Earth Observing System

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In this issue ...

EDITOR'S CORNER

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EOS Senior Project Scientist

I'm pleased to share with you news that NASA was nominated for and has won three of *Popular Science* magazine's "Best of What's New" awards for 2002. The Gravity Recovery and Climate Experiment (GRACE), the Aqua mission, and the Mars Odyssey mission were chosen in the Aviation/Space category of the magazine's annual awards program. The December 2002 issue of *Popular Science* features 100 winners in 10 categories. The winners are considered the best among thousands of new and innovative products and services reviewed annually by the magazine, and represent significant advancements in their categories.

Of the three NASA missions, two are within the Earth Science Enterprise (ESE). GRACE is nine months into its mission to precisely measure the Earth's shifting water masses and map their effects on the Earth's gravity field. A global gravity field map created from just 14 days of GRACE data is proving to be substantially more accurate than the combined results of more than three decades of satellite and surface measurements collected before GRACE (see map on next page). These new gravity maps provide unprecedented insight into variations in the weight of the Earth's oceans and polar ice sheets, which will greatly advance studies of ocean circulation and ice sheet mass. GRACE is a joint partnership between NASA and the German Aerospace Center. The University of Texas Center for Space Research has overall mission responsibility, and the Jet Propulsion Laboratory manages the U.S. portion of the project for NASA.

Aqua is the latest in a series of larger EOS spacecraft dedicated to advancing our understanding of climate and global change. As its name implies, Aqua's instruments are primarily designed to gather information on the Earth's water cycle. Aqua is enabling greatly improved understanding of the global water cycle and its influence on the Earth's climate system. All of Aqua's six

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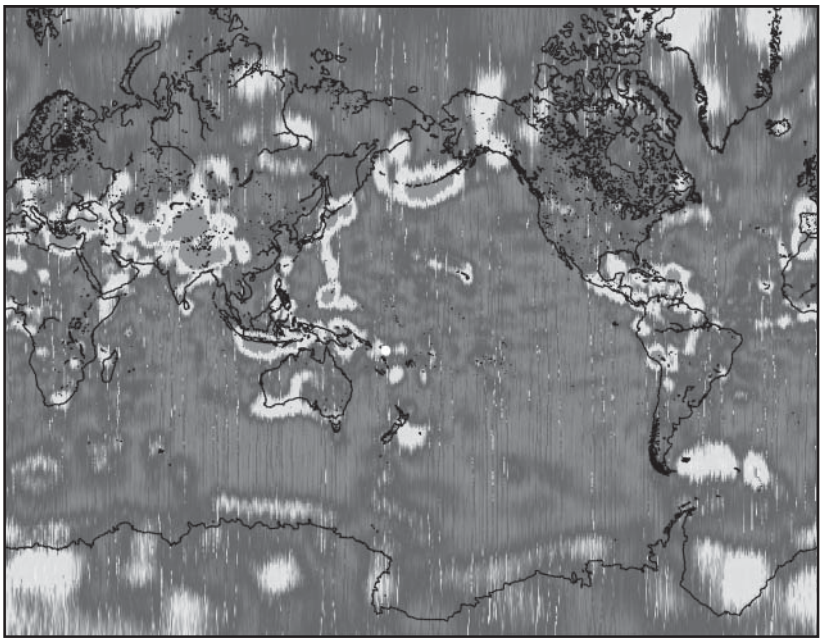

GRAVITY EFFECT SENSED BY GRACE IN MICROMETERS

First Data from GRACE. The Gravity Recovery and Climate Experiment was selected by *Popular Science* magazine as one of three NASA recipients of **"The Best of What's New"** award. The image above is a grayscale version of a color graphic depicting the sensitivity of the two GRACE satellites to changes in the Earth's gravity field. The changes are measured using the K-band Ranging system onboard GRACE, which is sensitive to changes in distance down to one-tenth the width of a human hair. The influence of larger scale spatial features on gravity has been removed for this calculation so that smaller scale changes in gravity can be highlighted. The GRACE Science Team will process this and similar images and expects to have a preliminary map of the Earth's geoid—mean gravity field—by the Spring. Byron Tapley, GRACE Project Scientist, says, " In 30 days, the GRACE mission has exceeded the information gained [about Earth's gravity field] in over 30 years of previous study!"

instruments are performing exceptionally well and are beginning to provide validated data products and exciting new science discoveries. In addition, data gathered from the MODIS and CERES instruments on Aqua are complemented by identical instruments on Aqua's sibling satellite Terra, effectively doubling the data archive from these instruments, and enabling the generation of valuable blended data products. Aqua is also a joint international project among NASA, the National Space Development Agency of Japan, and Brazil.

I am pleased to be associated with these prestigious awards, and I hope you share with me the sense of contribution and excitement that they bring. Together with several other important operational and future EOS missions, these recent accomplishments highlight the significant scientific and societal contributions of NASA's Earth science program.

The EOS Investigators Working Group meeting was held November 18-20 at the Turf Valley Resort and Conference Center in Ellicott City, MD. The IWG meeting is the primary forum for sharing information on the latest EOS program and science activities, and this year focused on new science results from Aqua and other recently launched missions, including Jason-1, GRACE, and SAGE III.

Aqua Project Scientist Claire Parkinson chaired a session on new science results from Aqua, and Terra Project Scientist Jon Ranson chaired a similar session on Terra. Both sessions emphasized integrated data sources from multiple missions. There was also a special session on Earth science applications, chaired by Ron Birk, Director of the NASA Headquarters Applications Division, which included several presentations by program managers leading the 12 specific NASA themes involving human health and the environment, community growth management, public health, air and water quality, and others.

Finally, I'm happy to report the appointment of Steven Platnick as the Aqua Deputy Project Scientist. Platnick recently joined Goddard Space Flight Center after having been a Research Associate Professor at the University of Maryland, Baltimore County for the past 6 years. Platnick received his Ph.D. in Atmospheric Sciences from the University of Arizona and his M.S. and B.S. degrees in Electrical Engineering from Duke University and the University of California-Berkeley, respectively. He has had considerable experience with remote sensing of cloud optical properties using MODIS, AVHRR, and MODIS Airborne Simulator data, and has participated in numerous satellite validation airborne field campaigns. I look forward to his participation in Aqua validation and related activities.

An Overview of the Ice Clouds and land Elevation Satellite (ICESat)

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"Possible changes in the mass balance of the Antarctic and Greenland ice sheets are fundamental gaps in our understanding and are crucial to the quantification and refinement of sea-level forecasts."
—Sea-Level Change Report, National Research Council (1990)

"In light of…abrupt ice-sheet changes affecting global climate and sea level, enhanced emphasis on ice-sheet characterization over time is essential."
—Abrupt Climate Change Report, National Research Council (2002)

Introduction to ICESat

Are the ice sheets that still blanket the Earth's poles growing or shrinking? Will global sea level rise or fall? NASA's Earth Science Enterprise (ESE) has developed the Ice Clouds and land Elevation Satellite (ICESat) mission to provide answers to these and other questions - to help fulfill NASA's mission to understand and protect our home planet. The primary goal of ICESat is to quantify ice sheet mass balance and understand how changes in the Earth's atmosphere and climate

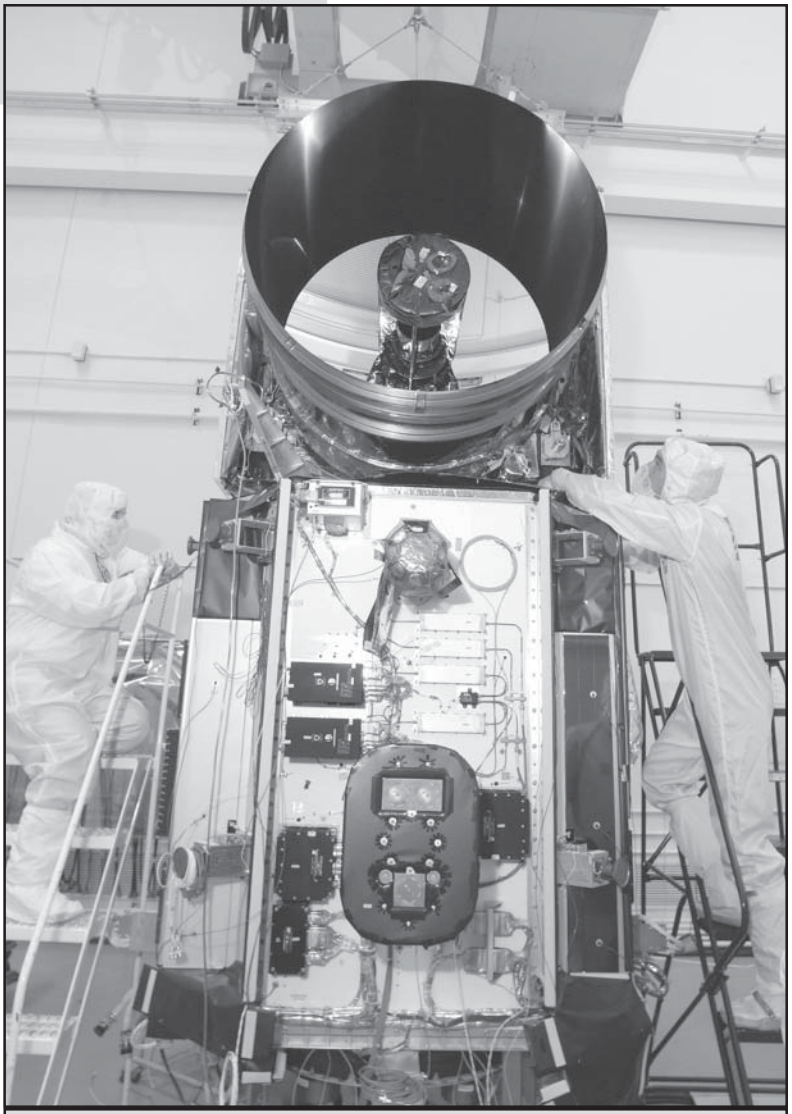


FIGURE 1: The Geoscience Laser Altimeter System (GLAS) on the Ice, Clouds, and land Elevation Satellite (ICESat) spacecraft immediately following its initial mechanical integration on June 18, 2002. Note that ICESat's solar arrays have not yet been attached. Left – Gordon Casto, NASA/GSFC. Right – John Bishop, Mantech. **Photo Credit**: Courtesy of Ball Aerospace & Technologies Corp.

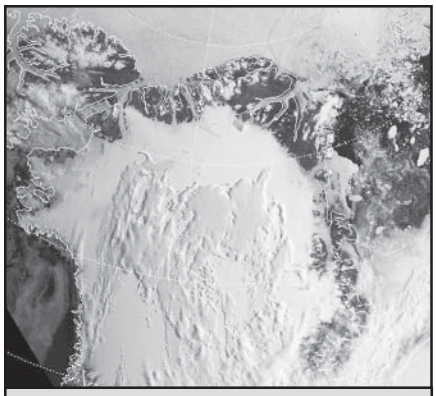


FIGURE 2: This 1-km resolution image of clouds and sea ice around northern Greenland was obtained by the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Aqua satellite on July 13, 2002. ICESat will greatly enhance our understanding of the role these important phenomena play in regulating Earth's climate. **Image Credit**: Aqua MODIS Science Team.

affect the polar ice masses and global sea level.

The ICESat satellite, part of NASA's Earth Observing System (EOS), has been shipped to Vandenberg AFB, Lompoc, CA, and is scheduled to launch in December 2002 on a Boeing Delta II rocket (**Figure 1**). The Geoscience Laser Altimeter System (GLAS), ICESat's scientific instrument, will spend years measuring ice sheet elevations and their change through time, heights of clouds and aerosols, land elevations and vegetation cover, and approximate sea ice thickness. Together with other elements of NASA's ESE and current and planned EOS satellites, the ICESat mission will enable scientists to study the Earth's climate and, ultimately, predict how ice sheets and sea level will respond to future climate change.

Are The Greenland and Antarctic Ice Sheets Growing or Shrinking?

This question lies at the heart of NASA's rationale for the ICESat mission. The Greenland and Antarctic ice sheets are an average of 2.4 km (7900 ft) thick, cover 10% of the Earth's land area, and contain 77% of the Earth's fresh water (33 million km^3 or 8 million mi^3). If their collective stored water volume were released into the ocean, global sea level would rise by about 80 m (260 ft). Their vast size and inhospitable environment make satellites one of the most appropriate means for monitoring their changes.

ICESat is designed to detect changes in ice sheet surface elevation as small as 1.5 cm (0.6 in) per year over areas of 100 km by 100 km (62 mi by 62 mi). Changes in ice sheet thickness are calculated from elevation changes by correcting for small vertical motions of the underlying bedrock. Elevation time-series constructed from ICESat's continuous observations throughout its 3- to 5-year mission will detect seasonal and interannual changes in the mass balance, caused by short-term changes in ice accumulation and surface melting, as well as the long-term trends in the net balance between the surface processes and the ice flow.

How Fast is Sea Level Rising?

Fifteen thousand years ago, vast ice sheets covered much of North America and parts of Eurasia. In Antarctica, the ice sheet reached to the edge of the continental shelf, as much as 200 km (125 mi) farther out to sea than today. As the climate warmed during the end of the last Ice Age, much of the Earth's ice cover melted. Global sea level rose rapidly by almost 100 m (330 ft) between 14,000 and 6,000 years ago.

The Antarctic and Greenland ice sheets (**Figure 2** shows Greenland), which are the most significant remnants of that period, are currently reacting to present and past climate changes. Global sea level is believed to be rising about 2 cm (0.8 in) every 10 years, less rapidly than at the end of the ice age, but still significantly. Thermal expansion as the oceans warm accounts for 25% of the observed sea level rise, and another 25% is attributed to the melting of small glaciers around the world. The remaining 50% could be due to ice loss from Greenland and Antarctica, but our uncertainty concerning their actual contributions (plus or minus) is as large as the total rise in recent decades. Of particular concern is the "marine" ice sheet in West Antarctica, much of which is grounded on bedrock and sediment below sea level. Some researchers believe that West Antarctica's ice could thin rapidly and impact global sea level dramatically with continued climate warming. ICESat's multi-year elevation-change data, combined with other satellite, atmospheric, oceanic, and ice flow data, should enable more accurate predictions of ice-sheet changes that could impact sea level.

How do Clouds and Aerosols Affect Climate?

The distribution of atmospheric clouds and aerosols is one of the most important factors in global climate. Clouds can cool the Earth's surface by reflecting solar radiation or warm the surface by trapping its radiated heat. Low clouds are typically more reflective than the Earth's surface, and primarily reflect solar radiation and cause relative cooling. High, thin clouds, on the other hand, are usually less effective at reflecting solar radiation but effectively trap outgoing infrared heat radiation. Accurate knowledge of the type and height of clouds is thus very important for climate studies. Like clouds, aerosols tend to cool the Earth's surface and heat the atmosphere by

scattering and absorbing solar radiation. In general terms, aerosols are distinguished from clouds by existing at humidity levels below saturation and by a particle size which is typically 10 to 100 times smaller than the size of cloud droplets.

The laser-profiling measurements from GLAS are a fundamentally new way to study the atmosphere from space. To better understand climate, scientists need to distinguish the multiple cloud and aerosol layers that typically exist in the atmosphere. Other satellite remote-sensing techniques currently in use are limited to passive observations, i.e., the sensor images the Earth at a given wavelength but views all atmospheric layers simultaneously. Another issue is that such passive instruments cannot measure the height of layers sufficiently to fully understand the role of clouds in global climate change. The GLAS instrument on ICESat will enable the accurate, multi-year height profiling of atmospheric cloud and aerosol layers directly from space for the first time.

Measuring Earth's Land Surface and Vegetation

The topography and vegetation cover of the Earth's land surface form a complex mosaic. The landscape we see today is the cumulative result of the interaction of those many formative processes through time. Measurement of landscape properties, including elevation, slope, roughness, and vegetation height and density, is a necessary step toward understanding the interplay between formative processes and better modeling of future changes. Knowledge of these properties and their changes with time is important for resource management, land use, infrastructure development, navigation, and forecasting the occurrence and impact of natural hazards such as volcanic eruptions, landslides, floods, and wild fires.

The ICESat elevation profiles will provide a global sampling of the Earth's land surface at unprecedented accuracy. This globally-consistent grid of high-accuracy elevation data will be used as a reference framework to evaluate and improve the accuracy of topographic maps acquired by other airborne and space-based methods such as conventional stereo-photogrammetry and radar interferometry. In particular, ICESat profiles will be combined with the near-global mapping accomplished by the Shuttle Radar Topography Mission to greatly improve our knowledge of the Earth's topography.

In addition to acquiring elevation data, ICESat's measurement of the laser pulse return shape provides unique information about the height distribution of the surface features within each laser footprint. In areas lacking vegetation cover, this is a measure of relief (ground slope and roughness), an indication of the intensity of geomorphic processes. In vegetated areas of low relief, the elevation of the ground and the height and density of the vegetation cover can be inferred from the return pulse. The vegetation observations enable estimation of above-ground biomass and its loss due to deforestation, an important component of the carbon cycle.

How Will ICESat Measure Earth's Ice, Clouds, Oceans, Land, and Vegetation?

The GLAS instrument on ICESat will determine the distance from the satellite to the Earth's surface and to intervening clouds and aerosols (**Figures 3a and 3b**). It will do this by precisely measuring the time it takes for a short pulse of laser light to travel to the reflecting object and return to the satellite. Although surveyors routinely use laser methods, the challenge for ICESat is to perform the measurement 40 times a second from a platform moving 26,000 km (16,000 mi) per hour. ICESat will be about 600 km above the Earth and the precise locations of the satellite in space and the laser beam on the surface below must be determined at the same time. The GLAS instrument on ICESat will measure precisely how long it takes for photons from a laser to pass through the atmosphere, reflect off the surface or clouds, return through the atmosphere, collect in the GLAS telescope, and trigger photon detectors. After halving the total travel time and applying corrections for the speed of light through the atmosphere, the distance from ICESat to the laser footprint on Earth's surface will be known. The GLAS receiver uses a 1-m (3-ft) diameter telescope to collect the reflected laser light. A digitizer records each transmitted and reflected laser pulse with 1 nanosecond (ns) resolution. When each pulse is fired, ICESat will collect data for calculating exactly where it is in space using on-board GPS (Global Positioning System) receivers augmented by a network of ground GPS receivers and satellite laser ranging stations. The angle at which the laser beam points relative to stars and the center of the Earth will be measured precisely with a star-tracking camera that is integral to GLAS. The data on the distance to the laser footprint on the surface, the position of the satellite in space, and the pointing of the laser are all combined to calculate the elevation and position of each point measurement on the Earth.

GLAS measures continuously along ground tracks (**Figure 4**) defined by the sequence of laser spots as ICESat orbits the Earth. The GLAS laser pulses are emitted at a rate of 40 per second from the Earth-facing (nadir) side of ICESat. This produces a series of approximately 70 m (230 ft) diameter spots on the surface that are separated by nearly 170 m (560 ft) along track. These tracks will be repeated every 8 days during the initial calibration-validation phase of the mission and every 183 days during the main portion of ICESat's multi-year mission. Elevation-change data sets can be analyzed along repeat ground tracks as well as at orbital crossover points. In addition, ICESat has the ability to point GLAS off-nadir to repeatedly measure areas of interest such as an erupting volcano or a collapsing ice shelf. ICESat will also provide detailed information on the global distribution of clouds and aerosols. To do this, GLAS emits laser energy at both 1064 nm and 532 nm, as this allows co-located elevation and atmospheric data to be obtained simultaneously. This will also aid precise determination of the distance between ICESat and the Earth, as it is important to know if the laser pulses have traveled through cloud and aerosol layers—such phenomena can diffuse the laser energy and thereby extend the distance the laser light travels.

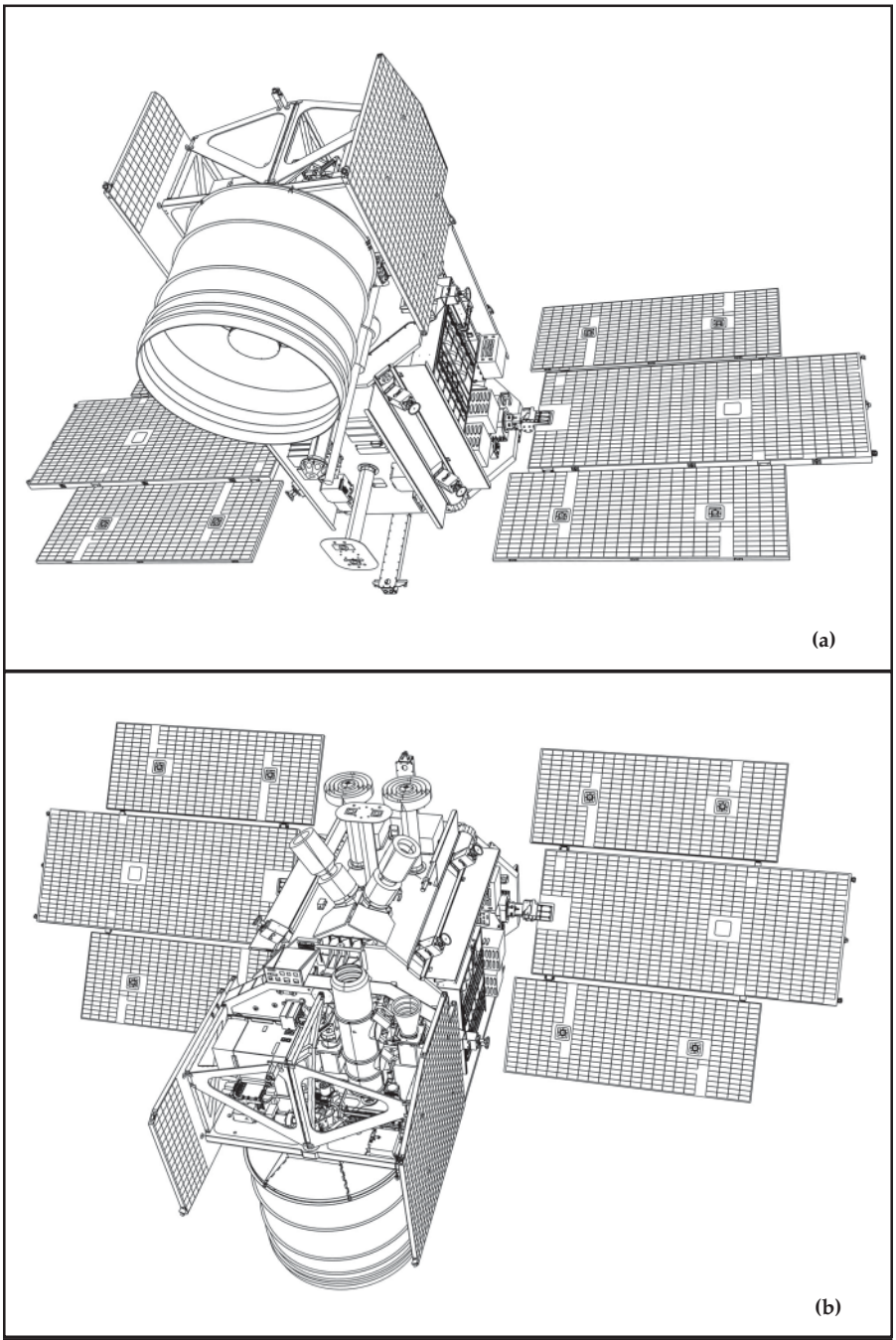


FIGURE 3: These two line drawings show two perspectives of the GLAS instrument. The top drawing (a) presents a nadir (pointing down toward earth) view, while the bottom drawing (b) presents a zenith (pointing upward toward space) view. **Image Credit**: Jason Budinoff, NASA/GSFC and the GLAS Instrument Team.

Land, vegetation, and ocean elevation data will also be obtained around the globe along ICESat's ground tracks. Data on elevation of the world's oceans and ice-free landforms is expected to be of great interest to the broader scientific community. The recently launched Gravity Recovery and Climate Experiment (GRACE) satellite will enhance the ICESat mission by mapping the Earth's gravitational field in unprecedented detail. The GRACE data, in conjunction with ICESat results, will enable a greater understanding of any changes in the distribution of snow, ice, and water around the globe.

ICESat Mission Summary

The overall mission is composed of the GLAS instrument, the ICESat spacecraft, the launch vehicle, mission operations, and the science team. Goddard Space Flight Center (GSFC)

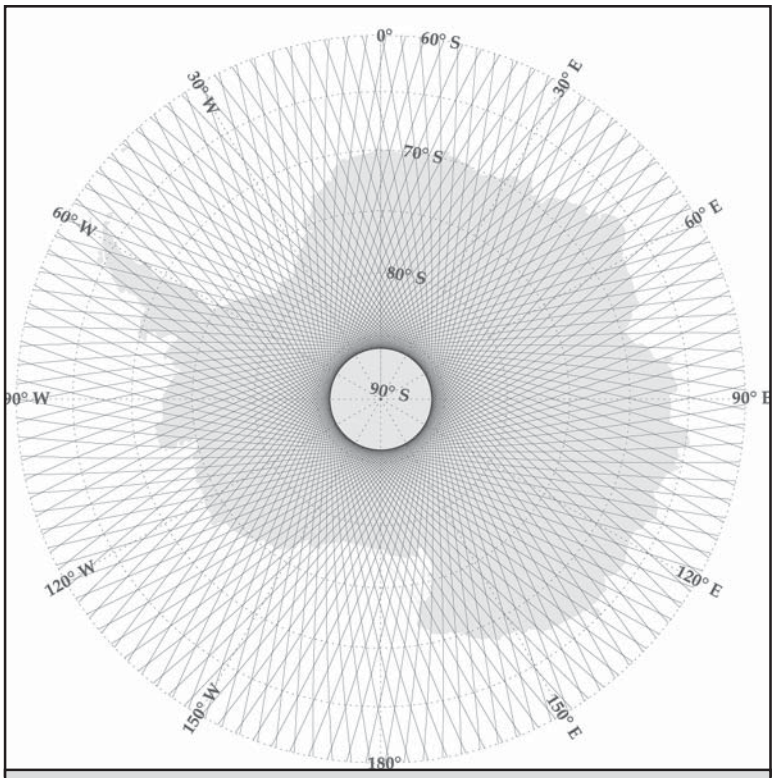


FIGURE 4: Illustration of ICESat's 8-day repeat ground track relative to the continental area of Antarctica. Note the convergence of the ground tracks around the South Pole. Coverage will be much denser in the 183-day repeat orbit. ICESat's orbit was designed to maximize coverage over the polar ice sheets. The pattern is similar over the northern polar region. **Credit:** Bob Schutz.

staff developed the GLAS instrument in partnership with university and aerospace industry personnel. Ball Aerospace & Technologies Corp. in Boulder, CO, developed the ICESat spacecraft. NASA Kennedy Space Center is providing the expendable Boeing Corporation Delta II launch vehicle (**Figure 5**). The science team is composed of researchers from universities, GSFC staff, and supporting industry personnel. They are developing the science algorithms and is responsible for all science data processing, as well as the generation of science data products.

Once ICESat is on orbit, mission operations will be conducted by two organizations. The Earth Science Data and Information System (ESDIS) Project at GSFC will provide space and ground network support. The University of Colorado's Laboratory for Atmospheric and Space Physics (LASP), teamed with Ball Aerospace, will provide mission operations and

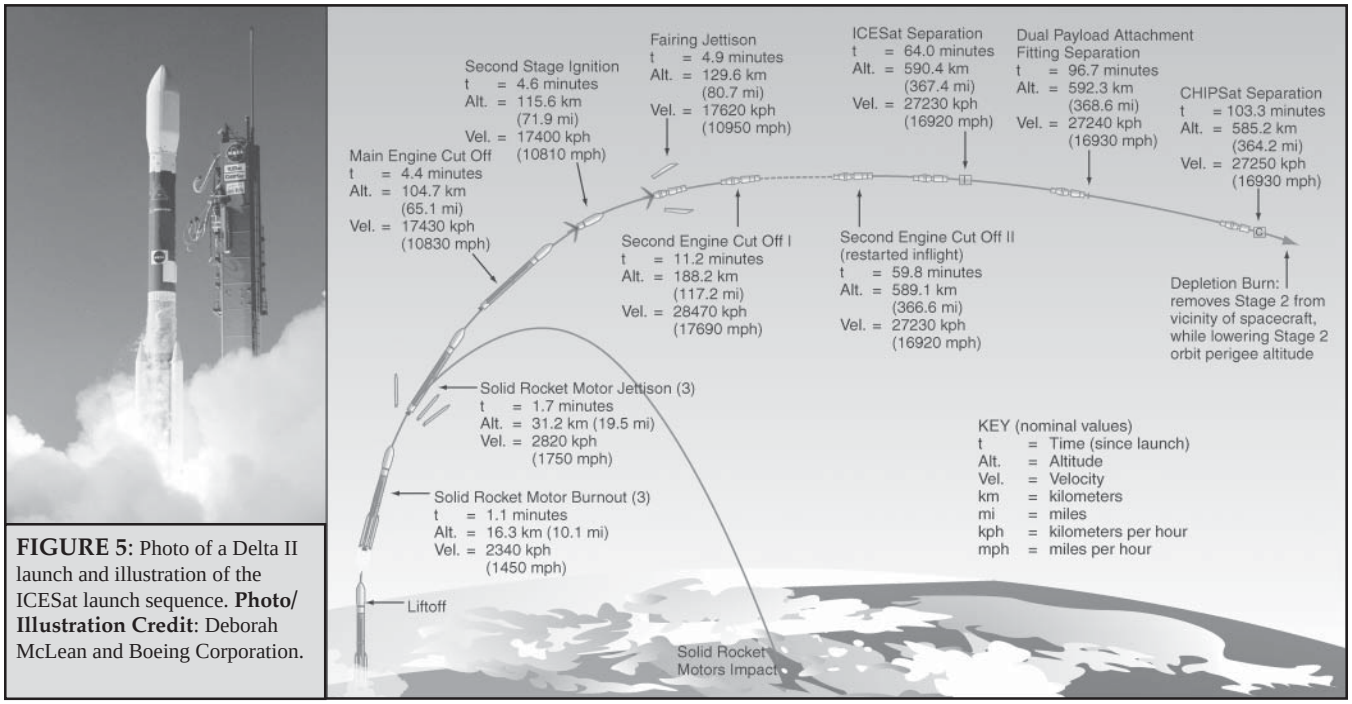
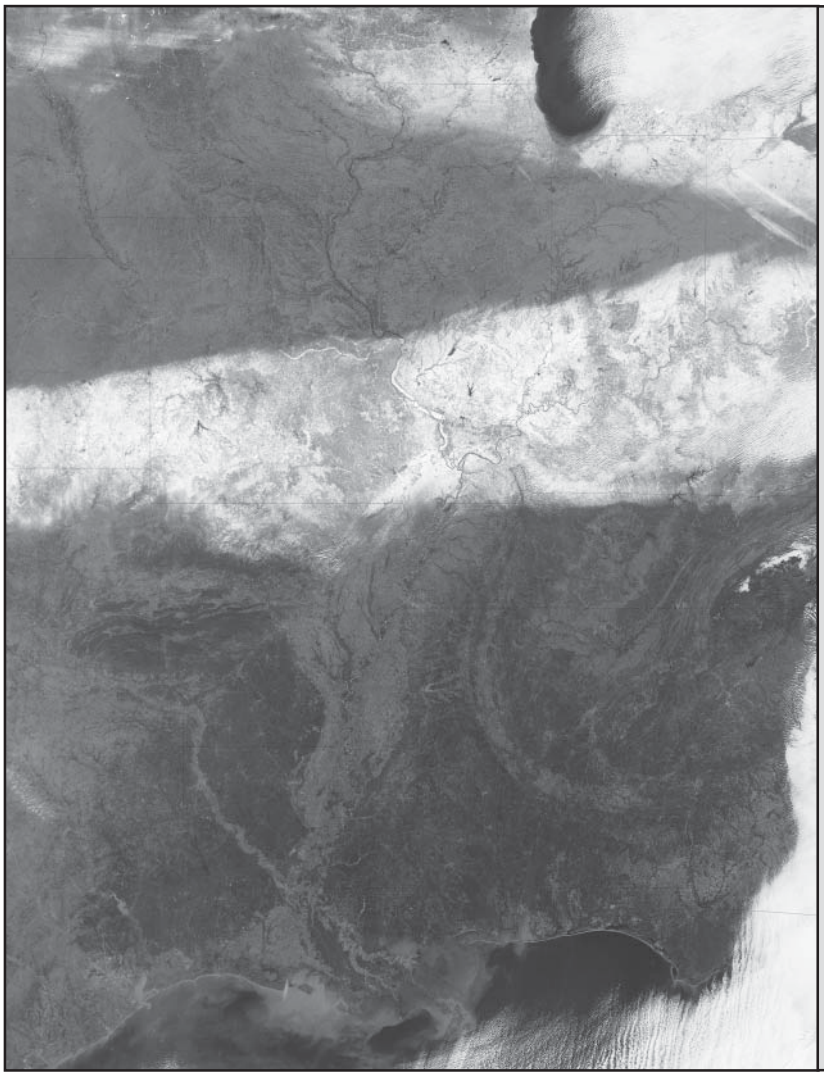


FIGURE 5: Photo of a Delta II launch and illustration of the ICESat launch sequence. **Photo/ Illustration Credit**: Deborah McLean and Boeing Corporation.

flight dynamics support. The ICESat Science Investigator Processing System (I-SIPS) at GSFC will conduct data processing and generation of products with support from the Center for Space Research (CSR) at the University of Texas, Austin. The National Snow and Ice Data Center (NSIDC), located at the University of Colorado in Boulder, will archive and distribute ICESat data products to the scientific community and other users.

In the 60 days following launch, ICESat will undergo a series of tests to establish that all systems are functioning as expected in the orbital environment. This commissioning phase will be followed by a period of intense activity to verify the performance of GLAS and all related systems. The objective of this intense calibration/validation (cal/val) period, is to help insure that geophysical interpretations can be drawn from the data products. Cal/val includes evaluation of the GLAS measurements against ground truth observations. A variety of instrumented and precisely mapped ground-truth sites will be used, including dry lakebeds, landscapes with undulating surface topography, and the ocean, all of which will be periodically scanned.

More information on the ICESat mission can be found at *icesat.gsfc.nasa.gov*, as well as links to many other supporting sites related to this and other NASA EOS satellite missions.



MODIS Views Midwest Snow. The Moderate Resolution Imaging Spectroradiometer (MODIS) on the Aqua spacecraft acquired this image of the Midwest U.S. on December 6, 2002. From left to right, a swath of snow is clearly visible across southern Kansas and northern Oklahoma, southern Missouri and northern Arkansas, southern Illinois, southern Indiana, Kentucky, and southern Ohio. Another streak of snow runs from northern Ohio into Michigan, northern Indiana, northern Illinois,Wisconsin, and eastern Minnesota. The southern end of Lake Michigan is visible at the top of the image (partially covered by clouds), the western tip of Lake Erie is just visible at the top right corner, and the Gulf of Mexico is visible at the bottom of the image. **Credit:** Image Courtesy of Jacques Descloitres—MODIS Rapid Response Team and text taken from the Earth Observatory website and modified.

Minutes of 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 27th Clouds and the Earth's Radiant Energy System (CERES) Science Team meeting was hosted by **Leo Donner** at the NOAA Geophysical Fluid Dynamics Laboratory (GFDL) in Princeton, NJ, on September 17-19, 2002. The meeting focused on the status of new Tropical Rainfall Measuring Mission (TRMM) and Terra data products, Aqua instrument calibration, and Science Team results. The next CERES Science Team Meeting is planned for Spring 2003 near Langley.

CERES on NPP and NPOESS

Bruce Wielicki (Langley Research Center [LaRC]) noted that a clearer picture of whether or not a CERES instrument will be included on the National Polar-orbiting Operational Environmental Satellite System (NPOESS) is not expected to emerge for perhaps 4-6 months. NPOESS is working on major cost and schedule startup issues with the major imager and sounder instruments, and since CERES has flown before, it is on the back burner for now.

There will be an October meeting of the NASA Earth Science Enterprise (ESE) Program Management Council to decide whether to add a CERES instrument on the NPOESS Preparatory Project (NPP) to fill the anticipated gap in the radiation budget data record between Aqua and NPOESS.

Data Products Approved

The Science Team approved production processing of the validated Terra single scanner footprint (SSF) data product, this is a major step as this is the integrated MODIS/CERES (MODIS is the Moderate Resolution Imaging Spectroradiometer) cloud-aerosol-radiation Level 2 data product. Two years of data will be processed by February 2003 and will be used to develop and validate the new Terra angular distribution models (ADMs) by August 2003. The early-validated SSF product will take advantage of the TRMM CERES ADMs at low and middle latitudes. Early looks at night polar clouds and surface fluxes indicate some remaining problems and users will be cautioned in the data-quality summary about polar-night cloud properties and surface longwave (LW) fluxes. Polar top-of-atmosphere (TOA) flux accuracies will also be in question until the new Terra angular models are produced.

The Science Team also approved Edition 2 of the validated Terra Level 1b Bidirectional-Scan (BDS) data and the ERBE-like (ERBE is the Earth Radiation Budget Experiment) TOA flux Levels 2 and 3 data products. These new products correct all known changes in ground to in-orbit calibration as well as the small gain drifts seen in one of the channels on the Flight Model 2 (FM2) instrument.

The Science Team tentatively approved the TRMM-validated Surface Radiation Budget Average (SRBAVG) Level 3 gridded and time averaged (monthly) data products. These are the first of the new generation of CERES Level 3 data products that improve diurnal sampling and reduce time interpolation errors. The team accepted the TOA fluxes in these products, but final verification of the new surface fluxes requires further analysis. Integrating the 3-hourly diurnal sampling of geostationary satellite data with the broadband calibrated CERES data improves diurnal sampling error in the CERES TRMM data by a factor of 2, and even larger improvements are expected in future Terra versions because of the systematic diurnal sampling of the Terra sun-synchronous orbit.

The Science Team approved the validated TRMM Cloud and Radiation Swath (CRS) data product. This is the first CERES data product to include radiative fluxes at the surface, in the atmosphere, and at the TOA. This product constrains the surface and atmosphere flux estimates to be consistent with state-of-the-art radiative transfer theory as well as the CERES TOA flux measurements for each field of view. It is our best view of the atmospheric-column radiative heating/cooling.

Instrument Working Group

Kory Priestley (LaRC) reported on calibration and validation for the CERES instruments. Terra and Aqua CERES instruments continue to function nominally. Work is continuing on early calibration and consistency-check studies of the Aqua CERES instruments. Four of the six channels appear nominal (in-orbit versus ground calibration). Two others differ from

ground calibration by 2% and 4%, respectively, and a coding error is suspected. (**NOTE**: Shortly after the meeting, the Instrument Working Group found the Aqua instrument code bug that caused the large 6-7% differences in three-channel-consistency tests shown at the meeting.) The Instrument Group has an action item to make the first validated Aqua Level 1b radiances and ERBE-like Levels 2 and 3 TOA flux products available by late December 2002.

SARB and Surface-only Working Groups

The Surface and Atmospheric Radiation Budget (SARB) Working Group and Surface-Only Working Group meeting was jointly chaired by **Thomas Charlock** and **David Kratz** (both from LaRC). Charlock led the discussions and invited those in the audience to make use of the validation data sets and the coupled ocean-atmosphere radiative transfer model available at the CERES/Atmospheric Radiation Measurement (ARM) Validation Experiment (CAVE) web site. **Zhonghai Jin** (Analytical Services & Materials, Inc. [AS&M]) presented a discussion of the many issues related to the presence of snow and ice at the surface and their considerable importance to CERES processing and other radiation and climate studies. Jin also discussed the microphysical and optical properties of snow/ice that are relevant to radiative transfer models. **David Kratz** examined the effect of the evolving versions of the HITRAN database on the results obtained from the Fu-Liou radiative transfer code, which is used as the primary processor for CERES/SARB. Results showed that window fluxes and broadband infrared (IR) fluxes at the TOA and surface were not affected significantly by either the changes of the HITRAN database or the continuum, but the continuum had a large effect on broadband shortwave (SW) fluxes.

The SARB group has the following action items:

- Complete the TRMM CRS Edition 2B data quality summary so the data products can be released.
- Test the Terra beta CRS including improved Fu-Liou code and MODIS aerosols over land with monthly aerosol background maps.

CERES ADM Working Group

Norman Loeb (Hampton University [HU]) led the ADM working group meeting with a general overview of critical ADM/inversion research issues. **Konstantin Loukachine** (Science Applications International Corporation [SAIC]) presented an overview of a neural network scheme for TOA flux estimation that relates measured CERES SW and LW radiances directly to anisotropic factors for TOA flux estimation. **Nitchie Manalo-Smith** (AS&M) presented preliminary results of LW ADMs for clear and overcast conditions using four months of CERES/Terra measurements. **Arvind Gambheer** (AS&M) presented an update of a study on the azimuthal-angle dependence of LW radiances over land. **Seiji Kato** (HU) presented a progress report on ADM development over snow. **Wenbo Sun** (HU) presented an overview of a technique for inferring optical depth, asymmetry factor, and albedo for ice clouds using multi-angle measurements. **Lin Chambers** (LaRC) presented early results of a theoretical study that examines how sigmoidal fits to CERES radiances as a function of imager-derived cloud properties can be used to develop CERES/Terra ADMs in cloudy conditions.

Cloud Working Group

Patrick Minnis (LaRC) summarized the activities of the CERES Cloud Working Group. Minnis and **Xiquan Dong** (University of North Dakota) presented recent efforts to validate cloud properties from both the Visible and Infrared Scanner (VIRS) and MODIS instruments. There are instrument problems with the 1.6-μm channel, so the group discussed the possibility of allowing a different version of the cloud algorithm for MODIS on Terra with 2.13 μm replacing the unreliable channel. The group discussed the effects of relatively low vertical resolutions, particularly near the surface, in both Goddard Data Assimilation Office (DAO) and European Centre for Medium-range Weather Forecasts (ECMWF) soundings.

The Cloud Working Group has several action items:

- Complete Terra SSF data-quality summary in October so that the new Terra Edition 1 SSF processing can be released to the public.
- Test early Aqua MODIS data.
- Advance the next critical step in matching CERES cloud properties to surface ARM-based estimates by using wind speed/direction at the dominant cloud layer.

Time Interpolation Spatial Averaging (TISA) Working Group

The TISA Group has the following action items:

- Complete validation of 3-hourly and monthly mean surface-flux products in TRMM SRBAVG by early October.
- Complete data quality summary

for TRMM SRBAVG so final data products can be released.
- Begin testing Terra gridded beta products and development of Synoptic and AVG products.
- Add daily means to future SRBAVG products.

Invited Presentations

Roger Davies (JPL) summarized early Multi-angle Imaging SpectroRadiometer (MISR) spectral albedo results. He and Norm Loeb are now ready to begin more detailed comparisons of the CERES broadband and MISR narrow band angular results.

Paul Stackhouse (LaRC) summarized the newly available 1-degree gridded Surface Radiation Budget (SRB) data products for 1985-1995 using International Satellite Cloud Climatology Project (ISCCP) clouds and Goddard Earth Observing System (GEOS-1) meteorological input and multiple SW and LW algorithms. Stackhouse included comparisons to Global Energy Balance Archive (GEBA) and Baseline Surface Radiation Network (BSRN) surface data. He also ran 1998 data using the same ECWMF input as CERES to allow direct comparisons of SRB and CERES data products. These results will be available soon.

Investigator Presentation Highlights

David Kratz (LaRC) presented results on the validation of surface SW and LW fluxes from Terra SSF for November 2000 to July 2001. These fluxes were derived from the surface-only algorithms, which are based on fast radiation parameterizations or TOA-to-surface transfer algorithms. Surface measurements for validation were obtained from three ARM sites. Clear-sky SW comparisons at most sites showed a negative bias. Clear-sky LW fluxes showed good agreement as did all-sky fluxes for one LW model.

Robert Cess (State University of New York at Stony Brook) compared the dramatic CERES cloud-radiative forcing (CRF) ratio changes found in the tropics at the peak of the 1998 El Niño (but absent in the 1987 El Niño) to current climate-model simulations from the National Center for Atmospheric Research (NCAR) Community Climate Model (CCM). The simulations suggest that the model is not responding correctly to the El Niño sea surface temperature (SST) forcing (cloud response is too weak). The focus is on deep convective and marine boundary layer cloud modeling. This dramatic signal will be used as a metric to test improved cloud models.

Leo Donner (GFDL) presented results from a study of closures for cumulus parameterizations and examined the conditions for equilibrium in deep cumulus convection. The closures currently utilized relate cumulus intensity to the properties of resolved flow in the model, e.g., the convective available potential energy (CAPE) or the cloud work function (CWF). These closures are widely used in the general circulation models (GCMs), yet there is little observational evidence that they are realistic. Donner concluded that cumulus intensity was not related to CAPE or CWF in a simple way, and that CAPE evolution under deep cumulus convection was driven primarily by large changes in the planetary boundary layer.

Xiquan Dong compared cloud properties derived from satellite data with ground measurements at the ARM Southern Great Plains (SGP) site for November 2000 to June 2001. LaRC retrievals of cloud height from MODIS showed good agreement with ground data during daytime, but overestimation at night. Stratus retrievals from MODIS with LaRC and GSFC algorithms agreed well with each other and with ground data, but cirrus retrievals need more work.

Gerald Mace (University of Utah) analyzed the errors incurred in retrievals of cirrus cloud properties using an estimation-theory algorithm framework. Errors in retrievals are generally related to instrument calibration problems, assumptions made in the models, and specifications of model parameters. Mace also presented comparisons of TOA SW and LW parameters derived using cloud properties and other data available from ground-based measurements at the ARM sites and those derived from CERES observations. He concluded that the integrated systems developed and deployed at the ARM sites are sufficient to provide TOA fluxes and CRF.

Taneil Uttal (NOAA Environmental Technology Laboratory) reported on ground-based Arctic cloud validation data sets obtained at the ARM North Slope of Alaska (NSA) site and several ground-satellite comparisons. She reported good progress on retrievals for water and ice clouds but limited progress with mixed-phase clouds.

Bing Lin (LaRC) examined cloud-liquid-water feedback in the tropics, midlatitude, and polar regions. He found negative feedback in polar regions, but positive in mid and low latitudes.

Qingyuan Han (University of Alabama - Huntsville [UAH]) presented a study of ice-crystal shapes using CERES/

TRMM data obtained in the rotating azimuth plane scanner (RAPS) mode. Han recommended that CERES should use polycrystal phase functions in the retrieval of cloud properties and fluxes.

Ron Welch (UAH) reported on the validation of satellite-derived cloud masks using data obtained from ground-based instruments. These satellite cloud masks were derived from MODIS data using neural network methodology. Comparisons with different ground-based instruments provided differing degrees of agreement. Welch concluded that multiple instruments should be used for validating satellite retrievals.

Robert Kandel (Laboratoire de Meteorologie Dynamique [LMD] France) reported on the effort at the LMD to derive broadband SW fluxes using Meteosat-5 visible counts over the Indian Ocean Experiment (INDOEX) region during March 2000. Kandel also gave a presentation on the Earth Clouds, Aerosols, and Radiation Explorer (EarthCARE) project, which is currently in planning stages at the European and Japanese Space Agencies.

Nicolas Clerbaux (Royal Meteorological Institute of Belgium [RMIB]) gave a status report on the Geostationary Earth Radiation Budget (GERB) data processing system. The GERB instrument was launched onboard the Meteosat Second Generation satellite in August 2002 and is currently awaiting commissioning.

Lou Smith (Virginia Tech) made a presentation on the status of the GERB instrument and on the cooperative activities between GERB and CERES projects. CERES and GERB ADMs will be compared by analyzing matched footprints. The 15-minute temporal resolution of GERB measurements will be utilized to validate CERES time-interpolation schemes.

F. Li and **Anand Inamdar** (both from Scripps Institute of Oceanography) presented studies of radiative forcing of TOA SW and LW radiation by Saharan and Arabian dust aerosols using CERES and MODIS data from Terra.

Alexander Ignatov (NOAA National Environmental Satellite, Data and Information Service [NESDIS]) compared aerosol properties from Terra/SSF derived using the VIRS-like single-channel algorithm to those derived with the MODIS multi-channel algorithm as provided by the MODIS processing system. Aerosol optical depth values from the two algorithms for those footprints were in good agreement suggesting that the differences between VIRS-like and MODIS retrieval algorithms were not significant.

Tom Zhao (NESDIS) presented comparisons of aerosol properties from CERES SSF derived from VIRS and MODIS radiances. The objective of the comparisons was to assess the consistency of aerosol data sets as transition occurs from VIRS-based to MODIS-based products.

Tom Charlock (LaRC) compared CERES/SARB surface albedos from SSF data with those derived from helicopter measurements made at the ARM SGP site. The objective of this experiment was to survey the surface albedo of an area about the size of a CERES footprint centered on the SGP site and then compare satellite retrievals with these and other ground-based measurements.

Shi-Keng Yang (NOAA National Centers for Environmental Prediction [NCEP]) presented comparisons of radiative fluxes from the global ensemble forecast model runs at the NCEP. He showed that ensemble forecasts provide very valuable information for numerical weather prediction but less so for climate runs. The forecast skill of the ensemble mean was much higher than for a single control run. He stressed that ensemble forecasts do not resolve model biases, and the spread among members shows the degree of agreement between members and not the degree of confidence in predictability.

David Randall (Colorado State University [CSU]) discussed a new radiation parameterization scheme being developed at the CSU by Graeme Stephens and colleagues. This parameterization is currently being tested in the CSU GCM and CAM2, the latest in the series of NCAR Community Climate Models (CCMs). It is being tested to test the feasibility of using it to replace the old parameterization (by Harshvardhan) in the above GCMs because it provides better spectral accuracy in both SW and LW and includes aerosols. Also, it has a linear scaling with the number of layers which makes it very efficient even with a high vertical resolution.

Minutes from the Aura Science and Validation Team Meeting

— *Anne Douglass, Anne.R.Douglass@nasa.gov, NASA Goddard Space Flight Center*

The Earth Observing System's (EOS) Aura Science and Validation Team meeting took place at the National Center for Atmospheric Research in Boulder, CO, September 17-20, 2002. The meeting had two goals:

1. Develop an implementation strategy for validation of Aura measurements as described in Version 1.0 of the Aura validation document (available from the Aura website at *eos-aura.gsfc.nasa.gov/mission/validation.html*).
2. Develop the basis for the Aura Science Plan. This plan encompasses the science goals of the Aura mission and includes expanded science goals associated with sub-orbital measurements. A series of presentations demonstrated how the Aura observations will be combined with the aircraft missions to address the primary questions facing Earth Scientists (*www.earth.nasa.gov*).

Aura Validation

Aura validation will include observations from existing ground- and balloon-based networks and from new aircraft missions designed to investigate specific chemistry issues. The aircraft missions will be planned so that both satellite-validation and mission-science requirements are met. Examples of missions are the Intercontinental Chemical Transport Experiment (INTEX), planned for Summer 2004 and Spring 2006, and several other proposed missions including the Tropical Composition and Climate Coupling Experiment (TC3), a related mission called Cirrus Regional Study of Tropical Anvils and Cirrus Layers - Tropical Western Pacific (CRYSTAL-TWP), and a polar mission. Aircraft observations in the tropical western Pacific during the northern hemisphere winter for TC3/TWP would provide constituent observations for comparison with satellite observations where the atmosphere is coldest. Such measurements will be most valuable for validation if coincidence criteria are met, and the aircraft flight path follows the satellite line of sight. A polar mission would also provide important validation for the High Resolution Dynamics Limb Sounder (HIRDLS) in a region of very low temperature. Polar observations of Nitric Acid (HNO_3) will also test the satellite observations under extreme conditions. In addition, Chlorine Nitrate ($ClONO_2$) is expected to be high in the collar region of the polar vortex and there should be strong gradients in Hydrochloric Acid (HCl), Nitrous Oxide (N_2O) and Methane (CH_4). In situ measurements in this region would test the HIRDLS measurements of $ClONO_2$ and CH_4 and also test the Microwave Limb Sounder's (MLS) measurements of HCl and N_2O.

It is anticipated that observations from high altitude balloons will be required to provide correlative data for the entire suite of Aura constituents. **Jim Margitan** provided a summary of balloon capability. The instruments are available to meet all requirements, and it will be possible to achieve coincidence with the Aura flight track to within 2° latitude and 15° longitude and less than 1 day, criteria that have proven adequate for stratospheric observations (depending somewhat on meteorology). Possible sites include Fairbanks, AK, in the U.S., Kiruna, Brazil, and a site in Costa Rica.

Rich Stolarski stressed the role of the Ozone Monitoring Instrument (OMI) in continuing the global total ozone record from space. Overlaps do not necessarily provide the whole story when developing a trend quality data set. He stressed the need for the Network for Detection of Stratospheric Change (NDSC), Dobson/Brewer, sondes, and lidar ozone observations for the duration of the mission. Calibration of Dobsons is necessary periodically; the intercomparison exercises are not expensive (though not free) and will require leadership and planning

Ozone (O_3) and its precursors in the troposphere are highly variable due to meteorology and spatial variability in the sources and sinks of pollution. Validation of these species is one of the major challenges facing the Aura community. The Tropospheric Emission Spectrometer (TES) will retrieve ocean

scenes first because the surface emissivity is known over the ocean. Thus correlative data over the ocean is needed for TES validation soon after launch. **Pierternel Levelt** described how OMI will provide very high spatial resolution observations and emphasized that validation is needed for measurements in the lower troposphere, tropospheric profiles, and in both polluted and clean conditions.

Kaley Walker described the Atmospheric Chemistry Experiment (ACE) instrument on the Canadian SCISAT. ACE will provide satellite-to-satellite validation for Aura. The primary instrument is a high-resolution Fourier transform infrared spectrometer (ACE-FTS) with two-channel near infrared (NIR)/visible/ultraviolet (UV) imager. A dual channel spectrograph called Measurements of Aerosol Extinction in the Stratosphere and Troposphere Retrieved by Occultation (MAESTRO) will provide coverage in the visible and near UV spectral regions. ACE will provide sunrise and sunset measurements mainly at high latitudes that will be useful for comparison with Aura stratospheric observations. **David Lary** showed how similar observations from the Atmospheric Trace Molecule Spectroscopy Experiment on Spacelab (ATMOS) could be assimilated with photochemical and transport models to account for the lack of spatial and temporal coincidence with Aura observations.

Much of the validation of Aura measurements will rely on routine observations of ozone and temperature, observations from other satellite platforms including the Upper Atmosphere Research Satellite (UARS), ENVISAT, and SCISAT, and ground-based observations from NDSC. **Bojan Bojkov** and **Lucien Froidevaux** discussed possibilities for a data center to facilitate access to these data and also possible requirements for documentation and format of validation data. Ozonesonde data will be key to validation of OMI and TES observations; thus it will be necessary to develop procedures to obtain coincident launches and to ensure observations in different conditions. **Sam Oltmans** presented observations from the Southern Hemisphere Additional Ozonesondes (SHADOZ) network; such measurements will play a key role in validation of Aura measurements in the tropical troposphere. **Jay Herman** presented a proposal for a mobile suite of ground-based instruments for validation of OMI measurements. **Mike Newchurch** showed the capabilities of the Regional Atmospheric Profiling Center for Discovery (RAPCD). RAPCD should provide continuous measurements of ozone and complex information on aerosols and thus information on short temporal scales that is needed for Aura validation. Information in this talk was supplemented by several posters.

Aura Science

Thorough understanding of the role of water vapor in the upper tropical troposphere and lower stratosphere is key to prediction of global climate change. As a consequence, this topic occupied a prominent location on the meeting program. **Andy Dessler** showed satellite and in situ observations to argue that the monsoon does not play a role in producing the "tape recorder" as observed in tropical water vapor. **Eric Jensen** used back trajectories to show the dependence of cirrus formation on dehydration, ice nucleation, thermodynamics, cloud properties, and the ice-crystal-size distribution. **Hugh Pumphrey** showed that the Microwave Limb Sounder (MLS) instrument flying on Aura will produce a much better data set for lower stratospheric/ upper tropospheric water than UARS MLS. There will be more than twice as many profiles per day, with much better vertical resolution. **Bill Read** argued that MLS ozone and water measurements could be used to test whether convective dehydration or cold-trap dehydration is responsible for low stratospheric water. Ozone and water should be correlated if the convective dehydration is dominant, but not if cold-trap dehydration predominates. **Mark Schoeberl** pointed out the possibility that the Atmospheric Infrared Sounder (AIRS) on Aqua could provide information for an MLS analysis such as this. **Bob Harwood** discussed possible mechanisms to produce a trend in stratospheric water that would not rely on a trend in the tropopause temperature. For example, El Niño does not significantly impact tropopause temperature, but it does alter the location of the most intense convection. **Dong Wu** discussed the MLS ice-cloud measurements and implications for water vapor transport near the tropopause. There are three steps that must be followed to retrieve cloud ice. In step one, the radiances must be identified that are not within clear sky limits. In step two, the ice-water path must be determined. Step three requires conversion to cloud properties. Both steps two and three have large errors. This work will be enhanced by cooperation with CloudSat (both Aura and CloudSat are members of the A-Train satellite formation), and could profit from correlative observations of total-water content. **Liz Moyer** showed results from a mission flown in Costa Rica during the summer of 2001. Her results

suggest that convection can hydrate or dehydrate the upper troposphere, depending upon the ambient state of the air into which the cirrus remnant of convection is injected. **Bill Randel** showed an analysis of the thermal variability of the Tropical Transition Layer (TTL) using Global Positioning Satellite (GPS) data. The variability could be related to the outgoing longwave radiation.

The Aura platform brings new capability to tropospheric chemical measurements. Analysis of these new measurements will lead to improved understanding of the sources and distribution of pollution. **Dylan Jones** showed that it should be possible to use TES data to constrain the sources of Carbon Monoxide (CO) by deriving a TES-like data set from the Harvard Three-Dimensional Tropospheric Chemistry and Transport Model (known as GEOS-CHEM) simulation, and inverting this simulated data set to obtain the original sources. This work shows how INTEX aircraft data will be complemented by data from Aura. The former will provide high-resolution measurements of outflow from the North American continent, and the latter will provide the global coverage necessary to constrain the CO sources. Both sets of observations will be interpreted using the same global model. **Lucien Froidevaux** discussed MLS measurements of Ozone (O_3), Carbon Monoxide (CO), Methyl Cyanide (CH_3CN) and Cyanide (HCN) in the upper troposphere. Since the latter two constituents are associated with biomass burning, these observations may be used to decouple biomass burning from fossil fuel burning, further constraining the sources. **Reggie Newell** reminded the team that atmospheric layers are ubiquitous, as shown by observations from various aircraft. Layers of about 1-km vertical extent can be characterized as elevated in ozone and depleted in water (or vice versa), giving clues to their origin. These layers will impact Aura tropospheric observations even though the layers cannot be resolved.

The Aura platform will provide new information on aerosols that can be used with observations from other platforms to understand their effect on climate. **Steve Massie** showed results for aerosols from the Moderate Resolution Imaging Spectroradiometer (MODIS) on Terra, the second Stratospheric Aerosol and Gas Experiment (SAGE II), and the Total Ozone Monitoring Spectrometer (TOMS). Sulfate can be distinguished from dust and smoke using the aerosol index in the visible and a near UV index. Smoke and dust show different indices for much of the range; it may therefore be possible for OMI to distinguish dust from smoke as well. The HCN and CH_3CN from MLS may also be useful to distinguish dust from smoke. **Simon Carn** gave an overview of TOMS work on volcanic clouds. Strong eruptions are important, and some volcanoes such as Nyranuregira in the Democratic Republic of the Congo erupt continuously for weeks at a time every year or two. In addition, some volcanoes "de-gas passively" nearly constantly. Because of its small pixel size, OMI should detect such volcanoes. **Pepijn Veelfkind** suggested that ground-based monitoring of the single scattering albedo for a long time would be useful to OMI validation. This work would define the direct effect of aerosols. **Randall Martin** showed results from the Global Ozone Monitoring Experiment (GOME) as a prelude for OMI. Biomass burning aerosols reduce the sensitivity of GOME to tropospheric ozone by up to 50%, whereas scattering aerosols increase the sensitivity to tropospheric ozone by 10% or more. These results may explain why GEOS CHEM differs from GOME in different directions for various polluted regions in the U.S.

The Aura platform will also provide unique information about stratospheric composition and processes to understand long-term changes in ozone. **Michelle Santee** provided an overview of the details concerning polar processes that will be clarified using observations from EOS MLS and its superior observations of nitric acid, water, and Chlorine Monoxide (ClO) relative to those obtained by UARS. A climatology of UARS MLS ClO was presented in a poster. **Gloria Manney** described information expected from Aura MLS and HIRDLS that can be used to assess aspects of polar vortex behavior such as mesospheric descent that are not well understood. The six years of measurements expected from Aura will be used to evaluate variability in water vapor that is inferred using potential vorticity mapping from Polar Ozone and Aerosol Measurement (POAM) data, as such variability is important to polar processes involving Polar Stratospheric Clouds (PSCs). Limitations to determining ozone loss from constituent correlations were presented in a poster (**Gloria Manney**), as were techniques for identifying ozone laminae (**Hope Michelson**). EOS MLS will provide information to make more detailed assessment of contributions of chemical loss and dynamics to interannual variability in lower-stratospheric high-latitude ozone during northern hemisphere spring (**Gloria Manney**). These discussions can be used to develop a proposal for the polar mission mentioned below.

Such a mission is needed in order to validate MLS and also can provide additional information about particles.

Validation and Science

The document , *Aura Collaborative Science - The Union of Missions*, will serve to merge these concepts. Satellite observations, ground based observations, and in situ and remote measurements from aircraft will be brought together with meteorological information using global and regional chemistry and transport models and modern assimilation techniques to bring unprecedented power to both interpretation of observations as well as to aircraft mission planning. An outline of this document and the persons responsible for developing the various sections are available on the Aura web site. A draft of this document is expected by January 2003. Further development of these concepts will take place at the next Aura Science Team Meeting planned for March 18-21, 2003.

Although some progress was made towards development of an implementation plan for Aura validation during this meeting, many important details remain to be resolved. These will be considered through the validation-working group chaired by **Lucien Froidevaux** and **Anne Douglass**, with assistance provided by representatives of each instrument and by program managers at NASA Headquarters.

Joanne Simpson Honored by the World Meteorological Organization

NASA research scientist Joanne Simpson has been awarded the prestigious International Meteorological Organization Prize by the Executive Council of the World Meteorological Organization (WMO), the first woman ever to win this prize.

Simpson, internationally acclaimed for her 54 years of pioneering work on cloud modeling, observational experiments on convective cloud systems and hurricane research, is being honored for her role as a leading participant in the aircraft aspects of several WMO Global Atmospheric Research Programme (GARP) experiments and for helping to establish a basic understanding of tropical circulation and heat balance.

The IMO Prize originates from WMO's predecessor body, the International Meteorological Organization (IMO), founded in 1873. The award is presented annually and consists of a gold medal, a sum of money and an official citation.

Simpson is currently chief scientist for Meteorology at NASA's Goddard Space Flight Center in Greenbelt, Md. Previously, she served as the project scientist for the Tropical Rainfall Measuring Mission (TRMM) Observatory. Simpson is the first woman to ever receive a Ph.D. in meteorology, which she obtained at the University of Chicago in 1949.

Summary of the International Workshop on Surface Albedo Product Validation

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Introduction and Overview

Boston University hosted the Committee on Earth Observation Satellites/Working Group on Calibration and Validation (CEOS/WGCV) Land Product Validation (LPV) Workshop on Surface Albedo October 23-24, 2002. The international workshop was held in association with the Moderate Resolution Imaging Spectroradiometer (MODIS) Radiation Products Outreach Workshop, and marked the fourth LPV topical workshop (following assemblies on Leaf Area Index, Fire/Burn Scar, and Land Cover). About 25 experts in satellite-product development, field measurements, and process modeling participated.

With Aqua and ENVISAT joining Terra in space this year, the volume of operational land products has become immense by traditional standards. Each new product has unique characteristics, the performance and accuracy of which can only be determined through postlaunch data analysis. To allow credible and responsible product use, these characteristics must be determined and described to the user community as quickly as possible. The LPV Subgroup of the CEOS/WGCV helps coordinate researchers and activities to achieve these goals more effectively and economically.

MODIS Albedo Product Accuracy

The albedo workshop included both plenary presentations and breakout group discussions. **Crystal Schaaf** and **Yves Govaerts** briefed participants on the MODIS and METEOSAT albedo products, respectively, and their evaluation activities to date. Other researchers described their approaches to measuring plot-level albedo and comparing field-derived and airborne data to the MODIS product.

Collectively, the researchers found that the mean accuracy of the MODIS broadband (visible, near-infrared and shortwave) products is about 0.02 (absolute) over vegetated areas. A back-up algorithm ("Magnitude Inversion"), used when an insufficient number of independent cloud-free samples are available in a 16-day compilation window, produces consistent results relative to the main algorithm. The current broadband product appears to be systematically underestimating completely snow-covered areas, although it appears to handle mixtures of canopy and snow competently. In general, the MODIS algorithm appears to be robust for missing data (few cloud-free samples), but is sensitive to noise in data. Thus, subpixel clouds or geolocation errors can diminish accuracy. Impacts of sensor degradation with time (e.g., decreasing signal-to-noise) have yet to be determined.

Key Issues

Breakout groups, focused on site-level measurements and product developers' validation needs, met on both days. The site-level group developed a prioritized list of challenges, including scaling point measurements to values commensurate with product cell sizes, instrument calibration, aircraft-based data, "footprint" analysis and standards, and cloud-filtering.

The group emphasized the validation of broadband (vs. spectral) products due to the relative maturity and prevalence of the associated field instrumentation and satellite algorithms. Some science networks, e.g., the Baseline Surface Radiation Network (BSRN), have developed error budgets for point-scale broadband measurements. At present, however, the various data validation chains to scale up field data (from point to satellite-product cell size) are relatively complex and involve many stages. It is not clear which are the critical elements in terms of error sources (e.g., radiometric calibration of the ground-based instrumentation, atmospheric correction of the intermediate spatial resolution image data, application of plant-growth models (where appropriate), spatial aggregation, or narrow-to-broad-band conversion of satellite

data). Guidelines for field instrument height relative to surface-heterogeneity scale are also not established. Participants agreed that a rigorous, statistical error-budget analysis is required, and this could be achieved through a community effort including aircraft-based pyranometers.

Group members also noted that a wide range of field instrumentation is currently used to acquire field albedo data. The significance of differences between the values from these instruments, variations from manufacturer to manufacturer, or variations between similar instruments produced by the same manufacturer, are currently unknown. In part, this arises from varying practices relating to the absolute radiometric calibration of the instruments by the manufacturers and the users. To resolve some of these issues, participants suggested a coordinated field-measurement and calibration campaign or a "round robin" approach using a reference-calibration instrument passed between user sites. This effort could be supported by a national standards or instrument vendor calibration laboratory.

The product developer subgroup noted that product accuracy is estimated through a convergence of evidence, including that from site, aircraft, and other satellite product comparisons. Global validation priorities, particularly the number and spatial distribution of sites, remained unresolved, pending further analysis of the MODIS and other satellite products. Climate modelers in attendance advocated closer ties between their community and product validation scientists such that regional albedo outliers found through modeling studies could be rapidly addressed and resolved via campaigns. This would complement long-term monitoring sites required for annual cycles.

Next Steps

The final session was dedicated to developing a research agenda and discussing albedo community coordination. The Oak Ridge National Laboratory (ORNL) DAAC accepted an action to create and distribute 7-km x 7-km ASCII-formatted subsets of the MODIS albedo product over more than 200 sites involved in various science networks (e.g., FLUXNET, BSRN, EOS Core Sites). The data will complement other MODIS product subsets currently available through the DAAC (see *public.ornl.gov/fluxnet/modis.cfm*). The action will be expedited such that subsets are generated for the complete MODIS Collection 4 reprocessing, slated to begin in November 2002. **Alan Strahler** proposed that participants meet again in about one year to discuss evolving priorities, including coordinated activities, as validation extent and quality mature.

Details of the workshop, including copies of presentations and breakout group recommendations, will be available through the LPV web site (*modis.gsfc.nasa.gov/MODIS/LAND/VAL/CEOS_WGCV/surfrad.html*). Boston University will host an LPV-sponsored land-cover-validation workshop in December 2002. The next meeting of the CEOS WGCV will be in Hobart, Australia on February 12-14, 2003.

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Summary of the GOFC/GOLD Regional Workshop: Information Products for Forest and Land Management in Siberia/Far East

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Introduction

The boreal forests of Siberia and the Far East (Siberia/Far East) stretch from the Ural Mountains of Russia on the west across northern Asia to the Pacific Ocean on the east; and from the northern reaches of Central Asia and China on the south to the reaches of the tundra on the north. For the NASA ESE (Earth Science Enterprise) to complete a global picture of carbon dynamics, knowledge of this region is increasingly important. The boreal forest of Siberia/Far East is the world's largest forest. In addition, this region is one of the greatest global stores of carbon, is a dynamic fire-dominated landscape, is growing in importance—and risk—in regional (Russia-China-Japan) timber-based economics, and may already show early effects of global warming.

A deeper ESE scientific understanding of the boreal forest and carbon dynamics of this region is also increasingly possible. In 1991, the new Russian Federation and the Russian Academy of Sciences opened the doors for much greater international scientific cooperation. In 1994, the NASA Land-Cover/Land-Use Change (LCLUC) program began supporting research projects in the region. In 2000, the Global Observation of Forest Cover/Global Observation of Land Dynamics (GOFC/GOLD) program, which is part of the Global Terrestrial Observing System (GTOS), began holding regional workshops addressing development of, and access to, remotely sensed data sets for global-change science and natural-resource management. This international program recognizes the need for improved coordination with respect to ground and satellite observations and is being implemented through a series of regional networks. The Northern Eurasian Earth Science Partnership Initiative (NEESPI), coordinated at NASA by **Garik Gutman** and **Don Deering**, is aimed at developing a new science program that will identify critical science and applications questions and coordinate research on the state and dynamics of terrestrial ecosystems in northern Eurasia and their interactions with Earth's climate system (*neespi.gsfc.nasa.gov*). Development of regional networks in northern Eurasia under the GOFC/GOLD program will provide support to NEESPI infrastructure and NEESPI projects relevant to GOFC/GOLD goals will feed in the necessary science to the newly emerging networks.

The purpose of this article is to report on an important element of this growing program, the GOFC/GOLD Siberia/Far East Regional Information Network (SFERIN) and the recent workshop that established this network. The great geographic extent and the constant dynamics of the Siberian/Far East boreal forest make good access to remotely-sensed data an increasing advantage in forest science and forest management of the region. Therefore, the GOFC/GOLD Siberia/Far East regional workshop was held at the V.N. Sukachev Institute of Forest, Krasnoyarsk, Russia August 7-8, 2002. The theme for the workshop was GOFC/GOLD Satellite Information Products for Forest and Land Management in Siberia/Far East. **Eugene Vaganov** (Russia) and **Kathleen Bergen** (U.S.A.) co-organized the workshop. The workshop was held in conjunction with the International Boreal Forest Research Association (IBFRA) conference that took place August 5-8, and attendance at the workshop and conference included 150 scientists from Russia and the international community. The website for the SFERIN network (*www.snre.umich.edu/ruworkshop/index.htm*) is hosted jointly by the V. N. Sukachev Institute of Forest and the University of Michigan.

Role of GOFC/GOLD

The goals of the GOFC/GOLD program are to coordinate ongoing space-based and *in situ* observations of forests, to facilitate sustainable man-

agement of terrestrial resources, and to obtain an accurate understanding of the terrestrial carbon budget. Regional meetings, leading to regional networks, act as a mechanism for achieving these objectives. The Siberia/Far East workshop was the third in a series of GOFC/GOLD workshops in Russia, including the Global Observation of Forest Cover Boreal Forest Initiative Workshop held in Novosibirsk, Russia in August 2000, and the Western Russia/Fennoscandia Workshop held in St. Petersburg, Russia in June 2001. The first workshop recommended that regional workshops and networks be formed. The Siberia/Far East region is distinguished by the remoteness and inaccessibility of large amounts of the forested area; the significance, size, number of forest fires and management challenges in monitoring and managing them; the proximity to neighboring wood-consuming countries of China, Japan, and other Asia-Pacific economies; and strong regional forest-science and remote sensing institutions.

Siberia/Far East Workshop Goals

The goals of the GOFC/GOLD Siberia/Far East regional workshop were to:

1. Discuss and define the critical boreal forest science and resource management issues.
2. Discuss and define the priority GOFC/GOLD information products and network needs.
3. Establish the components of a regional GOFC/GOLD network.
4. Plan and implement the next steps in the new regional network.

Schedule and Venue

The GOFC/GOLD 2002 workshop included: 1) overview presentations on the GOFC/GOLD program, 2) one-half day of invited formal presentations focused on science and management issues concerning the dynamics of the Siberian/Far Eastern forest, 3) one-half day of invited formal presentations focused on satellite information needs and GOFC/GOLD information products, and 4) one-half day of participatory discussion time. In addition, participants were exposed to the IBRFA conference science papers. **Kathleen Bergen** moderated the sessions.

Summary of Invited Presentations

A successful workshop necessitated a sound understanding of the aims of GOFC/GOLD and its programmatic context. **Chris Justice** (U.S.A.), the GOFC/GOLD representative at the meeting, delivered the following presentations.

- Global Observations of Forest Cover/Global Observations of Land Cover Dynamics (GOFC/GOLD): An International Program for Improved Observations and Monitoring.
- GOFC/GOLD Priorities for Development of a Global Forest and Land Cover Characteristics and Changes Observatory.
- GOFC/GOLD-Fire: A Mechanism for International Coordination on Fire Observations and Their Use.

Following these GOFC overviews, a series of invited presentations summarized important issues in forest science and management in the Siberia/Far East region. Abstracts are available and selected papers will be published.

- **Shvidenko** et al. (Austria/IIASA and international). An Integrated Approach to Assessing the Major Greenhouse Gases Budget of Northern Eurasia Forests.
- **Sheingauz** (Russia). Forest Cover Dynamics in the Russian Far East: Trends, Factors, Method Difficulties.
- **Belov** et al. (Russia). Satellite Monitoring of Forest Fires in the Tomsk Region of Boreal Forests of Western Siberia.
- **Blam** et al. (Russia). Timber Industry Complex in Siberia - Strategies of Survival and Development.

Papers that provided an overview of data and information management issues and needs followed.

- **Isaev and Bartalev** et al. (Russia, Italy) A Land-Cover Database for Forest and Land Management in Northern Eurasia. (SPOT-VGT classification).
- **Bergen** et al. (U.S.A.). Using Heterogeneous Landsat ETM+, TM, and MSS for Land-Cover Change Detection in the Siberian Boreal Forest.
- **Mironov** et al. (Russia). Microwave Methods in Airborne Remote Sensing of Eurasian Boreal Forest Areas.
- **Vekshin** et al. (Russia). Problems of Forest Management in Siberia.
- **Malykh and Faleychik** (Russia). GIS for Environmental Investigations of Nature-Protected Forests of Chita Oblast.

Because the GOFC/GOLD Siberia/Far East Regional Network should coordinate with other existing networks or projects, reports were solicited providing overviews of these other programs.

- **Erickson** (Germany) gave an update on the SIBERIA project in the absence of project coordinator **Schmullius**.

- **Krankina and Isaev** (U.S.A./Russia) reviewed the GOFC/GOLD Western Russia/Fennoscandia Regional Network.
- **Gutman and Deering** (U.S.A.) introduced the Northern Eurasian Earth Science Partnership Initiative (NEESPI).
- **Efremov** (Russia) discussed issues and data needs in the Siberian Far East
- **Dye** (Japan) reported on two programs concerning the Far East hosted in Japan: the Frontier Research Program (FRSGC) and the MODIS station at the University of Tokyo.

Discussion and Recommendations

An open discussion session was held on the second day of the workshop. The topics included: 1) Users and Participants, 2) Science and Management Priorities, 3) Computer Networks, and 4) Data Integration and Network Organization.

Users and Participants: Discussion

A key question for all GOFC/GOLD networks concerns identification of the data users and their information requirements. Representatives from the major forest administrative units in Siberian Russia, including **Tomsk Oblast, Krasnoyarsk Krai, Chita Oblast, Khabarovsk Krai**, and others were present. Scientists from the institutes of the Russian Academy of Science (RAS) dominated the numbers present; however, there were also representatives from national and regional government, non-governmental organizations (NGOs), and development organizations. **Alexander Isaev** (Russia) summarized the main users of GOFC/GOLD network data in Russia.

In the Russian Federation there is a multilevel system of government: regional, national, and federal; all require information products. The federal and national level includes the Forest Protection Service, governmental land-surveys, and weather services. A new component of interested users includes new commercial wood and mining companies. Finally, this information is critical for ecological-monitoring specialists who are now increasing in number across Russia. The need for satellite and *in situ* information products will increase in the near future in both government and private sectors. Other participants noted that training would be needed for the most fruitful application of the data.

Users and Participants: Recommendations

- There should be one international Siberian/Far East network for GOFC/GOLD rather than splitting it into two Russian and non-Russian networks. Future meetings of the network should be hosted in different centers in the region.
- In addition to scientists represented by the RAS institutes, it will be important to include local and regional government and the non-science community in setting the information requirements and in the evaluation and use of emerging data and information products.
- Data should be made available but should be translated into efficient applications products for new users. The information products should be considered as a component to decision and resource-management-support systems within the region.

Science and Management Priorities: Discussion

Alexander Isaev (Russia) summarized the five main science and management priorities in the region for the products and services to be provided by the regional network. The first includes forest fire extent, behavior, management, and control. Russian scientists have considerable experience in these areas and there is already much interest on a national level, indicating good governmental support. From the workshop it is clear that the same can be expected from other countries in the region.

The second area is carbon. This includes the mapping of forest cover; estimation of carbon pools, emissions, and carbon balance; adherence to Kyoto protocol standards; and economic implications of forest and carbon management.

Forest pests are a third priority. Insect outbreaks in Siberia are often extensive and cause considerable economic damage. The future goal is to record outbreaks across the region in a similar way to which fire is currently being detected and monitored by satellite.

These are the three main areas; the fourth area is related to monitoring the location and extent of logging and control of illegal cutting, and the fifth to monitoring industrial pollution.

Science and Management Priorities: Recommendations

- In its initial phase, the Siberia/Far East Network should provide data and services that emphasize the three areas: 1) fire, 2) carbon, and 3) insect outbreaks.
- The Siberia/Far East Network should provide data and services that secondarily emphasize the

following areas: 1) logging, and 2) industrial pollution effects.

Computer Networks: Discussion

Good data and network capabilities for GOFC/GOLD depend on two things: 1) network technology and organization, and 2) funding. In terms of technology, Internet access and high-speed networks are inconsistent in Russia and across the region. The technology exists; however, services are often limited at the local level and this needs to be addressed. **Susan Conard** (U.S.A.) noted that there are often high-speed cables to important locations in Russia such as Krasnoyarsk, but the problem is that there is often no money for the service and that this is a major obstacle to accessing the existing data sets. Thus, it is important that those who manage institutes understand that each project needs the data management component to be supported financially. **Alexander Isaev** (Russia) and **Garik Gutman** (U.S.A.) noted that new computer networks are emerging in Russia. For example, Tomsk Oblast is building a well-equipped computer center. There are also plans to build similar computer centers in Novosibirsk and other cities.

Don Deering provided a summary of the Fast-Net project underway beginning September 2002. This is a joint NASA-Russian Ministry of Science project that could include an activity to transfer MODIS fire data processed in the U.S. to Russia. The organizers are discussing the way that data could be transferred to Moscow and on to locations such as Tomsk and Irktusk, where the data could be used by fire-monitoring specialists. **Peter Schlesinger** (U.S.A.) noted that data transfer is currently possible on a smaller scale; it is also possible to access Landsat, ASTER scenes and similar data via FTP for locations such as Krasnoyarsk.

Computer Networks: Recommendations

- It is important that individual projects that rely on products and network services need to have a data-support component written into the implementation plan or proposal.
- As the network begins hosting data associated with research projects, there needs to be a mechanism in place to host and maintain the data once individual research projects are finished.
- There needs to be an increased emphasis on metadata and control on data and product quality.

Data Integration and Network Organization: Discussion

Data requirements need to be identified based on the regional-science and resource-management priorities outlined above. Common themes and data requirements between projects indicate one basis for prioritizing regional data sets. **Anatoly Shvidenko** (Austria/IIASA) identified the need for focal points responsible for data integration, especially for Siberia, and suggested that such a focal point could be located somewhere within the Presidium of the Siberian Branch of the Russian Academy of Sciences. At the regional level of the Siberia/Far East network, most participants agreed that data integration is a group effort. **Chris Justice** (U.S.A.) offered examples from other GOFC/GOLD regional networks. There was a discussion about generating a form to send out to all participants at the workshop. It was suggested that the host institute for a website be in the region. **Eugene Vaganov** (Russia) explained that the Sukachev Institute has had similar prior experience working with the European Commission. Participants suggested that if the Sukachev is willing to host the network, other institutions could help support the data hosting. Those who agreed to coordinate this were **Eugene Vaganov** (Russia), **Dennis Dye** (Japan), **Kathleen Bergen** (U.S.A.), and **Anatoly Shvidenko** (Austria/IIASA).

Data Integration and Network Organization: Recommendations

- The first step is to send a form to all potential participants to list their completed, ongoing, and planned projects and data sets, plus data needs and point of contact.
- This list should be analyzed and data sets key to several projects should be given priority.
- The priority data sets should be generated and hosted by the network.
- The Sukachev Institute and **Eugene Vaganov** (Russia) should be the Russian host for the Siberia/Far East Network. Several international partners including **Shvidenko** (Austria), **Bergen** (U.S.A.), and **Dye** (Japan) should also assist with organization.
- During the workshop a small regional network subgroup was developed focused on fire. The group led by **Evgeny Loupian** (Russia) consists of scientists and data providers across the region developing and using satellite-based fire information. A small follow-up workshop on fire monitoring and use is planned for 2003. It is hoped that other thematic groups will self-organize

around the priority themes identified above.

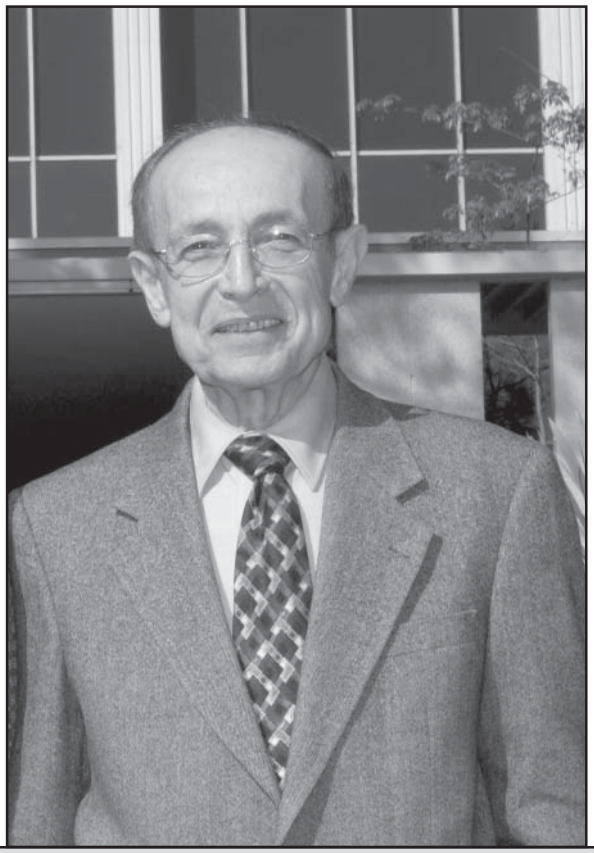
Acknowledgments

NASA ESE provided support for workshop planning. START (**Amy Freise**, U.S.A.), with funding from NASA, provided support for some of the regional scientists to participate in this workshop. **Elena Muratova** (Russia) and **Mike Apps** (Canada) successfully integrated the IBFRA conference and the GOFC workshop. **Julia Gorbunova** (Russia), **Lara Peterson**, **Bryan Emmett**, and **Tingting Zhao** (University of Michigan, U.S.A.) assisted in activities during the workshop and afterwards. We thank the Sukachev Institute of Forest of the Siberian Branch of the Russian Academy of Sciences and all of the Russian and international presenters who traveled to this meeting to share their work.

References

Gutman, G., O. Krankina, and J. Townshend, 2001: Remote Sensing of Forest Cover in Western Russia and Fennoscandia. *The Earth Observer*, **13:5**, pp. 23-24, 26.

Kasischke, E., G. Gutman, and T. Perrott, 2000: The CEOS Global Observation of Forest Cover Boreal Forest Initiative Summary of August 25-September 1 Workshop. *The Earth Observer*, **12:5**, p. 29.



Mous Chahine Honored at International Space Congress

At the International Space Congress in Houston October 10-19, Mous Chahine (pictured above) AIRS Science Team Leader, was awarded the Nordberg Medal from COSPAR for "distinguished contributions to the application of space science to the study of the environment." The Nordberg Medal is named for William Nordberg (1930-1976), a Goddard Space Flight Center pioneer in using remote sensing for Earth observations. Chahine has worked on the Advanced Microwave Souding Unit (AMSU) and the Humidity Sounder for Brazil (HSB) as well as the Atmospheric Infrared Sounder (AIRS) instruments on Aqua from the beginning and, most notable, the retrieval techniques for the AIRS/AMSU/HSB system are based in part on the relaxation inversion algorithm proposed by Chahine back in 1968 in an article in the *Journal of the Optical Society of America* entitled "Determination of the temperature profile in an atmosphere from its outgoing radiance."

The Earth Observer staff and the entire EOS community wishes to congratulate Chahine on this outstanding achievement, and thank him for his contributions to the success of the EOS program.

Summary of the SAFARI 2000 Synthesis Workshop

— R.J. Swap, swapper@virginia.edu, University of Virginia

Introduction

The Southern African Regional Science Initiative (SAFARI 2000) Synthesis Workshop, held in Charlottesville, Virginia, from October 7 - 11, 2002, was focused on the analyses, results, and working group discussions of the key SAFARI findings to date. The workshop provided an opportunity for scientists involved with both the SAFARI 2000 Wet Season Campaign **[1]** and the Dry Season Campaign **[2]** to interact and to make key contacts with respect to developing Phase II science questions (i.e., post-data collection and initial analysis into synthesis activities).

Approximately 110 registrants, comprised of scientists, students, and program officers, participated in the workshop. Nearly 40 of the participants came from southern Africa. NASA's Terra mission was well represented with workshop participants from the Moderate Resolution Imaging Spectroradiometer (MODIS), the Multiangle Imaging SpectroRadiometer (MISR) and the Measurement of Pollution in the Troposphere (MOPITT) science teams. There was also representation from a number of U.S. governmental agencies such as Department of State, U.S. Agency for International Development (USAID), and National Science Foundation (NSF).

More than three-fourths of the presentations focused on science, with the remainder addressing highly applied or policy-related topics. This was in response to the overall objectives of SAFARI 2000 to produce science that is relevant to the needs of societies in the region **[3]**. Along those lines, the SAFARI 2000 community was challenged both by **Diane Wickland**, NASA Research and Analysis Program Manager and by **Rejoice Mabudafhasi**, Deputy Minister of Environmental Affairs and Tourism of South Africa and Chair of the African Process, to continually relate in plain terms the SAFARI agenda and accomplishments with respect to the goals of program managers, government administrators, and other policy makers, both regionally and internationally. Mabudafhasi emphasized the relevance and timeliness of this facet of SAFARI research with clear ties to the outcomes of the World Summit on Sustainable Development that was recently hosted by the Republic of South Africa in Johannesburg.

Thematically, the plenary sessions were organized around the following progression:

- Relevance of SAFARI 2000 Science to national and international program goals;
- aircraft science to date;
- examples of SAFARI science synthesis components;
- ecosystem and land processes;
- fuel, fires, and emissions; and
- atmospheric processes and transport.

Nearly 70 oral and poster presentations were given during the first three days of the workshop on topics that included improved Terra algorithm development; use of Terra fire products for improved assessment of economic losses in farming; use of airborne remote sensing data to monitor drainage from mine tailings; biogenic production of trace gases; regional models on fire-fuel-load production; how SAFARI 2000 results can feed the Air Pollution Information Network in Africa (APINA); inter-comparisons of ground-based, *in situ* and remotely sensed data; and the determination of preliminary regional emissions estimates. Students gave a significant number of these presentations (nearly 20).

The SAFARI 2000 Data Team unveiled and distributed the second volume in the CD-ROM Series of SAFARI 2000 data (5 disk set). Through the workshop, the team solicited further data and metadata to be included in the third and final volume in the series (expected in late 2003).

The working groups focused on the following issues:

- What do we know now as a result of SAFARI 2000 that we didn't know before?
- What currently funded analytical

efforts are underway regarding SAFARI 2000 and what types of products are expected?
- What next science efforts are needed over the next 12 months or so to enable project-wide synthesis?
- What can the SAFARI 2000 community say that relates to issues of natural resource management, air quality, and fire management in southern Africa?
- What can be done to keep southern African scientists plugged into larger international programs during the post-field-campaign phase of SAFARI 2000?

Participants broke into one of three large working groups: 1) Fire, Fuel, and Emissions; 2) Ecosystem Processes; and 3) Aerosols, Trace Gases, Clouds, and Radiation. Summary reports from the groups indicated that much had been learned about the physical, chemical and biological characterization of their respective systems along gradients of ecosystem and land-use types in southern Africa since the previous large-scale science initiative in 1992 (The Southern Africa Fire-Atmosphere Research Initiative - SAFARI-92). Participants stressed the need for a greater involvement of the atmospheric chemistry modeling community and their interfacing with current SAFARI 2000 modeling activities to aid in the drive towards project synthesis.

Way Forward

Although the field component of SAFARI 2000 has ended, participants indicated that SAFARI 2000 coordination should continue in terms of overseeing, guiding, and facilitating the analytical and synthesis efforts, the dissemination of information, and the collection and archiving of metadata, data, and scientific products. Consensus was reached on several synthesis objectives during the closing plenary session. Regarding the integrative, interdisciplinary science efforts that need to occur before complete project synthesis can take place, participants agreed to start by following a set of events. First, the group proposed an analysis of the Timbavati controlled burn on Sept. 7, 2000 from vegetation to fuel-load production to determination of emissions from *in situ* sampling to the use of remotely sensed data to the modeling of that system from the empirical evidence. Second, the "River of Smoke" event that occurred roughly from August 29 to September 7 over much of southern Africa must be further studied, with emphasis on usage of field, laboratory, *in situ*, remotely sensed, and modeled data pertaining to fuel, fire, and emissions. And finally, participants suggested extensive analysis of the emissions that occurred during the SAFARI 2000 period from mid-August to the end of September 2000.

To address policy maker needs, both regionally and internationally, it was agreed that SAFARI 2000 will help facilitate the production of fact sheets that deal with issues such as: Fire in Africa; Trans-boundary Air Pollution; Global Change and Radiative Forcing; Rural and Urban use of biofuels; and Remote Sensing of the Environment. Representatives from APINA and the Miombo Network agreed to work with SAFARI 2000 leadership to help distribute this information to the appropriate people involved with environmental policy making both nationally and regionally in southern Africa. As a project, SAFARI 2000 will take steps to more actively communicate with in-region science-to-policy/science-to-management efforts such as APINA, Miombo Network, and the Southern African Fire Network (SAFNET).

Several avenues were recommended as a lasting legacy for SAFARI 2000 activities, data, and results. The first is the completion of the third volume in the SAFARI 2000 CD-ROM series composed of newly emerging data sets. Accordingly, the SAFARI Data Team is currently developing this CD-ROM in concert with the needs of the larger SAFARI community. The volume should be ready for release in late 2003 to coincide with the public release of the entire SAFARI 2000 data archive. The second focus, again coordinated by the SAFARI Data Team, is the push for the continued population of the SAFARI 2000 metadata and data archive to serve the broader community in the future. The third focus is on compilation of relevant information in the form of one to two books. A need was articulated by the southern African participants, in particular, to produce a book that presents an overview of what is known to date about the operation of the southern African biogeophysical system and that can be used by upper-level undergraduate and entering graduate students, as well as policy makers, as a desk reference for interdisciplinary information. It was agreed that much of the information for such an effort already exists and that SAFARI 2000 should go forward with a proposal to produce and publish this contribution. During the concluding plenary session, it was also agreed that while a book representing the synthesis of SAFARI 2000 is needed, publication should await the next set of integrative, interdisciplinary studies that have been identified for SAFARI Phase II.

For more details on the SAFARI 2000 Synthesis Workshop program, abstracts, presentations, and summary, please visit *www.safari.gecp.virginia.edu*. Interested readers can also watch for special issues dedicated to SAFARI work in four journals: *J. Geophysical Research*, *J. Arid Environments*, *Int. J. Remote Sensing*, and *Global Change Biology*. Each is currently in the review phase.

References

[1] Otter, L.B., R.J. Scholes, P. Dowty, J. Privette, K. Caylor, S. Ringrose, M. Mukelabai, P. Frost, N. Hanan, O. Totolo and E.M. Veenendaal, 2002: The Southern African Regional Science Initiative (SAFARI 2000): wet season campaigns. *South African Journal of Science*, **98:3-4**, pp. 131-137.

[2] Swap, R.J., Annegarn H.J., Suttles J.T., Haywood J., Helmlinger M.C., Hely C., Hobbs P.V., Holben B.N., Ji J., King M.D., Landmann T., Maenhaut W., Otter L., Pak B., Piketh S.J., Platnick S., Privette J., Roy D., Thompson A.M., Ward D., Yokelson R., 2002: The Southern African Regional Science Initiative (SAFARI 2000): overview of the dry season field campaign. *South African Journal of Science*, **98:3-4**, pp. 125-130.

[3] Swap R.J., H.J. Annegarn, and L. Otter, 2002: Southern African Regional Science Initiative (SAFARI 2000) summary of science plan. *South African Journal of Science*, 98:3-4, pp. 119-124, 2002.

Summary of the Alaska SAR Facility User Working Group Meeting

— Harry Stern, harry@apl.washington.edu, University of Washington, Seattle

The Alaska SAR Facility (ASF) User Working Group (UWG) met in Seattle October 28-29, 2002. A brief summary of the meeting follows.

Nettie LaBelle-Hamer was appointed Director of ASF in September. The UWG expressed their approval of the new appointment and their confidence in the new Director.

ASF is doing very well with data delivery and customer service. They received praise from representatives of the National Oceanic and Atmospheric Administration (NOAA), the Radarsat Geophysical Processor System (RGPS), and Level 0 data users.

ASF has established closer ties with the Geophysical Institute at the University of Alaska/Fairbanks, and plans to interact more with other units on campus and externally. The UWG encourages ASF to make these connections.

A new five-year contract between NASA and ASF will be in place by March 2003. The contract will preserve funding for core functions such as data reception, processing, distribution, and archiving, but science activities will have to compete for new funding through research announcements from NASA and other agencies.

The Japanese Advanced Land Observing Satellite (ALOS) is scheduled for launch in 2004. ASF, in partnership with NOAA, will become the ALOS Americas Data Node. A formal agreement between the University of Alaska and NOAA was recently signed. The Memorandum of Understanding between NOAA and the National Space Development Agency (NASDA) of Japan will be in place by April 2003. ASF will pay royalties to NASDA and will receive (by tape from Japan) all the data collected over North and South America. ASF will then distribute the data to American users for the cost of reproduction. ASF is hosting the fifth ALOS Data Node meeting in Fairbanks in March 2003.

Among the recommendations made by the UWG to ASF and NASA are:

- ASF should coordinate the writing of a science plan for ALOS data of the Americas.
- ASF should try to negotiate advance agreements for bulk purchase of ALOS data by interested government agencies and organizations.
- The UWG encourages NASA to pursue agreements with the European Space Agency in connection with ENVISAT data, and with the Canadian Space Agency in connection with Radarsat-2 data.

ASF has compiled an on-line SAR bibliography with over 1700 entries. See *asfbd.asf.alaska.edu/sarweb.html*. The UWG is seeking new members—contact Harry Stern if interested. More information, including notes from past meetings, is available at *psc.apl.washington.edu/ASFUWG*.

Summary of the DAAC Alliance Data Interoperability Workshop

— *Bob Chen, bchen@ciesin.columbia.edu, Socioeconomic Data and Applications Center (SEDAC)*

The Distributed Active Archive Center (DAAC) Alliance held a DAAC Alliance Data Interoperability (DADI) workshop at the Socioeconomic Data and Applications Center (SEDAC) in Palisades, New York on August 13-15, 2002. The overall purpose of the workshop was to assess the usefulness of emerging standards for spatial data interoperability for providing access to different types of Earth Science data for research and applications. All nine DAAC Alliance members were represented at the workshop, along with representatives from the NASA Geospatial Interoperability Office (GIO), the ESDIS Science Operations Office (SOO), and the Open GIS Consortium (OGC). More detailed information, including workshop presentations and related materials are available online at: *nasadaacs.eos.nasa.gov/0int/dadi/*.

Participants recognized the importance of exploring new interoperability approaches in order to meet emerging user needs, improve data flow both within the NASA Earth Observing System Data and Information System (EOSDIS) and between EOSDIS and external data sources, and assess ways to reduce costs, improve system reuse, and allow for evolution. Specific benefits for DAAC involvement in interoperability activities include:

- boosting the Alliance's overall capabilities to share and disseminate data from different disciplines;
- responding more flexibly and quickly to user needs; and
- adopting new open standards and technologies as they become available.

Moreover, it is important for the Alliance to ensure that it remains at the cutting edge in terms of data management and user support within NASA, across the larger Earth Science data community, and in the context of the National Spatial Data Infrastructure (NSDI) and the Federal Geospatial One-Stop Initiative. This includes direct involvement in developing, testing, and implementing emerging data-management standards.

During the workshop, it became clear that a number of Alliance members are already heavily involved in developing new data services based on open standards, such as those under development by the OGC. For example, both the Global Hydrology Resource Center (GHRC) and SEDAC have been involved in recent OGC Open Web Services testbeds, and the Jet Propulsion Laboratory (JPL) Physical Oceanography DAAC (PO.DAAC) and SEDAC have lead roles in NASA's Federation of Earth Science Information Partners (ESIPs) Interoperability Committee and GIS Services Cluster. However, these efforts by individual Alliance members have not generally been coordinated across the Alliance and for the most part address different applications and user groups.

Therefore, the workshop participants agreed that coordinated development of one or more interoperability prototypes would be beneficial to the Alliance as a whole, to individual Alliance members, and, in the long run, to the general user community. The group identified a number of specific criteria for selecting prototypes, including:

- the existence of a clear need and identifiable user community;
- the applicability of data from multiple Alliance members to the need;
- the potential evolvability of a prototype into one or more useful operational services; and
- the degree to which a prototype might facilitate external collaboration through open standards.

Certainly, the lack of interoperability of current data sets and data systems must be one of the chief limiting factors in more widespread use of EOS and other data by a specific user community. The data interoperability and integration promoted by a prototype must also have a sound scientific basis.

The group also recognized that development of multiple prototypes may be desirable, if these are selected in a way to cover the range of desired

goals in a complementary way. For example, it may be sensible to select at least one prototype focused on science community needs, e.g., a field experiment or science issue, and another on an application area, e.g., a decision-support problem. Similarly, it may be desirable to explore a mix of lower-risk, more mature technologies and higher-risk, more experimental approaches, a range of open standards, and a diversity of data types and sources. Some prototypes may scale up from a specific location or region to the globe and others from a narrow topic, e.g., a single hazard to a broad set of related topics, e.g., multiple hazards. Some prototypes may be relatively quick to implement with only modest additional effort, whereas others may require more time and extra resources to develop. However, the latter more expensive alternative may do a better job of demonstrating the long-term potential using these approaches to scale up to fully operational systems.

Workshop participants considered a number of interoperability specifications under development by the OGC, such as the Web Map Service (WMS), the Web Feature Service (WFS), the Web Coverage Service (WCS), and the Coverage Portrayal Service (CPS). These are in different stages of implementation, ranging from fairly mature specifications with numerous implementations by commercial and noncommercial organizations to early draft specifications with rapidly evolving implementations by a limited number of groups. Also important to consider are standards and specifications emerging from the science community such as the Earth Science Markup Language (ESML) and the Distributed Oceanographic System (DODS) Data Access Protocol, as well as standards for metadata and data registry functions. Using a mix of specifications is clearly required given the diversity of data types held by the DAAC Alliance members, and it will be important to ensure compatibility and consistency among prototypes as these evolve into operational systems.

The workshop highlighted the wide range of questions and issues surrounding the emerging set of interoperability approaches, including their short- and long-term costs, possible performance opportunities and limitations, and their scalability. The implications of current and future requirements relating to metadata, billing and accounting, metrics, software reuse, privacy, and security have not yet been addressed in detail. Workshop participants discussed some of the pros and cons of open source versus proprietary versus custom-coding approaches, and recognized that a key issue is how to share knowledge and learning experiences to promote efficient and effective collaboration and data integration. For example, most ongoing interoperability efforts have not explicitly dealt with underlying data projection issues that must be carefully addressed in order to support high quality co-registration of different data sets, accurate spatial search functions, and appropriate data visualization and analysis.

Through a set of working group discussions, workshop participants identified four candidate prototypes: Southern California Coast, Volcanoes, Environmental Features, and Cold Land Processes. Each is discussed below.

Southern California Coast: The Southern California Coast prototype would expand on a JPL initiative to meet the data needs of both researchers and decision makers concerned with human-environment interactions in the Southern California "bight," the coastal waters and region extending from Point Conception (just west of Santa Barbara) past Los Angeles and south to San Diego. With more than 20 million people in the region, recognition of the need for spatial data integrated seamlessly across the coastal land/ocean boundary is growing. Satellite data on surface ocean conditions, land cover, hydrology, and atmospheric parameters are applicable to a variety of coastal issues, but must be accessed in conjunction with a diverse set of *in situ* environmental measurements and socioeconomic data. Alliance members could make a wide range of region-specific data holdings accessible through open interfaces, building on JPL's initial development of a user interface.

Volcanoes: A prototype focused on volcanoes would capitalize on the Earth Science Enterprise's substantial focus on mapping and monitoring volcanoes using visible, near-infrared, and thermal sensors. Data from Terra and Aqua (e.g., MISR, CERES, MODIS, and ASTER), Earth Probe (TOMS), and Landsat 7 are being used to assess thermal hot spots, lava flow, volcanic ash, volcanic clouds, and other volcanic activity. These data could be made more accessible on an ongoing basis in conjunction with georeferenced data on human settlements, infrastructure, and land use. An initial prototype would likely focus on a few selected volcanic areas and attempt to demonstrate the potential for development of a near-real-time service for delivering integrated volcano-related data to selected user groups, e.g., emergency

managers and local municipal officials.

Environmental Features: Medium-to-high-resolution data from various EOS satellites may be useful in identifying and characterizing certain environmental features such as large piles of discarded tires, landfills, and wetlands. For some local and regional governments, identifying and monitoring these features across large land areas can be a difficult and costly task. This prototype effort would explore development of algorithms for identifying environmental features of interest from EOS data and make derived products available through interoperable interfaces in combination with other relevant spatial data.

Cold Land Processes: The Cold Land Processes mission is a NASA ESE activity within the Land Surface Hydrology Program designed to integrate microwave observations from space within an Earth System Science modeling framework. A mesoscale field experiment is being conducted in 2002 and 2003 in the Colorado Rockies that involves intensive collection and analysis of active and passive microwave data, ground- and aircraft-based snow and soil observations, and optical and radar remotely sensed data. Some of these data have already been organized into a Geographic Information System (GIS) database. A prototype system would attempt to make a wide range of relevant Alliance data sets available for the specific field sites through an integrated interface tailored to the needs of the science team.

The workshop did not attempt to make a final selection of which prototype efforts to pursue, since this is dependent on a number of different factors including staff availability, user feedback, e.g., from the relevant science teams and incremental resources. Moreover, it was recognized that these initial ideas need to be fleshed out in more detail before firm decisions can be made. It was agreed that subgroups of workshop participants would take responsibility for writing up more detailed prototype-planning documents. Leads for the four groups are: **Rob Raskin** (JPL) for the Southern California coast; **Sue Heinz** (JPL) for volcanoes; **Bruce Barkstrom** (LaRC) for environmental features; and **Ron Weaver** (NSIDC) for cold land processes.

An important short-term need is to explore the interest of key user groups and get their feedback on specific prototype ideas. In parallel, it may be worthwhile to explore potential cross-prototype functions that should be developed regardless of the final selection of prototype efforts.

Last but not least, it is important to explore sources of additional support for these prototype efforts, as not all DAAC Alliance members will be able to contribute actively solely from their current resource base. Possible sources include the Data System Enhancement projects sometimes funded by the ESDIS Project and a new GIO testbed activity under development in conjunction with the OGC. Collaboration with the Synergy Project, especially with respect to the current development and implementation of data pools and associated interfaces, needs to be explored. Alliance members may also need to consult with their User Working Groups concerning user needs relative to the various possible prototypes and the relative priority to be given to these efforts. It was envisioned that these initial follow-on activities could be completed before the end of 2002 and that the DAAC Alliance as a whole would consider going ahead with specific prototype efforts in early 2003.

An Overview of SEEDS: The Strategic Evolution of the Earth Science Enterprise's Data Systems

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Introduction

NASA's Earth Science Enterprise (ESE) has had a number of initiatives to advance its data systems and deliver data products and results to the Nation. First, it initiated a multiyear Earth Science Information Partner (ESIP) Experiment that formed a federation of competitively-selected data centers to explore the issues associated with distributed, heterogeneous data and information systems and service providers. Second, the EOSDIS architecture evolved to accommodate the generation of data products by external processing systems developed under the direction of the EOS instrument teams. Third, the ESE chartered a study team called New Data and Information Systems and Services, or "NewDISS," to capture and consolidate the input from the community in a series of recommendations (see *lennier.gsfc.nasa.gov/seeds* for this and other SEEDS documentation referred to throughout the article). SEEDS is an outcome of this study, leveraging the lessons learned from earlier efforts. Its purpose is to establish a strategy and coordinating program to evolve the Earth Science Enterprise network of data systems and service providers from 2004 to 2010. What follows is a brief history of Earth Science data systems; an overview of SEEDS, Formulation Team findings and recommendations; and suggestions for how you, the user, can be involved.

The Context

The acquisition of more data from public and commercial systems—data with better spectral and spatial resolution than ever before—presents a challenge to government and commerce to make those data and data products readily available to the user community, to extract the information and knowledge content from these rich observations, and assimilate the data and knowledge into decision-support systems.

The central element of NASA's response to the challenge is the Earth Observing System Data and Information System (EOSDIS). EOSDIS archives, distributes, and manages data and information from ESE activities and other data required for production and effective use of Earth observations. A set of discipline-oriented Distributed Active Archive Centers (DAACs) provides production, distribution, and user services to members of the community.

Concurrent with the implementation of the DAACs, ESE has sponsored projects to facilitate use of the ESE data for specialized research community needs and to support broader user community access to the data and data products from the ESE missions. These projects included Pathfinder data sets, the Regional Earth Science Applications Centers (RESACs), the Applications Research Centers (ARCs), Earth Science Information Partners (ESIPs), and the Synergy Program.

Pathfinder data sets date back to 1991. They were compiled and released under the EOS Program to provide research-quality, consistently calibrated and processed data sets to the community prior to the availability of data from the EOS satellites. The Pathfinder data sets focused initially on long-term, calibrated and validated data sets for studying climate change. In 1995, additional types of data products were added along with reprocessing of some earlier product sets and the development of new data-processing algorithms.

In 1995, the National Research Council recommended that NASA shift appropriate functions of its EOSDIS implementation to a federation of competitively selected ESIPs. Three types of ESIPs were defined. Type 1 ESIPs are responsible for standard data and information products and associated services whose production requires considerable emphasis on reliability and disciplined adherence to schedules. While the DAACs provide some processing, much of the production for EOS Standard Products has shifted to Science Investigator-led Processing Systems (SIPS). Type 2 ESIPs are responsible for data and information products and services in support of global change research

(other than those provided by the Type 1 ESIPs) that are developmental or research in nature and where emphasis on flexibility and creativity is key to meeting the advancing research needs. Type 3 ESIPs provide data and information products and services to users beyond the ESE science research community.

The RESACs, established in 1998, focus NASA's Earth science research on applications of regional significance, integrate remote sensing and its attending technologies into the local decision-making processes, and support regional assessments associated with the U.S. global change research. Through the ARCs, NASA encourages partnerships between U.S. companies and university affiliates to work on commercialization of information technologies, including spatial information technologies, remote sensing, geographic information systems, and the Global Positioning System. The ARCs help project participants become familiar with remote sensing technologies, and the information provided by the technologies.

The ESIPs federated in 1998 as part of the NASA-assigned prototyping activities and in recognition that a federation would assist its members in meeting project objectives. The existing Federation has embraced the nomenclature of ESIPs, and has grown to include new non-NASA-funded members. The existing Federation encourages and establishes the use of best science practices in the production of high-quality data, information, products, and services; ensures that data and information are readily accessible and easily exchanged so that Earth science data products can be developed readily; contributes to the development of an Earth science information economy through the comprehensive consideration of applications, research, and commerce; and increases the diversity and breadth of users and uses of Earth science data, information, products, and services.

In 1999, the Pathfinder Program also focused on understanding critical interactions and feedback mechanisms among physical, chemical, and biological processes. In order to study these processes, a more regional focus was required, with combined data sets consisting of the available satellite and airborne remote sensing data along with relevant in situ data for tuning algorithms and validating results.

The ESE recognizes its responsibility to assure that all the information, knowledge, and capabilities derived from its research programs achieve maximum usefulness in research, applications, and education. ESE is evolving its science data and information systems towards a more open, distributed set of data systems and service providers. This approach will capitalize on the expertise and resources of the community of providers and facilitate innovation. Implementation of this approach relies, in part, on leveraging information technologies from the commercial sector, such as web-based techniques for data discovery and access, and involving the end-user community in technology assessment and evolution. The SEEDS effort is the embodiment of this approach.

SEEDS

The guiding principles of SEEDS were defined in the NewDISS Strategy Document. SEEDS starts from the premise that systems and services must be informed by, and supportive of, science concerns and questions. It is also recognized that individual scientists and disciplinary communities of scientists are both consumers and producers of data products and derived information and therefore must be partners. Other principles relate to the issue of immediate and long-term services for a highly distributed and heterogeneous user base in the face of rapid technological change. These principles are summarized as follows:

1. Science questions and priorities must determine the design and function of systems and services.
2. Future requirements will be driven by a high data volume, a broader user base and increasing demand for a variety of data and data products.
3. Technological change will occur rapidly: systems and services must be able to take advantage of these changes.
4. Competition is a key NASA tool for selection of NewDISS components and infrastructure.
5. Principal Investigator (PI) processing and PI data management will be a significant part of future missions and science.
6. Long-term stewardship and archiving must occur.
7. NewDISS evolutionary design must move beyond data and information and towards knowledge-based systems.

The objective of the SEEDS Formulation is to recommend a framework and management strategy to enable evolution of ESE data systems towards a future network of ESE data systems and providers that:

- Leverages the capabilities and lessons learned from the EOSDIS

and other ESE data-systems efforts.
- Encourages development and evolution of heterogeneous systems and services.
- Gives systems and service providers appropriate local control over data-system design, implementation, and operation.
- Leverages competition, technology infusion, and reuse to improve system effectiveness.
- Ensures that products and services meet norms for utility and accessibility.
- Ensures that systems and products meet NASA security and survivability requirements.
- Monitors collective performance in meeting the Enterprise objectives and goals.
- Maintains sufficient organizational structure to allow effective resource management and implementation for NASA to carry out its science mission.

Formulation Approach

To achieve its objective, the SEEDS Formulation Team has set up study teams to investigate specific subjects of concern to SEEDS and make recommendations. Currently there are seven study teams with members from government agencies, universities, and industry. The seven study teams and their tasks are described below.

Standards for Near-Term Missions: The tasks of the team include considering ESE's near-term systematic-measurement missions; recommending science data, metadata, and interoperability standards for applications; and incorporating advice and experience of the mission-science community in making recommendations.

Levels of Service, Benchmarks, and Cost Estimation: This study team will work with the research and applications communities to develop the minimum and recommended levels of service for core data sets and services required from ESE data-management-service providers. It will determine, from benchmarking, what data-management services should cost, and develop a capability to perform end-to-end cost estimates for ESE data-management services.

Standards and Interfaces Processes: This study team will define a process for SEEDS to develop, adopt, evolve, and maintain standards and interfaces for data and information systems and services across the Earth Science Enterprise. The process should capitalize on the methods and experience of existing relevant data-systems standards bodies (e.g., ISO, OGC) and NASA programs (e.g., EOSDIS, ESIP Federation).

Data Life Cycle and Long-Term Archive: The tasks of this study team are to ensure safe handling of SEEDS-era data products as they migrate from data providers to active archive and long-term archive (LTA), even as numerous individuals and institutions take responsibility for the product during its life cycle.

Reference Architecture and Reuse Assessment: This study team aims to answer the following questions:

- Should NASA/SEEDS invest in a software-and-component reuse effort?
- Should NASA/SEEDS invest in developing a reference architecture?
- If NASA/SEEDS should invest in either of these efforts (i.e., reuse and/or a reference architecture), what is the best method to assure effective and accountable community involvement; what is the best technical approach?

Criteria for judging, in order of priority, were determined to be cost savings over time; increasing flexibility/responsiveness to new missions and increasing use of NASA data for research/applications; and promoting an increase in effective and accountable community participation.

Metrics Planning and Reporting: This study team will define appropriate metrics and reporting requirements for the participants in ESE Data Management Activities and demonstrate that the proposed SEEDS organization structure can provide adequate accountability.

Technology Needs and Infusion Plans: This study team will determine processes by which technology needs are identified and technology investments are infused into the evolving NewDISS. New strategies for technology infusion are being explored for the SEEDS initiative to address the gap for technology development beyond the research stage and into the mid-technology readiness levels. The study team will recommend ways for SEEDS to leverage the processes of the NASA Earth Science Technology Office's (ESTO) Advanced Information System Technologies (AIST) Program, involve the ESE user community, and designate roles of AIST and SEEDS with regard to prototyping needs.

Over the past decade, NASA ESE has made a substantial investment in the development of data and information

systems. This is most evident in the EOSDIS Core System (ECS) but also includes unique components developed by the DAACs, data processing systems developed by the instrument teams, and a variety of other capabilities that are still actively used and maintained as a result of heritage missions and initiatives. SEEDS is not intended to be a replacement of these capabilities but rather the evolution of existing systems, through improved effectiveness and efficiency of operation, and services to maximize the return on those previous investments.

The SEEDS Formulation effort has been, and will continue to be, outward looking and inclusive. Wherever appropriate, the SEEDS studies are addressing as wide a range of related activities as possible, within government, industry, and academia in the U.S. and abroad. By taking a broad view, it is expected that the recommendations that emerge from the SEEDS studies will capitalize on the extended experience base and the best practices and latest technical approaches available to achieve maximum effectiveness and efficiency in development and operation of the NASA Earth Science data and information management system.

SEEDS continues to seek the active and substantial involvement of users and providers of Earth Science data and services in the definition and execution of the SEEDS processes, practices, and policies. A number of the study teams have representatives of these communities either as members or consultants, and all of the teams individually and collectively are making every effort to interact with the community through interviews, meetings, and workshops.

Preliminary Findings and Recommendations

The SEEDS Formulation Team is presently assembling and integrating its separate study-team recommendations into a single document. Simultaneously, these findings are being circulated among various groups, including NASA Code Y advisory groups (through presentations at their meetings), the data provider and science communities (through articles and workshops), and other interested users (through talks at conferences and other venues). What follows are, at a high level, the initial SEEDS findings and recommendations.

Programmatic:

- In order to effectively govern the processes in the SEEDS era, there should be a SEEDS Program Office: Scope, location, and other details still to be determined.
- In order for the processes themselves to work, there must be community participation to the maximum extent possible in each process.
- Accountability and authority should be pushed down to the most appropriate level, even as the SEEDS Program Office is coordinating efforts.
- Working groups will be established to implement several of the major processes developed during the study phase (initially for standards, metrics, reuse, and technology infusion.)

Levels of Service/Cost Estimation:

- A comprehensive list of Levels of Service has been compiled, by function, and is available for review in Working Paper 5, available on the SEEDS website.
- An initial cost-estimation model by analogy derived from those levels of service will be completed during fiscal year 2003, but the initial database will be small.
- Levels of service and cost-estimation information should be built into future funding documents.
- A parallel effort to model costs from the PI point of view is under development.

Standards and Interfaces:

- Common standards and interfaces are critical to the effective exchange of data and information between and among data providers and users.
- In general, standards processes should: be open; encourage wide participation (users, other agencies, entities, standards bodies, etc.); encourage use of existing standards where applicable; make specific recommendations (still under review) concerning data interface, packaging, distribution, and interchange formats, and metadata and documentation standards; and provide a process for evolving and/or adopting standards
- A draft standards review/approval/adoption process has been developed (see the SEEDS site for further information)

Data Life Cycle and Long-Term Archive:

- Balance must be struck between 'save it all no matter what' and 'save only what we can afford right now.'
- Considerations of data life-cycle issues should be built into the entire process, but not be considered expendable when budgets decline.

- Complete documentation is vital to whatever is archived, no matter where it is archived.
- Missions should have a 'data point of contact' for questions about the data.
- Many internal and interagency issues must still be resolved.

Technology Infusion:
- Develop a 10+ year SEEDS capabilities vision to aid in community understanding and guide technology-infusion efforts.
- Develop a technology-infusion process modeled after successful commercial/academia/government cooperative processes (e.g., World Wide Web Communications [W3C], Open GIS Consortium [OGC]).

Metrics Planning and Reporting:
- Current funding activities are adequate to address metrics and reporting issues; current metrics are useful.
- Metrics and reporting requirements should be explicitly requested in future solicitations, and costed in responding proposals.
- Outcome metrics are needed, are currently lacking, and should be developed.

Reuse and Reference Architecture:
- ESE should actively support reuse through "improved clone-and-own" and "open source" approaches.
- Mission-critical environments should have a different approach than mission-success environments.
- Mission-critical environments are defined as driven by launch schedules and a need for daily, highly reliable production or archiving needs.
- Mission-success environments are defined as driven by need for research and innovation in science, applications, or information systems.
- ESE should develop a "coarse-grained," notional reference architecture, with concrete details in a limited set of functional areas.

What's Next?

For the moment, the SEEDS team is concentrating its effort on refining and disseminating study findings by compiling a draft study-phase-findings report, presenting SEEDS recommendations in user forums and conferences, and iterating the recommendations based on inputs received.

Over the course of fiscal year 2003, the Formulation Team will be developing a transition plan to define how the recommendations are to be implemented. This entails establishing working groups, working through allocation of roles and responsibilities, and integrating study-phase recommendations.

In the near term, we will be chartering the working groups and defining their initial set of activities, and gathering comments from the community. As of this writing, we are planning the next public workshop for February in the Annapolis area.

How Can You Contribute?

SEEDS is, by definition, an ongoing evolutionary process. Although there is no end point per se, we seek to maximize and balance both the effectiveness of ESE data systems and the involvement of its users. It is important to note here that SEEDS is not in the business of defining an overall system architecture a la EOSDIS. We will, however, provide a coordinating role for ESE data systems consistent with the principles outlined above, and with the needs of both the Enterprise and the science community.

As such, we need feedback from you, the science user. We invite you to look at the information on the SEEDS website and comment. We encourage you to attend the SEEDS workshops that are held roughly twice per year. As we present to various User Working Groups, we encourage challenging questions about relevant issues.

And, as the SEEDS Working Groups are chartered and populated, we encourage you to become involved in those processes and provide your expertise in metrics development, reuse and open-source issues, technology-infusion processes, and standards and interface issues.

Note: This article has been compiled from existing presentations, documents, and notes written for various purposes by members of the SEEDS Formulation Team. Please feel free to contact the author of this article with questions, concerns, or comments about SEEDS.

Thirty Years of Airborne Research at the University of Washington

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After more than 30 years of airborne studies, the Cloud and Aerosol Research Group (CARG) at the University of Washington has flown its last research flight. The CARG, under the direction of Professor Peter Hobbs, has owned and instrumented three aircraft for atmospheric research purposes. From a research standpoint, the unique feature of all three aircraft was that they were equipped with state-of-the-art instrumentation for the measurement of aerosols, trace gases, cloud structures, and radiation. This made it possible for the CARG and its collaborators to carry out pioneering studies in many areas of atmospheric sciences.

Brief History

In the early 1960s, the research work of the CARG revolved around laboratory simulations and theoretical studies of cloud processes. In the late 1960s, the CARG started to do ground-based field studies of aerosols and clouds, including measurements from a field station near 8000 ft. on Mt. Olympus in the Olympic National Park.

In 1970, the CARG obtained its first research aircraft, a World War-II Douglas B-23, previously owned by Howard Hughes (**Figure 1a**). Between 1970 and 1984 the CARG flew 3400 hours on the B-23. Data collected on these flights provided the basis for some 80 scientific papers and 30 student theses on subjects ranging from atmospheric aerosol and cloud chemistry to cloud physics and mesoscale meteorology. Large field projects of note were: the Cascade Project (1970-1974), in which the structures of clouds and the formation of precipitation over the Cascade Mountains, and their modification by cloud seeding, were studied; and, the Cyclonic Extratropical Storms (CYCLES) Project (1973-1986), which was concerned with cloud microphysics and the mesoscale organization of rainfall in cyclonic storms in the Pacific Northwest. The demonstration that color-display Doppler radars can be used to track mesoscale cloud and rainfall features was first shown in the CYCLES Project, some 20 years before it was to be used routinely by television weather forecasters. The B-23 was also used in some of the first airborne studies of volcanic effluents: Mt. Baker (in 1975), several volcanoes in Alaska and, most spectacularly, Mt. St. Helens in 1980.

In 1984, the B-23 was replaced by the considerably larger Convair C-131A (**Figure 1b**), which the CARG fitted with state-of-the-art instruments for studying atmospheric aerosols, clouds, atmospheric chemistry and radiation. Studies with the Convair C-131A over the next 12 years focused on the structures of clouds (with emphasis on ice in clouds), the effects of clouds on solar radiation, pollution in the Arctic, the properties of smoke and its effects on climate, the chemistry of the marine atmosphere, and aerosol-cloud interactions. Of particular note were the CARG's studies of smoke from the 1991 Kuwait oil fires, extensive study of smoke from biomass burning in the Amazon Basin as part of the Smoke Clouds and Aerosol—Brazil (SCAR-B) experimental campaign in 1995, and studies of cloud structures and the organization of precipitation on the East Coast and in the Central United States. The latter studies led to a new conceptual model known as the Structurally Transformed by Orography Model (STORM) for cyclones west of the Rockies. Some other studies with the C-131A include the Monterey Area Ship Track (MAST), the Arctic Radiation Measurement in Column Atmosphere-surface System (ARMCAS), and the Tropospheric Aerosol Radiative Forcing Observational Experiment (TARFOX).

In March 1997 the CARG obtained a Convair-580 aircraft (**Figure 1c**). Within a year of receiving the Convair-580 the CARG had modified it for research purposes, transferred to it some of the research instrumentation from the Convair C-131A, and added new instruments. This made it one of the best equipped aircraft in the world for measurements of trace gases, atmospheric aerosols, clouds, and radiation.

Recent Research

The first field project with the Convair-580 was the First International Satellite Cloud Climatology Project [ISCCP] Regional Experiment—Arctic Clouds

FIGURE 1:These photographs show the three different aircraft that have been employed by the Cloud and Aerosol Research Group (CARG) at the University of Washington. These include: (a) A World War-II era Douglas B-23, previously owned by Howard Hughes—**Photo Credit**: University of Washington Clouds and Aerosol Research Group (CARG); (b) a considerably larger Convair C-131A—**Photo Credit**: CARG; and (c) a Convair-580 aircraft. Each was modified to be equipped with scientific instrumentation for studying clouds and aerosols—**Photo Credit**: NASA Dryden Flight Research Center.

Experiment/Surface Heat Budget of the Arctic Ocean (FIRE-ACE/SHEBA) in the Arctic in the spring of 1998. In this large cooperative project, the Convair-580 flew 23 flights over the Arctic Ocean, many above a research ship frozen into the Arctic ice. The measurements obtained from the Convair-580 are being compared to remote sensing measurements from the ship, satellites, and the NASA ER-2 high-altitude aircraft. Extensive measurements were also obtained from the Convair-580 on aerosols and cloud structures in the Arctic, and the reflectivity properties of various ice surfaces. These data are being used to increase understanding of aerosol-cloud-climate interactions in the Arctic.

In 1999, the Convair-580 was used to study convective clouds over the western tropical Pacific Ocean in the Kwajalein Experiment (KWAJEX), and to determine how well precipitation from these clouds can be monitored from the Tropical Rainfall Monitoring Mission (TRMM) satellite.

Summer 2000 saw the Convair-580 in southern Africa for the South African Regional Science Initiative—2000 (SAFARI 2000) field project. Thirty-one research flights were carried out in five countries for the purpose of obtaining *in situ* measurements of aerosols and trace gases for comparison with remote sensing measurements from the NASA Terra satellite, ER-2 aircraft, and ground-based instruments; to measure emissions from biomass burning and industries; to study regional hazes; and to investigate cloud structures off the west coast of southern Africa.

In the winter of 2000-2001, the CARG carried out the first phase of the Improvement of Microphysical Parameterizations through Observational Verification Experiments (IMPROVE) field project. The goals were to obtain measurements of the microphysical structures of precipitating systems within a dynamical framework for the purpose of improving the representation of cloud and precipitation processes in mesoscale models. IMPROVE-1 concentrated on frontal systems off the coast of Washington State. During the winter of 2001-2002, IMPROVE-2 studied orographic systems over the Oregon Cascades.

The CARG, with the Convair-580, participated in the Chesapeake Lighthouse and Aircraft Measurements for Satellites (CLAMS) field study off the Delmarva Peninsula, USA, in the summer of 2001. Airborne measurements were made to validate NASA EOS-Terra data products.

CARG's Legacy

After more than 30 years of science missions, the CARG closed down its aircraft flight facility at the end of 2001. The productivity and value of the CARG's work over the past 30 years is probably best indicated by its over 300 publications, the more than 60 graduate students who have received their M.S. or Ph.D. degrees for research carried out in the CARG, and its training of many scientists in airborne research (both the current and former Director of the National Center for Atmoshperic Research's (NCAR's) aviation facility, and the current Director of the National Science Foundation (NSF)/NCAR's High-performance Instrumental Airborne Platform for Environmental Studies (HIAPER) Project Office, are all former CARG students). Although the CARG has flown its last aircraft, its research will continue, concentrating on the analyses of the many large data sets collected in recent years.

The "Firemapper™" Airborne Sensor and Flight Plans to Support Validation of MODIS Fire Products over Brazil

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In the context of the joint NASA-Ministry of Science and Technology of Brazil's Large Scale Biosphere-Atmosphere Experiment in Amazônia (LBA), a validation campaign has been designed to address MODIS (Moderate Resolution Imaging Spectroradiometer) fire-product quality over the Amazon basin. To accomplish this task, data from both high-resolution Earth Observing System (EOS) spaceborne sensors, such as the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) and Landsat 7 Enhanced Thematic Mapper Plus (ETM+), and airborne missions will be used. The airborne instrument, called Firemapper™, comprises two digital cameras and an infrared sensor based on an uncooled detector array. Five primary areas were chosen as potential core sites; these were areas with the highest fire frequency during previous years. Flight lines will be planned to match coincident satellite overpasses, providing high-spatial -resolution data (down to 1.5 m @ 10000-feet flight altitude). This article describes the Firemapper™ instrument and its current flight plans.

Introduction

Satellite monitoring of vegetation fires over the Brazilian Amazon forest has proven to be of exceptional value in the past decade. Given the large aerial extent and the limited number of roads in the region, observations from above are the only practical way to track land-cover dynamics in the Amazon basin. As a result, satellite data from NOAA's Advanced Very High Resolution Radiometer (AVHRR) have been used effectively since the 1980´s by the national fire-monitoring facility of the Brazilian Institute for the Environment and Natural Renewable Resources (IBAMA). During this time, a number of aircraft-based validation campaigns were conducted in cooperation with the U.S. Forest Service (USFS) to address satellite data quality and other fire-related issues such as emission factors and area burned (Riggan et al., 1993; Miranda et al., 1996; Miranda et al., 1997).

With the launch of the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor onboard the Terra and Aqua spacecraft, a new set of satellite derived fire products became available (Justice 2002). In order for IBAMA to explore these data sets to their full extent and use them operationally, it is necessary to validate these products. With this purpose in mind, a cooperative group from NASA Goddard Space Flight Center, University of Maryland, and IBAMA was established to quantify the uncertainty in satellite-derived active fire and burn-scar products concentrating primarily on new MODIS fire products. The group will also investigate land-cover-change dynamics and their relations with fire. This work is part of the LBA-Ecology Phase II program. The fundamental data set for this study will be the airborne Firemapper™ imagery.

The Firemapper™ System

IBAMA, through a cooperative agreement with the USFS, has been participating in different airborne data-acquisition campaigns flown over Brazil since the very early stages of the development of that nation's national fire-monitoring system. Many airborne campaigns have been scheduled and flown since 1991, when the cooperative agreement between IBAMA and USFS was first signed. During this time, a variety of airborne configuration systems were used, from small twin-engine propeller aircraft (like the USFS Piper Navajo) to high-speed-high-altitude jet aircraft (like the Brazilian Air Force Learjet). These flights have involved various imaging sensors, including NASA's Airborne Infrared Disaster Assessment System (AIRDAS), a four-band cryogenic-cooled infrared sensor, and most recently the SIVAM (a Brazilian program for monitoring the Amazon Forest) multi-spectral scanner (MSS) mounted on a Brazilian Air

Force EMBRAER-145 regional jet aircraft.

The experience gained during previous airborne campaigns helped both IBAMA and the USFS address the most important aspects of the science behind airborne-data acquisition. As a result, in 1998 the USFS - Pacific Southwest Research Station, started working on the development of an instrument called Firemapper™. This instrument was designed to have the major characteristics needed to accurately sense active fires and land-cover conditions associated with burning, deforestation and selective harvesting. Firemapper™ was designed and fabricated by Space Instruments, Inc., of Encinitas, CA, with funding from the U.S. Department of Agriculture (USDA).

Firemapper™ is made of two sensor components: a 3-band microbolometer infrared sensor and a pair of visible/NIR digital cameras (details of these components are given below). The system includes a server for data acquisition and recording during flight. The Firemapper™ infrared sensor design was based on a microbolometer sensor built previously by Space Instruments for NASA. This space sensor called Infrared Spectral Imaging Radiometer (ISIR) was flown successfully by NASA as an experiment on shuttle mission STS-85 in 1997. During this mission, over 50 hours of multispectral data were collected at 240-meter spatial resolution (Hoffman et al., 1998). ISIR was the first demonstration of an uncooled microbolometer sensor in space.

FIGURE 1: This is a photograph of the Firemapper(tm) airborne system. The system consists of two visible/near-infrared digital cameras and an infrared microbolometer sensor.

The Firemapper™ sensors cover approximately 35 degrees in the cross-flight direction and map contiguously in the direction of flight in all 5 spectral bands. The 16-bit dynamic range allows accurate fire-intensity measurements to be made without saturation. An internal calibration system provides accurate absolute calibration of the entire optical, detector, and electronics train. A photograph of the Firemapper™ airborne system is shown in **Figure 1**.

Visible Bands - Digital Cameras

The visible bands of the Firemapper™ were designed based on two Kodak Megaplus 1.6i digital cameras, each containing 1.6 million pixels. Triggering can be selected at frame intervals down to 1.5 seconds to obtain desired image overlap in the flight direction. Camera integration is also selectable down to 1 msec to accommodate a wide range of scene conditions. The Instantaneous Field of View (IFOV) of the digital cameras is 0.375 mrad, and the crosstrack field of view is 32.8º. Given these characteristics, the total number of usable pixels per image frame is 1528 rows x 1024 columns. This configuration produces the curves shown in **Figure 2**, from which ground-pixel area and total frame swath can be calculated according to flight conditions. The two digital cameras have spectral filters at 615-685 nm and 815-885 nm to obtain Normalized Difference Vegetation Index (NDVI) maps of the vegetation and allow the detection of vegetation-cover disturbance.

The cameras are mounted on an aluminum base plate fixed to the aircraft's bottom compartment, specially designed for receiving the instrument. Both cameras are controlled by software installed in the Firemapper™ server, where the operator can set different parameters to adjust image acquisition for frame exposure, gain and trigger timing (among others), depending on flight altitude and desired image overlapping. The in-flight operator can modify any of the parameters for best results and highlight frames containing special features during image acquisition, facilitating the job of image selection after landing.

IR Sensor

The microbolometer is based on the concept of an uncooled-detector array. This technology eliminates the need of cryogenic cooling, making operation simpler and reducing instrument total weight. The infrared bands utilize a single uncooled microbolometer detector array and operate without mechanical scanning. The detector array features an internal calibration system and automatic drift correction to obtain stable, highly calibrated radiometric measurements. The three infrared spectral bands are separated as follows: (i) 8.2 to 9.0 μm (to line up with MODIS band 29 at 8.55 μm); (ii) 11.5 to 12.5 μm (to match AVHRR channel 5 and MODIS band 32); and (iii) 8.0 to 12.5 μm (for wideband, maximum sensitivity imaging). Flame temperatures and radiant intensities

can be calculated from the 8.5-μm and 12-μm band data. The instrument field-of-view (IFOV) of this sensor is 1.85 mrad and the crosstrack field of view is 34.7°. Total number of usable pixels amounts to 327 rows x 245 columns. As in the case of the visible bands, the system operator controls image parameters (frame rate in hertz, scan mode, filter selection, among others), data recording, and management.

Airborne Data Acquisition System

The Firemapper™ onboard system control is accomplished by a Micron NetFrame server mounted in the aircraft's passenger compartment. The equipment can hold up to six 18 GByte removable hard disks of high-speed data-recording capacity. These disks can be taken out of the aircraft for transfer to another computer, erased and reused in another flight.

A real-time display of any of the spectral images is available to the in-flight operator through a flat-screen LCD monitor. The operator can control image display features (color palette), zooming, and make all modifications regarding flight parameters. All of the five spectral images are automatically tagged with a header containing GPS coordinates, flight speed, and acquisition parameters.

Software has been specifically designed for visualizing and preprocessing Firemapper™ images. The software performs image selection, and resampling, and creates images in standard formats that can be exported to other image-processing software.

Individual image referencing is accomplished through an 8-channel XTS/III Motorola ONCORETM GPS receiver that is integrated to the Firemapper™ system's operating server. Information on frame acquisition date, time, central latitude and longitude, aircraft speed and heading are automatically fed into the file header where it can be used for post-flight image georeferencing.

An Example of Firemapper™ Observations

Firemapper™ was completed in August 2000 and taken to Brazil in September 2000 for flight demonstrations over the Amazon region. The Firemapper™ imagery was collected coincident with IBAMA field experiments, flown in a Piper Navajo research aircraft owned and operated by the Pacific Southwest Research Station of the USFS. Several fires and agricultural areas in the Amazon region were mapped in these initial flight experiments.

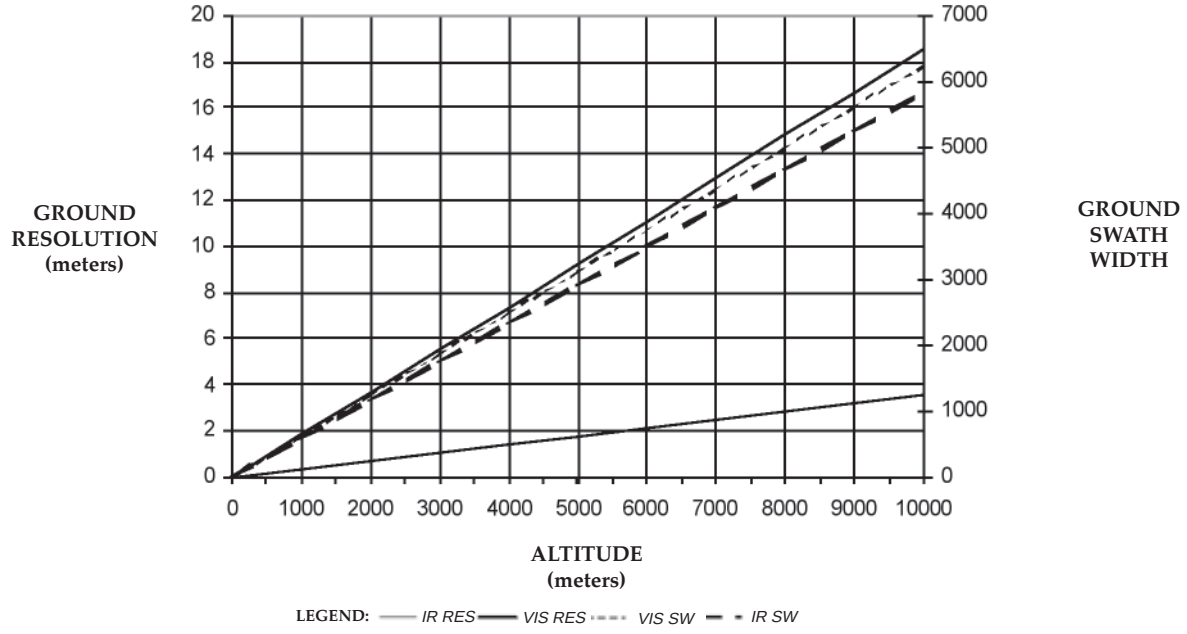


FIGURE 2: This graph shows Firemapper(tm) image acquisition properties for different flight altitudes.

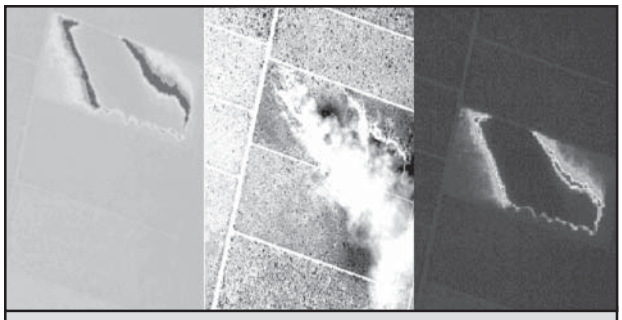


FIGURE 3: The above images of a fire at the IBGE Ecological Reserve in Brasília, Brazil were acquired September 19, 2000, using Firemapper™. The 8.5-µm image is on the left, the visible band is in the center, and the 12-µm image is on the right.

Figure 3 shows images of a fire at the Brazilian Institute of National Statistics and Geography (IBGE) Ecological Reserve in Brasília taken on September 19, 2000, with the Firemapper™ system. The infrared imagery illustrates the capability to detect temperature variations within the flames. The visible imagery is not able to resolve within-flame variability, but clearly shows the location of the most intense flames and the smoke plume.

Planned Flight Areas

Having over 60% of its continental area originally covered by the Amazon Forest, Brazil plays a major role in tropical land-cover dynamics. This large extent of forested areas, together with the widespread use of fire as a mechanism for land management results in a high number of vegetation fires being observed every year (*www2.ibama.gov.br/proarco*). This is particularly true for the Arc of Deforestation, a 1.6 million-km^2 area separating the dense Amazon forest from the surrounding cerrado (savanna) vegetation. In this area, thousands of vegetation fires are detected every year from June to October, when the combination of reduced rainfall, high temperatures, and low air humidity creates ideal conditions for fire to spread. Out of the seven Brazilian states covered by the Arc of Deforestation, Pará is most impacted. Three sites in Pará appear as the leading locations in terms of the number of vegetation fires detected and are thus included in this study. Furthermore, there are two distinct fire seasons in Brazil; the second affects the state of Roraima during the months of December through March every year. Thus, a fourth site was chosen in Roraima. This also feeds the study with a more-periodic flow of data.

Following the hot spot frequency maps derived from NOAA/AVHRR detection during the last four years (July 1998 - July 2002), four potential areas were selected for the study. These are:

1. Santa Maria das Barreiras, state of Pará: central coordinate 50º 48' 00"W, 08º 30' 00"S;
2. São Felix do Xingu, state of Pará: central coordinate 51º 36' 00"W, 06º 12' 00"S;
3. Marabá, state of Pará: central coordinate 49º 12' 00"W, 05º 24' 00"S;
4. Boa Vista, state of Roraima: central coordinate 60º 54' 00"W, 02º 42' 00"N.

A related LBA investigation comprises Foster Brown's et al. sites in the state of Acre (*lba-ecology.gsfc.nasa.gov/cgi-bin/web/investigations/inv_abstracts.pl*), located in the western-most region of the Arc of Deforestation, where some complementary studies on vegetation fire research are being carried out. If budget and time allows, Firemapper™ imagery will be acquired over Acre to complement the work of Brown et al.

The aircraft selected for use during the LBA airborne campaigns is a Bandeirante-EMB 110 owned and operated by the National Institute for Space Research (INPE) in Brazil. The aircraft is specially designed for remote sensing activities with its original frame modified to accommodate a variety of instruments. The base plate where both visible and IR sensors are mounted is fixed to the bottom of the aircraft.

For all sites, data acquisition requests will be submitted to obtain coincident Terra/ASTER and Landsat/ETM+ imagery as well as data from the experimental fire satellite Bi-spectral Infrared Detection (BIRD) – *spacesensors.dlr.de/SE/bird/*).

References

Hoffman, J. W., K. Cashman, R. Grush, K. Manizade, J. Spinhirne, 1998: ISIR (Infrared Spectral Imaging Radiometer) flight results from shuttle mission STS-85. *SPIE Optical Science & Instrumentation '98 Symposium*.

Justice, C. O., L. Giglio, S. Korontzi, J. Owens, J.T. Morisette, D. Roy, J. Descloitres, S. Alleaume, F. Petitcolin, and Y. Kaufman, 2002: The MODIS Fire Products. *Remote Sensing of Environment*.

See FIREMAPPER; page 45

Kudos

Vince Salomonson Receives Nordberg Award

The William Nordberg Memorial Award for Earth Sciences is given each year to an Outstanding Leader in NASA's Earth Observing System. Salomonson, a senior scientist for NASA's Earth Science Directorate and team leader for the Moderate Resolution Imaging Spectroradiometer (MODIS) instruments on both Terra and Aqua, was the 2002 recipient. The award was presented at the November 15 Scientific Colloquium during the William Nordberg Memorial Lecture presented by Eric G. Adelberger from the University Of Washington. Salomonson is the ninth recipient since the Goddard honor was first introduced in 1994.

NASA and Department of Interior (DOI) Honor Achievements in Remote Sensing

NASA and DOI officials presented the 2001 and 2002 William T. Pecora award, a prestigious federal award given to individuals and groups for contributions in remote sensing at a ceremony in Denver, Colorado.

The **2001** award winners were:

- Ronald J. P. Lyon
- The Landsat 7 Team

The **2002** award winners were:

- Ichtiaque Rasool
- The Upper Atmosphere Research Satellite Team.

Mary Cleave, Deputy Associate Administrator for Earth Science (Advanced Planning) in the NASA Office of Earth Science, and U.S. Geological Survey (USGS) Regional Director **Tom Casadevall**, representing the DOI, presented the award at the annual Pecora 15/Land Satellite Information IV Symposium.

The award, sponsored jointly by NASA and the DOI, recognizes outstanding contributions to the understanding of the Earth by means of remote sensing. It has been presented annually since 1974 in memory of William T. Pecora, whose early vision and support helped establish what we know today as the Landsat satellite program. Pecora was Director of the USGS from 1965-71, and later served as Undersecretary, Department of the Interior, until his death in 1972.

The Earth Observer staff congratulates these individuals and teams for their achievements.

Shifts in Rice Farming Practices in China Reduce Methane Emissions

— *Krishna Ramanujan, kramanuj@pop900.gsfc.nasa.gov, NASA Goddard Space Flight Center*
— *Sharon Keeler, sharon.keeler@unh.edu, University of New Hampshire*

Excerpts taken from Press Release No. 02-172. For more information and full release, please see www.gsfc.nasa.gov/topstory/2002/1204paddies.html.

Changes to farming practices in rice paddies in China may have led to a decrease in methane emissions, and an observed decline in the rate that methane has entered the Earth's atmosphere over the last 20 years, a NASA-funded study finds.

Changsheng Li, a professor of natural resources in the University of New Hampshire's Institute for the Study of Earth, Oceans, and Space, and lead author of the study, notes that in the early 1980s Chinese farmers began draining their paddies midway through the rice growing season when they learned that replacing a strategy of continuous flooding would in fact increase their yields and save water. As an unintended consequence of this shift, less methane was emitted out of rice paddies.

Methane is 21 times more potent as a greenhouse gas than carbon dioxide (CO_2) over 100 years. At the same time, since 1750, methane concentrations in the atmosphere have more than doubled, though the rate of increase has slowed during the 1980s-90s.

"There are three major greenhouse gases emitted from agricultural lands—carbon dioxide, methane and nitrous oxide," said Li. "Methane has a much greater warming potential than CO_2, but at the same time, methane is very sensitive to management practices." Currently, about 8 percent of global methane emissions come from the world's rice paddies.....

..... The researchers have spent more than 10 years developing a biogeochemical model, called the Denitrification-Decomposition (DNDC) model, which handles all the major factors relating to methane emissions from rice paddies. These factors included weather, soil properties, crop types and rotations, tillage, fertilizer and manure use, and water management. The model was employed in the study to scale up the observed impacts of water management from the local sites to larger regional scales. Remotely sensed data from the NASA/U.S. Geological Survey Landsat Thematic Mapper (TM) satellite were utilized to locate the geographic distributions and quantify the acreage of all the rice fields in China. A Geographic Information System data base amended with this Landsat data was constructed to support the model runs at the national scale and to predict methane emissions from all rice fields in the country.

The researchers adopted 1990 as a mean representative year as they had detailed, reliable data for that year, and then ran the model with two water management scenarios to cover the changes in farming practices from 1980 to 2000. The two scenarios included continuous flooding over each season, and draining of paddy water three times over the course of each season.

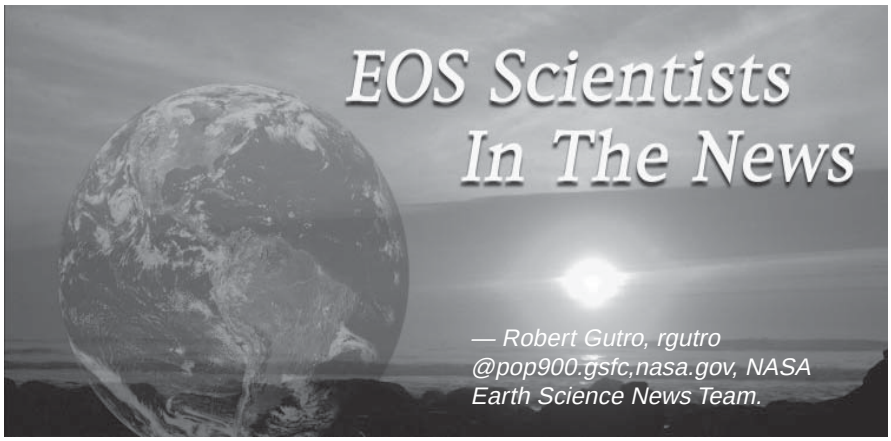
When the two model runs were compared, the researchers found that methane emissions from China's paddy fields were reduced over that time period by about 40%, or by 5 million metric tons per year, an amount roughly equivalent to the decrease in the rate of growth of total global methane emissions.

"The modeled decline in methane emissions in China is consistent with the slowing of the growth rate of atmospheric methane during the same period," Li said. "Still, more work will be needed to further verify the relationship demonstrated in this study with limited data points."

Demand for rice in Asia is projected to increase by 70% over the next 30 years, and agriculture currently accounts for about 86% of total water consumption in Asia, according to a recent report from the International Rice Research Institute. Changes to management practices like this will be more important and likely in the future as the world's water resources become increasingly limited, Li said.

"Just like the Chinese farmers did, if farmers around the world change management practices, we can increase yields, save water and reduce methane as a greenhouse gas," Li said. "That's a win-win situation."

The study, which appears in the print version of *Geophysical Research Letters* in late December, was funded by NASA through grants from the multi-agency Terrestrial Ecosystems and Global Change Program, and also NASA's Earth Science Enterprise.



Measurements in Lake Pontchartrain, Nov. 28; *Times-Picayune*. **Richard Miller** (NASA Stennis) is using remote sensing to measure the incidence and causes of re-suspension in Louisiana's Lake Pontchartrain.

The Arctic Perennial Sea Ice Could Be Gone By End Of The Century, Nov. 27; *CBS Evening News, CNN, CBS Newspath*. Estimated audience for the story so far is 14 million. **Josefino Comiso** (NASA Goddard) found that perennial sea ice in the Arctic is melting faster than previously thought—at a rate of 9 percent per decade. If these melting rates continue for a few more decades, the perennial sea ice will likely disappear entirely within this century, due to rising temperatures and interactions between ice, ocean, and the atmosphere that accelerate the melting process.

NASA Maps Lewis and Clark's Trails, Nov. 26, *NASA Commercial Technology Network*. **Marco Giardino** (NASA Stennis) directed a project using remote sensing to create precision 3-D maps and visualizations of Lewis and Clark's trail and campsites. The project coincides with the upcoming Lewis and Clark bicentennial commemoration and examines how the ecosystem has changed in the last 200 years.

Study Shows Global Warming Will Devastate Water in West, Nov. 21; *CNN*. Global warming will have a devastating effect on water availability in the Western United States over the next 25 to 50 years, a new national climate forecasting effort says. **Dennis Lettenmaier** (U-WA) and **Bill Patzert** (JPL) were quoted.

Scientists Dismiss 'Chemical Trail' Theories, Nov. 18; *Durango, CO Herald*. **Paul Newman** (NASA Goddard) and **B. Owen Toon** (U-CO-Boulder) said there is nothing dangerous about the white contrails from aircraft that a New Mexico scientist and some Durango-area residents say are causing sickness and drought around the county.

NASA Satellite Flies High to Monitor Sun's Influence on Ozone, Nov. 15; *Spacedaily, Comsiverse, UPI*. **Gary Rottman** (U-CO) and **Charles Jackman** (NASA Goddard) explained that in October, the Upper Atmosphere Research Satellite (UARS) completed the first measurement of the solar ultraviolet radiation spectrum over the duration of an 11-year solar cycle, a period marked by cyclical shifts in the Sun's activity.

New Method Strikes an Improvement in Lightning Predictions, Nov. 7, *Cosmiverse, Honolulu Star Bulletin, Der Wissenschaft (Scientific Germany), ScienceDaily, The Weather Channel, Village 2 on-line (42 Canadian Newspapers)*. **Steve Businger** and **Robert Mazany** (both U-HI), discuss a new lightning index that uses measurements of water vapor in the atmosphere from Global Positioning Systems and has improved the lead-time for predicting the first lightning strikes from thunderstorms.

Ocean Temperatures Affect Intensity of South Asian Monsoons, Nov. 7; *UPI, SpaceDaily, Cosmiverse*. **Man Li Wu** (NASA Goddard) says warmer or colder sea surface temperatures affect the Madden-Julian Oscillation, a large-scale atmospheric circulation that regulates rainfall associated with South Asian and Australian monsoons.

Transition from El Niño to La Niña Affected Vegetation, Nov. 6, *ScienceDaily, Cosmiverse*. **Compton Tucker**, **Assaf Anyamba** and **Bob Mahoney** (all NASA Goddard) have used satellite data to show that shifts in rainfall patterns from one of the strongest El Niño events of the century in 1997 to a La Niña event in 2000 significantly changed vegetation patterns over Africa.

Changing Rain Patterns Could Ruin Crops, Oct. 31, *Weather Channel, Der Wissenschaft Scientific Germany, Edie.com, Environment News Service, UPI*. **Cynthia Rosenzweig** and **Francesco Tubiello**, (NASA Goddard Institute for Space Studies and Columbia Univ.) found that an increased frequency of extreme precipitation events has been observed over the last 100 years in the United States. Using computer climate and crop-model simulations, they predict that U.S. agricultural produc-

tion losses due to excess rainfall may double in the next 30 years, resulting in an estimated $3 billion per year in damages.

NASA Joins International Ozone Study in Arctic, Oct. 31, *Cosmiverse.com, Spaceflightnow.com, US Global Change Research Program*. NASA researchers will join more than 350 scientists from the United States, the European Union, Canada, Iceland, Japan, Norway, Poland, Russia, and Switzerland this winter to measure ozone and other atmospheric gases using aircraft, large and small balloons, ground-based instruments, and satellites.

NAUTILUS Project, Oct. 15, *Spacedaily.com*. **Rodney McKellip** (NASA Stennis) is managing a Regional Earth Science Applications Centers project, the Northeast Application of Usable Technology in Land Planning for Urban Sprawl, or NAUTILUS, developed to make data from satellites such as Landsat 7, Terra, Aqua, and Jason-1 available to decision makers at the local level.

NASA Developing Tools to Track and Predict West Nile Virus, Oct. 7; *Ananova, CNN, Spacedaily, CBS, NBC, ABC news and many more*. 175 total stories were picked up in the top 200 markets; 20 live television interviews. Audience estimate: 12 million viewers. **Robert Venezia** (NASA HQ), program manager for NASA's Public Health Applications Program, said NASA researchers are developing tools that may one day allow public health officials to better track and predict the spread of West Nile Virus. NASA hopes to provide people on the front lines of public health with innovative technologies, data, and a unique vantage point from space through satellites, all tailored into useful maps and databases for streamlining efforts to combat the disease.

Land Use Alters Climate, Oct. 2, 2002; *BBC, CNN, Coloradoan Newspaper, Cosmiverse, Der Wissenschaft Germany, Earthwatch Radio, Environment News Service, Washington Times, and many more*. A study by **Roger Pielke, Sr.**, an atmospheric scientist at Colorado State University, Fort Collins, CO, points to the importance of also including human-caused land-use changes as a major factor contributing to climate change.

Ozone Hole Splits in Half, Sept. 30, *ABC, CBS, CNN Newssource, Australian Broadcasting, Ananova, Canadian Broadcasting Corp., Chicago Sun Times, Discovery Channel, Fox News, India Times, MSNBC, Newsday, NY Times, Philadelphia Inquirer, Reuters, The Weather Channel., and many more*. The story ended up in virtually every top 20 U.S. media market. Estimated total audience between 25-30 million. **Paul Newman** (NASA Goddard) and scientists from the Commerce Department's National Oceanic and Atmospheric Administration (NOAA) have confirmed that the ozone hole over the Antarctic this past September was not only much smaller than it was in 2000 and 2001, but has split into two separate "holes."

Firemapper™

Continued from page 41

Miranda, A. C.; H. S. Miranda, J. Grace, J. Lloyd, J. McIntyre, P. Meier, P. J. Riggan, R. N. Lockwood, and J. A. Brass, 1996: Fluxes of CO_2 over a Cerrado sensu stricto in Central Brazil. In. *Amazonian Deforestation and Climate*. J. H. Gash; C. A. Nobre; J. M. Roberts and R. L. Victoria (Eds.). John Wiley and Sons, Chichester, 353-363.

Miranda, A.C.; H. S. Miranda, J. Lloyd, J. Grace, J. A. Francey, J. McIntyre, P. Meir, P. J. Riggan, R. N. Lockwood, and J. A. Brass, 1997: Fluxes of carbon, water and energy over Brazilian cerrado: an analysis using eddy covariance and stable isotopes. *Plant, Cell and Environment*, **20:315-328**.

Riggan, P. J., J.A. Brass, R. N. Lockwood, 1993, Assessing Fire Emission from Tropical Savanna and Forests of Central Brazil. *Photogrammetric Engineering & Remote Sensing*, **59:6**.

Earth Science Education Program Update

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

PUMAS—Practical Uses of Math And Science: The On-Line Journal of Math and Science Examples for Pre-College Education

Here's an opportunity to make a high-impact contribution to K-12 education with a relatively small investment of time and effort. PUMAS is an on-line journal of brief examples illustrating how math and science concepts taught in pre-college classes are actually used in everyday life. PUMAS examples may be activities, anecdotes, descriptions of "neat ideas," formal exercises, puzzles, or demonstrations, written primarily by scientists, in any style that serves the material well. They are intended mainly to help K-12 teachers enrich their presentation of science and math in the classroom. All examples are distributed via the PUMAS web site.

All submissions are peer-reviewed by at least one scientist with a relevant background, and at least one teacher at an appropriate grade level. Once accepted, an example is a citable reference in a refereed science education journal, and may be listed in your resume. Teachers can search the PUMAS collection based on curriculum topic, grade level, or subject. They can select relevant examples and develop ideas of their own about how to integrate the material into their lesson plans.

Interested in participating? The examples are available to everyone via the PUMAS web site—*pumas.jpl.nasa.gov*. Teachers at all grade levels, scientists, and engineers are needed to serve as volunteers for the pool of PUMAS reviewers. Good examples of the Practical Uses of Math And Science are always welcome.

Sun-Earth Day 2003: Live from the Aurora

Students and educators are invited to "Join the Search" in February in preparation for NASA's Sun-Earth Day 2003. There are many exciting opportunities for both formal and informal education communities leading to Sun-Earth Day on March 18th. For example, a documentary, "Auroras—Living with a Star," will air on February 11 and will be divided into short video segments by topic and placed online. Each topic will be supported with a series of activities including a web quest. Sun-Earth Day 2003 will introduce educators to a new and exciting method to involve students with real NASA data called the Student Observation Network. To learn more about these, as well as the many other exciting events, programs, activities, and resources leading up to Sun-Earth Day 2003, visit sunearth.gsfc.nasa.gov.

ChemMatters Magazine: Special Issue on NASA's EOS Aura Mission

ChemMatters is an award-winning quarterly magazine for high school chemistry students. Each issue includes articles that reveal chemistry at work in everyday life. A teacher's guide is available which provides additional information on articles, follow-up hands-on activities, classroom demonstrations, and additional resources. The September 2002 issue is the second in a series designed to tell the story of NASA's Aura mission, which will study the chemistry of our changing atmosphere. This issue focuses on people: the fascinating stories of the scientists and engineers behind the mission. It is downloadable as a PDF file with an accompanying teachers' guide at www.chemistry.org/portal/. Simply search on EOS Aura (top left) and you will be directed to the proper sites.

Science and Applications News

For the latest NASA Earth Science Enterprise news, visit the NASA Earth Observatory (*earthobservatory.nasa.gov*), or Science@NASA (*science.nasa.gov*).

EOS Science Calendar

January 29-30

CERES Data Products Workshop, Norfolk, VA. Contact: Shannon Lynch, Email: s.m.lynch@larc.nasa.gov, URL: asd-www.larc.nasa.gov/ceres/DP_wkshp/.

February 12-14

Committee on Earth Observation Satellites (CEOS) Working Group on Calibration and Validation (WGCV)—Plenary 20, Hobart, Australia. Contact: Jeffrey Privette, Email: privette@ltpmail.gsfc.nasa.gov, URL: www.wgcvceos.org/index1.htm.

February 25-28

2003 AVIRIS Earth Science and Applications Workshop, Pasadena, CA. Contact: Robert Green, Email: rog@mail2.jpl.nasa.gov.

March 18-20

3rd SEEDS Public Workshop, Annapolis, MD. Contact: Kathy Fontaine, Email: Kathleen.S.Fontaine@nasa.gov, URL: www.westoverconferences.com.

March 18-21

Aura Science Team Meeting, Greenbelt, MD. Contact: Anne Douglass, Email: Anne.R.Douglass@nasa.gov.

Global Change Calendar

February 9-13

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

February 13-18

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

March 11-13

Eleventh Annual Workshop on Adaptive Sensor Array Processing (ASAP 2003), Boston, MA. Contact: James Ward, Email: jward@ll.mit.edu, URL: www.ll.mit.edu/asap.

March 31-April 2

Challenging Times:Towards an operational system for monitoring, modeling, and forecasting of phenological changes and their socio-economic impacts, Wageningen, The Netherlands. Contac: Mark Grutters, Email Mark.Grutters@wur.nl, URL: www.dow.wau.nl/msa/epn/challengingtimes/

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 2-3

16th Annual Geographic Information Sciences Conference, Towson University, Baltimore, MD. Contact John Morgan, tel. (410) 704-2964, Fax: (410) 704-3888, Email: jmorgan@towson.edu, URL: cgis.towson.edu/tugis2003.

May 5-8

Final Open Science Conference, "A Sea of Change: JGOFS Accomplishments and the Future of Ocean Biogeochemistry.," Washington, DC. URL: usjgofs.whoi.edu/osc2003.html

June 4-6

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

August 30-September 6

Second International Swiss NCCR Climate Summer School: "Climate Change – Impacts of Terrestrial Ecosystems." Grindelwald, Switzerland. Contact: Kaspar Meuli, Email: nccr-climate@giub.unibe.edu, URL: www.nccr-climate.unibe.ch.

September 8-10

Sixth Baiona Workshop on Signal Processing in Communications, Baiona, Spain. Contact Carlos Mosquera, Email: baiona03@baionaworkshop.org, URL: www.baionaworkshop.org

September 23-26

Oceans '03, San Diego, CA. Contact: Brock Rosenthal, Email: brock@o-vations.com, Tel: (858) 454 4044, URL: www.o-vations.com.

November 10-14

30th International Symposium on Remote Sensing of Environment, Honolulu, HI. Email: isrse@email.arizona.edu, URL: www.symposia.org.

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