphere and atmosphere. Further studies are needed to understand the dynamics of tropical ecosystems, as well as how they affect and are affected by global climate change. Already, two campaigns are in the earliest stages of planning—LAMBADA (or Large-scale Atmospheric Moisture Budget of Amazonia/Data Assimilation) and BATERISTA (or Biosphere-Atmosphere Transfers/Ecological Research/In situ Studies in Amazonia).

Funding Sources

The U.S. component of BOREAS was funded primarily by NASA, but the campaigns also received sponsorship in the United States from NOAA, NSF, U.S. Geological Survey, and EPA. In Canada funding came from Agriculture and Agri-Food, Atmospheric Environment Service, Centre for Remote Sensing of Natural Resources, Forest Service of Natural Resources, National Research Council, Natural Sciences and Engineering Research Council, Global Change Program of the Royal Society of Canada, and Parks Canada.

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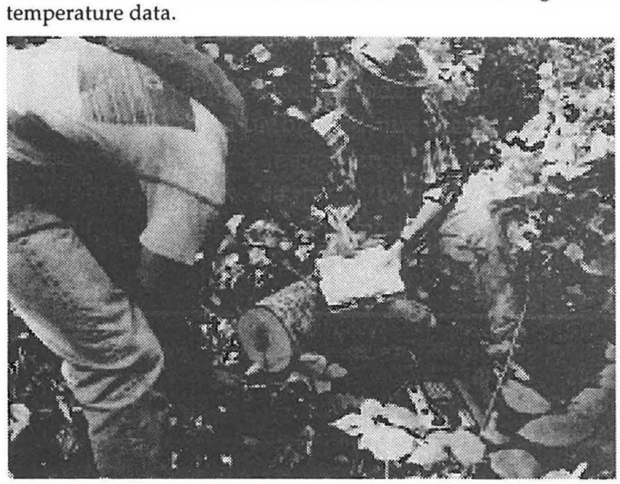
Mounted on special platforms and flown on the NASA Helicopter were various instruments for measuring optical thickness, bidirectional reflectance off of the forest canopy, and taking remote sensing data in the visible, near infrared, and infrared regions of the spectrum. The platforms were designed by Jan Kalshoven of Goddard Space Flight Center.

Canada's Twin Otter aircraft was used to take flux measurements within the forest-atmosphere boundary layer. Also, three microwave radiometers were mounted to collect calibrated brightness temperature data.



(Photos by David Herring)

George Washington University Graduate Students Randy Cacciola (left) and Ozlem Kilic are using a microwave dielectric probe to measure soil and vegetation dielectric constants. Protective netting was worn to help repel swarming mosquitos and other biting insects.

From EOS.News

Republicans and Science
The New House Science Committee Chairman Sets Agenda

Public Information Division
American Institute of Physics
FYI No. 169, December 16, 1994

Wednesday afternoon, the incoming chairman of the newly-renamed House Committee on Science held a briefing to explain his committee's agenda for 1995. At the end of the hour-long presentation, it was clearly evident that Robert Walker (R-PA) has a clear view of where he wants to take his committee.

Rep. Walker's views are important from a number of perspectives: as chairman of the House Science Committee, vice chairman of the House Budget Committee, and as a key player in the House Republican leadership. Because of the great interest in the direction of science policy and funding in the new Congress, this FYI is of an extended length. Topics are shown in capital letters.

Walker began by noting current chairman GEORGE BROWN's (D-CA) presence, saying "we intend to work in close cooperation on developing the agenda of this committee, as we have done in the past...I assure you that our continued working relationship will serve the best interests of science and the country."

Addressing the COMMITTEE'S NEW NAME, Walker said that dropping the words "technology" and "space" is not an indication that the committee was diminishing the importance of these areas. He noted that it was keeping its current jurisdiction, and was adding energy research, oceanography, and other responsibilities. The NEW SUBCOMMITTEE NAMES (Space and Aeronautics, Basic Research, Energy and Environment, and Technology) "reflect what the true priorities of this committee will be over the next couple of years."

Walker said FULL COMMITTEE HEARINGS will be "related to the future." An early January hearing will receive testimony from relevant cabinet members asking them "to look at the next century, and tell us what they think their various agencies and departments should be doing to prepare us for the new economy and the new culture...." NASA has already agreed to participate.

The SUBCOMMITTEES will work "aggressively" on MULTI-YEAR AUTHORIZATION bills for NASA, DOE, NSF, and NOAA. Walker hopes for better cooperation from the Senate in passing these bills than there has been in the past. This should help, he later said, to place science policy decisions back in the authorization committees. The subcommittees will also be charged with doing "a lot" of oversight activity.

"As chairman of the committee, what I'd like to do is engage in a DIALOGUE with the American people, the SCIENCE COMMUNITY, and with my colleagues which reasserts the value of science as a means for bringing our country a future of sustained growth built on new discoveries, and based upon improved technology that's derived from those new discoveries," Walker said.

The new chairman predicted that his committee will highlight how ECONOMIC EMPOWERMENT and reduced regulations will nurture an environment conducive to being able to "invent our ways out of crises." As an example, he plans to act soon on the House-passed HYDROGEN RESEARCH BILL, which died upon adjournment.

"In my view, real science is not something that should be used to confirm a political agenda," Walker stated. He predicted early hearings on MISSION TO PLANET EARTH, the GLOBAL WARMING PROGRAM, and a number of other programs where he said there have been "concerns raised about whether some of the science being done is more in tune with politics than it is with real scientific measurement." Walker said he wants to ensure that the Mission to Planet Earth program is "going in the right direction."

In fulfilling the committee's portion of the Republican Contract with America, Walker said that he would act "very quickly" on RISK ASSESSMENT LEGISLATION.

Regarding the SPACE STATION, Walker described himself as an "enthusiast," and said the committee will move "aggressively on" the program. He later said, "As far as I am concerned, it's certainly safe," adding "Republicans have always been pretty supportive of space station...." Walker supports incentives for commercial space activities, and has already talked with the new House Ways and Means chairman.

Asked about future NASA FUNDING, Walker replied, "I believe that the space program, if it is going to maintain its ability to be a technological driver in our society, has to at least get resources enough to allow it to keep up with inflation." Walker wants to get more nongovernmental space funding, saying, "I don't think that everything we do in space has to come through the front door of NASA." He later expressed support for the "small sat" program.

The new chairman wants the committee to be "dramatically involved" in EDUCATION, citing its jurisdiction over the National Science Foundation. He continued, "I believe in UNIVERSITY-BASED RESEARCH," saying that some federal science centers should move to a university association. He cited NASA's Jet Propulsion Laboratory as a model.

Walker characterized Rep. Brown's moves against academic EARMARKING as courageous. "That is work we will continue in this Congress." Walker will work for a way to penalize academic institutions seeking earmarks. "They need to know that if they try to by-pass us, there may be a penalty for them in so doing." He will work with the appropriations committee to prevent earmarking.

During a question period, Walker was asked about NIST's TECHNOLOGY PROGRAMS. He said he was supportive of NIST's core program "that provides a very, very important role for our country," citing standards-setting. "I am less than enthusiastic about some of the places where they have moved toward becoming the font of national industrial programs; the ATP Programs [Advanced Technology Program] and some things of that type. I would rather divert some of the monies that are headed in that direction toward the core program...." He later said he favors the ultimate elimination of ATP.

"We are probably going to look at the ELIMINATION OF SUCH AGENCIES," Walker said, when asked about a Republican Budget Committee staff memo suggesting that USGS and the Bureau of Mines be eliminated. In regard to specific agencies, Walker said, "I don't know." Insofar as the Office of Technology Assessment, he declared, "I have an open mind on that; I believe that they have done some valuable work." He wants the office restructured to "be more relevant to the legislative process." Walker later added that his committee will work closely with the appropriations committee if any programs are defunded. He was "not prepared" to discuss specific programs.

Walker indicated his continued support for a new cabinet-level DEPARTMENT OF SCIENCE. He is awaiting the administration's plans for downsizing the federal government. Such a department would "ensure that there is a voice for science at the cabinet table."

When asked about FUSION PROGRAM funding, Walker replied: "I think we need to take a look at the money we have been spending in the fusion area. It's certainly an area that we have to look at in hearings; the Department of Energy may be coming forth with some recommendations in that area.... What we can't afford to do is to have massive cost overruns in that program. It is a program where there has been a lot invested over a period of a lot of years. And I think it now needs to be examined very, very carefully in light of a lot of budget constraints that we're going to have."

Later in the briefing, discussion returned to the DOE FUSION PROGRAM, and Tokamak funding. "I am concerned about the fact that particular project has gone up in cost by about 50%, and as a result, has captured my attention," Walker exclaimed. He said he "was not prepared to make that kind of judgement" when asked about shutting down magnetic fusion research. Walker supports international cooperation for expensive programs.

The new chairman was also asked about the NATIONAL SCIENCE FOUNDATION. "I will tell you that my own bias with regard to NSF is toward having NSF be essentially a basic science agency, rather than an applied science agency. I believe that too much of NSF money is getting diverted these days toward applied research. And I would like to see NSF be far more concentrated on being a basic research kind of agency, supporting basic research at the university level." When asked about a Republican Budget Committee staff suggestion to limit budget increases for NSF, Walker replied, "I don't know. I'm not familiar with the staff document. I wasn't on the Budget Committee at that point." He then spoke of his, and incoming House Speaker Newt Gingrich's (R-GA) long-standing desire "to see these programs move forward. I don't think that has changed. How much we are able to do with the constraints...and the need to approve our balanced budget, I'm not sure yet." Walker said that his service as Vice-Chairman of the House Budget Committee will be important in this regard.

At the end of the briefing, Walker spoke of a commonality of science and technology interests with the WHITE HOUSE. He advocated cooperation between his committee and White House policy makers on moving programs forward.

Contact: Richard M. Jones
E-Mail: fyi@aip.org, telephone: (301) 209-3095

Science Calendar

February 20-22	LIS Science Team Meeting, Global Hydrology and Climate Center, Huntsville, AL. Contact Steven Goodman at (205) 922-5891 (steven.goodman@msfc.nasa.gov)
February 21	AIRS Science Team Meeting, UCSB,Santa Barbara, CA. Contact Dr. H.H. Aumann at (818) 354-6865, (hha@airs1.jpl.nasa.gov)
February 28-March 1	SAGE III Science Team Meeting, NOAA, 3100 Marine Street, Boulder, CO. Contact Pat McCormick at (804) 864-2669 (m.p.mccormick@larc.nasa.gov).
February 28-March 2	SWAMP Meeting, NASA/GSFC area, Greenbelt, MD. Contact Piers Sellers at (301) 286-4173 (piers@imogen.gsfc.nasa.gov).
March 6-8	Workshop on Results from the GEOS-1 Five Year Assimilation, NASA/GSFC, Greenbelt, MD. Contact Siegfried Schubert at (301) 286-3441, (schubert@dao.gsfc.nasa.gov), or Richard Rood at (301) 286-8203 (rood@dao.gsfc.nasa.gov).
April 19-21	CERES Science Team Meeting, NASA Langley Research Center. Contact John Nealy at (804) 864-4412 (j.e.nealy@larc.nasa.gov).
May 3-5	MODIS Science Team Meeting. Contact David Herring at (301) 286-9515 (herring@ltpsun.gsfc.nasa.gov).
May 22-26	ASTER Science Team Meeting, Flagstaff, AZ. Contact Anne Kahle at (818) 354-7265 (anne@lithos.jpl.nasa.gov)
July 5-7	MIMR Science Advisory Group Meeting, ESRIN, Frascati, Italy. Contact Chris Readings at (+31) 1719-85673 (creading@vmprofs.estec.esa.nl).
September 20-22	CERES Science Team Meeting, NASA Langley Research Center. Contact John Nealy at (804) 864-4412 (j.e.nealy@larc.nasa.gov).

Global Change Calendar

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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.
March 14-18	American Association of Geographers, Chicago, IL. Contact AAG Registration Coordinator (202) 234-1450.
April 3-6	Combined Optical-Microwave Earth and Atmosphere Sensing, Atlanta, GA. Contact IEEE/Leos, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ. 08855-1331. Tel. (908) 562-3898, FAX (908) 562-8434.
April 5-6	"Understanding Earth; Retrospectives and Visions," Washington, DC. Contact Wendy Raeder, (313) 994-1200, ext. 3234.
May 15-18	Preliminary Announcement and Call for Papers, Workshop on Pollution Monitoring and GIS, LESPROJEKT—Forest Management Institute, Brandys and Labem, Czech Republic. For further information contact: Tomas Benes, Tel. +42 202 3581, ext. 330; +42 202 3727; FAX: +42 202 3371.
May 29-June 2	American Geophysical Union Spring Meeting, Baltimore, MD. Contact Karol Snyder (800) 966-2481.
June 6-9	Eighth Annual Towson State University GIS Conference (TSUGIS '95), Baltimore, Maryland. Contact Jay Morgan (410) 830-2964, FAX (410) 830-3888.
July 2-14	International Union of Geodesy and Geophysics, Boulder, CO. Abstract deadline is February 1. Contact Karol Snyder (800) 966-2481, FAX (202) 328-0566.
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.
August 14-18	International Symposium on Radiative Transfer, Kusadasi, Turkey. First announcement and call for papers. For further information contact: Prof. M. Pinar Mengüc, Dept. of Mechanical Engineering, U. of Kentucky, Lexington, KY 40506-0046; Tel. (606) 257-2673; FAX: (606) 257-3304; e-mail: menguc@ukcc.uky.edu.
August 28-31	10th International Photosynthesis Congress, "Photosynthesis and Remote Sensing," Montpellier, France. Call for papers - abstracts due March 1, 1995. For details, contact Les Portes d' Antigone, 43 place Vauban, 34000 Montpellier, France. Tel. (33) 67 15 99 00, FAX (33) 67 15 99 09.
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.
September 25-29	Global Analysis, Interpretation, and Modelling (GAIM), The First GAIM Science Conference, Garmisch-Partenkirchen, Germany. GAIM is an Activity of the International Geosphere-Biosphere Programme (IGBP). For further information contact: IGBP Secretariat, Institut für Meteorologie, Freie Universität Berlin, Carl-Heinrich-Becker-Weg 6-10, 12165 Berlin, Germany or Dr. Dork Sahagian, GAIM Task Force Officer, Institute for the Study of Earth, Oceans and Space, U. of New Hampshire, Morse Hall, 39 College Road, Durham, NH 03824-3525, U.S.A. Tel. (603) 862-1766; FAX: (603) 862-1915; e-mail: gaim@unh.edu.

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