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In this issue

EDITOR'S CORNER

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On March 30, Dr. Ghassem Asrar, Associate Administrator of the Office of Earth Science, announced the selection of CloudSat for an end-to-end small spacecraft mission known as an Earth System Science Pathfinder (ESSP). CloudSat, which will fly in 2003, is a mission focused on understanding the role of optically thick clouds on the Earth's radiation budget, and is led by Prof. Graeme Stephens of Colorado State University, Fort Collins, CO. CloudSat will use an advanced cloud-profiling radar to provide information on the vertical structure of highly dynamic tropical cloud systems. This new radar will enable measurements of cloud properties for the first time on a global basis, revolutionizing our understanding of cloud-related issues. CloudSat is a collaboration between the United States, Canada, Germany, and Japan, and will be managed by the Jet Propulsion Laboratory. It is estimated to cost $135 M in total, of which NASA's contribution will be approximately $111 M, with additional funding provided by the Canadian Space Agency, the U.S. Department of Energy and the U.S. Air Force. The Canadian Space Agency also is developing key radar components and contributing scientific expertise. Ball Aerospace, Boulder, CO, will build the CloudSat spacecraft.

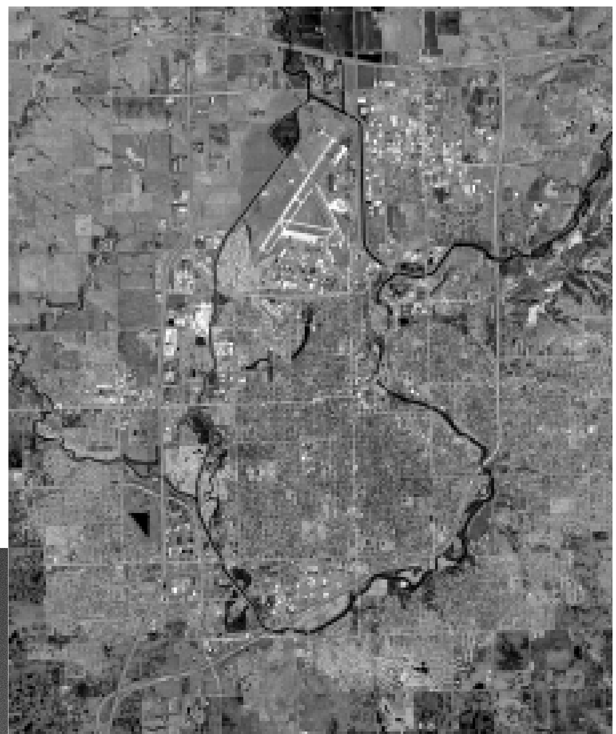
An important contribution of CloudSat is the way it will fly in formation with the EOS PM-1 and PICASSO-CENA satellites. PICASSO-CENA (Pathfinder Instruments for Cloud and Aerosol Spaceborne Observations–Climatologie Etendue des Nuages et des Aerosols), led by Dr. David Winker of NASA Langley Research Center, Hampton, VA, was recently selected as an ESSP mission for full-scale development. It is designed to address the role of clouds and aerosol particles and their impact on the Earth's radiation budget—a balance between incident solar energy absorbed by the Earth and emitted longwave energy lost to space that ultimately controls the temperature of the Earth—and is especially important for optically thin clouds, boundary layer aerosols, and stratospheric aerosols and polar stratospheric clouds. The combination of PICASSO-CENA, CloudSat, and PM makes a major contribution to the process studies of clouds and radiation and their corresponding forcing of the Earth's radiation budget and climate.

In anticipation of the launch this year of the Landsat 7, QuikSCAT, Terra, Meteor-3M/SAGE III, and ACRIMSAT, the EOS Project Science Office has completed the EOS Science Plan, under development by the broad EOS scientific community for the past 4 years. The plan consists of an overview chapter followed by seven topical science chapters that discuss, in considerable detail, all aspects of EOS science. This document is published in two parts, an Executive Summary, consisting of summaries of all 8 chapters in the Science Plan, and a separate volume with the full text of each chapter. It is available in hard copy, CD-ROM, or from the World Wide Web at http://eospso.gsfc.nasa.gov/sci_plan. Additional copies can be obtained by sending e-mail to Lee McGrier at lmcgrier@pop900.gsfc.nasa.gov.

Landsat 7 was successfully launched on April 15 from Vandenberg Air Force Base, California aboard a Delta II rocket. Landsat is a dual-agency program between NASA and the U.S. Geological Survey, who will operate the spacecraft beginning in October 2000. The spacecraft, built by Lockheed Martin Missiles and Space in Valley Forge, Pennsylvania, is now on orbit and producing data. Its only instrument, the Enhanced Thematic Mapper Plus (ETM+), built by Raytheon Santa Barbara Remote Sensing, is currently undergoing calibration activities and detailed checkout. The first image from the ETM+ is shown below.

Landsat 7 launch by Delta II (photo courtesy of Senior Airman, Linda Miller, Vandenberg Air Force Base, CA)

Terra (formerly AM-1) was shipped from Lockheed Martin Missiles and Space to Vandenberg Air Force Base for launch aboard an Atlas IIAS rocket no earlier than July 28. Activation of the five instruments onboard this spacecraft has been completed, and launch-site processing is proceeding on schedule. Recent launch failures may affect the launch date, but this is not yet certain.



The first Landsat 7 image, Southeast South Dakota, acquired April 18, 1999 (USGS/EROS Data Center).

The SORCE (Solar Radiation and Climate Experiment) mission has been formed by combining two planned missions, SOLSTICE (Solar Stellar Irradiance Comparison Experiment) and TSIM (Total Solar Irradiance Mission). The SORCE mission is led by Dr. Gary Rottman of the Laboratory for Atmospheric and Space Physics, University of Colorado. This mission is aimed at making precise and accurate measurements of total solar irradiance as well as solar spectral irradiance from the near -infrared through the visible and near-ultraviolet, to the far ultraviolet and soft X-ray, with spectral resolution varying from 30 nm in the infrared to 0.2 nm in the ultraviolet. Specifically, SORCE consists of four instruments: TIM (Total Irradiance Monitor, a 4-cavity electrical substitution radiometer), SIM (Spectral Irradiance Monitor, a double Fery prism spectrometer, 200 - 2000 nm), SOLSTICE (a two-channel grating spectrometer, 115 - 300 nm), and XPS (XUV Photometer System, 1 - 31 nm). I am happy to report that Dr. Robert Cahalan has agreed to serve as Project Scientist of this solar-radiation mission.

An Investigators Working Group (IWG) meeting is scheduled for June 15-17 at the Manor Vail Lodge, Vail, Colorado. The primary focus of this meeting is to learn of recent progress and exciting accomplishments obtained thus far by various EOS and related Earth-science investigations, and to assess plans and expectations for EOS over the next couple of years. In particular, science sessions will be organized around the following themes: (i) the global water cycle, including large river and surface-water bodies, cold-season processes, and the influence of the land surface on precipitation, (ii) expeditions, science results, and data products from the Arctic and Antarctic, (iii) science results and early plans for Landsat 7, SORCE, TRMM (Tropical Rainfall Measuring Mission), TOMS (Total Ozone Mapping Spectrometer), CloudSat, and PICASSO-CENA, and (iv) terrestrial carbon science programs and early results.

AIRS/AMSU/HSB on EOS PM-1 Instrument Performance and Product Generation

— H. H. Aumann (Aumann@jpl.nasa.gov),
AIRS Project Scientist, Jet Propulsion Laboratory
— Moustafa T. Chahine, AIRS Science Team Leader,
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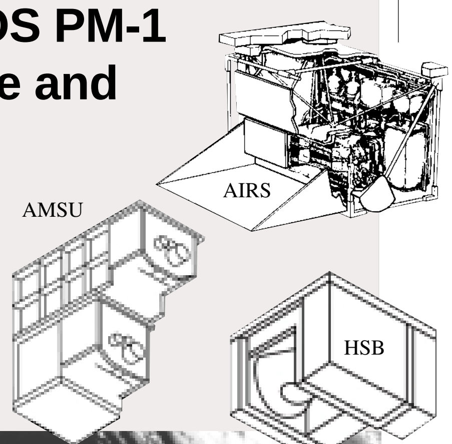

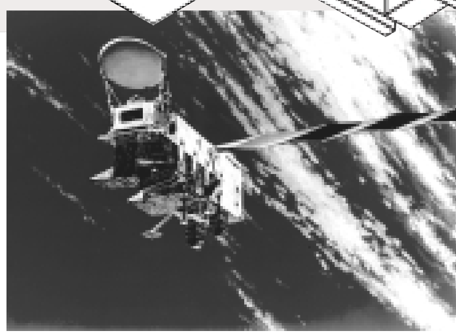

AIRS, the Atmospheric Infrared Sounder on the EOS PM-1 spacecraft, is an infrared radiometer that covers the 3.7-15.4 µm spectral range with spectral resolving power of 1200. AIRS, together with the AMSU and HSB microwave radiometers, is expected to achieve retrieval accuracy better then 1 K rms in the lower troposphere under clear and partly cloudy conditions. Launch of AIRS on the EOS PM-1 platform is scheduled for December 2000. In the following, we present results from the recent sensor-level AIRS flight-unit testing, highlights of the AIRS ground-data-processing system, and temperature-retrieval results under partly cloudy conditions.

Introduction

The requirement to achieve radiosonde-equivalent accuracy under operational conditions using remote sensing from low-Earth-orbit is a challenge to retrieval algorithms and to the designers of infrared sounders. The presence of clouds is an additional complication. TOVS operational processing of NOAA-10 data for June 1988 treats 48% of the retrievals as "clear," i.e., no cloud clearing necessary, while the more research-oriented Goddard Laboratory for Atmospheres (GLA) retrieval declares 35% of the retrievals as "essentially clear" (Chahine and Susskind 1989). Recent assimilation of TOVS data into the ECMWF analysis model indicates that typically less than 10%, not 30-40%, of the TOVS retrievals come in fact from "clear" areas. The limited information content of the HIRS/MSU system (only 19 infrared and 4 microwave channels), in addition to poor vertical resolution, prevents accurate and reliable retrievals from partly cloudy scenes. AIRS, a pupil-imaging grating spectrometer that covers the 3.7-15.4 µm spectral range with 2378 spectral channels with spectral resolving power of 1200, provides two orders of magnitude more spectral information content than HIRS (Aumann and Miller 1995). AIRS, together with the AMSU-A and HSB (Humidity Sounder of Brazil, made in collaboration between the Brazilian Space Agency and the prime contractor of the AMSU-B), is expected to operationally achieve retrievals with 1 K rms accuracy in 1 km layers in the presence of clouds. Copies of AMSU-A and AMSU-B are currently in orbit on NOAA-15. The final calibration of the AIRS flight instrument is currently in progress. AIRS is designed to satisfy operational NOAA and Department of Defense vertical-temperature and moisture-sounding requirements, as well as supporting the climate research interests of NASA. The launch of AIRS, AMSU-A, and HSB on the EOS PM-1 platform is scheduled for December 2000.

In the following, we briefly review infrared-sounder performance considerations in general and additional requirements related to sounding in the presence of clouds. We then discuss results from the AIRS instrument flight-unit testing currently in progress with reference to these considerations. Preliminary test results indicate that AIRS will meet the sensitivity, spectral resolution, and spatial co-alignment requirements to operationally achieve the 1 K/1 km sounding requirement under up to 50% fractional cloud cover.

Infrared Sounder Performance Requirements

In order to achieve radiosonde equivalent accuracy, interpreted as 1 K rms accuracy in 1 km layers below 100 mb and in the presence of the potentially high spatial contrast of a partly cloudy field of view, generally accepted performance requirements include:

a) spectral coverage from 3.7 to 15.4 µm with spectral resolving power of the order of 1200. This includes the 4.2 and 15 µm CO_2 bands and super-window channels and weak water lines in the 3.8 µm region to aid the determination of boundary-layer water vapor.

b) system sensitivity, usually expressed as noise-equivalent temperature difference, NEΔT = 0.2 K at 250 K.

c) spatial coverage adequate to support weather forecasting, usually interpreted as soundings on a 50 km grid, with FOV of 10-15 km diameter.

The system-sensitivity requirement refers to the total system noise. In addition to fundamental detector noise the two most significant instrument-related contributions to the system noise are spatial co-alignment and spectral calibration accuracy. Discussion follows:

a) Since the retrieval algorithm assumes that the measured spectral radiances refer to the same vertical column, all spectral channels must be accurately co-aligned. It can be shown that for a FOV with 50% fractional cloud cover, a 2% misalignment of the spatial response function corresponds to a brightness temperature error of approximately 0.14 K. At 5% misalignment, the error increases to 0.4 K rms. Co-alignment to within 1% of the FOV is desirable. For HIRS/2 on the NOAA-K all 19 channels are co-aligned within 2% of FOV.

b) Instrument alignment or spectral response function (SRF) scene illumination dependence, due to high-contrast clouds, can create uncertainty in the SRF centroid position and shape. The resulting brightness temperature uncertainty may not be distinguishable from random noise. With spectral resolution of 1200 an SRF position or width uncertainty of 1% of the width is equivalent to a 0.2 K error in regions of high spectral contrast, such as in the 690-720 cm^{-1} region and near the center of the R-branch at 2382 cm^{-1}.

In the following, we discuss the performance measured for the AIRS flight model relative to the above-discussed performance considerations.

AIRS Flight Model Sensor System Test Results

AIRS is a pupil-imaging, cross-track-scanning spectrometer. The pupil-imaging design assures a high degree of scene illumination independent of the SRF. Global spatial coverage is obtained by cross-track scanning, i.e., by rotating a 45-degree scan mirror at the rate of 1.06 degree/0.022 sec from +49.5 to –49.5 degrees perpendicular to the spacecraft velocity vector. Testing of the AIRS flight-model spectrometer and detector system (cooled by an active cooler) in a small vacuum test chamber with electronics attached through a special cable was completed in January 1999. Radiometric testing of the entire system in a large vacuum chamber started at the end of March 1999. The final calibration phase is scheduled to be completed by June 1999. Details of the test setup are described in the AIRS Calibration Plan (Aumann and Overoye 1997). In the following, we present results of AIRS flight-model tests completed in January 1999 and discuss how the results compare to the requirements and the general sounder design considerations:

a) AIRS spectral coverage from 3.7-15.4 μm and spectral resolving power are shown in Figure 1. Spectral resolving power ranges from 1100 to 1500, depending on wavelength. The spectral calibration uses a Fourier Transform Spectrometer (Bruker IFS 66V). The signal from a blackbody, modulated by the FTS as a function of the optical path difference (OPD), is measured simultaneously on all 2378 AIRS detectors. In order to eliminate polarization, self-emission, and illumination effects, the signal from the FTS is scrambled in an integrating sphere before it is projected onto the AIRS entrance pupil.

b) Detector Sensitivity: The sensitivity of all AIRS channels, expressed as the noise-equivalent temperature difference NEΔT, is measured simulta-

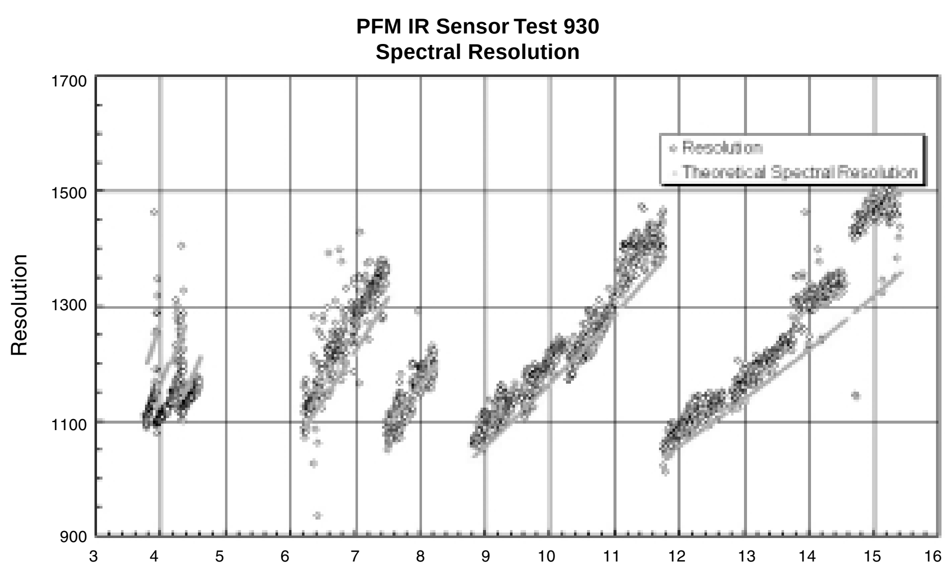

Figure 1. The AIRS-measured resolving power (wavelength/full width at half peak of the SRF) is slightly better than the required resolving power (solid line)

neously by measuring the radiometric gain and the noise of each channel. Figure 2 shows the NEΔT for all channels, referred to a 250 K scene temperature. The median NEΔT is 0.1 K. 90% of the spectral channels have NEΔT of better than 0.2 K. The NEΔT of 0.05 K and less in the mid-band region comes as a "free" consequence of cooling the spectrometer to 150 K and operating the detectors at 60 K in order to meet the sensitivity requirement in the key 4.2-micrometer and 15-micrometer temperature-sounding regions.

c) **Spatial Response:** The static spatial-response function of AIRS was measured simultaneously for all detectors by raster scanning the field of view with a 0.1°-diameter source in 0.07° steps. The 0.1°-diameter source was imaged by a spatial collimation system to appear at infinity in front of a 2.5°-diameter 140 K cold background. The measured radiometric diameter of the field of view was 1.06°. Figure 3 shows the distances of the radiometric centroids of all channels in degrees as a function of wavelength from the mean centroid. 60% of the channels, including all key sounding channels are within 0.02° of the common centroid. Since the FOV diameter is 1.06°, this corresponds to a co-alignment within 2% of the FOV.

Data Product Generation

Data processing for the AIRS/AMSU/HSB system has been developed through an intensive data-simulation effort, including realistic cloud effects. Experimental NOAA general circulation models (GCM) were used to calculate the upwelling spectral radiance measured from Earth orbit. The data simulation assumes a contribution of 0.14 K from sources of noise in addition to the detector NEΔT. This is consistent with 2% FOV misalignment in the presence of 50% cloud cover. These simulations are currently being refined, based on the measured instrument performance. After the conversion of the raw data (Level 1a) to calibrated radiances (Level 1b), the

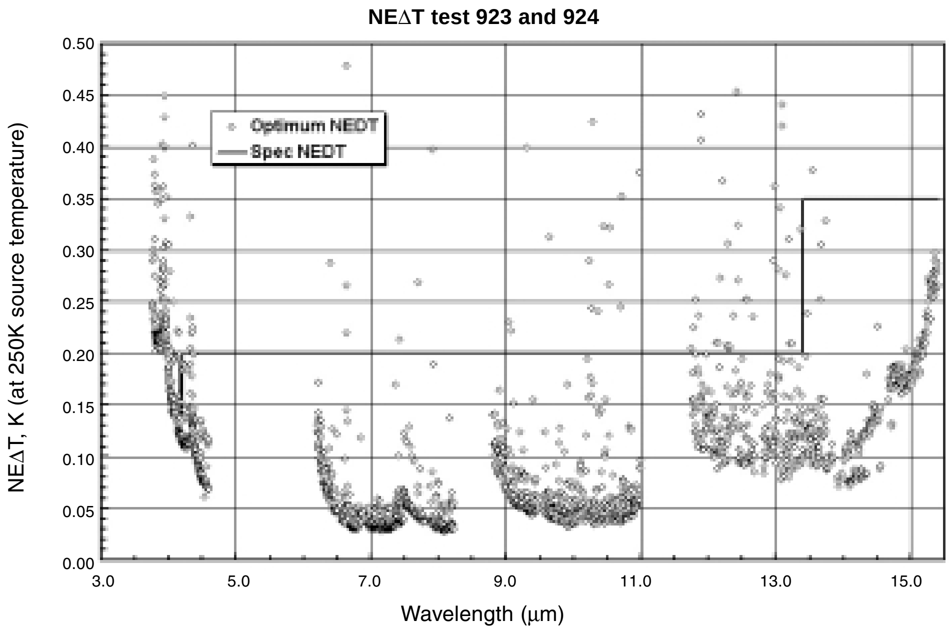

Figure 2. Detector NEΔT for all channels, referred to 250-K scene temperature, exceeds the requirement (solid line) at most wavelengths.

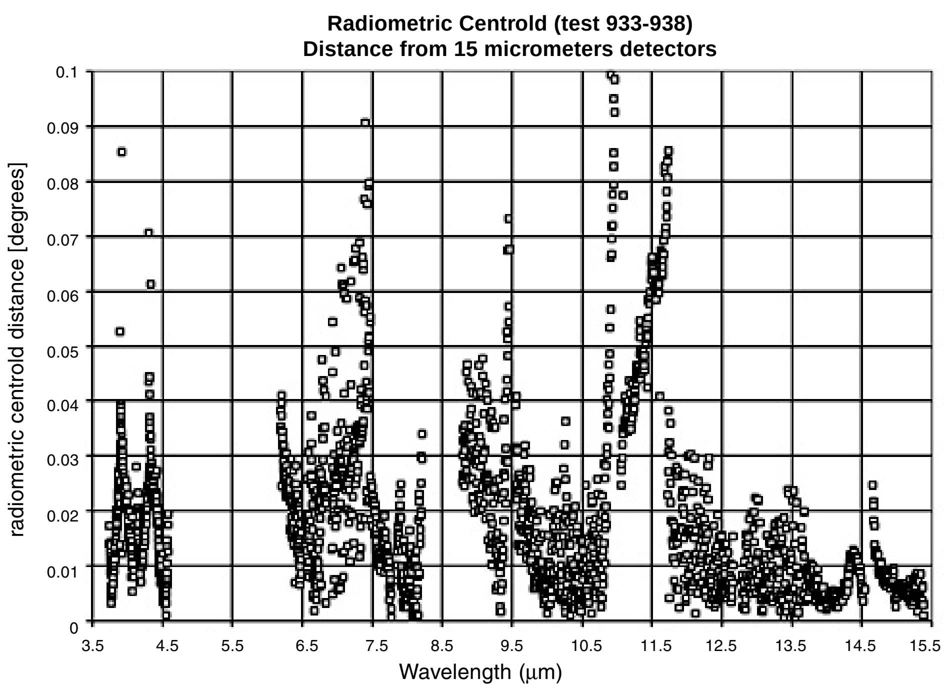

Figure 3. 60% of the radiometric centroids of all AIRS channels are located within 2% of the FOV diameter; all critical sounding channels are within 1%.

Product Generation System (PGS) generates the temperature and moisture retrievals based on the combination of 9 AIRS footprints and 9 HSB footprints, all centered on one AMSU-A footprint. The six major steps in the temperature-and-moisture-profile retrieval are:

1. retrieval, using microwave channels only;
2. preprocessing to the standard frequency set and common slant angle;
3. first-pass cloud clearing and generation of cloud–cleared radiances;
4. first product generation using regression;
5. second-pass cloud clearing; and
6. final product generation, including surface temperature and emissivity, and error estimates, using the regression retrieval as input.

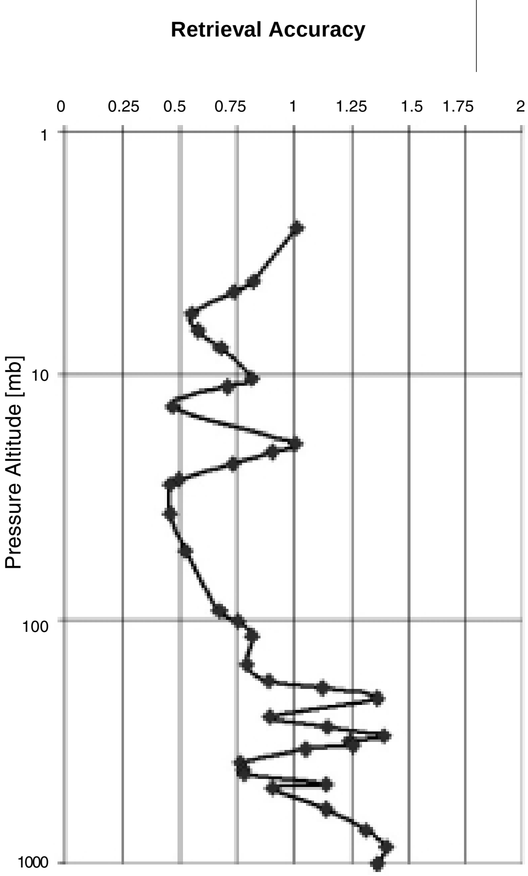

Figure 4. Results from AIRS data simulation indicate 0.8-K-rms retrieval accuracy in the troposphere under cloud-clearable conditions (Susskind 1998)

Details of the instrument calibration and retrieval algorithms have been published in Algorithm Theoretical Basis Documents (see http://eospso.gsfc.nasa.gov). Figure 4 shows temperature-retrieval results (Susskind 1998) under mid-latitude conditions and an average 50% cloud cover using simulated data. Actual cloud cover in the individual FOVs ranged from 10% to 80%, with no clear FOVs. These are fairly stressing conditions. Nevertheless, the retrieval accuracy in the troposphere is better than 1 K rms.

The PGS has to keep up with the data. In addition, NOAA's operational weather forecasting system requires access to the data within 3 hours after the data are received on the ground. Since there are 30 AMSU-A footprints per scan line of 8-second duration, retrievals have to be processed at the minimum rate of 260 msec per retrieval. Current estimates indicate that four SGI/R10000 class processors in coarse-grain parallel-processing mode can produce the calibrated radiances, cloud-cleared radiances, and the first products at a rate consistent with the NOAA operational requirements. The estimated computing power required to keep up with the final product generation, including a factor-of-two margin for reprocessing, is 128 SGI/R10000 class processors.

Summary

Based on the measured instrument sensitivity, spectral and spatial performance, and the performance of the PGS software, AIRS, together with the AMSU and HSB microwave radiometers, is expected to achieve operational retrieval accuracy better then 1 K rms in 1 km thick layers in the troposphere under clear and partly cloudy conditions.

Acknowledgements

The AIRS instrument is being built at Lockheed Martin Infrared Imaging Systems in Lexington, MA under a system contract with the Jet Propulsion Laboratory. Ken Overoye of Lockheed Martin provided Figures 1, 2, and 3. The Jet Propulsion Laboratory, California Institute of Technology, operates under contract with the National Aeronautics and Space Administration.

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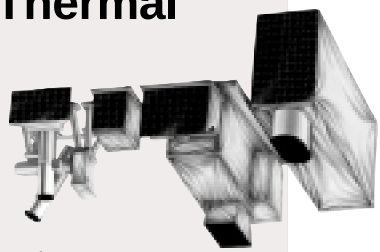
For ATBDs see;
http://www.eospso.gsfc.nasa.gov

16th Advanced Spaceborne Thermal Emission and Reflectance Radiometer (ASTER) Science Team Meeting



— A. D. Morrison (andy@aster.jpl.nasa.gov), Jet Propulsion Laboratory

Summary

The 16th ASTER Science Team meeting was held Tuesday through Thursday, January 12 through 14, 1999, at the Pasadena Convention Center, Pasadena, California. There were approximately 100 participants, representing the ASTER Science Team, Jet Propulsion Laboratory (JPL), Goddard Space Flight Center (GSFC), Earth Remote Sensing Data Analysis Center (ERSDAC), Japan Resources Observation Systems Organization (JAROS), the ASTER Ground Data System (GDS) Project, the instrument vendors, and the Japanese algorithm-development contractors. The three-day meeting was composed of an Opening Plenary Session on January 12th, several individual Working Group meetings January 13th and the morning of January 14th, and a closing Plenary Session on the afternoon of the 14th.

During the meeting, reports were given on the instrument status, the spacecraft status, the new flight-operations system development schedule and status, and the EOSDIS readiness to support ASTER after launch. Progress was made in several areas including: 1) the participation of the Science Scheduling Support Group (SSSG) in the new flight-operations system end-to-end tests and exercises and 2), the responsibilities of the SSSG during the initial check-out-period (launch to launch+118 days). In addition, the Joint Review Panel for Science Team Acquisition Requests (STAR) met. The Panel reconfirmed its agreement on the criteria for selecting STARs and began reviewing and approving post-initial-check-out period STAR proposals. This panel reviews and approves requests for data acquisitions that are of interest to more than one investigator.

Plenary Session I
Tuesday, January 12

A. Kahle and H. Tsu opened the meeting and welcomed the attendees.

J. Ranson reviewed the Terra Project status—hardware, software, and EOSDIS interfaces. There is no official launch date at this time.

A. Unger addressed the Spacecraft and Instrument Status and reviewed changes since the last ASTER Science Team meeting. This included details and schedule of the integration and test program and a list of remaining activities at Valley Forge. He said that the platform is scheduled to be shipped to Vandenberg Air Force Base (VAFB) on April 15.

M. Kikuchi reviewed the progress of the testing of ASTER at Valley Forge during 1998. He was able to report that ASTER has had no trouble with the hardware and has required no rework and no removal from the platform.

D. Williams presented the Landsat 7 update. He said that Landsat will be shipped to VAFB on January 27, 1999. Although the official launch date is April 15, they are working towards a March 31 launch. Immediately after launch, Landsat 7 will underfly Landsat-5 for a couple of days for cross-calibration purposes. After the ASTER launch, coordinated Landsat 7/Terra same-day data takes will be performed with an expected separation of approximately 20 minutes.

D. Perkins reviewed the EOSDIS status and schedule. There is no padding in the schedules—the EOS Mission Operations System (EMOS) is the critical path for the Terra launch. She said that all instrument command and data-collection capabilities will be in place at launch.

M. Moore continued the EOSDIS status presentation by reviewing various EOSDIS Core System (ECS) options and limitations and specifically addressing impacts on ASTER products. He said that:

◊ Limitations under Option A+ will have no impact on ASTER products.

◊ Total Cloud Cover (TCC), derived from NOAA data will be used by the ASTER Ground Data System (GDS) for planning and scheduling the ASTER instrument.

◊ They are currently working on two problems with the L1 expedited data.

◊ On other fronts;
  The first test of the ASTER Digital Elevation Model (DEM) was

successful and it is moving ahead well.

The first version of the Java DAR tool will be ready for test in early May. It should be operational by the end of May.

H. Watanabe presented the ASTER GDS development status. He reviewed the communications between the U.S. and Japan regarding the Flight Operations Segment (FOS) problems and the launch date slip. Regarding the ECS-Instrument Support Toolkit (ECS-IST), he said that of the three subsystems, only the Mission Management System will be delivered before launch. The Real Time System and the Analysis System will be delivered at Launch plus 30 days. GDS is now moving from the Development to the Operational Phase. Finally, he said that GDS is waiting for MITI to decide how the Japanese data products will be priced.

S. Hook reported that the MODIS-ASTER Simulator (MASTER) is working. The instrument was switched to operational on a KingAir Beachcraft B200 in January 1999. Data were presented that favorably compared MASTER data with TIMS data. MASTER will be deployed on the ER-2 and DC-8 this summer.

T. Schmugge presented early MASTER data for New Mexico. The results ranged from generally poor quality, to good quality but with some clouds, to good quality. Good agreement with Landsat data was obtained for the southern part of the reservoir.

H. Fujisada summarized the status and schedule of the ASTER Level 1 Products. He reviewed the Level 1 radiometric and geometric parameters and summarized the anticipated Level 1 product accuracies vs. requirements. In every case, the anticipated accuracies meet or exceed the required accuracies.

K. Matsumoto presented an overview of the Initial Check-out (ICO) Geometric Validation activities including their planned procedures, ICO and post-ICO targets, and ICO and post-ICO schedule. Their objective is to have 300 Ground Control Point (GCP) points prepared for the calibration activity.

H. Kieffer reported that the U.S. Geometric Working Group is "on track and we're working away." They have 23 STARs submitted to support Geometric Calibration.

I. Sato showed examples of parts of the Japanese Users Guide which is being prepared and presented the schedule for its completion. He invited anyone who is interested to visit their web site at http://astweb.ersdac.or.jp/guide and return any comments to hozuma@mri.co.jp or isao@gsj.go.jp.

Y. Yamaguchi reviewed the results of the October 1998 Operations and Mission Planning Working Group (OMPWG). The topics discussed at that meeting included

◊ Impact of the FOS development problem—no major impacts were forecast

◊ Operations documents—the Mission Guidelines document is awaiting GDS approval and sign-off; the Operations Procedure Document v2 will be delivered in March 1999.

◊ Development status reports and demo—Instrument Support Terminal (IST), ASTER Mission Simulator (AMS), and Mission Analysis Tool (MAT) were reviewed, and the IST was demonstrated.

A. Morrison summarized the status of the U.S. STARs. He noted that there are approximately 190 U.S. ICO STARs totaling approximately 422 scene equivalents, 79 U.S. non-ICO STAR proposals, comprising over 2700 individual STARs totaling an estimated 100,000 scene equivalents, and another few STARs that will be considered for scheduling once the non-ICO STARs have been put to bed. In the future, STARs will have to be submitted to the STAR Review Committee, an ASTER Science Working Group, the ASTER Science Project (Japan), the U.S. ASTER Science Team, or the SSSG, as required by the Guidelines Document.

H. Sekine summarized the status of the Japanese STARs. He said that there are approximately 33 Japanese non-ICO STAR proposals, comprising over 2553 individual STARs totaling an estimated 515,900 scene equivalents. Sekine reported that U.S. and Japanese ICO STARs and Japanese non-ICO STARs had been transmitted to R. Molloy for the testing of the AMS.

Working Group Summaries:

K. Thome, U.S. Atmospheric Correction Working Group (ACWG), reviewed details and status of thirteen U.S. ACWG STARs, which included STARs for validation of ASTER, MISR, MODIS, and CERES instrument data and validation of International Satellite Cloud Climatology Project (ISCCP) cloud-droplet-particle-size products. M. Moriyama, Japanese Atmospheric Correction Working Group, presented details of the fifteen Japanese atmospheric-correction-related non-ICO STAR sites in Japan.

F. Palluconi and K. Arai, TIR Atmospheric Correction Working Group, presented a list of their Working Group's Calibration/Validation STARs and reviewed their purposes.

R. Welch, Digital Elevation Model (DEM) Working Group, summarized the activities of the Working Group. He said that over the last three years of testing, three DEM software packages have consistently provided DEMs with residual 2-coordinate errors of less than $\pm$10 m. Typically, the root-mean-square equivalent for the vertical direction ranged from $\pm$4 to $\pm$9 m. He reported that there was no appreciable difference in Z-coordinates determined from Level 1A and Level 1B data. The cost of these software packages ranged from less than $5 K to more than $30 K. He added that the joint Working Group has agreed to a total of eleven prioritized validation sites, seven in Japan, three in the U.S., and one in Mexico.

L. Rowan, U.S. Geology Working Group, presented a list of twenty-one U.S. Geology WG Cal / Val STARs. Eleven of those came from ASTER Science Team members, one from an ASTER Science Team Associate, one from an EOS IDS member, and eight were from other submitters. M. Urai, Japanese Geology Working Group, said that they have eight STARs, all from ASTER Science Team members. He said that Japan is developing a new higher-level volcano map product.

T. Schmugge, Ecology Working Group, discussed the twenty-nine U.S. Ecology STARs. Of the twenty-nine, fourteen were submitted by ASTER Science Team members. Three are for MODIS parameter validation.

M. Abrams, Oceanography and Limnology Working Group, summarized the status of the six-to-eight joint Working Group lake and ocean sites.

A. Gillespie, Temperature-Emissivity (T-E) Separation Working Group, pointed out that the T-E algorithm needs real data to fine tune it, and, therefore, they will need as much data as early as possible and their need will taper off after that.

Field Campaign Results:

F. Palluconi presented the plan for the upcoming field campaign at the Salton Sea and Ivanpah Playa. He said that three groups will participate: JPL (Salton Sea), the University of Arizona (Ivanpah Playa), and several Japanese investigators (both sites). He also reported on the results of the June 1998 field trip to June Lake, the calibration at UC Davis of the JPL temperature-sensing buoys, and a comparison of various sun photometers and their ability to obtain water-column figures.

N. Bower from the University of Wisconsin gave a brief overview of the AeriBago. The Aeribago is a high-resolution (<1 wavenumber) interferometer mounted in a Winnebago. The instrument was used to make surface and atmospheric measurements coincident with the MASTER overpass at the Salton Sea.

K. Thome summarized three past campaigns:

◊ A joint campaign to Railroad Valley, June 1998, that acquired a cloud-free Landsat image and enjoyed a successful overflight of MAS / AVIRIS

◊ MASTER evaluation flights in August and December 1998 to acquire data at Ivanpah Playa for calibration / validation of VNIR and SWIR bands.

He said that the planned January campaign at Ivanpah Playa was expected to acquire same-day Landsat-5, MASTER, and ground data. He also expects numerous field campaigns after the launch of Landsat 7 that will provide useful lessons for the evaluation phase of ASTER. He said that the planning for a large joint field campaign after the ASTER launch will be delayed until a launch date is set.

H. Tonooka described a field campaign at Lake Kasumigaura in September 1998.

Participants included Tonooka and two assistants from Ibaraki University, S. Machida and N. Doi of ERSDAC and F. Palluconi of JPL. Objectives of the campaign included comparison of U.S. and Japanese buoys, comparison of three sources of precipitable water vapor measurements, and preliminary validation of the Global Data Assimilation System (GDAS)-based atmospheric correction technique under wet humid conditions using NOAA / AVHRR data.

M. Abrams summarized ASTER education and outreach activities. These included:

◊ articles in IJRS, IEEE, and the ERSDAC newsletter;

◊ exhibits at the LA County Fair, California in Space, JPL Open House, IWG, and ERSDAC;

◊ preparation and printing of the ASTER brochure;

◊ posters at ERIM Oceanography and Geology sessions;

◊ preparation / distribution of ASTER pins;

◊ development of the ASTER web site;

◊ participation in the JPL / Cal State ALERT Project to incorporate NASA information and data into Earth science curricula;

◊ coordination with Regional Earth Science Applications Centers; and

◊ Support for Yoram Kaufman's Executive Committee on Science Outreach.

He added that the ground rules for release of information are now being debated at GSFC. GSFC is aware that ASTER is not just a GSFC/NASA instrument, but that Japan is part of the Project and that Japan has its own rules and requirements that must be considered.

T. Kawakami gave examples of education and outreach activities by ERSDAC. He showed a timetable of active and passive Public Relations (PR) activities and showed the expected science data content of PR materials as a function of mission phase.

J. Ranson summarized the EOS Terra. A Terra web page is ready for review at http://terra.nasa.gov/terra.html (the /terra.html will drop off at publication).

Y. Yamaguchi presented five topics that he urged the Science Team to address in their discussions during this meeting. The first was the participation of the ASTER Science Team in EOS-planned operations exercises and rehearsals. The second was the need for an algorithm validation plan for the mission—both ICO and post-ICO phases. Third was the topic of STAR collection, including the need to establish and agree on consistent STAR criteria. The fourth was publication/presentation of early science results. And finally, the fifth was about a Public Relations/Outreach plan including ASTER PR/Outreach activities, cooperation with NASA/GSFC activities, and collaboration with other instrument activities.

Over the next day and a half, the ASTER Working Groups and the STAR Review Committee each met. Summaries of their meetings were presented in the Second Plenary Session.

Plenary II
Thursday, January 14, 1999

Working Group Meeting Summaries:

Geology Working Group: The meeting discussion topics were reviewed—these included frustrations with the STAR submission policy and a request for clarification of the process. The status of the Working Group's STARs was presented

Radiometric Calibration Working Group meeting: Topics covered included possible procedures for getting updated calibration coefficients into the GDS, lunar calibration procedures, past and future field campaigns, Radiometric Calibration Working Group participation in operations tests, and a review of the Working Group's STARs

Operations and Mission Planning Working Group (OMPWG): The Group reviewed the xAR development schedule put together by G. Geller. This includes STAR development, IST, ECS DAR tool, Data Product Request tool, xAR submissions, and the Scheduling schedule. They also reviewed the status of the Mission Procedures Document (v2.1 will be available in May 1999), listened to a report of the SSSG meeting held earlier, discussed SSSG participation in GDS-GSFC day-in-the-life (DITL) tests and discussed the status of the ASTER mission simulators (development of the U.S. AMS is scheduled to end on April 30, 1999) and the Mission Analysis Tool (due to be operational before Launch+118).

DEM Working Group: U.S. co-Chair Harold Lang invited anyone who was interested to make contributions to the DEM ATBD update being prepared for submission February 1, 1999. He especially asked for any publications/citations that might be appropriate. Because the U.S. will produce only one absolute DEM daily, an effort was initiated to come up with a plan for prioritizing DEM requests. The Working Group reviewed its STAR status, which remains unchanged—eleven STARs for the ICO period, the same sites annually thereafter.

Atmospheric Working Group: Among other topics, the Working Group reviewed the status of its algorithms (ATBDs are being revised) and code development (v2.1 has been delivered; v2.2 will be the at-launch version). The latest version of the adjacency-effect code will be incorporated in v2.4 of the atmospheric-correction algorithm (the second delivery after launch). They also reviewed ACWG STAR requests and will ask investigators with large requests to prioritize their data needs to meet the STAR Guidelines. Other WG discussion topics included QA plans, comparison of column-water-vapor test results for three different instruments, field campaign plans and results, and the results of TIR correction using GDAS data (GDAS has some trouble with cirrus clouds—inclusion of GPS data improved the GDAS-based correction).

Temperature-Emissivity Separation (TES) Working Group: Discussion topics included the status of the TE algorithm and of the TE STARs. The TE software has been tested on both sides of the ocean, and its performance is well within specification. In addition, the algorithm seems to be robust and useful for other instruments as well. The Working Group members are working to overcome discrepancies between the U.S. and Japanese versions of the TES QA plan. After launch, using early data, the algorithm parameters will be fine tuned for the ASTER instrument. The Working Group has 13 validation STARs. Three of them will be coordinated with field campaigns.

Speaking for the Level 1 and Geometric Working Groups, G. Geller said that the Level 1 and Geometric Working Groups currently have no role in the planned EOS exercises, but will participate at GDS or elsewhere if requested to do so. He said that their algorithm validation plan has been submitted to S. Hook. Algorithm parameter tuning and update plans and procedures were presented to the ASST in June of 1998, and they will be documented in the GDS-EROS Data Center (EDC) Operations Agreement as appropriate.

A. Kahle reviewed the discussions that took place in the STAR Review Committee meeting. She reported that the proposed Japanese and U.S. non-ICO STARs were reviewed by the Committee. Many were approved (31 of 33 Japanese proposals and 66 of 81 U.S. proposals), some will need additional work, and some were changed to DARs. At Y. Yamaguchi's request, the criteria for Local STARs and Regional STARs were discussed, and the Committee concurred with him that the originally agreed to criteria should be firmly adhered to. These are that Local STARs (less that ten scene equivalents) should be restricted to Cal/Val, Emergency, PR, field-campaign support, and special Science Team and Program-level requests and that Regional STARs should be restricted either to observations that require large resources exceeding the DAR allocation limit or observations authorized by an ASTER Working Group and the STAR Review Committee. Yamaguchi also reviewed the submittal path for small Area of Interest (AOI) requests that will be used to determine whether some proposals will be categorized as Local STAR candidates, DAR candidates, or Regional STAR candidates.

M. Pniel presented the ASTER calendar and solicited additions and then adjourned the meeting.

Tropical Clouds and Associated Sea Surface Temperatures

[From the Goddard Earth Sciences Update; Earth Sciences Directorate weekly bulletin]

Several scientists have noted the emergence of towering clouds (also called convective clouds) over tropical oceans at sea surface temperatures (SST) above 28° C. They also offered plausible explanations for the observed upper limit of SST at about 30° C. Sud et al. (1999) of the Climate and Radiation Branch at NASA Goddard have shown that the previous explanations for the upper limit of SST were incomplete because they did not include the dynamical influences of clouds on oceanic cooling. With good agreement between theory and observations, Sud et al. (1999) have offered a more-complete explanation for the coupled behavior of tropical SST and its overlying clouds.

First, the new calculations performed with the observed atmospheric data yield a SST of 28-29° C for providing the necessary humidity and temperature (called moist-energy) for generating towering clouds in the tropics. Second, for cloud-free conditions, the intense solar radiation continually warms the SST and evaporates the sea water, thereby increasing the moist-energy of the overlying air. This energy build-up initially causes shallow clouds that moisten the lower atmosphere. Eventually, the ambient atmosphere (for SST at or above 28° C) gathers sufficient moist-energy for towering clouds to emerge. These clouds use up the moist air accumulated by the shallow clouds and produce intense rain. The resulting cloud cover effectively shields the sea surface from solar radiation. In addition, these clouds are accompanied by cool and dry air, streaming down from aloft (commonly called convective downdrafts), that spreads near the surface.

This produces the well-known cooling that follows an intense convective event. The downdrafts make the tropical oceans evaporate and cool significantly. In this way the ongoing rise of SST is abruptly reversed by the convective event.

In summary, the authors show how tall clouds emerge at 28-29° C and how the subsequent oceanic cooling is jointly caused by reduced solar radiation and downdrafts. Both processes have a pivotal role in containment of SST at or below 30° C. It is fascinating to note that convective cloud and ocean processes work together to maintain the observed SST limit.

Reference: Sud, Y. C., G. K. Walker, and K. M. Lau, 1999: Mechanisms Regulating Deep Moist Convection and Sea-Surface Temperatures in the Tropics. *Geophys. Res. Lett.*, **26**, 1019-1022.

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TOPEX/Poseidon and Jason-1 spaceborne altimetry missions

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Overview

Spaceborne altimetry is alive and well with the US/French TOPEX/Poseidon and the French/US Jason-1 projects. TOPEX/Poseidon continues to perform well and data from this instrument have fueled many scientific studies of ocean circulation, ocean processes, and deep-ocean tides. Data from the satellite were viewed by the public worldwide during the ‘97-98 El Niño, and the data proved to be of value in operational climate analysis. Operational use of altimeter data has also extended to mariners and the fishing industry. Public awareness of the role of altimetry is increasing through museum exhibits and educational materials that are available to educators and the general public. The work of this highly successful satellite will continue with the launch of Jason-1 in May 2000. Progress on Jason-1 is proceeding as planned and it is hoped, that for a period of time in the second half of 2000, both satellites will be operational paving the way for a ten-year-plus period of time with altimeter measurements of sea-surface height to an accuracy of better than 3 cm. TOPEX/Poseidon, launched in August 1992, was originally designed to last three-to-five years. Jason-1, planned to be launched in May 2000 is also designed to last three-to-five years. The web site for the projects is http://topex-www.jpl.nasa.gov; this site contains a lot of informational and educational information, and sections on El Niño/La Niña, science, Jason-1, and news items. Recently, a subscribe-news button was added. A new section on applications will be added in the near future.

TOPEX/Poseidon has a new lease on life

Engineers have given the TOPEX/Poseidon ocean-topography satellite a new lease on life by successfully switching the principal instrument onboard the satellite to operate on its backup unit, extending the spacecraft’s already unprecedented lifetime of monitoring global ocean circulation patterns. With the switch from side A to side B, a redundant set of altimeter electronics, the highly productive TOPEX/Poseidon mission, is hoped to last beyond the launch of the sister mission, Jason-1.

To accomplish the side A to Side B switch, commands were sent to the U.S.-French satellite on 10 February ‘99 to turn off its primary radar altimeter, which was showing signs of age, and to activate the backup altimeter. Preliminary data from the satellite, analyzed by the TOPEX/Poseidon team at NASA’s Jet Propulsion Laboratory (JPL), Pasadena, NASA’s Goddard Space Flight Center at Wallops, and CNES at Toulouse, indicated that the “side-B” instrument is operating smoothly. Validation and calibration are now underway and initial results indicate that the series of highly accurate measurements will continue.

Scientific results

TOPEX/Poseidon has successfully acquired data on sea-surface heights, produced global maps of winds and waves, and detailed land and ice-sheet topography since 1992. It has recorded billions of time-specific measurements of ocean and topography to an accuracy of approximately 3 centimeters. An international team of scientists has used the data to study global climate changes and such phenomena as the El Niño warming pattern in the Pacific Ocean. The principal objective of the mission is to better understand global ocean topography in relation to ocean circulation and climate; data from the mission have been shown to be very useful in meeting that objective, as shown in a wide variety of studies including the propagation of Rossby and Kelvin waves, climate models, ocean seasonal variations, ocean-current variations, and better understanding of air-sea interactions. As an effort to remove tidal signals for studying ocean circulation, TOPEX/Poseidon data were used to derive the most accurate information on the deep ocean tides. A CD-ROM containing the tide models can be obtained from http://podaac.jpl.nasa.gov/cdrom/tide/index.htm. TOPEX/Poseidon data have also been used in studies of sperm whales in the Gulf of Mexico and in studies of success of lobster larvae. A bibliography of papers from this project is located at http://topex-www.jpl.nasa.gov/science/post-nov.html.

Applications

During this period, information derived from the TOPEX/Poseidon altimeters: sea surface height, significant wave height and wind speed, have found uses outside the scientific community. It is anticipated that many of these applications will mature over the next few years such that altimeter data will become a product in routine use, similar to the proven use of Sea Surface Temperature (SST) data.

Information products have been used by the fishing industry, mariners, for marine mammal studies, and by the hydrocarbon industry. The fishing industry is using images of sea-surface height and geostrophic currents to define fronts that are associated with higher productivity. The information is used both in image format and as digital input to Geographic Information Systems (GISs) that are located on the bridge of fishing trawlers. Mariners, including both commercial shipping and sailboat racers, have used the data in efforts to avoid adverse currents. To commercial vessels the ability to avoid adverse currents can result in considerable economic savings. The hydrocarbon industry has also used data to avoid high-velocity eddies in the Gulf of Mexico.

It is anticipated that in the next few years additional uses of the data will evolve aided by the routine provision of near-real-time images and data through sites at JPL, the University of Colorado, NOAA Laboratory for Satellite Altimetry, NOAA's Coastwatch program, and the Stennis Space Flight Center. Links to these sites are provided though http://topex-www.jpl.nasa.gov/science/science.html. In Europe, Developing Use of Altimetry for Climate Studies (DUACS) also provides near-real-time products (http://www.cls.fr/duacs).

Education and information products

During the past six months several outreach efforts have come to fruition, including museum exhibits, an educational CD-ROM, and other teaching materials.

Museum exhibits

Three interactive multi-unit museum exhibits were completed in 1998 and early 1999. They join an earlier kiosk designed and made by the University of Colorado/Space Grant College. A selection of these exhibits can be viewed on http://topex-www.jpl.nasa.gov/discover/exhibit.html. The exhibits have proved to be highly successful and appreciated by a wide audience.

The interactive museum exhibit on altimetry and El Niño designed and built by the Oregon Museum of Science and Industry in conjunction with Oregon State University features a number of units, the highlight of which is a working altimeter that allows people to see profiles of objects including themselves. This exhibit is currently at the museum, and a traveling version of the exhibit is currently at the California Science Center in Los Angeles. Following this it will be put on tour through other museums across the United States. This exhibit is twinned with a scatterometer exhibit, an arrangement that is very successful.

A second interactive-exhibit series on altimetry and information available from altimetry was made by the New England Aquarium in conjunction with Bowdoin College and the Massachusetts Institute of Technology. Two nearly identical units have been made and they 'opened' early this year at the Aquarium and in the Maine Mall, a shopping center in Portland, Maine. The exhibits are also slated for tour, and one set will exclusively tour shopping malls in its first year of operation.

The third interactive exhibit is in Europe. The 'Space and Sea' exhibit opened at Toulouse Space Museum (http://www.cite-espace.com/) earlier this year. It is also drawing rave reviews and will be there from March to September 1999. Duplicates of the exhibit will be made in several languages for distribution to other venues.

Educational CD-ROM

Packed full of information, movies, activities, and interactive learning games, the 'Visit to an Ocean Planet' CD-ROM is an exciting, informative and fun resource for students and teachers. The CD-ROM provides basic information on science principles linked to physical oceanography, and exposes students to cutting-edge science and engineering. Aimed at the Grade 8 level it is aligned with the national science, math, and geography teaching standards at many grade levels. Material in the CD-ROM can be directly incorporated into the classroom. The CD-ROM can be previewed and ordered free of charge through http://topex-www.jpl.nasa.gov/education/cdrom.html.

Educational Materials

Both the TOPEX/Poseidon office at JPL (http://topex-www.jpl.nasa.gov) and AVISO (http://www-aviso.cls.cnes.fr/) distribute educational and informational products. A new educational poster on the 'Rise and fall of the 97-98 El Niño' is part of a physical oceans educational package that is available to teachers. It can be ordered on line from http://podaac.jpl.nasa.gov/edu/package.html. The posters can also be viewed and ordered on line as a separate product through http://topex-www/education/el-nino-poster.html. French posters are also available on the web site http://www-aviso.cls.cnes.fr in the newsstand section.

Statistics on the DAAC Usage

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Abstract

A primary objective of EOSDIS is to provide efficient and responsive data and information services to users. This paper presents the results of several years of EOSDIS operations, based on the statistics collected during that time, and expands on the difficulties and imprecise measurements encountered. The statistics show tremendous growth in serving the Earth science data user communities over these years. This paper includes estimates of increases in Distributed Active Archive Center (DAAC) usage, based on current systems and data, but does not include estimates of the increases that are expected to follow the availability of Landsat 7 and Terra data.

This white paper considers the statistics on DAAC operations for fiscal years 1996, 1997, and 1998, showing the growth over those years and projecting to 2001 based on the current systems and data. During these years, the statistics show that EOSDIS has been providing more data to more users, with annual increases of 20% or more in almost all categories examined. For some categories, the increase was considerably more. During FY 98, the DAACs delivered 69 TB of data to 150,000 users, an increase of 56% in the volume and 41% in the users from FY 97. These results are generated from the Statistics Collection and Reporting System (SCRS) reports. SCRS was established in 1995 to provide information on the amount of data being delivered from the DAACs and the number of requests for data and information being received and processed.

Table 1. DAAC Access Statistics

a. Number of Distinct Users Accessing DAACs

Access Method	FY96	FY97	FY98
ESDIS	2,435	5,504	8,016
Local Search and Order	1,290	686	364
WWW	403,854	716,952	1,017,599
FTP	15,173	8,988	10,175
Off-line	11,347	11,791	12,865
Total Number of Users	**434,099**	**743,921**	**1,049,019**

b. Number of Accesses

Access Method	FY96	FY97	FY98
ESDIS	7,711	15,666	27,568
Local Search and Order	13,742	6,029	1,591
WWW Inquiries	634,194	1,115,934	1,667,111
WWW Data Retrievals	22,908	106,549	137,392
FTP	29,953	27,061	32,075
Off-line	11,347	11,791	12,865
Total Number of Accesses	**719,855**	**1,283,030**	**1,878,602**

Number of Users and User Characteristics

Table 1 summarizes the DAAC access statistics for fiscal years 1996 to 1998. The category labeled as ESDIS is the summation of information from the cross-center search-and-order methods available to users. This table shows an overall growth of 40% in number of users from 1997 to 1998. The WWW users include those accessing the DAAC Web for general information as well as those obtaining data or catalogs from these sites. If the WWW users are removed from the statistics, the increase in the number of distinct users is still a respectable 17%. The off-line users are those who made inquiries though user services personnel, via phone, mail, e-mail, FAX, etc.

The second half of the table shows accesses for each of the same categories, except for the WWW accesses, which are divided into general inquiries and data retrievals. For both WWW and FTP accesses, the number of accesses is counted as the number of distinct users on each day for the reporting period. Multiple accesses by the same e-mail address of host on the same day are counted as one access. The growth in the number of accesses mirrors the growth in number of distinct users, with an increase of 46% from FY97 to FY98 in the total number of accesses. If the WWW inquiries are removed, the number of accesses increased by 27% in FY98.

The total number of users accessing the DAACs is plotted in Figure 1, which projects the numbers to FY01, using an assumption of an annual growth of 10% in the number of users for current systems and data. This conservative estimate does not include a consideration of the increase in the number of users following the availability of data products from the Landsat 7 and Terra spacecraft.

The second table shows the characterization of the users who have received products from the DAACs, as determined from their e-mail addresses. These numbers differ from those in Table 1, which counts user accesses. Some users are included in both tables, but some are only in one or the other. Users who only make inquiries are not included in Table 2, which eliminates most users making off-line accesses or making WWW inquiries. This table shows a considerable increase from 1995, with a 44% growth from FY97 to FY98 in the total number of DAAC users receiving products.

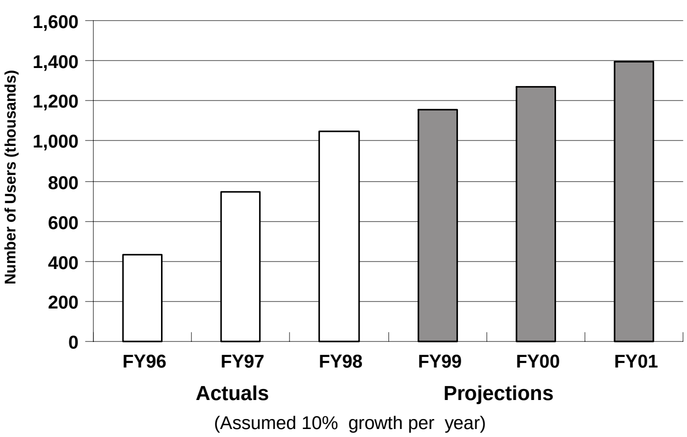

Figure 1. Number of distinct users accessing the DAACs

The entry in this table of total new users shows that a sizable fraction of the users are new to the DAACs each year. Another way of interpreting this would be that the DAAC users, on average, receive what they want in relatively few contacts and do not repeatedly patronize the DAACs.

For SCRS, the DAAC user identification depends on the e-mail address and only the e-mail address. This has the advantage of ease of use for the DAACs, since they do not need to provide any additional information specifically for the statistics, although they do provide dummy addresses for users ordering data off-line, when necessary. Using the e-mail addresses for the user identification does introduce some imprecision into the statistics. Users with multiple addresses, say for home and for work, will be counted more than once. Users of multiple DAACs will be counted once for each DAAC. The number of users accessing multiple DAACs is computed separately each month, and varied from less than 200 to over 400 through 1998, a small percentage of the total number of users, but still a source of imprecision in the statistics. Users, or their Internet service providers, may use a temporary or a dummy e-mail address, resulting in multiple people reported under the same address (‘a’ is a favorite) as well as a single individual reported with a different address for each access. Accesses and requests made by staff, user services personnel, and testers / developers have been removed, based on host identification or on information provided by the DAACs, in which there is also some imprecision. As a result, statistics on the number of users can only be regarded as reasonable approximations, and not precise counts.

Products and Volume Delivered

The deliveries from the DAACs are characterized in Table 3, which shows the total volumes delivered by the various mechanisms, and the average volume per delivery for the mechanism. In the categories, “tape” includes deliveries on 8 mm, 4 mm, 9-track, and DLT; “other” includes recordable CDs, diskettes, and deliveries for which no media type was reported. It can be seen that most deliveries are files of relatively small sizes. The larger average size for the CD-ROM is an artifact of the SCRS processing, in which

Table 2. Characterization of DAAC Users Receiving Products

Community	FY96	FY97	FY98
US Government	3,550	6,398	7,922
Educational	8,215	14,332	16,397
Commercial	12,036	36,865	53,708
Non-Profit	732	1,207	1,440
Other USA	559	742	923
Total USA	25,092	59,544	80,390
Foreign	9,192	26,883	46,518
Unknown	6,440	19,719	26,080
Total	40,724	106,146	152,988
Total New Users	**36,665**	**91,490**	**127,570**

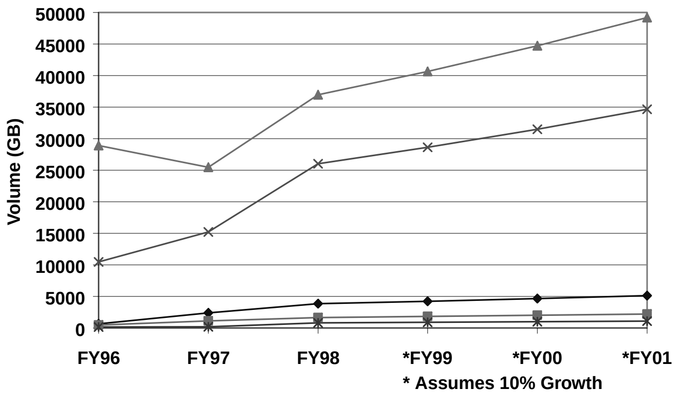

Figure 2. Volume delivered

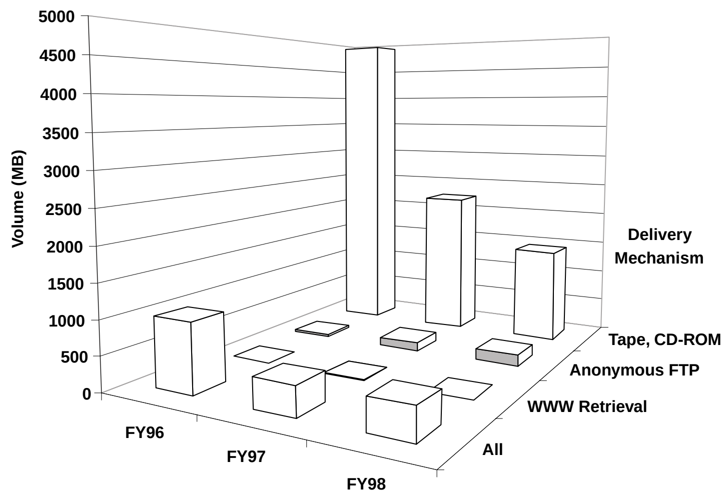

Figure 3. Average volume delivered per user

the DAACs are asked to report the products as the smallest unit which can be separately ordered. The CD-ROMs are pre-recorded, and are not generated upon demand. Multiple files delivered on tape would be reported as a number of individual deliveries, while the same files delivered on CD-ROM would be reported as a single, larger, delivery, on the grounds that the CD-ROM would be requested as a unit, while the files are separately selected. Also, there is some inconsistency in the reporting of compressed versus uncompressed volumes. The deliveries increased 33% from FY97 to FY98, and the volume delivered increased 56% during that time.

It is interesting to note the large size of staged FTP data files versus those that are retrieved by anonymous FTP. The staged FTP files are comparable in size to files delivered on tape.

Figure 2 shows the volume delivered, with the actual values for FY96-FY98 and projected values for FY99-FY01. Here again, the assumed growth rate was a conservative 10%. It is expected that there will be a considerable increase in the number and volume of deliveries as the new data products become available. Also, no attempt has been made to adjust the predictions to show a shift in the proportion of data delivered electronically versus data delivered on media. The prediction of 90 TB of data for FY01 includes a prediction of more data delivered on CD ROM than was delivered by all mechanisms in FY97.

Table 3. Characterization of Deliveries

	Volumes by Delivery Media (Mb)			Average Volume per Delivery (Mb)		
Media Type	**FY96**	**FY97**	**FY98**	**FY96**	**FY97**	**FY98**
Staged FTP	650,370	2,392,177	3,840,608	12.25	15.15	9.71
Tape	10,460,397	15,227,757	26,124,982	28.09	26.48	19.17
CD ROM	28,927,314	25,472,613	36,969,501	742.91	601.11	520.62
WWW Retrieval	34,665	170,389	355,457	0.17	0.27	0.49
Anon FTP Retrieval	476,984	1,112,274	1,658,031	0.45	0.57	0.85
Other	107,031	30,879	463,483	5.09	0.96	20.83
Total Volume	**40,656,761**	**44,406,089**	**69,412,062**	**23.39**	**13.16**	**15.37**

Figure 3 shows the average volume delivered per user over the three years of statistics. One of the interesting points this makes is that the average volumes of data received by data users decreased during these three years. The category labeled “Tape, CD-ROM” includes any delivery that is neither via WWW retrieval nor via anonymous FTP, which means that it also includes staged FTP.

Detailed statistics for FY96-FY98 are available on the EOS anonymous FTP server (eos.nasa.gov) under directory /EosDis/Daacs/Statistics in the spread-sheets fy990108.xls and pl990108.xls. Detailed statistics reports are posted to this site on a monthly basis. This directory also has the public data bases and descriptive material on the reports. The monthly plots can also be viewed via a browser at http://ulabibm.gsfc.nasa.gov/charts/. Access to the ftp server, as well as additional information, can be obtained via the DAAC Science Operations Office homepage at http://ivanova.gsfc.nasa.gov/SOO.

NASA Unveils Earth Observatory Web Space

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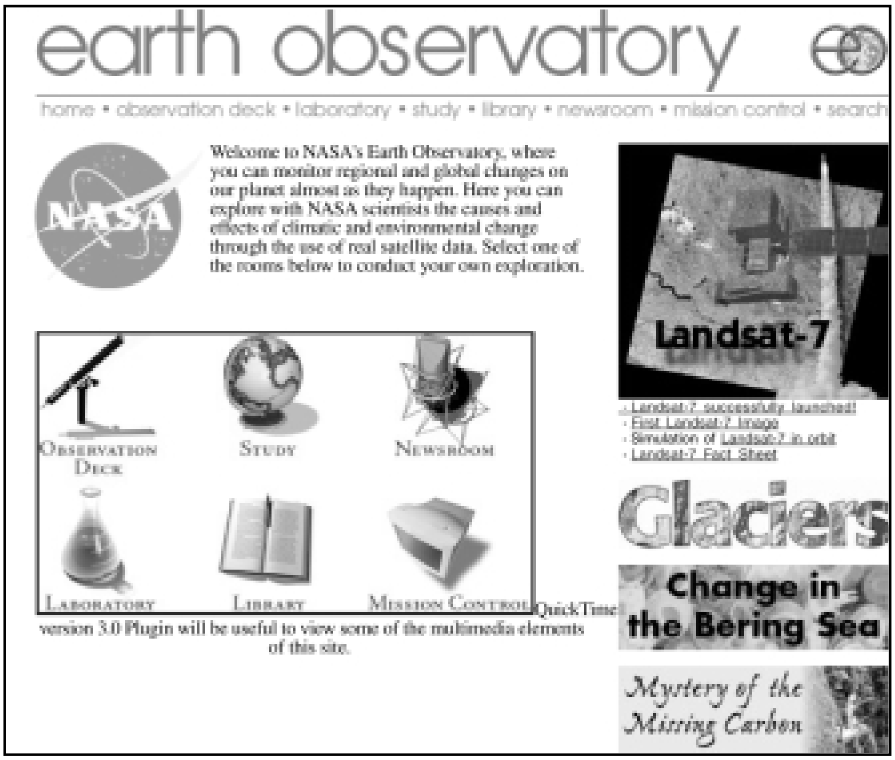

To help improve communications between its Earth scientists and the general public, NASA recently unveiled the Earth Observatory, a Web site where the public can learn about global climatic and environmental change. The Earth Observatory presents, in lay terms, stories, images, and animations that illustrate the complexities of Earth system science, as well as NASA's use of satellites and remote-sensing data to study our home planet. The site's URL (Uniform Resource Locator) is http://earthobservatory.nasa.gov.

The new Web site is sponsored by the Earth Observing System's (EOS) Project Science Office, Landsat 7, Terra, EOS PM-1, and the Goddard DAAC (Distributed Active Archive Center). It is designed to take advantage of new, rapidly-emerging Internet technologies for distributing multi-media information resources via the World Wide Web. As such, the Earth Observatory features real remote-sensing data that show key phenomena of change on global and regional scales, as well as background and contextual information written in lay terms.

In the first two weeks after its publication (April 29), the site received more than 91,000 visits from people around the world.

Who does the site serve?

Updated weekly, the purpose of the Earth Observatory is to serve as an information resource for educators, interested lay persons, and media writers. The site presents a new way of communicating the goals, objectives, and science results of EOS and NASA's Earth Science Enterprise to the public, using methods that better fit the next "electronic" century, rather than the present "paper-based" century. The goal of the site is to become a "living document" that the Earth science community continually updates to chart its progress as it extends human awareness and understanding of our home planet. So, whether accessed by an elementary school "whiz kid," a graduate student, a journalist, or a member of Congress, the Earth Observatory will serve as an interactive resource for learning the newest information about the causes and effects of environmental change through the use of remote-sensing data.

Since the site is designed for the general public, it is not tied to a particular satellite mission or NASA center (we feel that visitors want to learn about Earth, not NASA's internal structure). Our ultimate goal is to promote science literacy by sharing our new discoveries with those who are paying for them.

The Earth Observatory serves EOS and Earth Science Enterprise scientists by publicizing their work in ways that the general public can understand and appreciate. A Science Editorial Board, comprised of senior scientists from among the EOS community, guides the contents and development of the site. This board will help ensure that contents of the Earth Observatory are timely, accurate, and well balanced in their presentation.

The Earth Observatory also serves EOS data centers (Distributed Active Archive Centers, or DAACs) by giving examples of their data holdings, as well as low-level introductions to those visitors who may wish to order their own data to conduct their own analyses. Links to the respective DAACs will be added to facilitate public access to these data.

A room metaphor

The site is divided into six virtual rooms, each with a unique purpose. This design approach is intended to both render it easy for visitors to navigate (what will eventually become) our very large Web space and to provide a convenient way of "grouping" the types of information published in the site.

The Observation Deck contains global-scale data sets. Visitors can visually correlate animated movies or three-dimensional global data sets of any two global-change parameters available.

The Study presents in-depth science feature articles about new scientific discoveries or significant new Earth events. The room is designed to inform visitors both about what we know and what we still don't know about our home planet.

The Newsroom is designed to be a tool for journalists who want access to the very latest press releases, images, or other information that will assist them in their coverage.

The Library contains NASA Fact Sheets, a glossary of terms, and other background reference materials to help the novice understand the often abstract terms and concepts surrounding the Earth Science Enterprise.

The Mission Control room enables visitors to track NASA satellites that are in orbit. Currently, visitors can track the SeaWiFS and Landsat 7 spacecraft. Plans are underway to include TRMM, as well as QuikSCAT, Terra, and EOS PM-1 when they launch.

A call for submissions

Although, the Earth Observatory is supported by a core team that focuses on the Landsat 7, Terra, and EOS PM-1 missions, we (the core team) hope that the larger EOS and Earth Science Enterprise communities will also submit articles and images for publication on the site. To facilitate this, we intend to develop Web templates that render it easy and convenient to submit new materials to us. An online style guide is already available on the site to assist prospective authors.

The site is divided into virtual "rooms." Each room has its own editor who is responsible for its contents, as well as maintaining style and consistency. For all submissions, the room editor provides a first round of edits. Then new materials are forwarded to the Earth Observatory copy editors (Renny Greenstone and Bill Bandeen) for a second round of edits. During this process, if any major questions arise concerning the accuracy or credibility of a submission, the material is routed to a member of the Science Editorial Board for a final edit. This Board has the final say in whether a piece gets published or needs revision.

Credits

We wish to emphasize that although the Earth Observatory is managed within the EOS Project Science Office, it is the Earth Science community's web site. But special recognition goes to the following site designers, writers, graphic artists, and editors: Steve Ackerman, Jesse Allen, Bill Bandeen, Stephen Cole, Valerie Corey, Steven Graham, Renny Greenstone, Michael Heney, David Herring, Emilie Lorditch, Craig Mayhew, Greg Shirah, Robert Simmon, Reto Stockli, Stephanie Stockman, Barbara Summey, Mark Sutton, Marguerite Syvertson, Annette Varani, Kevin Ward, and John Weier.

Many thanks go to Michael King, Yoram Kaufman, Kevin Grady, Claire Parkinson, and Darrel Williams for funding the development of the site.

The Earth Observatory's governing Science Editorial Board is comprised of Mark Abbott, Michael Abrams, John Gille, James Hansen, Ralph Kahn, Yoram Kaufman, Michael King, Claire Parkinson, V. Ramanathan, Steven Running, Darrel Williams, and Bruce Wielicki.

EOS Scientists in the News

"Study Links Solar Activity to Earth's Climate," *CNN Interactive* (April 13). A paper in *Science* by **Drew Shindell** (NASA GISS) reports a link between solar activity and the Earth's climate. Increased solar activity leads to an increase in upper-atmosphere ozone, and this ozone warms the atmosphere causing changes in wind patterns. Model results showed stronger westerly winds in North America from increased solar activity, and that increased solar activity does not affect global warming.

"Is Another Dust Bowl Likely?," *The Denver Post* (April 12) by Ann Schrader. More than 60,00 square miles in the High Plains could turn into another "Dust Bowl," but that does not have to happen says **Alexander Goetz** (Univ. of Colo). Landsat 7 will provide an "eye in the sky" for Earth-watching scientists like Goetz.

"A New Force in High-Latitude Climate," *Science* (April 9) by Richard A. Kerr. **John M. Wallace** (Univ. of Wash.) explains how the Arctic Oscillation is a natural atmospheric response. The Arctic Oscillation has the potential to change minor atmospheric disturbances into major climate shifts. Wallace says that finding the triggers of Arctic Oscillation will help in the understanding of high-latitude climate variability.

"Amazon Rain Forest Fading," *Associated Press* (April 8). **Compton Tucker** (NASA GSFC) discusses new reports that the rain forest is being destroyed twice as fast as previously thought and the lack of control in monitoring rain-forest destruction.

"NASA Set To Launch Earth-Watching Satellite," *CNN Interactive* (April 1). High-resolution images of Earth from space will be available when NASA launches the Landsat 7 Earth-observing satellite. **Darrel Williams** (NASA GSFC) says that Landsat 7 will improve use of remotely sensed data in our daily lives. Landsat 7 will monitor surface changes such as urban sprawl, deforestation, agriculture land-use trends, glaciation, and volcanic activity.

"Rainy Night in Georgia, at Least in Atlanta," *Science News* (March 27). **Dale Quattrochi** (NASA MSFC) explains how using high-resolution satellite data has resulted in a detailed portrait of Atlanta's climatic geography. Quattrochi also says that over the past 25 years 380,00 acres of forest have been added to the "heat island" of Atlanta. Quattrochi's research was also featured in *Discovery Channel Online*.

"Jet Traffic Blamed for Global Warming," *San Francisco Examiner* (March 17) by Keay Davidson. **Patrick Minnis** (NASA LaRC) discusses the impact of increased cirrus cloud cover and its impact on global warming. Minnis used data from three National Weather stations in Northern California since 1971 and discovered an increased cirrus cloud cover of 5 percent, which could lead to a regional temperature increase between 0.5 to 1.2 degrees Fahrenheit.

"Study Looks at Prehistoric Climate," *Associated Press* (March 11) by Joseph B. Verrengia. **Richard Alley** (Penn State) says that the carbon dioxide changes over the last few thousand years have been small and slow in comparison to the changes in carbon dioxide caused by human activities.

"Sulfate Aerosols' Role in Climate Change Studied," *CNN Interactive* (March 10). **Jeffrey Kiehl** (NCAR) is investigating how much sulfate aerosols cool the climate. Kiehl says that the results of aerosol studies will improve the models used in predicting climate change.

"Taking Global Warming to the People," *Science* (March 5) by Kathryn S. Brown. **Cynthia Rosenzweig** (NASA GISS) models the result of temperature and rainfall changes on crop and water supplies worldwide. Rosenzweig believes the model can be used as a tool for economic development as well as research.

"Shrinkage Detected In Greenland's Ice," *Washington Post* (March 5) by Curt Suplee. Greenland's ice sheet has been shrinking by up to 6 feet in thickness per year. Scientists are relying on satellite observations to monitor the ice sheet. **Curt Davis** (Univ. of Mo.) says that many glacial experts think that satellite observations of elevations below 5,500 feet are unreliable. Two fifths of Greenland's ice sheet is at or below this elevation. These data are the first to show large shrinking rates over such a large area.

"Survey Uncovers Substantial Melting of Greenland Ice Sheet," *New York Times* (Mar. 5) by William Stevens. **Richard Alley** (Penn State) said that the shrinking of the Greenland ice sheet might be related to the general warming of the Earth. Alley also said that he is unsure if that warming is natural, human, or a combination of the two causes.

"Early Signs of Spring and Global Warming," *New York Times* (Mar. 2) by William Stevens. **Ranga B. Myneni** (Boston Univ.) found that spring arrived a week earlier in the early 1990s than ten years earlier. In a study published in *Nature*, Myneni says that as temperatures rise, growing seasons will be longer, resulting in an increase in global vegetation.

EOS researchers please send notices of recent media coverage in which you have been involved to:

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NASA's Resolute Bay/North Pole 1999 Expedition: Communications, Science, and Cultural Exchanges

— Steve Graham (smgraham@pop900.gsfc.nasa.gov), EOS Project Science Office/ Raytheon ITSS
— Claire Parkinson (clairep@neptune.gsfc.nasa.gov), EOS PM Project Scientist, Goddard Space Flight Center
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Preface

Imagine this: Out in space at an altitude of 22,300 miles, a 16-year-old, 2.5-ton NASA Tracking and Data Relay Satellite (TDRS-1) points her 24-karat gold-plated 16-ft antenna right to the spot where a small group of NASA engineers and scientists have just landed their ski plane on the ice floes (floating sheets of ice) at the North Pole. Quickly they unload the "big blue box" containing their portable ECOMM satellite ground station, connect the video camera, mount the 18-inch "pizza pan" antenna on its tripod, and whip it around to find the TDRS-1 satellite at only 0.9 degrees above the horizon. Suddenly, they're connected to the Internet, and students all over the world are participating in a virtual field trip to the North Pole! "What's that you have in your hand?", asks a student from Pennsylvania. "This is an ice auger bit, and here's how we are using it to measure the thickness of the ice floes at the North Pole," answers the Chief Scientist. This is outrageous educational outreach, reaching the next generation of our planet's caretakers right on their own computers.

On a recent trip to the Arctic, the North Pole was the unique site for a technology demonstration showing how NASA-developed technology and the Internet have made it possible for scientists working in very remote locations to send and receive data using NASA communications satellites. Goddard Space Flight Center (GSFC) engineers, scientists, and outreach personnel traveled to Resolute Bay and Eureka, Canada, before heading north to the "top of the world" where the first-ever Internet webcast was broadcast from the North Pole. What is unique about this expedition is that students worldwide participated in some of the scientific activities at remote locations via their personal computers. This "virtual field trip" involved the exchange of dialogue from their own computers while hearing responses to their questions as they watched live video demonstrations by the expedition team.

Communications and Science

Part of the expedition's objective was to demonstrate three separate communications packages: TILT (TDRS Internet Link Terminal), ECOMM (Early Communications), and PORTCOMM (Portable Communications). The TILT provided full duplex Internet Protocol data links at 1 megabit per second, ECOMM provided full duplex Internet Protocol data links at 128 kilobits per second, and PORTCOMM provided transmit-only file-transfer links at 4.8 kilobits per second. All three communication packages were developed at GSFC and use NASA's Tracking and Data Relay Satellite-1 (TDRS-1) to complete the communication links. Launched in 1983, TDRS-1 is currently in a geosynchronous orbit (an orbit in which the orbital velocity of the satellite matches the spin rate of the Earth) that is inclined sufficiently to make it visible to the polar regions of the globe four hours each day, with a maximum elevation of 1.6 degrees above the horizon.

In addition to the communications element, and as an integral component of the expedition, scientific observations and measurements were made. The team collected ozone measurements with a hand-held Microtops photometer provided by Gordon Labow of GSFC Code 916, and Global Positioning System (GPS) measurements with a Trimble GPS Unit provided by Steve Cohen and Erricos Pavlis of GSFC Code 921; and sea-ice-thickness measurements were drilled with both powered and manual ice augers. The ozone measurements will be compared with satellite observations made by NASA's Total Ozone Mapping Spectrometer (TOMS), as checks on both the Microtops and the satellite data. The GPS measurements from Resolute Bay will be used, in conjunction with additional measurements after several years, to examine glacial rebound, i.e., the uplifting of the land surface in response to the removal of the weight of the Pleistocene ice sheet. The GPS measurements from the North Pole will be compared with corresponding measurements taken concurrently at the South Pole and in equatorial locations, to allow students to quantify easily the polar flattening of the Earth, i.e., the fact that the distance from the North Pole to the South Pole is less than the equatorial diameter of the Earth. The sea-ice-thickness measurements are being compared with other Arctic ice-thickness measurements made from the surface and from submarines (sonar data). In addition, soil samples were collected, air temperatures were measured, and cloud-type and cloud-cover observations were recorded in conjunction with the protocols set forth by the Global Learning and Observations to Benefit the Environment (GLOBE) program and Elissa Levine of GSFC Code 923. These measurements added a new location for the global atmospheric-and soil-measuring efforts of the GLOBE program, as students worldwide will compare our data with data from their local schools.

From GSFC to the Arctic

The expedition team departed GSFC in Greenbelt, Maryland on April 19 for Resolute Bay, Canada (75°N, 95°W). Resolute Bay is located on Cornwallis Island in the new Canadian territory of Nunavut. While in Resolute Bay, we worked closely with Principal Shannon Adams, the 6 teachers, and the 70 students of the local K-12 school, called “Qarmartalik” (meaning “land of many sod houses” in the native language of Inuktituk). Expedition leader Mike Comberiate and Chief Scientist Claire Parkinson presented slide shows and lectures to the students, and our team’s first official webcast was broadcast from the school. For most of the students, it was their first exposure to the Internet. Subsequent webcasts were done from other locations around the town (hamlet), including the adjacent frozen bay, a mountain overlooking the town, and the facilities at Environment Canada. While performing the webcast from the mountain we experienced blizzard conditions with wind-chill temperatures in the -50 °F range; the planned 60-minute webcast was quickly shortened to 20 minutes.

On April 26, we departed for Ellesmere Island and the airport at Eureka, Canada (80°N, 86°W), a necessary refueling station for the two DeHavilland DHC-6 “Twin Otter” aircraft that we chartered from Resolute Bay. While in Eureka, we conducted webcasts, performed ozone and soil measurements, and were treated to a tour of the Environment Canada weather office by the airport station manager. The next day, five members of our expedition team headed for the North Pole. During a necessary refueling stop at 85°N, 100°W, the expedition team successfully drilled three holes for ice thickness measurements. Data from these and other measurements are currently being analyzed.

Approximately two hours later, and after circling the world three times (we crossed every line of longitude as we circled the pole), the Twin Otter touched down on the ice floes of the Arctic Ocean at 89° 58’N, 69° 41’W, approximately 2.5 miles from the exact North Pole. Numerous pressure ridges (convergence zones of ice floes) and leads (breaks in the ice) made for impossible landing conditions at the exact North Pole. Soon after landing, a prompt set up of the ECOMM, laptop computers, and video camera enabled a webcast and webchat from the North Pole, a historic first! The live webcast and chat session had to be timed precisely in order to coincide with the short TDRS-1 visibility window.

Twelve hours after the live webcast, the TDRS-1 satellite was over the opposite end of the Earth. Normally used to provide daily Internet connectivity to the South Pole, on that day TDRS-1 provided the only means of making a voice phone call to the South Pole. With an Iridium Satellite telephone at the North Pole and TDRS-1 at the South Pole, the team completed a call from its tent to NOAA and National Science Foundation personnel at the Amundsen-Scott Research Station, located at the exact South Pole. Also online for this historic phone call were expedition sponsor George Morrow, EOS PM Project Manager, GLOBE Headquarters representative Vince Hurley, and a GLOBE School in Pennsylvania.

A total of 28 hours were spent in the vicinity of the North Pole. Fortunately, the weather cooperated with us as the wind was mostly calm, visibility was good, and the temperature held steady at -20°F. Since it was springtime in the Arctic, the Sun never set, instead circling the horizon once every 24 hours.

Numerous pressure ridges and leads surrounded our camp, offering evidence that we were not on a stationary ice floe. Our GPS instruments indicated that the ice floe we worked and camped on was moving at approximately three-tenths of a mile per hour. Needless to say, where the Twin Otter dropped us off was not going to be at the same place where we would be picked up. We used an Iridium phone to contact the planes while they were waiting back at Eureka, and to provide them our GPS coordinates.

While keeping our fingers and toes warm was certainly a challenge, it was even more of a challenge warming the ECOMM, laptop computers, and video equipment to minimal operating temperatures. The same generator that powered our equipment also provided power to heating pads that were placed on top of the sensitive electronics. In some cases, hand and toe warmers were used to keep our camera and laptop batteries from freezing in the extreme temperatures encountered at the North Pole.

Many watchful eyes in the sky

During the entire expedition, five polar-orbiting weather satellites were regularly watching and imaging the locations where the field team was working. Data from weather satellites operated by NOAA provided real-time images of the weather and leads in the sea ice for planning the tactical deployment of the fuel cache on a suitable ice floe midway between land's end and the North Pole. NOAA satellite meteorologist Wayne Winston interpreted the NOAA satellite imagery and weather observations collected at Resolute Bay and posted a discussion of the daily weather situation for both the expedition team and students to follow. Additionally, David Walsh and others at the National Ice Center provided near-real-time 550-meter-resolution operational linescan system (OLS) imagery from satellites of the Defense Meteorological Satellite Program (DMSP) on a routine basis. They also provided very-high-resolution (50 meter) Synthetic Aperture Radar (SAR) imagery from the Canadian Radarsat satellite. Combined with the Arctic expertise of our pilots, this imagery enabled the team to see through the cloud cover to help pinpoint the appropriate ice floes on which to land.

Education and Outreach

In the weeks leading up to the trip, the expedition team worked closely with Tom Albert and Bob Gabrys of GSFC's Education Office on the design of the education and webcast plans. Schools selected through the EOS PM Project's "You Be the Scientist" program participated in the adventures by interacting with the team via a special webchat during the live webcasts. The webcasts were available to anyone with Internet access, while the chat sessions were restricted to the pre-selected participating schools. Topics of the webcasts included Inuit culture, sea ice, ozone, remote sensing, and satellite technology. During the webcast from the Qarmartalik School, cultural themes were exchanged between the local Inuit students and students from schools in the United States. The following U.S. schools participated in the live chat sessions: Indian Valley Middle School, Harleysville, PA; Forest Hills High School, Sidman, PA; Brigantine North Middle School, Brigantine, NJ; Red Cloud High School, Pine Ridge, SD; DuVal High School, Lanham, MD; Northwest High School, Gaithersburg, MD; Mississippi School for the Deaf, Jackson, Miss; and Terry Parker High School, Lanham, FL. Other schools from Europe, South America, Asia, and Australia were online at various times as well.

All-in-all, ten webcasts were completed, usually at 22 kilobits per second to allow schools with 28.8 kilobits per second (or higher) modem connections to participate. However, exclusive webcasts were broadcast to San Francisco's Exploratorium on April 24 at 100 kilobits per second and another to GSFC on April 30 at 50 kilobits per second, the latter in concert with the Center's 40th Anniversary celebration. On April 29, Goddard Space Flight Center's Deputy Director, William Townsend, participated in a live web chat with a select group of students from the Qarmartalik School.

Many of the students from the Qarmartalik School observed and participated in the webcast from the ice on Resolute Bay.

The Team

The GSFC North Pole 1999 expedition team included Mike Comberiate, Team Leader, EOS PM Project, Code 422; Claire Parkinson, Chief Scientist, Oceans and Ice Branch, Code 971; Andre Fortin, Communications Engineer, Space Network, Code 451; David Beverley, Webmaster / Producer, EOS PM Project, Code 422, EER; Chris Morris, Logistics Chief, EOS PM Project, Code 422; and Steve Graham, Education Liaison and Webcast Moderator, EOS Project Science Office, Code 900, Raytheon ITSS. In addition to the GSFC personnel, six others rounded out the expedition team: Richard Gamble, Videographer, Columbia, MD; Bill Schmidt, Consulting Engineer, Minneapolis, MN; Joel Berger, Technology Teacher, Indian Valley Middle School, Harleysville, PA; Tim Roberts, Technology Coordinator, Souderton School District, PA; Adam Siegel, Student, Walt Whitman High School, Bethesda, MD; and Tommy White Eyes,

The entire K-12 student body of the Qarmartalik School in Resolute Bay.

Student, Red Cloud High School, Pine Ridge, SD.

History in the making

Five historic milestones were accomplished during the expedition:

1. The first Internet link to the North Pole, 1930 - 2015 GMT on April 27, 1999.
2. The first live webcast video from the North Pole, 1945 - 2015 GMT on April 27, 1999.
3. The first virtual participation by students in NASA Arctic field work via the Internet, including live interactive chats and videos between students worldwide and NASA scientists at 75°N, 80°N, and 90°N.
4. The first North-Pole-to-South-Pole telephone conversation, 1030-1115 GMT on April 28, 1999. This conference call was coordinated by NASA's Marshall Space Flight Center and included the NASA North Pole 1999 Expedition Team, National Science Foundation and NOAA representatives at the South Pole, and representatives from NASA GSFC, Project GLOBE Headquarters, and a GLOBE school in Pennsylvania.
5. The first placement of a piece of the exact South Pole onto the exact North Pole, in commemoration of Earth Day 1999. This benign example illustrated the impact that humankind can have on the environment. (Expedition leader Mike Comberiate had collected a snow sample from the South Pole on a previous trip and brought the sample with him to the North Pole for this demonstration.)

For more information on NASA's "You Be the Scientist" Program and an archived collection of the expedition's webcasts and digital pictures, please visit the COOLSpace website at: http://coolspace.gsfc.nasa.gov/

EOS Science Calendar

June 15-17
Investigators Working Group Meeting, Vail, CO. Contact Mary Floyd, tel. (301) 345-3211, e-mail: mfloyd@westover-gb.com.

July 6-7
Joint AMSR Science Team Meeting, Hampton Inn Airport, Oklahoma City, OK. Contact Elena Lobl, tel. (256) 922-5912, e-mail: elena.lobl@msfc.nasa.gov.

July 14-16
AIRS Science Team meeting, Pasadena, CA. Contact Dr. H.H. Aumann, e-mail: aumann@jpl.nasa.gov, tel. (818) 354-6865.

Global Change Calendar

June 15-17
Joint Fire Science Conf. & Workshop, Boise, Idaho. Call for Papers. Contact Jon Ranson, tel. (202) 358-0276, Fax: (202) 358-2771, e-mail: jranson@hq.nasa.gov.

June 23-25
ATSR Workshop, ESRIN, Frascati, Italy Contact: ifyall@esrin.esa.it, Fax: (+39 06 94180362); http://www.esrin.esa.it/atsrconf/.

June 28-July 2
1999 Coherent Laser Radar Conference, Mt. Hood, Oregon. Contact Michael Kavaya, Michael.Kavaya@msfc.nasa.gov, URL: http://space.hsv.usra.edu/tenth_biennial_coherent_laser.html.

June 28-July 2
IGARSS, Hamburg, Germany. Contact Tammy Stein, e-mail: stein@phoenix.net, URL: http://www.igarss. org.

July 11-16
29th Conference on Radar Meteorology, Montreal. Contact Monica Tolson, email: tolson@smtpgw.dc.ametsoc.org.

July 18-30
The 22nd General Assembly of the International Union of Geodesy and Geophysics, University of Birmingham, UK. Contact: IUGG99, Beacon House, Long Acre, Birmingham B7 5JJ, UK. tel. +44 (0)121 322 2722; Fax: +44 (0)121 322 2240, URL: http://www.bham.ac.uk/IUGG99/.

August 2-6
18th Congress of the International Commission for Optics, San Francisco, CA. Contact: ICO XVIII Conference Manager, SPIE, 1000-20th Street, P.O. Box 10, Bellingham, WA 98225, tel. (1) 360 676 3290; Fax: (1) 360 647 1445; email: ico18@spie.org

September 8-10
Non-CO_2 Greenhouse Gases (NCGG-12) Scientific understanding, control and implementation, Noordwijkerhout, The Netherlands. Call for Papers. Contact Joop van Ham, e-mail j.vanham@plant.nl, Fax: +31-15-261 3186.

September 13-15
IEEE International Workshop on Multimedia Signal Processing, Copenhagen. Contact Jenq-Neng Hwang, e-mail: hwang@ee.washington.edu, URL: http://eivind.imm.dtu.dk/mmsp99/

September 13-17
Sixth Scientific Conference of the International Global Atmospheric Chemistry Project (IGAC), Bologna, Italy. Call for Papers. URL: http://www.fisbat.bo.cnr.it/IGAC99/.

September 15-17
Second International Workshop on Multi-angular Measurements and Models, ISPRA, Italy. Contact Michel Verstraete, e-mail: michel.verstraete@jrc.it, URL: http://www.enamors.org.

September 20-24
Conference on Sensors, Systems and Next Generation Satellites V, University of Florence, Italy. Call for Papers. Contact Steve Neeck, email: steve.neeck@gsfc.nasa.gov.

2000

March 27-31
28^{th} International Symposium on Remote Sensing of Environment, Cape Town, South Africa. Call for Papers. For abstracts submission: abstracts@mikom.csir.co.za or http:www.isrse.co.za, Fax: +27 21 883 8177; Tel: +27 21 886 4496 (ask for Deidré Cloete); postal: The 28^{th} ISRSE technical committee, PO Box 452, Stellenbosch, 7599, South Africa.

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