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In this issue . . .

EDITOR'S CORNER

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I'm pleased to announce that NASA's Earth Science Enterprise is sponsoring a problem for the Odyssey of the Mind competitions during the 2001-2002 school year. It is a technical problem involving an original performance about environmental preservation. The competitions will involve about 450,000 students from kindergarten through college worldwide, and will culminate in a World Finals next May in Boulder, CO where the "best of the best" will compete for top awards in the international competitions. It is estimated that we reach 1.5 to 2 million students, parents, teachers/administrators, coaches, etc. internationally through participation in this program.

The Odyssey of the Mind Program fosters creative thinking and problem-solving skills among participating students from kindergarten through college. Students solve problems in a variety of areas from building mechanical devices such as spring-driven vehicles to giving their own interpretation of literary classics. Through solving problems, students learn lifelong skills such as working with others as a team, evaluating ideas, making decisions, and creating solutions while also developing self-confidence from their experiences. For more information on NASA's involvement with Odyssey of the Mind, see www.odysseyofthemind.com/ and our Odyssey of the Mind web site at earthobservatory.nasa.gov/odysseyofthemind/.

After lengthy discussions, the U.S. Geological Survey has secured funding to keep Landsat 5 operational through this September. The decommissioning of Landsat 5 had been scheduled to begin in early July due to the high cost of operating both Landsat 5 and 7 simultaneously. The continued operation of Landsat 5 is important as a complement to Landsat 7, providing 8-day repeat coverage during the North American growing season. Without this coverage, cloud free imagery used to determine crop vigor and projected harvests could be scarce.

On a related note, the decommissioning of Landsat 4 has been completed. A final re-orbit thruster burn has been executed, which is expected to gradually send the spacecraft into the atmosphere within the next 8 to 10 years. Also, a draft Request For Proposals for the Landsat Data Continuity Mission was released in early August. This mission is intended to follow

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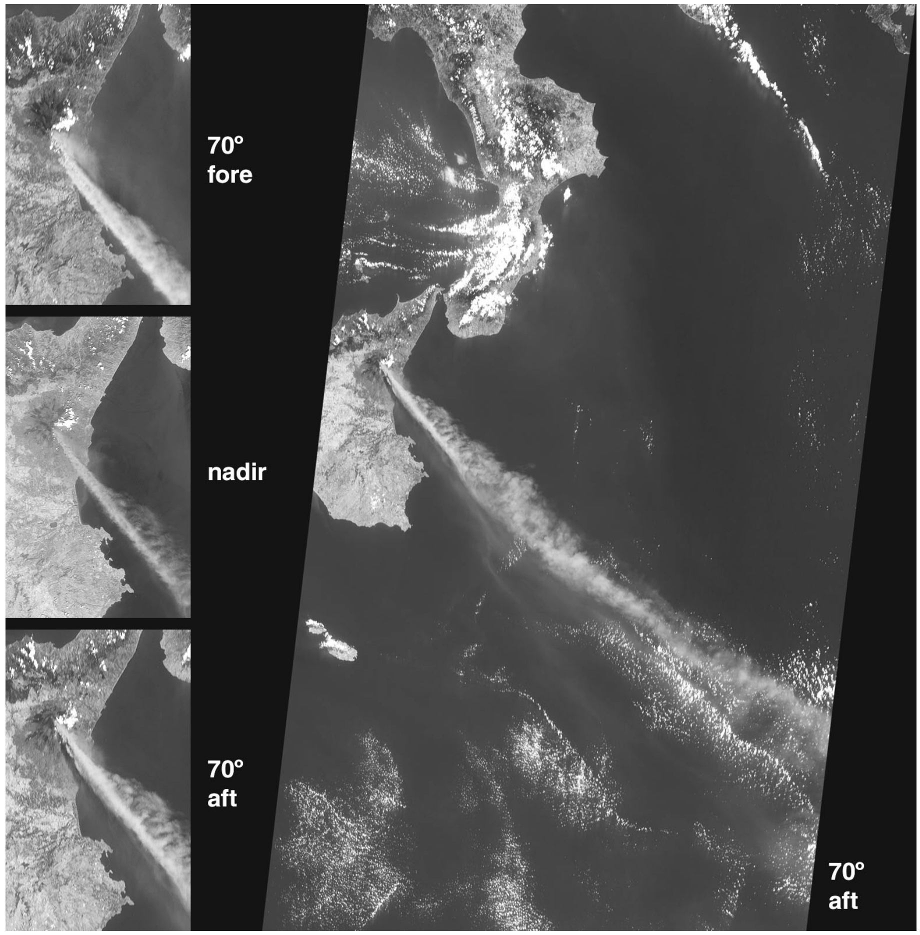
Landsat 7, and extend the data record of the Landsat series of spacecraft.

A proposer conference for the Earth System Science Pathfinder (ESSP) program was held on June 14, with approximately 75 attendees. The procedure for the proposal was described along with the mechanism for funding. This will include Step 1 limited proposals, followed by solicitation of six to eight Step 2 proposals and site reviews, then three to four missions carried into design reviews. The cost cap for the final two projects will be $125 M each, not including launch services. The ESSP budget is $4.5 M for FY 2002, increasing incrementally for two years, then tapering off over the following few years.

Finally, I'm pleased to report that the Earth Science Enterprise Education CD-ROM was recently translated to Portuguese by the Instituto Nacional de Pesquisas Espaciais (INPE), Brazil. The ESE CD-ROM is a collection of satellite imagery and animations of the Earth, with an accompanying audio narration explaining the interactions between the ocean, atmosphere, ice and land surface. It is intended as an introduction to Earth system science for high school and higher grade levels. Its translation to Portuguese will greatly increase the value and utility of this popular educational resource in Brazil. The English edition is available through the EOS Project Science Office web site at eospos.gsfc.nasa.gov which is currently averaging over 1,000 orders per day.



Mt. Etna, July 2001

Two volcanic plumes from Mt. Etna, each composed of different materials, are visible in new images from NASA's Multi-angle Imaging SpectroRadiometer on the Terra satellite. A bright, plume drifting southeast over the Ionian Sea is made up primarily of volcanic ash—tiny frozen fragments of lava. A fainter plume seen near the summit contains very fine droplets of water and dilute sulfuric acid. The images, taken July 22, 2001, are available at http://www.jpl.nasa.gov/images/earth/volcano.

Etna is located near the eastern coast of Sicily, to the southwest of mainland Italy. Major eruptions have been issuing from both summit and flank vents. Fine ash falling onto the Province of Catania closed the local airport, and a state of emergency was declared for the town of Nicolosi, which was threatened by lava flows from the southern flanks of the volcano.

At the left of this image set are views from the instrument's 70-degree forward-viewing camera, the vertical-viewing (nadir) camera and the 70-degree backward-viewing camera, concentrating on the area around the volcano. Each of these images covers an area of 143 by 88 kilometers (89 by 55 miles). The right-hand image is a full-swath view from the instrument's 70-degree backward-viewing camera; the area imaged is approximately 400 kilometers wide (about 250 miles).

Although Etna is one of the world's most studied volcanoes, it is difficult to classify, being a mixture of overlapping shield and strato volcanoes, partially destroyed by repeated caldera collapse and partially buried by younger volcanic structures. Eruptions are related to a complex tectonic situation, including subducting plates, numerous major faults intersecting at the volcano and perhaps also hot-spot volcanism.

Mt. Etna is Europe's highest (3,315 meters, 10,876 feet) and most active volcano. In ancient Greek mythology, Etna was identified with the forge of Volcan. Image courtesy of NASA/GSFC/LaRC/JPL

Joint Advanced Microwave Scanning Radiometer (AMSR) Science Team Meeting

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ADEOS-II AMSR homepages:
http://yyy.tksc.nasda.go.jp/Home/Projects/EOS-PMI/index_e.html
http://sharaku.eorc.nasda.go.jp/AMSR/index_e.html
Aqua AMSR-E homepage:
http://wwwghcc.msfc.nasa.gov/AMSR.html.

A Joint AMSR Science Team meeting was held in Boulder, Colorado, March 22-23, 2001. Topics covered were Aqua and ADEOS-II program status, science updates and validation plans. Two airborne AMSR simulators were also discussed: the existing, operational PSR (Polarimetric Scanning Radiometer) and the design concept of AESMIR (Airborne Earth Science Microwave Imaging Radiometer). The day and a half meeting ended with a tour of the NSIDC (National Snow and Ice Data Center) facilities.

Roy Spencer (AMSR-E Science Team Leader, MSFC) opened the meeting, and introduced **Ramesh Kakar** (NASA Headquarters). Kakar discussed briefly the proposal process for all Aqua instrument teams. The MODIS and CERES teams will have to write proposals this year. The decision was not made yet whether the AIRS and AMSR-E teams will write proposals this year, (before launch) or 18 months after launch.

P. Hwang (Aqua Project Office, GSFC) presented the Aqua project status. The three major problems in the spacecraft I&T were FMU/SSR Single Bit Errors, TIE lockup and transponder reset. The transponder reset should be completed by May 4, 2001 and the FMU/SSR repairs finished by May 23, 2001. The most important milestone is the thermal vacuum test scheduled for June 29 to August 9, 2001. The plan is to ship the spacecraft to Vandenburg Western Test Range on December 3, working toward a launch on December 21, 2001.

S. Nasu (NASDA – Earth Observation Research Center) presented the ADEOS-II hardware and software status. The launch target month for ADEOS-II is February 2002, provided that the H-IIA rocket is successfully fired prior to February. All system tests have been completed in early December 2000. A system PQR (Post Qualification Review) is being held March 21-23, 2001, with an initial flight operations team to be organized in early April 2001. The seven standard algorithms (water vapor, cloud liquid water, precipitation, sea surface wind speed, sea surface temperature, sea ice concentration and snow equivalence) and one research (soil moisture) algorithm have been successfully tested at EOC (Earth Observation Center). In April 2001 there will be an end-to-end test involving NASDA/Earth Observation Planning Department (EOPD), NASDA/Earth Observation System Engineering Department (EOSD), ADEOS-II Hardware Project Team, NASDA/EOC, Tracking & Control Division and Satellite Communication Network Division. Mr. Nasu mentioned briefly the calibration and validation plan and the new DAS (Data Analysis System) that will be implemented at the new EORC office in early August 2001.

A. Shibata (JMA/MRI) had the difficult task of explaining a problem with the warm calibration target (hotload). The AMSR and AMSR-E warm targets are manufactured from a material with a thermal conductivity of 0.13 W/m/K. (SSM/I's target had an epoxy covering an aluminum core with a thermal conductivity of 1.37 W/m/K) The plan is to move 2 PRTs (Platinum Resistance Thermometer) from inside the pyramids to the outside surface of the warm target, and to develop a method for calibration of the data that has two independent variables: temperature of the instrument and channel frequency.

Dawn Conway (AMSR-E lead software engineer, UAH/MSFC) reviewed a number of items: the current software status, production rules, browse images, Q/A statistics, file versioning approaches, metadata, reprocessing, production histories, delivered algorithm packages, science software update schedule, and MOSS testing. All algorithms are delivered and used in production testing at the AMSR-E SIPS. Several algorithms will be updated following MOSS 3 testing in May. Browse images will be available on the TLSCF web site. For the swath products, the browse images will be daily composites. Other Q/A statistic summaries will also be available on the web site. The TLSCF software team will write and implement the metadata routines for the science algorithms. Production histories will be written operationally and will include such items as I/O file names, DAP name and version, PGE version, file version, science software error and informational messages, and some Q/A statistics. Science software updates delivered to the TLSCF by COB July 15, 2001 (launch minus 6 months) will be integrated in the launch version operational SIPS software. The TLSCF is currently writing a Q/A plan and science product README files. The AMSR-E objectives for MOSS 3 are:

- all science algorithms integrated into SIPS;
- automated processing of all standard products;
- delivery of products with cloned metadata; and
- delivery of sample Delivered Algorithm Packages (DAPs).

Following Conway, **Melinda Marquis** (NSIDC) presented general information about the plans for managing the AMSR-E data by NSIDC. The main points of Ms. Marquis presentation were: basic information for ordering data, NOSE (the spatial search/location mechanism for AMSR-E data) implementation, and data distribution services offered by NSIDC (including restricted distribution of L0 data, and other topics, e.g., subsetting in the future). The documents that NSIDC is responsible for are: the DIFs (metadata submitted to the Global Change Master Directory), guide documents (detailed user guides), and post-launch communications, (documented in the OA between NSIDC and AMSR-E SIPS).

The rest of the day, all scientists presented a short update of their research.

Peter Ashcroft (Remote Sensing System) presented an overview of the Level 2A format, and the associated Level 2A Quality Assessment flags. The Level 2A file is now structured as three HDF-EOS swaths containing the low-frequency observations, the A scan high-frequency observations, and the B scan high-frequency scans. Quality assessment flags include four bytes for every scan in every swath, as well as two bytes for every scan and channel (for both the original Level 1A channels, and the resampled Level 2A channels) in whatever swaths are appropriate.

Frank Wentz (Remote Sensing System) gave a presentation on recent advances in the microwave retrievals of sea-surface temperature (SST) and ocean wind speed. The SST retrievals show a pronounced diurnal warming in the mid-afternoon when the wind speed is below 4 m/s. The wind retrievals agree very well (within 0.7 m/s) with buoys and scatterometer winds.

K. Aonashi (JMA/MRI) focused his talk on the AMSR precipitation validation project in Wakasa Bay in 2001. This project studies precipitation at high latitudes, especially the microwave bright band signature. Measurements were taken with a Doppler radar (9410 MHz), a ground-based microwave radiometer (23.8 and 31.4 GHz) and a microwave radar (10.3 GHz). The case study presented was during the TRMM overpass 18522 (1054 UTC February 14, 2001). Aonashi found significant differences between the MWR Tb peaks and the surface snow intensity. There are no plans for further observations before launch of ADEOS-II.

Roy Spencer (AMSR-E Science Team Leader, MSFC) discussed the discrepancy between passive microwave estimates of rainfall variations during El Niño, wherein the satellite estimates are at least twice what theory predicts for monthly tropical oceanic anomalies. He showed new cloud resolving model simulations that reveal a similar, very large increase in atmospheric integrated rainwater content during warmer conditions that was several times the increase in model surface rainfall. Since the satellite passive microwave radiometers measure the integrated rainwater content, and not surface rainfall, this might be a source of bias in rainfall estimates of interannual rainfall variability.

Chris Kummerow's (Colorado State University) presentation covered four aspects:

1) *Analysis of the AMSR-E production run*. During MOSS1, the rainfall algorithm required approximately 7 hrs. to complete one orbit. After thoroughly checking the algorithm the problem was found to be a function of a navigation error (land-type T_b values were placed over oceans). The decision was made to leave the algorithm unchanged, and instead use this problem as a QC tool for the satellite navigation.

2) *Artificial spike in the rain rate histogram*. Frank Marks (Hurricane Research Center) identified a problem with the AMSR-E algorithm (as applied to the TRMM-TMI). The problem was an artificial spike in the rain rate histograms for hurricanes, at about 12 mm/hr. This problem was corrected by modifying the a priori databases.

3) *Ongoing research related to climate signals*. It was shown that differences between the freezing level and the bright band, as identified by the TRMM PR, could be responsible for some of the different signals in the climatologies of El Niño/La Niña transition between the radiometer and the radar.

4) *20% bias between TMI and TRMM PR*. It was shown that the DSD could be obtained from the TRMM PR itself, and that the retrieved DSD was smaller than the assumed one. Correcting the DSD brought the two estimates to with 10% of one another.

Ralph Ferraro (NOAA/NESDIS) presented an update on the status of the rain over land algorithm and the Eureka, CA, NEXRAD/rain gauge validation site effort. Recent improvements to the GPROF - land component (by J. McCollum and R. Ferraro) include the development of a stratiform and convective set of profiles. This work was done by utilizing co-incident match-up TMI and PR data. Then, the actual rain rate retrieved is a weighted average of the stratiform and convective profiles, where the fractional coverage of convective rain in the FOV is determined through a statistical relationship based upon four existing convective-stratiform separation scheme. Application to global TMI data results in about a 20% reduction in monthly rainfall (primarily in convective zones) and brings the retrievals in much closer agreement with other data sets, such as the GPCP merged product. The TRMM ground validation team (D. Wolff and D. Silberstein) has been processing the Eureka, CA NEXRAD data, in combination with gauge measurements, to develop preliminary ground validation products similar to those generated for TRMM. A preliminary web site has been developed for this data, trmm-fc.gsfc.nasa.gov/Eureka/index.html.

The next two presentations were given by two of Tom Wilheit's students, **Dong Lee** and **Kyoung-Wook Jin** of Texas A&M. Dong Lee examined the log-normal assumption on the distribution of the rain rates for estimation of monthly rain totals proposed in Wilheit et al 1991. Since the log-normal assumption was originally used for the SSM/I, it is necessary to re-evaluate the assumption and to determine a more effective method for estimates from TMI, which has a 10 GHz channel that the SSM/I lacks. The minimum chi-square estimation was used for the log-normal method. To check the credibility of the estimation routines, log-normally distributed synthetic data were used. Using real data from TMI, Gaussian smoothing on the rain rates was performed to get all three channels, 10, 19 and 37 GHz, to have a common resolution so that the rain histograms were merged into a single histogram. The log-normal method estimate averaged about 5% more rainfall than the direct sum method, but the log-normal assumption may have made a false estimation. Also, the random error involved in the TMI measurement was estimate. The result showed that the log-normal assumption contributed more error than it removed, especially when the number of rain samples was small.

Kyoung-Wook Jin discussed the microwave radiative transfer in the mixed-phase regions of tropical rainfall. Current physically-based Radiative Transfer Model (RTM) algorithms for estimating oceanic rain use a very simplified hydrometeor profile that ignores the mixed-phase regions (Wilheit et al., 1977). However, to estimate hydrometeor profiles more accurately in the tropical precipitation regions, understanding of the brightness temperature (T_b) variations in the mixed-phase regions is essential. Further, establishing physical assumptions for the microwave transfer in the mixed-phase regions is necessary to minimize uncertainties in rainfall retrievals. Consequently, the objective of the study was to quantify uncertainties and to achieve a solid basis for improvement of the current rainfall retrieval, which is based on a Radiative Transfer Model (RTM). To accomplish this, they examined data taken by the Convair-580 aircraft during the KWAJEX (Kwajalein Experiment). In order to calculate radiative transfer, they combined radiosonde data and aircraft microphysics data with AMMR (Airborne Multi-channel Microwave Radiometer) data. Analyses were performed for the stratiform and convective rainfall regions, respectively. In stratiform rainfall regions, tests were conducted to examine the validity of physical assumptions made to describe the abrupt change in T_b observed just below the freezing level that causes the characteristic bright band on the radar. Results indicate that the bright band absorption would need to be twice as strong to explain the observed dramatic change in brightness temperature. In convective precipitation regions, the effective additional rain layer corresponding to super cooled water droplets above the freezing layer was examined. It was discovered that, due to strong updrafts, approximately a 1/2 km supercooled layer thickness is sufficient to describe the additional hydrometeor layer that is observed.

Boris Petrenko (USRA, supporting R. Spencer at MSFC) discussed the retrieval of the horizontal hydrometeor distribution (HHD) parameters within the field of view of a satellite microwave radiometer. The information about variations in a small-scale horizontal hydrometeor distribution within the microwave radiometer's field of view is necessary to control "beamfilling" errors in rainfall retrieval. The ground–based radar measurements are now considered as the only source of this information within the framework of the Aqua AMSR-E mission (as listed in the AMSR-E Science Data Validation Plan ftp://eospso.gsfc.nasa.gov/ATBD/REVIEW/AMSR/validation-amsr.pdf.) This presentation substantiated the potential and the method of determination of the HHD parameters directly from spectral/polarization microwave radiometer measurements based on the recently developed Beamfilling Algorithm [Petrenko, B.Z. "The Beamfilling Algorithm for retrieval of hydrometeor profile parameters from passive microwave measurements," *IEEE Trans. on Geosci. Remote Sensing*, **39**, pp. 117-124, 2001]. HHD parameters selected for the retrieval are shown to provide an effective description of the HHD, and at the same time their variations are detectable and distinguishable from radiometer measurements. The method has been tested for available hydrometeor profile simulation and demonstrated with the example of TMI measurements processing. Unlike radar measurements, the proposed method makes it possible to acquire the HHD information on the global base along the satellite orbit without any additional instrumentation.

Thorsten Markus (NASA/GSFC-UMBC JCET) presented sea ice activities concentrating on the validation of sea ice concentration retrievals during the Arctic summer season. The summer season is the most difficult time for passive microwave sea ice retrievals because of rapidly changing surface conditions. Landsat 7 data have been acquired coincident with the Meltpond2000 aircraft experiments. The high spatial resolution of Landsat 7 (15 and 30 m) and its various spectral bands enable the distinction between different surface types, such as wet snow and melt ponds. Because the Meltpond2000 PSR data currently still have some problems with the 89 GHz vertical polarization channel, comparisons of Landsat 7 with passive microwave data were limited to SSM/I data as the 85/89 GHz channels are critical for NASA Team 2 (NT2) sea ice concentration retrievals.

Adequate comparisons between these two sensors were ensured by convolving the Landsat 7 retrievals with the SSM/I antenna pattern. The results show that the overall agreement of ice concentrations is very good (correlation coefficient of 0.98). However, in areas with a high fraction of melt ponds, the NT2 algorithm underestimates ice concentrations by up to 11% for areas with a high fraction of melt ponds. This will be investigated in more detail once the PSR data calibration is completed. The PSR data have a spatial resolution of between 0.5 and 1 km (depending on aircraft altitude) so that distinct surface features can be identified and analyzed. A significant change in producing daily average sea ice concentration maps, compared to the SSM/I processing, occurs because NT2 ice concentrations are now calculated from single swath data which are then averaged to provide daily maps (to date, SSM/I daily ice concentrations have been calculated using daily averaged brightness temperatures). The reason for this is that for non-linear algorithms the use of daily averaged brightness temperatures does not necessarily produce correct daily average ice concentrations. This is particularly critical for the NT2 algorithm with its explicit weather correction since the atmospheric signal in the brightness temperatures is diluted through the averaging process.

Joey Comiso (GSFC) presented his study of the spatial and temporal variability of sea ice concentrations derived from currently available passive microwave satellite data and the co-registered high resolution infrared satellite data derived from the Advanced Very High Resolution Radiometer (AVHRR). Cloud-free infrared data provide temperature at the surface and may be used to validate spatial variability in ice temperatures that will be retrieved from AMSR-E brightness temperature data. Yearly anomalies in ice concentrations and surface temperatures were generated for each year from 1981 to 1999 and comparative analysis showed very similar patterns. Results from correlation analysis also show the intuitively expected negative relationship between the anomalies in ice concentration and those in surface temperature. However, the correlation values were unexpectedly very strong at around 0.9 in the seasonal regions in both the Arctic and the Antarctic. These results imply that changes in the ice concentrations are coherent with changes in the surface temperatures on a pixel by pixel basis. This means that dynamic forcings on the ice cover, such as those caused by wind, tides, and waves, are reflected in both the ice concentration and surface temperature maps. Since these are independent measurements, in a sense, one data set validates the other, and the results provide strong confidence in the derived products. This also means that both data sets are very useful for polynya studies and ice-ocean-atmosphere studies in the polar regions, especially in divergent areas. In the perennial ice regions of the Arctic, the correlation values are not so good, even positive at times, because of the impact in the rise in emissivity of sea ice during onset of melt. Such results may be useful in identifying variations of melt areas from one year to the other over the perennial ice cover.

Jim Maslanik (University of Colorado) presented the proposed plans to validate AMSR sea ice and near-ice sea surface temperature products. These plans include collection and analysis of in-situ surface and aircraft data in the Barrow, Alaska area in conjunction with AMSR-E Science Team aircraft flights. These data will be combined with radiative transfer modeling to determine the contribution of specific physical conditions to algorithm errors. Rationale for this additional data collection and modeling effort includes the need for coordinated in-situ measurements as well as the value of acquiring atmospheric column data and detailed surface mapping coincident with NASA aircraft and satellite overpasses. The latter is to be accomplished using unpiloted aerial vehicles currently being tested in Barrow. The presentation described the proposed field plan, the capabilities of the UAV, and the types of modeling to be performed.

Recently **Al Chang** (GSFC) showed that SSM/I passive microwave tends to underestimate snow cover at a global scale. Chang *et al*. (1987), Foster *et al.* (1997) produce snow estimates that are not finely tuned to local conditions. Good examples of SSM/I snow cover underestimation is demonstrated by Tait et al. (2000) and Hall et al. (2001). The solution is to develop a spatially and temporally dynamic snow water equivalent (SWE) calibration scheme to provide improved local estimates of SWE . Using the NASDA compiled data set that consists of 100 stations over the Northern Hemisphere each with snow depth, surface temperatures and SSM/I data from 1992-1995 (inclusive). An empirical calibration scheme is generated that is temporally and spatially dynamic and that can be updated with new observations that become available. [Chang, A.T.C., J.L. Foster and D.K. Hall, 1987: Nimbus-7 derived global snow cover parameters, *Annals of Glaciology*, 9, 39-44. Foster, J.L, A.T.C. Chang and D.K. Hall, 1997: Comparison of snow mass estimates from a prototype passive microwave snow algorithm, a revised algorithm and snow depth climatology, *Remote Sensing of Environment*, **62**:132-142. Hall, D.K., R.E.J. Kelly, G.A. Riggs, A.T.C. Chang and J.L. Foster, (submitted) 2001, Assessment of the relative accuracy of hemispheric-scale snow-cover maps. Submitted to *Annals of Glaciology*. Tait, A.B., D.K. Hall, J.L. Foster and R.L. Armstrong, 2000, Utilizing multiple datasets for snow-cover mapping, *Remote sensing of Environment*, **72**:111-126.]

Don Cline (National Operational Hydrologic Remote Sensing Center National Weather Service, NOAA) presented the plan for the Cold Land Processes Field Experiment (CLPEX). This campaign will address a number of science objectives pertaining to snow and frozen ground, including the validation of AMSR snow water equivalent retrieval algorithms. A major theme of the experiment is the effect of scale and relating processes, measurements, and models between scales. CLPEX will be conducted in north central Colorado, in a 5-level set of nested study sites. Data to be collected include: 1) active and passive microwave remote sensing data sets from ground, aircraft, and satellite sensors; 2) intensive ground measurements of snow and soil characteristics, including snow depth, water equivalent, surface wetness, stratigraphy, and temperature and soil moisture, temperature and frost content; and 3) intensive gamma radiation observations from low-flying aircraft to measure snow water equivalent over 25-km x 25-km grid cells for AMSR-E validation. Land surface modeling will be an important component of the experiment, and will be used diagnostically to provide insight into AMSR retrieval algorithm performance.

Richard Armstrong reported on the study that evaluates several different passive microwave snow algorithms which include both mid- and high-frequency channels, vertical and horizontal polarizations and polarization difference approaches. All frequencies and polarizations being evaluated will be available on the AMSR-E instrument. Evaluation of snow extent is undertaken through comparison with the NOAA Northern Hemisphere snow charts, while evaluation of SWE is based on snow course data from the former Soviet Union and North America. Results from the current phase of the study indicate that horizontal polarization-based algorithms, while apparently underestimating snow extent during shallow snow conditions of early winter, appear to provide the best overall estimates of snow extent. Vertical polarization-based algorithms provide similar results but with a tendency to overestimate snow extent in the presence of desert soils and/or frozen ground. Algorithms which include the 85 GHz channel are capable of detecting shallow snow but in their current form may frequently overestimate snow extent. As the snow cover becomes deeper and the layered structure more complex, all algorithms tend to show improved agreement with the validation data. When applied at the hemispheric scale, regional algorithms developed to detect wet snow using a polarization difference approach appear to be accurate for only limited land surface types. Results also indicate a general tendency for the algorithms tested thus far to underestimate SWE. Unlike snow extent, differences between the SWE validation data and the microwave algorithms appear to be generally consistent throughout the winter season. The algorithm significantly underestimates SWE as fractional forest cover increases. Errors begin to increase as fractional cover increases beyond 30 percent but the algorithm can reasonably accommodate fractional forest cover so long as the cover is 50 percent or less. Future work will continue the comprehensive multi-year comparison of at least four of the most promising algorithms as well as the development of a methodology that will combine visible and passive microwave data to provide an optimal satellite-derived snow product.

Eni Njoku presented an update on the soil moisture algorithm development and validation activities. Results from the PSR-C airborne radiometer (~6.9 GHz) flown during the 1999 Southern Great Plains Experiment (SGP99) in Oklahoma show good sensitivity to soil moisture at the 1-km resolution scale for the pasture and low biomass crops in the region. This is consistent with achieving the expected soil moisture accuracy for those vegetation conditions when scaled to the AMSR-E footprint. An extended experiment in Oklahoma and Iowa (SMEX02) covering higher biomass conditions is planned for summer 2002. Time-series comparisons of point in-situ soil moisture data (USDA SCAN site) and 25-km microwave radar data (QuikScat) were shown indicating the high temporal correlation observed between footprint and point data at a given site. These activities and comparisons will be a key element of the post-launch validation.

Tom Jackson discussed his plan to involve both ground-based observations and model/data assimilation results in the validation of the soil moisture products from AMSR. Ground-based observations will be provided by dedicated validation sites, available soil moisture networks and intensive field campaigns. The NASA and ADEOS-II AMSR science teams have agreed to cooperate in data collection and analysis at an ADEOS-II dedicated validation site in Mongolia. This effort (AMPEX: ADEOS-II Mongolian Plateau Experiment) will be led by Prof. Kaihotsu and will involve continuous recording weather and soil stations with data loggers. In addition, several intensive field sampling campaigns will be conducted throughout the first two years of AMSR observations. The U.S. AMSR-E science team will join this effort and provide a Soil Climate Analysis Network (SCAN) station. This will be installed by an USDA team (Garry Schaefer, Ron Paetzold, Chien-Lu Ping) in June 2001 in Mongolia. It is expected that this effort will complement the ADEOS-II effort and provide a means of cross-referencing to other SCAN stations in the world. The USDA in cooperation with others has a network of 140 soil climate stations worldwide. Most of these are on data loggers and are retrieved annually, while 40 of these stations are available in real time on their website www.wcc.nrcs.usda.gov/scan/. The SCAN network will be a key component of AMSR validation. Plans are progressing for the development of a set of dedicated validation sites in the U.S. built around several of these stations. An aircraft field campaign is being planned for the summer of 2002 (SMEX02) pending the successful launch of Aqua and ADEOS-II.

On the second day, most of the discussions involved the validation plans and the airborne radiometers involved in the campaigns. **E. Lobl** presented a summary of the planned validation campaigns. SMEX02 and the Antarctica Sea ice experiment will take place in the summer of 2002. In early 2003 there are three campaigns planned: precipitation in Wakasa Bay in collaboration with the Japanese AMSR Science Team, a snow campaign in collaboration with Don Cline of NOHRSC (see description of campaign above), and a sea ice experiment in the Arctic. In 2004 and 2005, the plan is to repeat all campaigns as necessary (SMEX04 and sea ice in the Antarctic in 2004, and precipitation, snow and sea ice in the Arctic in 2005).

At the March 2001 AQUA/AMSR-E Science Team meeting, **Peter Hildebrand** (GSFC) reported on Goddard's project to construct an AMSR-E airborne flight simulator. The Airborne Earth Sciences Microwave Imaging Radiometer (AESMIR) is a seven channel, polarization radiometer designed for a multitude of science measurements. The AESMIR system includes 6.9, 10.65, 18.7, 23.8, 36.5, 50.3-52.8, and 89 GHz radiometer channels, all of which are dual polarization and three of which will include measurement of all 4 Stokes parameters. The AESMIR scanning system is a dual axis—azimuth below elevation—scanner that provides easily programmable, complete scan flexibility—conical, cross-track, fixed pointing, etc.—within the full 360° azimuth and up to 65° incidence angle. Considerable attention is being given to AESMIR radiometer calibration, with the goal of less than 1 K absolute error. Hot and cold loads will be mounted close to the radiometer scan head, on the azimuth turntable, but above the 65° incidence angle limit. The radiometer can be programmed to observe these targets as desired. Visible and IR channels will be included. The system has been designed to be compatible with a wide variety of aircraft including P-3, DC-8, ER-2, Proteus, etc. On the P-3 aircraft, mounting options will include both the belly and a new tail mounting option. AESMIR is being built in-house at Goddard and will be ready for field operation in the spring of 2002. Once completed, AESMIR will be an in-house Goddard instrument in support of NASA Earth Science Enterprise goals, Goddard science and engineering research and development, and support of missions including Aqua, GPM, NPOESS, etc. and science goals including soil moisture, snow and cold surfaces, precipitation, and ocean surface conditions.

Marian Klein (ETL/NOAA) described the PSR and plans to improve it. The Polarimetric Scanning Radiometer was originally developed at the Georgia Institute of Technology starting with a concept proposal in 1995, and first operated on the NASA P-3B aircraft in 1997 for the Labrador Sea Ocean Winds Imaging (OWI) experiment. Since this initial deployment it has been upgraded and successfully operated by the NOAA Environmental Technology Laboratory (ETL) during several airborne campaigns, for example the Third Convection and Moisture Experiment (CAMEX-3) in August and September 1998, Southern Great Plains Experiment (SGP99) during July 1999, and Meltpond 2000 during June 2000. As a result of these campaigns the first airborne passive microwave imagery of ocean surface wind vector fields [Piepmeier, J.R., and A.J. Gasiewski, "High-Resolution Passive Polarimetric Microwave Mapping of Ocean Surface Wind Vector Fields," *IEEE Trans. Geosci. Remote Sensing*, vol.**39**, pp.606-622, March 2001], the first multi-band conical-scanned imagery of hurricanes and intense convection, the first high-resolution C-band imagery of soil moisture, and the first high-resolution conical-scanned imagery of sea ice have been produced. Several deployments in support of AMSR-E post-launch calibration and validation activities are planned for 2002-2003. Since its initial deployment, the PSR system has been continuously improved to make the instrument more reliable, accurate, versatile, and to provide shorter turn-around times for calibrated data. There are currently two operational PSR scan-heads (PSR/A and PSR/C), two high-emissivity calibration targets, three new positioners and two new scan-heads (PSR/S and PSR/L) under development, and two new aircraft integrations under design (WB-57F and Proteus). A real-time operating system and new instrument control and data acquisition software was developed in 1998 in preparation for CAMEX-3. Infrared radiometers and color video cameras are standard within each PSR scan-head, and software for calibration of the PSR is improved with each mission. Synchronized operation of more than one PSR scan-head on either a NASA or Navy P-3 has been proposed for AMSR-E and WindSat Coriolis underflight missions during 2002. Integration of at least one PSR into the NASA WB-57F aircraft is also ongoing in support of SSMI/S calibration and validation underflights. (PSR home page at www1.etl.noaa.gov/radiom/psr/)

Roy Spencer ended the meeting with a discussion on a few miscellaneous topics: ideas for first images, workaround data issues, and Science Team proposals. Then M. Marquis conducted a tour of NSIDC for those interested.

Acronym list:

AMR
Airborne Microwave Radiometer

AMSR
Advanced Microwave Scanning Radiometer for ADEOS-II

AMSR-E
Advanced Microwave Scanning Radiometer for EOS

AMSS
Advanced Multi-Spectral Scanner

AVHRR
Advanced Very High Resolution Radiometer

AVIRIS
Airborne Visible and Infrared Imaging Spectrometer

DAP
Delivered Algorithm Package

DIF
Data Interchange Format

DSD
Drop Size Distribution

EOSD
Earth Observation System Development

GAME
GEWEX Asian Monsoon Experiment

GEWEX
Global Energy and Water Cycle Experiment

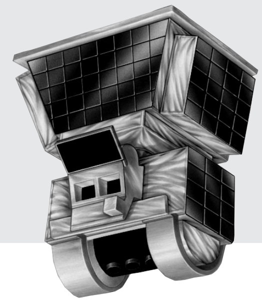
GRASP
Greenland Arctic Ocean Shelf Project

GTS
Global Telecommunications System

IOP
Intense Operating Period
MICRORAD
Microwave Radiometry and Remote Sensing of the Environment
MOSS
Mission Operations and Science System
MRI
Meteorological Research Institute
MWR
Microwave Radiometer
NASDA
National Aeronautics and Space Administration of Japan
NOSE
Nominal Orbital Spatial Extent
NT2
NASA Team (algorithm) 2
PSR
Polarimetric Scanning Radiometer
SIPS
Science Investigator-led Processing System
SMEX
Soil Moisture EXperiment
SSM/I
Special Sensor Microwave/Imager
SST
Sea Surface Temperature
Tb
Brightness Temperature
TIE
Transponder Interface Electronics
TLSCF
Team Lead Science Computing Facility
TMI
TRMM Microwave Imager
TRMM
Tropical Rainfall Measuring Mission (U.S.-Japan)
UAV
Unmanned Airborne Vehicle

Clouds and The Earth's Radiant Energy System (CERES) Science Team Meeting

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



The 24th Clouds and the Earth's Radiant Energy System (CERES) Science Team meeting was held in Newport News, VA, on May 1-3, 2001. The meeting focused on Science Team results and the status of new data products in development and validation. This meeting was a major milestone as we saw the first CERES Tropical Rainfall Measuring Mission (TRMM) angular distribution models (ADMs), early validation results, and archival of the first year of Terra CERES ERBE-like top-of-atmosphere (TOA) flux data. The Data Assimilation Office (DAO) Goddard Earth Observing System (GEOS 3.3.1) meteorological fields are providing improved results and, after further skin temperature tests by the cloud group, may replace the European Center for Medium-Range Weather Forecasts (ECMWF) data. There were interesting results concerning aerosol radiative forcing from TRMM, the use of long-term radiative fluxes in models, and data to evaluate climate clear-sky and all-sky sensitivity.

Bruce Wielicki (LaRC), CERES Co-Principal Investigator, gave an Earth Observing System (EOS)/CERES status report. The Request for Proposals for CERES-like instruments on the National Polar Orbiting Environmental Satellite System (NPOESS) is expected in the fall of 2001. The new instruments will be as good or better than CERES, but NPOESS plans to leverage EOS developments and is not expecting major new capability. A gap in radiation data still exists from the end of the Aqua mission in 2006 until the first NPOESS mission in 2009. Wielicki led a discussion of the value of science teams in peer reviewing algorithms and data products. Science teams have played critical review and oversight roles on the Earth Radiation Budget Experiment (ERBE) and CERES projects which have significantly improved the content, quality, and usefulness of the data products. The next CERES Science Team Meeting is scheduled for September 18-20, 2001 in Brussels, Belgium.

Instrument Status

Larry Brumfield (LaRC) presented the instrument hardware status report. Terra instruments continue to operate without problems, and Aqua instruments are being readied for launch on schedule (currently no earlier than December 2001). The Terra Deep Space Calibration for scan-dependent offset determination and verification should take place at the end of the summer or in early fall.

Kory Priestley (LaRC) analyzed the first year of CERES/Terra on-board calibration and consistency checks. CERES/

Terra instruments are still performing very well, and anomalies are small. Evidence of possible calibration drifts of 0.25 to 0.5% in first year for the total channels is under investigation. Shortwave (SW) and window (WN) channels show no detectable drift. The instrument team will evaluate the necessity of fixing an apparent 0.1% SW leak in the Flight Model 1 (FM-1) WN channel (an issue primarily for daytime deep convective clouds). Spatial uniformity in the FM-2 WN channel detector's response was determined by conducting special lunar scanning. Mirror Attenuator Mosaic (MAM) coatings on Terra instruments appear to be degrading, so lamps will be the only onboard source useful for monitoring SW channel stability. Martial Haeffelin (Virginia Tech) presented results of special scanning operations to obtain enhanced coverage of the upcoming Chesapeake Lighthouse and Aircraft Measurements for Satellites (CLAMS) experiment.

Data Production Status and Issues

Jim Kibler (LaRC) discussed several Data Management System items. He reported dramatic improvement since the beginning of the year in the delivery of CERES Level 0 data from the EOS Data and Operations System (EDOS) as well as ephemeris and attitude data from the EOSDIS (Earth Observing System Data and Information System) Core System (ECS). He summarized the recent CERES code deliveries to the Atmospheric Sciences Data Center. Nearly half a million lines of executable code have been delivered along with an additional 140,000 lines of scripts and configuration files. He reviewed the CERES data products that are available to both the science team and the public and showed public CERES data product distribution statistics totaling 1.4 terabytes in the last 6 months. Finally, he requested feedback on the usability of the data product documentation.

Terra ERBE-like TOA Fluxes

Takmeng Wong (LaRC) summarized first year of archived Terra CERES ERBE-like global and zonal mean TOA SW and longwave (LW) fluxes. Wong showed that the first year of Terra global average LW flux was 6 Wm-2 higher than the first year of combined Earth Radiation Budget Satellite (ERBS)/ NOAA-9 ERBE data (1985/86). About 1.5 Wm-2 of this difference is due to a NOAA-9 underestimate of daytime LW fluxes. The remaining 4.5 Wm-2 is under investigation. Zonal differences vary from 1.5 to 6.5 Wm-2 with the largest differences near the poles. The SW global mean Terra fluxes cannot be evaluated more accurately than about 3 to 5 Wm-2 until the 3-hourly geostationary data are merged with the Terra observations, and the new Terra ADMs are available.

Cloud and Aerosol Properties

Patrick Minnis (LaRC) summarized the progress and problems related to determining cloud properties. For TRMM, comparisons with the Belgian Geostationary Earth Radiation Budget (GERB) optical depth determinations showed sizeable differences in optical depth with the CERES/VIRS (Visible InfraRed Scanner) values for some viewing conditions. This was attributed to approximations in the cloud property parameterizations that account for surface anisotropy and varying gas absorption as a function of cloud optical depth and viewing condition. Minnis is testing an improved parameterization to reduce this uncertainty by about a factor of 2. The cloud properties on VIRS/TRMM were also found to be a function of viewing zenith angle with a 10% increase from nadir to 48-degree viewing zenith. This change was correlated with the viewing angle systematic dependencies in the first draft ADMs from the TOA flux group. The viewing zenith dependence is likely due to two different factors: 3-D cloud geometry, and the ability to detect thin clouds easier from slant views where cloud optical path length increases.

The Moderate Resolution Imaging Spectroradiometer (MODIS) team is planning a major reprocessing of all data starting in mid-May. Minnis verified that in CERES processing we need only use every other MODIS pixel and scan line to keep cloud/radiation consistency in CERES fields of view within 1%.

Angular Modeling

Norman Loeb (Hampton University, HU) reported that the first draft of the CERES TRMM angular models are complete – a major milestone for the project. He showed some of the early validation results from these models. The new ADMs are the foundation for all of the advanced CERES data products. The first draft TRMM angular models are a major improvement on ERBE capability. Further improvements are needed to reduce cloud fraction dependence on viewing angle, verify the cost/benefit of spatially averaging CERES data to a more constant field of view with viewing angle, and complete validation of regional angular model biases.

TRMM draft ADMs were judged sufficiently advanced to warrant producing a "beta" version of TRMM SSF Edition 2 for all 10 months for science use. Fully validated TRMM SSF Edition 2 is scheduled to be available in September 2001. This will be the first validated matched cloud-aerosol-broadband radiation data set.

Surface/Atmosphere Fluxes

Thomas Charlock (LaRC) noted that the new beta TRMM ADMs represent the first chance for the Surface and Atmospheric Radiation Budget (SARB) team to begin serious validation of surface fluxes using the improved TOA flux constraint. As instantaneous ADM errors are reduced with improved ADMs, SARB consistency tuning should become more linear and well behaved. SARB tests of GEOS 3.3 water vapor fields looked comparable in accuracy to past results using ECMWF data.

The SSF estimates of surface fluxes are meant to tie most closely to the TOA fluxes, and to be least dependent on the radiative transfer theory or 4-D assimilation data input. David Kratz (LaRC) and Shashi Gupta (Analytical Services and Materials, AS&M) have updated the Langley parameterized SW algorithm, and results from this as well as the Li/Leighton method were shown for clear-sky SW fluxes. Results for Gupta's LW surface flux algorithm looked remarkably good against Baseline Surface Radiation Network (BSRN) data. Tests of the Inamdar/Ramanathan clear-sky model and the new Zhou and Cess LW cloudy sky algorithm are underway.

CERES Validation Experiment

Bill Smith, Jr. (LaRC) updated plans for the CLAMS mission. CLAMS will focus on validating Terra data products, improving SARB calculations for CERES, and validating MODIS and Multi-angle Imaging Spectro-Radiometer (MISR) retrieved aerosol properties. The intensive measurement campaign is scheduled from July 6 to August 2, 2001.

Surface and Atmospheric Radiation Budget Working Group Meeting

Thomas Charlock (LaRC) chaired the meeting and led the discussions. Zhonghai Jin (AS&M) presented results of a 1-year simulation of upward and downward SW fluxes with a coupled ocean-atmosphere radiation model and compared results with measurements made at the CERES Ocean Validation Experiment (COVE) site. Site measurements varied with season; this could be related to the changes in sea state.

Fred Rose (AS&M) compared CERES/SARB TOA LW fluxes and corresponding computations from the Fu-Liou radiative transfer model. The model consistently overestimated LW parameters. Largest differences were observed for scenes with high clouds of moderate optical depths. **David Rutan** (AS&M) compared SARB-derived downward SW fluxes with corresponding ground measurements. Comparisons for clear-sky conditions at the Atmospheric Radiation Measurement (ARM) Southern Great Plains (SGP) site showed larger differences for direct and diffuse fluxes separately and smaller differences for global fluxes.

Ellsworth Dutton (NOAA Climate Monitoring. & Diagnostics Laboratory, CMDL) apprised the group of the status of several surface-based radiation measurement programs. Data from these programs, e.g., the CMDL network and BSRN, are used widely by modelers for validation of their results. The BSRN archive has been out of service for about a year awaiting hardware and software upgrades, but is expected to be up and running within a few months. **Fred Denn** (AS&M) presented results of multi-filter rotating shadowband radiometer calibrations at the Mauna Loa Observatory and at the COVE site.

Shi-Keng Yang (CPC/NOAA) reported on the status of the Stratosphere Monitoring Ozone Blended Analysis (SMOBA), which is the primary source of ozone data for the CERES Meteorology, Ozone and Aerosol (MOA) product. SMOBA processing was recently switched to Solar Backscatter UltraViolet (SBUV-2) data from the NOAA-16 satellite. NOAA-16 ozone values were slightly higher than both the NOAA-14 and Total Ozone Monitoring System (TOMS) values.

Cloud Working Group Meeting

The CERES Cloud Working Group, led by **Patrick Minnis**, established a timeline for algorithm changes for the Edition 2 Beta and Edition 2 cloud products.

Minnis reported that the calibration of VIRS and MODIS is relatively well understood with some outstanding issues related to the VIRS 1.6 and 3.7 micron channels as well as some MODIS thermal channels. Larry Stowe (NOAA NESDIS) pointed out a thermal leak in the MODIS 1.6 micron channel that is about one third the magnitude of the VIRS 1.6 micron leak. Shaima Nasiri (University of Wisconsin) showed the potential impact of MODIS calibration changes due to a switch to the B-side electronics system on November 1, 2000.

Potential algorithm improvements for Edition 2 cloud processing include a CO^2 slicing algorithm, new polar nighttime retrievals, multi-layer cloud determination, and improved retrievals of mixed phase cloud properties. Bing Lin (LaRC) will revisit TRMM liquid water path retrievals over ocean as a possible modification for Edition 2.

ADM and TOA Flux Working Group

Norman Loeb led the ADM and TOA Flux Working Group meeting. He began with a general overview of critical ADM/inversion research issues. Yongxiang Hu (LaRC) then presented results from CERES monthly deep convective albedo distributions for 9 months of TRMM and showed that the CERES instrument has been very stable. Nitchie Manalo-Smith (AS&M) showed results from regional comparisons between LW and WN fluxes from TRMM ADMs and fluxes based on direct integration of the radiances.

Konstantin Loukachine (Science Applications International Corporation, SAIC) compared LW fluxes based on pre-Edition 2 ADMs with SSF Edition 1 fluxes. The results show a 1-2% dependence on wind speed and precipitable water. Seiji Kato (HU) presented an improved method for computing clear-sky upward SW radiances over ocean surfaces with the discrete ordinate radiative transfer (DISORT) model. Lin Chambers (LaRC) presented the results of a study exploring the effect of angular bin size on direct integration. Erika Geier (LaRC) discussed the temporal differences between the TRMM SSF and TRMM ES8 cloud comparisons in the Warm Pool and in the Tropics.

Temporal Interpolation and Spatial Averaging (TISA) Working Group

David Young (LaRC) led discussions of TISA issues. Studies are in progress to determine the sensitivity of Geostationary Operational Environmental Satellite (GOES) calibration uncertainty for the diurnal cycle correction and to verify that the constraint against CERES broadband radiances eliminates the sensitivity to GOES calibration. The TISA team is currently focusing on TRMM Edition 1 development and testing.

Invited Presentation

Gary Rottman (University of Colorado) briefed the team on the Solar Radiation and Climate Experiment (SORCE) which is a part of the NASA solar irradiance monitoring program and is scheduled for launch in July 2002 with an expected mission lifetime of 5 years. The primary objective of SORCE is to monitor the variability of total solar irradiance and its spectral components. This will enhance our understanding of solar processes and the effects of solar variability on atmospheric and climate processes.

Investigator Presentation Highlights

Robert Cess (State University of New York at Stony Brook) analyzed atmospheric LW feedbacks for clear and cloudy conditions and discussed what we could learn from a long-term record of ERBE-like LW observations. A 120-year run of the National Center for Atmospheric Research (NCAR) Climate System Model (CSM) found that both clear-sky and cloud LW feedbacks are slightly positive and exhibit considerable temporal variability. Cess concluded that a 15-year record of ERBE-like LW observations would allow us to assess the realism of the temporal variabilities seen in the CSM results and provide data to understand the feedback variabilities.

James Coakley (Oregon State University) presented estimates of aerosol direct (radiative) effect derived using CERES TOA radiances from Edition-1 SSF and Aerosol Robotic Network (AERONET) observations. Studies based on Indian Ocean Experiment (INDOEX) data had indicated that narrowband-broadband relations were insensitive to the assumed aerosol model. Aerosol optical depth (AOD) was derived using broadband TOA radiances which, in turn, were used to compute the direct effect. Coakley recommended the use of broadband retrieval of AOD over single-channel retrievals.

Steven Dewitte (Royal Meteorological Institute, Belgium, RMIB) presented an overview of an ongoing project on smooth blending of CERES and GERB TOA radiative fluxes. RMIB is responsible for developing the GERB inversion algorithms. The GERB team will use several CERES-developed algorithms and databases, including ADMs.

Xiquan Dong (University of Utah) compared boundary layer stratus cloud microphysical and radiative properties derived from surface observations, in-situ airborne measurements, and satellite (GOES/MODIS) data during the March 2000 Cloud IOP at the ARM SGP site. Good agreement with surface and aircraft measurements suggests that satellite retrievals of cloud properties are reliable.

Leo Donner (NOAA Geophysical Fluid Dynamics Laboratory) presented results of a General Circulation Model (GCM) study of the role of the precipitation from mesoscale convective clouds in radiative forcing of the atmospheric circulation. Cumulus cells were found to be important heat sources, and they became stronger in the absence of mesoscale circulation. Donner concluded that mesoscale stratiform clouds were an important heat source, a moisture sink, and alter the mass flux profiles.

Qingyuan Han (University of Alabama - Huntsville, UAH) analyzed methods for determining cloud base heights and their uncertainties. The analysis was based on rawinsonde and radar/lidar data taken at the ARM SGP site. The rawinsonde technique often resulted in false detection of clouds, and the uncertainties in the base height were highly dependent on the threshold used, the non-uniformity of cloud base, the presence of supercooled water in the clouds, and the occurrence of fog and precipitation. The rawinsonde method also overestimated cloud top heights.

Anand Inamdar (Scripps Institution of Oceanography) presented results of a study of the atmospheric greenhouse effect for the broadband LW, the 11mm window, and the non-window regions. Comparisons of clear-sky weighted sea surface temperature (SST) with true SST over tropical oceans showed good agreement for the ERBE and TRMM periods. For the Terra period, however, the true SST was found to be about 0.5K higher than the clear-sky weighted value.

A. J. Miller (NOAA Climate Prediction Center, CPC) presented the status of long-term NOAA ozone and stratospheric temperature data sets. The drift of the equator crossing time for NOAA satellites was addressed by adjusting all satellite data sets relative to NOAA-9. The long-term ozone record is based on SBUV/SBUV-2 data from several NOAA satellites. This data set agrees well with the results of 2-D photochemical models from the University of Illinois and NASA/GSFC for total column ozone.

Shaima Nasiri (University of Wisconsin) presented results of a study of cloud overlap detection using MODIS Airborne Simulator (MAS) data over the ARM SGP site. The algorithm, which is based on the use of 8.5 and 11 mm temperature differences, was able to detect overlap conditions. Nasiri also showed comparisons with ground-based measurements from the SGP site.

David Randall (Colorado State University, CSU) presented results of a study in which ECMWF analysis fields were ingested into the CSU GCM. Forcing by the analysis data was used to simulate weather events. In the current runs, these were used to diagnose pressure and moisture tendencies which, in turn, can be used to force the cloud system model. A 2-D cloud system model has now been incorporated into the global GCM. Results from the new GCM runs showed reasonable agreement with satellite cloud and radiation fields.

Larry Stowe and **A. Ignatov** (NOAA National Environmental Satellite, Data & Information Service) reviewed the development of the third generation aerosol retrieval algorithm. Simultaneous retrieval of AOD in both VIRS channels (0.63 μm and 1.61 μm) and the Angstrom exponent was tried using a bimodal size distribution. A basic aerosol model developed by T. Nakajima provided the best results, but multi-channel retrievals underestimated AOD when compared with single-channel results.

Taneil Uttal (NOAA Environmental Technology Laboratory) reported on a database of cloud properties derived from ground-based observations at the ARM NSA site. This database is valuable for validating satellite cloud retrieval algorithms and GCM simulations because, in the Arctic, GCMs show the largest disagreements, greenhouse effects are greatly amplified, cloud-radiation feedback and snow/ice-albedo feedback are strong, and the Arctic atmosphere is generally cloudy. In addition, low contrast between clouds and snow/ice surfaces, and the presence of multiple layers and mixed phase clouds confound the satellite retrieval algorithms.

Michel Viollier (Laboratoire de Météorologie Dynamique, LMD, France) presented results of consistency checks between CERES ERBE-like and Scanner for Radiation Budget (ScaRaB) results. Comparison of CERES/Terra data with LMD GCM results showed good agreement for all months, while ScaRaB comparisons showed CERES outgoing LW to be higher and reflected SW to be lower than ScaRaB.

Ron Welch (UAH) reported on the status of a database of surface-based measurements of cloud cover assembled from a variety of instruments at the ARM SGP and North Slope of Alaska (NSA) sites. This database is currently being used for validation of the cloud mask derived from MODIS data.

Bruce Wielicki (LaRC) reported on the results of a study using CERES TRMM data to examine the recent Lindzen et al. (*Bulletin of the American Meteorological Society*, **Vol. 82**, No. 3, pp. 417–432) iris hypothesis for controlling the outgoing LW radiation in response to changes in surface temperature. Bing Lin and Lin Chambers found a small positive feedback of anvil clouds instead of a strong negative feedback.

Shi-Keng Yang (NOAA/CPC) presented results from National Centers for Environmental Prediction (NCEP) Global Data Assimilation System (GDAS) forecasts of relative humidity (RH). The model exhibits drying in the Tropics and moistening at high latitudes at all levels. Comparison of the RH profile averaged for the Tropics with the corresponding McClatchey profile showed the model profile to be wetter. Yang suggested that major convection centers in the Tropics advect moisture to high latitudes only at the lower levels.

Education and Outreach

The CERES Students' Cloud Observations On-Line (S'COOL) educational outreach now has over 800 schools in 55 countries participating in the program. A S'COOL summer teacher workshop will be held at LaRC July 16-20, 2001.

NASA Earth Scientist Honored With AMS Anderson Award

NASA Goddard Space Flight Center research scientist, Dr. Joanne Simpson, has been awarded the Charles F. Anderson Award by the American Meteorological Society (AMS). The Anderson Award is given to an individual or organization in recognition of outstanding and/or extraordinary contributions to the promotion of educational outreach, educational service, and diversity in the AMS and broader communities. Simpson is Goddard's Chief Scientist for Meteorology and the former Project Scientist for the Tropical Rainfall Measuring Mission. She was the world's first woman to obtain a Ph.D. in Meteorology in 1949. For more information, see: www.gsfc.nasa.gov/pub/PAO/Releases/2001/01-44.htm

The ACRIMSAT/ACRIM III Experiment — Extending the Precision, Long-Term Total Solar Irradiance Climate Database

— Richard C. Willson (acrim@acrim.com), Center for Climate Systems Research Columbia University

Introduction

Total solar irradiance (TSI) provides the energy that, through interactions with the Earth's oceans, land masses and atmosphere, determines the Earth's climate. A National Research Council study recently concluded that gradual variations in solar luminosity of as little as 0.25 % may have been the principal forcing for the 'little ice age' that persisted in varying degrees from the late 14th to the mid-19th centuries. Paleoclimate 14C proxy records implicate periodic TSI variations as the forcings of past climate change on time scales of centuries to millennia. The sensitivity of climate to solar irradiance fluctuations is demonstrated by the subtle changes in effective TSI caused by variations of the Earth's orbital and rotational parameters. These so-called Milankovich cycles are known to be responsible for large climate swings, including numerous extensive glaciations including the one that ended about 10 k-years ago, corresponding to the combinations of the 100, 41 and 22 k-year basic frequencies.

Monitoring TSI variability is clearly an important component of climate research, particularly in the context of understanding the relative contributions to climate change of natural and anthropogenic processes. To provide this understanding, a precise and/or accurate TSI database must be established and maintained on centuries-long time scales. This will require the deployment of many TSI monitoring experiments with precise overlapping observations, periodic highly accurate ones or a combination of the two. The ACRIMSAT/ACRIM III experiment is the most recent component of this measurement strategy.

TSI Monitoring and Strategy

Monitoring TSI with sufficient precision and persistence for a climate database became possible when a new generation of electrically self-calibrating sensors, so-called active cavity radiometers (ACR's), and opportunities for extended space flight became available in the 1970's. The modern record began in late 1978 with observations by the Earth Radiation Budget (ERB) experiment on the NOAA Nimbus 7 satellite. This was followed in early 1980 by the first experiment designed for and dedicated to TSI monitoring, the Active Cavity Radiometer Irradiance Monitor (ACRIM I) on NASA's Solar Maximum Mission. The ACRIM measurement approach invoked a new mode of electrical and degradation calibration, providing a precision level that enabled unambiguous detection of intrinsic solar variability on timescales from minutes to the sunspot cycle. Four other satellite TSI experiments have since made contributions to the long-term database including the ERBS, UARS/ACRIM II, SOHO/VIRGO and ACRIMSAT/ACRIM III.

Past and present TSI monitoring results are shown in Figure 1. The spread of values reflects the bounds of absolute uncertainty for TSI observations by different experiments, which have varied from about +/- 0.3 % to +/- 0.1 % between 1978 and the present. The most recent values, in units of watts per square meter, normalized to one Astronomical Unit, are considered the most accurate due to continuing improvements in sensor calibrations.

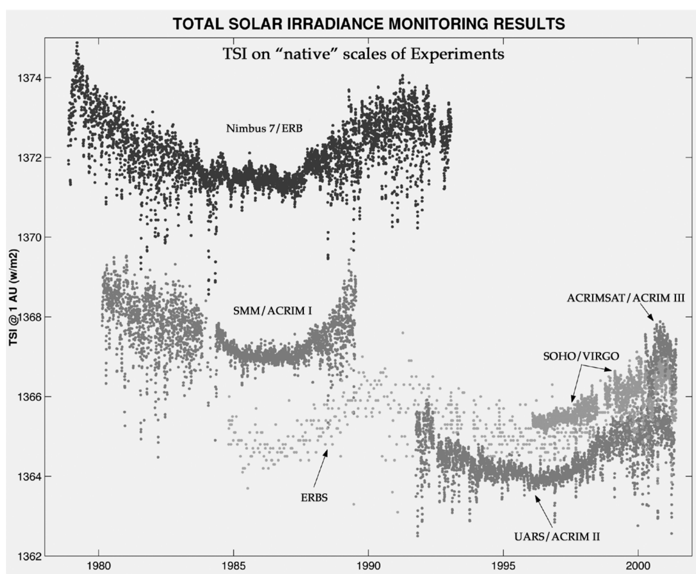


Figure 1.

The long-range objective of TSI monitoring is to provide a database for comparison with the climate record that will be capable of resolving systematic variability of +/- 0.1 % on time scales of a century. This is about equal to the absolute uncertainty of the satellite experiments responsible for the current database, which operate at ambient temperature (~300K) and process results in the time domain. Clearly an 'overlap strategy' that relies on transferring measurement precision, which is orders of magnitude smaller than absolute uncertainty, is required to produce a useful climate database from these devices.

The ACRIMSAT/ACRIM III Experiment

NASA accepted the ACRIM experiment for three EOS five-year mission segments following the initial selection process in the late 1980's. The 2nd mission segment has since been recompeted with selection of the SOURCE/TSIM experiment. The 3rd has yet to be defined. The first mission segment (ACRIM III) was scheduled for launch as part of the EOS/CHEM platform payload. EOS restructuring removed it from the CHEM satellite in the mid 1990's and placed ACRIM III in a 'flight of opportunity' status. Since few opportunities were available at that time the implementation approach shifted to a 'faster, better, cheaper' mode of a small dedicated satellite and launch as a secondary payload. The instrument was redesigned, updated and miniaturized to conform to the latest techniques and technology, and maximize its adaptability to a small satellite environment. The ACRIM III instrument embodies an optimized combination of the best features of the ACRIM I, ACRIM II and SpaceLab ACRIM instruments, together with new electronics and package design. The entire cost of the instrument, dedicated satellite, launch and science to date is less than the projected cost of the originally proposed ACRIM instrument for the EOS CHEM platform.

ACRIMSAT/ACRIM III was launched from Vandenburg AFB on December 20, 1999 into a 700 km. orbit with a 98° inclination. Solar pointing by the spin-stabilized ACRIMSAT satellite, while less accurate than provided by SMM and UARS, is adequate for its mission purposes and well within design limits of +/- 0.25 deg. ACRIM III can obtain more than 60 minutes of solar observations per orbit, 10 percent more than the SMM/ACRIM I and nearly twice that possible with the UARS/ACRIM II experiment. The additional data makes ACRIM III daily mean results, its standard data product, the most precise of all the ACRIM experiments to date.

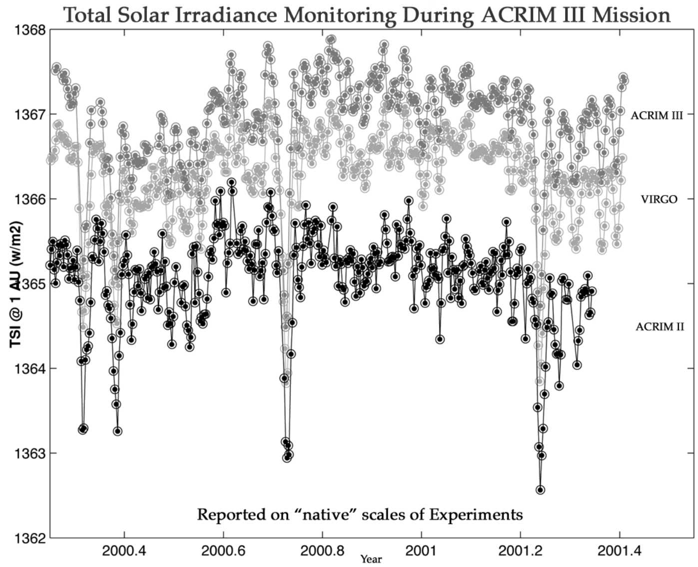


Figure 2.

The primary objectives of the ACRIMSAT/ACRIM III experiment are:

1. The continuation of the precision TSI database during solar cycle 23 for an EOS 5-year minimum mission.

2. Determination of its precise relationship to previous and successive experiments.

3. Analysis of TSI variability on all time scales with respect to their climatological and solar physics significance.

Satisfaction of the first objective is well under way. Although it required 4 months to stabilize and fine-tune ACRIMSAT's solar pointing, the science mission finally began without compromise in early April 2000.

The first part of the second objective was accomplished through comparison of overlapping results from the ACRIM-II, VIRGO and ACRIM III experiments as shown in Figure 2. The second part of the second objective will be overlapping comparisons between ACRIM III, VIRGO and the SOURCE/TSIM experiment (to be launched in mid-2002). Although the UARS/ACRIM II experiment failed abruptly in May 2001 after more than 9 ½ years of operation, the year of overlapping comparisons with ACRIM III, coupled with reprocessing ACRIM II results using more advanced ACRIM III algorithms, have facilitated a highly precise knowledge of the relativity of their observations. By the time ACRIM III completes its 5-year minimum mission it will have several years of overlapping comparisons with the SOURCE/TSIM observations, providing a high precision connection to previous results and continuity of the TSI database.

The results of the ACRIM III experiment demonstrate the efficacy of its design. Detailed registration of virtually all significant solar-induced variations can be seen in the co-plotted results of ACRIM II, VIRGO and ACRIM III. The downward excursions are caused by the radiative deficit effect of sunspot area in solar active regions caused by their substantially lower average temperatures relative to the undisturbed photosphere. Excursions above the average are caused by the radiative excess effects of faculae, areas slightly hotter than the average photosphere in the same solar active regions. The peaks before and after large ‘dips’ are an artifact of the location of active region faculae on the periphery of the sunspot area, where they are the first radiative feature seen when the active region rotates onto our side of the sun and the last seen as they rotate off the other limb of the sun. The sunspot deficit dominates during passage of the active region across the visible side of the solar disk.

The ACRIM composite TSI database

Construction of the long-term composite database required for climate change studies requires the combined results of many individual experiments. Since each experiment reports observations on the performance of their sensors (their so-called ‘native scale’) they must be related to each other by normalizing to the same ‘scale’ using comparisons of overlapping results.

Degradation of the sensors in the spaceflight environment is a significant factor in understanding the quality of each data set. The experiments with the most effective self-calibration approaches will provide the best results. The composite database shown in Figure 3 has been constructed using these principles

Table 1. Components of ACRIM Composite TSI database

Experiment	Operational Span	Data Used
Nimbus 7/ERB	1978–1993	1978–80, 1989-1991
SMM/ACRIM I	1980-1989	1980-1989
UARS/ACRIM II	1991-2001	1991-2000
ACRIMSAT/ACRIM III	2000 ⟶	2000 ⟶

which dictated the use of the following TSI data sets: Nimbus 7/ERB, ACRIM I, ACRIM II and ACRIM III. Some of the highest quality observations are available from the VIRGO experiment but are not used in this model because of their redundancy with ACRIM II and data ‘gaps’.

The use of Nimbus 7/ERB data is important for several reasons. The first is that its observations precede ACRIM I and extend the composite database back to late 1978. The second is that it has the most observations during the 2-year gap between ACRIM I & II. The third is that it’s the best-calibrated database available for establishing the precise relationship between the results of ACRIM I & II through overlapping comparisons. The ERBS database also overlaps ACRIM I & II but was not used because it has substantially fewer observations and larger uncertainties than Nimbus 7/ERB. The composite database is normalized to the scale defined by ACRIM- III, the most accurately calibrated ACRIM instrument.

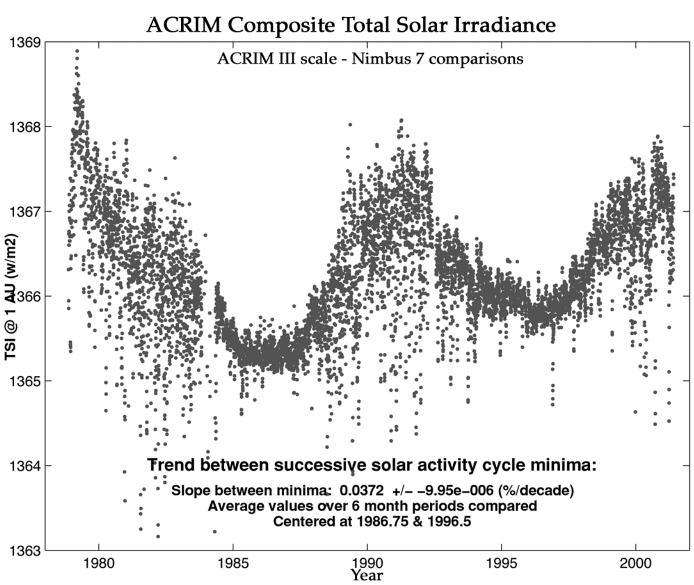


Figure 3.

The ACRIM data products are available on the ACRIM Science Team web site: acrim.com. Links to the other data are provided there as well.

Several features of the 22+ year TSI record stand out clearly. On the timescale of a sunspot cycle (~ 10 - 11 years) there is the characteristic ~ 0.1 % peak-to-peak variation in solar luminosity between solar maximum and minimum periods. The higher variation of TSI during solar activity maxima is caused by the sunspot and facular components of active regions as discussed above. The quieter solar minima reflect the solar luminosity ‘background’ level for TSI.

TSI trend discovered in composite database

The discovery of climate-significant, systematic long-term trends in TSI is the primary objective of monitoring. Detection of such a trend would most likely occur by comparing successive minima in solar magnetic activity since active regions and their sunspot and facular components are nearly absent then, as are the chaotic variations of TSI they cause.

The composite record now allows comparison of two solar cycle minima. TSI has been integrated over 6 month periods centered on the reckoned minima at 1986.75 and 1996.5 years. An upward trend, visually obvious in Figure 3, was found to have a value of 0.037 %/decade. The 1-sigma uncertainty quoted is computational and does not include sources of possible systematic measurement uncertainty, such as uncorrected instrument degradation or errors in electrical self-calibration. The trend is believed to be significant relative to systematic uncertainties in the results of the ACRIM experiments, which incorporate the most comprehensive degradation and electrical calibration schemes. Knowledge of the Nimbus 7/ERB data quality over this period is less well understood since it lacked its own degradation calibration capability. However, since sensor degradation is primarily dependent on the amount of solar-exposure, the much lower duty cycle of the ERB experiment would place the bounds for its possible degradation well below the approximately 400 ppm signal between these minima.

Wavelet analysis of the TSI database

Wavelet spectra of the TSI record have provided a powerful analytical tool for detecting non-stochastic structures in solar variability. The composite TSI time series and its wavelet transform, calibrated on a decibel scale, are shown in Figure 4. Each level in the plot represents a corresponding amount of oscillatory power for a given periodicity and time.

Evolutionary changes in the distribution of spectral power on time scales up to about 180 days can be seen during the most active periods of solar cycles 21 and 22. This corresponds to the upper limit for lifetimes of identifiable solar activity complexes that drive short term TSI variability. The intermediate-term inclined patterns of high oscillatory power (marked by large spots) show a cascade of spectral power downward to greater time scales during the declining phase of solar cycles. These are believed to be the signatures of dissipation and transformation of active region faculae to the 'bright' network, providing a definitive physical link between the evolution of active region faculae and the observed solar cycle TSI variation.

A strong annual component is seen in the wavelet spectra during the maximum of cycle 22 (1989 – 1993). This results from the semiannual orbital movement of the Earth through the solar equatorial plane. The two solar hemispheres are viewed more directly at different times of the year and any north-south asymmetry of TSI-varying solar activity will produce an annual signal.

Conclusions

The precision TSI database for climate has logged 22 ½ years of useful results. The experiments providing this database use ambient temperature sensors and process data in the time domain. They are fundamentally limited to an absolute uncertainty of about 0.1 %. The ACRIM III follow-on experiment, SOURCE/TSIM, will use ambient temperature sensors but process data in the frequency domain. Some improvement in accuracy is expected from filtering measurement cycle errors outside the basic sampling frequency. However, an order of magnitude accuracy improvement would be required to calibrate a centuries-long climate database and this is likely unattainable with ambient temperature sensors.

The TSI monitoring paradigm would change if flight observations could be calibrated with 0.01 % absolute uncertainty. The only known approach capable of this requires sensors operating near liquid Helium temperatures. Periodic flight calibrations by such cryogenic sensors need to be deployed to calibrate ambient temperature TSI monitors. This would relieve the TSI monitoring strategy of its dependency on an 'overlap strategy', protect the database from catastrophic failure of a critical element and provide a well understood approach for experimentally evaluating the accuracy of new instruments and techniques.

The TSI trend between the solar cycle minima of 1986 and 1996 is potentially significant. However, its climate implications await future observations to determine whether a persistent variation is present. The ~ 0.04 % per decade trend for solar cycles 21 – 23 would not be expected to produce detectable climate change on time scales shorter than several decades.

The ACRIM data products are available on the ACRIM Science Team web site: acrim.com. Links to the other TSI databases are provided there as well. ACRIM II and ACRIM III data products are also available at the NASA Langley Research Center's Atmospheric Sciences Data Center, eosweb.larc.nasa.gov/.

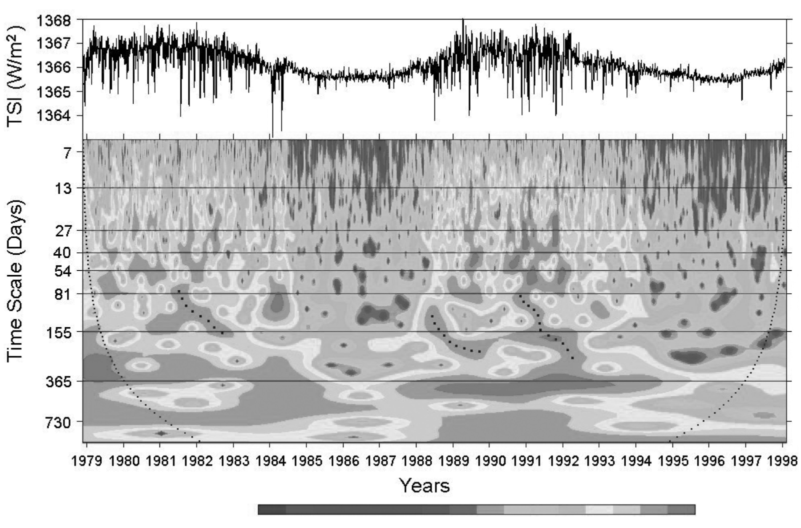


Figure 4

Summary of the International Workshop on LAI Product Validation

— Jeffrey L. Privette (privette@chaco.gsfc.nasa.gov)
— Jeffrey Morisette (jeff.morisette@gsfc.nasa.gov)
— Frèdéric Baret, S. Tom Gower, and Ranga B. Myneni

More than 20 scientists representing 10 countries met on June 7-8, 2001 in Frascati, Italy for the first workshop dedicated to the validation of satellite-derived Leaf Area Index (LAI) products. The gathering was the first topical workshop of the CEOS Working Group on Calibration and Validation (WGCV) Subgroup on Land Product Validation (LPV). The workshop was convened alongside meetings of the WGCV Plenary and Terrestrial Carbon Observation (TCO) group to encourage cross-fertilization. The LPV Subgroup was chartered in 2000 to establish standard guidelines and protocols and to foster data and information exchange relevant to validation. The Subgroup effectively operates via the topical workshops and resulting activities.

Participants were charged with:

1. assessing current LAI products on a biome-by-biome basis, and

2. developing a "standards document" outlining the present "best practice" protocols for experimental design, field data collection, analysis and LAI product evaluation.

Although the Moderate Resolution Imaging Spectroradiometer (MODIS) LAI Product (Principal Investigator: R. Myneni, Boston U.), is the first operational (daily and 8-day) global product, Marc Leroy (CESBIO/CNES) presented results from a POLDER derived product based on inversions of a bidirectional reflectance model. Plans for an ENVISAT/MERIS product, determined via vegetation indices, and a Global Land Imager (NASDA) LAI product were also discussed.

Results from ongoing validation efforts conducted at sites in Canada (CCRS), Europe (VALERI), U.S. (BigFoot) and southern Africa (NASA/SAVE), suggested that the MODIS and POLDER LAI products were most accurate for cropland, broadleaf forests, and savannas and woodlands. Both products were problematic for needleleaf forests and wetlands, and neither had been quantitatively assessed for high biomass locations. Participants agreed that the number of sites and results were grossly insufficient to determine statistically significant global uncertainties.

Frèdéric Baret (INRA) led a round-table session on field protocols and practices, which included lively discussions on limitations and preferred operation of widely used approaches (i.e. direct versus indirect) and optical instruments (e.g., LICOR Plant Canopy Analyzer, 3rd Wave Engineering TRAC, hemispherical photography, and Decagon ceptometer). The session evolved into an equally lively discussion on sampling strategy. Consensus on optimal, generally applicable approaches was difficult to achieve given the early state of land product validation (all activities were less than 5 years old). Instead, participants endorsed a series of guidelines for selecting a plot size and location (e.g., with fine-resolution imagery) and spatial sampling strategy (e.g., at a minimum accounting for all spatial scales up to the lag of the semivariogram sill, as well as including several "renegade" sample locations). Error budgeting, particularly in scaling point data up to thousands of hectares, was highly recommended, although a single scaling approach (e.g., data correlation with Landsat ETM+, SPOT or IKONOS) was not endorsed.

The group outlined research priorities, and will collaboratively evaluate the accuracy of the reprocessed MODIS LAI product (staggered delivery will begin in mid-2001) at test sites for which field data were or will be collected during MODIS operations (see Table 1). For these sites, different methods of producing fine resolution LAI maps will be compared, and results will be correlated against the moderate resolution LAI products. Further, the group will develop a WWW-based document outlining protocols endorsed at the workshop; a summary of this document will be prepared for peer-reviewed literature. The group agreed to meet several months following final delivery of the reprocessed MODIS data to evaluate the results. Interested researchers with field data/results from other sites are strongly encouraged to participate (contact information provided at WWW site given below).

After participating in the two-day workshop, representatives of WGCV, TCO and the Global Observations of Forest Cover (GOFC) announced strong support for LPV's continuing activities. The next topical workshops co-sponsored by the Subgroup will be dedicated to fire/burn scar product validation (July 6-8, 2001, Lisbon, Portugal; Point-of-contact: José Pereira), and land cover/land use

(Continued on page 22)

An Introduction to the Federation of Earth Science Information Partners

— Alan Ward (alan_ward@sesda.com), EOS Project Science Office, NASA Goddard Space Flight Center, SSAI

History

NASA established the Federation of Earth Science Information Partners (ESIP) in 1998 as an experiment in developing a federated system for data management. The notion was that this should be a decentralized, heterogeneous and distributed data distribution system - something different from the existing homogeneous and centralized Earth Observing System Data and Information System (EOSDIS) that is based on the EOSDIS Core System. One of the key aspects of the experiment was to work on governance and interoperability issues. The hope was that the "Working Prototype" Federation would grow beyond the initial NASA-sponsored experiment and come to involve institutions sponsored by other agencies as well.

The initial Federation partners each entered into individual Cooperative Agreements with NASA. The Cooperative Agreements required the ESIPs to participate in forming the Federation and to work together to develop processes for governance and system-wide interoperability. The task was challenging, but some initial Rules of Governance were developed which allowed the Federation to function until a more permanent system of governance could be developed. Shortly after its inception, NASA's eight Distributed Active Archive Centers and the Global Hydrology Resource Center (Huntsville, AL) were added to the Federation.

A new Constitution and Bylaws were agreed upon in January of 2000. The success of the Federation experiment had begun to attract the interest of other institutions and the new governance structure provided a means by which the Federation could add new partners. In July 2000, the first two new partners joined the Federation. As of Summer 2001, a total of eight new partners have been added and others are considering joining. The Federation experiment has succeeded; the Federation continues to grow and should soon become a legal entity, which is seen as a key step in the evolution of the organization.

Goals of The Federation

The Federation, in January of 2000, adopted the following as the preamble of their Constitution. It is a concise statement of their mission.

"We believe that society's quality of life, economic opportunities, and stewardship of the planet are enhanced by regular use of scientifically accurate Earth science information provided in a timely matter by a Federation of groups collaborating to improve their collective services"

Based on this mission, the goals of the ESIP Federation are twofold:

1. to increase the quality and usage of Earth science data, and

2. to create interoperability tools for Earth data resources.

Each goal is elaborated on below.

Increasing the quality and usage of Earth science data. Images and information from Earth orbiting satellites have demonstrated in compelling ways that our planet is finite with only a thin shell to support life as we know it. Today, mankind is affecting this life–support system to an extent that might prove irreparable. We also have unprecedented amounts of data available, which, if easily accessible, can be used to study the Earth and diagnose its condition more accurately than ever before.

The Federation of ESIPs brings together scientists and students, engineers and farmers, government agencies and businesses to achieve its goals. By engaging the full range of stakeholders, the Federation hopes to derive maximum benefits from data just becoming available from the powerful new generation of Earth observing satellites. By combining efforts, the pace of Earth science accelerates and society's understanding of the Earth System is improved. By including groups that reach beyond the science communities, it becomes easier for the best science to find effective use throughout society. The idea here is that "the whole is greater than the sum of the parts." That is to say, members can do far more to benefit society by working together as Federated partners than they could ever do apart and working independently. Partners pool their resources and put them to work to solve real world problems.

Creating interoperability tools for Earth data resources. NASA's Terra and other Earth observing satellites have sophisticated sensors to record Earth radiation patterns, surface land and sea temperatures, vegetation's vitality, biomass, water availability and clarity, ocean winds and currents, plus air pollution. The Federation helps make available these data for science and community empowerment. But the Federation realizes that all the science data in the world is useless if it cannot be accessed in a timely fashion and with minimal effort.

The quality and usage of Earth Science data will only increase if it is practical for end-users to access and process this information.

The Federation has developed interoperability tools. They have developed a System Wide Interoperability Layer, which is a common interface that all partners participate in (see Website: esipfed.net/committees/interop/swil.html). Not only does this promote easy exchange of information among partners but by creating common data structures and processing capabilities, those with data can be more easily connected with those who can make use of this data. These tools also make it easier for end-users to make use of the data without having to navigate through a maze of data and cataloging issues.

Benefits

The information coming from space-based imagery and related Earth Science data products and services are powerful tools for many communities of users. These include:

- Scientists, who can better understand basic biological, geophysical and chemical cycles of the Earth.
- Business people who create value in imagery and support further missions.
- Teachers who use data and information to enhance education.
- Professors who are educating future scientists, policymakers, etc.
- Civil servants who need to assess and plan for sustainable resources.
- Environmental decision makers, including regulators, legislators, attorneys, and land use planners.
- Emergency management authorities, who can make critical decisions, e. g. regarding evacuations.
- Ship captains who can safely plot their course around storms.
- Public health officials who can predict outbreaks of disease and pestilence.
- Farmers and ranchers, who can improve the productivity, quality and consistency of their crops and/or rangeland.

Types of ESIPs

In accordance with its Bylaws, the Federation has established a number of different partnership categories. These are not meant to be rigid divisions, and picking the appropriate category for some institutions is difficult. However, having these categories allows for the Federation to strive to have balanced representation among its participants. Currently, five categories have been established and they are described below.

Category I ESIPs. These are institutions whose primary focus is disciplined adherence to operational schedules in data processing, archiving and distribution. Currently all of NASA's Distributed Active Archive Centers (DAACs) are participating in the Federation as Category I ESIPs, as are the Global Hydrology Resource Center (Huntsville, AL), and NOAA's National Climatic Data Center.

Category II ESIPs. These are institutions whose primary focus is on Earth Science research. These include universities and groups from a number of NASA sponsored projects including several of the Regional Earth Science Application Centers (RESAC).

Category III ESIPs. These are institutions whose primary focus is on developing applications for Earth Science data. Partners here range from non-profit educational organizations to new e-businesses offering information through the internet. Several NASA RESACs have joined as Category III ESIPs.

Category IV and V ESIPs. These two Categories are reserved for institutions that sponsor Federation activity. The difference between these two membership categories is that a Category IV ESIP may vote in the Federation assembly while a Category V ESIP elects not to be a voting member. Both types of sponsoring agencies offer major financial and/or in-kind support of Federation activities. Presently, NASA is the sole sponsor of the Federation (a Category IV ESIP) but this should change as the Federation evolves.

List of Current ESIPs

Category I ESIPs

Alaska SAR Facility (ASF DAAC) specializing in synthetic aperture radar, Fairbanks, AK.
tel. 907.474.6116
e-mail: asf@eos.nasa.gov
www.asf.alaska.edu

The EROS Data Center (EDC DAAC) specializing in land processes, Sioux Falls, SD.
tel. 605.594.6116
e-mail: edc@eos.nasa.gov
edcdaac.usgs.gov

The Global Hydrology Resource Center (GHRC) specializing in global hydrologic cycle and climate, Huntsville, AL.
tel. 256.961.7932
e-mail: ghrc@eos.nasa.gov
ghrc.msfc.nasa.gov

The Goddard Space Flight Center (GSFC DAAC) specializing in upper atmosphere, ocean color, and meteorology, Greenbelt, MD.
tel. 301.614.5224
e-mail: gsfc@eos.nasa.gov
daac.gsfc.nasa.gov/

The JPL Physical Oceanography DAAC (JPL PO.DAAC) specializing in physical oceanography and air-sea interaction, Pasadena, CA.
tel. 626.744.5508
e-mail: podaac@podaac.jpl.nasa.gov
podaac.jpl.nasa.gov

Langley Research Center (LaRC DAAC) specializing in radiation budget and upper atmosphere,
Hampton, VA.
tel. 757.864.8656
e-mail: larc@eos.nasa.gov
eosweb.larc.nasa.gov

National Snow and Ice Data Center (NSIDC DAAC) specializing in snow and ice, University of Colorado, Boulder, CO.

tel. 303.492.6199
e-mail: nsidc@eos.nasa.gov
www-nsidc.colorado.edu

Oak Ridge National Laboratory (ORNL DAAC) specializing in biogeochemical dynamics, Oak Ridge, TN.
tel. 865.241.3952
e-mail: ornldaac@ornl.gov
www.daac.ornl.gov

Socioeconomic Data and Applications Center (SEDAC DAAC) specializing in socioeconomic applications, Columbia University, Palisades, NY.
tel. 914.365.8920
e-mail: sedac@eos.nasa.gov
sedac.ciesin.org

National Climatic Data Center (NCDC), world's largest active archive of weather data, Asheville, NC.
tel. 828.271.4384
e-mail: benjamin.watkins@noaa.gov
www.ncdc.noaa.gov

Category II ESIPs

The Distributed Oceanographic Data System, contact **User Services, University of Rhode Island, Narragansett**.
tel. 401.874.6283
e-mail: support@unidata.ucar.edu
www.unidata.ucar.edu/packages/dods/

The Earth System Science Workbench, contact **James Frew, University of California, Santa Barbara.**
tel. 805.893.7356
e-mail: frew@icess.ucsb.edu
essw.bren.ucsb.edu/

Seasonal to Interannual Earth Science Information Partner, **George Mason University of Fairfax, VA.**
Menas Kafatos tel. 703.993.1997
e-mail: mkafatos@compton.gmu.edu
www.siesip.gmu.edu
Hank Wolf tel. 703.993.3637
e-mail: hwolf@scs.gmu.edu

Progressive Mining of Remotely Sensed Data for Environmental and Public Health Applications, contact **Howard Burrows, IBM, Yorktown Heights, NY.**
tel. 202.421.1049
e-mail: ghburrows@aol.com
www.research.ibm.com/networked_data_systems/esip/

A Web-Based System for Terrestrial Environmental Research, **University of New Hampshire, Durham.**
Berrien Moore III tel. 603.862.1766
e-mail: b.moore@unh.edu
eos-webster.sr.unh.edu/
Annette Schloss tel. 603.862.0348
e-mail: annette.schloss@unh.edu

ESP2Net: Earth Science Partners' Private Network, contact **Silvia Nittel, University of California, Los Angeles.**
tel. 310.825.0607
e-mail: silvia@cs.ucla.edu
dml.cs.ucla.edu/projects/dml_ esip

Evolution of Snow Pack in the Southwestern United States: Spatial and Temporal Variability from a Remotely Sensed and In Situ Data Set, contact **James Simpson, Scripps Institute of Oceanography, University of California, San Diego.**
tel. 858.534.2789
e-mail: jsimpson@ucsd.edu
landlub.ucsd.edu/projects/esip /esip.html

Tropical Rain Forest Information Center, contact **Dave Skole, Michigan State University, East Lansing.**
tel. 517.432.7774
e-mail: skole@pilot.msu.edu
www.bsrsi.msu.edu/trfic

The Passive Microwave ESIP, contact **Michael Goodman, Global Hydrology & Climate Center, Huntsville, AL.**
tel. 256.961.7890
e-mail:michael.goodman@msfc.nasa.gov
pm-esip.msfc.nasa.gov

The Global Landcover Facility, contact **John Townshend, University of Maryland, College Park.**
tel. 301.405.4558
e-mail: jtownshe@geog.umd.edu
glcf.umiacs.umd.edu

GPS Environmental and Earth Science Information System: GENESIS, contact **Thomas Yunck, Jet Propulsion Laboratory, Pasadena, CA.**
tel. 818.354.3369
e-mail: thomas.p.yunck@jpl.nasa.gov
www-genesis.jpl.nasa.gov

The Ocean ESIP, contact **Victor Zlotnicki, Jet Propulsion Laboratory, Pasadena, CA.**
tel. 818.354.5519
e-mail: vz@pacific.jpl.nasa.gov
oceanesip.jpl.nasa.gov

California Water Resources Research and Applications Center, contact **Norman Miller, University of California, Berkeley.**
tel. 510.495.2374
e-mail: nlmiller@lbl.gov
www-esd.lbl.gov/RCC

Great Plains Regional Earth Science Applications Center, contact **Theresa Crooks, University of Kansas, Lawrence, KS.**
tel. 785.864.7369
e-mail: tjcrooks@ukans.edu
www.kars.ukans.edu/resac/ resac.htm

Numerical Terradynamic Simulation Group, contact **Steve Running, University of Montana, Missoula, MT.**
tel. 406.243.6311
e-mail: swr@ntsg.umt.edu
www.forestry.umt.edu/ntsg/

Category III ESIPs

Institutionalizing MTPE Data for Land and Environmental Management, contact **Thomas Burk, University of Minnesota, St. Paul.**
tel. 612.624.6741
e-mail: tburk@forestry.umn.edu
terrasip.gis.umn.edu/

California Land Science Information Partnership, contact **Gary Darling, California Resource Agency, Sacramento.**
tel. 916.653.4279
e-mail: gary@ceres.ca.gov
ceres.ca.gov/calsip

The Earth Data Analysis Center, contact **Stan Morain, University of New Mexico, Albuquerque.**
tel. 505.277.3622 x228
e-mail: smorain@spock.unm.edu
edacesip.unm.edu

Integrating Environmental and Legal Information Systems, contact **Konstantinos Kalpakis, University Space Research Association (USRA), Greenbelt, MD.**
tel. 410.455.3143
e-mail: kalpakis@csee.umbc.edu
www.csee.umbc.edu/~elis

A Public Access Resource Center (PARC) Empowering the General Public to Use EOSDIS Phase III Operations, contact **George Seielstad, Upper Midwest Aerospace Consortium, University of North Dakota, Grand Forks.**
tel. 701.777.4755
e-mail: gseielst@aero.und.edu
www.umac.org/EOSDIS/

WeatheRoute, contact **Kevin Meagher, Reading Information Technology, Inc., Reading, MA.**
tel. 781.942.1655 x15
e-mail: kjm@riti.com
www.riti.com

Earth Data Discovery Consortium, contact **Bruce Caron, Planet Earth Science, Inc., Santa Barbara, CA.**
tel. 808.569.1343
e-mail: bruce@planearthsci.com
www.planearthsci.com

Bay Area Shared Information Consortium (BASIC), contact **Dave Etter, San Jose, CA.**
tel. 408.345.1573
e-mail: geodata@basic.org
www.basic.org

Museums Teaching Planet Earth, contact **Patricia Reiff, Rice University, Houston, TX.**
tel. 713.348.4634
e-mail: reiff@rice.edu
earth.rice.edu

Terrain Intelligence Products from EOS Sensor Data, contact **Doug Kliman, Veridian, Tucson, AZ.**
tel. 520.326.7005
e-mail: dkliman@mrj.com
www.terraindata.com

Stormcenter.com, contact **Dave Jones, Washington, DC.**
tel. 410.647.4299
e-mail: dave@stormcenter.com
www.stormcenter.com

MTPE-Derived Data Products for the Fisheries, contact **Patrick Simpson, Scientific Fishery Systems, Inc., Anchorage, AK.**
tel. 907.563.3474
e-mail: pat@scifish.com
www.scifish.com

Northeast Regional Earth Science Applications Center, contact **Chester Arnold, Haddam, CT.**
tel. 4511.4511.4511
e-mail: carnold@canr.uconn.edu
resac.uconn.edu/

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Category IV ESIP

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(Continued from page 18)

Summary of the International Workshop on LAI Product Validation

product validation (January, 2002, Ispra, Italy, cooperatively with a Global Land Cover 2000 meeting; point of contact: Alan Belward).

For more information on the Land Product Validation Subgroup and the LAI Workshop, see: modarch.gsfc.nasa.gov/MODIS/LAND/VAL/CEOS_WGCV/

Site	*Country*	*Major Biome*	*Latitude*	*Longitude*	*Sponsor*
Alpilles	France	Cropland	43° 46′ 59′′ N	4° 15′ 0′′ E	VALERI
Bondville	IN, USA	Cropland	40° 00′ 23″ N	88° 17′ 27″ W	BigFoot
BOREAS NSA	Canada	Conif. Forest	55° 52′ 46″ N	98° 28′ 50″ W	BigFoot/CCRS
BOREAS SSA	Canada	Conif. Forest	53° 39′ 21″ N	105° 19′ 23″ W	CCRS
Brasschaat (De Inslag)	Belgium	Mixed Forest	51° 18′ 00″ N	4° 31′ 00″ E	VITO
Forêt de Nezer	France	Pine forest	44° 33′ 58′′ N	1° 1′ 59′′ W	VALERI
Harvard Forest	MA, USA	Decid. Forest	42° 32′ 17″ N	72° 10′ 17″ W	BigFoot/BU
Jrvselja	Estonia	Boreal Forest	58° 16′ 00″ N	27° 18′ 00″ E	VALERI
Kejimkujik Park, Nova Scotia	Canada	Decid. Forest	44° 30′ 00″ N	65° 30′ 00″ W	BU/CCRS
Konza	KS, USA	Grassland	39° 04′ 56″ N	96° 33′ 36″ W	BigFoot
Krasnoyarsk	Russia	Boreal Forest	57° 17′ 59″ N	91° 35′ 59″ E	NASA/Sukachev Inst.
Mali	Mali	Shrubland	15° 20′ 00″ N	1° 32′ 00″ W	VALERI
Maun	Botswana	Woodland	19° 55′ 22″ S	23° 35′ 40″ E	BU/SAVE
Mongu	Zambia	Woodland	15° 26′ 16″ S	23° 15′ 10″ E	SAVE
Okwa River Crossing	Botswana	Shrubland	22° 24′ 33″ S	21° 42′ 47″ E	BU/SAVE
Pandamentanga	Botswana	Woodland	18° 39′ 19″ S	25° 30′ 01″ E	BU/SAVE
Park Falls	WI, USA	Decid. Forest	45° 56′ 45″ N	90° 16′ 20″ W	BigFoot
Romilly	France	Cropland	48° 26′ 00″ N	3° 48′ 00″ E	VALERI
Ruokolahti	Finland	Conif. Forest	61° 31′ 58″ N	28° 42′ 62″ E	BU
Skukuza	S. Africa	Savanna	25° 01′ 12″ S	31° 29′ 48″ E	SAVE
Tshane	Botswana	Savanna	24° 09′ 51″ S	21° 53′ 34″ E	BU/SAVE
Watson Lake, Yukon	Canada	Conif. Forest	60° 5′ 24′′ N	129° 23′ 1′′ W	CCRS

Tools and Systems for EOS Data

— Jeanne Behnke (jbehnke@rattler.gsfc.nasa.gov), and
— Richard Ullman (richard.ullman@gsfc.nasa.gov), ESDIS 23Project

At the recent Spring Meeting of the American Geophysical Union, a special poster session, titled *Tools and Systems for EOS Data*, was convened by the Earth Science Data Information Systems (ESDIS) Project. The poster session, held May 29-30, covered the use of tools to search, order, visualize and manipulate data collected from the various Earth Observing System (EOS) missions. The purpose of the session was to inform EOS Science data producers, data users, planners and managers of available data systems and tools for managing EOS data. These systems and tools help users to process, archive and access data and information for research, applications, planning and management.

Thirty-two poster papers were presented at this session. The papers covered such categories as:

- Systems for Finding and Getting EOS Data
- Tools Designed for EOS Data in General
- Tools Designed for Specific EOS Instrument Data
- Standards Supporting EOS Data both current and under development

PCs were available at several of the posters to provide hands on demonstrations of the tools and to support impromptu queries and data analysis. In particular, poster papers addressed progress on and issues with analysis tools, data population tools, specific EOSDIS data sets and metadata types, tools for metadata creation and management, tools for distribution, EOSDIS data formats and distribution techniques. The session was well attended over the two-day period, not only by Earth scientists but also by scientists in other related fields (e.g. solar physics) who were interested in tools being developed for EOS. The interaction between the authors (tool developers) and the AGU attendees involved discussions of tools, formats, data access, basic questions on the data, and future directions. As noted by one author, the session gave him the time to "directly talk and interact with some of the real users of his software tool for their research and routine applications." Several attendees noted that they were saved a lot of "hunting for the right tools" by virtue of their interactions at this session with several developers.

This session represented a good opportunity for the developers to meet with scientists who are now in the position to really begin looking at Terra data. Following the session, authors have noted additional hits on tool web pages, phone calls, and emails referring to the discussions started at the AGU meeting. An unexpected outcome of the session was that it also afforded the opportunity for tool developers to see what is being developed in the broad community. The unstructured time in the session allowed developers to discuss in an open forum how such tools fit into the end-to-end data analysis cycle, user needs, and issues. Discussion also included ideas on future plans developers had for their software. It was clear that while the developers understand the need for a diverse set of tools, the users find this diversity of tools confusing. Based on discussions and follow-up by the AGU attendees, one opinion given was that there is an indication "that a lot more people are interested in tools specific to an instrument than are interested in a general-purpose tool." The developers all plan to continue discussion on enhancing and consolidating tools for the benefit of users based on information and impressions gained at the AGU session. Such discussions will also be central to discussions at the upcoming HDF-EOS Workshop, September 19-21 in Champaign, IL. See hdfeos.gsfc.nasa.gov for details.

The table on Page 24 lists the posters that were presented at the AGU session. Abstracts for the posters can be found on the AGU web page at www.agu.org/meetings/sm01top.html. Please contact Jeanne Behnke (jeanne.behnke@gsfc.nasa.gov) or Richard Ullman (richard.ullman@ gsfc.nasa.gov) with any questions or comments about this article.

Category	Title	Authors
Introduction/Overview	EOSDIS Science Data Systems for 2001	J Behnke, R Ullman
General Tools	The Earth Observing System Data Gateway	M S Nestler, R Pfister
	A New Guide System for the EOSDIS	J Yang, P Agbu, J Tyler, A Warnock, R Ullman
	Data and Information Access Link (DIAL)	R Suresh, L Di, K McDonald
	EDG Valids Processing (EVP): A web-based metadata ingest and test tool	Z Yin, J Yang, R Ullman, F Corprew
	Innovative Technologies for Science Data Processing	R Ramachandran, H T Conover, S J Graves, K Keiser, M R Smith
	Demonstration of the Application and Visualization of Environmental Satellite Remote Sensing Data in a Geographic Information System	M P Soracco
Data Set Accessibility	Making MISR Images Using Utilities Available From The ASDC	J O Olson
	Web-based Hierarchical Ordering Mechanism (WHOM) tool for	M S Sikder, P Eaton, G Leptoukh,
	MODIS data from Terra	N McCrimmon, B Zhou
	Functionality of the Langley TRMM & Terra Information System (LATIS)	S Sorlie, J O Olson
	EOS Snow and Ice Products at NSIDC DAAC	A E Machado, B McLean, G Scharfen, M M Holm
	TERRA/MODIS Data Products and Data Management at the GES-DAAC	A K Sharma, S Ahmad, P Eaton, J Koziana, G Leptoukh, D Ouzounov, A Savtchenko, G Serafino, M Sikder, B Zhou
	MODIS Ocean Primary Productivity: Data Products and Services	K R Turpie, W E Esaias
HDF-EOS Specializations	HDF-EOS Tools and Information Center Web Site	V Sagar, G W Schwenke, R E Ullman
	Interactive Visualizer and Image Classifier for Satellites (IVICS)	T A Berendes, R M Welch, U S Nair, D A Berendes
	HDF-EOS Dump Tools	U Prasad, A Rahabi
	HDF-EOS in MATLAB(R)	R P Comer, C Lawton, M M Yale
	Browse and Utility Tools for HDF-EOS Formatted Files	F Milburn, L Klein
	Visualization of HDF/HDF-EOS Format Earth Observing System Data Using the ISIS "cv" Program	J M Torson
	Vector Data Model: A New Model of HDF-EOS to Support GIS Applications in EOS	E Chi, R d Edmonds Jr.
	NWGISS and GIS Translators: The Generic Tools for Making HDF-EOS Data Accessible to GIS	L Di, W Yang, M Deng, K McDonald
	The Polar HDF-EOS Data Imaging and Subsetting Tool	S S Khalsa, R L Weaver
MODIS Tools	The MODIS Swath-to-Grid Toolbox	T M Haran, S S Khalsa, K Knowles, L E Gumley
	Simple Mapping Tools from the Goddard DAAC Earth Sciences MODIS Data Support	A K Savtchenko
	The MODIS Reprojection Tool	J Dwyer, J Weiss, G Schmidt, T Logar, R Burrel, G Stubbendieck, J Rishea, B Misterek, S Jia, K Heuser
	Web-Based System for Visualization and Quality Assurance of MODIS Ocean Products	R L Vogel, M Necsoiu, K R Turpie, W E Esaias
	Web-Based Tools for Checking EOS Data Integrity	K Tewari, A K Sharma, L Fenichel, S Kreisler, G Leptoukh, C Lynnes, G Roth, R Strub
	Online Analysis of BUFR-formatted Quality-controlled NCEP Final Observation Data at the Goddard Earth Sciences DISC/DAAC	C S Phelps, J Qin, M S Hegde, D R Frank
CERES Tools	view_hdf: A tool to visualize CERES data products	N R Silvers, L Hunt
MISR Tools	MISR Data Visualization and Analysis Using the hdfscan Tool Tools for Visualizing MISR data	K A Crean, D J Diner, P K Banerjee N A Ritchey
	MISR Data Access and Visualization Using misr_view	J R Hall, C K Thompson

Status and Plans for HDF-EOS, NASA's Format for EOS Standard Products

— Richard Ullman (ullman@gsfc.nasa.gov), ESDIS Information Architect, NASA Goddard Space Flight Center, Greenbelt, MD.

Introduction

In the early 1990s, NASA's Earth Science Data Information Systems (ESDIS) Project began to address the technological challenges involved in producing, distributing, analyzing and archiving the Earth Observing System (EOS) Standard Products. Since data interuse and interdisciplinary science investigation are central to Earth systems science in general, and particularly to the goals of EOS, NASA found that a standard data format would best facilitate data exchange and interoperability. Furthermore, the existence of a common format would encourage the development of tools for analysis that could be applied across the spectrum of data sets.

When it was determined that a common format could provide important benefits to EOS, ESDIS engaged a number of DAACs and science teams in examining and testing their data products using a variety of common scientific formats. In 1993, after careful review of more than a dozen alternatives, NASA chose the Hierarchical Data Format (HDF) as the file format for EOS Standard Products. The HDF is a file format, application programming interface (API) and implementing library developed by the National Center for Supercomputing Applications (NCSA). HDF is well suited as a standard for Earth Science data. It is self describing, it is portable across many computing systems, and it is designed explicitly for scientific use with predefined structures common to scientific data. Furthermore, EOS teams have found HDF to be actively and effectively supported by NCSA, a national leader in the advancement of applications computing.

To further facilitate data sharing, certain "idioms" with respect to geo-referencing, data organization, and metadata storage are encouraged. The EOS standard use of HDF for satellite swath data, gridded data, and point data are implemented by HDF-EOS, developed by NASA under the EOSDIS Core System (ECS) contract. HDF-EOS is an API and library of routines that invoke HDF to create standard groups of HDF objects that form HDF-EOS idioms. Within HDF-EOS are 'structural metadata' that provide a common mechanism for attaching geo-referencing information to science data. In addition, a software library, called the ECS Science Data Processing Toolkit is provided to implement a standard for attaching inventory metadata to HDF-based files. At the time NASA selected this standard for use by EOS, HDF was in version 4. In this article, I refer to the version of HDF-EOS built on HDF4 as HE4.

In 1999, NCSA released HDF version 5, a greatly improved, but structurally incompatible format. That is, the data model or internal storage implemented by HDF version 5 is very different than that implemented by HDF version 4.For many, the new data format has been a reason for concern; either about costs to transition from HDF4 to HDF5 or about potential termination of support for HDF4. However, NASA will not terminate support for HDF4 as long as the format is needed. And, NASA, ECS and NCSA are working together to develop tools to help in data transition. HDF5, the new standard, is different from HDF4, the format for EOS standard products adopted for TRMM, Terra, ACRIM, SAGE III and Aqua. The new standard is not backward compatible either in code or in the underlying conceptual model with the old. This is not good news for long-term science endeavors. Changes in computing technologies pose a real and serious challenge to maintenance of long series data collections.

Why HDF5?

As science computing systems evolved, it became clear to NCSA's HDF group that HDF4 would have difficulty evolving to meet the demands of these systems. The future of Earth observing systems is likely to include parallel processing environments, very large data sets, data spanning multiple computing environments, new data models, and complex data analysis and visualization capabilities requiring industry standard interfaces. But, HDF4 supports only datasets smaller than 2 gigabytes, with fewer than 20,000 datasets in any one file, and is not capable of efficiently performing I/O in parallel computing environments. Size and complexity are an issue. The HDF4 library consists of over 300,000 lines of mature, heritage code that represents a variety of disparate scientific data models. The lack of underlying commonality in the implementation of these models contributes to the complexity of the code. This conceptual complexity, in turn, makes it difficult to adapt the library to modern high performance computing architectures.

NCSA spent three years looking for ways to extend and adapt HDF4 to meet these challenges, but in the end it was clear that such an adaptation would only result in an extremely complex format and I/O library, which would not only be difficult to maintain, but would not meet these new requirements nearly as well as a completely new design would. Indeed, it was felt that, if the HDF libraries were not completely overhauled, the data format and software would gradually become unable to support the modern computing needs of scientists. These pressures, and the lessons learned by NCSA in developing and supporting HDF4 over many years, led to the development of HDF5, a new data paradigm built from a solid foundation of computing science data principles.

The good news is that HDF5 is clearly superior to HDF4. The underlying concepts are more robust and the workmanship is cleaner, more compact, direct and simply more maintainable. HDF5 will be a powerful, flexible and pragmatic data format for many years, or decades. There are no plans for a future transition to another, different "HDF6."We believe that HDF5 "got it right;" that the capabilities built into HDF5 will directly benefit the Earth Science Community because they directly map into our needs in the near and distant future. Just as NASA defined certain aggregates of HDF4 structures to represent HDF-EOS point, swath and grid in HE4, so HE5 is a standard usage of HDF5 to implement these same structures. In October, 2000, the EOS Aura Data Systems Working Group adopted HE5 as the Aura platform standard. This is the first EOS mission to use HDF5 and HE5 for all standard products. The Aura instrument teams are together working to further standardize their products to assure compatibility among the teams by defining standard file metadata and other conventions.

Continued Support for HDF4

HDF4 heritage and transition from HDF4 to HDF5 are important considerations. Many years of effort have gone into developing high quality data production software based on the HDF4 and HE4 standards, and any change to a new standard is a rightful concern. NASA and NCSA understand this, and are striving to assure that these challenges will not be any more burdensome for science data producers than necessary, especially for the science data end users. We will do that by developing compatibility and transition tools, by working closely with teams that make the transitions, and by continuing to maintain the HDF4 code as long as required.

Despite the new HDF5, HDF4 and HE4 are not "dead" or even "heritage" formats. All standard products from Terra use these formats, as do the standard products from other missions mentioned above. The standard products from the upcoming Aqua mission will also use HE4. NASA's support for HDF4 and HE4 will continue for as long as significant data holdings use this standard. The level of support for HDF4/HE4 includes correcting errors, porting to new operating systems, adding functionality as required and providing help-desk support for installation and use.

NCSA understands the requirements of the EOS community and NASA's Earth Science Enterprise. The overriding concern is that we must assure that our data remain usable over time. NCSA shares our goal of maintaining viability of scientific data over an extended period. At NASA's request, they have produced detailed documentation of the HDF4 data format and software. This documentation is indispensable for long term preservation of the data because it will retain the format design independent of implementing code. This is necessary insurance, but we do not intend to rely on it. NCSA will continue to maintain HDF4 for as long as NASA identifies this as a requirement. The most recent release of HDF4 (4.1r4) is dated November 2000 and the next is expected this coming fall. That release will include some minor new functionality as well as bug fixes and tools updates.

The HE4 libraries will also continue to be supported under NASA's direction under the ECS contract and in the future. The HE4 API is stable at HDF-EOS 2.72 released March 1, 2001. The next release is planned for September 2001. There are no major new capabilities, only bug fixes. NASA anticipates that HE4 will continue to have maintenance releases that include error corrections and porting to new hardware or operating systems at a rate of once to twice a year for as long as support for HDF4 is required.

Facilitating the Transition to HDF5 and HE5

HDF-EOS helps

The lack of direct backward compatibility of either the API or the file format complicates the transition from HDF4 to HDF5. However, by minimizing the science impact of the changing format standard, HDF-EOS simplifies things enormously. To the extent that EOS products adhere to the HDF-EOS standard format and API, we will be able to provide tools that automatically convert to the new representation or provide common read access across implementations. That is, if applications use only the HDF-EOS swath, grid, and point objects, and HDF-EOS metadata, the transition from HDF4 to HDF5 is greatly simplified. Another benefit for product developers and users is that the HE5 API bears a very strong resemblance to the HE4 API. This is one of the primary reasons for defining standard EOS types using HDF.

Transition tools

Together with our software developers, NASA and NCSA are investigating several transition tool strategies. In evaluating potential tools, we are considering the following kinds of questions:

- How difficult is it to map HDF4 to HDF5?
- Is it possible to extend the HDF5 library so that it can read and write both formats?

- Can we provide stand-alone converters that will effectively convert data from HDF4 to HDF5 or HE4 to HE5?

- How can we accommodate the transition of EOS products that contain not only HE4 objects, but also contain other HDF4 objects such as images and annotations?

- Should products be converted a suite at a time, a collection at a time or one granule at a time?

- How long can we assume support from third party applications?

We think that the answers to these questions, like so many technical details that relate to such a large and varied field, will differ by application area, science discipline and product.

NASA and NCSA are providing direct help in the form of "compatibility tools" to many science product developers and vendors of tools that work with EOS data. With compatibility tools in place, the science team can confidently time any contemplated conversion to the point of least disruption. It is likely that such a change would be in conjunction with scientifically necessary reprocessing. Such reprocessing generally makes previous instances of the product obsolete and so interuse between product versions is not as great a concern. Still, data interoperability requires that a data product in HE5 must be operable with older HE4 products.

The most basic transition tool is a data file converter. This is a utility or API whose input is a file in one format and whose output is a file in another format.

Converting simple HDF-EOS files from HE4 to HE5

The ECS contractor has developed a tool called "heconvert" that converts HE4 Grid, Point and Swath objects to the same respective HE5 objects. The "heconvert" program incorporates both HE libraries. We are exploring ways to publish this capability for HDF-EOS objects as a separate API. Such a high level compatibility library would rely on the HDF4 API but would incorporate code to detect whether the file is HDF4 or HDF5 to call the corresponding HE library.

Converting simple HDF4 files to HDF5

Likewise, NCSA has developed a tool called "h4toh5" that converts an entire HDF4 file into a corresponding HDF5 file. "h4toh5" can be used as a stand-alone utility, or it can be incorporated into other software. For example the NCSA HDF5 viewer/editor, H5View, uses "h4toh5" to read an HDF4 file, convert it to HDF5, and view it. Hence, it is already possible with H5View to view an HDF4 file as if it were an HDF5 file. NCSA is now also developing an "h4toh5" library, which consists of a collection of function calls for converting individual HDF4 objects to HDF5. This library provides more fine-grained conversions than does the "h4toh5" tool, and can, for example, be used to convert only selected HDF4 objects to HDF5, or to change the relative placement of objects in moving them from HDF4 to HDF5.

Converting complex HE4 files to HE5

The EOS standard does not require products to contain HDF-EOS objects exclusively. Typically, science data product developers have placed both HE4 and HDF4 objects into a single product. These products pose special challenges for automated conversion. Each HE4 object (a set of related HDF4 objects) must be replaced with its corresponding HE5 object and then each remaining HDF4 object must be converted to an HDF5 object. If there were implicit relationships between the HDF-EOS objects and the other HDF objects, the conversion software would likely not know about these and so may not act appropriately. In these cases the data format conversion requires engineering intervention to retain the intent of the designers. One tool facilitating complex conversions is an HE file cracker tool, called Java EOS Browser. This application can open and display contents of either HE4 or HE5 granules.

Computer aided data engineering tool

We are studying the possibility of creating a computer aided data engineering tool. This tool would combine components of several tools already developed to display the structure of an EOS product in HDF4 and permit the user to interactively transform selected objects into equivalent HDF5 objects. Guided by standard transformations, the user would efficiently create a standard translation for a particular product type. One result of this interaction would be the production of the framework of a C language program that could be used to transform other instances of the same EOS product. This code could be developed into a stand-alone converter, an import front end to a higher level tool, or inserted into a later version of product generation software.

Wrapping the HDF4 and HDF5 libraries into one I/O library

It has been suggested that a single library be implemented that could entirely support both the HDF4 and HDF5 APIs, making it possible for tools to read data either from HDF4 or from HDF5 without knowing the difference. This approach has been studied extensively by NCSA, and unfortunately it was found to be nearly impossible to create a wrapper for all HDF read and write operations. This is because of fundamental differences between the HDF4 and HDF5 data models and APIs. While the HDF4 and HDF5 libraries are not backward compatible in general, it may yet be possible to create a top layer that wraps both libraries for specific HDF read and write operations (i.e. the HDF-EOS operations). Such a narrow compatibility may be sufficient to provide most necessary product capabilities to general purpose application layers such as Matlab, IDL or other data analysis or visualization environments.

That said, it is almost certain that there will be products that use HDF4 capabilities in unique ways. High level HDF4 to HDF5 compatibility for these products may not be possible for a general library.

Writing and accessing metadata

An example of specific high level compatibility is the writing and access of metadata in HE4 and HE5 files. HDF-EOS files contain inventory and archive metadata conformant to the EOSDIS data model and stored in Object Description Language (ODL). The inventory metadata is a copy of the metadata produced at the time the data product is created and stored in a database for purposes of locating data in the archives. The ECS Science Data Processing Toolkit version 5.2.7.3 can access EOSDIS metadata in either HE4 or HE5 files. The API will recognize which version of HDF-EOS is being processed and respond accordingly.

Conclusion

NASA recognizes that a burden has been placed on EOS data producers and users by the introduction of HDF5. In the case of EOS Terra, Aqua and other current HDF4 users, no requirement will be levied to convert data to the newer format. HDF4 will be supported by NASA as long as a requirement exists. Data granules based on HDF4 will remain accessible though EOSDIS and currently available services will be supported indefinitely. Given the superior quality of the newer HDF5 format, we believe that science teams should, over the next few years, carefully consider definition of new products using the HDF5 standard as the Aura team has. For conversion of existing products, change should likely be in the context of scientifically appropriate data processing or re-processing. To facilitate transition to the new standard, a variety of tools will be available.

The status of the HDF and HDF-EOS standards is the subject of an annual

(Continued on page 32)

PoDAG Meeting XVIII, National Snow and Ice Data Center, Boulder CO.

— Ron Weaver (weaverr@kryos.colorado.edu), NSIDC DAAC Manager, National Snow and Ice Data Center

The 18th meeting of the NSIDC DAAC User Working Group (PoDAG) was held at NSIDC in Boulder April 25 and 26. PoDAG members in attendance were: Dave Bromwich (chair), Cecilia Bitz, Jennifer Francis, Dorothy Hall, Gregory Hunolt, Jeff Key, Thorsten Markus, Chris Shuman, Koni Steffen, Mike Van Woert, Anne Walker, Quinton Barker (NASA ESDIS), and Waleed Abdalati (NASA HQ).

The purpose of this group is to provide user feedback on NSIDC DAAC datasets, DAAC scientific data priorities, and to generally represent the cryospheric user community's data related interests in NSIDC DAAC programs. The PoDAG has met every six to nine months for the past ten years.

Discussion at the most recent meeting resulted in the following actions:

- The NSIDC DAAC will develop information or tools to facilitate access and use of MODIS data sets.
- PoDAG members will review and comment on NSIDC dataset Guide Documents with the aim to improve their readability.
- NSIDC will review the gaps in the topics spanned by the DAAC in response to the NRC report on NASA Polar Geophysical Data Sets.
- NSIDC will review the availability of data at other DAACs that could be used to address some of the data gaps identified by the NRC. If there is appropriate data available, NSIDC will assess it usability for polar applications.

The above are the major recommendations. For a complete set please consult the minutes on the DAAC webpages at: nsidc.org/NASA/PODAG/. These webpages also contain action items and recommendations from all the past meetings, as well as the current membership and their email addresses. Anyone wishing further contact with the PoDAG should email either Dave Bromwich, the current PoDAG chairman or Ron Weaver the NSIDC DAAC Manager.

The next meeting of the PoDAG will be November 1-2 at Goddard Space Flight Center, Greenbelt, MD. For details of this meeting, please consult the PoDAG website noted above.

EOSDIS' EOS ClearingHOuse (ECHO) Architecture Designed to Assist Diverse User Community

— Richard Ullman (ullman@gsfc.nasa.gov), ESDIS Information Architect
— Robin Pfister (pfister@gsfc.nasa.gov), ESDIS IMS System Engineer

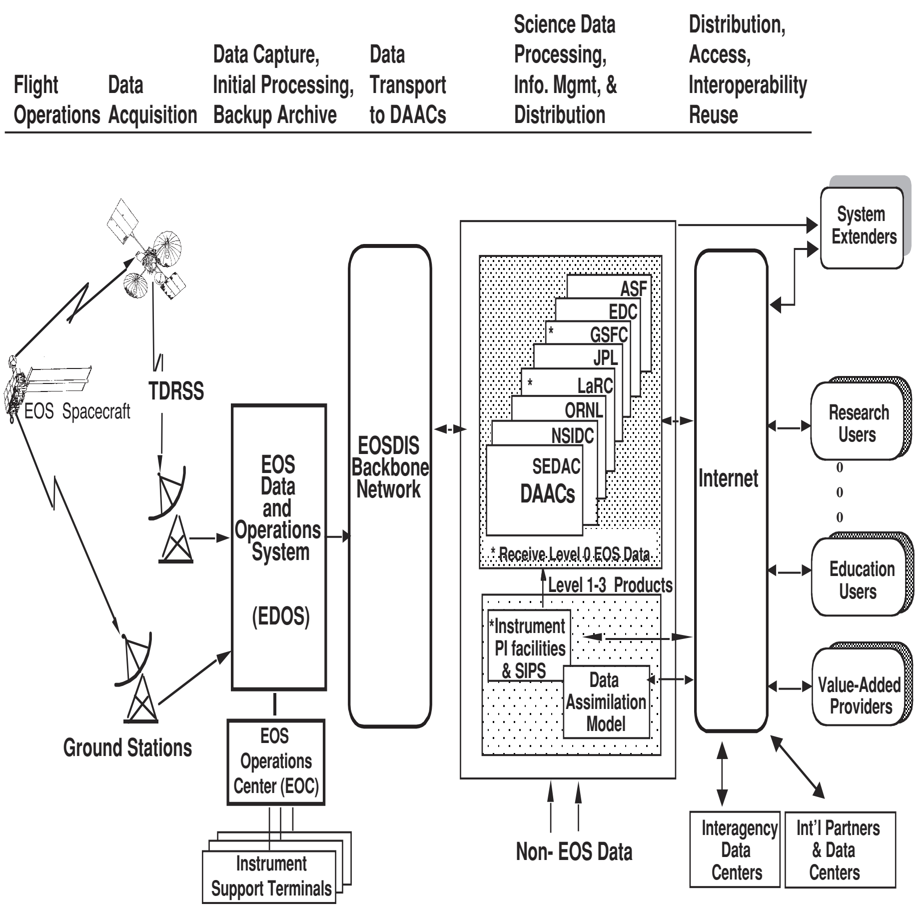
Introduction

Over the past decade the Earth Science Data and Information System (ESDIS) Project at Goddard has been developing, operating and improving components of an Information Management System (IMS) to provide users access to EOS and related data. There have been many changes since early prototyping began a decade ago. User's needs have changed and information technology has been revolutionized. These changes have driven the evolution of the basic architecture and design of the IMS. Figure 1 illustrates the overall functional architecture of the EOSDIS in 2001.

EOSDIS is an end-to-end ground data processing system that includes flight operations, data acquisition, data capture, initial processing and backup archival. Data are routed to the Distributed Active Archive Centers (DAACs) or Science Investigator-led Processing Systems (SIPSs) where data are further processed into higher level products. The processed data are archived in the DAACs and distributed to the end user community.

The Information Management Subsystem (IMS) is in the area of "Access and Interoperability" on the right in Figure 1. The IMS components that provide search and order of data among the distributed archives are based on a prototype that was initiated in 1991. The Version-0 (V0) prototype was a proof-of-concept for interoperability among distributed archives. The infrastructure was designed to provide data search, browse (viewing a sample image), and order functions to scientists in all Earth Science sub-disciplines. Over a 4-year effort, V0 was developed on top of the existing data and services at each DAAC. The V0 prototype succeeded in providing single-point access, through a common interface, across distributed data at the archives (Figure 2). During the development of V0, information technology was revolutionized. As technology evolved, the user community expected the user interface to be presented in the latest technology on their desktop. In the beginning, character-based user interfaces run on VT100 terminals were the standard. After a year into prototyping, X-Windows-based graphical user interfaces took over the market. At the operational release of the X-Windows-based Graphi-

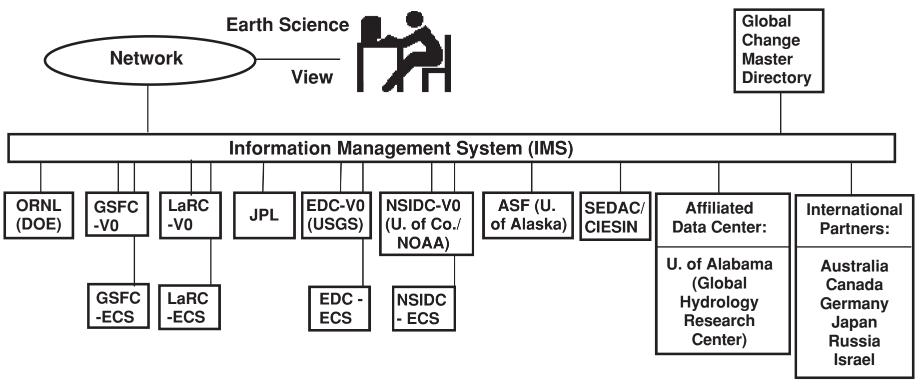
Figure 1. EOSDIS Functional Components.



cal User Interface (GUI), html interfaces emerged and quickly took over the market. Just as users were getting used to the cumbersome click-and-wait interaction of html, Java emerged as a more interactive option. Our development team could barely develop basic functionality before it all needed to be redone with a new user interface technology.

Operational since August of 1994, the prototype, now called the EOS Data

Figure 2. Version 0/EDG Interoperability



Gateway (EDG), has grown in capability, user base, and data provider base. In addition to the archives in the U.S., EOSDIS has interagency and international partners who supply data through interoperable links and collaborate on other EOSDIS activities. Today, EDG provides access to over 1200 datasets at 18 heritage, international and ECS data archives. The URL for EDG is eos.nasa.gov/imswelcome.

New Architecture Supports Varied Data Access Paradigms

Changes in User Needs and Community Characterization

Early in the EOSDIS specification process, scientists had limited experience with large data search and retrieval systems so it was difficult to know and communicate needs for data access. With the information technology revolution, information systems are now pervasive in everyday life. Our user community has gained experience with search and order systems as Internet navigation and paradigms of e-commerce have become routine. Users have also become more familiar with the EDG interface to EOSDIS. Through this experience and user feedback, we have learned that different science disciplines sometimes desire very different ways to access data. Using the "one-size-fits-all" approach with the V0/EDG, IMS cannot continue to satisfy our community's expectations.

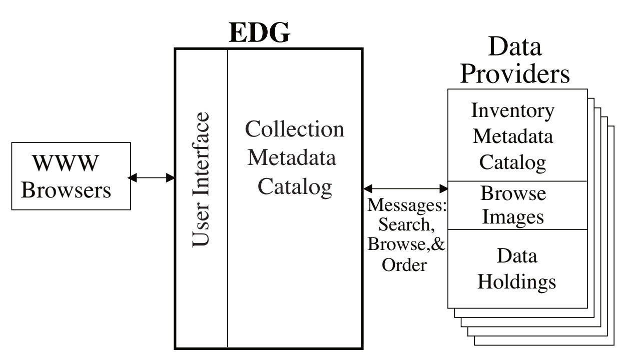
To address these changing expectations, NASA is re-architecting the IMS and developing a component called ECHO (EOS ClearingHOuse) that will support varied paradigms needed by our users. Through the use of the eXtensible Markup Language (XML) and e-commerce concepts, ECHO will provide more flexibility for end users and strengthen the ability of discipline specific groups and data providers to serve particular sub-communities. The ECHO-provided framework will enable better access to data because discipline specific clients will show a view of the data holdings that better meets the needs of target user groups.

The EDG Architecture

The V0/EDG architecture (Figure 3) is designed to support an iterative search and retrieval paradigm for data access. The system defines two tiers of metadata that describe data holdings. The most general level is a catalog of datasets; a small core of metadata used to describe each collection. Key attributes are dataset name, topic area, coverage extent and archive location. The more detailed tier is the inventory of granules (the smallest unit of data independently managed in the inventory) for every dataset. In the heritage and present EOSDIS, the granule is also the smallest unit of data that can be retrieved by the end-user. The EDG architecture reinforces the logical hierarchy of collection and inventory metadata by physical separation of the classes and their hierarchical application to the search process. Using catalog metadata, the EDG guides the user in construction of a search query. After it is constructed, the query is submitted by EDG in parallel to each of the interoperable data centers that are identified by the catalog as having granules that may result in a hit. The two-tier system is intended to reduce the occurrences of nonsensical queries. Even so, it is still possible to generate a query that results in too many or too few data items.

Other shortcomings with the architecture have been identified. The query is performed in parallel among the distributed archive systems. The final result is not known until all systems have responded. The performance and reliability of the system as a whole and at any particular moment is bound to the performance of each member. If network traffic or systems problems affect one member archive, all queries are affected. If a member archive experi-

Figure 3. Present EDG Context Diagram.



ences an outage, access to that respective inventory is unavailable. The tight coupling of the EDG web server to the collection catalog middleware is another source of difficulty. The additions of new data collections to the catalog or new client/server functionality are unacceptably intertwined and it is difficult to provide alternate views through the single server. Equally important is the emergence of new ways of searching. The EDG concept is a first generation office automation system. The construction of queries based on catalog metadata is a familiar and a natural extension of traditional library catalog searches translated to a computer environment. Other data access paradigms made possible with computer technology rely on much richer metadata than is available at the catalog level. Many of our users prefer the paradigm of navigation and discovery. Rather than performing iterative queries, these users want the system to present the available data so they can simply navigate the options (presented by metadata) and discover desired data. Prototyping efforts have revealed that the navigation and discovery paradigm cannot be supported with the present architecture because network separation of the collection-level metadata from the inventory metadata makes such an application impractical.

The ECHO Architecture

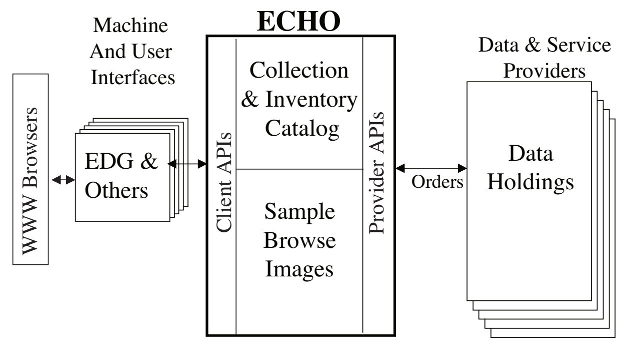
The new ECHO architecture makes several important changes from the heritage EDG architecture. Two are most significant. First, the metadata holdings are no longer fragmented by the catalog and inventory hierarchy, all metadata is brought into the clearinghouse. The second is that the strong coupling between the metadata holdings and the user interface is severed (see Figures 3 and 4 for comparison). In its place is an abstraction layer consisting of an XML based message protocol.

The integration of catalog and inventory metadata with the inclusion of browse imagery is the key to implementation of navigation and discovery. The old EDG architecture mandated a multilevel search and discovery paradigm. ECHO opens possibilities to new methods because bringing all the metadata into a clearinghouse solves the problems of "slowest member" IMS reliability and performance. System performance for inventory search is dependent only on the ECHO system itself. Resources necessary to maintain reliability can be focused on the single system. Not only will clients have efficient access to multiple levels of metadata, but an added benefit is that users can search and find data regardless of provider down time. Only after the user identifies the granules of choice, is the link to the data providers necessary to place an order. Even then, if the provider or network link to the provider is down when the user submits an order, ECHO will store the order on behalf of the user and forward it when the data provider system is accessible. The user may not even know that the order was not immediately submitted.

The client message passing layer permits varied clients to interact with the metadata in the clearinghouse. In order to build a data access client, developers will code to the standard message protocol. All clients will have the same level of access to the metadata representing data holdings from all providers to ECHO. The traditional iterative query interface of the EDG can be supported. But new clients may become interfaces of choice as they can be designed for the specific needs of particular user communities. These clients may provide navigation- and discovery-based views of the combined data holdings. They might provide tailored views of particular kinds of data products or shortcut identification techniques unique to certain classes of data. These end-user communities will benefit from ECHO because they will have data identification and access tools that best suit their needs.

Data providers benefit too. Providers need not provide direct public access to data holdings. The resources required for enabling public search and access can be off-loaded to ECHO. By publishing data holdings through ECHO, providers give data inventory access to all clients. Novel clients will attract new customers to find these data.

Figure 4. ECHO Context Diagram.



This new architecture offers other opportunities to streamline user processes. Currently, we see several data services such as subsetting and on-demand processing being developed independently and remotely from the data providers. Although, these services are intended to operate with the data in the provider archives, there is no present mechanism in the EDG system to connect data to these value-added services. The burden, therefore, is on the user to find the data, to separately find the service, make the necessary connections to get the data transported to the service location, and finally apply the service to the data. The ECHO design includes a service brokering mechanism to transparently interact between data and service providers so the user is never aware of the data transport and service application details.

Conclusions

The clearinghouse architecture based on

common web and e-business practices and open interfaces will enable better access to EOSDIS data. The infrastructure will benefit both users and providers by permitting reliable access to system-wide metadata and fostering development of targeted client interfaces. The heritage EDG client will continue to be supported, but niche community clients will have new access to multiple provider sources. ECHO allows diverse communities to share tools, services and metadata, while empowering communities of similar users to implement unique views of the inventory and methods of data exploration that best serve their needs. Greater system-wide reliability and network response is more economically possible using ECHO. Data users and data providers both will enjoy a higher level of service.

(Continued from page 28)

Status and Plans for HDF-EOS, NASA's Format for EOS Standard Products

workshop open to all. This year, the Fifth Annual HDF/HDF-EOS Workshop is to be held September 19-21 at the Hawthorne Suites Hotel in Champaign IL. Strategies and plans for the new format standard will be a major focus of discussion. The workshop also features demonstrations and tutorials. See the HDF-EOS web site: hdfeos.gsfc.nasa.gov for more details.

The following URLs contain information about the HDF4 to HDF5 transition:
http://hdfeos.gsfc.nasa.gov/HE5.html
http://hdf.ncsa.uiuc.edu/h4-h5.html.

EOSDIS Training

— Robin Pfister (pfister@gsfc.nasa.gov), NASA Goddard Space Flight Center, Greenbelt, MD

NASA's Earth Science Data Information Systems Project is sponsoring free training on the use of tools to search and order EOS and related data held in the EOSDIS archives, and to visualize and manipulate HDF-EOS data. This includes data collected from the Terra satellite. Instruments on Terra include ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer), CERES (Clouds and the Earth's Radiant Energy System), MISR (Multi-Angle Imaging Spectroradiometer), MODIS (Moderate Resolution Imaging Spectroradiometer), and MOPITT (Measurements of Pollution in the Troposphere). The training URL can be found at esdis-it.gsfc.nasa.gov/workshop

This training is open to all interested scientists, data managers, data processing specialists, programmers, and others.

Two identical all-day sessions will be held at the GSFC Building 1 Training Center. Session 1 is Tuesday, October 16. Session 2 is Wednesday, October 17. Each session begins at 8:30 am and runs to 5:30 pm.

Training will include:
- EOS Data Gateway (EDG) for search and order of data
- HDF-EOS Tools for organizing, dumping and some manipulation of data
- Data Visualization Tools for HDF-EOS

Space is limited due to the hands-on nature of most of the sessions so please sign up early. Questions about the training session should be directed to Robin Pfister, Code 423, NASA/GSFC, Greenbelt, MD 20771, e-mail: robin.pfister@gsfc.nasa.gov; tel. (301) 614-5171).

Please complete the registration form below and e-mail to Robin Pfister by September 30.

Everyone must answer these:
Citizenship: If not U.S., do you have a visa? If so, what kind?
Name:
Affiliation:
Address:
Phone:
Fax:
E-mail:
What would you like to get out of this class.

Our training website is at http://esdis-it.gsfc.nasa.gov/workshop
If you are more interested in learning about HDF-EOS format (as opposed to data access tools) there will also be an HDF-EOS workshop in Champaign, IL September 19-21, that concentrates more on the content of the HDF-EOS files. The URL for the workshop is hdfeos.gsfc.nasa.gov/hdfeos/workshop.html

Earth Science Education Program Update

Black Rock Forest Carbon Initiative

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

NASA Goddard Institute for Space Studies (GISS) has begun piloting its second research program for teachers and students. The Black Rock Forest carbon study is being lead by two teachers who have previously participated in research through GISS' Institute on Climate and Planets (ICP) and their science advisor, Dorothy Peeteet. The Black Rock Forest Director is also a science advisor to the project.

Students and teachers throughout the NY metro area participate in research conducted by science teams at NASA GISS. The majority of these projects take place at NASA GISS on the campus of Columbia University. This is the first summer that they will have an outdoor field experience program for students and teachers in Black Rock Forest.

Black Rock Forest is a scenic area comprised of several different ecosystems and plant/animal habitats about 50 miles north of New York City. Participants will be a part of a science team organized to improve our understanding of human and natural contributions to the carbon cycle in this typical East Coast forest. By conducting a range of outdoor field investigations over a three week period, the science team will: 1) characterize and classify the forest ecosystems, 2) collect measurements on carbon sources and carbon storage in plants and soils, 3) analyze these data sets to quantify carbon processes, 4) apply the new knowledge gained to current science questions and environmental issues of public concern in the New York metropolitan area such as urban development and sprawl from New York City.

The ICP is a research, science education, and minority education program. It involves pre-college and undergraduate students in current NASA climate and planetary investigations in collaboration with teachers and faculty from their schools and colleges and GISS research scientists. Learning modules and tools for teaching Earth system science are available on the ICP WWW site. These include lessons, computer models, tutorials, and datasets and analysis tools. For more information on ICP and GISS, see icp.giss.nasa.gov/ or contact Carolyn Harris at charris@giss.nasa.gov.

JPL Releases New WWW Site

On May 18, NASA's Jet Propulsion Laboratory released its new WWW site, which includes new Earth science pages, at www.jpl.nasa.gov/earth/earth_index.html. These pages focus on JPL research and missions by topic: Air & Ozone, Solid Earth, Ocean Motion, Natural Hazards, Weather and Climate, Missions, and Images & Video.

New Earth Science Applications Site

NASA Earth Science Enterprise's Applications Division applies the results of the nation's investment in NASA research to issues of national concern, such as environmental quality, resource management, community growth, and disaster management. Their new WWW site, gaia.hq.nasa.gov/eseapps/, provides information and links to over 200 Earth science applications projects sponsored by NASA. Users can also search applications projects by state, affiliation, sponsoring program, and principle investigator.

Argonautica Project

Agronautica is an initiative of the French Space Agency CNES' (Center Nationale d'Etudes Spatiales) Education and Youth Department, developed to promote the upcoming Jason-1 launch. It is intended to show both students and teachers how space oceanography may help to understand the Earth's climate and the socio-economic impacts of global warming.

One project sponsored by Agronautica is the "Vendee Globe" buoys project. For this effort, skippers participating in the "Vendee Globe" round-the-world yacht race have released a total of 10 buoys. They are tracked by satellite (Argos), and the data are transmitted several times per day.

A total of 15 schools are participating, comprising 24 different classes ranging from nursery school to secondary school. They study a diverse range of subjects including science, geography, computing and technology. The 550 youngsters involved are enthusiastically following the progress of the boats and buoys. Buoy positions are displayed on CNES's educational website, www.cnes-edu.org, where participants from all over France can exchange ideas, positions, and even deductions. Each school

(Continued on page 34)

Major EOS news hotspots in this period include carbon sinks, cooling clouds, African dust, El Niño effects and satellites.

"Measuring America's Greenhouse Effect," (June 21) MSNBC.com. New research estimates that U.S. forests, crops and rivers absorb up to one-half of all carbon dioxide emitted into the air annually when Americans burn fossil fuels, but that amount may decline according to Stephen W. Pacala (Princeton University). Jerry M. Melillo (Ecosystems Center of the Marine Biological Lab in Woods Hole) commented on the U.S. carbon sink.

"Both Sides Now: New Way That Clouds May Cool," The New York Times, by Andrew Revkin (June 19). While scientists largely agree that humans are warming the Earth by adding greenhouse gases to the atmosphere, debate continues about the role that clouds play as a cooling influence. O. Brian Toon (University of Colorado), John H. Seinfeld (Caltech), and James E. Hansen (NASA/GISS) appear in this article.

"African Dust Brings Bacteria to the Americas," (June 14) The New York Times, Associated Press, CNN, ABC News, MSNBC.com. Jay Herman (NASA/GSFC) was one of four researchers who discovered that microbes are being transported in clouds of dust blowing into the Americas from Africa.

"Research Satellites to Ride in Tandem to Orbit," (June 8) CNN.com. The TIMED and Jason-1 satellites slated for launch this September will give scientists new information about the Earth's upper atmosphere and oceans. Lee-Lueng Fu (NASA JPL) explained that Jason-1 will replace the TOPEX/Poseidon satellite.

"El Niño Phenomenon Boosts Snowfall," (May 31) Associated Press by Randolph E. Schmid, and USAToday.com. New research from James J. O'Brien and Shawn Smith of Florida State University indicate that the El Niño phenomenon brings more snowfall to Stowe, Vermont, and Amarillo, Texas, and can reduce snowfall in other areas of the United States.

"MOPITT Satellite Paints Smoggy Portrait of the Planet," (May 30), CNN Cable News, MSNBC.com, and CBS Evening News. John C. Gille (NCAR) and Daniel J. Jacob (Harvard University) said the MOPITT instrument on NASA's Terra satellite has tracked plumes of carbon monoxide moving around the world, indicating that pollution is not a local problem.

(Continued from page 33)

Earth Science Education Program Update

has been allocated a buoy and has received an educational kit with a map to plot the buoy's position and compare its route with ocean current charts. Additional data on wind and wave heights, acquired by oceanographic satellites, can be made available for teachers who wish to do a more in depth study of this subject or for those who wish to have extra material to use in the classroom.

Digital Library for Earth System Education (DLESE) Science Policy Collections Group

The purpose of the DLESE Science Policy Collections Group is to create a national forum for organizing science policy documents which are relevant to Earth System Science education and the sustainable development of our society at global to local levels.

To achieve its purpose, the INSPIRE program (Integrating Science into Policy: Interdisciplinary Research Education) was designed for the National Science, Mathematics, Engineering, and Technology Education Digital Library (NSDL) 'collection track' through the National Science Foundation. Examples of science policy documents that have been organized into searchable databases are: Antarctic Treaty Searchable Database: 1959-1999 webhost.nvi.net/aspire, and United Nations Law of the Sea Convention Searchable Database webhost.nvi.net/inspire.

If you are interested in participating in the Science Policy Collections Group, please contact: Paul Arthur Berkman, Byrd Polar Research Center, PAUL+@osu.edu or berkman.1@osu.edu. For more information about DLESE see www.dlese.org/.

EOS Science Calendar

September 18-20
CERES Science Team Meeting, Brussels, Belgium. Contact: Jennifer Hubble, NASA Langley, tel. (757) 864-8333, e-mail: j.m.hubble@larc.nasa.gov

September 19-21
5th Annual HDF-EOS Workshop, University of Illinois at Urbana Champaign. Contact Richard Ullman, e-mail: ullman@gsfc.nasa.gov.

September 24-26
MODIS Science Team Meeting, location: TBD (local to GSFC). Contact: Barbara Conboy, NASA GSFC, e-mail: barbara.conboy@gsfc.nasa.gov

October 29 - November 1
U.S. TRMM Science Team Meeting, Fort Collins, CO. Contact: Robert Adler, e-mail: Robert.Adler@gsfc.nasa.gov

October 30-November 1
EOS IWG Meeting, San Antonio, TX Contact: Mary Floyd, e-mail: mfloyd@westover-gb.com, For registration and location details see URL: eospso.gsfc.nasa.gov/

Global Change Calendar

Oct. 2-5
Conference on Regional Haze and Global Radiation Balance - Aerosol Measurements and Models: Closure, Reconciliation and Evaluation, Bend, Oregon. Contact Terry Mohr, tel. (412) 232-3444, ext. 3147, URL: www.awma.org

October 7-10
2001 International Conference on Image Processing, Thessaloniki, Greece. Call for Papers. Contact Diastasi, tel. +30 31 938 203, Fax +30 31 909 269, e-mail diastasi@spark.net.gr

October 15-18
11th Conference on Satellite Meteorology & Oceanography, Madison, WI. Contact Christopher Velden, e-mail: chrisv@ssec.wisc.edu, URL: fermi.jhuapl.edu/sat_met_ocean/

December 5-7
'The times they are a changing': Climate change, phenological responses and their consequences for biodiversity, agriculture, forestry, and human health, Wageningen, The Netherlands. Call for Papers. Contact Arnold van Vliet, arnold.vanvliet@algemeen.cmkw.wau.nl, tel. 31 317 485091/484812, URL: www.dow.wau.nl/msa/epn/conference/

December 10-14
2001 AGU Fall Meeting, San Francisco, CA. For more informatino, tel. 1 (800) 966-2481 or 1(202) 462-6900; Fax: 1(202) 328-0566; e-mail meetinginfo@agu.org; URL: www.agu.org/

2002

January 21-23
Non-CO_2 Greenhouse Gases (NCGG-3) scientific understanding, control options and policy aspects, Maastricht, The Netherlands. Contact Dr. Joop van Ham. e-mail: j.vanham@plant.nl; tel. 31-15-285-2558; Fax: 31-15-261-3186; URL: www.et.ic.ac.uk/Dept/LocalNews/greenhouse.htm.

April 7-12
29th International Symposium on Remote Sensing of Environment "Information for Sustainability and Development," Buenos Aires, Argentina. Call for Papers. Contact Secretariat: email 29isrse@conae.gov.ar, URL: www.symposia.org.

July 7-10
2nd Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA) Science Conference, Manaus, Brazil. Contact Flavio Luizao of the National Institute for Space Rsearch (INPA), Manaus, Brazil, e-mail: luizao@cptec.inpe.br

July 9-12
2002 Joint International Symposium on GeoSpatial Theory, Processing and Applications, Ottawa, Canada. Call for Papers. For details, tel. +1 613 224-9577; e-mail: exdircig@netrover.com; URL: www.geomatics2002.org.

Oct. 26-28
3rd International Symposium on Sustainable Agro-environmental Systems: New Technologies and Applications, Cairo, Egypt. Contact Prof. Derya Maktav, e-mail: dmaktav@srv.isn.itu.edu.tr

November 8-15
Integrating Remote Sensing at the Global, Regional and Local Scale, The 15th William T. Pecora Memorial Remote Sensing Symposium/Land Satellite Information IV Conference and the ISPRS Commission I (Platforms and Sensors) Symposium, Denver, Colorado; conference Website www.asprs.org/Pecora-ISPRS-2002.

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