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Editor's Corner

On September 24, the U.S. House of Representatives and Senate approved the Appropriations Conference Committee bill that provides funding to the Veterans Administration, Department of Housing and Urban Development, and Independent Agencies (including NASA) for FY97. The NASA budget was approved at $13.7 B, of which the Office of Mission to Planet Earth was $1.402 B. After adjustments to the distribution of the overall budget within NASA, the total new obligation authority for MTPE is $1.327 B. Of this budget, $571.1 M is for EOS flights, $250.6 M for EOSDIS, and $368.4 M for science, including both the research & analysis program, the EOS Interdisciplinary Science (IDS) investigations, and $50 M for purchase of MTPE-related data from the commercial sector. This budget represents a $75 M reduction to the Mission to Planet Earth program from that requested by President Clinton. The conference report includes earmarks of $25 M of the MTPE budget for a LightSAR, Windsat, and a museum addition, and a blanket reduction of $100 M to NASA overall (of which $75 M was assigned to Mission to Planet Earth).

The MTPE/EOS Data Products Handbook (Volume 1) has recently been completed. This Handbook, edited by Stephen Wharton and Monica Myers, provides a brief description of the science data products that will be available from the Earth Observing System Data and Information System (EOSDIS). The objective of this Handbook is to promote a broader understanding of how the EOS data products will contribute to science research in the understanding, analysis, and monitoring of global climate change. This volume describes data products that will be produced from instruments onboard the Tropical Rainfall Measuring Mission (TRMM) and the Earth Observing System (EOS) morning satellite (AM-1), as well as products to be produced from the Four-Dimensional Data Assimilation investigation led by Richard Rood. The data descriptions in this reference, available from the Project Science Office or electronically via the World Wide Web (http://eospso.gsfc.nasa.gov), have been reviewed by the science teams for accuracy. Readers should be aware that this reference is only the "tip of the iceberg" of information available on MTPE/EOS data products to be produced as early as next year.

Plans are now underway to conduct a biennial review of MTPE in Spring 1997. This review is an important element in periodically reassessing the MTPE program status and direction in response to increased scientific understanding, evolving technology, new opportunities in the commercial, international, and operational arenas, and budget constraints. This review will consider progress made in MTPE/EOS since the National Academy of Sciences' Board on Sustainable Development review in July 1995, and will further consider (i) strategies for the second series of missions (AM-2, PM-2, Chemistry-2, etc.), (ii) the relationship between EOS and the National Polar Orbiting Environmental Satellite System (NPOESS), (iii) balance in the Research & Development program between basic and applied research, airborne science, modeling, and global observations, (iv) the insertion of new technology through programs such as the New Millennium Program (NMP), Earth System Science Pathfinders (ESSP), and the instrument incubator program, (v) plans under development by international partners, and (vi) data archival and distribution, including EOSDIS plans for federation.

I am happy to report that Michael Freilich, Oregon State University, has been elected chairman of the EOS Oceans Panel, succeeding Jim Yoder who has joined NASA Headquarters as the Ocean Biology Program Manager. Prof. Freilich is the principal investigator of the NASA Scatterometer (NSCAT), recently launched into space on ADEOS, as well as SeaWinds, to be launched in 1999 on ADEOS II. Prior to his election as chair of the Oceans Panel, Prof. Freilich has been supportive in establishing the EOS calibration/validation program, now coordinated and led by the Project Science Office.

—Michael King
EOS Senior Project Scientist

Note

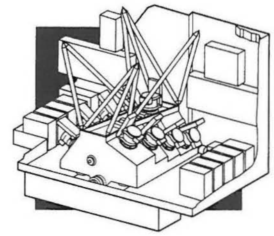
NASA press releases and other information are available automatically by sending an Internet electronic mail message to domo@hq.nasa.gov. In the body of the message (not the subject line) users should type the words "subscribe press-release" (no quotes). The system will reply with a confirmation via E-mail of each subscription. A second automatic message will include additional information on the service. NASA releases also are available via CompuServe using the command GO NASA.

Kudos

M. Patrick McCormick, Principal Investigator of the SAGE III instrument, was awarded the 1996 William T. Pecora Award during the Pecora Thirteen Symposium held in Sioux Falls, SD, in August. McCormick was honored for his contributions to the pioneering advancements of both active and passive remote sensing of the Earth's atmosphere from space.

The EOS community congratulates Dr. McCormick on his outstanding accomplishments.

Multi-angle Imaging Spectro-Radiometer (MISR) Science Team Meeting



— **Stuart McMuldroch** (stuart@jord.jpl.nasa.gov), MISR Science Coordinator,
Jet Propulsion Laboratory

The MISR Science Team met August 12-14, 1996, at the Jet Propulsion Laboratory in Pasadena, CA. As in previous years, the MISR annual meeting was an opportunity for all members of the team to obtain the latest information regarding the MISR instrument status. This year was also an opportunity to ratify MISR's existing data analysis algorithms and to discuss the science research possible, given the emphasis on the Level 2 and Level 3 products. The following text briefly describes the focus of the meeting and highlights the most important aspects of the proceedings.

Introduction

The Principal Investigator, Dave Diner, opened the session, bidding welcome to the team and summarizing resolved issues from the previous science team meeting. He then gave a brief overview of the meeting's objectives: 1) to update the team on instrument and software development status, 2) to identify critical time-sensitive issues, 3) to develop a research plan, thereby honing the MISR science emphasis, 4) to review test data requirements, and 5) to refine MISR's validation strategy.

Instrument Status, Software Development Status, and In-flight Calibration

Terrance Reilly gave the instrument and project status report. The construction of the MISR instrument is approaching completion with all flight subsystems, except the digital electronics, ready for integration. The previous problems with the digital electronics, namely the field-programmable gate arrays (FPGAs), are fixed, but have left little flexibility in the schedule. However, the MISR project expects to deliver an excellent scientific instrument by the scheduled delivery date while staying within budget. Francesco Bordi, EOS Project Office, continued by placing MISR's development in context with a description of the overall progress of the AM-1 project.

The science data system status was presented by Graham Bothwell. In the last year, MISR activities in this area have expanded, with staffing levels being increased to nearly full complement and system specification and development work progressing on defining the overall software system for Version 1. This delivery of the software system is expected to be as fully functional as possible, building upon the successful delivery of the earlier Beta Version in March, 1996. Most of the software analysis and design has been completed for Level 1, which includes the raw data handling and geometric and radiometric calibration procedures. For the Level 2 software, which performs the science data processing, final requirements analyses, based upon the completed ATBDs, are well underway. The production of MISR's ancillary data sets is expected to be completed in the next few months, while other issues, such as browse data and quality assessment, are being further defined. Progress also continues with the MISR home page on the "web" at http://www.misr.jpl.nasa.gov.

Carol Bruegge continued the meeting by describing the status of the MISR cameras and plans for in-flight radiance scaling and conditioning. Dynamical, thermal, radiometric, and spectral testing of 10 cameras (nine flight and one spare) has been successfully completed. With some additional ground processing to reduce out-of-band errors and to perform a point-spread-function deconvolution, the cameras meet all requirements. Once in orbit, the MISR cameras will continue to be calibrated using the on-board calibrator, vicarious calibration relying on field measurements, histogram equalization, and trend analyses which incorporate the preflight calibration data. Veljko

Jovanovic continued the discussion on in-flight calibration by detailing MISR's plans to perform geocalibration and coregistration using ground targets.

MISR Algorithm Development and Associated Science

As opposed to previous years, this section of the meeting focused on ratifying the existing MISR algorithms and discussing how a better link could be forged between the MISR products and proposed research topics.

Top of Atmosphere/Cloud

This session began with an overview presented by Roger Davies. In the last year, MISR cloud detection and classification algorithms were finalized, and significant progress was made on the design of the Level 2 software. New cloud masks, using stereoscopic and radiometric techniques, were also defined. These methods have been successfully tested on simulated images of Mexico and Hawaii, projected to the view angles of the MISR cameras. Peter Muller showed examples of applying MISR stereo retrievals to Along Track Scanning Radiometer (ATSR-2) data. Davies then described the methodology used by MISR to determine local albedos from which are calculated expansive and restrictive albedos.

Chris Borel and Sig Gerstl presented their work on calculating clear sky albedos. Their method utilizes a semi-empirical model which is fit to the observed radiances and then used to extrapolate to sun and view angles not observed by the MISR cameras. Comparisons with simulated MISR data, generated from multiple-stream radiative transfer codes, suggest that retrieval errors can be constrained to less than 1.5%.

Aerosol/Surface

John Martonchik started his briefing regarding MISR Aerosol/Surface issues by reviewing the MISR aerosol products. He then described the data sets crucial for determining MISR aerosol parameters, namely the Simulated MISR Ancillary Radiative Transfer (SMART) data set and the Aerosol Climatology Product (ACP) data set. The SMART data set contains the radiative transfer parameters for ten aerosol pure particle types. These types are combined, using a modified linear mixing theory, to reproduce the scattering properties of particle mixtures. The ACP is a collection of three files describing aerosol optical properties and the likelihood of an aerosol being observed. The SMART data set has been successfully built and is in the process of being tested while the ACP is under construction. Having reviewed MISR surface products, Martonchik continued by describing the algorithms and models used in their determination.

The MISR aerosol retrieval calculation uses a modified linear mixing method, which assumes that the scattering properties of an aerosol mixture can be estimated by linearly adding the contributions of the individual aerosol components. The standard linear mixing method fails if the mixture's components differ in their absorption properties. Wedad Abdou presented results showing that the modified method is a substantial improvement over the standard technique.

Since MISR aerosol retrievals are performed over land as well as ocean, it is necessary to determine what terrestrial surfaces are suitable for aerosol retrieval, and to construct simple Bidirectional Reflectance Function (BRF) models. Michel Verstraete presented work carried out with Bernard Pinty and Ola Engelsen regarding the most suitable land type—dense, dark vegetation (DDV). Their parametric BRF model adequately reproduces observations of reflectance factors from wheat fields to hardwood forest canopies over a range of sun zenith angles.

Ralph Kahn presented his summary of the sensitivity of the MISR instrument to aerosol properties. Preliminary studies indicate that column extinction optical depth can be retrieved to about 0.05 or 10%, whichever is larger, under a wide range of sky conditions. The aerosol retrieval will also be able to distinguish among many common particle types, which represent constraints on a combination of particle shape, size distribution, and composition. For example, MISR can distinguish spherical from non-spherical particles over calm ocean.

Tom Ackerman discussed results from the Atmospheric Radiation Measurement (ARM) Enhanced Shortwave Experiment (ARESE) field campaign. Comparison of observed-to-computed irradiance suggests that calculations overestimate the diffuse component by 5-10%. The only way to match all the observations is to include an unknown gaseous absorber that absorbs predominantly towards shorter wavelengths. This absorption could possibly be due to dissociation and/or fluorescence of trace gases such as NO_2. The implications of these results for MISR are yet to be determined.

Ranga Myneni continued the science discussion, describing results from AVHRR studies of the global vegetation index. Evidence suggests that the photosynthetic activity of global vegetation increased from 1981 to 1991 in a manner consistent with a prolonged growing season. The correlation with the increase in atmospheric carbon dioxide suggests that the carbon cycle has responded with fluctuations in temperature which are small on the global scale but have great regional significance. Ranga further described some of the MISR/MODIS surface product synergy.

Test Data

Test data can be considered as having two basic functions: 1) to test the scientific validity of a certain algorithm, and 2) to demonstrate that software produces expected results in accordance with specified requirements. Robert Ando described the methodology being used by the MISR team, emphasizing how test data can be used to ratify software. MISR tests range from unit tests which verify the functionality of individual executable components to full system-wide tests. Dave Diner led the discussion to decide upon a plan to improve upon the existing test data sets from both a software and scientific perspective. In addition to simulations, data from AirMISR, the airborne version of MISR, may give the closest approximation to MISR observations in the pre-launch time frame.

Level 3 Products

Dave Diner opened the discussion by describing the "at launch" Level 3 products. MISR products will be spatially-and-temporally-binned Level 2 parameters expressed monthly on the global equal-angle-1 grid adopted by the AM-1 instruments.

"Post launch" products will be much more mature, being more in number and possessing more intermediate spatial and temporal resolution. They may also be reported on a more-advanced grid. Jon Kimerling presented an alternative gridding scheme using hexagonal and pentagonal cells of equal area. Such a grid has the advantage of requiring no special projection for the poles, having no geographical singularities, and being nestable over many orders of magnitude in spatial scale. However, this gridding scheme has not yet been adopted since several implementation details need to be resolved.

Ralph Kahn continued in the "post-launch" theme by leading the discussion regarding strengthening the link between the team's specific science goals and the Level 2 and Level 3 products. These issues ranged from establishing and comparing climatologies to regional "process" studies. Each team member was charged with outlining specific research topics and describing which products would be necessary for the research.

Validation

Pre-launch validation efforts concentrate on algorithm validation and technique development, while post-launch efforts focus on MISR product validation and vicarious calibration. Jim Conel discussed possible field campaign agendas and how they may be combined with instrument networks. Since MISR cloud validation is necessarily difficult and as yet in the nascent stages, it was suggested that future planning efforts be concentrated in this area. Tom Ackerman suggested that MISR cloud validation efforts emphasize climatologies by comparing retrievals with long-term databases at existing measurement sites. Such sites should possess radar and lidar instrumentation, as these methods are the most preferable ways of quantifying cloud heights and motions.

A major advance in the last year, relevant to field instruments, has been the development of an airborne version of MISR (AirMISR). Tom Chrien discussed AirMISR's design, its abilities, and its relationship to MISR itself. Constructed from a spare MISR camera, AirMISR yields pushbroom images with views ranging from 70° forward to 70° aft by utilizing a gimbal system. Flying aboard an ER-2 aircraft at an altitude of 20 km, it will produce nadir-view images about 10 km on a side with 7 m resolution. Construction and engineering tests are expected to be completed in 1996. AirMISR's primary mission is to collect MISR-like data sets to support development and validation of MISR parameters. AirMISR will also provide an additional radiometric calibration path to assist with in-flight instrument characterization.

EOS Calibration Panel Meeting

— **James J. Butler** (butler@highwire.gsfc.nasa.gov), NASA/Goddard Space Flight Center, Code 920.1, Greenbelt, MD 20771

The eighth EOS Calibration Meeting was held at NASA/Goddard Space Flight Center (GSFC) on July 9, 10, and 11, 1996. Attendees included science and engineering representatives from the EOS AM-1, PM-1, and Chem platform instruments and from Landsat-7 Enhanced Thematic Mapper Plus (ETM+), the Active Cavity Radiometer Irradiance Monitor (ACRIM), the Tropospheric Emission Spectrometer (TES), the Stratospheric Aerosol and Gas Experiment III (SAGE III), and the Solar Stellar Irradiance Comparison Experiment (SOLSTICE). In addition, representatives from the National Institute of Standards and Technology (NIST), NASA Headquarters, the EOS Data and Information System (EOSDIS), NASA/GSFC Codes 400 and 700, the Canada Centre for Remote Sensing (CCRS), the University of Arizona Optical Sciences Center, and Northern Arizona University (NAU) attended the meeting.

Meeting Day 1: July 9, 1996

On the first day of the meeting, the EOS Calibration Scientist, Jim Butler, quickly reviewed the agenda for the three-day meeting. The first presentations were calibration status reports from each of the EOS instruments in attendance. Each presenter was instructed to summarize the calibration status of his/her instrument, clearly indicating any calibration-related problems.

Phil Slater of the University of Arizona Optical Sciences Center presented the calibration status report for the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) on behalf of Kohei Arai. The testing and calibration of the ASTER visible/near infrared (VNIR) and shortwave infrared (SWIR) instruments are reported to be progressing on schedule, but the thermal infrared (TIR) instrument is experiencing a delay due to scan mirror problems. The out-of-band rejection of the ASTER filters has been measured but a time line for the review of these data by the science team has not been established. Slater also stated that he was not sure if radiation exposure tests have been performed on the ASTER instrument. An optical defect in an ASTER VNIR filter was determined to affect the calibration of 3 ASTER pixels. This effect was discovered when illuminating the ASTER instrument with an F/84 beam but was not apparent when illuminating the instrument with an F/4 beam. Earth view data will be able to be corrected for this effect. There is no plan for a hardware fix to eliminate this effect.

Bob Lee of NASA/Langley Research Center (LaRC) presented the calibration status report for the Clouds and the Earth's Radiant Energy System (CERES) instruments. Lee reported no show stoppers with respect to the CERES instruments and their calibration. The CERES instrument for the Tropical Rainfall Measuring Mission (TRMM) was delivered to NASA/GSFC in October 1995 and successfully integrated in January 1996. The AM-1 CERES calibration is scheduled for completion in September 1996. Lee reported that the new CERES instruments do not exhibit the 20 count offsets of the Earth Radiation Budget Experiment (ERBE) instruments. The CERES instrument is calibrated prelaunch in a hard vacuum environment. On orbit, CERES plans to perform calibrations initially at high frequency then decreasing with time. Data validation techniques will not be sufficient to verify the CERES on-board calibration. On AM-1 the two CERES instruments plan to use series of common cross-over points to perform sensor cross-calibration. Lastly, the CERES concern that the deployment of diffuse calibration panels by the Multi-angle Imaging Spectro-Radiometer (MISR) instrument on the AM-1 platform interferes with the field of view of CERES has been resolved.

Carol Bruegge of the Jet Propulsion Laboratory (JPL) presented the calibration status report for MISR. Bruegge reported that the MISR camera calibrations were being finalized. In that process several sets of bulbs have been installed and replaced in the MISR integrating sphere. During the course of the calibration, several interesting problems were discovered and either have been or are being addressed. These items include the following: (1) strong, strategically positioned sources causing anomalies in the MISR optical performance, including saturated pixels affecting neighboring pixels; (2) illumination of MISR channel stops causing erroneous digital number (DN) output; (3) MISR performance when viewing dark targets in bright scenes; and (4) a 3% out-of-band contribution to certain MISR in-band signals. Bruegge reported that the out-of-band contribution will be corrected to 0.5% or better using MISR channel reflectance retrievals. The implications of this correction for MISR data processing will be determined by the MISR processing team and communicated to the EOSDIS.

Bill Barnes of NASA/GSFC presented the calibration status report for the Moderate Resolution Imaging Spectroradiometer (MODIS) on behalf of Bruce Guenther. Barnes reported that MODIS has experienced scattered light problems, some of which could be characterized by performing deep space and lunar spacecraft maneuvers on orbit. Barnes presented information on the variable response of the MODIS instrument with scan angle, the changes being implemented to remedy optical cross-talk problems, ghosting, and the MODIS near-field and far-field response.

Concerning MODIS near-field and far-field response, bright clouds located over a dark ocean will adversely affect the ocean data due to scattered light contamination. The near-field response of MODIS can be measured but the far-field response is much more difficult to measure. The possibility of an on-orbit maneuver to provide MODIS a near-solar view in order to quantify the far-field response was introduced and discussed.

Jim Drummond of the University of Toronto presented the calibration status report for the Measurement of Pollutants in the Troposphere (MOPITT) instrument. Drummond stated that MOPITT is concerned with temperature gradients being introduced by perturbations to the normal Earth-viewing thermal environment. The need for a stable, thermal environment for the proper operation of MOPITT was emphasized.

Brian Markham of NASA/GSFC presented the calibration status report for the Landsat-7 ETM+ instrument. Markham provided an overview of ETM+ instrument operation and calibration. With respect to possible calibration problems, the ETM+ employs a partial aperture on-board solar calibrator similar to that which was used on the MultiSpectral Scanner (MSS). This calibrator is exposed on orbit. Markham reported that the primary focal plane has been integrated, and the cold focal plane has been integrated into the radiative cooler. System level tests will conclude in July 1996, with projected delivery of the instrument to the platform integrator at the end of calendar year 1996.

Richard Willson of Columbia University presented the calibration status report for the ACRIM instrument. ACRIM is a flight-of-opportunity instrument scheduled for launch in the 1998-1999 time frame. Willson emphasized the importance of developing a precise overlap strategy to maintain continuity in the total solar irradiance database. It was also suggested that ACRIM instruments should engage in comparison exercises with those existing absolute cryogenic radiometers currently being used as standards.

Bill Chu of NASA/LaRC presented the calibration status report for the SAGE III instrument. The SAGE III preliminary design review (PDR) was held in July 1995, and the critical design review (CDR) was scheduled for August 1996. SAGE III is scheduled for launch in August 1998 aboard a Russian Meteor 3M. The calibration issue of detector linearity was discussed. Chu stated that SAGE III detector linearity is characterized over a dynamic range which encompasses the dynamic range experienced on orbit.

George Aumann of JPL presented the calibration status report for the Atmospheric Infrared Sounder (AIRS), the Humidity Sounder from Brazil (HSB), and the Advanced Microwave Sounding Unit (AMSU). With respect to AIRS, which will fly on the PM-1 platform, Aumann expressed concern that the implementation of orbital maneuvers might upset the thermal environment of the platform and cause discontinuities in the climate record. Aumann reported that AMSU, built by Aerojet Corporation, is exceeding specifications. The

HSB will probably be a copy of the National Oceanic and Atmospheric Administration (NOAA) K, L, M instrument.

Brian Johnson of the National Center for Atmospheric Research (NCAR) presented the calibration status report for the High Resolution Dynamic Limb Sounder (HIRDLS). HIRDLS desires a small pitch maneuver of the Chem spacecraft to enable HIRDLS to measure radiometric strays via a full elevation and azimuth scan of deep space. A suggestion was made during the presentation that an interferometer could possibly be used instead of a monochromator in the Oxford calibration chamber. The concern that calibration could be lost in shipment of the instrument between the United Kingdom and the United States was discussed.

Ron Holm of JPL presented the calibration status report for the Tropospheric Emission Spectrometer (TES). TES is scheduled for a 2001 launch. Holm presented an overview of the instrument and its science. Currently, the Airborne Emission Spectrometer (AES) serves as a testbed for TES. The calibration plan for TES is being developed, and the instrument will eventually be moved into the MISR cleanroom facility at JPL. The plan is to maximize the use of MISR personnel and instrumentation in the build of the TES instrument.

Gary Rottman of the University of Colorado presented the calibration status report for the SOLSTICE instrument. The SOLSTICE instrument has a strong heritage with the SOLSTICE instrument which was launched on the Upper Atmosphere Research Satellite (UARS). Rottman reported that, upon opening the instrument, the UARS SOLSTICE experienced a 10% degradation over 5 years. The importance of maintaining and operating beam line 2 at the NIST Synchrotron Users Research Facility (SURF) in support of the calibration of SOLSTICE was emphasized.

Carol Johnson of NIST presented preliminary results on the February 1995 EOS Radiometric Measurement Comparison held at NEC, Yokohama, Japan on the ASTER and Ocean Color and Temperature Sounder (OCTS) integrating spheres. Participants in the comparison included NIST, the University of Arizona Optical Sciences Center Remote Sensing Group, NASA/GSFC, and the National Research Laboratory of Metrology (NRLM). Radiometric measurements were made by NEC on the two spheres the week before the formal comparison. Comparison of the percent differences between the comparison participants' measurements and the NEC measurements indicated agreement to better than 2 to 3% for 3 light levels on the ASTER sphere and 4 light levels on the OCTS sphere.

Following her presentation on the February 1995 Radiometric Measurement Comparison, Carol Johnson presented detailed information on the EOS Visible Transfer Radiometer (VXR) and plans for an EOS Shortwave Infrared Transfer Radiometer (SWIRXR). The EOS VXR follows the optical and electronic design of the SeaWiFS Transfer Radiometer (SXR). The EOS VXR is reported to be assembled and ready for characterization at NIST. The design for the SWIRXR is about to begin.

Joe Rice of NIST presented detailed information on the EOS Thermal Infrared Transfer Radiometer (TIRXR). The TIRXR is a portable radiometer which can operate in ambient or vacuum environment and can be used to verify the radiance scale of the blackbody sources used in the thermal infrared calibration of EOS instruments. Rice indicated that the TIRXR will be absolutely calibrated against the NIST Low Background Infrared Facility's (LBIR) Absolute Cryogenic Radiometer (ACR) using a large-aperture transfer blackbody. The accuracy of that calibration is anticipated to approach 1% in absolute radiance. In addition, the TIRXR will be used to place EOS instrument calibration blackbodies on a relative radiance temperature scale to 20 mK. Rice presented a number of compatibility and interface issues which must be addressed by the EOS instrument calibration facilities and NIST in advance of deployment of the TIRXR. The possibility of sending EOS calibration blackbodies to NIST for calibration was discussed.

Stuart Biggar of the University of Arizona made a presentation on their visible/near infrared and shortwave infrared transfer radiometers. The University of Arizona visible/near infrared radiometer operates from 0.4 to 0.9 μm using a silicon trap detector. The shortwave infrared radiometer operates from 0.7 to 2.5 μm using a cooled indium antimonide detector. Both radiometers use a series of interference filters for wavelength channel selection. The visible/near infrared and shortwave infrared radiometers will participate in the August radiometric measurement comparison at Santa Barbara and Pasadena, CA.

Jim Butler of NASA/GSFC presented information on the NASA/GSFC Scanning Spectroradiometer. The scanning spectroradiometer transfers the irradiance scale from an irradiance standard lamp to the integrating sphere under test. A knowledge of the geometry of the measurement of the integrating sphere is then used to calculate the sphere radiance. Butler outlined a number of improvements in the NASA/GSFC equipment which, upon implementation, should improve the efficiency of the NASA/GSFC measurements in the EOS radiometric measurement comparisons.

Jim Butler outlined plans for future radiometric measurement comparisons. In August, a comparison is planned to perform radiometric measurements on the MODIS and Landsat-7 ETM+ integrating spheres at Hughes Santa Barbara Remote Sensing and on the MISR sphere at the Jet Propulsion Laboratory. In addition, the second ASTER comparison has been scheduled for October 1996 in Yokohama and Kamakura, Japan. Future comparison and comparison-related activities will include revisiting the MODIS sphere in Santa Barbara, coordinating the deployment of the EOS TIRXR to EOS instrument calibration facilities, and investigating approaches for creating radiometric links to other international remote sensing instruments.

The final presentation of the first day of the meeting was by Yvonne Barnes of NIST on the status of the EOS artifact bidirectional reflectance distribution function (BRDF) round-robin. Barnes indicated that the purpose of the round-robin was to circulate a set of common reflectance targets among EOS instrument calibration laboratories and other metrology laboratories in an effort to quantify the anticipated spread of diffuse reflectance measurements. The round-robin approach will employ a set of 4 targets to be measured by 6 laboratories at a number of wavelengths in the visible/near infrared and shortwave infrared wavelength region. The NIST Spectral Tri-Function Automated Reference Reflectometer (STARR) facility will serve as the hub institution during the round-robin.

Meeting Day 2: July 10, 1996

The first presentation on the second day of the meeting was by Phil Slater. Slater provided a preliminary report on the first vicarious calibration cross-comparison campaign held in May/June 1996 at Railroad Playa and Lunar Lake in Nevada. Slater stated that the purposes of the comparison were: (1) to compare top-of-the-atmosphere spectral radiances at specified monochromatic wavelengths and selected passbands in the solar reflective range, and (2) to provide an opportunity to conduct a variety of infrared experiments. The comparison also provided an excellent indication of the robustness of the vicarious calibration techniques. Slater stated that the preliminary results of the campaign are being analyzed now, and that reports will be completed by the participating groups by the end of July. Slater suggested that July would be a good time to begin to solicit suggestions from potential participants in a 1997 campaign, with a goal of October 1996 for finalization of plans. Slater also emphasized the important role that vicarious calibration will play in the EOS program. Slater estimated that there are 30-to-40 vicarious results being produced by more than a dozen research groups world-wide. The work of these groups should possibly be coordinated by the EOS Calibration Scientist in order to maximize global calibration science benefits.

The remainder of the morning was devoted to presentations by each AM-1 instrument on plans for validation of their Level 1 (i.e., radiance) products. Phil Slater began by presenting information on the role of vicarious calibration in the ASTER Level 1-B product. Slater stated that the U.S. and Japanese ASTER teams have extensively discussed how to use vicarious calibration results with respect to the ASTER radiance product. He said that an approach for incorporating vicarious results into the Level 1 product is to convene a meeting of a review panel of specialists in pre-flight round-robin activities and vicarious calibration, science team members, and instrument experts. The weighing of the importance of vicarious calibration results will be determined through meetings of that group. Slater also proposed the use of a newsletter to communicate changes in vicarious calibration results and their effect on the Level 1 product.

The CERES Level 1 data validation plans were presented by Bob Lee. Lee stated that CERES does not plan to change calibration coefficients based on validation results unless the coefficients exceed certain pre-flight-determined levels. Lee also stated that CERES on TRMM plans to use deep space views provided through spacecraft maneuvers to quantify their DC offset.

Carol Bruegge stated that the source of MISR vicarious calibration radiances will be the MISR validation team. The MISR approach will be to decide up-front on the criteria for updating Level 1B calibration coefficients and then automatically to implement those updates. Bruegge also reported that MISR will use the high-altitude instrument, AirMISR, to perform vicarious calibration.

Bill Barnes presented the MODIS plans for validating the Level 1B product. Barnes stated that the MODIS Science Team wants the Level 1B algorithm to remain constant. The recommendation was made from the panel that since the international community wants these data in a timely manner, MODIS should be prepared to implement any changes to the calibration coefficients in the first quarter of 1999, as dictated by Level 1 validation results. Barnes also presented an indexing scheme to reflect the quality/uncertainty of MODIS data at the pixel level.

Jim Drummond and Mark Smith presented the MOPITT plans for validating their Level 1B data product. Drummond stated that the MOPITT Level 1B product is an intermediate one, in the sense that it is a feed to the Level 2 processing. Drummond also stated that MOPITT is searching for other sources of methane concentration data for validation purposes, such as the data from the Network for the Detection of Stratospheric Change (NDSC). Smith presented information on the two MOPITT aircraft instruments: the MOPITT Algorithm Test Radiometer (MATR) and MOPITT Airborne (MOPITT-A). A desire was expressed for MATR to be included in the list of potential participants in future vicarious calibration campaigns.

Phil Slater led a discussion of plans for future vicarious calibration campaigns. Slater proposed round-robin laboratory BRDF measurements of large diffuse panels in support of the reflectance-based field measurements. A complementary or alternative approach would be to perform an in-field comparison of diffuse panels and radiometers employing the sun as a common light source. Slater pointed out that similar approaches would work for radiance-based measurements. Thermal infrared radiometers could be compared through cross-comparison measurements on accompanying blackbodies. Agreement between vicarious calibration results depends on detailed description of each participant's procedures, careful characterization of instruments and artifacts, and the establishment of a set of common, accepted measurement, data analysis, and reporting protocols. Slater indicated that the adoption of a single solar spectral exo-atmospheric irradiance scale by comparison participants would contribute to reducing measurement uncertainties. Slater stated that a subgroup of the EOS Calibration Panel should be formed under the leadership of the EOS Calibration Scientist to organize the next vicarious calibration campaign.

An overview of the SeaWiFS Intercalibration Round-Robin Experiment (SIRREX) was given by Carol Johnson. The purpose of SIRREX is to transfer the NIST scale of spectral irradiance through NASA/GSFC to all participating national and international laboratories in the SeaWiFS ocean color community and to the standards used to calibrate the SeaWiFS instrument for radiance responsivity. Johnson stated that crucial to this process was the formulation by the SeaWiFS ocean color community of a series of protocols to define validation instrument setting parameters and measurement protocols.

Ambler Thompson of NIST presented information on the North American UltraViolet-B (UV-B) Intercomparison Program. Thompson presented information on the participating instruments and their measurements obtained during the UV-B intercomparisons held at Table Mountain, Colorado.

Jim Butler led a discussion on strategies for the extension of the EOS calibration program to EOS validation instruments. The discussion was not limited just to validation instruments involved in vicarious calibration but also included instruments used in the validation of higher order data products. Butler led discussions on a number of related topics in this area including defining the proper balance between measurement and review and assessing program budgetary and technological feasibility. Butler's proposed strategy separated the validation community into the vicarious calibration community and the higher order data product validation community. The formation of working groups in each community was proposed with the higher order data product validation working groups involving representation across all EOS instrument teams, broadly organized along the lines of the EOS 24 Measurement Sets: Atmosphere, Solar, Land, Ocean, and Cryosphere. The recommendation was made by the Calibration Panel that higher order data product validation and vicarious validation activities not be separated so rigorously.

Carol Bruegge led the final discussion of the day on radiance and reflectance products in EOS. Bruegge presented three areas in which a uniformly adopted approach by EOS will facilitate the exchange, use, and comparison of results between EOS instruments. These areas included the following: the effect of source color temperature and accounting for its effects in the form of instrument out-of-band contributions, the calculation of band-averaged radiance versus monochromatic radiance, and the adoption of a common solar irradiance spectrum.

Meeting Day 3: July 11, 1996

The first portion of this final half-day session was devoted to presentations on two calibration techniques. The first technique, presented by Phil Slater, was Solar Radiation Based Calibration (SRBC) as an example of a unified approach to the pre- and in-flight, full-aperture calibration of satellite sensors. Slater clearly identified several areas in SRBC where protocols could be established for defining and standardizing the technique. These areas included measurement of the BRDF of solar diffusers, calibration of radiometers, calculation of the solar aureole correction, agreement on exo-atmospheric spectral irradiance values, characterization of the mirror used to reflect solar irradiance into the instrument under pre-flight calibration, and use of an EOS transfer radiometer to determine the radiance of the diffuser at the time of the SRBC. Stuart Biggar followed with a detailed error budget for the SRBC technique.

Hongwoo Park of NASA/GSFC presented an overview of the Total Ozone Mapping Spectrometer (TOMS) instrument, its prelaunch calibration, and the backscattered ultraviolet (BUV) measurement approach. Park provided information on the prelaunch irradiance, radiance, and goniometric calibration of the TOMS instrument and their effective use of multiple calibration approaches.

Jim Butler and Greg Hunolt, both of NASA/GSFC, presented information on archiving calibration data. Butler, in his presentation, identified the following eight sources of archivable calibration data: radiometric measurement comparison data, artifact round-robin data; Level 1 validation data, pre-flight instrument calibration data, on-orbit instrument calibration data; data from the calibration of higher order data product validation instruments, image-based analysis data, and cross-comparison satellite data. Hunolt stated that archiving calibration data is recognized by EOSDIS as a fundamental requirement for science support. Calibration data will be archived at the Distributed Active Archive Centers (DAACs), and these data will be accessible from EOSDIS Core System (ECS) data servers. Hunolt charged the instrument teams to define those calibration data which need to be archived to ensure that scientists have all the information needed to understand the data. The instrument teams then need to coordinate this information with the responsible DAAC. Hunolt suggested that the Science Software I&T Procedures could possibly be where the specific archiving requirements for these calibration data should be documented.

James Anderson of Northern Arizona University (NAU) presented an overview of the lunar radiometric measurement program being conducted jointly by NAU and the United States Geological Survey (USGS) in Flagstaff, Arizona. This is a multi-year program in which Earth-based observations of the Moon are accumulated, corrected for atmospheric extinction using a series of standard star observations, and calibrated using an in-dome integrating sphere and standard lamp observations. The calibrated and corrected lunar images are used to produce an exo-atmospheric lunar radiometric model for each lunar pixel. The lunar radiometric model will be used by those EOS instruments which are able to view the Moon in the on-orbit determination of those instruments' visible, near infrared, and shortwave infrared radiometric responsivities.

Jim Butler concluded the calibration meeting with a discussion of EOS platform maneuvers for deep space and lunar viewing. The five-step MODIS roll-based maneuver and the MISR/ASTER five-step pitch-based maneuver were illustrated and discussed. The five-step maneuvers satisfy the deep space and/or lunar viewing desires of MODIS, CERES, MISR, and ASTER. However, in order to minimize thermal impact on the MODIS passive cooler and to provide ASTER with a view of the Moon between 4 and 11 degrees lunar phase, the two maneuvers must be performed on orbits separated by several days. This is contrary to the desire of the EOS AM-1 project to present these maneuvers as a single maneuver performed on consecutive orbits. Butler warned that a discussion of lunar/deep space viewing requirements needs to begin for the PM-1 platform with the formation of a calibration attitude maneuver (CAM) working group for the PM-1 platform.

NASA Announces Winning EPSCoR States

— **Beth Schmid**, NASA Headquarters, Washington, DC. (Phone: 202/358-1760)

NASA has selected South Carolina, Kansas, Oklahoma, and Nebraska to each receive three-year, $500,000 annual awards to enable them to develop Earth science, space science and applications, aeronautical and space research, and technology programs.

The selection is part of NASA's Experimental Program to Stimulate Competitive Research (EPSCoR). The program is designed to assist states in developing an academic research enterprise directed toward a long-term, self-sustaining, nationally competitive capability that will help contribute to the state's economic viability in the future.

Of the 14 proposals submitted, the proposals from these four states were selected after a thorough peer review process involving NASA, university, and industry experts.

The states eligible to apply for this award were those designated by the National Science Foundation (NSF) as eligible for the NSF EPSCoR and/or those states currently designated as Capability Enhancement grantees in NASA's National Space Grant College and Fellowship Program.

NSF established EPSCoR in 1979 in response to congressional concerns that federal research and development efforts were supporting only a handful of states. A decade later, in 1990, Congress began the process of expanding EPSCoR beyond NSF. Consequently, NASA, the Departments of Agriculture, Energy, and Defense, the Environmental Protection Agency, and the National Institutes of Health have implemented EPSCoR programs. NASA's EPSCoR program began in 1994.

As part of the Agency's Education Division, Washington, DC, NASA's EPSCoR program was conceived to improve a state's competitive research capacity in areas relevant to the agency's mission. NASA's EPSCoR goals are to contribute to a stronger science and technology base, broaden geographic participation of technologically sophisticated businesses and industries while supporting a more competitive national economy, strengthen science education and expand science and engineering training opportunities, particularly for women and minorities, and reinforce the importance of supporting science and technology.

Aerosol Remote Sensing Workshop

— **Yoram Kaufman** (kaufman@climate.gsfc.nasa.gov), EOS AM-1 Project Scientist, NASA Goddard Space Flight Center

A workshop on the "Passive Remote Sensing of Tropospheric Aerosols and Atmospheric Correction for the Aerosol Effect" was conducted in Washington, DC, April 15-19, 1996. The interest in tropospheric aerosols (liquid and solid particles suspended in the air) was resurrected recently when climate modelers indicated that tropospheric aerosols generate the main uncertainty in anthropogenic forcing considered in predicting climate change, twice as large as the uncertainty in the greenhouse warming. Aerosols may counteract a large part (or most) of the present, globally-averaged, greenhouse forcing; but their regional rather than global scale is expected to introduce even more important climate effects, from cooling in the North Atlantic region to possible reduction of atmospheric mixing in the tropics. Aerosols are also increasingly important in understanding atmospheric chemistry, being sinks to atmospheric species and surfaces for fast chemical reactions. Aerosols are considered the main long-range transport mechanism for nutrients between continents and between continents and oceans. They fertilize the Amazon Basin, generate the red top soil in Bermuda, and are the main source of iron for oceanic phytoplankton. Aerosols serve as an indicator of the presence of air pollution, reflect the magnitude of biomass burning, and are involved in acid depositions. Aerosol interaction with solar radiation inhibits observations of the Earth's surface, including oceanic and land productivity.

The workshop brought together, in a highly scientifically stimulating but socially relaxing atmosphere, most of the U.S. and international experts on remote sensing of aerosols and of atmospheric corrections, that are presently responsible for the development of algorithms for the new satellite systems: EOS (MODIS, MISR, and EOSP), ADEOS (POLDER, OCTS, and GLI), MERIS, the new AVHRR, and others. The workshop, combining 30-minutes presentations and 2 hours of discussions each day, reviewed and intercompared the physical principles used by the different algorithms, in order to stimulate critical discussions aimed at understanding the differences between the algorithms. Such discussions can foster the generation of improved algorithms for the individual satellite sensors and generate collaborations on algorithms that will use the data from several sensors simultaneously. In order to share the results of the workshop with a wider community, a special issue in the Journal of Geophysical Research (JGR) will be devoted to up to 26 papers. A discussion paper that summarizes the 5 discussions in the workshop is planned for the special issue. An introduction was written by Prof. Jacqueline Lenoble, a long-time expert in the field and founder of the Department for Atmospheric Optics in Lille that fostered many of the scientists who participated in the workshop.

The workshop was organized by Yoram Kaufman (NASA/GSFC) from the MODIS Science Team (presently also the AM project scientist), Didier Tanré (University of Lille) from the MODIS and POLDER Science Teams, Teryuyki Nakajima (University of Tokyo) leader of the GLI Science Team and a close associate of the MODIS team, Howard Gordon (University of Miami) from the MODIS and MISR Teams, and Michael King (NASA/GSFC) MODIS team member and EOS Senior Project Scientist. The workshop was considered to be very successful, probably due to its focused objectives and special format. The workshop was organized by a scientific steering committee, with key scientists representing a broad array of instruments and disciplines. A detailed agenda was written before the prospective attendees were contacted, resulting in a high response rate. The workshop included a mixture of presentations (30 minutes each, mostly in the morning) and discussions (2 hours every day) and was limited to 30 presenters, and 50 total participants. The discussions were led by prominent scientists, most of them with no direct role in the new satellite systems. To achieve a friendly and relaxed social atmosphere we all stayed in one hotel in the best part of the city, had social events, and long 2-4 hour lunch breaks. We had excellent technical support provided by Jorge-Scientific and Applied Research Corporation (ARC).

Presentations invited for the workshop by the steering committee included 5 background papers, 25 papers related to the algorithms being developed, and 2 general talks on the aerosol effect on climate. The first 4 days of the workshop were devoted, respectively, to the 4 main topics: remote sensing of aerosols over land, remote sensing of aerosols over the ocean, atmospheric corrections for the aerosol effect over land and ocean, and evaluation of the remote sensing data using ground-based and airborne measurements. In each day, 4-8 papers on the subject were presented, followed by a two-hour discussion. Friday was devoted to discussions only and a summary. The following is a summary of the activity in the workshop.

MONDAY — Remote sensing of aerosols over the land

The workshop started with 4 background papers. J. Prospero talked about long-term ground-based monitoring of aerosol physical and chemical properties by the Atmosphere/Ocean Chemistry Experiment (AEROCE) island network. He emphasized the role of dust in the aerosol forcing, including its anthropogenic component due to land use change. Thirty years of AEROCE monitoring shows a systematic increase of the dust deposition in Barbados, associated with expansion of land use in the Sahel and reduction in the rainfall index. The combination of the AEROCE data with the NOAA aerosol product from AVHRR indicates that half of the dust originates from arid regions with land disturbance, rather than from deserts (see articles in *Nature* April 4, 1996). The ground-based measurements are used to separate the scattering coefficient (an indicator of the aerosol scattering of radiation and backscattering of solar light to space) into the contribution from several components. P. Koepke discussed a global data set of climatology of the aerosol microphysical data and the corresponding optical properties. M. King presented an overview of the new satellite systems that will be used to monitor aerosols. These followed a talk by J. Penner on the aerosol characterization that is used in estimating aerosol effects on the global climate. This includes sources, budgets, chemical transformations, and interaction with radiation. The main difficulty is in estimating the aerosol forcing on climate through aerosol effects on cloud microphysics and albedo (indirect effect). This is difficult due to a feedback effect of cloud maximum saturation to the aerosol concentration and the nonlinear and complex relationship between the aerosol mass and the number of cloud condensation nuclei (CCNs) it can produce, due to variations in the aerosol size distribution. The aerosol indirect effect depends also on the concentration of preexisting aerosol particles that is difficult to estimate. The simplifications used in present climate models were emphasized. It is concluded that the complex aerosol problem can be seriously addressed only by a combination of long-term monitoring from space-based and ground-based platforms accompanied by monitoring the properties of the aerosolvertical profile and by extensive field campaigns.

Six talks on remote sensing of aerosols over the land started in the afternoon with presentations for EOS—MODIS, MISR, and EOSP; and ADEOS—POLDER and TOMS. These satellite systems differ in their spectral, angular, and spatial monitoring of aerosols. In the talks and the discussion that followed, headed by H. Grassl, the advantages and limitations of satellite remote sensing were indicated. Over land, satellites can determine the spatial distribution of the aerosol optical thickness with accuracy and coverage that depend on the sensor characteristics, from an error in the optical thickness of 0.05-0.10 in the solar channels to 0.01 in the IR channels. The aerosol size distribution cannot be retrieved, though some information on the aerosol type is present. Polarization measurements may be useful for determining the aerosol refractive index or shape (sphericity). The satellite data are evaluated and supplemented by measurements of the spectral optical thickness and size distribution from a network of sun/sky radiometers and by chemical measurements in order to distinguish between the forcing of different aerosol species and sources. Comparisons with aerosol transport and evolution models are also being planned. Field experiments with aircraft sampling and lidar systems are needed to evaluate the vertical structure of the aerosol layers. Many problems were discussed, including: the effect of particle non-sphericity on the satellite analysis; the possibility of deriving the aerosol radiative forcing directly from the measured radiances rather than from the derived optical thickness; and the need for reporting on and consistency between the assumptions used in deriving the aerosol optical thickness and the later use of them in climate models. The satellite data can give only partial information on the vertical distribution. The use of the water vapor band at 1.375 μm or the use of oxygen absorption bands can distinguish between tropospheric and stratospheric aerosols. There is a need for a satellite lidar system (GLAS planned for EOS) and ground-based monitoring of aerosols with lidars. The only information on absorption given today by satellite data is from the absorption difference in TOMS UV channels. There is a need to develop operational methods for estimation of the aerosol absorption from satellites and from ground-based measurements. Some experimental methods are available.

TUESDAY — Remote sensing of aerosols over the ocean

Tuesday we started with 7 papers describing techniques for operational remote sensing of aerosols over the ocean from EOS—MODIS and MISR (an overall talk on EOSP was given the previous day); ADEOS—GLI, OCTS, and POLDER; and enhanced AVHRR, SeaWiFS, and MERIS. They were followed by a paper on laboratory measurements of aerosols and a discussion headed by B. Herman of the remote sensing techniques. Over the oceans, the dark and more predictable water surface reflectance allows the determination of additional aerosol parameters. The aerosol optical thickness is derived with higher accuracy (an error of 0.01-0.05). Information on the aerosol model or the particle size can be obtained from most systems, and refractive index from polarization measurements. Many of the problems mentioned in regard to remote sensing over the land were discussed in the context of measurements over the ocean. Even though the satellite aerosol information is much more accurate and informative over the ocean than over the land, there is a need for an island-based network of sun/sky radiance measurements to derive the detailed aerosol properties, in collaboration with aerosol chemical measurements and lidar measurements of the aerosol vertical distribution.

The assumptions used in the inversion of the satellite data are used differently by the algorithm developers. There was a discussion about unifying the assumptions. The conclusion, suggested by H. Grassl, was that since it is not possible before launch to determine what is the optimum type of analysis, and since the need for assumptions varies from sensor to sensor, any unification of the assumptions should be postponed for data reanalysis a few years after launch.

WEDNESDAY — Atmospheric corrections over land and ocean

Three papers on atmospheric corrections over land were given for MODIS and for POLDER. A discussion of corrections for MISR was given the first day as part of the derivation of the aerosol optical thickness. Derivation of the surface BRDF was stressed in the last talk and in the other talks. Over-the-ocean-correction discussion included 5 papers which were discussed in the framework of MODIS, MISR, MERIS, OCTS, and POLDER. Two parallel discussions followed, one for the ocean and one for the land.

Atmospheric corrections over the land use two pathways. In the first (e.g., MODIS), the aerosol optical thickness is derived and used with the proper aerosol model for the correction, using surface BRDF properties derived from recently corrected satellite data. In the second, preferred by the multi-view MISR instrument, the surface BRDF properties and the atmospheric corrections are derived simultaneously with remote sensing of aerosols. We discussed the problem of generation of aerosol models used in the correction, and the methods for supplementing aerosol data missing from satellite remote sensing with aerosol climatology.

Atmospheric corrections over the ocean are difficult, due to the large (10 times) contamination of the signal by the atmospheric aerosol. The correction works to overcome this difficulty by using the difference in the spectral properties of the ocean surface (almost black in the near IR) and of the aerosol (monotonously decreasing optical thickness with wavelength, with a decrease rate that depends on the particle size distribution). In addition to spectral properties of the water, uncertainty in the prediction of the far glint effects and of foam spectral effects makes the analysis even more difficult. But previous success using validated retrievals from the CZCS and the improved spectral and calibration capability of the new satellite systems makes a workable solution a possibility. Two basic procedures for the inversion of the satellite data were suggested. For typical scanning radiometers (MODIS, SeaWiFS, OCTS, and MERIS) most procedures use the near-IR radiances to find the aerosol loading and model, using look-up tables to extrapolate this information to the visible channels, and then remove the aerosol effect from the satellite data. For sensors with multi-angle capability (POLDER and MISR) this additional information is incorporated in the near IR to better constrain the aerosol model.

Thursday — Evaluation of the remote sensing methods

The day started with two general talks on the measurement techniques. F. Valero discussed aircraft measurements, emphasizing that the vertical variation of direct and diffuse radiative fluxes, as influenced by the presence of aerosols, can be used directly to relate the aerosol optical thickness, derived from space, with the aerosol direct radiative forcing of climate. J. Reagan followed with discussion of ground-based instrumentation, emphasizing the need and availability of inexpensive pulse lidar systems to study the vertical distribution of aerosols and their optical properties. The validation session included 4 papers: 2 for validation of remote sensing of aerosols and 2 for validation of atmospheric corrections over the ocean. No presentations were made for validation of the atmospheric correction over the land, though plans to do so exist. The validation of the remote sensing of aerosols is based on ground-based sun/sky radiometers, including measurements of polarization. Sky measurements of radiance and polarization are similar in their physical sense to satellite measurements of upwelling radiation. The ground-based measurements have the advantage of observations on a background of black space (not ocean or land reflectance or polarization) and of measurements in a wide range of scattering angles (2-150°) instead of the narrower range from satellites (40-180° in the best conditions and 100-160° in average conditions). The physical similarity and advantages of the ground-based instruments make them the prime source of evaluation of the satellite data. The ground-based instruments can also measure the incident solar radiation, thus allowing the direct derivation of the spectral optical thickness and, by comparison with the analysis of the sky data, the aerosol single scattering albedo (a measure of aerosol absorption).

Validation of the correction over the ocean will also use sun/sky observations to determine the correctness of the aerosol model derived in the correction, but will concentrate on detailed measurements of the spectral water-leaving radiance.

Conclusions

The success of the workshop is probably due to the combination of a focused objective and a special format that promotes plenty of discussion, formal and informal, in a relaxed atmosphere. A special issue in the JGR will summarize the scientific material and discussion from the workshop for the general scientific community. The two main scientific conclusions resulting from the workshop are: (1) the present remote sensing strategy is weak in deriving the aerosol single scattering albedo, a measure of the aerosol absorption and a critical parameter in understanding the effects of aerosols on climate; and (2) the use of algorithms with different types of data and different assumptions is expected to be beneficial in improving aerosol remote sensing techniques.

What's New?

The Earth Observing System Project Science Office (EOSPSO) WWW Homepage has moved to a new server. The new URL for the EOSPSO homepage is: http://eospso.gsfc.nasa.gov/.

A new EOSDIS link has been added to our main page which provides better access to EOSDIS and related sites.

A new link has been added to the Advanced Solid-state Array Spectroradiometer (ASAS) Project page: http://asas.gsfc.nasa.gov/asashome.html.

Many updated Validation Plans and Summary Charts are given on the EOS Validation page: http://eospso.gsfc. nasa.gov/validation/valpage.html.

EOS Radiometric Measurement Comparisons at Hughes Santa Barbara Remote Sensing and NASA's Jet Propulsion Laboratory

— **James J. Butler** (butler@highwire.gsfc.nasa.gov), NASA, Goddard Space Flight Center, Code 920.1, Greenbelt, MD 20771
— **B. Carol Johnson**, National Institute of Standards and Technology, Optical Technology Division, Gaithersburg, MD 20899

The first National Aeronautics and Space Administration (NASA)/National Institute of Standards and Technology (NIST) Earth Observing System (EOS)-sponsored spectral radiometric measurement comparison experiment was conducted at Hughes Santa Barbara Remote Sensing (SBRS) in Goleta, California, and at the Jet Propulsion Laboratory (JPL) in Pasadena, California, from 12 August to 20 August, 1996. Radiance measurements were made by several participants on three integrating sphere sources. These sphere sources are used in the pre-flight radiance calibration of the EOS Moderate Resolution Spectroradiometer (MODIS) and Multi-angle Imaging SpectroRadiometer (MISR) and the Landsat-7 Enhanced Thematic Mapper+ (ETM+). The Optical Technology Division of NIST was the lead laboratory, coordinating the measurement plan and activities with the EOS Calibration Scientist. The measurement sequence was designed to address the issues of repeatability, evaluation of unknown systematic effects, and stability. Due to the limited time available at Hughes SBRS and at JPL, simplification in terms of the number of instruments and sphere output levels was necessary. The goals were, in order of importance, to: 1) compare the spectral radiance of the sphere sources as calibrated by the EOS instrument providers with that determined by NIST using NIST-calibrated radiometers; 2) compare the spectral radiance determined by the participants from the outside laboratories using the sphere sources as common targets; and 3) evaluate the findings in terms of measurement procedure and basic metrology.

At Hughes SBRS, the Spherical Integrating Source 100 (SIS100) used in the radiometric calibration of MODIS was measured at four different levels by five teams of researchers over a three-day interval. On the fourth day, the SIS 122, which is used in the radiometric calibration of ETM+, was measured by the same participants. At JPL, five teams spent three measurement days recording the output of the SIS 165 source. The SIS 165 was recently used to calibrate the nine MISR cameras.

At Hughes SBRS, the participants were: 1) NASA/GSFC-EOS (John Cooper and Jim Butler), with a scanning single grating monochromator that measured from 400 nm to 2500 nm; 2) NASA/GSFC-ETM+ (Brian Markham and Ken Brown), with the recently acquired Landsat Transfer Radiometer (LXR); 3) NIST (Carol Johnson), with the SeaWiFS Transfer Radiometer (SXR) and the EOS Visible Transfer Radiometer (VXR); 4) the University of Arizona (UA) (Stuart Biggar and Paul Spyak), with the UA visible/near infrared (VNIR) and UA shortwave infared (SWIR) transfer radiometers; and 5) National Research Laboratory of Metrology (NRLM) (F. Sakuma and J. Ishii) with three Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) VNIR transfer radiometers and two ASTER SWIR transfer radiometers. The LXR, SXR, and VXR have six image locations and separate interference filter/detectors at each location. The interference filters are narrow band (~10 nm) with the exception of four of the filters in the LXR, which are similar to the ETM+ flight filters. The UA VNIR and UA SWIR use a rotating filter wheel to alternately measure at select wavelengths that correspond to MODIS and ASTER bands. The NRLM radiometers are separate units, each making measurements at or near particular ASTER bands. Hughes SBRS calibrated the Landsat

SIS 122 sphere prior to and during the comparison measurements on the SIS 100. They planned to calibrate the SIS 100 immediately following the comparison starting on 16 August.

Each day consisted of a series of measurements followed by reporting of preliminary results. The typical measurement procedure was to turn the SIS 100 to a given radiant level determined by the specific lamps illuminated, measure using the SXR, then measure using the other participants' radiometers, and then repeat the SXR measurement. In this manner, over the complete course of the comparison, the SIS 100 was measured at the same level at least twice by NIST and in most cases twice by other participants. During the time the other participants were measuring the sphere, the VXR was used off-axis in order to monitor the stability of the sphere. Linda Fulton of Hughes SBRS adjusted the sphere lamp currents according to Hughes SBRS procedures, and records were made of the lamp currents and voltages during the exercise. Two levels were measured in this fashion each day, except for 12 August, where the morning was devoted to organization and laboratory preparation. In addition to the above measurements, a particular level was selected for study with the SXR every day so that the sphere repeatability could be assessed. A single day (i.e., 15 August) was devoted to measurements of the SIS 122. In order to assess the SIS 122 repeatability, the same level was measured by all participants in the morning and afternoon, with the sphere turned off in between. A second level was measured using only the SXR, the LXR, and then the SXR. At the end of each measurement day, the participants reported and discussed preliminary results. Since SBRS had not provided their SIS 100 calibration data beforehand, Hughes representatives were excluded from presentation and discussions of any preliminary results. These preliminary results indicated a very reasonable level of internal consistency in absolute spectral radiance among the outside laboratories (i.e., 1% to 2% scatter). The Landsat 7 ETM+ team was unable to report absolute results at the time of the comparison because the LXR was not characterized or calibrated. The SIS 100 appeared to be stable and, except in one measurement where a 1% shift was observed in the blue, repeatable.

The comparison participants packed their equipment late on 15 August and traveled to JPL on 16 August. The afternoon of 16 August was devoted to unpacking and cleaning equipment at JPL and deploying instruments in the MISR cleanroom. At JPL, the participants were: 1) NASA/GSFC (John Cooper and Jim Butler), with a scanning single grating monochromator operating from 400 nm to 1100 nm; 2) NIST (Carol Johnson), with the SXR and the VXR; 3) the University of Arizona (Stuart Biggar), with the UA VNIR; 4) NRLM (F. Sakuma and J Ishii) and NEC (K. Suzuki) with three ASTER VNIR transfer radiometers and a commercial single grating monochromator that utilizes a diode array; and 5) JPL (Carol Bruegge and Dan Preston), with the MISR laboratory standard radiometer utilizing 4 interchangeable visible filters.

Radiance measurements were made on the SIS 165 on 17, 19, and 20 August with results being reported on 20 August. In accordance with JPL calibration and operation procedures for the SIS 165, the measurement technique was changed from that employed at Hughes SBRS. Instead of operating the sphere at a single level for several hours while participants made measurements, the sphere was turned on to the brightest level of a set of four designated levels to be measured, allowed to warm up for 20 minutes, measured by one participant, turned to the next brightest level of the set, and so on. On 20 August the comparison participants decided to operate and measure the SIS 165 at a single level in order to assess the long-term stability of the sphere. This approach also provides a more accurate comparison of the participating radiometers. As at Hughes SBRS, during the time the other participants were measuring the sphere, the VXR was used off-axis in order to monitor the stability of the sphere. However, on the day at JPL that a single level was selected for study, the SXR was used off-axis as the monitor. At NIST's request, records were made of the lamp currents and voltages during the exercise and were provided to comparison participants. The preliminary results on the SIS 165 indicate up to an 8% spread in absolute spectral radiance among the outside laboratories. The SIS 165, which was measured at four levels, also exhibited drifts of up to 0.08%/min. The preliminary data also indicate that the SIS 165 is non-lambertian at the 1% to 3% level, as measured by the VXR or the SXR at angles up to 50 degrees from normal incidence. This, coupled with the sphere drift, complicates the analysis of these data.

NIST is currently coordinating the data analysis from this radiometric measurement comparison through its Statistical Engineering Division. All comparison participants were given a list of items needed by NIST (e.g., description of radiometers, raw data files, detailed measurement log sheets, etc.) for accurate analysis and reporting of comparison results. Most of this information has been obtained and mounted on a server at NIST. NIST plans to re-examine the raw data, and compare the results to those determined by the participants based upon their algorithms for analyzing the radiometer data. A draft report including the comparison results and findings is planned by the end of 1996.

First Global Image Of Total Atmospheric Ozone Obtained From NASA Instrument Aboard Japanese Satellite

— **Douglas Isbell**, Headquarters, Washington, DC. (Phone: 202/358-1753)
— **Allen Kenitzer**, Goddard Space Flight Center, Greenbelt, MD. (Phone: 301/286-2806)
— **Hideo Hasegawa/Hiroyuki Ikenono**, National Space Development Agency of Japan, Tokyo. (Phone: 81-3-5470-4127)

Excerpts from NASA Press Release: 96-188

Daily global mapping of the Earth's ozone layer from space has resumed with the acquisition of the first image from the U.S. Total Ozone Mapping Spectrometer (TOMS) instrument aboard the Japanese Advanced Earth Observing Satellite (ADEOS) on September 12.

ADEOS continues the series of TOMS total ozone and volcanic sulfur dioxide observations that began with the Nimbus-7 satellite in 1978 and continued through the operation of a TOMS on a Russian Meteor-3 satellite, until that instrument ceased functioning in December 1994.

Data from another TOMS instrument flying on the recently launched NASA TOMS-Earth Probe spacecraft complement the global ADEOS data by providing high-resolution imagery of atmospheric features related to urban pollution, biomass burning, forest fires, desert dust, and small volcanic eruptions, in addition to ozone measurements.

In recent years, the depleting effects of industrial chlorofluorocarbons (CFCs) on ozone were demonstrated through the sudden appearance of the Antarctic ozone hole and other, more gradual losses in global ozone. The principal mission of TOMS/ADEOS is to monitor global ozone trends during the period when CFC-related depletion is predicted to be near its maximum.

"Stratospheric concentrations of chlorine from CFCs are expected to peak near the end of the century and then decline as a result of the Montreal Protocol," said Arlin Krueger, Principal Investigator for the TOMS/ADEOS mission. "TOMS/ADEOS will help us track this prediction. It also will continue to measure the concentrations of sulfur dioxide in the atmosphere in the wake of volcanic eruptions, thus extending the existing database of more than 100 eruptions, including Mt. Pinatubo in 1991 and El Chichon in 1982."

The first TOMS/ADEOS image is available electronically at the following URL: http://jwocky.gsfc.nasa.gov/adtoms/adeos.html.

The HITRAN Atmospheric Workstation

— **Larry Rothman** (lrothman@mars.harvard.edu), Harvard-Smithsonian Center for Astrophysics Atomic and Molecular Physics Division
— **Dave Starr** (starr@climate.gsfc.nasa.gov), NASA Goddard Space Flight Center

New editions of the HITRAN molecular spectroscopic database and the high-temperature analog (HITEMP) have recently been released.[1,2] They are included in a compilation called HAWKS (HITRAN Atmospheric Workstation). HAWKS represents more fully a "matter" database. Besides an updated HITRAN high-resolution molecular database of about one million transitions, there are files of aerosol indices of refraction; UV line-by-line and cross-section parameters; supplemental files of gases such as ionic species and ozone parameters suitable for atmospheric non-local thermodynamic equilibrium conditions; extensive IR cross-sections now at different pressures and temperatures; and molecular parameters suitable for modeling high-temperature radiance. In addition there is a moderate-resolution band-model code, MODTRAN 3. There is also vastly improved software handling of the data in both WINDOW and UNIX platforms, such as more-sophisticated selection filters, plotting capabilities, pointers to significant references, and documentation.

The line-by-line portion of the compilation, HITRAN, now contains about one million transitions for some 37 molecular species. Table 1 illustrates the number of transitions, broken down by molecule. This table, however, does not reflect the fact that many species in HITRAN include significant isotopic variants, which are necessary for atmospheric simulations. One also notices that certain "heavy" molecules, such as ozone and nitric acid, have a very large number of transitions; this occurs as new bands or more-extensive coverage of bands are achieved in new editions. On the other hand, species like water vapor and carbon dioxide remain rather constant in terms of the number of transitions, even though there may be considerable improvement in the quality of the individual parameters.

The enhancements to the new compilation have been particularly focused on improving the capabilities for atmospheric remote sensing. Parameters for molecular transitions that will be needed for remote observations from space-borne missions (EOS) and ground-based measurements Atmospheric Radiation Measurement (ARM) program have been the top priority of the recent development of the compilation. Further efforts will be made to improve the parameters for weak, but nonetheless significant, transitions and bands, especially in spectral regions where there is presently a deficiency. Some of these transitions act as atmospheric interferents in the EOS experiments rather than sources. A considerable effort is now being made to include cross-sections of species at different pressure-temperature pairs. These coefficients are now being successfully incorporated into various transmission calculation schemes. Finally, aerosol indices of refraction are now being included in the compilation. It is in this area that we expect development of a standardized format that can be applied to general codes.

With regard to the major improvements in the line-by-line portion of HITRAN, in the compilation, we summarize the changes for several species in particular. For water vapor, the changes affected have been in the long-wavelength region where use of DND (Direct Numerical Diagonalization) and high-temperature experiments conducted at the Geophysics Lab have corrected or validated almost 1000 line positions. Some of the previous errors can be attributed to high-J lines, where there were previously insufficient levels for proper determination using combination differences. Carbon dioxide has been thoroughly updated using DND for the intensities of bands not measured in the laboratory; however, the changes are mostly small compared to the last edition of HITRAN. Ozone has seen a major revision: numerous new bands are now included, improvements have been made to some existing bands, and more isotopic bands have been included. Nitrous oxide (N_2O) has had a major revision; carbon monoxide has been marginally improved using a subset of the parameters that have gone on the HITEMP database; oxygen has undergone a major recalculation; nitric oxide (NO) has seen an update of the fundamental and overtone bands; nitrogen dioxide (NO_2) has had a major revision; and overtone bands of SO_2 have been added. Ammonia (NH_3) has also had a major revision, and the nitric acid (HNO_3) parameters have been extended and enhanced. Several "trace" atmospheric species have been added, bringing the total number of species in HITRAN to 35. A supplemental directory has been created to incorporate line-by-line data that either have not been fully validated (as is the case for HOBr) or differ from the mainstream HITRAN (such as the ionic species NO^+).

HAWKS is available on CD-ROM. The CD-ROM is being distributed to government agencies, contractors, universities, overseas research organizations, and industry. The database is in ASCII and can be accessed by a variety of operating systems. A web page, www.HITRAN.com, has been initiated. This site contains updates to the HITRAN data, new software modifications, and other relevant information concerning the molecular spectroscopic databases.

The HITRAN molecular database has been a project with strong international cooperation during its development. Laboratories throughout the world have contributed both experimental data and theoretical calculations. The impact of the HITRAN database has recently been particularly notable in areas such as global climate modeling, ozone depletion studies, the greenhouse effect, laser propagation studies, lidar, surveillance, target discrimination, and industrial process monitoring. The database is usually used as input to either high-resolution (line-by-line) transmission codes, or indirectly in moderate-resolution, band-model codes.

The current effort has been supported by the NASA EOS program, the ARM program under the Department of Energy, and the USAF Office of Scientific Research.

References

1. L.S. Rothman *et al.*, "HITRAN, edition 1996," submitted to the *Journal of Quantitative Spectroscopy and Radiative Transfer.*

2. L.S. Rothman *et al.*, "HITEMP, the High-Temperature Molecular Spectroscopic Database," submitted to *the Journal of Quantitative Spectroscopy and Radiative Transfer.*

Table 1. Statistics of Molecular Data for HITRAN/HAWKS 1996

Molecule No.	Band Statistics for HITRAN '96	No. of lines	Molecule No.	Band Statistics for Supplemental Files	No. of lines
1	H_2O	49444	3	High-vib O_3	184724
2	CO_2	60802	36	NO^+	1206
3	O_3	275133	37	HOBr	4358
4	N_2O	26174			
5	CO	4477		**HITEMP**	
6	CH_4	48032	1	H_2O	1283468
7	O_2	6292	2	CO_2	1032269
8	NO	15331	5	CO	113022
9	SO_2	38853			
10	NO_2	100680		**UV**	
11	NH_3	11152	7	O_2	11020
12	HNO_3	165426			
13	OH	8676			
14	HF	107			
15	HCl	533		**Cross-section Sizes/Bytes**	
16	HBr	576		N_2O-UV	143308 Bytes
17	HI	237		SO_2-UV	2377758 Bytes
18	ClO	7230		IR	17963586 Bytes
19	OCS	858			
20	H_2CO	2702		**Aerosols/Bytes**	
21	HOCl	15565			229014 Bytes
22	N_2	120			
23	HCN	772			
24	CH_3Cl	9355			
25	H_2O_2	5444			
26	C_2H_2	1668			
27	C_2H_6	4749			
28	PH_3	2886			
29	COF_2	54866			
30	SF_6	11520			
31	H_2S	7151			
32	HCOOH	3388			
33	HO_2	26963			
34	O	2			
35	$ClONO_2$	32199			
Total		999363			

Second EOSDIS Science Software Integration and Test Workshop

— **Steve Kempler** (steven.kempler@gsfc.nasa.gov), ESDIS Project, Code 505, NASA Goddard Space Flight Cemter

On August 7-8, 1996, the Second EOSDIS Science Software Integration and Test (SSIT) Workshop was hosted by NASA's Langley Research Center (LaRC) Distributed Active Archive Center (DAAC). The purpose of this workshop was to:

1. Share lessons learned and experiences of DAAC and Instrument Team (IT) personnel that resulted from the integration and test of the Beta version of Science Software into the EOSDIS Core System (ECS).

2. Understand the ECS implementation and plan for the SSIT of the Engineering Version (Version 1) of Science Software.

The workshop was attended by representatives from all the AM-1 platform ITs, SAGE III, the LaRC DAAC, GSFC DAAC, JPL DAAC, HAIS (ECS contractor), and GSFC's Mission To Planet Earth (MTPE, Code 170) and Earth Science Data and Information System (ESDIS, Code 505) Project. All teams contributed towards satisfying the purpose of the workshop.

For the AM-1 ITs, delivery of their Science Software to the DAACs is coupled with releases of the ECS (and, therefore, the bigger EOSDIS Ground System, which includes ECS, EOS Data and Operations System [EDOS], institutional facilities, etc.). SAGE III, SeaWinds, and other future ITs have similar associations of their Science Software with ECS deliveries. The science software deliveries for AM-1 instruments, and the associated ECS Releases are threefold: Beta Science Software and ECS IR-1 Release; Engineering (Version 1) Science Software and ECS Release A; and Operational (Version 2) Science Software and ECS Release B. Generally, the content and purpose of each Science Software delivery are:

1. Beta Version: To demonstrate the delivery, integration, and test procedures, as well as test the software environment and resource estimation. Science Software is mostly stand-alone (i.e., not an integrated production system).

2. Engineering Version: To demonstrate the functionality of 'not final' production science software and science software/ECS interfaces.

3. Operational Version: To demonstrate the total production science software/ECS integrated system, ready for end-to-end prelaunch system testing and operational use.

It is expected that delta Science Software deliveries will be made after Operational Versions are delivered in order to fine-tune algorithms, include last-minute processing parameters, and execute final bug fixes.

After the experience and interactions encountered from the Beta SSIT, participants presented and discussed the following information:

◊ IR-1 Lessons Learned.

◊ Beta SSIT Lessons Learned.

◊ Implementing Lessons Learned.

A detailed list of these lessons learned was also provided in the form of a document entitled *ECS IR-1 Lessons Learned* (see e-mail address provided below to obtain a copy.).

The remainder (and bulk) of the workshop was devoted to the preparation for, and better understanding of, the Engineering Version SSIT requirements, IT needs, and community expectations at ECS Release A. The major accomplishment of this workshop was to provide information and discussion, ensuring that all questions and concerns were addressed in the following relevant areas:

◊ Beta Science Software resource and performance measurements

◊ Baseline Release A SSIT operations

◊ Earth Science Data Type (ESDTs) and collection metadata population for Version 1 (Engineering Version) Science Software

◊ Release A remote access for SSIT

◊ Release A production rules

◊ Release A SSIT tools

◊ Release A COTS baseline

◊ Release A SSIT schedules

◊ Science Software Archive Packages (SSAP)

◊ Engineering Version SSIT success criteria

◊ Science Software documentation

The session on Engineering Version SSIT success criteria allowed an individual from each group to describe his/her team's success criteria for SSIT of that science software delivery (i.e., goals, measure of success, etc.). In the last session, a common format for the Data Set User's Guide was suggested. It was pointed out that this is needed for general data users and EOS Interdisciplinary Investigators. Examples of existing guides were mentioned such as the one at "http://seawifs.gsfc.nasa.gov." This topic raises the importance of producing a good set of documentation to go along with software deliveries.

Several Action Items were captured. For Workshop session summaries and action items, Workshop handouts, or a copy of the ECS IR-1 Lessons Learned document, please contact Steve Kempler (steven.kempler @gsfc.nasa.gov).

Attention:
Oceanography Enthusiasts

— Diana Sunday (sundance@eosdata.gsfc.nasa.gov)
Blanche Meeson (meeson@daac.gsfc.nasa.gov)

"Oceanography From the Space Shuttle," an out-of-print, 200-page limited edition pictorial survey of oceanic phenomena visible to the naked eye from space has been published on the World Wide Web by the Goddard DAAC. Don't let the size of this volume put you off - this site is organized for efficient, remarkably quick navigation.

As scientific knowledge of the world's oceans increased and as accuracy of the physics in oceanographic forecasting models improved, the need became clear for a real-time, global, daily oceanographic observation system. To be cost effective, such a system had to be unmanned with various sensors onboard to collect image data. However, the human eye and brain, with the aid of optics, can observe oceanographic phenomena in the visual part of the electromagnetic spectrum over broader physical scales and between more subtle changes in color than any unmanned sensor technology currently flying in space. Consequently, humans in space and books of this nature are unique tools for oceanographic research.

Originally prepared in 1989 as a joint project of the University Corporation for Atmospheric Research and the Office of Naval Research, United States Navy, "Oceanography From the Space Shuttle" was conceived in late 1985 for the purpose of educating and stimulating those who conduct oceanographic research and to illustrate the ocean's complexity to those who operate on or below the ocean's surface. This volume is an excellent collection of oceanographic photos taken by U.S. astronauts from space.

To see what our astronauts saw, go to http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/OCDST/shuttle_oceanography_web/oss_c over.html

Click on the Shuttle, and then follow the arrows pointing right (or you can reach any page from the table of contents). Thumbnail images give a preview of each chapter's hi-res photographs. For more information about the site, viewing the images, and awards we've won, link to Appendix D: Web Site Notes.

Stratospheric Ozone and Human Health World Wide Web Site

— **Richard Robinson,** (rrobins@ciesin.org), Consortium for International Earth Science Information Network (CIESIN)

CIESIN and its Socioeconomic Data and Applications Center (SEDAC) are pleased to announce the availability of the Stratospheric Ozone and Human Health World Wide Web (WWW) site. This is an online service that integrates NASA remote-sensing and atmospheric data on stratospheric ozone depletion and ultraviolet radiation with health-related data and information to provide a multidisciplinary data resource for health officials, decision makers, government officials, researchers, and the general public. The Uniform Resource Locator (URL) for the Stratospheric Ozone and Human Health WWW site is: http://sedac.ciesin.org/ozone.

The Stratospheric Ozone and Human Health WWW site has several components:

1.) The Ultraviolet Interactive Service (UVIS)

This service provides ultraviolet (UV) radiation climatology data for selected locations around the United States. Average hourly, daily, and monthly estimates of biologically effective doses from 1979-1990 are accessible through an interactive query engine that allows users to visualize data of interest. These data are derived using NASA satellite data and other geophysical input parameters in an atmospheric radiative transfer model. A description of the model used to develop this service is also provided.

UVIS allows users such as epidemiologists to access detailed historical estimates of UV radiation exposure. These data can be useful for a variety of purposes, including the reconstruction of historical exposure patterns. It can help answer a range of questions such as:

◊ How much higher are exposure levels in Albuquerque compared with Seattle?

◊ How many days in the summer of 1988 were exposure levels higher in Detroit as compared with Atlanta?

◊ What was the estimated cumulative DNA-damaging exposure amount during the spring of 1990 in the Salt Lake City area?

◊ What was the range in hourly exposure levels during the month of August 1980 in Honolulu?

2.) Searchable Bibliographic Database

This service provides a searchable index containing more than 3,000 citations of journal articles, conference presentations, books, and other periodicals on the topics of ozone depletion, UV radiation, and ecological and human health. Users may query the database through several search fields: text string, author, source, subject category, year, and title. Users can find results such as:

◊ a list of publications by a particular author;

◊ recent publications on possible links between UV exposure and skin cancer incidence; and

◊ early efforts and studies on ecological impacts of UV exposure.

3.) Human Health Data Resources

This service provides a guide to statistical and epidemiological data sets and related resources from disease registries, surveys, and studies that provide information on human health effects related to UV exposure. It includes links to subnational as well as national and international data sources, disease registries, surveys, and epidemiological studies. Data sources accessible through this service include:

◊ the New South Wales Cancer Registry;

◊ State Cancer Registries in the United States;

◊ the Surveillance, Epidemiology, and End Results (SEER) Cancer Statistics Review, 1973-1991; and

◊ the North American Association of Central Cancer Registries (NAACCR).

4.) Related Internet Resources

This component of the Stratospheric Ozone and Human Health WWW site provides a guide to additional resources available via the Internet in the areas of ozone depletion, UV radiation, and human health.

CIESIN's Thematic Guide resource provides overview documents and full-text access to peer-reviewed publications related to stratospheric ozone depletion, potential impacts on human and ecosystem health, chlorofluorocarbons, and more.

You will need a forms-capable WWW browser to take full advantage of this WWW site. Alternatively, if you have telnet access to the Internet, you may telnet to infoserver.ciesin.org and log in as "lynx" to use a character-oriented WWW browser.

For more information, please contact CIESIN User Services by e-mail at ozone@ciesin.org or by telephone at 517/797-2727.

Toll-free Line to Atmospheric Radiation Measurement Information

The Atmospheric Radiation Measurement (ARM) Experiment Center is announcing the availability of a new toll-free ARM Information hotline: 1-888-ARM-DATA (1-888-276-3282).

This toll-free phone line has been established to provide a single phone number for ARM Scientists to contact the ARM infrastructure. The phone is staffed Monday through Friday from 8:00 am - 8:00 pm (Eastern) to receive your requests for:

◊ ARM data
◊ changes to existing Experiment Operations Plans
◊ specific data quality/availability information
◊ identification of points-of-contact (e.g., Instrument Mentors)
◊ general ARM information

Please do not hesitate to call with any questions or problems you are experiencing. While we may not be able to answer your question immediately, we will make every effort to identify someone who can. Our goal is to continually increase the scientific utility of the ARM data and we are always grateful for suggestions for improvement.

You may also contact us at info@arm.gov if you prefer to communicate via e-mail.

Please feel free to distribute this information to your students and colleagues.

Education Highlights

NASA Headquarters has approved the Goddard DAAC's unsolicited educational proposal "NASA Goddard DAAC, Earth Science Educational Series." The series will focus on global environmental changes of Earth's atmosphere and biosphere and global climate phenomena. Each of the series will contain scientific information with diagrams, data, and freeware image processing software to display and analyze the data. Contact Carla Evans: evans@daac.gsfc.nasa.gov.

Dixon Butler has joined the Global Learning and Observations to Benefit the Environment (GLOBE) Program as Assistant Director for Science. In this capacity, he functions as the chief scientist for GLOBE and manages the science investigations of the Program. Butler is also working to ensure the validity of GLOBE student data.

Announcing: "The Practical Uses of Math and Science (PUMAS)" Web Site, an on-line *"Journal of Math and Science Examples For Pre-College Education."* Scientists are invited to help K-12 teachers enrich their presentation of math and science topics by contributing one-page examples based on their interests and experience. All examples are peer-reviewed; once accepted, they are citable references in a referred journal of science education. Examples are currently being collected. It is anticipated that the Site will be open to general users in Spring or Summer 1997, once the collection contains a number of entries.

K-12 teachers are also needed now, as well as scientists, to serve in the pool of PUMAS reviewers. The on-line "Participant Volunteer/Update Form" can be found on the Navigation portion of the Help page, or from the hyperlink at the top of the PUMAS examples Search page.

The PUMAS Web Site is at: http://pumas.jpl.nasa.gov. For additional information, contact: ralph.kahn@jpl.nasa.gov.

RESOURCES ON THE INTERNET

These sites give an overview of the project, and information for teachers to use such as curriculum support materials, project ideas, etc.

Global Quest
http://quest.arc.nasa.gov/

SeaWiFS Project - Studying Ocean Color from Space
http://seawifs.gsfc.nasa.gov/SEAWIFS/LIVING_OCEAN/LIVING_OCEAN.html

NASA's Classroom of the Future
http ://www.cotf.edu

NASA Langley Research Center's High Performance Computational Center IITA Program
http://k12mac.larc.nasa.gov/hpcck12home.html

NASA's EOS IDS Volcanology Team educational support materials
http://www.geo.mtu.edu/eos/

Discover Magazine's School Science Programs
http://www.enews.com/magazine/discover/page7.html

IMAGES TO DOWNLOAD

Various science-related items
http://www.lerc.nasa.gov/WWW/PAO/html/paogalry.htm

Real time satellite images, especially meteorology-related images
http://www.ssec.wisc.edu/data index.html#special

More images
http://www.meto.umd.edu/~owen/POSTIX/postix.html

Science Calendar

January 14-15	SAGE III Science Team Meeting, Tucson. Contact Sandra Smalley, tel. (757) 864-6211, Fax (757) 864-8676, e-mail: s.e.smalley@larc.nasa.gov
February 19-20	Algorithm Theoretical Basic Document (ATBD) Review for PM-1, ACRIM, SAGE III, Data Assimilation. Contact Mary Hurlbut, tel: (301) 220-1701, Fax: (301) 220-1704, e-mail: mhurlbut@pop200.gsfc.nasa.gov
February 25-27	EOS Investigators Working Group Meeting, Tucson, AZ. Contact Mary Hurlbut, tel: (301) 220-1701, Fax: (301) 220-1704, e-mail: mhurlbut@pop200.gsfc.nasa.gov

Global Change Calendar

December 15-19	AGU 1996 Fall Meeting, San Francisco, California. Contact Karol Snyder, tel. (202) 939-3205.
• 1997 •	
January 13-15	Conference on GIS and Applications of Remote Sensing to Disaster Management, Greenbelt Marriott, Greenbelt MD. Contact Sandie Jones, tel. (301) 220-1701, Fax (301) 220-1704, e-mail: sjones@pop200.gsfc.nasa.gov, WWW: http://ltpwww.gsfc.nasa.gov/ndrd/GIS_conference.html.
January 26-30	Space Technology and Applications International Forum, Albuquerque, NM. Contact Professor Mohamel S. El-Genk, tel. (505) 277-2813/0446/4950, Fax (505) 277-2814/5433.
February 3-6	AMS 77th Annual Meeting, Long Beach, CA. Contact Monica Tolson, tel. (202) 682-9006.
February 13-18	AAAS Annual Meeting and Science Innovation Exposition, Seattle, WA. Contact Dee Valencia, tel. (202) 326-6417, Fax (202) 842-1065.
March 10-14	Atmospheric Effects of Aviation Annual Conference, Virginia Beach, VA. Contact Julie Catloth, tel. (301) 286-7912, e-mail: catloth@polska.gsfc.nasa.gov.
April 1-5	Association of American Geographers, Ft. Worth, TX. Contact Kevin Fitzpatrick, tel. (202) 234-1450, Fax (202) 234-2744, e-mail: kfitzpat@aag.org.
April 7-9	ACSM-ASPRS Annual Convention and Exposition, Seattle, WA. Contact Nadine Derowitsch, tel. (301) 530-1619, Fax (301) 571-1988.
May 28-29	Tenth Annual Towson State University GIS Conference (TSUGIS '97). Contact Jay Morgan, Department of Geography and Environmental Planning, Towson State University, Baltimore, MD 21204-7097. tel. (410) 830-2964, Fax (410) 830-3888, e-mail: e7g4mor@toe.towson.edu
June 12-13	The International Climate Change Conference and Technologies Exhibition, Baltimore, MD. Call for Papers. Contact Exhibition Office, tel. (301) 695-3762, Fax (301) 295-0175.
July 1-9	1997 Joint Assemblies of the IAMAS, and IAVCEI: Earth, Ocean, Atmosphere — Forces for Change, Melbourne, Australia. Contact Prof. Alan Robock, tel. (301) 405-5377, e-mail: alan@atmos.umd.edu, WWW: http://www.dar.csiro.au/pub/events/assemblies/
July 7-10	Third International Airborne Remote Sensing Conference, Copenhagen, Denmark. Paper submission by 13 December 1996. Contact ERIM/Airborne Conference, P.O. Box 134001, Ann Arbor, MI 48113-4001, USA. tel. (313) 994-1200 ext. 3234, Fax (313) 994-5123, e-mail: wallman@erim.org.
July 21-23	2nd International Symposium on "Reducing the Cost of Spacecraft Ground Systems and Operations, " Keble College, Oxford University, UK. Abstracts of 500-1000 pages due January 15. Contact Richard Holdaway, Rutherford Appleton Laboratory, tel. +44 (0) 1235 445527, Fax +44 (0) 1235 445848, e-mail: r.holdaway@rl.ac.uk.
August 4-8	IGARSS '97, Singapore. Call for Papers. Contact IEEE Geoscience and Remote Sensing Society, tel. (713) 291-9222, Fax (301) 295-0175.
September 8-12	WMO Fifth International Carbon Dioxide Conference, Cairns, Queensland, Australia. e-mail: 97CO2@dar.csiro.au, WWW: http://www.dar.csiro.au/pub/event/co2_conf/index.html

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