Earth Observing System

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In this issue ...

EDITOR'S CORNER

Michael King
EOS Senior Project Scientist

I'm pleased to announce the selection of two new space mission proposals as part of the Earth System Science Pathfinder (ESSP) program that will give new insight into the Earth's carbon cycle and how oceans affect and respond to climate change. NASA has selected the Orbiting Carbon Observatory (OCO) and the Aquarius mission from 18 ESSP proposals received. Of the original 18 proposals, six were selected for a detailed assessment, with the OCO and Aquarius missions now moving on toward final implementation.

The Orbiting Carbon Observatory will provide global measurements of atmospheric carbon dioxide needed to describe the geographic distribution and variability of carbon dioxide sources and sinks. Aquarius will provide the first-ever global maps of salt concentration on the ocean surface, a key area of scientific uncertainty in the oceans' capacity to store and transport heat, which in turn affects Earth's climate and the water cycle. Dr. David Crisp of NASA's Jet Propulsion Laboratory will be the principal investigator for the OCO mission and Dr. Chet Koblinsky of NASA's Goddard Space Flight Center will serve as principal investigator for the Aquarius mission. Both of these missions will involve several university, corporate, and international partners. See the full press release on these ESSP selections on page 39 of this issue.

The next EOS Investigators Working Group meeting will be held November 18-20 at the Turf Valley Resort and Conference Center in Ellicott City, MD. This convenient venue offers first-class conference facilities, fully networked guest rooms, and is easily accessible from either Baltimore or Washington, DC. The IWG meeting is held nominally every nine months, and is the primary forum for sharing information on the latest EOS pro-

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gram and science activities, attracting between 150 and 200 attendees.

The agenda is being formulated at this time, but the general format of the meeting will include EOS program sessions, missions status, science results, and applications sessions. The format of the science portion of the meeting will again follow the ESE science research strategy, which is based on questions (variability, forcing, response, consequence, prediction) rather than science themes (e.g., atmosphere, ocean, etc.). I believe this format represents a broader view of Earth system science, and stimulates thought on individual contributions to the overall EOS science plan.

In addition to scientific and programmatic sessions on the status and future of EOS, the meeting agenda will include early science results on recent EOS missions such as Aqua, Jason-1, GRACE, and SAGE III. Presentations will also be given on SORCE, ICESat, Aura and other upcoming missions, including the newly selected ESSP missions. The meeting will also address new and exciting EOS applications themes, including the National Applications Initiative, vector-borne diseases, fire season and droughts, and others. Several science team meetings and posters will also be held in conjunction.

More information on the meeting will be available shortly on the EOS Project Science Office web site at *eos.nasa.gov*. I hope you will plan to participate in this important opportunity to share the latest EOS program and science activities.

Finally, I'm grateful to have had the opportunity to organize a short course on Remote Sensing of the Earth's Environment from Terra which was presented at the International Summer School on Atmospheric and Oceanic Sciences in L'Aquila, Italy, August 25-30, 2002. Twenty investigators associated with the algorithms and analysis of Terra data provided a very engaging series of presentations describing NASA's remote sensing program. This short course was a compilation of professional electronic presentations on satellite remote sensing engineering, science highlights, and socio-economic applications and included spectacular imagery and data animations. The students consisted of undergraduate and graduate science and engineering students, faculty, and staff from area universities. Many thanks to **Yoram Kaufman, Didier Tanrè** and Guido Visconti who assisted me in this very stimulating and successful class.

Kudos

The following groups and individuals affiliated with the Earth Science Enterprise/Earth Observing System were recipients of NASA 2002 Agency Honor Awards:

- **Exceptional Scientific Achievement Medal. Thomas P. Charlock**, Langley Research Center; **Si-Chee Tsay**, Goddard Space Flight Center.
- **Exceptional Service Medal. Vanessa L. Griffin**, Goddard Space Flight Center; **Ralph A. Kahn**, Jet Propulsion Laboratory; **Gregory Williams**, Headquarters.
- **Exceptional Achievement Medal. Anne B. Kahle**, Jet Propulsion Laboratory; **Ramesh K. Kakar**, Headquarters; **Stephen G. Ungar**, Goddard Space Flight Center.
- **Outstanding Leadership Medal. Robert F. Adler**, Goddard Space Flight Center; **Ghassem R. Asrar**, Headquarters; **Bruce Wielicki**, Langley Research Center.
- **Distinguished Service Medal. Robert A. Schiffer**, Headquarters.

The Earth Observer staff and the entire ESE/EOS community wishes to congratulate these individuals on their outstanding achievements.

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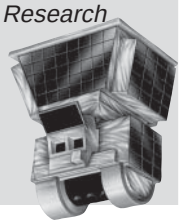
Minutes from the CERES Science Team Meeting

— *Gary G. Gibson, g.g gibson@larc.nasa.gov, NASA Langley Research Center.*
— *Shashi K. Gupta, s.k.gupta@larc.nasa.gov, NASA Langley Research Center*



The 26th Clouds and the Earth's Radiant Energy System (CERES) Science Team meeting was held in Williamsburg, VA on May 14-16, 2002. The meeting focused on: deciding whether new Tropical Rainfall Measuring Mission (TRMM) and Terra data products are sufficiently validated and ready for production, status of meteorological data sets in CERES algorithms, Terra long-term calibration stability, and Science Team results.

Introduction

Bruce Wielicki (LaRC), CERES Principal Investigator, gave an Earth Observing System (EOS)/CERES status report. An EOS science/analysis research announcement is expected in August, with funding for successful proposals starting in June 2003. Proposals with the two NPOESS (National Polar-Orbiting Operational Environmental Satellite System) teams for Earth radiation budget (CERES-like) instruments and data products were submitted to NPOESS. NPOESS has not yet accepted climate data product requirements or archive requirements. Wielicki assessed the risk of having a gap in radiation budget data based on the probabilities of having a CERES scanner operate longer than designed on Terra. There is still a small possibility to get a CERES instrument on the NPP (NPOESS Preparatory Project) mission as a gap-filler for radiation budget data. The Aqua spacecraft was successfully launched on May 4, 2002, and the first science data from CERES on Aqua are expected in June. The next CERES Science Team Meeting is scheduled for September 17-19, 2002 in Princeton, NJ.

Instrument Status

Kory Priestley (LaRC) reported on calibration and validation for the CERES instruments. Terra continues to perform well, and early Aqua diagnostics show no changes from pre-flight values. The Aqua deep-space pitch-over maneuver is scheduled for mid-July. Edition 2 Bidirectional Scan (BDS) and ERBE-like (ERBE is the Earth Radiation Budget Experiment) products will be publicly available by the end of June. Edition 2 will account for pre- to post-launch gain changes as measured by the internal calibration modules.

TRMM CRS Validation and Readiness

Thomas Charlock (LaRC) and **Fred Rose** (Analytical Services & Materials, Inc., AS&M) reported on TRMM Cloud Radiation Swath (CRS) Edition 2b data product validation and readiness for release. CRS is the instantaneous footprint-scale Surface and Atmospheric Radiation Budget (SARB) product. Charlock showed a number of improvements in the Edition 2b version and some validation results. . e Science Team concurred with the recommendation that the CRS data are ready for distribution.

TRMM TISA Validation and Readiness

David Young (LaRC) discussed the status of the CERES Temporal Interpolation and Spatial Averaging (TISA) Edition 2 data products. Most major hurdles have been cleared with only some geostationary satellite calibration and validation remaining. Validation activities are continuing, and final delivery of Edition 2 products is expected in June.

Terra SSF Edition 1 Cloud Properties

Pat Heck (AS&M) presented an overview of efforts to determine cloud properties from the Visible-Infrared Scanner (VIRS) imager on TRMM and the Moderate Resolution Imaging Spectroradiometer (MODIS) on Terra. Calibration issues have been addressed and the VIRS/MODIS comparisons are improved. The ECMWF (European Centre for Medium-Range Weather Forecasts) continues to provide superior meteorological data compared to the DAO (Data Assimilation Office) data, especially surface temperature at night. Early validation results show consistency between VIRS and MODIS cloud properties.

Terra Edition 1 TOA Flux Accuracy Using TRMM ADMs

Norman Loeb (Hampton University, HU) reported on the status of TRMM Single Scanner Footprint (SSF) Edition

2 Angular Distribution Models (ADMs) and TOA flux validation. TRMM SSF Edition 2B will begin processing at end of May. Terra regional mean TOA flux errors (based on TRMM ADMs) are less than 0.5 Wm^{-2} in the Tropics, but can reach 2 Wm^{-2} near the poles.

Terra SSF Edition 1 Surface Fluxes; TRMM Edition 2b

David Kratz (LaRC) and **Shashi Gupta** (AS&M) summarized recent improvements to the surface-only flux algorithms and presented results of validation studies. The suite of shortwave (SW) and longwave (LW) algorithms is providing good results for both clear- and all-sky conditions.

Data Production

Mike Little (LaRC) gave a Data Management Status report covering data products, processing issues and environment, and some observations on customers for the data. No problems were noted for TRMM and Terra processing, and data products are generally on schedule. Bruce Barkstrom, head of the Atmospheric Sciences Data Center (ASDC) at LaRC, discussed a number of changes and approaches being investigated at the ASDC to improve CERES data production, archiving, and retrieval.

Invited Presentation

Kuan-Man Xu (LaRC) presented early results from a new method for evaluating cloud parameterizations used in General Circulation Models (GCMs) by using high-resolution cloud-property retrievals. Xu compared cloud properties from ECMWF-predicted cloud fields for March of 1998 and 2000 with CERES cloud properties over areas of deep convective clouds in the tropics. He found that ECMWF-predicted clouds tended to be deeper and colder than the observed clouds in CERES SSF. He also described 2-D and 3-D cloud-resolving models (CRMs) which have spatial and temporal resolution comparable to satellite data. There was good agreement between CRM simulations and satellite data in most cases. Xu identified inadequate ice-phase microphysics and single-column advective forcing as the main deficiencies in the CRMs.

Investigator Presentation Highlights

Bing Lin (LaRC) showed decadal variations of the tropical mean radiative energy and Iris estimations. Tropical convection was enhanced during the 1990s compared to the 1980s, and sea-surface temperature (SST) increased slightly (0.144 K). Radiative anomalies from ERBE correlated well with changes in SST. There is no indication in the ERBE/CERES observed decadal data that tropical cloud systems would produce strong negative feedback to stabilize the climate system, as suggested by the Iris hypothesis. Lin Chambers (LaRC) used radiative properties determined from CERES data in the 3.5-box greenhouse model calculations and found that a decrease in anvil clouds with increasing SST results in a very small positive or negative feedback compared to the strong negative feedback of Lindzen et al.

Bruce Wielicki gave an update on the observed decadal variability in the tropics. No calibration problems were identified which could explain Earth Radiation Budget Satellite (ERBS)-observed decadal changes. Seasonal changes in 1990s tropical shortwave (SW) radiative fluxes cause some aliasing of the ERBS diurnal cycle into the monthly means, but increased 1990s variability remains for both 36-day and 72-day precession cycle averages. Stratospheric Aerosol and Gas Experiment (SAGE)-II cloud-height decreases explain one-third of the 3 Wm^{-2} longwave (LW) radiative flux change.

David Kratz (LaRC) presented validation results for surface SW and LW fluxes derived with the surface-only algorithms. The Li-Leighton-Cess SW and Inamdar-Ramanathan LW algorithms were modified recently to remedy problems identified in earlier studies. These models only provide clear-sky fluxes. The Langley Parameterized Shortwave Algorithm (LPSA) and Langley Parameterized Longwave Algorithm (LPLA) models remain unchanged and provide both clear- and all-sky fluxes.

Eric Wilcox (Scripps Institution of Oceanography) presented results from a study of the spatial and temporal scales of precipitating tropical cloud systems over the Indian Ocean in early 1999 and their comparison to satellite imagery and GCM simulations. Maximum precipitation rate for observed clouds was higher than for model clouds.

Robert Cess (State University of New York, Stony Brook) presented results from a study of the variability of atmospheric greenhouse effects from 1985 to 1999 using ERBE fluxes and corresponding International Satellite Cloud Climatology Project (ISCCP) total cloud amounts. Using a 29-year simulation from the National Center for Atmospheric Research (NCAR) community climate system model (CCSM), Cess showed that radiative forcing of the atmosphere increased

with time for both model and satellite data, but satellite data also showed a decreasing cloud amount for the period. From an analysis of a cloud dataset for 1900-1986, Cess showed the existence of a 24-year cycle of cloud amount and suggested that the observed radiative flux variations could be a response to the decreasing phase of the cloud cycle rather than to the greenhouse effect.

Anand Inamdar (Scripps) presented a modified parameterization scheme for the model for producing surface-only clear-sky LW fluxes over all land areas of the globe. The modifications resulted in better agreement between model results and site observations. Inamdar also compared LW cloud radiative forcing (CRF) in the window and non-window regions derived from ERBE-like data.

Todd Berendes (University of Alabama-Huntsville, UAH) presented results of activities aimed at validating satellite-derived cloud properties with measurements from a variety of ground-based instruments. Berendes found that measurements from several ground instruments are necessary for constructing a complete description of clouds.

Steven DeWitte (Royal Meteorological Institute of Belgium) presented results on homogenization (smooth blending) of CERES/TRMM and European Geostationary Earth Radiation Budget (GERB)-like/MeteoSat-7 reflected SW fluxes. The GERB instrument is scheduled to fly on board the MeteoSat Second Generation (MSG-1) in August 2002. DeWitte stated that CERES ADMs are being incorporated into the GERB processing system.

Michel Viollier (LMD, France) presented results of a combination of CERES and Scanner for Radiation Budget (ScaRaB) broadband (BB) fluxes with MeteoSat-5 narrowband (NB) radiances. The objective was to derive broadband SW and LW fluxes from MeteoSat-5 NB data. Derived outgoing LW values were in very good agreement with broadband CERES measurements, but SW fluxes showed much larger errors in comparison to CERES fluxes. He apprised the science team of Megha-Tropiques, an Indo-French mission aimed at the study of convective systems, water cycles, and energy budgets in tropical atmospheres.

Bill Smith, Jr. presented a mission summary and early results from the Chesapeake Lighthouse and Aircraft Measurements for Satellites (CLAMS) experiment. CLAMS conducted nine successful coordinated aircraft experiments coincident with Terra overpasses. On one moderate aerosol "Golden Day," CLAMS had six aircraft vertically stacked over the Chesapeake Lighthouse at the Terra overpass time. CLAMS papers were presented in a special session at the Spring American Geophysical Union (AGU) meeting this past May.

David Randall (Colorado State University) presented results from a study of advanced cloud parameterizations and efforts to incorporate them into GCMs. He suggested that cloud-system-resolving models (CSRM), which represent dynamical processes explicitly, are a possible answer, but would stretch present-day computer resources to the limit. The Community Atmospheric Model with a 2-D version of Marat Khairoutdinov's CSRM simulated the Madden-Julian oscillation well. It also simulated explicit deep convection, fractional cloudiness, cloud overlap, and gravity waves, but took about 180 times longer to run. Randall emphasized that to really advance the state-of-the-art of cloud simulation in the GCMs, much more complex parameterizations have to be incorporated.

Shi-Keng Yang (National Centers for Environmental Prediction, NCEP) presented results from a study of the Arctic Oscillation (AO) using ERBE and CERES data. For May-June-July averaged over the ERBE years, he showed that AO Index and LW anomalies were correlated. In a related study, the analysis of the new global data assimilation system showed that the model heats the higher levels of the atmosphere more than earlier versions, and is now in better agreement with CERES measurements.

Xiquan Dong (University of Utah) compared cloud properties retrieved from MODIS data using CERES cloud algorithms with ground measurements over the Atmospheric Radiation Measurement (ARM) site in Alaska during March, 2001. Marine stratocumulus was the dominant cloud type. Comparisons of cloud heights showed that while satellite retrievals often indicated multiple layers, ground measurements detected only one layer. Dong noted that during March, clouds over this site are mostly of mixed phase, making retrievals of microphysical properties difficult and less accurate.

James Coakley (Oregon State University) presented results of cloud property retrievals for partly cloud-filled imager pixels. The threshold method generally overestimated, relative to the

partly cloudy method, cloud amount and particle size and underestimated cloud height, optical depth, and liquid water path.

Bryan Baum (LaRC) presented results from a study on the detection of multi-layered clouds in daytime MODIS data. The objective was to separate multi-layered clouds from the single-layered ones to improve the inference of cloud phase. This method is currently being prepared for application to MODIS direct broadcast data for both Terra and Aqua.

Qingyuan Han (UAH) presented results from a study of the effects of ice-crystal habits (shapes) on many aspects of satellite-based cloud retrievals. As an example, although the asymmetry parameter may be very different for different ice-crystal shapes, most cloud retrieval schemes use only a single value. In the GCMs, results of the cloud parameterization schemes are highly dependent on the assumption regarding ice-crystal shape. Multi-angle scattering observations for different ice-crystal shapes may be the only way to derive their properties; thus, observations from CERES rotating azimuth-plane scanners hold great promise.

Alexander Ignatov (NOAA) presented results of work on developing a method of correcting for the thermal leak which contaminates the radiances in the VIRS 1.6-μm channel. Ignatov proposed to apply a new correction scheme based on principal component analysis. Results from the new scheme showed that the biases occurring earlier were effectively removed and a small spurious signal in the 0.63 micron channel was also corrected.

Wenying Su (HU) reported on plans to place CERES validation instruments on a long-duration balloon experiment. The CERES validation package will consist of two pyranometers and two pyrgeometers on a Goddard-supplied balloon called Nightglow. Instrument integration is scheduled for June, and a launch from Alice Springs, Australia is scheduled for December.

Applications and Outreach

Paul Stackhouse (LaRC) briefed the team on the Surface meteorology and Solar Energy (SSE) project accomplishments and future goals. The success of SSE has proven the value of scientific data for industrial use. The next step is to transition SSE to a new initiative called Prediction of Worldwide Energy Resource (POWER). The new thrust sets the framework to target other industries, ultimately providing a predictive data set for energy resource planning.

Doug Stoddard (Science Applications International Corporation, SAIC) presented an update on the CERES Students' Cloud Observations On-Line (S'COOL) educational outreach program. S'COOL now has over 1100 participating schools in 60 nations. In the last 4 months, S'COOL leaders have participated in eight teacher workshops, visited 10 schools, participated in a live Aqua webcast, and distributed the S'COOL newsletter in English, French, and Spanish. This summer's teacher workshop will include 22 elementary school teachers representing 15 states, 2 teachers from Puerto Rico, and 1 DOD teacher.

Kudos *(cont from page 2)*

The following groups affiliated with the Earth Science Enterprise/Earth Observing System were recipients of NASA 2002 Agency Honor Awards:

Public Service Group Achievement Award

- Southern Africa Regional Science Initiative (SAFARI) 2000 International Leadership Team
- Tropical Rainfall Measuring Mission Boost Team from Japan

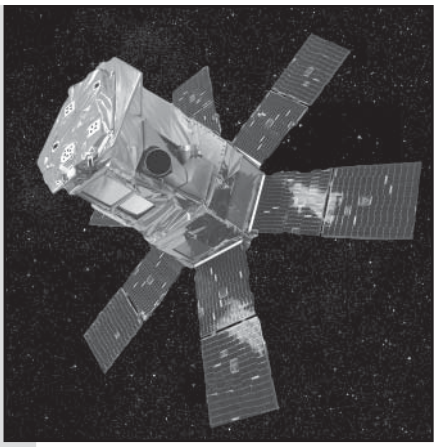
Group Achievement Award

- Atmospheric Sciences Data Center Team
- Earth Observer-1 (EO-1) Formation Flying Team
- Earth Science Data and Information System (ESDIS) Project
- Earth Science Data and Information System (ESDIS) Project - Project Information Management System Development Team
- MODIS Power Supply #2 Shut Down Investigation Team
- New Millenium Earth Observing-1 Project Team

The Earth Observer staff and the entire ESE/EOS community wishes to congratulate these individuals on their outstanding achievements.

Minutes from the Solar Radiation and Climate Experiment (SORCE) Science Working Group Meeting

— *Gary Rottman, gary.rottman@lasp.colorado.edu, Laboratory for Atmospheric and Space Physics, University of Colorado*
— *Tom Woods, tom.woods@lasp.colorado.edu, Laboratory for Atmospheric and Space Physics, University of Colorado*
— *Robert Cahalan, robert.cahalan@gsfc.nasa.gov, NASA Goddard Space Flight Center, Greenbelt, Maryland*
— *Vanessa George, vanessa.george@lasp.colorado.edu, Laboratory for Atmospheric and Space Physics, University of Colorado*



The SOlar Radiation and Climate Experiment (SORCE) Working Group Meeting was held July 17-19, 2002, in Steamboat Springs, Colorado. Thirty-five people participated in the two-and-one-half days of oral presentations and poster sessions. SORCE is one element of NASA's Earth Observing System (EOS), and is scheduled for a December 2002 launch.

Introduction

Tom Woods, the science meeting program chair, began with a welcome and introduction to the Working Group Meeting goals. Scientists studying the Sun and Earth's atmosphere and climate came together to explore the variable Sun and its influence on the terrestrial environment. By focusing on three time domains, the group worked to define the present understanding of solar and climate variations in three sessions, as listed in Table 1. The group explored the most important time periods for variations in the Sun and Earth systems. The shorter time periods will be an additional focus for the SORCE science team members as they analyze the SORCE data.

Status of SORCE

Gary Rottman, SORCE Principal Investigator, provided an overview of the SORCE mission and updated everyone on the current status. (A complete review of the SORCE mission and the instruments on board is presented in the May/June issue of *The Earth Observer*.) Rottman began by quoting a primary recommendation made in a 1994 National Academy of Sciences Report regarding solar influences on global change. "One activity ranks above all others for determining solar influences on global change: Monitor the total and spectral solar irradiance from an uninterrupted series of spacecraft radiometers employing in-flight sensitivity tracking." This is the main objective for SORCE and it will be accomplished by collecting data from the four instruments on board. This mission will continue the precise measurements of total solar irradiance (TSI) that began with the Nimbus-7 Earth Radiation Budget (ERB) instrument in 1978 and have continued to the present with the Earth Radiation Budget Satellite (ERBS), three Active Cavity Radiometer Irradiance Monitors (ACRIM), and the Variability of Solar Irradiance and Gravity Oscillations (VIRGO) measurements. SORCE will also provide measurements of the solar spectral irradiance from 1 to 2000 nm.

TABLE 1: SORCE Science Working Group Sessions

Session	Time Scale	Solar Phenomena	Terrestrial Phenomena
1	Short Term: Minutes to 2 years	eruptive events oscillations sunspots & active regions solar rotation tachocline oscillations	eruptive events diurnal variations 27-day solar-driven events seasonal variations
2	Medium Term: 1 to 30 years	sunspot cycle magnetic (dynamo) cycle	Quasi Biennial Oscillation ocean circulation 11-year solar-driven events anthropogenic events
3	Long Term: >30 years	cycle-to-cycle variations Maunder minimum stellar evolution	droughts ice ages historical records (tree rings, ice cores, etc.)

The SORCE mission, designed for a 5-year duration will: 1) establish a data set of Total Solar Irradiance (TSI), with an absolute accuracy better than 300 ppm(3σ) and a relative accuracy between measurements of 0.001% (10 ppm) per year; 2) establish a data set of solar spectral irradiance from 1 nm to 2 μm with an absolute accuracy of 2% to 5% in the ultraviolet, and 0.1% in the visible to near infrared; and 3) improve understanding and generate new inquiry into how the variable solar irradiance affects our atmosphere and climate, and how and why variability occurs on the Sun. This knowledge can then be used to estimate past and future solar climate relations.

The Earth's radiation and energy balance is shown in **Figure 1**. Because of selective absorption and scattering processes in the Earth's atmosphere, different regions of the solar spectrum affect our environment in different ways. Approximately 20-25% of the TSI is absorbed by atmospheric water vapor, clouds, and ozone, impacting convection, cloud formation, and latent heating via processes that are strongly wavelength dependent. To understand the effects that solar variability has on Earth's climate, it is important to accurately monitor the TSI and its spectral composition.

After reviewing basic radiometric quantities, why solar irradiance varies, and current TSI measurements and concepts, Rottman gave an overview of each of the four instruments on SORCE. The Total Irradiance Monitor (TIM) measures TSI, introducing modern state-of-the-art technologies to the electrical substitution radiometer (ESR), and at the same time taking full advantage of the best heritage of previous radiometers. The Spectral Irradiance Monitor (SIM) instrument measures spectral irradiance from 200 to 2000 nm with a newly developed prism spectrometer, also including a miniaturized ESR. There are two Solar Stellar Irradiance Comparison Experiment (SOLSTICE) instruments on SORCE to measure spectral irradiance from 120 to 320 nm. These instruments are an evolutionary refinement of the Upper Atmosphere Research Satellite's (UARS) SOLSTICE, and they observe bright blue stars as a long-term calibration standard. The XUV Photometer System (XPS) instrument measures broadband spectral irradiance from 1 to 34 nm, and is designed similarly to the XPS on the Thermosphere-Ionosphere-Mesosphere Energetics and Dynamics (TIMED) satellite.

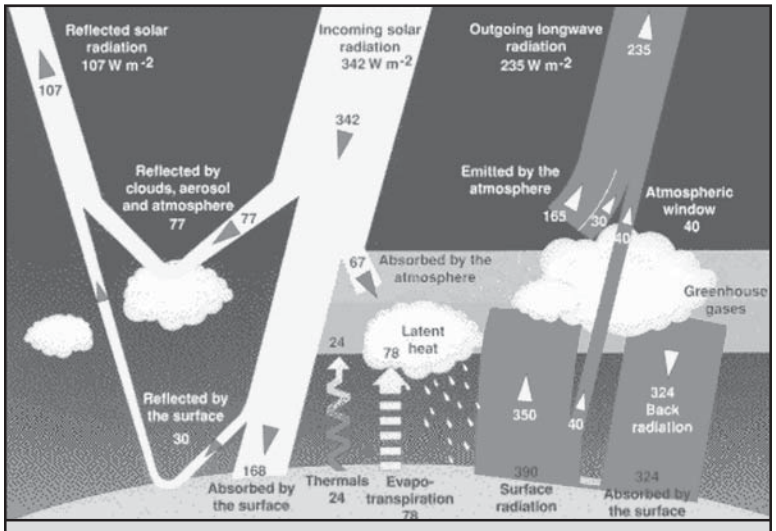


FIGURE 1: The diagram above illustrates the Radiation Balance of the Earth showing how much solar energy is received and how it is redistributed—either reflected back to space or absorbed by the planet to warm the Earth. (Provided by Jeffrey T. Kiehl and Kevin Trenberth.)

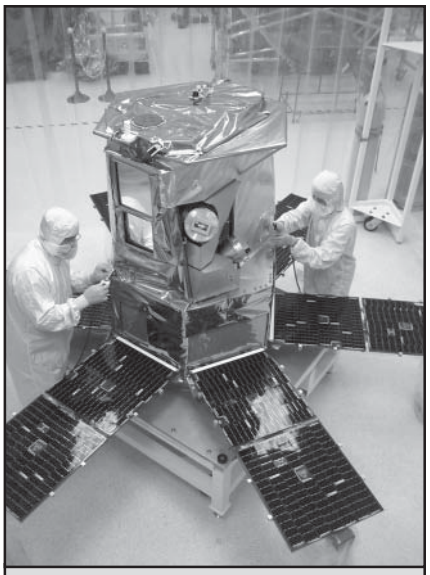


FIGURE 2: The SORCE spacecraft during Integration and Testing at the Orbital facility in Dulles, VA. The picture shows the spacecraft with the solar arrays deployed.

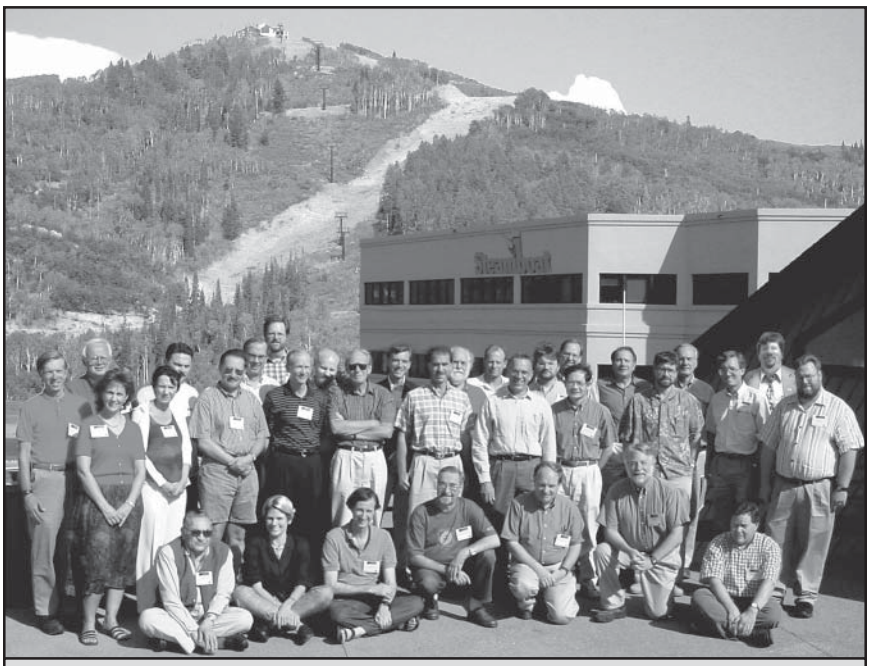
The Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado has full programmatic responsibility for the SORCE mission. Under sub-contract with LASP, Orbital Sciences Corporation in Dulles, Virginia has provided a highly capable free-flying and low-risk spacecraft bus. After integration (see **Figure 2**), the launch will occur in late 2002 from the Kennedy Space Center in Cape

Canaveral, Florida on a Pegasus XL. LASP will operate SORCE from its Mission Operations Center in Boulder, Colorado for a period of 5 years or more. The LASP facility will process, analyze, validate, and distribute all irradiance data collected.

To summarize, Rottman emphasized how important this research and data collection is for present and future climate studies. There is much to learn about the Earth's radiation and energy balance through continuous TSI measurements. Global energy balance considerations may not provide the entire story, and how TSI variations are distributed in wavelength is critically important in understanding the Earth's response to solar variations. Recalling the earlier National Academy of Sciences Report, Rottman stressed that it must be a priority to continue monitoring the total and spectral solar irradiance after the SORCE mission is complete, and that we should now be planning for future measurement programs.

Session I: Short-Term Variations (Minutes to ~2 years)—Greg Kopp (LASP) Chair

Jesper Schou (Stanford University) began Session I with a talk on ***Solar Changes from Helioseismology***, which has become an invaluable tool for studying the solar interior and how it varies with time. He gave a brief overview of helioseismology, and then went on to describe some of the recent results, with an emphasis on temporal changes. In particular, the near-surface changes and the so-called tachocline oscillations were discussed, and how the various changes relate to the solar dynamo. Schou also touched on the current ability to detect changes on the backside of the Sun and to predict short-term variability.



The SORCE Working Group attendees take a break from their meeting at Steamboat Springs for a picture with the scenic Colorado Rockies in the background. Shown: **Front Row sitting left to right** – Devendra Lal, Judith Lean, David Rind, Dominique Crommelynck, George Lawrence, Bob Cahalan, Jerry Harder; **second row standing left to right** – Vanessa George, Judit Pap, Rashid Akmaev, Lon Hood, George Reid, Matt DeLand, Matthew (Geoff) McHarg, Guoyang Wen, Jeff Kuhn, Greg Kopp, Marty Snow; and **back row left to right** – Bill McClintock, Bill Ochs, Randy Meisner, Linton Floyd, Frank Eparvier, Jesper Schou, Jeffrey Hall, Claus Fröhlich, Peter Fox, Chris Pankratz, Tom Woods, Gary Rottman, Oran White, Tom Sparn.

Jeffrey Kuhn (Institute for Astronomy, University of Hawaii) explored the question, ***Solar Irradiance Variability: How well do we really understand how it works?*** While there are no consistent models of the solar cycle that account for the solar irradiance variability, there is much more information available about solar variability than magnetic field observations tell. Kuhn discussed aspects of a consistent physical model while exploring the implications of past and future variability observations.

Lon Hood (University of Arizona) spoke on the ***Effects of 27-Day Solar Ultraviolet Variations on the Stratosphere***. Solar ultraviolet radiation at wavelengths near 200 nm photodissociates molecular oxygen, leading to the formation of ozone in the upper stratosphere. Although a trace constituent (only a few parts in 10^6), ozone is important both for radiative heating of the stratosphere and for shielding the biosphere from biologically harmful solar UV radiation at wavelengths in the 250 to 300 nm range. Under solar maximum conditions, solar UV variations near 200 nm are as large as 6% on the 27-day time scale. Measured ozone responses were as large as ~3% in the tropics near 40 km altitude. Current work focuses on observational and theoretical studies of mechanisms by which 27-day solar UV variations may produce secondary dynamical effects in the tropical and extra-tropical stratosphere.

Tom Woods (LASP, University of Colorado in Boulder - shown in **Figure 3** above) reviewed the ***Early Results of***

FIGURE 3: Tom Woods was the science meeting chair. He is pictured here giving a presentation to the group assembled.

the Solar Extreme Ultraviolet Irradiances from the TIMED Solar EUV Experiment. The Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED) satellite was launched in December 2001 and normal operations began on January 22, 2002. The Solar EUV Experiment (SEE) onboard TIMED measures the solar spectral irradiance from 0.1 nm to 195 nm. This presentation focused on the 27-day variations, caused by the solar rotation, and the large X class flare on April 21, 2002.

Matthew DeLand (Science Systems and Applications, Inc. [SSAI] – Lanham, MD) presented a talk on the ***Short-Term Solar Irradiance and Mg II Index Variations.*** Previous work has shown a close correlation between ozone abundances at 30-50 km and 205-nm irradiance variations on solar rotational time scales. The Mg II index of solar UV activity has often been used as a proxy for 205-nm irradiance. Excellent correlations are typically observed for solar cycle (~11-year) and rotational (~27-day) time scales. On some occasions, a 13-day periodicity is present in 205-nm irradiance data, but is weaker or absent in coincident Mg II index data. DeLand discussed these variations and the potential impact for modeling of solar irradiance variations.

Session II: Medium-Term Variations (1 to 30 years)—Tom Woods (LASP) Chair

Claus Fröhlich (World Radiation Center – Davos, Switzerland) presented a talk on ***Solar Irradiance Variability.*** Fröhlich discussed the TSI measurements that are available from space, beginning in 1978 and extending over a time period of more than 23 years. From measurements made by different space radiometers (HF on NIMBUS-7, ACRIM-I on SMM, ACRIM-II on UARS, and VIRGO on SOHO) a composite record of TSI has been compiled. This time series is compared to an empirical model based on sunspot darkening and brightening due to faculae and magnetic network.

Oran R. White from the High Altitude Observatory at the National Center for Atmospheric Research presented ***A Current Picture of Irradiance Measurements.*** White reviewed the solar irradiance measurements from 1978 to 2002 that give the solar cycle variability for three solar maxima and two minima. He summarized these data with emphasis on the most recent measurements in solar cycle 23. This provides a basis for estimating values of the solar irradiances to be obtained with SORCE's TIM and SIM instruments. When SORCE launches, solar cycle 23 should be past its maximum and into its declining phase. The next critical base-line measurement will be at solar minimum in about 2007.

Robert Cahalan (NASA Goddard Space Flight Center – Greenbelt, Maryland) spoke on ***Earth, the Water Planet.*** Cahalan, NASA's SORCE Project Scientist, began with a discussion on recent multi-year and multi-decadal changes in Earth's climate, emphasizing the dominant energy control mechanisms of the 3 phases of water. Regional ocean basins and land masses are associated with characteristic cloud types that mainly cool the climate system, but are likely to produce less cooling in a globally warmed climate. Fresh water, stored primarily in polar ice, and secondarily in large subsurface aquifers, exhibits decadal trends that are largely, but not completely, consistent with global warming. Cahalan concluded by summarizing modes of natural variability such as El Niño - Southern Oscillation (ENSO) and its cousins, contrasting these with anthropogenic forcing due to greenhouse gases and aerosols.

Rashid A. Akmaev (Cooperative Institute for Research in Environmental Sciences [CIRES] at the University of

Colorado and the National Oceanic and Atmospheric Administration [NOAA] – Boulder, Colorado) gave a talk on ***Upper-Atmospheric Structure Response to CO_2 Increases.*** The atmospheric response to CO_2 increases in recent decades has been studied with the Spectral Mesosphere/Lower Thermosphere Model. The model predicts colder temperatures in the thermosphere with an increase in CO_2 and the thermospheric response is much stronger than in the lower atmosphere.

Matt DeLand (SSAI) presented the ***SBUV Observations of PMCs over Two Solar Cycles.*** The appearance of cloud-like structures at high altitudes during local summer at polar latitudes has been documented for more than 100 years. These phenomena are called noctilucent clouds (NLC) by ground-based observers, and polar mesospheric clouds (PMC) when observed from space. DeLand presented PMC results from five Solar Backscatter Ultraviolet (SBUV) and SBUV/2 instruments covering 23+ years (1978-2002). The overlapping data sets from nearly identical instruments give an accurate picture of long-term variations. PMC occurrence frequency is anti-correlated with solar Lyman α irradiance.

Linton Floyd (Interferometrics, Inc. and the Naval Research Laboratory) reviewed the ***Measurements of Solar UV Irradiance over Solar Cycle Time Scales.*** The experience and prospects for long-term solar UV irradiance measurements are explored in the context of the Solar Ultraviolet Spectral Irradiance Monitor (SUSIM) experiment aboard the Upper Atmosphere Research Satellite (UARS). SUSIM has measured the solar UV irradiance (115-410 nm) for nearly 11 years, about the duration of a solar sunspot cycle. Like its SOLSTICE counterpart on UARS, SUSIM is able to measure changes in its own responsivity. This is made possible through analysis of measurements of the UV output of 4 stable deuterium lamps and by solar and lamp measurements using redundant optical elements. Floyd reviewed the correspondence of solar UV irradiance time series in various wavelength ranges to that of the MgII index.

Judit Pap (Goddard Earth Sciences and Technology Center at the University of Maryland, Baltimore County) presented a talk on ***Solar Magnetic Activity and Irradiance Variations: Agreements and Discrepancies.*** Total solar irradiance and UV irradiances have been measured from space for almost three decades. Correlative studies indicate that a major portion of irradiance variations is explained by the Sun's surface magnetic activity features. However, there is growing evidence that empirical models based on sunspots, faculae and the magnetic network cannot explain all aspects of the observed irradiance changes, especially during solar cycle 23. These results underscore the necessity of continuous space irradiance monitoring and improvement of irradiance models used for climate studies.

Session III: Long-Term Variations (>30 years)—Jerry Harder (LASP) Chair

Jeffrey Hall (Lowell Observatory – Flagstaff, Arizona) shared information on ***Long-Term Echelle Spectroscopy of the Sun and Solar Analogs.*** In the 40 years since Olin Wilson began long-term monitoring of Sun-like stars, stellar-activity cycles research has been presented with increasing attention to its relevance to analogous observations of the Sun. Hall reviewed the important data sets, in particular the Mount Wilson Observatory time series that spans 30 years or more, and presented what is currently known about variations of Sun-like stars on 30-year timescales. Hall discussed the current best candidate solar "twin," the G2 star 18 Sco (or HR6060) which not only closely matches the Sun in mass, luminosity, and spin, but also has a magnetic-activity cycle apparently in phase with the Sun.

Judith Lean (E. O. Hulburt Center for Space Research at the Naval Research Laboratory) reported on the ***Relationships between the Sun and Climate on Time Scales of Decades to Centuries.*** There are numerous empirical associations between solar variability and climate change throughout the Holocene, on multiple time scales. Recent examples include surface temperatures in the past 1000 years, solar-like 22- and 210-year cycles in drought, and 1500-year solar-related fluctuations in North Atlantic ice drifts. The nature of long-term solar forcing of climate remains

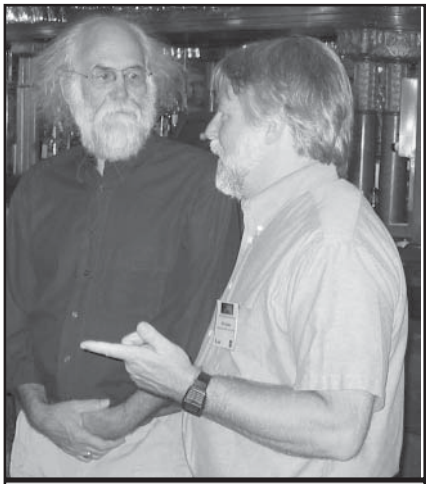


FIGURE 4: Bob Cahalan (right) is Project Scientist for SORCE and was present at the SORCE Science Working Group meeting. He is pictured with Claus Fröhlich from the World Radiation Center in Davos, Switzerland.

ambiguous. Also uncertain are the geophysical mechanisms responsible for climate response to solar forcing. Speculated processes include direct heating of land and ocean surfaces by changes in visible and near-infrared solar radiation and indirect influences of solar UV radiation on ozone concentrations and stratospheric heating, with subsequent radiative and dynamical coupling to climate. Lean summarized recent Sun-climate relationships and possible mechanisms on time scales of decades to centuries, and described current understanding of long-term solar-irradiance changes, and how they may – or may not – relate to cosmogenic isotope proxies.

David Rind (Goddard Institute for Space Studies [GISS] – New York) addressed the question, ***Was there a Maunder Minimum cooling, and should there have been?*** Some controversy has arisen over the actual magnitude of cooling during the Maunder Minimum (MM) time period (approximately 1650-1715). A recent reconstruction indicated that the global cooling was only about 0.6˚C, actually less than during the late 1800s, primarily due to a muted tropical response. Climate-model simulations for this time period are reviewed, comparing the importance of solar, volcanic, and trace-gas plus tropospheric aerosol forcing. The results show that anthropogenic effects by themselves should have produced close to 1˚C cooling for the Little Ice Age in general (including the MM). Reconstructions of volcanic aerosols imply a potentially large contribution to the MM. The solar contribution has been estimated as anywhere between <0.1% to ~0.4% change. Whether large cooling did occur in the MM, and whether it should have, remain open questions.

Devendra Lal (Scripps Institution of Oceanography, Geosciences Research Division – La Jolla, California) shared information on ***Recent Lessons in Solar Physics Based on Studies of Surface Lunar Soils and Ice Cores from Summit, Greenland.*** It is now well recognized that solar phenomena produce appreciable changes in the radiations we receive in the interplanetary space and on the Earth. Lal discussed the composition of the solar wind on radionuclides in lunar soil and ice cores. Lal also reviewed the experimental methods and the reasons which lead us to the two conclusions which suggest that, (1) the solar wind contains relatively short-lived radionuclides which must be concurrently produced in the outer photosphere or coronal regions, and (2) the Sun could exhibit rather long periods (~1000 years) of very low solar activity, and therefore very weak solar modulation of the galactic cosmic ray flux, mimicking the historically recorded 70 years duration (solar) Maunder Minimum epoch during 1645-1715.

Matthew (Geoff) McHarg (U.S. Air Force Academy – Colorado Springs, CO) wrapped-up Session III by reporting on ***Long-Term Variations in Ionospheric Joule Heating in Response to the Interplanetary Magnetic Field.*** Joule heating is caused by currents flowing in the Earth's ionosphere, and is one of the three major sources of thermospheric heating. McHarg reported on a study of the effects of the Interplanetary Magnetic Field (IMF) on ionospheric joule heating, and the long-term variations in the joule heating as derived from a proxy magnetic index. IMF causes a generally linear increase in integrated joule heating over the polar cap, with greater heating for southerly IMF conditions.

Poster Session

Natural Variability of the Atmosphere: Limitation of Ground-based Estimates of Solar Irradiance, by **Guoyong Wen** from the Joint Center for Earth Systems Technology [JCET]/UMBC, and NASA's Goddard Space Flight Center.

The San Fernando Observatory Program of Full-Disk Photometry, by **Gary Chapman** with the San Fernando Observatory, California State University in Northridge.

Variations in Solar EUV Flux as Measured by SOHO / CELIAS / SEM, by **Judit Pap** at Goddard Earth Sciences and Technology Center and the University of Maryland.

Solar Irradiance Variability – Comparison of Models and Observations, by **Peter Fox** with the High Altitude Observatory at the National Center for Atmospheric Research in Boulder, Colorado.

Stellar Observations with the UARS SOLSTICE, by **Marty Snow** with the Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado.

SORCE Data Processing and Distribution, by **Chris Pankratz** with LASP at the University of Colorado.

Total Irradiance Monitor (TIM) Instrument, by **Greg Kopp** with LASP at the University of Colorado.

Spectral Irradiance Monitor (SIM) Instrument, by **Jerry Harder** with LASP at the University of Colorado.

TABLE 2: Summary of Connections to SORCE

SORCE Instruments	Spectral Range	Validation (Time Series)	Solar Irradiance Models	Atmosphere/Climate Models
TIM	Total Solar Irradiance	SOHO ACRIM Picard NIST Area Cal.	Improve Proxy Models New Physical Models Solar Dynamic Models	Atmosphere-Ocean Coupling Solar-Climate Effects Indirect Solar Forcing Maunder Minimum
SIM	Near-Ultraviolet Visible Near Infrared	SBUV UARS SOHO ATLAS (past) Ground-based	SunRise Model New Proxy Models	Same as TIM, but with spectral information.
SOLSTICE	Far-Ultraviolet Mid-Ultraviolet	UARS SBUV TIMED	SunRise Model New Proxy Models Improve FUV Models	Ozone Models Upper Atmosphere Models
XPS	Extreme Ultraviolet	TIMED SOHO	NRLEUV Model SOLAR2000 Model Improve XUV-EUV Models	Upper Atmosphere Models Nitric Oxide Models
Outstanding Issues:	NA	*SORCE Overlap*: UARS? SIGF Mission? Future FUV Hole?	*Improvements*: Proxies? Physical Models?	*Better Coupling*: Atmospheric Layers Amosphere-Ocean *Solar-Terrestrial Relations*: Do we understand them? Solar indirect forcing?

XUV Photometer System (XPS) Instrument, by **Tom Woods** with LASP at the University of Colorado.

Solar Stellar Irradiance Comparison Experiment (SOLSTICE) Instrument, by **William McClintock** with LASP at the University of Colorado.

Conclusions – Connections to SORCE

Tom Woods ended the SORCE Working Group Meeting by summarizing the relevance of the discussions to SORCE. There are three aspects of the discussions during this meeting that are connected to the SORCE program: validation of the solar-irradiance time series, solar irradiance modeling, and atmosphere/climate modeling. A summary of these connections as grouped by the SORCE instruments is given in **Table 2**. The EUV region, which is not measured by the SORCE instruments and thus not listed in Table 2, will be measured during the SORCE mission by the TIMED Solar EUV Experiment (SEE).

The SORCE team is planning to have another science meeting shortly after the December launch to discuss initial results and data validation. Next summer the SORCE science working group will meet for more in-depth scientific discussions.

Acknowledgements

The authors would like to acknowledge the following individuals for their contributions to the SORCE mission and this Science Working Group Meeting.

- **SORCE Team Members**: Jerry Harder, Greg Kopp, George Lawrence, Bill McClintock, Tom Sparn, Mike Anfinson, Rick Kohnert. All are at the LASP, University of Colorado.
- **SORCE Project Manager**: William Ochs – NASA Goddard Space Flight Center.

More information is at available at: *lasp.colorado.edu/sorce*.

CloudSat/CALIPSO Outreach Planning Session (CCOPS)

— *Alan B. Ward, alan_ward@sesda.com, SSAI, ESSP Outreach Scientist NASA Goddard Space Flight Center*
— *Debra Krumm, dkrumm@atmos.colostate.edu, CloudSat Outrreach Coordinator – Colorado State University*
— *Dianne Q. Robinson, dianne.robinson@hamptonu.edu, CALIPSO Outreach Coordinator – Hampton University*

A group gathered in Washington, DC at the headquarters of Global Learning and Observations to Benefit the Enviornment (GLOBE) on July 11 and 12, to have preliminary discussion about outreach and educational activities related to the CloudSat/Cloud Aerosol Lidar Infrared Pathfinder Satellite Observations (CALIPSO) mission. CloudSat and CALIPSO are both Earth System Science Pathfinder (ESSP) missions scheduled to be co-manifested on the same launch vehicle and launched in 2004. Since they are being launched together, the outreach coordinators for these missions have decided to combine their efforts to get maximum results from limited outreach funding. They further hope to collaborate with the other A-Train missions on outreach efforts and two of these missions (Aqua and Aura) were also represented at this meeting. It is anticipated that there will be a series of teacher training workshops beginning in the Summer of 2003 and one of the main purposes of this meeting was to bring a group of scientists and educators together and brainstorm about outreach activities related to these workshops. After a series of individual presentations on the science of the mission and on various outreach and education activities that are ongoing or planned, the group mapped out some very tentative plans for the format for the workshops. Further discussions will be needed to finalize the agenda.

Participants: Jim Botti – Wheeling Jesuit University; David Brooks – Drexel University; Mark Burnett – WHRO Public Television; Lin Chambers – NASA Langley; Carol Conroy – GLOBE HQ; Anita Davis – NASA Goddard; Andy Fisher – Utah State University; Steve Graham – NASA Goddard; David Hudak – Meteorological Services of Canada; Burt Kaline – Chief Dull Knife College RSI; Frank Kozusko – Hampton University; Debra Krumm – Colorado State University; Susan Lini – Colorado State University; Christos Michalopoulos – GLOBE HQ; Claire Parkinson – NASA Goddard; Thomas Pinelli – NASA Langley; and Dianne Robinson – Hampton University.

THURSDAY JULY 11, 2002

The meeting began with **Dianne Robinson** and **Debra Krumm** welcoming everyone and introducing the participants. They presented their ideas about what they would like to get out of this meeting.

This was followed by a brief presentation by **Christos Michalopoulos**, who gave an overview of the Global Learning and Observations to Benefit the Environment (GLOBE) program. While GLOBE is dedicated to science and education, it is not a program for science education. GLOBE is not an environmental advocacy group, although they do advocate the environment. Students get hands-on experience collecting data and the program meets rigorous academic standards. The observations use an inquiry-based method of teaching. Students do much more than simply memorize facts. They learn why they study particular topics; then they take observations and interpret the data they collect. This translates to real science that can be used by real scientists. GLOBE is working in support of several NASA missions. NASA has now become the lead agency in GLOBE, replacing NOAA in that role. GLOBE seeks to expose students to technology, teaches them to make measurements and interpret results, and gives students opportunities to interact with scientists. In turn, the students aid the scientists by collecting data to help them in their research. Some student-collected data are actually appearing in peer-reviewed publications. The GLOBE program has been very successful with schools in every state in the U.S, and in 98 countries around the world. Approximately 18,000 teachers are involved in the GLOBE program and over 8-million observations have been compiled to date.

The next four presentations all gave overviews of the science involved in these missions. The first talk was an overview of the A-Train, followed by reviews of the CloudSat and CALIPSO missions respectively. The final talked focused on a hand-held sun photometer developed for as a GLOBE protocol and planned for use to assist in validating measurements obtained by CALIPSO.

David Hudak presented an overview of the "A-Train". This is the nickname given to a constellation of satellites that will be launched including: Aqua; CloudSat; CALIPSO; PARASOL; and Aura. (Apparently, the name "A-Train" was chosen because Aqua and Aura – the front and rear members of the "train" of satellites – both begin with the letter A, and borrows from the title of an old jazz song by Duke Ellington.) All of the satellites are scheduled to be in place by 2004, but as of now, Aqua is the only one of the five planned members of the A-Train that is currently in orbit. Aqua is the second of three major EOS missions (Terra being the first) and, as implied by its name, focuses on studies of water in the Earth/atmosphere system. Aura is the third major EOS launch, and will focus on atmospheric chemistry. CloudSat and CALIPSO will launch together on the same vehicle and are part of the ESSP program – smaller, lower cost missions that focus on a particular measurement of scientific interest. CloudSat is to study clouds in detail and better characterize the role they play in regulating the Earth's climate, while CALIPSO will look at the role aerosols play in regulating climate including how they interact with clouds. PARASOL (whose acronym doesn't translate well to English) is being developed by the Centre Nationale d'Etudes Spatiale (CNES) – the French Space Agency – and will make polarized light measurements. It is possible that a sixth member will be added to the A-Train in the future. The idea with formation flying is that by combining several measurements, one is able to get more information about the condition of the planet than one could get with only one satellite. The notion is that, "The whole is greater than the sum of the parts." Hudak presented some of the details about formation flying and highlighted how precisely aligned the satellites will need to be for this concept to succeed. The lead satellite, Aqua and the trailing satellite, Aura are separated by about 15 minutes. CloudSat and CALIPSO have very small swaths or "footprints" relative to the instruments on Aqua and Aura, so they will need to follow very closely behind Aqua in order for the data the three satellites collect to be comparable.

Hudak also reviewed the CloudSat mission. CloudSat is intended to allow for a global survey of cloud properties. Data returned should lead to improvements of how clouds are parameterized in atmospheric models, which should help improve the accuracy of weather forecasts made using data from these models. At this point, prompted by a question by Frank Kozusko, David presented an overview of the basic physics of radar measurements. Radar sends out an electromagnetic pulse and essentially makes a time measurement as to how long it takes for the pulse to return from the target (e.g., a cloud). Since the device actually sends out a pulse and receives a return signal, radar is known as an active remote sensing instrument. This compares to most instruments currently in orbit, which simply measure incoming electromagnetic radiation through a detector and are thus called passive remote sensing instruments. CloudSat will carry a cloud profiling radar that will look straight down. It is not a scanning device like many of the other instruments currently flying on other satellites. Hudak observed that, compared to most missions, the physics of the cloud profiling radar is straight–forward; the difficulties arise in implementing these concepts on an orbiting platform in space. Since the radar transmits in the microwave region where the signal is not significantly attenuated by clouds, it should be able to detect 90% of all ice clouds and 80% of all water clouds. The radar itself will only make measurements of the locations of the clouds and the intensity of the received signal. All additional information about the clouds is derived from empirical formulas based on cloud physics. Therefore, the initial measurement in and of itself will take up very little storage space. However, the information will be processed into a dozen or more parameters and add an order of magnitude of information content. Some of the parameters are standard and others are considered experimental – some require information from other members of the A-Train, such as the lidar on CALIPSO, in order to be computed. Hudak also touched on the plans for validating the data from CloudSat. The main issue here is getting ground-based data from a wide range of locations around the globe. This is why the possibility of getting GLOBE students involved in the process appears to have a great deal of potential.

Dianne Robinson presented details on the CALIPSO mission. She reviewed the objectives of the mission. CloudSat focuses on expanding our knowledge of the role clouds play in regulating the Earth's climate. CALIPSO, in turn, will study the very important but as yet poorly quantified role that aerosols play in regulating Earth's climate. CALIPSO will obtain key measurements of cloud and aerosol properties and improve our understanding of these phenomena. It should lead to improved parameterization of aerosols in atmospheric models, which should

improve their accuracy. CALIPSO will carry a three-channel lidar. Like the radar on CloudSat, the lidar on CALIPSO is an active remote sensing device that sends a pulse of light down and measures the time it takes to receive a return pulse. These data can be used to construct a vertical profile of the atmosphere. These vertically resolved measurements are needed to better understand the impact of aerosols on cloud formation. In addition to the lidar, CALIPSO also carries three passive co-aligned, nadir-viewing instruments to collect additional data. Validation efforts are also planned for CALIPSO. A hand-held sun photometer has been developed by **David Brooks** at Drexel University. Brooks is head of the Sun Photometer protocol for GLOBE. The plan is to integrate sun photometer training into the teacher workshops, and then have the teachers train students in their classrooms so that the students can make measurements that will help in validating data from CALIPSO. Once again, a partnership with GLOBE will be very helpful in this effort.

Brooks followed Robinson and gave more details about his sun photometer. He reports that his hand-held devices match very well with the Aeronet sun photometers. There was spirited discussion about how well students would relate to the concept of Aerosol Optical Thickness and also to how precise the times of data acquisition have to be in order for the data to be comparable to the conditions observed by the satellite at the time of overpass. With many of the instruments onboard Terra and Aqua, for example, there is leeway in matching with the exact time of overpass. However, the CloudSat and CALIPSO footprints are rather small so it might be necessary to match fairly closely with the time of satellite overpass. This could present logistical problems for students and teachers as they attempt to acquire data. Certainly, this is an issue that will require further discussion with the scientists to figure out how precise the time of data collection will need to be for the data to be useful to them.

Now, the focus of the discussions turned more to education and public outreach efforts for these missions. The emphasis here is to come up with plans that derive the most benefit from the limited funds available for education and outreach. Since CloudSat and CALIPSO are now comanifested on the same launch vehicle, it is quite natural to combine the outreach and educational activities. It also makes sense from the standpoint that the parameters each mission will measure are very much related to one another. Furthermore, where possible it is desirable to work with the other A-Train missions to promote the concept of formation flying and the fact that all of these NASA missions are really tied together in the sense that they share the common goal of better understanding the Earth's climate.

Debra Krumm spoke on CloudSat outreach plans. She touched on plans for Formal Education, Informal Education and for Public Outreach. Colorado State University (CSU) will be actively involved in formal education activities with CloudSat and activities will also be developed for grades K-12. Again, the plan is to develop a full curriculum for students and to work together with the CALIPSO mission and perhaps all participants in the A-Train to get the most out of the funding that is available for outreach. The GLOBE program will be a partner with CSU in the CloudSat mission and support their educational activities and will work with the other missions as well. (For example, GLOBE is a partner in the Aura mission.) For CloudSat specifically, the idea is to meet the demands of the scientists and the educators. Scientists clearly want a dataset of cloud identification every 16 days that will match with the time of overpass for CloudSat. As discussed earlier, this may not be a trivial matter to obtain but this is the hope. What the educators want or need is not as clear as of yet and in part, it is the purpose of this and future meetings to better determine what educators need for this project to succeed from their standpoint. Certainly, the goal is to develop an inquiry-based program of study but the exact details of what subjects to cover need to be hammered out in subsequent discussions. In addition to activities centered around formal education, a large component of the outreach on CloudSat will go toward informal education activities. Informal education is characterized by being multigenerational, voluntary, immediate, self-mediated and long-term. It can take place at science and nature centers, zoos, aquariums, malls, boy and girls clubs, and so forth. Several in attendance at this meeting may in fact have some suggestions for informal education opportunities.

Krumm also addressed the educational goals for these missions – particularly for CloudSat. She reminded everyone to keep a balance between technological innovation and old-fashioned human observations. Her point was that it is not desirable to completely remove human participation in data observations. This leads to the idea of data assimilation – using advanced technology to process data but still relying on good observations. Two

important goals of our discussion are to ask the right questions and to fit the material to the proper audience. The exercises under development for CloudSat will use the inquiry-based approach as discussed earlier by Michalopoulos. Krumm's example was about the subject of modeling. Students might initially think of all sorts of models and then, when they are ready for it, they can move into a discussion of models of the atmosphere. In time a teacher's guide, standards and student activities will all be developed. Discussions at this meeting and subsequent ones will help define this process.

Burt Kaline spoke about Native American views of nature and how he teaches these concepts to the Cheyenne people. He distributed a list of Cheyenne phrases and demonstrated how he uses the language to draw his people into a discussion of scientific ideas. He also takes them on field trips, since many of the students never get a chance to travel very far from their homes. He finds this is a very effective teaching tool for students such as his. The rewards he gives are rewards that have cultural significance to the Cheyenne. Kaline is definitely interested in teaching his students about the CloudSat/CALIPSO mission.

Lin Chambers spoke about the CERES Student's Cloud Observations on Line (S'COOL) Project. The Clouds and the Earth's Radiant Energy System (CERES) instrument is flying on both Terra and Aqua and student data are being used to help validate the measurements from CERES. Lin emphasized that students have to time their measurements carefully to match with the overpass of the satellite or the data are not that useful for comparison. Each time they take an observation, they fill out a standard form where they identify cloud amount, cloud height, number of vertical layers, and visual opacity. This information is then submitted for processing. Lin reviewed how the results collected to date (only a limited amount of data to date due to data processing issues) match with observations. The results suggest that CERES may miss thin cirrus in some situations. The failure to detect thin cirrus was already known to be an issue for CERES but the data collected by the GLOBE students may help quantify the problem. Much more data should soon be available for review. To date only 100 matches have been processed and over 15,000 observations have been collected! Therefore, an exponential increase in the amount of information available should occur in the near future.

Anita Davis reviewed informal education programs in NASA. To date, there is no structured plan for informal education as there is for formal education. However, a plan is being formulated. A draft strategy has been prepared which defines criteria for selection. In the plan, informal education is sub-divided into five categories: informal learning centers (museums and zoos for example); natural and cultural history sites; libraries; multiple media (the web, newscasts for example); and community/youth groups. Davis then went on to describe some specific opportunities that may be of interest to this group. The American Chemical Society sponsors Chemistry Week each year. This year the theme is "Chemistry Keeps Us Clean," and the focus is on water. Next year, the theme will focus on atmospheric chemistry. The Aura mission already has plans to be involved in this effort and it seems to make sense for the other missions in the A-Train to get involved as well. Additionally, the Weather Channel would like to work with NASA but legal issues need to be resolved before this can happen. There is also a radio broadcast called "Earth and Sky," which could be of interest. Perhaps A-Train missions would want to submit stories for this broadcast? Davis presented an example of a place where formal and informal education have been successfully integrated. There is a curriculum based remote sensing program under development at Cape Cod National Seashore. The teachers will receive training and assist in developing the curriculum for the students. The students will study remote sensing applications in the classroom focusing in on issues of particular interest at Cape Cod. Then they visit Cape Cod where they can take ground-based measurements related to the issues they have been studying. Upon returning to the classroom, the students can compare the kinds of information they gleaned from both modes of analysis, and have a fuller understanding of remote sensing, Earth system science and resource issues at Cape Cod. Other opportunities for involvement with the informal education community include presenting at informal education professional conferences, such as the Association of Science and Technology Centers, the National Association for Interpretation, and the American Association of Museums. There is also an opportunity to bring fresh material to youth groups such as Girl Scouts of America, with whom Arlene Levine (NASA Langley) has worked. Perhaps A-train missions could get involved with some of the existing projects – perhaps provide content. Also, Davis is always interested in new ideas for

programs such as these. Anita requests that she be kept posted on activities as they unfold, and is available to provide assistance as needed.

Jim Botti presented K-12 online educational materials developed for students and teachers by the NASA Classroom of the Future (COTF) in the Center for Educational Technologies (CET) at Wheeling Jesuit University. The web sites included Earth System Science online courses for teachers as well as K-12 student problem-based learning modules and simulations that involve remote sensing and geographic information systems (GIS). The COTF "Exploring the Environment" [www.cotf.edu/ete/] web site consists of 17 web-based (basic, comprehensive, and advanced) learning modules. Botti gave the group a quick tour of some of the more interesting modules, where learners confront real-world problems and environmental dilemmas worldwide. Working in teams like real scientists, students track a live hurricane, predict the global impact of a volcanic eruption, investigate the shrinking habitat of the mountain gorillas in Rwanda, and examine issues and images of the Amazon rainforest or the plight of the Florida Panther. Finally, CET simulations were highlighted. Students are asked to respond to "Requests for Proposals" to deal with human and natural events like forest fires, floods, toxic spills, or tornadoes when they occur.

Thom Pinelli spoke on "NASA CONNECT." He began by telling the people in attendance that Education is being raised to Enterprise status in NASA. This means there will be an Assistant Administrator (on the same level as Ghassem Asrar is for the Earth Science Enterprise) whose focus would be on educational activities in NASA. NASA CONNECT is looking at education both from the standpoint of educators and from the standpoint of those being educated. There seems to be a considerable proliferation of activities that are "Fire and Forget" in nature. That is, the metric of success is, "Did I make it?" Thom's group is interested in bringing about systemic changes in this area. They attempt to promote education across the continuum with the viewpoint that preservice must link to in-service. They believe that education is learning and learning isn't necessarily confined to a school; learning is an ongoing process. They hope to enhance learning opportunities for all ages. The philosophy followed seems to match well with "Classroom of the Future." In Thom's words, "When a child asks the question, this is a good indicator that he/she is ready to learn about the subject." This leads to a "Just in time," delivery of products. Thom distributed materials describing programs for the coming year – some of which will air on PBS stations. It is possible that NASA Connect could develop some programs relating to the A-Train – perhaps working with Mark Burnett.

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The first speaker of the morning was **Carol Conroy**, who is involved with curriculum integration at GLOBE. She spoke about the GLOBE partner network. On paper, 140 partners are involved but in practice, not that many participate. Activity level varies from full participation across the spectrum to very little if any. Her work focuses on helping partners know what they are expected to do when they become members and developing ways to increase participation by partners. Conroy spoke about outreach efforts that go beyond K-12 education. Some outreach is to various informal education activities. More recently, GLOBE is putting a much greater focus on supporting teachers in the classroom – developing pullout sheets they can use in class to guide them for example. Increased emphasis is placed on data entry as a learning tool. There is an expectation that data will be collected and entered but they don't just want students doing data entry to further populate the database. They actually want to see students learn from what they do. Emphasis is also placed on training teams. Again, the inquiry-based model of learning is used. So rather than sit through a lecture on a given subject, it is much preferable that a student experience the subject matter.

Returning to the subject of outreach efforts for A-Train, the next two talks focused on outreach efforts for Aqua and Aura respectively. These were followed by some presentations on other potential avenues for CloudSat/CALIPSO and A-train outreach. Again, the idea here is to start working together as A-Train participants and combine our efforts where possible. Also, some of the "lessons learned" by existing programs may benefit missions that are still on the drawing board.

Claire Parkinson, Aqua Project Scientist, presented an overview of the Aqua outreach efforts. Aqua was successfully launched on May 4, and all six Earth-observing instruments have been turned on and have returned high-quality data. A full color Aqua brochure has been published detailing the Aqua mission as a whole, and four separate brochures have been published detailing the individual Aqua instruments: one brochure each for MODIS, CERES, and AMSR-E, and a

combined brochure for AIRS, AMSU, and HSB, the three Aqua sounders. Parkinson spoke briefly about each instrument on Aqua and what measurements they would obtain. Other publications produced as part of the Aqua outreach effort are a lithograph, fact sheets on the Aqua mission, the water cycle, and weather forecasting, and an Aqua Science Writers' Guide. In addition to the print materials, there have been seven Aqua webcasts, the first focusing on the spacecraft, the next four on the science, and the last two on the launch. The webcasts are each between one and three hours long and are archived at the *aqua.nasa.gov* website. Another section of the website is dedicated to "cool science" and provides a series of short but informative clips of Aqua scientists and engineers describing concepts that fit into the National Academy of Sciences Science Content Standards for grades 9-12. Parkinson played one such clip, showing the AMSR-E U.S. Science Team Leader, Roy Spencer of the University of Alabama at Huntsville, describing the concept of latent heat. The webcasts and "cool science" web page are produced by the Special Project Initiatives Office at GSFC. Additional Aqua resources are available at the Aqua website, including images of the spacecraft, summaries of science, science teams and instruments, animations, and visualizations. Parkinson also showed animations of the Aqua launch and the Aqua orbit, and explained that the times of data collection vary considerably from the 1:30 p.m. and 1:30 a.m. equatorial crossing times. This was of interest in light of conversations from the previous day. Her last animation was of the A-train. It depicts all the satellites involved, with Aura lagging behind Aqua by about fifteen minutes.

Stephanie Stockman is outreach coordinator for the Aura mission and gave an overview of their activities. Aura should launch some time in 2004. Stockman emphasized that Aura definitely hopes to benefit from lessons learned during the Aqua mission, since Aqua and Aura are on identical spacecraft. The Aura mission focuses on studying the chemistry of the atmosphere. It will seek to answer three questions: Is the earth's ozone layer changing as expected; is the air quality of the lower atmosphere changing; and is the Earth's climate changing? Each of the three main questions can be further subdivided into subquestions that help reduce the broader questions to more specific inquiries that are easier to answer. Aura outreach is divided into three components. The first is to educate the public about why these EOS missions are necessary, and the Aura mission in particular. A second component is also dedicated to educating the Federal Government about what NASA is doing – the Environmental Protection Agency (EPA) for example. The third and final component is outreach to grades K-12. NASA has several partners working with them on Aura. These include the American Chemical Society, the Smithsonian, and GLOBE. The American Chemical Society is doing a series of special issues that focus on Aura, the first of which has been released and was distributed to the participants. This publication is sent to over 30,000 chemistry teachers around the nation so the prospect of A-Train coverage in this volume is very appealing. The Smithsonian has set up an exhibit in its Natural History museum called "Forces of Change." Next year, "Forces of Change" will focus on atmospheric chemistry with a display called "More than Meets the Eye." The formal education plan for Aura will include supporting the GLOBE Aerosols protocol as well as the GLOBE special UVA measurement. Aura outreach efforts also extend to the web. Jeannie Allen is a science writer who works as a liaison to the Earth Observatory website for Aura and focuses on atmospheric chemistry related topics. An Aura brochure will be developed, but it will be more appropriate for science peers.

Andy Fisher spoke about work she did in her graduate studies at Utah State. She is interested in working formal education activities into traditionally informal education settings. She has developed a curriculum for teaching weather to elementary students. Essentially, the project involved breaking the task of forecasting the weather into five sub-categories: atmospheric pressure; winds; temperature; precipitation (and humidity); and clouds (types and coverage). Each student had to learn about a particular aspect of the problem – namely, making a weather forecast. They become "experts" in a small portion of the larger problem. As an example, the group studying winds might consider, "Why does the wind in this area usually blow from the east in the morning and the west in the afternoon?" In this context, the students would learn about the local wind patterns around the nature center; information they will later need to solve the larger problem of making a forecast in that area. When the students gather together at the nature center, they form groups of five with one representative from each sub-category. The students combine their knowledge to solve a more involved forecasting problem. For example, "Meg, the camp director, is going camping tonight.

Make a list of items she should bring based on what you think the weather will do." The answer can't be arrived at without using information from all five sub-categories and the students also learn that these five sub-categories are interdependent. Fisher emphasized the need for assessment and accountability. There needs to be an effective means of evaluating how successful these programs are. Also, she agreed with the earlier statement that there should be a balance between the use of technology and human observations. The two should not be viewed as mutually exclusive. It is possible that a program such as this might be useful to draw upon as the CloudSat/CALIPSO curriculum is developed. Perhaps some variant of this could be used to teach students about the different missions of the A-Train and how combining the information from all five of these missions will give us more information than any one mission by itself.

Alan Ward presented on the Earth Observing System Project Science Office (EOSPSO) at Goddard. He works under the ESSP Project Scientist, Marc Imhoff, and coordinates outreach for the ESSP missions at Goddard. Ward reviewed the mission of EOSPSO. The office exists to increase the scientific literacy of the public and get the word out about NASA's Earth Science missions. It supports public outreach and informal education efforts. As part of that effort, the project office creates publications for the various missions, which are distributed at various conferences and as requested by individuals. As an example, Alan showed a fact sheet, lithograph and brochure that were designed for the Gravity Recovery and Climate Experiment (GRACE) – the first ESSP mission. There should be resources for similar products for CALIPSO and CloudSat. The Public Affairs Office at Langley has already developed a Fact Sheet for the CALIPSO mission, which Alan showed to the participants. There is also a possibility that outreach products could be developed to promote the A-train and formation flying. Further discussions are needed to see if this is an idea worth pursuing.

Mark Burnett spoke about working with Standards of Learning in Virginia. On previous projects, he worked with fourth grade teachers and students to develop curriculum appropriate material on Virginia history. Burnett is using these experiences and his background in marketing to develop appropriate material for education outreach on the CALIPSO mission to air on WHRO - a public television station in Norfolk, VA. Specific educational materials will be developed to engage and involve students and teachers in the research being done by CALIPSO and GLOBE. One example is the operational training tape for the use of the sun photometer, a hand-held device that can be used by students to do actual science research. Other tapes, CD's, or DVD's may also be developed to demonstrate different specific aspects of the CALIPSO mission. The materials will be designed to do more than announce and promote the CALIPSO project; they will also motivate and involve the participation of the teachers and students. Additional parallel materials can also be generated to involve and motivate parents and the general public. Perhaps Burnett's efforts can be expanded to help promote the A-train concept?

The final few hours on Friday were dedicated to some preliminary planning for the teacher workshops to be held beginning next summer.

Dianne Robinson and **Debra Krumm** spoke a little about what they envision for these meetings. The working concept is to have an approximately five-day meeting and include various modules that cover different topics of relevance to this mission. These would be topics that teachers will need to be familiar with in order to teach about the A-train missions. The group decided that it was important to have the topics presented by individuals who could interface well with the teachers. Some of the scientists participating in today's planning meeting might well be candidates to give presentations at the teacher workshops. Teachers participating in the workshop would be expected to make a commitment to participate: a small registration fee would be required to reserve a slot. There would likely also be some pre-workshop activities that they would be asked to complete in preparation for the meetings. It is also important to find out what the person's major in college was to help know how best to educate them. If people are from diverse backgrounds, then it makes it more challenging to prepare appropriate material for the participants. Based on past experience, Robinson expects a very good response to this from all across the nation and requiring a financial commitment is a good way to guarantee applicants are really serious about wanting to attend.

Lin Chambers shared her experiences in planning and presenting teacher workshops for the S'COOL program. She has found that one has to be careful to keep the number of participants relatively small and to have a fairly focused grade level range. She has also found that it is helpful to schedule the meeting from the middle of one week to the middle of the next week.

Including the weekend simply gives a bit more breathing room to expose the teachers to all the information they need without overwhelming them. They actually get a free day to go and do something other than sit in meetings, which is helpful for keeping them focused when they are in the meetings.

The remainder of the time was spent discussing specific topics that might be appropriate for the five days of meetings planned for each workshop. A tentative plan emerged that needs to be further refined and developed:

- **DAY 1**: AM – A-train; presentations by scientists; PM – Atmosphere: Clouds; Aerosols (Sun Photometer); Layers of atmosphere; Weather; Climate etc.
- **DAY 2**: AM & PM – Atmosphere (continued).
- **DAY 3**: AM – Atmosphere (continued); PM – Remote sensing: GPS; GIS; Radar; Electromagnetic spectrum; Satellites.
- **DAY 4**: AM & PM – Remote sensing (continued).
- **DAY 5**: AM – Remote sensing (continued); PM – Standards: Discussion of national and state standards; teachers apply their state standards to topics presented in workshop; teachers work activities into their school district's existing curricula; plans for follow-up workshops.

Breakout sessions can be added as needed and also GLOBE training for the teachers can occur throughout the course of the workshop.

World Meteorological Society Presents Prestigious Award to EOS Investigators

A paper titled *Stratospheric Temperature Trends: Observations and Model Simulations*, by lead authors V. Ramaswamy, Geodynamics Fluid Dynamics Laboratory (GFDL), Princeton, NJ, and M. L. Chanin, Centre National De La Recherche Scientifique (CNRS), France, won the 2003 World Meteorological Organization Norbert Gerbier Award. The paper was authored by several scientists under the umbrella of SPARC (Stratospheric Processes and their Role in Climate) and represents a consensus view of the field in 2001. The message to Dr. Ramaswamy from Dr. M.V.K. Sivakmar, Chief, Agricultural Meteorology Division, World Meteorological Organization is excerpted below:

Dear Dr Ramaswamy,

I am pleased to inform you that the Executive Council of WMO approved the proposal of the Selection Committee for the Norbert Gerbier-MUMM International Award for 2003 and conferred the 2003 award on you and your co-authors (M.-L. Chanin, J. Angell, J. Barnett, D. Gaffen, M. Gelman, P. Keckhut, Y. Koshelkov, K. Labitzke, J.-J.R. Lin, A. O'Neill, J. Nash, W. Randel, R. Rood, K. Shine, M. Shiotani, and R. Swinbank) for your paper entitled "Stratospheric temperature trends: observations and model simulations" published in Reviews of Geophysics in 2001 (Vol. 39, pages 71-122).

Please accept my hearty congratulations on this well-deserved honor. You and all the co-authors will receive in due course a formal letter from our Secretary-General informing you of this award. At a special Award Ceremony to be held in conjunction with the meeting of the Executive Council of WMO in May 2003, this award will be presented to you and the other co-authors, who may wish to attend the ceremony. I will communicate to you the exact date and time in due course.

Venkatachalam Ramaswamy is a SAGE III Co-investigator, **John Barnett** is Principal Investigator for the HIRDLS instrument, and **Richard Rood** is a member of the EOS Investigators Working Group and a member of the Science Working Group for the AM Platform (SWAMP).

The Earth Observer staff and the entire EOS community wish to congratulate Drs. Ramaswamy and Chanin, and the host of co-authors on this outstanding accomplishment.

Minutes from the 19th Polar DAAC User Working Group (PoDAG) Meeting

— *Ron Weaver, weaverr@kryos.colorado.edu, National Snow and Ice Data Center*

The Polar Distributed Active Archive Center (DAAC) User Working Group (PoDAG) held its 19th biennial meeting in Greenbelt, MD, on February 4-5. The minutes were compiled by the Chairman Dave Bromwich and Ron Weaver during presentations. They are intended to present an overview of the meeting and do not give detailed information on all presentations. For more information, contact Ron Weaver at the address above or consult the National Snow and Ice Data Center (NSIDC) DAAC website at: nsidc.org/daac/podag.html.

Attendees: Ron Weaver, Mark Parsons, Michelle Holm, Roger Barry, Koni Steffen, Dave Bromwich, Anne Walker, Jay Zwally, Chris Shuman, Thorsten Markus, Son Nghiem, Quinton Barker, Jeff Key, Dorothy Hall, Robert Thomas. Waleed Abdalati, Jennifer Francis.

DAAC Activities Status Report

Ron Weaver gave this presentation, highlighting what has been going on among the DAACs since the last meeting.

DAAC Activity

Weaver began with some general news relating to DAAC activities.

- *DAAC Alliance*: Ron Weaver will become the DAAC Alliance Chairman in February 2002. The Alliance is an effort by the DAACs to work together on common projects and to promote integrated data management for EOS data.
- *SEEDS (formerly New DISS)*: The Strategic Evolution of Earth Science Data Systems or SEEDS is an effort by NASA to plan for the next-generation data systems. Several workshops will be held in the coming year to help NASA plan this transformation of data systems. NSIDC DAAC staff are participating, and NSIDC encourages PoDAG members to join in the effort.
- *Long-Term Archive of EOS Data*: Planning for long-term archiving (LTA) of EOS data held by NSIDC (and other DAACs) is underway. Discussions are being held with NOAA and USGS as well as within the SEEDS workshop framework. NSIDC has concerns about where cryospheric data will eventually be placed in the LTA system.

Budget highlights

Ron also discussed a couple of budget-related items.

- *Renewal of contract for NSIDC*: The NSIDC DAAC contract will end early next year. NSIDC will have to compete for a follow-on contract.
- *Billing for Data:* Will start in at least a limited fashion on October 1, 2002, but probably not for electronic distribution or for NASA investigators.

Other Projects

The following were other issues that Ron discussed.

- *Cold Land Processes Support*: NSIDC DAAC is supporting the Cold Lands Processes (CLP) Experiment by providing subsetted MODIS snow products and radiance imagery. NSIDC (not the DAAC) is providing limited data-management services via non-DAAC funding direct from CLP.
- *AMSR-E Validation*: NSIDC DAAC is supporting AMSR-E Validation data coordination
- *Aqua Data Product Services*: Aqua launched in May 2002. NSIDC will provide data services for the AMSR-E and MODIS snow and ice products.

Data Set Report

Mark Parsons gave this report. Several new or revised data sets were described. Details can be found on the NSIDC website and, in particular, the data set catalog. In addition a number of other issues were discussed.

New Data Sets

Three new data sets were described.

- MODIS snow and ice products
- Ice melt over sea ice from passive microwave data
- Historical Arctic Rawinsonde Archive (HARA) updated through 2001

Other Discussion

There were also discussions focused on how NSIDC chooses the data it archives. Discussion with PoDAG membership recounted several issues but didn't come up with any actions.

It was also suggested that NSIDC should take over the management of the current NASA GSFC bootstrap and NASA team SMMR and SSM/I timeseries. NSIDC is to investigate and report back to PoDAG at the next meeting.

Data Set Documentation

Mark Parsons also reported on Data Set Documentation. An National Research Council (NRC) report on polar data sets requested improvements to data set documentation. NSIDC response is to improve our data set catalog and product websites. This work is well along, but not complete.

Report on NASA's Cryospheric Research Program:

Waleed Abdalati presented this report and suggested that PoDAG members read NASA Administrator O'Keefe's statements linked and the President's Management Plan, both of which are linked from the NASA homepage.

The cryosphere sciences program will not be geographically limited; it will be more science-problem oriented.

Waleed also reported on one action item from the last meeting that concerned access to NCAR-held data. He found out that there is a mechanism for NASA-funded investigators to access limited amounts of data from the NCAR archives.

Report on SEEDS

Vanessa Griffin gave this report, which included a high-level discussion of SEEDS. She also used the opportunity to help PoDAG members better understand what SEEDS will be. Further explanation should be forthcoming from the SEEDS Formulation Team. PoDAG noted that they should be participating in further workshops.

Griffin also raised a couple of other issues, which had been touched on in previous discussions:

- *Billing for data*: This will start in at least a limited fashion on October 1, 2002, but probably not for electronic distribution or for NASA investigators.
- *Long-term archive*: NOAA will be the lead agency, but timetable and details are uncertain.

Terra/MODIS Snow Cover Products Over Canada. CRYSYS

Anne Walker reported that problems of cloud overestimation in this product have been somewhat reduced. Requesting data via the EOS Data Gateway (EDG) still is problematic. It is, at best, a very tedious process. Multiple scene orders can and do often fail. Better communication is needed. A firewall change in January created many problems for users.

A product evaluation is in progress. The Canadian Prairies and Northern Prairies of the U.S. are the primary study areas. Multiple data sources are considered in relation to MODIS products. They are trying comparisons over different land-cover types. They are also doing a gross-scale assessment over the prairies near Edmonton.

Assessment of the sea-ice product has just begun. North Water Polynya is an area of particular interest.

Land Spillover Correction Options for the AMSR Processing

Thorsten Markus gave this presentation. Edge effects have been noted along land/ocean boundaries in SSM/I products. The same problem is expected in ASMR-E data. This error is not corrected in standard sea-ice products, but is addressed in NASA time-series data sets.

The question that then arises is: how should edge effects be corrected in the standard AMSR-E processing? AMSR-E will have 12-km resolution, which will require a new coastline file. Whatever changes are suggested should not affect the brightness temperature products. The group discussed options for addressing this problem but no conclusions were reached.

Thorsten was asked to provide an updated report at the next PoDAG meeting. The group leaned towards having no land-spillover correction to the time series, but towards providing a tool that could make the correction should a user desire it.

Data Needs of GCMs and Other Modellers:

Cecelia Bitz presented a list of potential data fields needed by modelers. There are a huge number of variables that modelers want to consider. Reanalysis is considered an important task in the modeling community. These reanalysis efforts require input data, especially from the cryosphere. The PoDAG discussed what input

fields should be made priorities but did not come to any definitive conclusions.

Update on the MODIS Cloud Mask Over Snow.

Jeff Key provided a status report on MODIS cloud-mask development in the polar regions. Refinements to existing tests and new cloud tests are being evaluated. Most of the effort to date has been on nighttime cloud detection.

Satellite Scatterometer Applications to Cold Regions

Son Nghiem gave a very comprehensive review of recent work on satellite scatterometry applications in polar regions. The report focused on data from QuickScat. QuickScat is the first conical-scan scatterometer. It has been operating for about three years. It covers a swath from 40º-latitude poleward in each hemisphere and obtains two polarization measurements twice per day. PoDAG agreed to continue monitoring scatterometry as it is a technology that shows great promise in cryospheric studies.

Plans for an Arctic System Reanalysis and the Role of NSIDC

Dave Bromwich outlined the current status of the Arctic System Reanalysis. This program is tied to the Study of Environmental Arctic Change (SEARCH) program. He discussed what might develop from their planning efforts.

Executive Meeting

Koni Steffen was thanked for his long service on PoDAG. He has attended all 19 meetings, and chaired PoDAG through most of them. Candidates for new PoDAG members were discussed. The need for University members was a primary consideration. The group discussed the selection of a new chairman to replace David Bromwich who will be leaving PoDAG in one year.

Action Items

The following Action Items came out of this meeeting:

- NSIDC needs to advise PoDAG of its action/participation in relevant planning groups such as SEEDS. **Actionee**: Ron Weaver.
- Develop a high-level plan for active management and long-term archiving of NSIDC-relevant data. **Actionee**: Ron Weaver (for NSIDC) by the next PoDAG meeting.
- Define PoDAG's role in SEEDS and/or the DAAC Alliance. **Actionee**: PoDAG, by the end of April (in anticipation of next workshop in June).
- Send to PoDAG a copy of the last 5-year operating proposal to NASA along with a synopsis of new directions. **Actionee**: Ron Weaver, by March 1.
- Report to the next PoDAG meeting on using MISR data to study sea ice. **Actionee**: Anne Nolin, for next PoDAG.
- Investigate the issues involved in using the NASA Team and/or Bootstrap algorithms for routine sea-ice processing. **Actionee**: Julienne Stroeve, NSIDC SSM/I Product Lead, report by next PoDAG.
- Investigate the feasibility of updating the HARA archive, extending it down to 45º N, and including other radiosonde data sets, such as from the Soviet drifting-ice camps. **Actionee**: Mark Serreze, by next PoDAG.
- Perform an in-depth analysis of the possible future of NSIDC DAAC in the SEEDS era, and solicit input from PoDAG on unconventional ideas. **Actionee**: Ron Weaver and DAAC management, before next PoDAG.
- Publicize to NASA management the great job that NSIDC is doing for the cryospheric community. **Actionee**: PoDAG, as soon as possible.

Recommendations

Two specific recommendations were put forth:

- *To Thorsten Markus*: Perform an in-depth review of land-spillover-correction options for AMSR data, and estimate the impacts in space and time of the options.
- *To EOS Data Gateway (EDG)* : Provide a browse product in EDG for snow and sea-ice products.

Next PoDAG Meeting

The next PoDAG meeting will be held at NSIDC in Boulder, CO, September 24-25, 2002. Potential agenda items include:

- Extended discussion on the future of NSIDC DAAC in the SEEDS era (5+ years from now).
- Progress report on Cold Land Surface Processes Project.
- Update on MODIS and AMSR data from Aqua.
- Update from Thorsten Markus on land-spillover correction for AMSR processing.
- NSIDC report on feasibility of routine sea-ice processing with NASA Team and/or Bootstrap algorithms.
- Briefing from Ann Nolin on use of MISR data to study sea ice.
- Briefing from Mark Serreze on updates to the HARA archive.

Radiometric Measurement Comparisons at NASA's Goddard Space Flight Center: Part II. Irradiance Lamp Comparisons and the NIST Sphere Source

– *James J. Butler, butler@ltpmail.gsfc.nasa.gov, NASA Goddard Space Flight Center*
– *B. Carol Johnson, cjohnson@nist.gov, National Institute of Standards and Technology*
– *Robert A. Barnes, rbarnes@seawifs.gsfc.nasa.gov, Science Applications International Corporation*

Introduction

The National Aeronautics and Space Administration (NASA) and the National Institute of Standards and Technology (NIST) are engaged in a program designed to ensure the radiometric calibration accuracy of sensors used in the Earth Observing System (EOS). The heart of this effort consists of measurement comparisons of radiometric sources using NIST-traceable radiometers **[1]**. In the spring of 2001, an extensive comparison was held at the NASA's Goddard Space Flight Center (GSFC). The facility used was the class 10,000 cleanroom that is part of the Radiometric Calibration Facility (RCF) in the GSFC Space Geodesy Networks and Sensor Calibration Office (Code 920.1). A total of thirteen radiometers from eight different research groups measured a number of uniform radiance sources. In Part I of this article (printed in the May/June *Earth Observer*) we summarized the preliminary results for the GSFC integrating-sphere sources **[2]**; here we conclude with the presentation of the preliminary results for the remaining sources.

Sources Measured

We present results of measurements of the NIST Portable Radiance Source (NPR) and a diffuse, high-reflectance plaque illuminated by lamp standards of spectral irradiance. These sources are representative of the two most important types of spectral radiance standards. The NPR provided direct traceability to NIST **[3]**; the plaque source was used with two FEL lamp standards of spectral irradiance to evaluate the implications of the recent improvements in the NIST spectral-irradiance scale **[4]** in a typical application used in the remote-sensing community.

The 30-cm-diameter NPR was developed by NIST as part of the EOS collaboration **[3]**. It is used during EOS comparison activities to verify the stability of the NIST absolute radiometers and to provide a calibration of the NIST transfer radiometers. There are four baffled lamps arranged symmetrically about the inner lip of the exit aperture, and different radiance levels are achieved by operating with one-to-four lamps illuminated. The relative expanded uncertainties (k = 2) in spectral radiance for the NPR are 0.5% in the visible, increasing to 1.0% at 300 nm, and 1.5% in the short wave infrared (SWIR). Because it is a stable source with two monitor photodiodes and the radiance assignment is made directly using the national radiance standards maintained at NIST, the NPR can also be used to assess the accuracy of the radiance calibration of participants' radiometers. Such an assessment is important because the common method of establishing spectral-radiance traceability to NIST involves the spectral irradiance standards (i.e., the FEL lamps) and reflectance standards. Thus the NPR provides a direct comparison to NIST's spectral radiance scale.

In the irradiance comparison, two FEL lamps from the RCF, designated F496 and F512, were used to illuminate a 25.4-cm square white Spectralon[1] plaque, producing a source of spectral radiance. Both lamps were calibrated at NIST over the same wavelength interval, but the underlying metrology was different because NIST has recently improved its method of realizing spectral irradiance **[4]**. The new procedure results in reduced uncertainties in the irradiance values assigned to FEL lamps, compared to the previous method, especially in the SWIR. In addition, a spectrally dependent bias between the two methods was observed **[4]**. Although the bias is within the combined expanded uncertainties (k = 2) of the two methods, it was important to test the ability of the transfer radiometers to discern this effect.

Radiometers

As outlined in Part I, thirteen radiometers were used in the comparison. **Table 1** describes the instrument

acronyms, operating wavelengths, institutional affiliations, responsible personnel, and measurement uncertainties (k = 1). There were seven filter radiometers (VXR, UAVNIR, UASWIR, UVFR, CTSS, LXR, and the SXR-II) and six grating instruments (SWIXR, UVSR, SDSU ASD, GSFC ASD, 746/ISIC, and Ames ASD). The VXR, the UVFR, the UVSR, and the SWIXR were calibrated using the NPR with all four lamps illuminated. The SXR-II and the LXR were calibrated at NIST using a laser-based method that provides absolute radiance responsivity within each channel **[5]**. The calibration of the remaining instruments involved lamp standards with NIST-traceable values of spectral irradiance (i.e., 1000 W-type FEL lamps); for radiance calibrations, the lamp illuminates a diffuse reflectance standard. See Reference **[1]** for a summary of the use of many of these radiometers in the EOS comparison activities.

Measurements

As described in Part I, the primary goal of the comparison was to assess the accuracy of the spectral radiance values assigned to two GSFC integrating-sphere sources that are used to calibrate field sensors used in EOS instrument networks or are related to flight programs **[2]**. As verification of these results and to provide additional information on the performance of the various transfer radiometers, measurements were made using the NPR during the course of the comparison. At the end of the comparison, we took the opportunity to examine the relationship between the previous 1990/1992 source-based and the current 2000 detector-based NIST spectral irradiance scales in a typical remote-sensing application.

NPR Sphere

All participating radiometers, with the exception of the Ames ASD, made multiple measurements of the NPR sphere with both four lamps and one lamp illuminated. The effect of the differences in the center wavelengths

TABLE 1: Radiometers Participating in the GSFC Radiometric Measurement Comparision

RADIOMETER	INSTITUTIONAL AFFILIATION	RESPONSIBLE PERSON	OPERATING WAVELENGTHS (nm)	MEASUREMENT UNCERTAINTY (k=1)
Visible Transfer Radiometer (VXR)	NIST/EOS	Carol Johnson	411.8, 441.0, 548.4, 661.4, 775.5, 870.0	1.2% @ 411.8 nm 0.7% @ 775.5 nm
Short-Wave Infrared Transfer Radiometer (SWIXR)	NIST/EOS	Steve Brown	800 to 2400	1.7%
Ultraviolet Scanning Radiometer (UVSR)	NIST	Ted Early	300 to 400	0.5%
Ultravioltet Filter Radiometer (UVFR)	NIST	David Allen	317.7, 325.1, 339.9, 388.0, 393.4	1.75%
U. of Arizona Visible/Near Infrared Radiometer (UAVNIR)	U. of Arizona	Stuart Biggar	412.8, 441.8, 488.0, 550.3, 666.5, 746.9, 868.1	2.1% @ 412.8 nm 2.2% @ 666.5 nm
U. of Arizona Short-Wave Infrared Radiometer (UASWIR)	U. of Arizona	Ed Zalewski	746.9, 868.7, 940.0, 1243.5, 1380.8, 1646.0, 2133.5, 2164.2, 2207.8, 2262.9, 2332.2, 2402.9	3.3% @ 900 nm 3.3% @ 1300 nm 3.3% @ 1600 nm 3.5% @ 2000 nm 3.9% @ 2400 nm
Landsat Transfer Radiometer (LXR)	NASA GSFC	Brian Markham Milton Hom Ed Kaita	480.7, 440.0, 560.7, 661.1, 662.3, 827.0	1.1% @ 440.0 nm 0.9% @ 662.3 nm
746 Integrating Sphere Irradiance Collector (746/ISIC)	NASA GSFC	John Cooper	400 to 2400	1.94% @ 400 nm 1.56% @ 1000 nm 2.22% @ 2200 nm
South Dakota State University Analytical Spectral Devices Field Radiometer (SDSU ASD)	South Dakota State University	Steven Schiller	350 to 2500	3% to 5%
GSFC Analytical Spectral Devices Field Radiometer (GSFC ASD)	NASA GSFC	Brian Markham Milton Hom Ed Kaita	350 to 2500	3% to 5%
SeaWiFS Transfer Radiometer II (SXR-II)	NASA GSFC	Gerhard Meister	410.7, 441.5, 487.6, 546.9, 661.9, 776.7	1.2% @ 410.7 nm 0.9% @ 776.7 nm
Calibration Transfer Standard Radiometer (CTSR)	Research Scientific Instruments	Don Heath	302.2, 305.6, 318.0, 321.6, 325.1, 339.7, 345.2, 437.5, 439.2, 525.0, 600.0, 674.6, 760.3, 923.3, 935.1	1.0%
Ames Analytical Spectral Devices Field Radiometer (Ames ASD)	NASA Ames	Pavel Hajek	350 to 2500	3% to 5%

and bandwidths of the transfer radiometers was accounted for using spectral responsivity information provided by the participants. First, the spectral radiance assigned to the NPR by NIST, $L(\lambda)$, was interpolated to intervals of 0.1 nm, as were the individual relative spectral responsivities, $r(\lambda)$, (or slit scattering functions in the case of the grating instruments). For each measurement wavelength, these two functions were multiplied and summed over all wavelengths to determine the predicted band-averaged spectral radiance, L_p:

$$L_p = \frac{\int r(\lambda) L(\lambda) d\lambda}{\int r(\lambda) d\lambda}.$$

Then the band-averaged spectral radiance measured by the radiometer, L_m, was compared to L_p. The comparison of the results with the NIST calibration for the four lamp level is shown in **Figures 1 and 2**. The expanded uncertainties (k = 2) in the spectral radiance of the NPR are shown as dashed lines. The level of agreement in the figures must be assessed in the context of these uncertainties, the radiometer uncertainties (**Table 1**), and additional systematic effects arising from the NPR or the radiometers that may be present (radiance uniformity in the NPR exit aperture, stray light effects in the monochromators, etc.)

Standard Irradiance Lamps

On the final day of the comparison, the VXR, SWIXR, UVFR, UAVNIR, and

FIGURE 1

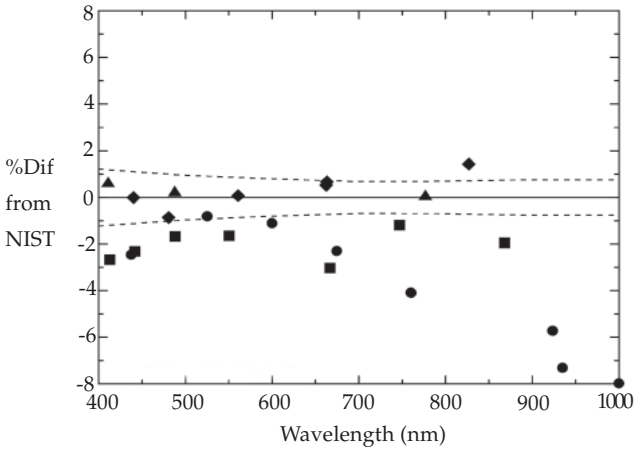


FIGURE 1 shows preliminary results for the NPR sphere measurements in the visible/near infrared compared to the NIST measured radiances. The dashed lines indicate the k=2 NIST calibration uncertainty of the source.

FIGURE 2

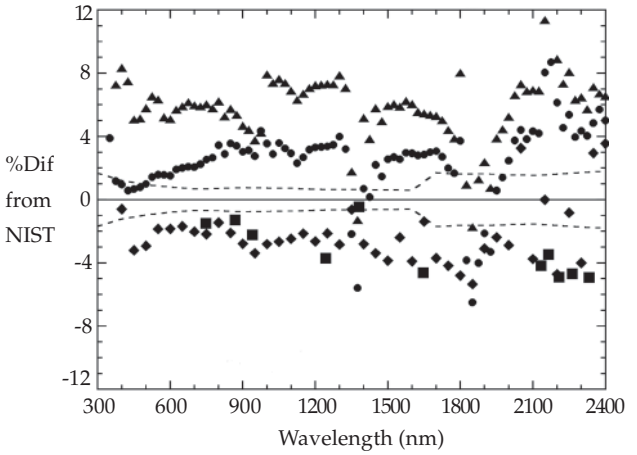


FIGURE 2 shows preliminary results for the NPR sphere measurements in the visible and short wave infrared compared to the NIST measured radiances. The dashed lines indicate the k=2 NIST calibration uncertainty of the source.

UASWIR measured the radiance from a NIST Spectralon plaque illuminated at a distance of 1 m by two FEL irradiance-standard lamps. These lamps are designated F496 and F512, and a photograph of the lamp/plaque setup is shown in **Figure 3**. At the time of these measurements, F496 and F512 had been operated a total of 2.5 hours and 3 hours, respectively. The spectral irradiance values of lamp F496 were assigned using a measurement sequence based on temperature (blackbody) standards, while those of F512 were assigned using a measurement sequence based on the NIST absolute cryogenic radiometer. **Figure 4** presents the ratio $\frac{S_{512}}{E_{512}}\frac{E_{496}}{S_{496}}$, where S is the measured signal and E the lamp irradiance at the appropriate wavelength. For the filter radiometers, interpolation to the center wavelengths was performed using a cubic spline. For the SWIXR and the 746/ISIC, only the subset of results at the NIST measurement wavelengths (in the NIST calibration report) was used.

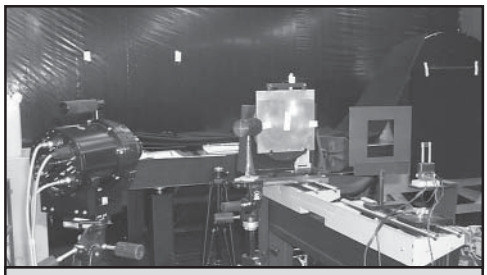


FIGURE 3 shows the experimental configuration for the lamp setup, with (left to right) the VXR, a beam block for ambient measurements, the plaque (covered by an alignment target), a lamp baffle, and the lamp alignment jig.

Discussion

The radiance measurements of the LXR, the SXR-II, and the UAVNIR are in agreement with the NPR four-lamp level (**Figure 1**) to within the combined uncertainties of the sphere calibration and radiometer measurements (k = 2). The CTSS agrees for some wavelengths, but not in the near-infrared channels. In the SWIR (**Figure 2**), the SDSU ASD is high compared to the NIST calibration; this same effect was seen with the GSFC sphere sources **[2]**. The GSFC ASD also appears consistently high compared to NIST, but is within the combined k = 2 uncertainties (see **Table 1**). The UASWIR and the 746/ISIC agree with NIST within their combined expanded uncertainties, but both results are less than the NIST values.

Assuming linearity[2] in the radiometer measurements of the lamp and reflectance-target source, the ratio shown in **Figure 4** should be unity if the NIST 1990/1992 irradiance scale used for F496 and the NIST 2000 irradiance scale used for F512 were equivalent, that is, traceable to SI base units with no bias. The deviations from unity are in the same sense as reported by NIST **[4]** and confirm those results that the 1990/1992 source-based scale underestimated the irradiance by a small amount within the expanded k = 2 uncertainty. While the results from the multiple radiometers confirm that this effect is measurable, it must be emphasized that the magnitude of the

FIGURE 4

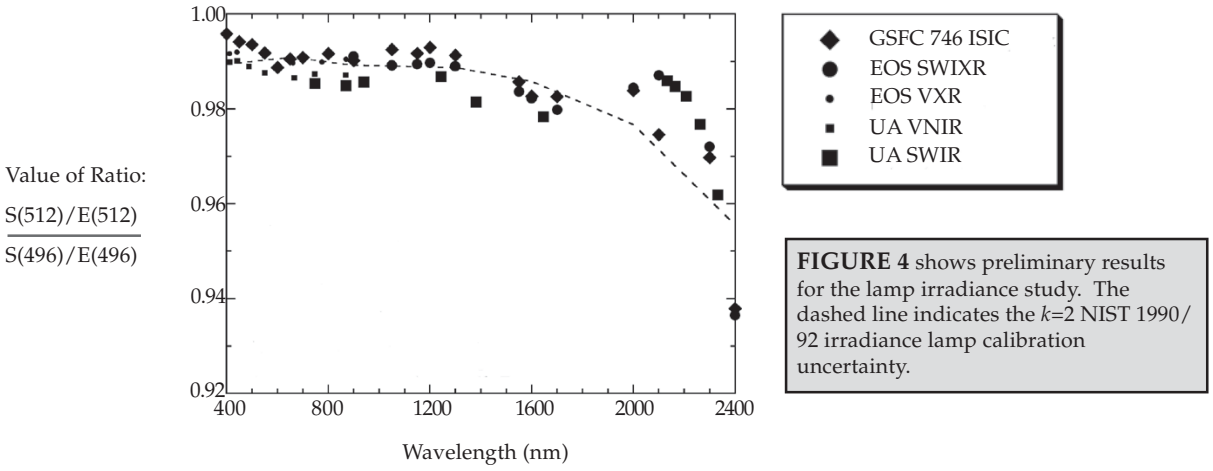


FIGURE 4 shows preliminary results for the lamp irradiance study. The dashed line indicates the k=2 NIST 1990/92 irradiance lamp calibration uncertainty.

effect is well within the combined $k = 2$ uncertainties of the lamp calibrations and radiometer measurements.

Summary

The NPR provided an important, NIST-calibrated uniform radiance source against which the participating radiometers assessed their radiance calibrations. The preliminary results for all three spheres, including the GSFC spheres discussed in **[2]**, indicate that for the majority of the spectral range covered, the spectral radiance values assigned by GSFC agree with those measured by the transfer radiometers within the combined uncertainties ($k = 2$); however in the blue region for the RCF sphere (named Hardy) discrepancies were observed that may arise from temporal drifts or instrumental effects. Implementation of the monitor detector system in Hardy will account for temporal drifts. Not all of the transfer radiometer results were satisfactory, for example the SDSU ASD over much of its spectral range and the CTSS at selected wavelengths disagreed with the spectral radiances of the integrating sphere sources by more than the $k = 2$ limit.

The comparisons of the spectral radiance of an illuminated diffuse reflectance standard using two different lamp standards indicate that the small bias in the 1990/1992 NIST irradiance scale could be a reason for discrepancies observed with transfer radiometers calibrated using irradiance standards on the 1990/1992 scale (e.g, the UAVNIR or the UASWIR) compared to those calibrated using radiance (e.g., the VXR) or detector-based standards (e.g., the LXR and the SXR-II). This reinforces the notion that all source-based calibrated irradiance lamps should be recalibrated at NIST, resulting in improved accuracy and reduced uncertainties.

List of Participants

Jim Butler and **Brian Markham**, NASA's Goddard Space Flight Center; **Carol Johnson, Steve Brown, Ted Early, and David Allen**, NIST; **Stuart Biggar and Ed Zalewski**, University of Arizona's Remote Sensing Group; **Milton Hom and Ed Kaita**, Science Systems and Applications Incorporated; **John Cooper, John Marketon, and Gilbert Smith**, Raytheon Information Technology and Scientific Services; **Gerhard Meister**, Futuretech Corporation; **Pavel Hajek and Bob Barnes**, Science Applications International Corporation; **Stephen Schiller**, South Dakota State University; and **Don Heath**, Research Scientific Instruments.

References

[1] Butler, J.J., B.L. Markham, B.C. Johnson, S.W. Brown, H.W. Yoon, R.A. Barnes, S.F. Biggar, E.F. Zalewski, P.R. Spyak, F. Sakuma, and J.W. Cooper, 1999: Radiometric measurement comparisons using transfer radiometers in support of the calibration of NASA's Earth Observing System (EOS) sensors. *SPIE Proc.*, **3870**, 180.

{2] Butler, J.J., B.C. Johnson, and R.A. Barnes, 2002: Radiometric measurement comparisons at NASA's Goddard Space Flight Center: Part I. The GSFC sphere sources. *The Earth Observer*, **14(3)**, 3.

[3] Brown, S.W., and B.C. Johnson, 2002: Development of a portable integrating sphere source for the Earth Observing System's calibration validation program. To appear in *Int. J. Remote Sensing*.

[4] Yoon, H.W., C.E. Gibson, and P.Y. Barnes, 2002: The realization of the NIST detector-based spectral irradiance scale. Accepted for publication in *Appl. Optics*.

[5] Brown, S.W., G.P. Eppeldauer, and K.R. Lykke, 2002: NIST facility for spectral irradiance and radiance responsivity calibrations with uniform sources. *Metrologia*, **37**, 579.

Endnotes

[1] Spectralon is a trade name of Labsphere, Inc. (North Sutton, NH). Certain commercial equipment, instruments, or materials are identified in this paper to foster understanding. Such identification does not imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the materials or equipment identified are necessarily the best available for the purpose.

[2] A valid assumption because the signal levels are similar and silicon photodiodes are linear over many decades of photocurrent.

ESDIS HDF-Tools and Information Website Has Been Revised

— *Richard Ullman, Richard.Ullman@gsfc.nasa.gov, NASA Goddard Space Flight Center*

Introduction

The Earth Science Data and Information System (ESDIS) Project at NASA/GSFC maintains an HDF-EOS Tools and Information web site (*hdfeos.gsfc.nasa.gov/*) from which visitors can obtain information about HDF-EOS data formats, libraries, and tools; past and future HDF & HDF-EOS Workshops; and links to other sites with related information. The web site recently underwent a major upgrade in order to facilitate more interactions with, and feedback from, HDF-EOS users. The site began to deploy several new features in May of this year and has received favorable feedback regarding its new features.

With this web site we hope to:

- Serve as a central location through which users can find information about HDF-EOS.
- Provide information about or download of tools that support HDF-EOS.
- Incorporate real users' feedback regarding the tools including what tools work best for what applications, etc.
- Announce upcoming HDF & HDF-EOS Workshops and provide an archive for proceedings from past Workshops.

New Features Implemented

One important component of the web site is a list of tools (both commercial and free of charge) that are available for use with data in HDF & HDF-EOS format, including data from NASA's Earth Observing System (EOS) Missions. The list presently contains forty-seven tools and related documents. One of the new features on the web site is the ability to filter the tool list by platform, tool category, and data application, enabling users to quickly locate tools appropriate for their needs.

Another benefit of the redesign is an enhanced user-feedback section for each tool. Users can now submit a tool review online and read reviews posted by other users. Users assign a numeri-

Same DAACs, New Names

Since the establishment of the NASA Distributed Active Archive Centers (DAACs) in the early 1990s, their roles have become more defined and their support for key discipline communities has coalesced. In recognition of this, several DAAC managers have established more descriptive names for their data centers. The ESDIS Project has agreed to use, henceforth, the following familiar names for three of theDAACs in all materials and documents.

- EDC DAAC is now the Land Processes LP DAAC.
- GSFC DAAC is now the GSFC Earth Sciences GES DAAC.
- JPL DAAC is now the Physical Oceanography PO.DAAC.

Their data holdings, expertise, and services remain at the level you've come to expect; only their names have changed.

All contact information remains the same.

cal rating in each of four categories (installation, features, stability, and usability) and may also provide summary and detailed text-based comments. Users also have the option to allow their name, e-mail, title, and affiliation to be posted with their review.

HDF & HDF-EOS Workshops

The HDF-EOS Workshop Section of the web site hosts the agendas and presentation materials from past workshops. These Workshops provide the community of data providers and users the opportunity to learn about new developments in HDF and HDF-EOS and to talk about what they need in the future. To date, five workshops have been held and all presentations given are available online in multiple formats (PDF, PowerPoint, etc.). Web site visitors looking for specific information are able to perform keyword searches on the presentation database.

Information for the upcoming HDF/HDF-EOS Workshop VI (December 4 and 5), to be held just prior to and in conjunction with the American Geophysical Union (AGU) meeting December 6-10, 2002 in San Francisco, CA, is available on the web site and updated periodically. At AGU, HDF and HDF-EOS tools will be presented in a poster session titled *EOS Data Access and Manipulation: Tools and Techniques Session* (Session OS25). (*www.agu.org*).

Online User Forum

Future plans include hosting an online and searchable archive of the eostools mailing list.

Feedback

Please send your comments and suggestions, either to me directly or to the site webmaster via the "contact" link.

FGDC and ANSI to Adopt a New Metadata Standard

Are you familiar with the Federal Geographic Data Committee (FGDC) Content Standard for Digital Geospatial Metadata (CSDGM Version 2)? CSGSM V2 was the basis for the new ISO standard for geospatial metadata: ISO 19115, "Geographic Information - Metadata". ISO 19115 was developed in ISO TC211 under the leadership of U.S. experts. FGDC has begun a process to adopt ISO 19115 as the replacement of CGDSM V2. In looking for ever-increasing participation, FGDC has turned to the American National Standards Institute (ANSI) to concurrently adopt ISO 19115 as a U.S. National Standard and the next FGDC CGDSM. This adoption process has just begun and we want your input.

NASA's Geospatial Interoperability Office (GIO) and the ESDIS project are coordinating NASA inputs to the ANSI adoption process of ISO 19115. ANSI will be looking to determine which elements in ISO 19115 should be mandatory over and above the twelve elements required by ISO. If you have interest in this process or comments on the document, contact Ben Kobler (kohlerb@rattler.gsfc.nasa.gov) of ESDIS, principal member of ANSI/INCITS L1, or George Percivall (percivall@gsfc.nasa.gov) of GIO, alternate member of ANSI/INCITS L1.

Seventh Biennial HITRAN Conference Held in Cambridge, Massachusetts

— *Larry Rothman, lrothman@cfa.harvard.edu, Center for Astrophysics – Harvard University*

On June 12-14, 2002, the Harvard-Smithsonian Center for Astrophysics (CfA) in Cambridge, Massachusetts hosted the Seventh Biennial HITRAN Conference. More than 70 spectroscopists and atmospheric scientists from around the world attended the three-day meeting to discuss the current status of, and future plans for, the HITRAN molecule database. The conference featured international participation, with about one-third of attendees traveling from the countries of Belgium, Canada, Finland, France, Germany, Japan, Russia, and the United Kingdom.

HITRAN, short for high-resolution transmission molecular absorption database, is the most cited reference in the geosciences. It is recognized as the international standard of spectroscopic parameters of atmospheric gases. The database is a compilation of spectroscopic parameters that a variety of computer codes use to predict and simulate the transmission, absorption, and emission of light in the atmosphere.

HITRAN is used in a wide range of applications, such as satellite- and ground-based remote sensing of the terrestrial atmosphere and atmospheres of other planets, pollution monitoring, homeland security, climate modeling, ozone-depletion studies, greenhouse effect predictions, laboratory spectroscopy, industrial process control, and astrophysics.

The database has a long history. It was created in the late 1960's in response to the need for detailed knowledge of the infrared properties of the atmosphere. The HITRAN compilation, and its analogous database HITEMP (high-temperature spectroscopic absorption parameters), are being developed at CfA's Atomic and Molecular Physics Division by Laurence S. Rothman. In addition to the mega-line HITRAN2000 database, the compilation includes aerosol indices of refraction, UV line-by-line and absorption cross-section data, and extensive IR absorption cross-sections. Information about the database and how to access it can be found in the HITRAN website: *cfa-www.harvard.edu/HITRAN/*.

Since 1989, Rothman has organized HITRAN meetings every two years to review the current status of the molecular spectroscopic database, discuss relevant new spectroscopic data, establish priorities for incorporation of new parameters, formulate future characterization of spectroscopic properties required by algorithms for transmission and radiance calculations, and improve user applications and access of HITRAN.

Reinhard Beer, of the Jet Propulsion Laboratory, was the invited opening speaker at this year's meeting. Beer is leading the development of the Tropospheric Emission Spectrometer (TES), an instrument that will fly on NASA's Earth Observing System's (EOS) Aura mission. He spoke on a "User's View of HITRAN," taken with the perspective of a principal investigator for the EOS program. Dr. Beer emphasized that "HITRAN is an indispensable resource for anyone doing remote sensing. However, it's not (yet) perfect!" He outlined some areas in particular where enhancements in HITRAN would significantly contribute to the success of Earth-atmosphere characterization.

There were 21 oral presentations and 31 posters presented. On the first day, **Ken Jucks** of the Smithsonian Astrophysical Observatory summarized the workshop on Molecular Spectroscopy for Atmospheric Sensing sponsored by the NASA Upper Atmospheric Research Program that was held in San Diego in October 2001. One of the conclusions of that meeting was the need to establish a more formal organization for the assimilation and evaluation of data being incorporated into HITRAN. A follow-up to that meeting was a panel meeting of the HITRAN advisory group held concurrently with the HITRAN meeting. Critical reviews were given on UV-visible ozone and nitrogen dioxide cross-sections by **Johannes Orphal** of the University of Paris, and on aerosol indices of refraction in HITRAN by **Steve Massie**

of the National Center for Atmospheric Research. **Alain Barbe** of the University of Reims, France summarized recent advances in ozone high-resolution studies.

Significant presentations were made in the following days on new spectroscopic laboratory and theoretical data, and the final session covered important aspects of line shape as relevant to the HITRAN compilation. A copy of the full Proceedings is posted on the HITRAN website. 

NASA'S Terra Satellite Refines Map of Global Land Cover

— *Lynn Chandlerolynn.chandler for.1@gsfc.nasa.gov, NASA Goddard Space Flight Center*
— *Bob Zalisk, bzalisk@bu.edu, Boston University*

[Selected excerpts from Press Release printed. See: *http://earthobservatory/nasa.gov/NewsroomLCC*, for more.]

Landcover maps developed at Boston University in Boston, MA. usiing data from the Moderate Resolution Imagings Spectroradiometer are providing scientists with the most detailed information on the distribution of Earth's ecosystems and land use patterns that has ever been obtained. High-quality land cover maps aid scientists and policy makers involved in natural resource management and a range of research and global monitoring objectives.

"These maps, with spatial resolution of 1 kilometer (.6 mile), mark a significant step forward in global land cover mapping by providing a clearer, more detailed picture than previously available maps," says Mark Friedl, one of the project's investigators.

The MODIS sensor's vantage point of a given location on Earth changes with each orbit of the satellite. An important breakthrough for these maps is the merging of those multiple looks into a single image. In addition, advances in remote sensing technology allow MODIS to collect higher-quality data than previous sensors. Improvements in data processing techniques have allowed the team to automate much of the classification, reducing the time to generate maps from months or years to about one week.

Each MODIS land cover map contains 17 different land cover types. Important uses include managing forest resources, improving estimates of the Earth's water and energy cycles, and modeling climate and global carbon exchange among land, life, and the atmosphere.

"This product will have a major impact on our carbon budget work," says Professor Steve Running of the University of Montana, Missoula, who uses the Boston University land cover maps in conjunction with other weekly observations from MODIS. "With the MODIS land cover product we can determine current vegetation in detail for each square kilometer; for example, whether there is mature vegetation, clear cutting, a new fire scar, or agricultural crops. This means we can produce annual estimates of net change in vegetation cover. This gets us one step closer to a global picture of carbon sources and sinks."

This first map is an important milestone, but the land cover mapping group in Boston has other projects in progress. "With data collected over several years," says Friedl, "we will be able to create maps that highlight global-scale changes in vegetation and land cover in response to climate change, such as drought. We'll also be establishing the timing of seasonal changes in vegetation, defining when important transitions take place, such as the onset of the growing season."

Workshop Held at NASA Headquarters to Discuss Incorporating NASA Data into Decision-Support Structures

— *Ronald J. Birk, rbirk@hq.nasa.gov, Director of NASA's Earth Science Enterprise's Applications Division – NASA Headquarters*

During a June 25, 2002, workshop held at NASA Headquarters in Washington, DC, representatives of several Federal agencies discussed their decision-support systems (DSSs) in terms of their operation and delivery of useful information in service to our Nation. The purpose of the workshop was to explore the potential for NASA Earth science research results (in the form of predictions and observations from aerospace technologies) to be assimilated into decision-support systems to help states and local communities tackle critical problems. DSSs are interactive computer-based systems designed to help people and organizations interact with complex data sets to conduct predictive analysis on scenarios to enable more informed decisions. NASA Earth science results have the potential to improve decision-support tools by providing data that provides more accurate predictions associated with weather, climate, and natural hazards. The workshop speakers included representatives from the Center for Disease Control (CDC), the Federal Aviation Administration (FAA), the Federal Emergency Management Agency (FEMA), the University of New Mexico, the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and NASA Langley Research Center.

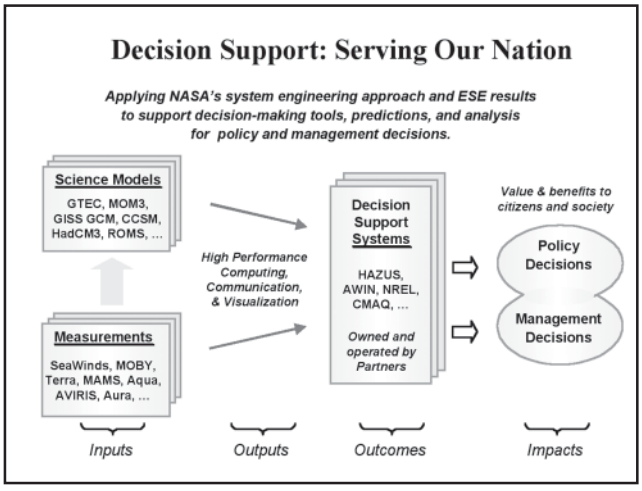
Introduction

NASA's Earth Science Applications Program works to bridge the gap between Earth science research results and the assimilation of data and prediction capabilities for reliable and sustained use in decision-support tools. Earth science applications are chosen to be consistent with national priorities.

The National Applications Initiative makes the connection between the results of NASA research and our Federal partner decision-support systems to benefit society in meaningful ways. Successful applications of Earth science research can save lives and money, enhance the quality of life, and protect natural resources."

For example, by minimizing unnecessary emergency evacuation measures, improved hurricane predictions could provide $40 million in savings per event. Similarly, improved weather forecasting can save as much as $8 million per energy company by better enabling utilities to plan more effectively for anticipated energy requirements. The ESE has identified the following initial national applications to be worked with Federal partners over the next decade:

- agricultural competitiveness;
- air quality management;
- aviation safety;
- carbon management;
- coastal management;
- community growth;
- community preparedness for disaster management;
- energy forecasting;
- homeland security;
- invasive species; and
- public health;
- water management.



Background on the National Applications Program

The Earth Science Applications Program Strategy is based on enabling the assimilation of Earth science model predictions and remote-sensing mission observations as outputs to serve as inputs to decision-support systems. The outcomes of Applications Program investments are manifested in enhanced decision-support and, also, the impacts of NASA contributions are projected to result in significant socio-economic benefits for each of the national applications areas that the NASA Applications Program is addressing. This process is shown in the diagram at the bottom of page 34.

Background on Decision-Support Structures

In 1974, Gordon Davis, a Professor at the University of Minnesota, defined a Management Information System as "an integrated, man/machine system for providing information to support the operations, management, and decision-making functions in an organization." **[1]** Dr. Davis' approach gave rise to the current way of thinking about decision- support systems. Decision support is based on providing the decision-maker with more accurate, timely information in a usable format. NASA, through its Applications Program, is working to ensure that decision support structures run by Federal partners are improved through the use of Earth science data. resulting in practical and measurable benefits for society.

Presentations on Selected Applications

The remainder of the workshop was devoted to presentations on a select number of these applications. Each presentation highlights a particular DSS and how the use of NASA data will improve the information returned. Included were talks on: air quality management, aviation safety, community preparedness for disaster management, and public health.

A public health information sharing tool

Stan Morain, Alan Zelicoff and Shirley Baros, representing CDC, U.S. DOE's Sandia National Laboratory, and the University of New Mexico respectively, discussed the use of geographic information systems (GIS) to share information regarding infectious diseases. The Rapid Syndrome Validation Project (RSVP) is designed to link physicians' offices and emergency rooms nationwide with global and local public health information. The RSVP uses a GIS, Internet-based system that tracks the spread of infectious diseases and provides information to physicians on syndromes to watch for.

"There are three areas that GIS technologies and [Earth science] applications are making a difference in right now," said Zelicoff. "They include respiratory diseases of a non-infectious nature, such as asthma, where monitoring the flow of particulates and NO_x can help with health warnings; vector-borne diseases such as those spread by mosquitoes or mice, to show disease locations geographically; and, in bio-terrorism, where the flow of potential fallout is critical for planning and response."

A natural hazard risk assessment tool

Scott McAfee of FEMA discussed the Hazards US (HAZUS) model. HAZUS is a comprehensive tool for risk based loss analysis to help local emergency managers more effectively navigate the natural hazard management cycle of mitigation, planning, preparedness, response, and recovery. The purpose of HAZUS is to reduce the loss of life and property from earthquakes. HAZUS utilizes census data, GIS-based attenuation maps, soil maps, building-inventory maps, and other data to yield direct and indirect economic and infrastructure losses. HAZUS also provides casualty estimates and shelter requirements.

A multi-hazard model to address hurricanes, floods, and earthquake hazards is currently in development. The improved wind-vector data returned from NASA's QuikScat mission has benefited hurricane prediction. The data are fed into model simulations of the wind field run by NOAA's National Weather Service and improves their accuracy. This leads to improved ability to predict the movement of hurricanes and is of great benefit to society. NASA is also currently working with other Federal agencies, including the U.S. Geological Survey, as part of FEMA's Flood Map Modernization Program. This effort will upgrade a 100,000-panel flood-map inventory by updating flood hazard data and providing digital-format maps that can be incorporated into HAZUS.

Aviation safety tools

John Murray and his team from NASA Langley Research Center and the FAA presented information on how NASA data are being utilized for synthetic vision and weather "nowcasting" for improved information delivery to pilots and air traffic controllers. Synthetic vision systems provide real-time visualization based on accurate

digital terrain models that help pilots improve their situational awareness to avoid runway incursions and other natural terrain hazards. Synthetic vision is being designed to replace 30-year-old technology that currently provides a very limited view of the Earth for pilots. NASA's Shuttle Radar Topography Mission (SRTM) mapping provides a comprehensive mosaic of the entire globe that aids in developing the synthetic-vision terrain database.

Advanced aviation information systems, referred to as "nowcasting tools," are designed to incorporate available weather data sources into a comprehensive weather analysis. This information, displayed in a format that optimizes ease of access, will allow pilots to avoid specific severe weather rather than be redirected around entire weather patterns, thus saving time, money and potentially lives. NASA, NOAA, and the Navy are collaborating to develop the Geosynchronous Imaging Fourier Transform Spectrometer (GIFTS) as a next generation sensor to contribute key vertical sounding measurements that will contribute to improving these predictions.

An air quality analysis tool

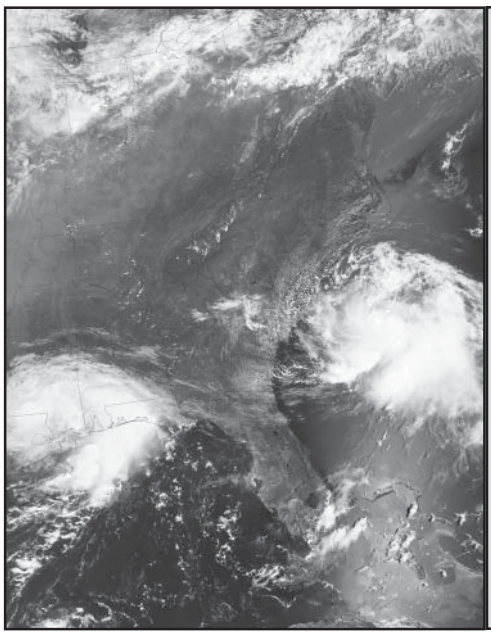
The U.S. EPA's **Mark Evangelista** discussed the Community Multi-scale Air Quality (CMAQ) model. CMAQ uses meteorology, chemistry, and emissions inventory data to yield air quality assessments, which are compatible with common visualization and analysis tools for decision support related to air quality. The model outputs provide scientific underpinnings for U.S. EPA's air quality regulations. There are four features that distinguish CMAQ from other air quality models:

- Modularity of science processes (different variables and conditions can be incorporated based upon need);
- multi-pollutant (considers all criteria pollutants in U.S. EPA regulations, as well as some air toxics of interest);
- full troposphere, including cloud processes; and
- community model architecture.

U.S. EPA is currently reaching out to all local regulators to reach a consensus on what modules should be included so that the CMAQ outputs will be consistent. A key aspect of assessing the value of the CMAQ as a regulatory tool is determining how well it is accepted by the community.

Reference

[1] Davis, Gordon, 1974: *Management Information Systems : Conceptual Foundations Structure and Development*, 5.



MODIS views the Eastern U.S.. The Moderate Resolution Imaging Spectroradiometer (MODIS) onboard NASA's Terra satellite obtained this image on August 5, 2002. Remnants of Tropical Storm Bertha can be seen along the Gulf Coast. This system dumped heavy rains across parts of Louisiana and Mississippi on that day and meandered around the gulf until it dissipated. As much as 6.73 inches of rain fell in Pascagoula, Miss., according to news reports. Meanwhile, another tropical depression can be seen off the South Carolina coast, which later became Tropical Storm Cristobol and was swept out to sea. Elsewhere in this scene, a widespread pall of haze (lighter gray) can be seen spanning from Arkansas and Missouri across Tennessee and Kentucky, and into Ohio, West Virginia, and Maryland. Many of these regions received Code Red air quality warnings on August 5. **Image Credit**: Jacques Descloitres, NASA–GSFC.

NASA Meets Virologists

— *Rob Gutro, rgutro@pop900.gsfc.nasa.gov, SSAI, Earth Science News Team/NASA Goddard Space Flight Center*

NASA-funded researchers have taken satellite data down to Earth and into the health field. Several projects funded under Goddard Space Flight Center's HealthyPlanet (Human Health Initiative) and other NASA public health applications programs have opened the doors for using satellite data to track climate conditions that prompt the outbreak of disease, through vectors such as mosquitos.

Several researchers have published papers over the last several years on the use of satellite data to monitor changing climate conditions in relation to Rift Valley Fever and Ebola in Africa, West Nile Virus in the U.S., and Bartonellosis in Peru. Other researchers have been looking at how tiny microbes from African dust storms hitch a ride in the cracks and crevasses of dust particles and survive a trans-Atlantic journey on trade winds, all the way to the Caribbean, the southern U.S., and northern South America where they cause disease in coral. The impact of these microbes on plants, animals, and humans is now under study.

These stories were originally press releases generated by NASA's Earth Science News Team and were presented in a poster at the Annual meeting of the American Society of Virology, held in Lexington, KY, from July 19-24, 2002.

Through the News Team, NASA received a personal invitation from the Chairperson of the ASV conference to present a poster on this research. The Team created the poster and presented it throughout the conference, receiving a great deal of attention.

The poster provided a new awareness of NASA's Earth Science Enterprise to federal, state and local government agencies that were unaware of the NASA research.

For example, a representative from the U.S. Department of Agriculture's Agricultural Research Service, who has been working on West Nile Virus for several years, was elated to discover NASA's work with West Nile Virus. A representative from a university in India also stopped by the poster and was extremely interested in using NASA's satellite data and algorithms to be able to predict changing climate conditions that produce the vectors needed for disease transmission in India. He will also be contacting NASA.

Several virologists also expressed interest in working with NASA on future applications including Ph.D. students from the University of North Carolina and Johns Hopkins University.

The people that came to the poster and took copies of all of the press releases represented by the poster left with a better understanding of how NASA is working with the health community. Gutro received many compliments on the poster, and many, many questions on the research.

NASA also received an invitation to attend a Virus Evolution Workshop in Oklahoma City and Dallas/Fort Worth in the month of August.

NASA's presence at the ASV conference created many connections in the university and government sectors and helped to promote NASA as an important contributor in the health field. The number of people that expressed interest in the program or in working with NASA on research involving tracking disease vectors was incredible. This poster and NASA's presence at this conference created an awareness of NASA's contributions that were completely unknown to the professionals in virology, for whom this sort of data will be very useful. These individuals can, in turn, be of the great help to NASA with its on-going research in the health field.

Satellites Reveal a Large Change in Earth's Gravity Field

— *David E. Steitz, dsteitz@hq.nasa.gov, NASA Headquarters*
— *Lynn Chandler, Lynn.Chandler.1@gsfc.nasa.gov, NASA Goddard Space Flight Center*

Satellite data since 1998 indicates that the bulge in the Earth's gravity field at the equator is growing, and scientists think that the ocean may hold the answer to the mystery of how the changes in the trend of Earth's gravity are occurring.

Before 1998, Earth's equatorial bulge in the gravity field was getting smaller because of the post-glacial rebound, or PGR, that occurred as a result of the melting of the ice sheets after the last Ice Age. When the ice sheets melted, land that was underneath the ice started rising. As the ground rebounded in this fashion, the gravity field changed.

"The Earth behaved much like putting your finger into a sponge ball and watching it slowly bounce back," said Christopher Cox, a research scientist supporting the Space Geodesy Branch at NASA's Goddard Space Flight Center, Greenbelt, Md.

Currently, the Earth has a significant upward bulge at the equator, and a downward bulge at the poles. "Observations of the Earth's gravity field show that some phenomena are counteracting the gravitational effects of PGR. Whereas PGR has been decreasing the bulge in the Earth's gravity field at the equator, this recent phenomenon is causing the bulge to increase," Cox said. Such changes in the gravity field can be sensed using ultra-precise laser tracking of satellites to observe tiny changes in the orbits of those satellites and by tracking changes in the length of day or rotation of the Earth.

Scientists believe movements of mass cause this recent change from the high latitudes to the equator. Such large changes may be caused by climate change, but could also be part of normal long-period climatic variation. "The three areas that can trigger large changes in the Earth's gravitational field are oceans, polar and glacial ice, and atmosphere," Cox said.

Cox and colleague, Benjamin Chao, have ruled out the atmosphere as the cause. Instead, they suggest a significant amount of ice or water must be moving from high- latitude regions to the equator, and oceans could be the vehicles of this movement.

Estimates of today's glacier and polar ice melting are too small to explain the recent changes in the gravity field. If melting ice were the cause of the recent changes in the gravitational field, it would require melting a block of ice 10 km (6.2 miles) on each side by 5 km (3.1 miles) high every year since 1997 and pouring it into the oceans.

"The recent reports of large icebergs calving in Antarctica can't explain this, because they were already floating in the ocean," Cox said. Further, radar altimeter observations of the average sea level rise provided by the TOPEX/POSEIDON satellite show no corresponding change in the rate of the global sea level increase.

Consequently mass must have been redistributed within the oceans. That's where the ocean circulation theory comes in. Ocean currents can redistribute mass quickly, in keeping with the 5- year time frame during which these changes were first observed. The TOPEX/POSEIDON observations of sea level height do show an increase in the equatorial bulge of the oceans corresponding to the observed gravity changes, but the data are not yet conclusive. One critical factor is the temperature of the world's oceans; another is the salinity of the ocean – for which detailed data are not yet available. [See the next page for exciting news about a new ESSP mission that will study salinity!]

NASA has launched Jason-1 and GRACE mission in the past eight months and will launch ICESat later this year. All of these missions will help to track more precisely these sorts of changes in Earth's geodesy.

An article on this study appears in the August 2 issue of the journal *Science*.

NASA Selects New Earth System Science Pathfinder Missions

— *David E. Steitz, dsteitz@hq.nasa.gov, NASA Headquarters*

As part of the Earth System Science Pathfinder (ESSP) small-satellite program, NASA has selected two new space mission proposals that will yield fresh insight into our home planet's carbon cycle and how oceans affect and respond to climate change — knowledge that will help better life here on Earth. Partnering with NASA centers, universities, industry, and international participants, the Orbiting Carbon Observatory (OCO) and the Aquarius missions will enhance NASA's mission: to better understand and protect our home planet.

"The Orbiting Carbon Observatory will provide global measurements of atmospheric carbon dioxide needed to describe the geographic distribution and variability of carbon dioxide sources and sinks," said Ghassem Asrar, Associate Administrator for Earth Science, NASA Headquarters, Washington.

The data returned by OCO will generate knowledge needed to improve projections of future carbon dioxide levels within Earth's atmosphere. Increasing carbon dioxide (CO_2) concentrations have raised concerns about global warming. Even though the biosphere and oceans are currently absorbing about half of the CO_2 generated by human activities, the nature and geographic distribution of these CO_2 sinks are too poorly understood to predict their response to future climate and land-use changes.

David Crisp of NASA's Jet Propulsion Laboratory, Pasadena, Calif., will be the principal investigator for the mission. The OCO mission will include more than 19 universities and corporate and international partners.

"Aquarius will provide the first-ever global maps of salt concentration on the ocean surface, a key area of scientific uncertainty in the oceans' capacity to store and transport heat, which in turn affects Earth's climate and the water cycle," Asrar said.

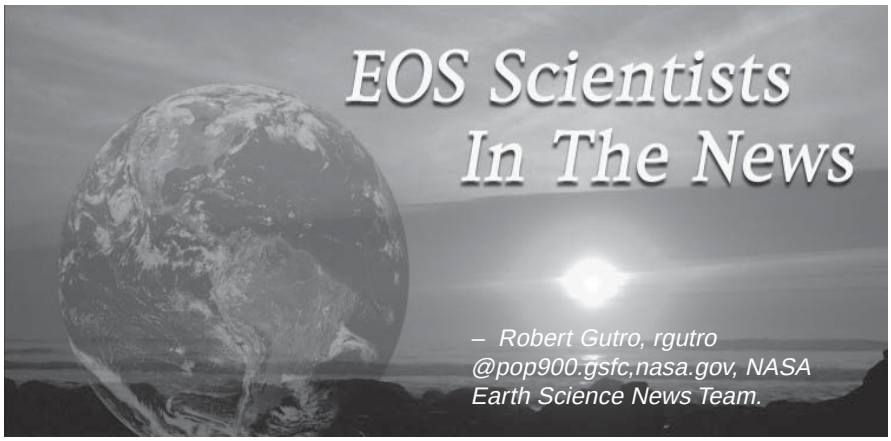
Aquarius will provide global maps of ocean-salt concentration on a monthly basis over its planned three-year mission life. By gaining these global, monthly maps researchers can better understand the nature of Earth's oceans and their role in storage and distribution of heat and thus their role in global climate change. Aquarius will also measure variations in salinity to determine how the ocean responds to the combined effects of evaporation and precipitation, ice melt and river runoff on seasonal and interannual time scales. This is critical information to understand how salinity variations modify ocean circulation and the global redistribution of heat.

Chet Koblinsky of NASA's Goddard Space Flight Center, Greenbelt, Md., will serve as principal investigator for the Aquarius mission. Aquarius also will partner with the Argentine Space Program, building on a successful, long-standing relationship between NASA and Argentina. In all, over 17 universities and corporate and international partners will be involved in the Aquarius mission.

In addition to the two selected new missions, a third proposal, called HYDROS, has been selected to serve as an alternate to the selected missions, should the primary missions encounter difficulties during the initial development phases. The HYDROS mission concept calls for a spacecraft that would monitor soil moisture from space — a measurement that would improve current models for weather and climate predictions.

NASA will fund up to $175 million for each of the two selected missions. The selected missions will have approximately nine months to refine their proposals to mitigate risk before mission development is fully underway.

NASA issued an Announcement of Opportunity and initially received 18 proposals, six of which were selected for detailed assessment, with two now moving on toward final implementation. NASA conducts Earth science research to better understand and protect our home planet. Through the examination of Earth, we are developing the technologies and scientific knowledge needed to explore the universe while bettering life on our home planet.



On Technology's Cutting Edge (June 2002) Civil Air Patrol News Feature article mentioning NASA JPL's AIRSAR instrument flying on Airborne Science's DC-8 during simulated search and rescue missions. NASA pilot Ed Lewis (Dryden) is pictured in the article as pilot of several missions and director of operations for CAP's Pacific region.

Air Pollution Changes Rainfall, May Cause Drought (July 23) Associated Press. Nearly two decades after one of the world's most devastating famines in Africa, scientists are pointing a finger at pollution from industrial nations as one of the possible causes. V. Ramanathan (Scripps) and Yogesh Sud (NASA/GSFC) comment on the findings.

Landsat Paints a Portrait of Our Changing Planet (July 23) Cosmiverse.com. Ghassem Asrar (NASA Associate Administrator of the Office of Earth Science) was quoted in this article about Landsat's 30 year anniversary.

Ice Crystals Clues to Climate (July 18 and July 27) United Press International. During the CRYSTAL-FACE mission, NASA researchers are investigating high tropical cirrus clouds composed of tiny ice crystals to better understand how the ice clouds affect global warming. The CRYSTAL-FACE mission includes scientists from as many as 40 organizations, agencies, and universities. The NASA Center participation includes: Ames, Dryden, GISS, GSFC, HQ, HQ/NIST, JPL, Johnson, Langley.

China's Pollution Found in Hawaii (July 16) San Jose Mercury News. Environmental monitoring stations in Hawaii find arsenic, copper, and zinc that were kicked into the atmosphere five-to-ten days earlier from smelting in China, thousands of miles away. Yoram Kaufman (NASA/GSFC) was quoted.

NASA Turns New Weather Bird Over to NOAA (July 16) SpaceDaily. Karen Halterman (NASA/GSFC) was quoted in this article about the turnover to NOAA of the NOAA-17 satellite on July 14.

Temperatures Indicate More Global Warming (July 11) Atlanta Journal Constitution. Jim Hansen (NASA/GISS) noted that 2002 will likely be the second warmest year ever, in this article focusing on the Earth in the midst of the warmest decade since weather records were first kept in 1867.

Earthshine Map Helps Predict Weather (July 11) BBC, UPI. Crystal Schaaf (Boston University) explained how NASA's Terra satellite has measured how much sunlight the Earth reflects back into space and that it will help determine climate change.

Satellite Detects Double Tropical Wind Zones (July 10) Ascribe News, Cosmiverse, Spacedaily, UPI. Tim Liu (NASA/JPL) said NASA's QuikSCAT has confirmed a 30-year-old, largely unproven theory that there are two Intertropical Convergence Zones that drive ocean circulation.

Mixed Crops Make Cool, Wet Summers (July 2) CNN, Cosmiverse.com. A diversity of crops and vegetation in a large swath of the Western U.S. could contribute to cooler, wetter weather in the region, according to Jim Shuttleworth (Univ. of Arizona) in this NASA study.

Students Help Measure Air Pollution (June 27) Environmental News Service. Elissa Levine (NASA/GSFC) leads a project that is enabling students and teachers at more than 20 Baltimore schools to collect pollution data to help asthma researchers.

As Summer Starts, Next El Niño is Slow to Grow (June 29) Spaceflight Now.com. William Patzert (NASA/JPL) and Tim Liu (NASA/JPL) noted that it appears we are in a "holding pattern" for El Niño as trade winds that were relaxing, which would hint at a coming El Niño, have again returned to normal

New Software Helps Satellites Pinpoint Fires Earlier (June 26) Scripps Howard News Service, Space.com. Elaine Prins (Univ. of Wisconsin) team was quoted on a product that utilizes satellite data and an algorithm to detect fire temperatures and size.

Successful EO-1 Satellite Monitors Earth (June 25) Cosmiverse, ENN, United Press International. One year after launch, NASA's EO-1 satellite has proven invaluable in its clarity and ability to identify objects on the Earth's surface. Bryant Cramer (NASA/GSFC) and Stephen Ungar (NASA/GSFC) were quoted.

Aqua Said to Be Alive and Well (June 25) SpaceDaily. Phil Sabelhaus (NASA/GSFC) and Claire Parkinson (NASA/GSFC) said NASA's newest Earth Observing System satellite, Aqua, is successfully providing data and engineering images.

Major Cities' Heat Leads to Downpours (June 19) ABC news, Associated Press, Atlanta Journal-Constitution, CBS news, CNN, MSNBC, NBC news, UPI, USAToday. Marshall Shepherd (NASA/GSFC) lead a study concluding that the heat from large southeastern cities leads to more rain downwind of urban centers in the summers.

The Greening of the North: Real, and Caused by Climate Change (June 19) Sciquest.Com, ScienceaGoGo.com, Sciencedaily.Com, Spacedaily.Com, Weather Channel, Newsweek International). Ranga Myneni (Boston University) was part of a group of international scientists who said that the 20-year "greening" trend in northern regions of the northern hemisphere was interrupted in 1992 and 1993 by the eruption of Mount Pinatubo.

Antarctic Fringes Vulnerable to Thaw (June 13) MSNBC. Eric Rignot (NASA/JPL) and a colleague surveyed 23 glaciers that flow off the Antarctic Ice sheet and suggest that the ice sheet's edges are most vulnerable to climate warming.

Greenland's Warming Ice Flows Faster (June 7) Atlanta Journal Constitution, Bayarea.com, BBC News, Cosmiverse, Greennature.com, Kyoda News, National Geographic TV, New Scientist.Com, NY Times, NPR Radio, ScienceDaily.com, Straits Times Singapore, Sunday Observer UK 6/9/02-in print, United Nations Foundation Wire Service, UPI. Jay Zwally (NASA/GSFC), and Waleed Abdalati (NASA/HQ) are featured in this story about new measurements that show that the Greenland ice sheet has been moving faster during the summer melting season since 1996.

The Global Transport of Dust (June 7) American Scientist. This feature story discusses research by Gene Shinn and Dale Griffin (both of U.S. Geological Survey) and Jay Herman (NASA/GSFC) on how bacteria and fungi have been hitching trans-Atlantic rides on dust from the Saharan desert and settling into the warm waters of the Caribbean.

Climate Change May Become Major Player in Ozone Loss (June 6) Cosmiverse, EDIE.Com, ENN, Greennature.com, SCIENCE, ScienceDaily, ScienceNow, SpaceDaily, Environment Canada and Chemistry Magazine UK, Earth & Sky Radio, Earthwatch Radio, Discover Magazine. While industrial products like chlorofluorocarbons are largely responsible for current ozone depletion, Drew Shindell (NASA/GISS) finds that by the 2030s climate change may surpass chlorofluorocarbons (CFCs) as the main driver of overall ozone loss.

NASA Sensors Find Hiding Pollution (June 2) Spaceflight Now, Nature News, Space.com. Anne Thompson and Jacquelyn Witte (both NASA/GSFC) and scientists from 10 tropical countries have used balloon-borne sensors to obtain the first picture of the structure of the ozone (pollution) in the tropical troposphere, the atmospheric layer between the surface and 50,000 feet.

Earth Science Education Program Update

– *Blanche Meeson, bmeeson@see.gsfc.nasa.gov, NASA Goddard Space Flight Center*
– *Theresa Schwerin, Theresa_schwerin@strategies.org, IGES*

2002-03 NSIP Earth Science Competitions

The **NASA Student Involvement Program (NSIP)** is a national program of six competitions that links students directly with NASA's diverse and exciting missions of research, exploration, and discovery. NSIP supports national education standards for science, mathematics, technology, and geography. Earth-science related competitions in 2002-03 include: **My Planet, Earth**, grades K-1 and 2-4; and **Watching Earth Change**, grades 5-8 and 9-12. Other 2002-2003 competitions are: **Aerospace Technology Engineering Challenge**, grades 5-8; **Design a Mission to Mars**, grades 5-8 and 9-12; **Science and Technology Journalism**, K-1, grades 2-4, 5-8, and 9-12; and **Space Flight Opportunities**, grades 9-12.

The **deadline for entering Space Flight Opportunities is January 15, 2003**. The **deadline for all other competitions is January 31, 2003**. For complete details and to obtain an entry form, competition rules, checklist, judging rubric, and resource guide, please visit education.nasa.gov/nsip. For questions, send e-mail to: *info@nsip.net* or call: 1-800-848-8429.

NASA CONNECT Earth Science Program Wins Sixth Regional Emmy Award

The **NASA CONNECT** program, **Data Analysis and Measurement: Ahead, Above the Clouds**, received a regional Emmy award on June 29, 2002, in the Children's Programming category in a competition sponsored by the Rocky Mountain Southwest Chapter of the National Academy of Television Arts and Sciences. This is the sixth regional Emmy the NASA CONNECT series has received. The winning program focuses on hurricanes and how meteorologists, weather officers, and NASA researchers use measurements and data analysis to predict severe weather such as hurricanes. Presently, more than 263,000 educators, representing over 8.7 million students, in 50 states have registered for the series. It airs nationally on Cable Access, ITV, and PBS-member stations. The series is funded by NASA's Aeronautics Education Coordinating Committee (AECC) and NASA HQ's Education Division. More information is available at *connect.larc.nasa.gov*.

Online Earth System Science Courses for Teachers — 2002-03

Several colleges, universities, and other science education organizations across the U.S. are offering **online Earth system science courses for K-12 teachers** that were developed for NASA by the **Center for Educational Technologies (CET) at Wheeling Jesuit University**. The organizations are part of the Earth System Science Education Alliance (ESSEA), a program led by CET and the Institute for Global Environmental Strategies (IGES), through funding from NASA's Earth Science Enterprise.

The three ESSEA courses for elementary, middle, and high school teachers use an innovative instructional design model. Delivered over the Internet, they feature student-centered, knowledge-building virtual communities, the optimal method for teaching and learning.

To see the schedule of course offerings, go to *www.cet.edu/essea* and click on the link for "Course Offerings." Here you will find a schedule of which institutions are offering the ESSEA courses in Fall 2002 and/or Spring 2003. At the ESSEA site you can also look at the course outline for each of the 16-week courses. For more information on ESSEA, contact Claudia Dauksys at *claudia_dauksys@strategies.org*.

EOS Science Calendar

September 17-19

27th CERES Science Team Meeting, Princeton, NJ, Contact: Anna Valerio, email: apval@splash.princeton.edu, tel: 865 574 7319.

September 24-25

NSIDC DAAC User Working Group (PoDAG) Meeting, NSIDC, Boulder, CO, Contact: Ron Weaver, email: weaver@nsidc.org

September 26-27

ICESat Science Team Meeting, Boulder, CO. Contact: Christopher A. Shuman,email: christopher.shuman@gsfc.nasa.gov.

November 18-20

EOS Investigators Working Group Meeting, Ellicott City, MD. Contact: Mary Floyd, email: mfloyd@wsestover-gb.com, URL: eospso.gsfc.nasa.gov.

December 4-5

HDF/HDF-EOS Workship VI, San Francisco, CA. Contact: Richard Ullman, email: Richard.Ullman@gsfc.nasa.gov, URL: hdfeos.gsfc.nasa.gov.

Global Change Calendar

September 18-25

Joint CACGP/IGAC 002 International Symposium, "Chemistry Within the Earth System: From Regional Pollution to Global Change," Crete, Greece. Contact: Maria Kanakidou, email: mariak@chemistry.uoc.gr, URL: atlas.chemistry.uoc.gr/IGAC2002.

September 23-27

Conference on Sensors, Systems, and Next Generation Satellites VIII (RS03), an SPIE Symposium on Remote Sensing, Crete, Greece. Contact: Steve Neeck, email steve.neeck@gsfc.nasa.gov **or** Contact: SPIE, email: spie@spie.org.

October 14-19

COSPAR Scientific Commission A, Houston, TX. Contact Robert Ellingson, email: bobe@metosrv2.umd.edu, tel. 301-405-5386.

October 14-19

World Space Congress, Houston, TX. Contact: AIAA, email: wsc2002@aiaa.org, URL: www.aiaa.org/WSC2002/.

October 23 - 27

SPIE's Third International Asia-Pacific Environmental Remote Sensing Symposium 2002: Remote Sensing of the Atmosphere, Ocean, Environment, and Space, Hangzhou, China. URL: spie.org/Conferences/Calls/02/ae/.

October 26-28

3rd International Symposium on Sustainable Agro-environmental Systems: New Technologies and Applications, Cairo, Egypt. Contact Derya Maktax, email: dmaktav@ins.itu.edu.tr.

November 10-15

PECORA 15/Land Satellite Information IV Conference, Denver, CO. Contact: Ron Beck, email: beck@usgs.gov, URL: www.asprs.org/Pecora-ISPRS-2002/program.html.

November 18-22

WOCE and Beyond: Achievements of the World Ocean Circulation Experiment, San Antonio, TX. Contact: Maureen Reap, email: woce2002@tamu.edu, URL: www.woce2002.tamu.edu.

December 3-6

International Symposium on Resource and Environmental Monitoring, Hyderabad, India, Contact R. Nagaraja, email: nagaraja_r@nrsa.gov.in, tel. 91-40-388-4239.

December 6-10

American Geophysical Union Fall Meeting, San Francisco, CA. Contact: E. Terry, email: eterry@agu.org, URL: www.agu.org/meetings/fm02top.html.

December 9-13

NOAA Satellite Direct Readout Conference for the Americas, Miami, Florida. Email: satinfo@noaa.gov, URL: noaasis.noaa.gov/miami02.

2003

February 9-13

American Meteorological Society Conference, Long Beach, CA. Email:amsinfo@ametsoc.org, URL: ametsoc.org/AMS/.

February 13-18

AAAS Annual Meeting, Denver, CO. URL: www.aaas.org/meetings/.

April 6-11

AGU/European Geographical Society (EGS)/European Union of Geosciences (EUG) Joint Spring Meeting, Nice, France. Email:EGS@copernicus.org, URL: www.copernicus.org/EGS/egsga/nice03/.

May 7-9

American Society of Photgrammetry and Remote Sensing, Anchorage, AK. Contact: Thomas Eidel, email:teidel@gci.net, URL: www.asprs.org/alaska2003/.

June 4-6

Oceanology International (OI) Americas, New Orleans, LA. URL: www.olamericas.com.

June 30-July11

International Union of Geodesy and Geophysics 2003, Saporo, Japan. Email: IUGG_service@jamstec.go.jp, URL: www.jamstec.go.jp/jamstec-e/iugg/index.html.

July 21-25

IGARSS 2003, Toulouse, France. Email: grss@ieee.org, URL: www.igarss03.com.

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