The Earth Observer

A Bimonthly EOS Publication

May/June 1995, Vol. 7 No. 3

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The Investigators Working Group (IWG) meeting was held recently in Santa Fe, New Mexico, and focused on two major themes: (i) innovative ways to implement the EOS Program in the post-2000 era, and (ii) progress on developing an EOS Science Implementation Plan. This was the first opportunity for the vast majority of EOS investigators to learn about recent studies (reported in the last issue of *The Earth Observer*): (i) to foster greater collaboration between NASA's research and development missions and NOAA's operational missions, especially the converged National Polar Orbiting Environmental Satellite System (NPOESS C-1), to be ready for launch in 2004, (ii) to develop an observational and programmatic strategy for the follow-on missions to the first 24 measurement sets (land vegetation, ice sheet elevation, chemistry of the stratosphere, ocean surface wind fields, etc.), (iii) to incorporate advances in technology into EOS to save money and improve data gathering, and (iv) to identify a program including EOSDIS, algorithm development, and spaceflight hardware that fits within a post-2000 cost cap.

At the follow-up Payload Panel meeting, held June 29, the scientific community endorsed a strategy for characterizing each EOS measurement into one of four categories: (i) those requiring *continuous* observations, (ii) those that permit *intermittent* observations with data gaps, (iii) measurements that are unique and permit *one-of-a-kind* observations, and (iv) *initial science*. The Implementation Science Team that I chaired had previously developed a strategy for identifying measurements as falling into categories of *monitoring* vs *process* studies, but the IWG wanted to define the broader set of categories outlined above. The charge to the various EOS disciplinary panels in the next few months will be to articulate and expand on this strategy for all EOS observations, and to refine these definitions at a Payload Panel meeting this fall.

NASA has been negotiating with the European Space Agency (ESA) for the past several years, in full anticipation that ESA would provide a Multi-frequency Imaging Microwave Radiometer (MIMR) to NASA for the EOS PM-1 spacecraft. It has now been determined by both ESA and NASA, that MIMR cannot be committed, developed, and provided in time for a PM-1 delivery; hence, both agencies have agreed to abandon MIMR as an international instrument on NASA's PM-1 platform. Dr. Charles Kennel, Associate Administrator of the Office of Mission to Planet Earth, has formally requested the National Space Development Agency of Japan (NASDA) to provide AMSR, a comparable conical scanning microwave radiometer, for launch on PM-1. NASDA is currently examining accommodation of a revised copy of AMSR, being developed for launch on ADEOS II in August 1999, for the PM-1 spacecraft (to be launched in December 2000). NASDA is also developing a cost, schedule, and accommodation impact for the Science and Technology Agency's budget review in August.

In the past month, the 1995 edition of the *Mission to Planet Earth/Earth Observing System (MTPE/EOS) Reference Handbook* was completed and published. This much-expanded edition includes enhanced descriptions of the Interdisciplinary Science Investigations (IDS), an up-to-date description of the national and international Earth Observing System, a new section describing EOS Data Quality, including calibration, validation, and quality assurance, and, for the first time, a description of the EOS data products to be produced by each Instrument Team.

This document, as well as the recently completed *EOS Posters* and *Earth Observing System Educators' Visual Materials*, has been added to the World Wide Web (http://spso.gsfc.nasa.gov/spso_homepage.html), thereby enabling on-line access to the latest information about EOS science implementation, strategy, and individual investigators. The *MTPE/EOS Reference Handbook*, as well as Algorithm Theoretical Basis Documents (ATBDs) for seven Science Teams, have been incorporated into World Wide Web using Adobe Acrobat PDF (portable document format) so that anyone with Acrobat Reader, a freely-distributed pdf reader, can view these documents from any Macintosh, Windows, or UNIX-based platform.

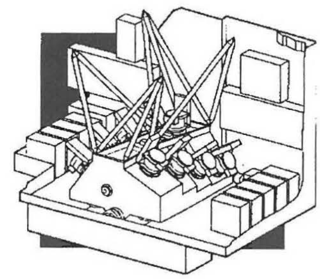
Finally, I would like to express my thanks, on behalf of the Earth Science community, for the marvelous job that Dr. Berrien Moore has done as chairman of the EOS Payload Panel since 1990. He has been both an even-handed and diplomatic chairman of the most influential panel of EOS, which consists of the principal investigators and team leaders of all EOS instrument and interdisciplinary science teams. He has been called upon frequently to convene the Payload Panel to consider and recommend new implementation strategies to NASA management as the EOS program has evolved. These meetings have involved prioritizing instruments and measurements, launch sequences, international and interagency areas of cooperation, reordering sensors on a given platform to optimize the scientific return of the mission, EOSDIS implementation strategies, and, most recently, a coordinated approach to convergence of NASA, NOAA, and DoD's polar orbiting environmental satellite systems for the next millennium. Berrien is succeeded by Dr. Mark Abbott, recently elected chair by the voting members of the IWG. Mark, like Berrien, is a principal investigator of an Interdisciplinary Science Team, and, in addition, is a Team Member of MODIS, with a special interest in biological oceanography.

In accordance with the by-laws of the IWG, four other EOS Panels recently held elections for new chairs. I am happy to report the election of Dr. Richard Rood to chair the Modeling Panel (succeeding Dr. Robert Dickinson), Dr. Richard Zurek to chair the Atmospheres Panel (succeeding Dr. Dennis Hartmann), Dr. Jim Yoder to chair the Oceans Panel (succeeding Dr. Drew Rothrock), and Dr. John Melack to chair the Biogeochemical Cycles Panel (succeeding Dr. David Schimel). These panel chair assignments represent a considerable time investment by these members of the EOS community, requiring attendance at bimonthly meetings of the Science Executive Committee (SEC), and thereby enabling frequent feedback and guidance to the EOS Project and Program Offices.

—Michael King
EOS Senior Project Scientist

Science Team Meetings

Minutes of the Multi-Angle Imaging SpectroRadiometer (MISR) Calibration Peer Review II



— **Carol Bruegge** (cjb@jord.jpl.nasa.gov), MISR Instrument Scientist, Jet Propulsion Laboratory

The MISR Calibration Peer Review II was held at the Jet Propulsion Laboratory (JPL) on 27-28 March 1995. Skip Reber, Goddard Space Flight Center (GSFC), chaired the review. Board members were Jim Butler (GSFC); Stuart Biggar, University of Arizona (U of A); Peter Jarecke, TRW; Robert Lee, NASA/Langley; Carol Johnson and Joe Rice, National Institute of Standards and Technology (NIST); Hugh Kieffer, U.S. Geological Survey; and Frank Palluconi, JPL.

Fifteen speakers from the MISR engineering, science, and data teams presented the status of the instrument development and test activities, as well as the in-flight calibration and data validation plans. The following paragraphs describe presentation areas.

Detector Standards

The 3% (1 sigma) absolute radiometric calibration of MISR is to be established with use of detector standards. That is, for this program, detectors are used to define the radiometric scale rather than national-standards laboratory traceable lamps. Detectors have the advantage of greater accuracy and lifetime stability, as compared to source standards, e.g., lamps. During preflight calibration each of the nine MISR cameras views, in turn, the output of a 65" integrating sphere. The sphere is used as a stable, flat-field source. The detector standards view the source to define the sphere output prior to each camera calibration.

The detector standards used in the preflight program are termed Laboratory Standards. They are commercially available and consist of three photodiodes in a trapped configuration such that front-surface reflection losses are collected by the next diode in series. High-purity silicon, as well as this light trapping, allow the devices to obtain near 100% external quantum efficiency. The Laboratory Standards, as well as the MISR flight detector standards, are fitted with field-defining baffle-tubes which contain precision apertures (manufactured using photo-lithography techniques). They also use filters which have been manufactured to the same design as the camera flight filters. This allows the source output to be characterized in the same spectral passbands as the flight instrument.

Post launch, MISR will be calibrated with use of an On-Board Calibrator (OBC) employing detector standards and sun-illuminated diffuse panels. The OBC utilizes three types of detector standards, termed Red and Blue High Quantum Efficiency (HQE) and PIN detectors. These have been designed and assembled within JPL. PIN refers to the p-type intrinsic n-type diode architecture.

There is one HQE for each MISR spectral band, four in total. The blue HQE detectors have high quantum efficiency at blue wavelengths and are used to calibrate MISR bands 1-3 (443, 555, 670 nm). The red HQE detector has high quantum efficiency at red wavelengths and is used to calibrate MISR band 4 (865 nm). The HQE detectors also use high-purity silicon in a light trap and achieve near 100% external quantum efficiency. They provide commonality with the preflight calibration methodology.

In addition, the OBC has five PIN wavelength sets. These are neither light-trapped, nor of high internal quantum efficiency, but rather have been optimized by design to be extremely radiation resistant. Preflight testing of the PIN detectors has demonstrated stability to radiation dosages simulating the six-year mission.

Radiation testing of the blue High Quantum Efficiency (HQE) photodiode flight standards has determined that these devices should not degrade during the EOS mission life. The red HQE device degraded within an acceptable range. Prior to testing it was believed that neither the red nor blue HQE devices would be radiation stable; hence the radiation-resistant PIN photodiodes were included in the instrument design. The better-than-anticipated performance of the HQEs will provide long-term multi-calibration pathways, thus reducing calibration uncertainties.

For the Laboratory and HQE Standards, 100% external quantum efficiency is verified by comparing the measured quantum efficiency of several devices, all of different photodiode architectures. The largest sources of uncertainty are knowledge of the aperture areas and aperture displacements within the baffle-tubes, and effective filter spectral transmittance for the as-built standard configuration. PIN internal quantum efficiency must additionally be measured by comparison to the Laboratory Standards. Radiance uncertainties of all standards are believed to be within $\pm$ 2% (1-sigma).

Round-Robin Results

MISR has emphasized the need for Round-Robin experiments to provide further verification of the detector-standard-established radiometric scale, and to provide a cross-comparison with other EOS instruments. In August 1994, MISR was the host for a Round-Robin experiment. In attendance were Stu Biggar, U of A, who brought a multi-channel filtered transfer radiometer; Sakuma Fumihiro, National Research Laboratory of Metrology (NRLM), Japan, with a 650 nm channel transfer radiometer; and John Cooper, GSFC, with a NIST-traceable source and spectroradiometer. In order to intercompare the sphere source output, as measured with one radiometer at one wavelength, to another radiometer at a different wavelength, a blackbody spectral distribution was assumed. The MISR and U of A sphere measurements agreed to better than 1.0% at 550 nm. The MISR and NRLM sphere measurements agreed to better than 0.9% at 650 nm. These results confirm MISR's claim of 2% (1 sigma) detector-standard accuracy.

Additionally, a filter transmittance intercomparison was conducted during the Round-Robin. It is recalled that accuracy of the detector standards is no greater than the accuracy of these filter transmittance measurements; therefore, results of this test were also of great interest. Transmittance measurements typically agreed to within 1%, except for one (non-MISR) instrument with known inconsistencies. Prior to this experiment MISR had assumed filter transmittance accuracy of 0.5%. Further spectrometer certification is recommended, although the added 0.5% uncertainty will not affect our calibration plans or schedule. It is noted that systematic biases can be removed at a later time.

Engineering Model Characterization

MISR completed the build of the Engineering Model (EM) A and D cameras (the largest and smallest focal lengths amongst the four lens designs) this past fall. Camera testing was then conducted from December to March of this year. The MISR team believes the Engineering Model has been invaluable in diagnosing and fixing problems that otherwise would have been undetected until manufacture of the flight hardware. These fixes include the identification and elimination of: 1) a white light leak due to bondlines between the respective filter bands; 2) a significant light leak due to illumination of silicon around the CCD bond pads; and 3) a focus error due to the interface ring-mating lens to camera head.

Other significant problems studied with the EM were insufficient out-of-band rejection and a low-level "halo" around the point-source image. Both problems were attributed to scattering within the filter and scattering between the filter and CCD. Improved quality of the flight filters has reduced the magnitude of these problems considerably. Our present plan is to compensate for any remaining deviations from specifications in the ground data processing software.

The filter scattering noted on the EM cameras has also affected the PIN photodiode performance. If uncorrected, out-of-band energy would lead to a violation of the calibration accuracy requirements. During the flight calibrations, the photodiode standards will measure sunlight reflected from diffuse panels which are spectrally flat. Because the spectral distribution of the input is known, the diode data can be adjusted for out-of-band response. This correction will be implemented in order to provide the required 3% calibration throughout the mission.

The primary objective of EM testing was to identify and correct weaknesses in the test and data analyses procedures (to dry run them), before the arrival of the flight cameras. Where possible the tests were additionally used to verify instrument design and recommend final changes. The unexpected halo, out-of-band response, and bond-pad light leak led to a more-extensive testing and characterization than originally planned. The flight procedures, therefore, have now been modified to include more extensive measurements.

Through EM radiometric calibration it was learned that the stability of the sphere lamps was increasing with time. Relying on vendor input, the original plan utilized each lamp set for 200 hours. Based upon experience with the EM, however, it appears there is a smaller window in which the lamps are stable to within our ± 1% requirement, thus a better plan is to replace the bulbs after 50 hours, in order to assure that stability is met. Our plans for the flight unit include changing the bulbs more frequently, as well as monitoring stability with a blue-filtered photodiode, the wavelength at which the lamp stability is greatest.

Electrically, the MISR cameras are extremely quiet. The camera signals are encoded to 14 bits and all signal-to-noise-ratio requirements are being met in EM testing. Requirements for local uniformity of response from pixel to pixel are also being met.

The spectral calibration data for MISR are collected from 400 to 1175 nm, in step sizes of 0.5 (1.0) nm for the in-band (out-of-band) characterization run. During EM testing it was discovered that if the monochromator output was spread sufficiently to illuminate the full-array (1504 pixels per array, ± 30 degrees for the A camera), the signal strength became insufficient to allow characterization of the out-of-band response. As out-of-band characterization is crucial, the output beam has been narrowed such that only 50 pixels are illuminated at a time. The beam will additionally be steered to characterize seven spatial positions across the array for the in-band test, and three positions for the out-of-band test.

Spectralon BRF Determination

In-flight the HQE and PIN detector standards view diffuse reflectance standards. These are flat panels made of Spectralon, a product of Labsphere, Inc. Spectralon is made of pure polytetrafluoroethylene (PTFE); is spectrally flat; and is highly reflective. The calibration panels are used to provide a flat-field source into the cameras. They are characterized preflight for relative reflectance versus view and illumination angle. In-flight degradation of the panel absolute reflectance, or illumination of the panels with a varying Sun/Earth atmosphere path length are accommodated in that the detector standards measure the radiance reflected from the panels throughout each calibration exercise.

Data from the EM Spectralon diffuse panel bidirectional reflectance factor (BRF) characterization were presented. MISR uses Spectralon panels as part of the in-flight calibration. The BRF set-up utilizes a HeCd

(442 nm), HeNe (632.8 nm), and diode (860 nm) laser to characterize the panels over the MISR spectral observation range. BRFs were measured at 11 spatial positions, both in- and out-of the principal plane, at both s and p illumination polarizations. At 442 nm the panel spatial uniformity was poorer than the 0.5% requirement. It was determined that spatially distinct regions (top, center, and bottom) existed, probably resulting from the manufacturing processing. During the final stage of panel preparation a sanding disk is swept across the panel; a central hole in this disk may give rise to the observed spatial variations. The flight panels, although manufactured to the same procedures, have improved spatial uniformity, meeting the 0.5% manufacture requirement. Evidence of non-uniformity in BRF due to cleats in the Spectralon, which are used for gripping the Spectralon panels by the aluminum holding trays, was sought. No such effect was observed.

Image Registration and Geolocation

Achieving and verifying repeatable instrument pointing has been a focus of the preflight instrument phase. Testing verification has been provided by a tool which uses nine distinct collimators in a fixture which rests on the MISR optical bench. Imaging of a collimator target by each MISR camera provides camera displacement with respect to the calibrated collimator assembly. Repeatability of camera pointing through temperature excursions is thereby verified.

In-flight, pointing is to be determined to within tens of arcseconds. This is achieved by a three-step process involving: 1) using ground control points to provide an accurate camera pointing model; 2) establishing a set of reference imagery, one image per each MISR camera per unique orbit; and 3) the routine registration of follow-on MISR imagery to the reference data set. Geolocation and nine-camera image registration is provided with this processing, as the reference imagery is geolocated with respect to a Space-Oblique Mercator map.

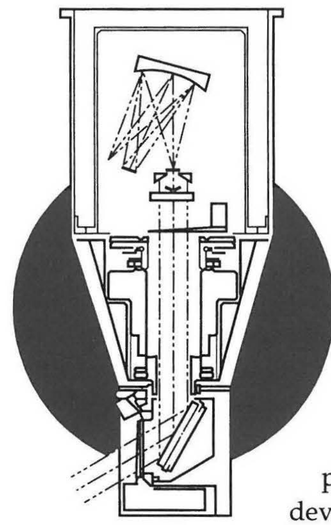
Review Board Comments

The MISR team felt that the Calibration Peer Review was a constructive process, and several key recommendations will be implemented. It was felt that, in addition to the Round-Robin Experiments, calibration accuracy of our detector standards should be verified by a standards lab, such as NIST. The MISR team believes that this can be done after the camera calibration data have been collected. Any systematic biases in the calibration can be removed prior to final documentation of the preflight camera calibration. Concern was expressed about our plan to swap out the Spectralon diffuser panels after testing at the spacecraft integration facility. The MISR team still feels this is our best option, in view of the sensitivity of Spectralon to hydrocarbon contamination. A recommendation was made to have the Cary spectrometer certified for transmission accuracy. Another comment pointed to the need to coordinate field campaigns for validation among AM platform instruments. We concur with these observations.

Science Team Meetings

Stratospheric Aerosol and Gas Experiment III (SAGE III) Science and Data Processing Meeting

— **Lelia Vann** (l.b.vann@larc.nasa.gov), SAGE III Science Manager, Aerosol Research Branch, NASA Langley Research Center



The first Meteor-3M/SAGE III Science and Data Processing Subgroup meeting was held at the Langley Research Center. The meeting began on Monday, April 3, with welcoming statements by M. Patrick McCormick, the SAGE III Principal Investigator. The meeting goals were to:

◊ Discuss the science portions of the Joint Program Implementation Plan:

- Science Team members
- Involvement in algorithm development
- Ground measurements and verification plans
- Comparisons of independently processed data products

◊ Discuss the Joint Mission Operations Plan.

◊ Introduce the EOS Data and Information System (EOSDIS).

◊ Discuss the Russian/U.S. science partnership.

The SAGE III Science Team was established in 1989. Team activities include the development of required Goddard Space Flight Center (GSFC) EOS documentation, involvement in algorithm development, involvement in verification, data correlation, etc. It is important that the science team results be coordinated and peer reviewed prior to publication.

McCormick and the SAGE III Science Team would like to have two Russians added as members of the SAGE III Science Team. In addition, there is a strong desire for Russian participation in the algorithm development, and McCormick extended an invitation to have one or two Russian scientists visit the U.S. to work side-by-side with the U.S. team in developing processing algorithms. (These Russian scientists working on algorithm development could be other than the Russian Science Team members.)

The Science Program highlights were presented by Jack Kaye, the SAGE III Program Manager from NASA Headquarters. SAGE III is critical to the EOS program and was strongly supported by the EOS Payload Panel and recognized as an overall international program for studying atmospheric chemistry and aerosols. Flying SAGE III aboard Meteor-3M in 1998 through 2003+ is important because other space-based sources of data may be severely limited, and it is predicted that the stratospheric chlorine levels should be peaking near 2000, so this timeframe will provide global coverage before and after the peak. The U.S. recognizes the Russian capabilities in ground-based measurements of ozone, aerosols, trace gases, and atmospheric chemistry; balloon measurements of ozone and water vapor; and use of models and remote sensing. We want the best Russian scientists involved, working jointly with the SAGE III Science Team. We envision Russia to have an independent team led and coordinated by their two members on the Science Team.

Co-investigator Joseph Zawodny described the instrument and data to be taken. Yuri Borisov had several questions about the instrument specifications and data sampling as well as detailed questions about the SAGE II data, which had previously been provided to him. Zawodny agreed to meet with him later during the week with a couple of the algorithm developers to explain in detail the SAGE II algorithms, processing, and archiving. Zawodny also provided Borisov with SAGE III instrument parameters as well as some papers that have been presented on some of the data results.

Borisov, Department Chief at Central Aerological Observatory in Russia, listed eight potential candidates for either the science team or the algorithm development team: Kokin, Ivanovsky, Shturkov, Glazkov, Stasuik, Kugaenko, Borisov, and Efinov. The SFM-2M Russian spaceborne instrument measures ozone from 30-60 km. Borisov thought it would be desirable to fly this instrument with SAGE III for data validation and correlation. The Russians have 20+ years of temperature, pressure, and ozone data for the 30-60 km altitude range.

Borisov suggested that the U.S. members of this subgroup identify the responsibilities of the Russian Science Team members, and the Russians would attempt to supply people to satisfy the responsibilities. The U.S. members agreed to draft some tasks and present them later in the afternoon (see below).

Co-investigator, William Chu, discussed the SAGE III algorithm development and data processing plans. The EOS philosophy is that the data production software will be in place, debugged, and operational at launch. Chu stated the EOS requirements for algorithms and processing software. He talked briefly about the Algorithm Theoretical Basis Documents (ATBD). SAGE III will generate an ATBD for eight data products. He explained that the SAGE III Science Team was grouped into Integrated Product Teams to develop each of these ATBDs. A sample copy of the ATBD was provided to Borisov to help him to understand the detail at which these documents will be generated.

McCormick presented the following as potential Russian Science Team tasks:

◊ Validation and correlative measurements:

- Subteam member or team leader, e.g., for aerosols, ozone, water vapor, etc.
- Organize Russian correlative measurement effort

◊ Algorithm Theoretical Basis Document (ATBD):

- Algorithm development, validation, or contribution to specific team (Integrated Product Team)
- Data use for investigations or model development

These potential tasks will be discussed with Albert Chernikov, Director of Central Aerological Observatory, next week. It is hoped that the Russian science team members will be chosen before the next SAGE III Science Team meeting which is currently targeted for this coming July.

On Tuesday, April 4, Chris Harris, Computer Sciences Corporation (CSC), gave an overview of EOSDIS. Paula Detweiler, also from CSC, briefly discussed the capabilities of the Langley Distributed Active Archive Center (DAAC). She explained how to access the Langley DAAC via Internet and how to obtain data products.

Mike Cisewski, Lockheed contractor supporting Mission Operations for SAGE III, presented a draft outline of the Meteor-3M /SAGE III Mission Operations Plan. The objective of this plan is to identify U. S. and Russian roles and responsibilities during the conduct of the integrated Meteor-3M/SAGE III operations. Current plans are to transmit science data twice every 24 hours to both the Russian and U.S. data stations. Every 2 weeks, routine spacecraft and instrument commands will be transmitted to the spacecraft. However, if there is a possible need to transmit commands to SAGE III more frequently than once every 2 weeks, then the Science team wants the capability to do that. It was agreed to conduct a more-detailed mission operations discussion at the next meeting in Russia. Another subgroup may be warranted since this would involve discussions with all parties that will be participating in the integrated mission operations.

Borisov presented information about the Russian ground, sounding rocket, and balloon measurements program. Recent data results were shown as well.

Zawodny, Borisov, Nina Iyer, and Mike Rowland met on Tuesday afternoon and Wednesday morning to discuss, in detail, the SAGE II algorithm and data processing. Absorption cross-section data and species climatologies for SAGE were provided to Borisov. Several papers on algorithms for data inversion were provided to Borisov as well.

In summary, the Science and Data Processing subgroup meeting was a huge success. The excitement shared with Borisov during these meetings was evidence that an overall feeling of a genuine Russian/ U.S. science partnership is being created.

Ames Research Center:
A Complete Service Center for Airborne Earth Observation

—**Jeff Jenner** (Jeff_Jenner@qmgate.arc.nasa.gov), Medium Altitude Missions Branch, NASA Ames Research Center

For more than 20 years, NASA Ames Research Center has provided a variety of aircraft platforms for Earth observations. Currently, Ames operates six airplanes, which form a fleet that can carry remote sensing and *in situ* instruments to altitudes as high as 70,000 feet and take them virtually anywhere in the world. The Ames fleet supports a wide range of studies—from small, inexpensive, single-investigator, "quick-look," experiments, to detailed, long-term, multi-aircraft research programs. The fleet carries investigators from NASA, other federal agencies, academic institutions, and international scientific organizations. Experiments conducted on Ames aircraft have made important contributions to the fields of geophysics, meteorology, atmospheric science, earth resources, geology, volcanology, and hydrology. Several experimental and developmental remote sensing instruments that were tested on Ames airplanes have eventually flown on satellites. Ames aircraft have also played key roles in disaster relief efforts and assessments.

Virtually all of the ground facilities required to design, build, and integrate the flight experiment hardware; calibrate remote sensing instruments; provide finished data products; and maintain the aircraft are located within walking distance of the main hangar. Also, much of the mission-critical support hardware is portable and is routinely deployed to remote sites around the world. Ames aircraft operations teams have established a long and distinguished record of service to the Earth science research community, continuously working towards their goal of "anytime, anyplace, anywhere."

The Airplanes

DC-8 Airborne Laboratory

The DC-8 Airborne Laboratory is a medium-altitude airplane, powered by four CFM-56 high-bypass turbofan jet engines. It can carry a payload of up to 30,000 pounds to cruising altitudes as high as 41,000 feet, with a range of more than 5,000 nautical miles. It has seated as many as 30 scientists working on 14 different experiments. Cruise speed is 425-490 knots True Air Speed.

Although it has no "core" instruments (those operated and maintained by Ames personnel), the DC-8 has a wide array of experiment support systems, including an inertial navigation system, a Global Positioning System (GPS) receiver, a Precision Thermal Radiometer, weather radar, hygrometer, radar altimeter, and weather facsimile. A Data Acquisition and Distribution System (DADS) records airplane navigation and environmental data and distributes it to the experimenter workstations. The DC-8 has seventeen large-aperture viewports (facing four different directions) that can accommodate windows up to 16 inches in diameter or plates with air sampling probes. It can also be equipped with an ejection system to release standard radiosondes, which relay atmospheric conditions to a receiver on the airplane as they parachute to the surface.

The DC-8 has true global-reach capability and is routinely deployed internationally. It has flown over both the North and South Poles; the Atlantic, Pacific, and Arctic Oceans; and all seven continents. Notable DC-8 airborne research programs are the Ozone Hole studies in the Arctic and Antarctic. It played a key role in quantifying the extent of the Ozone Holes and measuring atmospheric conditions that were thought to cause it. The DC-8 carried the Jet Propulsion Laboratory (JPL) L-, P-, and C-Band Synthetic Aperture Radar (SAR) systems to gather data on radar calibration sites in the United States, Canada, Europe, and Australia. JPL investigators and Earth scientists used this information to validate data from the Space Shuttle Imaging Radar missions. JPL investigators continue to use the airplane to test new concepts and to develop new techniques for SAR imaging. Atmospheric chemistry experiments conducted on the DC-8 have significantly increased our knowledge of the troposphere and how it is changing in response to human activity. Current experiments involve lidar (light detection and ranging), which is an effective tool for ocean and atmosphere pollution measurements.

C-130 Earth Resources Aircraft

The C-130 Earth Resources Aircraft is a low- and medium-altitude, moderate-speed airplane with a payload capacity of 20,000 pounds. It cruises at speeds between 150 and 300 knots and can reach altitudes to 31,000 feet. The C-130 has been extensively modified to include nadir and zenith viewports and can accommodate instruments that extend out over the edge of the aft cargo ramp. It can support a wide variety of onboard sensors, including multispectral scanners, radiometers, air sampling equipment, and aerial cameras. The Ames core instruments include:

◊ NS001 Thematic Mapper Simulator: The NS001 collects data in eight spectral bands, three that measure reflected energy in the visible portion of the spectrum, four that measure reflected infrared energy, and one that detects thermal infrared energy. The NS001 allows scientists to obtain data similar to that from orbiting scanners on Landsat-4 and -5, but with an order of magnitude improvement in ground resolution.

◊ Zeiss Aerial Mapping Cameras: Two Zeiss cameras provide high-resolution photographs to complement the digital imagery.

◊ Precision Thermal Radiometer: The PRT-5 measures and records ground surface temperatures from thermal radiation emitted by the Earth.

◊ Frost and Dewpoint Hygrometer: The hygrometer records the *in situ* dew and frostpoint temperatures.

◊ Radar Altimeter: The APN-222 radar altimeter measures the absolute altitude from 0 to 70,000 feet.

◊ Computer Assisted Data Distribution System: The CADDS records in-flight data parameters and distributes them in real-time to experimenter workstations throughout the airplane. Parameters include position, time, altitude, airspeed, heading, wind speed and direction, and aircraft roll and pitch. These parameters are also recorded on magnetic tape for post-flight analysis.

Another instrument that is carried on most C-130 flights is the Thermal Infrared Multi-spectral Scanner (TIMS). Geologists use its six discrete channels in the thermal infrared band extensively for rock type discrimination. Volcanologists use TIMS for temperature distribution measurements in volcanoes.

Although it primarily flies within the Continental United States and Canada, the C-130 has been deployed to sites as far away as Niger, Australia, and Germany. It has also served as a rapid response observation platform during local disasters such as the Oakland Firestorm (1990), the Malibu fires (1993), the Los Angeles Earthquake (1994), and the Northern California floods (1995). During the Malibu fires, for example, the near-infrared and thermal-infrared scanners penetrated the smoke and revealed the extent of the damage and locations of hot spots. A standard VHS videotape of the imagery was delivered to police and fire authorities at the airport minutes after acquiring the data.

Learjet Airborne Observatory

The Learjet Airborne Observatory is a Model 24 Corporate Class, medium-altitude, high-performance airplane with a range of 1500 nautical miles, a ceiling of 45,000 feet, and a payload capacity of 1,200 pounds. Cruise speed is 450 knots True Air Speed. An optional long-range fuel tank allows the Learjet to be deployed worldwide. It supports research in astrophysics, meteorology, planetary and atmospheric science, geophysics, and reduced gravity (parabolic flight). The primary observation instrument is a clear-aperture, gyro-stabilized, open-port, 30-cm infrared telescope that looks out the left side of the airplane.

An infrared camera carried on the Learjet recently photographed the engine exhaust plume from the Boeing 747 Shuttle Carrier Aircraft while the two airplanes were flying in formation. Post-flight analysis confirmed that background heat from the exhaust plume would have only marginal science impact on the proposed Stratospheric Observatory For Infrared Astronomy (SOFIA), which will be flown aboard a 747 at the end of the decade. This initial research has led to the proposal for the NASA Infrared Measurement System (NAIMS), which would permit in-flight imaging and spectral measurement of airborne targets. The Learjet has also been used for parabolic flight experiments, providing reduced gravity conditions for 20 to 30 seconds at a time, for a total of six events per flight.

ER-2 High Altitude Research Aircraft

The ER-2 High Altitude Research Aircraft carries a single pilot and up to 2600 pounds of payload to altitudes approaching 70,000 feet. It is a modified version of the U-2 aerial reconnaissance airplane. Ames currently operates three ER-2s, which support stratospheric and tropospheric chemistry experiments, remote sensing, geographic mapping, disaster assessment, and preliminary testing of spacecraft sensors. A typical mission lasts up to six-and-one-half hours and covers 2,200 nautical miles. Under certain conditions, it is possible to extend this to eight hours and 3,000 nautical miles. The maximum-altitude mission profile involves a steady climb from 60,000 feet to 70,000 at a constant mach number.

The ER-2 has flown over many areas of the globe, from the North Pole to the tropical Western Pacific to Antarctica. Each year, the ER-2 program conducts data collection flights for 40-50 individual scientists as well as for large multi-instrument research programs involving teams of scientists. Experiment objectives range from atmospheric sampling to simulations of spacecraft sensor observations.

The ER-2 is equipped with an Inertial Navigation System that can get position updates from an on-board GPS receiver. It also has a data recording and distribution system that records aircraft performance and navigation data and distributes it to each of the payload areas. The ER-2 core instruments include:

◊ Daedalus multi-spectral scanners with the following configurations:

- Thematic Mapper Simulator
- Multi-spectral Airborne Mapping System
- Airborne Ocean Color Imager
- MODIS Airborne Simulator

◊ Three types of aerial cameras that provide high-resolution photography at several scales and resolutions

◊ A video imaging system.

In 1994, one ER-2 participated in an eight-month study that examined the causes of the ozone loss in the southern hemisphere. Based primarily at Christchurch, New Zealand, it flew forty-five air sampling missions over Antarctica, including the first sampling of the exhaust from the supersonic passenger jet Concorde (Air France). Over the past eight years, air samples gathered by the ER-2 have played a key role in determining the chemical reactions thought to cause ozone depletion in the upper atmosphere.

Vehicles for Outreach

When deployed to airfields around the world, Ames airplanes and their crews are highly visible representatives of NASA and the United States. Local residents often come out to see the airplanes and, when feasible, tour them. The airplanes also attract members of the news media; some flight crew members give several interviews a day regarding the airplanes and their missions. This not only helps promote NASA, but provides many opportunities to increase the public's general awareness of remote sensing and the environment. At the working level, Ames flight crews routinely participate in multi-national, multi-aircraft field campaigns.

Educational outreach is a basic Ames mission and an important part of our operations. Recently, the C-130 carried a crew of graduate geology students during flights over Arizona, which resulted in several graduate research papers. The accessibility of the C-130 (with its relatively constant suite of instruments and local operation), together with the growing interest of K-12 teachers in remote sensing, also provides an opportunity for teacher involvement. Such a program would draw on the experience of the highly successful Ames C-141 Kuiper Airborne Observatory Flight Opportunities for Science Teacher Enrichment (FOSTER) program.

The Ground Facilities

Routine aircraft maintenance and repair is done in-house, with oversight from Ames Quality Control and Airworthiness personnel. Mission-peculiar hardware is fabricated by personnel from the sheet metal, machine, and model shops adjacent to the main hangar. A dedicated engineering staff designs and analyzes mission-peculiar hardware for many airborne science and Earth observation customers. Ames maintains calibration laboratories for many of the common remote sensing instruments and sensors.

All mission-related activities (including hardware design and fabrication) are coordinated by the members of the aircraft mission management offices. These mission managers also fly with the experiments (except in the ER-2) and provide interfaces between the flight crews and experimenters. Our on-site Aircraft Data Management Facility produces customized, finished images or magnetic tapes in a format readable by the customers' equipment. The Data Facility personnel assist many investigators in imagery interpretation and image format variations. Our film processing lab provides film developing services and finished aerial photographs.

New Equipment...New Capabilities

Ames Earth science aircraft continuously receive hardware upgrades or modifications that keep them up-to-date with the needs of the research community and developments in the remote sensing industry. The DC-8 recently received a new Navigation Management System (NMS), which allows pilots to navigate using a combination of data from the Global Positioning System (GPS) and Distance Measuring Equipment (DME). Flight tests showed that the NMS can determine the airplane's true position to within 100 feet.

The C-130 will soon be capable of carrying the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS). AVIRIS was developed by JPL and is the first operational hyper-spectral instrument. It is unique in that it can produce imagery in 224 discrete bands over the spectral range from 0.38 µm to 2.5 µm. The result is high spectral resolution as well as high spatial resolution, which greatly increases the scientific utility of the data and the probability of accurate interpretation of objects in the imagery. Hyperspectral imaging is on the edge of commercial acceptance, but its progress is presently impeded by the lack of satellite-based hyperspectral sensors and high demand for the few airplanes that can carry them. Extending the C-130's capability to include hyperspectral imaging would make this tool more accessible and may promote the development of many new commercial applications.

The Learjet was recently modified to carry the Airborne Infrared Disaster Assessment System (AIRDAS). AIRDAS is an innovative multispectral scanner that was designed and built at Ames using seed money from the Center Director's Discretionary Fund and the U.S. Forest Service Fire Research Laboratory. It is the only airborne instrument that can resolve high-temperature profiles in wild fires, thus allowing accurate measurement of fire intensities. The downward-looking port installed for AIRDAS can accommodate other instruments, such as aerial cameras and electro-optical sensors. The Learjet also has a new GPS receiver that can provide position data to experiment systems.

The ER-2 is being outfitted with Starlink, which should be operational by the end of 1995. Starlink uses the NASA Tracking and Data Relay Satellite System (TDRSS) to communicate with investigators on the ground. This new system will increase the ER-2's real-time data transmission capacity from 1.2 megabits per second with a range of 275 miles from a ground station to 274 megabits per second from virtually anywhere in the world. Starlink will also add an uplink capacity of 200 kilobits per second. The global coverage from the TDRSS will provide opportunities to reduce the amount of ground support hardware required for remote deployments.

The Future

Remote sensing of the Earth is a rapidly growing industry world-wide. The Ames Earth Science Aircraft Program, with its extensive experience in remote sensing, has the opportunity to play a key role in developing this fledgling industry—thereby helping to maintain U.S. leadership in it. Today, the primary challenge in remotely sensed data is to turn it into useful information. This will require adequate data storage and computer systems capable of managing, organizing, sorting, distributing, and manipulating the data at exceptional speeds. With its close proximity to Global Positioning System equipment companies, computer hardware manufacturers, and software developers, Ames is in a unique position to lead the integration of information systems with multispectral imaging scanners. Our current development efforts include a method to automatically combine GPS position information with data from multispectral imaging scanners. If successful, this system will eliminate the need for manual georectification, or "stretching," of most digital imagery (georectification makes an image geometrically correct with respect to corresponding points on maps of the terrain).

The aircraft mission management group is currently leading several efforts to increase the number of reimbursable flight projects. We hope to achieve a better balance between NASA-funded and reimbursable projects, in order to get the most from our aircraft resources. In reimbursable projects, non-NASA organizations pay for the use of NASA facilities to develop new and innovative remote sensing applications. These projects are performed such that they do not interfere with NASA-funded projects and typically involve research that will benefit NASA in some way. For example, the City of Scottsdale, Arizona, recently funded a C-130 flight to acquire multispectral and thermal infrared imagery of Lake Havasu, in an attempt to locate possible sources of high bacterial counts in the water.

Increasing awareness of remote sensing among state and local natural resource managers is creating many new opportunities to develop new and innovative applications. We are planning a series of technology demonstration flights for the San Francisco Bay Area Air Quality Management District (BAAQMD) to determine whether or not airborne thermal infrared imagery will provide a reliable and economical method of determining the density and spatial distribution of lit residential fireplaces. The BAAQMD wants to quantify the contribution of residential wood burning to the overall airborne particulate concentration. The ability of the C-130 to image a large portion of the Bay Area in a few hours will permit meaningful correlation with airborne particulate measurements made during the same timeframe. We also plan to create a standard briefing package and remote sensing applications handbook targeted at potential customers who could benefit from remote sensing but know little or nothing about it.

Our Goal

Our goal at Ames is to provide low-cost, high-quality, world-class airborne science research platforms with "global reach" capability. We are continuously reviewing the needs of the Earth science research community as well as our own capabilities and making the upgrades and changes necessary to achieve that goal. These improvement efforts will also help to ensure that our programs continue to follow NASA's overarching philosophies of informational and educational outreach and local relevance.

Scheduling a Flight

Although NASA-sponsored research takes priority, Ames airplanes perform research for other public agencies and private organizations on a cost-reimbursable basis. The primary criteria for reimbursable programs are that their objectives are consistent with NASA's mission of developing new or innovative methods and capabilities in airborne science. Investigators who want to use Ames aircraft can do so by submitting a Flight Request Form (OM-7) with the following information, as a minimum:

- experiment objectives
- aircraft type
- required instruments and sensors
- name of sponsoring organization and principal investigator
- study locations
- desired dates and times
- weather constraints
- flight altitudes
- source of funds.

Approval of flight requests is based on the relationship of the proposed research to NASA's scientific interests and aircraft availability. It normally takes one-to-two months to approve a flight request for a reimbursable program. Detailed information about Ames aircraft and sensors is available from the Medium Altitude Missions Branch, (415) 604-5336 (DC-8, C-130, and Learjet) or the High Altitude Missions Branch, (415) 604-5340 (ER-2). Also, much of the general information about our airplanes and sensors is now on the World Wide Web, and can be obtained from our server at: http://airsci-www.arc.nasa.gov/

The Ames C-130B has now been grounded by the Office of Mission to Planet Earth, NASA Headquarters, but a Wallops C-130Q will continue to be available to meet the scientific requirements of low- and medium-altitude remote sensing. —Ed.

Lidar In-space Technology Experiment (LITE) 1995 Science Steering Group Meeting

— **Lelia Vann** (l.b.vann@larc.nasa.gov), SAGE III Science Manager, Aerosol Research Branch, NASA Langley Research Center

A Lidar In-space Technology Experiment (LITE) Science Steering Group (SSG) meeting was conducted at the Langley Research Center (LaRC) on Friday, May 5, 1995. The purpose of this meeting was to share and discuss the LITE data analyses, research activities, and future plans, and to summarize the LITE papers to be presented at the American Geophysical Union (AGU) 1995 Spring Meeting. The LITE Principal Investigator, M. Patrick McCormick, welcomed everyone and briefly summarized the agenda and the objectives for the meeting.

The LITE Project Manager, John Rogers, presented a brief overview of the LITE mission including significant accomplishments, lessons learned, and in-flight anomalies. He outlined LITE post-flight activities leading up to a current status report. He also used selected photographs to discuss significant events concerning LITE while it was being prepared for launch at Kennedy Space Center (KSC), mission control activities at Johnson Space Center (JSC), and receptions held at JSC and LaRC.

Bill Hunt presented an overview of the LITE performance characteristics stating that early emphasis has been on identifying and characterizing baseline distortions (semi-systematic noise on the baseline). Two known types of distortion were covered: sinusoidal oscillation and ripple. Both types are potentially significant at low signal levels. Selected plots of actual LITE data were used to illustrate these distortions.

Kathy Powell presented an update on the current status of LITE data processing and discussed the future LITE data processing plans. A packet of information was distributed that contained a list of all the LITE high-rate data that were obtained during the mission and plots of the LITE high-rate data coverage along the orbit tracks. The list of all the LITE high-rate data shows the beginning and ending times, Greenwich Mean Time (GMT) and Mission Elapsed Time (MET) for each segment of LITE high-rate data and indicates which segments have been converted to the level 0, version 1 data format. The LITE level 0, version 1 data format contains time-sequenced, raw signal, backscatter profiles for each wavelength; nadir latitude and longitude of each profile; meteorological data; ephemeris data (orbiter position and attitude) obtained from the space Shuttle onboard Guidance, Navigation, and Control (GN&C) data; and a subset of the Instrument Status Data Block (ISDB).

Powell noted some limitations of the LITE level 0, version 1 data product. The latitude, longitude, and shuttle altitude parameters are approximate due to the use of the Space Shuttle onboard GN&C data. These parameters will be improved in the level 0, version 2 data product by using the ephemeris data from the PATH product. There will also be new information added to the LITE level 0, version 2 data product: latitude and longitude of the LITE footprint, the angle away from nadir to which LITE was directed, and a version identification descriptor. This next version is currently being processed and will completely replace LITE level 0, version 1.

Chip Trepte described the status and availability of meteorological products and satellite images collected during the LITE mission and acquired afterwards. He also provided a listing of the present satellite image catalog archived at Langley.

Mary Osborn reported on the LITE data distribution. A database has been created and is being maintained by Dave Woods. It identifies all reports of correlative measurements taken during LITE and all requests for

LITE data. Fifty data reports and 23 specific data requests have been received to date. A summary of LITE level 0 data and analyzed data products that have been distributed was presented. Examples of correlative comparisons with Renger's down-looking lidar on the Falcon aircraft and with Stefanutti's ground-based lidar were shown as well.

A good portion of the remainder of the meeting was spent covering the AGU LITE papers. Pat McCormick, also the co-convenor of the LITE Special Session, presented a listing of all 29 papers and the Special Session agenda. The session begins with an overview of the LITE mission, which identifies the dates, times, orbits, measurements, objectives, etc. Some measurement examples are shown, e.g., super typhoon "Melissa." Richard Couch follows this overview with a brief discussion of the LITE hardware elements. Bill Hunt discusses the overall LITE data characteristics including any artifacts found to date. These introductory papers are followed by initial data use investigations. Some are summarized below, as given at the LITE SSG meeting, along with future plans for each investigator.

C. M. Platt summarized the paper entitled "Observations on tropical clouds with LITE." The talk begins with a short introduction to the importance of tropical clouds in climate, how they are formed in the upper troposphere, and our present knowledge of their distribution. This is followed by an account of the available LITE orbits over both the West and East Pacific. Measurements from these orbits show something new: the three-dimensional distribution of the clouds, their coverage, and their chief characteristics. A brief description of an algorithm developed for determination of cloud boundaries follows, together with some preliminary results on cloud height and depth statistics. These statistics highlight differences between the quiescent East Pacific compared to the active West Pacific region in the vicinity of the warm pool and the relevance of the new results to climate studies.

Geoffrey Kent summarized his paper on LITE high-cloud measurements and the interpretation of SAGE II cloud data. The SAGE II aerosol extinction data show sharp gradients in extinction near or below the tropopause. These are interpreted as being due to the presence of high-altitude clouds along the optical path from the sun to the satellite instrument. Several climatological studies have been made on clouds observed in this manner. In spite of this, we are still unclear as to the exact nature of the cloud causing the extinction changes and how the data should be interpreted. Airborne lidar and, in particular, LITE offers the chance to resolve these issues. Cloud backscatter data obtained using these instruments has been converted, using a simple model, to extinction and inverted to obtain the equivalent SAGE II extinction profiles. Initial software development was done on airborne lidar data and has recently been converted and tested on LITE data. Airborne lidar data from flights ranging over 10,000 km have been processed. To this point only a small quantity of LITE data have been studied but now that we are confident that the software is working we plan to make a study of all suitable LITE cloud data between about 30°N and 30°S. Application to the SAGE II data set will include the following:

◊ How often and by how much are the SAGE II cloud altitudes in error?

◊ How are the inverted extinction values to be interpreted?

◊ As seen by SAGE II, what are the mean vertical and horizontal cloud sizes?

◊ Is there a bias in the inverted extinction value below a cloud?

◊ To what types of cloud do our climatologies apply?

Dave Winker summarized the paper entitled "Effects of Multiple Scattering on LITE Observations of Clouds." The LITE orbit altitude and field-of-view (FOV) result in a very large sample volume in the atmosphere: roughly 1 km in diameter at night and 300 meters during the day. This results in significant multiple scattering effects in clouds, which are usually insignificant for ground-based lidars with sample volumes that are orders of magnitude smaller.

Different types of effects are dominant in cirrus clouds and in boundary layer clouds. Cirrus clouds, with low optical depth and large particle sizes, produce sharply forward-peaked scattering. Much of the scattered light remains within the LITE FOV, resulting in a reduction in the apparent extinction by factors of 2 or more. Because the mean free photon path within boundary layer clouds (such as stratus) is much smaller than the diameter of the FOV, photons can be scattered many times before exiting the sample volume. The most obvious effect of this is the "beards" seen on returns from stratus clouds which sometimes extend a kilometer or more below the Earth's surface. These artifacts signify pulse stretching produced by multiple scattering within the cloud layers.

Raymond M. Hoff summarized the paper entitled "LITE Observations of Large Scale Anthropogenic Haze." As LITE passed over the continents it observed haze emanating from urban areas. Over 40 cities worldwide have been identified in the first half of the LITE data that have been analyzed to date. These haze masses are extensive, often extending over 1000 km from their source. In one case, haze from North America is followed over three LITE orbits and matched to wind trajectory information. This is believed to be the first documented North American haze plume reaching Europe. These results are especially important since the additional light scattering from human-made aerosols has been implicated as an opposite influence to global warming.

Harvey Melfi summarized his paper entitled "Comparison of LITE and Aircraft Observations of Planetary Boundary Layer and Cloud Structure of the Atlantic Ocean." Several important points made were:

◊ Scanning lidar data from the P-3 show interesting structure in the boundary layer both along and across the flight track of the aircraft.

◊ Statistics on the clear and cloud-topped boundary layer are consistent with moisture being the controlling influence.

◊ Strong correlation was observed between boundary layer height and surface wind speeds, as expected.

◊ Correlation analysis performed between the P-3 data and the LITE data showed good agreement.

William B. Grant, representing Ed Browell, summarized two papers. The first was entitled "LITE Observations of Biomass Burning Plumes over South America, Africa, and the Southern Atlantic Ocean." Grant presented plots of case studies from Brazil and Africa coverage. LITE flew over Brazil during orbit 149. Biomass burning plumes from near the equator to near 30^{o}S were observed. During orbit 146, LITE passed over Africa. Clouds obscured the view of the biomass burning aerosols north of about 4^{o}S. Light aerosol loading was noted from 4^{o} - 25^{o}S. The aerosols were kept below 4.5 - 5.5 km by an inversion layer. It is dryer in Africa than in Brazil so the aerosol plumes rose higher in Africa.

The second paper, was entitled "Comparisons of Electra-Lidar and LITE Atmospheric Measurements near the East Coast of the U. S. and Caribbean." Fifty-shot averages were found to be useful in improving the LITE determination of aerosol scattering ratios for 30-meter vertical resolution. The Electra flight matched the LITE lidar beam path very well, as determined by the aerosol features observed. The visible scattering ratios agreed very well, and were well within the uncertainty of the measurements. The UV scattering ratios also agreed well, but there was more scatter in the data.

Syed Ismail summarized his paper entitled "Simultaneous LASE and LITE Aerosol Profile Measurements over the Atlantic." The Lidar Atmospheric Sensing Experiment (LASE), an ER-2 aircraft instrument, made LITE underflights. The data presented were LASE and LITE aerosol profile measurements over the Atlantic on September 17, 1995. The urban aerosol layers, a shallow marine layer, some cloud activity in the boundary layer, a very clean mid- and upper troposphere, and Pinatubo aerosols were observed by both systems. There was excellent agreement in the boundary layer aerosol fine structure. There were some differences in regions of clouds. However, measurements in the mid-to-upper troposphere showed no bias. Aerosol backscatter wavelength-dependence measurements in the boundary layer indicated particle sizes with less than 1 μm diameter, and the Pinatubo aerosol region data needed more averaging. Additional analysis will be conducted to examine aerosol wavelength dependence for individual boundary layer features.

J. A. Reagan summarized his paper entitled "Some Results of LITE In-flight Calibration Experiments." Ground-based and aircraft measurements were made in conjunction with LITE overpasses to calibrate the LITE 532 nm and 1064 nm channels by using LITE surface returns from selected land surface standard target areas. Spectral sunphotometer measurements were used to correct for atmospheric transmission losses. The ground reflectances were determined from spectral radiometer measurements of ground reflected solar radiance plus modeling to account for non-backscatter measurement geometries and diffuse light effects. Reagan summarized the equations for estimates of LITE calibration factors, results of ground reflectance measurements, and the relation between atmospheric and surface return calibrations.

Kevin Strawbridge summarized his paper entitled "The LITE Validation Experiment Along California's Coast," which provides two interesting case studies: aerosol transport and marine stratus clouds. Large urban plumes were identified, moving up the coastline from both San Francisco and Los Angeles on Orbit 119. Cloud-top height comparisons with LITE and cloud-top distributions obtained from the marine stratus cloud deck on Orbit 135 were also shown. Particle probe data and nephelometer data from the aircraft will help provide some closure on future collaborative work with ground-based radiometer data and optical depth calculations.

Chip Trepte summarized his paper entitled "LITE Observations of Enhanced Aerosol Distributions associated with Biomass Burning," which presents LITE observations of enhanced aerosol layers over Africa, South America, and adjoining ocean areas and examines the implications of long-range transport.

Kathy Powell presented an overview of the poster "Observations of Saharan Dust by LITE." This poster shows elevated layers of Saharan dust extending from North Africa, across the Atlantic Ocean, and into the Caribbean Ocean. The dust layers over Africa extend vertically over the entire boundary layer to altitudes exceeding 5 km. Meteorological analyses [European Centre for Medium-Range Weather Forecasts (ECMWF) trajectories of air transport] and satellite images will be correlated with LITE color-modulated plots along orbit sweeps over the Atlantic Ocean to identify the sources of enhanced aerosol detected by LITE. To illustrate this, ECMWF back trajectories of air transport that terminated along Space Shuttle Discovery orbit track 116, and LITE measurements along the same orbit track were displayed. The trajectories showed the transport of air originating from the Northwest African coastal region, the Saharan Desert, and from a region over the Atlantic Ocean. Along the orbit track, LITE measurements showed enhanced aerosol in the regions that contained air that was transported from the Saharan Desert, indicating the transport of desert dust. The LITE measurements over areas which contained air originating from the ocean did not show the same aerosol enhancement.

M. C. Pitts summarized his poster entitled "Tropospheric Aerosols off the West Coast of South America as Observed by LITE" with illustrations from Space Shuttle Discovery orbits 71, 103, & 104. The data taken from these orbits were analyzed to estimate the spatial extent of aerosol layers. The available corresponding meteorological data were also analyzed to determine possible source regions and transport of the various aerosol layers.

This concluded the summary presentations of the AGU papers. Pat McCormick briefly presented charts which were prepared for NASA Headquarters justifying a LITE-2. In support of a possible LITE-2, Richard Couch has assembled a team to assess reflight options.

Mining Data from Climate Models and Observations

—**Jarrett S. Cohen** (jcohen@jacks.gsfc.nasa.gov), Hughes STX Corp., High Performance Computing Branch, Goddard Space Flight Center

Today's climatologists have a variety of tools at their disposal. Two of the most powerful are supercomputer models, which may be descriptive, predictive, or a combination of both; and observations; EOS will be the most comprehensive source of observational data. Beyond understanding the Earth system as a whole, scientists also want to probe the data for specific weather patterns and other phenomena. With many gigabytes of spatially and temporally complex data often on hand, this task is only feasible with a query processing environment that addresses both conceptual abstraction and exploratory analysis.

Researchers at the UCLA Data Mining Laboratory[1] and the NASA/Jet Propulsion Laboratory (JPL)[2] are building such a system in CONQUEST (CONcurrent QUEries over Space and Time), a computational environment for content-based searching. "To us [data mining] is being able to express easily and execute efficiently complex queries that allow you to get at phenomena," says Director Richard Muntz, professor of computer science. "The scientific user expresses what he or she is looking for; machine learning has algorithms that look for patterns in data."

"The goal is to make this painless," adds Edmond Mesrobian, laboratory co-director and postdoctoral researcher. Designed towards providing automated data exploration and analysis, CONQUEST (see Figure 1) consists of a Scientist Workbench, a Visualization Manager, Information Repositories, and the

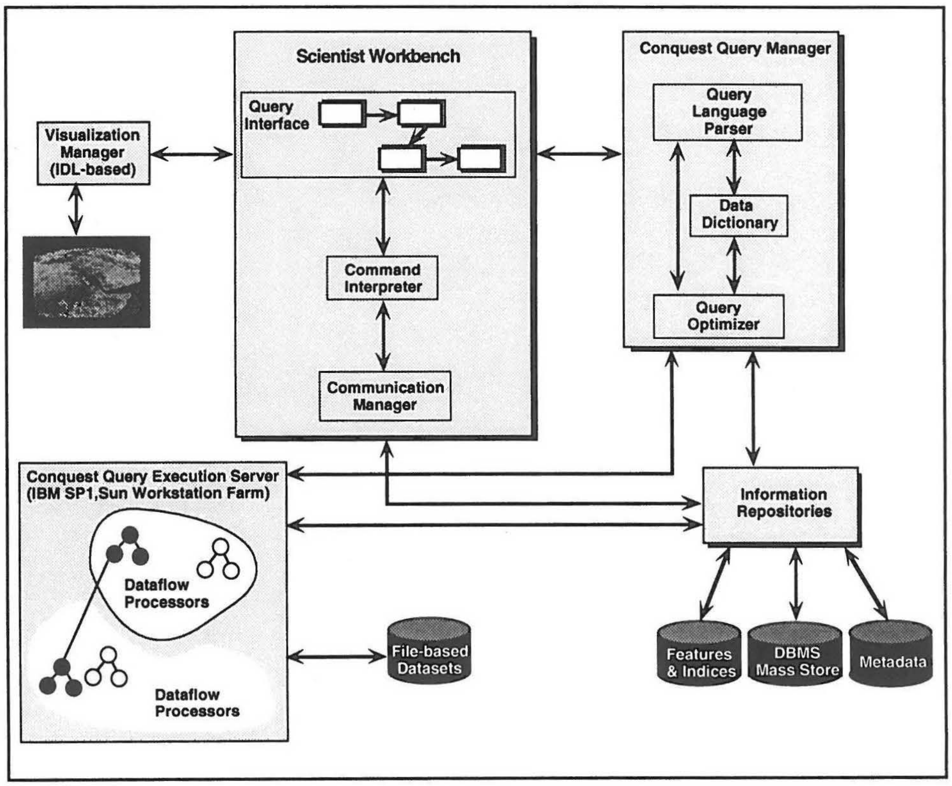


Figure 1.

[1]Richard Muntz, Edmond Mesrobian, Joseph Skrzypek, Carlo Zaniolo, Lawrence Chan, Shu Yao Chen, Mark Kriguer, Kenneth Ng, Jose Renato Santos, Eddie Shek, Jeonghee Yi, Computer Science Department; Roberto Mechoso, Department of Atmospheric Sciences.

[2]Dan McCleese, Earth and Space Sciences Division; Leon Alkalaj, Paul Stolorz, Robotic Systems and Advanced Computing Technology.

CONQUEST Parallel Query Processing System. CONQUEST is very similar to popular interactive packages such as the Application Visualization System (AVS), although the data model and execution paradigm are quite different. The Scientist Workbench acts as the top-level, graphical interface. From the Workbench, the user either chooses to visualize the retrieved data using the Visualization Manager or to index and store them in the Information Repositories for later use.

Made up of the Query Manager and the Execution Server, the CONQUEST Parallel Query Processing System executes the queries delivered from the Workbench. A library of operators, akin to modules in AVS, perform both generic algebraic functions and application-specific processes. Many are built in, but Mesrobian emphasizes that it is an open system to which researchers can add their own operators. This design is based on the University of Colorado's Volcano extensible query processing system. Another important aspect is a data model into which geoscientific datasets in multiple formats, e.g., HDF, GRIB, DRS, netCDF from a variety of sources, e.g., database management systems, geographic information systems, and general circulation models can be mapped. "We define a global data model and representation for the heterogeneous datasets to minimize what the user has to know," explains Eddie Shek, graduate student in computer science.

Applications

The UCLA researchers have been collaborating with several climate modeling teams in analyzing model output and have just initiated similar work with observational datasets. Studied models include the UCLA Atmospheric General Circulation Model (AGCM), the European Center for Medium-range Weather Forecasts (ECMWF) AGCM, and the ECMWF Global Basic Surface and Upper Air Advanced Analyses (observational data that have been assimilated using an AGCM). A data broker allows CONQUEST to do both post-processing and "live processing" of data from a climate model as it is running. The data broker can also work with several models, as it converts varying grid sizes to a common grid that is more convenient for the user.

The two principal phenomena under investigation thus far are cyclones and blocking events. "We are extracting cyclones and blocking events not only because they are important phenomena but also because they interact in ways that are imperfectly understood," says Paul Stolorz, a physicist in JPL's Robotic Systems and Advanced Computing Technology group. He describes one goal of the process as automating detection of features and then seeing if it is possible to extract and predict correlations and irregularities over a large time scale.

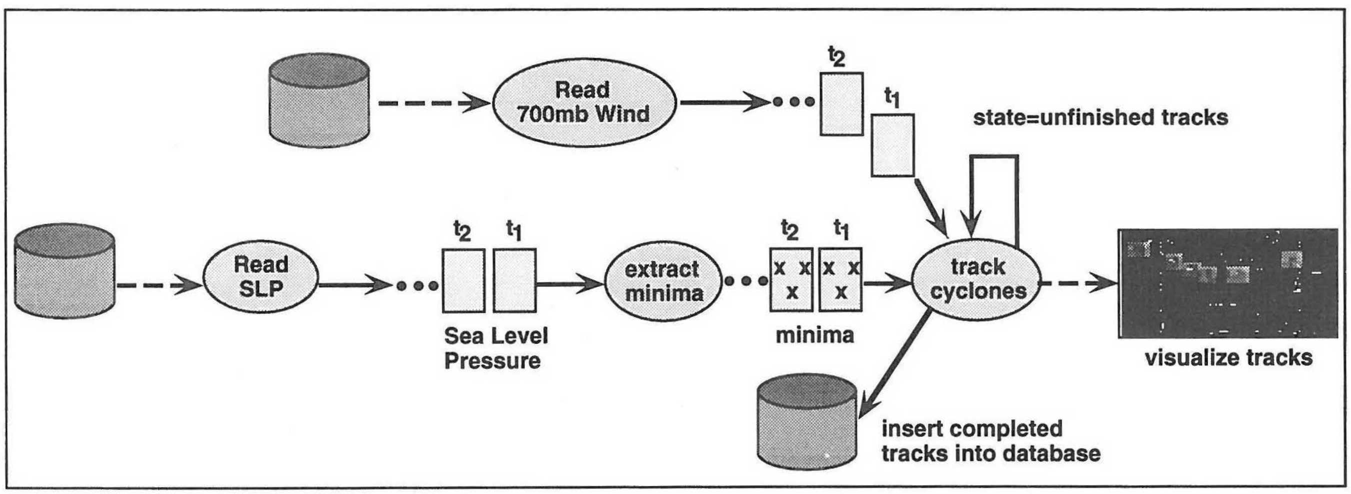


Figure 2.

Cyclones

Cyclones are areas of minimum sea level pressure (SLP), hundreds of kilometers in size, that are the generators of most of the weather. "With cyclones, the most difficult thing is tracking," Muntz says. In this several-step procedure (see Figure 2), distinct operators read the SLP values, extract minima from them, and use upper-altitude winds to determine the cyclone centers' most likely direction of movement. The final operator combines the minima and wind values to track the cyclone.

Cyclone trajectories, or "tracks," are put into the information repositories. "From 100 gigabytes, you can get down to 1 megabyte of salient periods of cyclones; you can then search these cyclones and do analysis," Muntz says. He explains that over 10 years of the model run, the user might obtain a few thousand cyclones. Searches can be basic and about the cyclones themselves, such as "find all the cyclones in the winter months." They can also be much more complicated, involving extraction of data related to the cyclone, such as "record the temperature in a 100 km region from the cyclone center," which in turn can be tracked as well.

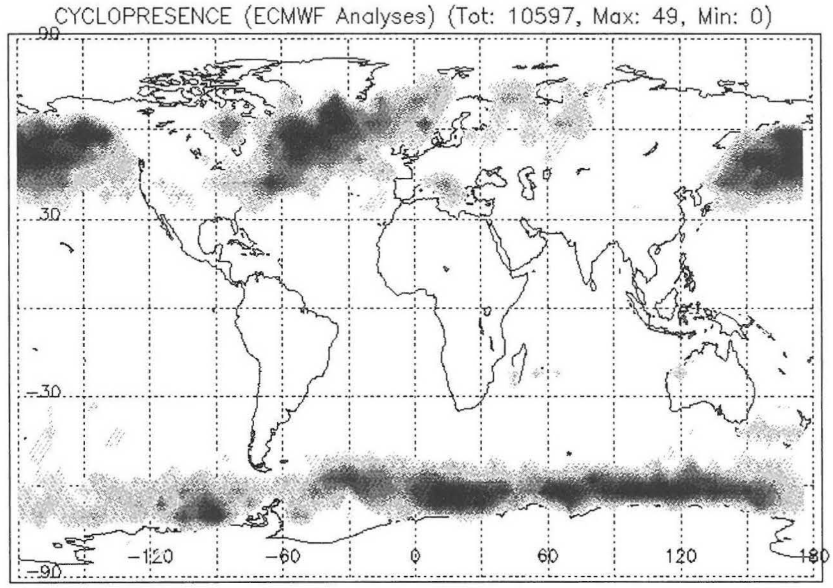


Figure 3a.

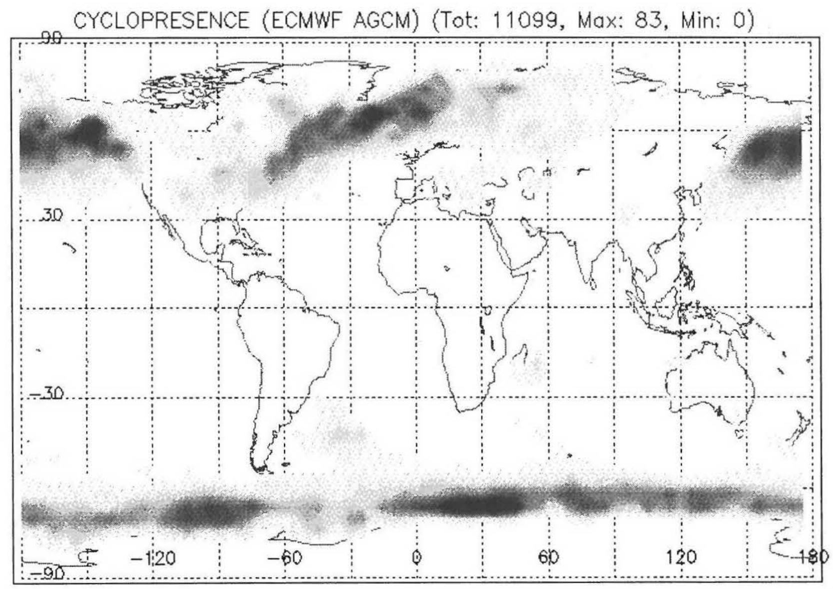


Figure 3b.

The Muntz team has produced several telling visualizations of cyclone tracks. In one, a world map outlined in white against a black background serves as a backdrop for eruptions of red slivers, which mark the cyclones' paths. Visualization is particularly useful for comparing different climate models. Mesrobian says that since scientists know where cyclones occur from observations, they can test the relative accuracies of the models. Density maps of cyclopresence (see Figure 3) for two ECMWF models show several differences; notably, the ECMWF AGCM (Figure 3b) generates significantly more cyclones than observed.

Blocking Events

A blocking event is a class of persistent anomaly in which the westerly jet stream in mid-latitudes splits in two and remains in this condition for 10 days or so. "It blocks the passage of normal wind flow, which affects the climate in that region; for example, storms flow around it," Stolorz explains. He says that scientists want to predict or understand the dynamics of typical patterns as well as why there would be deviations from the usual blocking pattern.

Plugging in operators for blocking event detection, a study of a 5-year dataset was carried out using the ECMWF Analyses and the UCLA AGCM (see Figure 4). "The results show where blocking events occur regularly, and we can see how they occur globally, both spatially and temporally," Stolorz says. From an initial 1 gigabyte of raw information, they found between 175,000 and 620,000 grid points with a strong blocking signal, which represent approximately 50 blocking events.

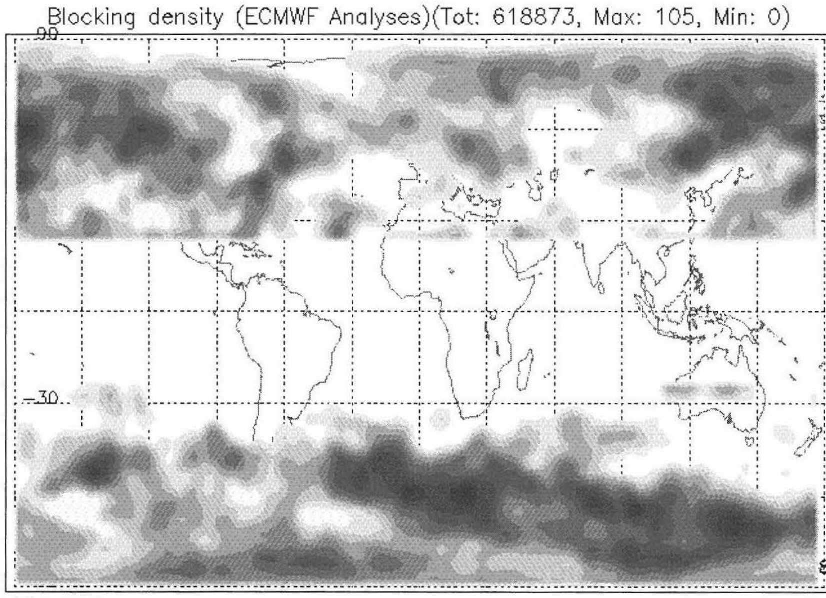


Figure 4a.

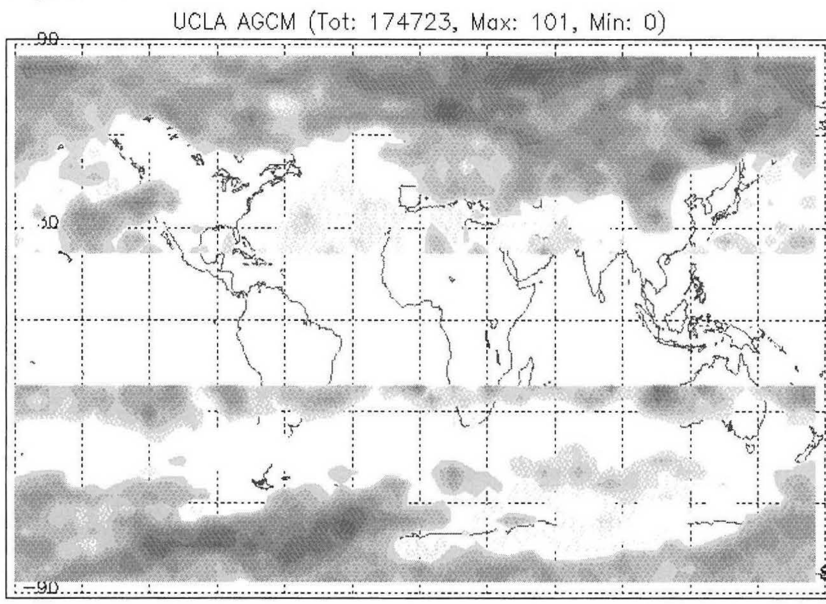


Figure 4b.

"We can use information theory to look at this behavior in more detail," Stolorz says. For example, scientists might want to know if the occurrence of 10 events in a certain place over 5 years is correlated with 20 events occurring in another location. Such an understanding leads to a more general comprehension of the climate system. "This is hard, outside the scope of the model," Stolorz stresses. "The computer has to put together information from a lot of different points. This step requires massively parallel computing resources, but it is do-able provided the search space is kept to a reasonable size."

Parallel Computing and Extensions

The sheer size and heterogeneity of the datasets together with the complexity of searches make data mining a "Grand Challenge" problem and thus a candidate for parallel computing. Parallel computers achieve multi-gigaFLOP (floating-point operations per second) speeds by dividing a problem across a large number of microprocessors, often the same ones as today's workstations. The NASA High Performance Computing and Communications Program is aimed at furthering the use of these machines, and Muntz's team receives primary funding from the Earth and Space Sciences (ESS) Project managed by the Goddard Space Flight Center. ESS also funds two Grand Challenge teams in global climate modeling and one in data assimilation, in addition to four astrophysics teams.

"The data model of CONQUEST allows you to view a large dataset as a sequence of data 'chunks' so that you don't have to have all the data in the machine at one time," Muntz explains. "Even the biggest massively parallel machines can't handle all the data . . . , not even a significant fraction." First developed for SUN workstations, CONQUEST now runs on the IBM SP-1/SP-2 family and the Intel Paragon.

A parallel computing technique known as dataflow processing manages the data and allows computation in different processes to overlap. CONQUEST supports several types of parallelism, including:

◊ Pipeline: The output of one operator is input to another. They can concurrently execute on different data chunks.

◊ Bushy: Two individual streams of data are processed in parallel and then merged.

◊ Partitioned: A single operator is replicated, and the data chunks are partitioned among the replicates to balance the load.

All these methods result in considerable speed-up of a content-based query. Postprocessing of 10 years of cyclone tracking data, for instance, used to take 20 minutes on a Sun Sparc 10 workstation but now takes less than 3 minutes on four Sun Sparc workstations and 23 seconds on an eight-node IBM SP-2.
For now, the user specifies the optimization, but Muntz says they are aiming for automatic optimization. "Optimizations would be based on the manner in which the datasets are organized and on the computational complexity of the individual operators," he says. One type of decision that would be made automatically is if CONQUEST should replicate an operator several times to perform the same function simultaneously on different data.

The EOS Data and Information System (EOSDIS) program is supporting extension of CONQUEST to a distributed object management environment, in which phenomena attributes and associated operators are combined into "objects" that contain all the information necessary to retrieve the desired data products. This capability will be crucial with data residing in different repositories, Shek stresses. Connection to a testbed Distributed Active Archive Center (DAAC) for advanced prototyping is planned. Stolorz points out that the team is also working on automating what it means for something to be a blocking feature or a cyclone. "To describe them, it will decide what the factors are," he says. The difficulty here is that there is often no consensus on the definitions. Thus, "an individual researcher needs a way to quickly and efficiently iterate on the definitions until the result is judged to be acceptable," Muntz says. "He or she then can check the results by visualizing subsets of the raw data and modifying the definitions as needed."

Two other improvements underway to make the system more user-friendly are a simpler method for adding new operators and an interface that will create its own query forms for additional phenomena.

The first release of CONQUEST to the research community is planned for early 1996. By then, its designers' aim is to have "a robust language, like an erector set," Muntz says. "We want to make extracting cyclones or any other phenomena over a certain time as easy as searching for employees making over $30,000 in a company."

Land Processes DAAC Science Advisory Panel Meeting

— **Bryan Bailey** (gbbailey@edcserver1.cr.usgs.gov), U.S. Geological Survey, Sioux Falls, SD

During April 11-13, 1995, a Land Processes Distributed Active Archive Center (DAAC) Science Advisory Panel Meeting was held at the EROS Data Center (EDC) in Sioux Falls, South Dakota. The meeting was attended by a quorum of Panel members, as well as by participants and interested observers from EDC, NASA, JPL, and the EOSDIS Core System (ECS) contractor, Hughes Applied Information Systems.

Tuesday, April 11

DAAC Manager, Lynn Oleson, gave an overview presentation aimed at providing the Panel's new members with relevant background information about EOSDIS and EDC DAAC programs and activities. Action items from the September meeting were reviewed. Notably, the Panel examined and provided comments on:

◊ a new outline for a DAAC Science Support Plan;

◊ additional information on EOS electronic information options;

◊ upcoming conferences as candidates for presentations or exhibits describing EDC DAAC programs;

◊ issues related to publication of DAAC-generated technical papers;

◊ rationale for ingesting Shuttle Imaging Radar-B (SIR-B) and Seasat data at the DAAC and possible option of processing and archiving these data at the Alaska Synthetic Aperture Radar (SAR) Facility;

◊ availability and cost of Landsat Thematic Mapper (TM) data in the National Satellite Land Remote Sensing Data Archive;

◊ response from the NOAA Administrator on pricing policy for Landsat-7 data; and

◊ results of the "At Launch" Digital Elevation Model (DEM) meeting held in October, 1994, at NASA HQ.

Highlights of Instrument Team updates included:

◊ The ASTER Science Team has been charged with developing a strategy for prioritizing ASTER data acquisition, including defining the process by which, and from whom, data acquisition requests (DARs) will be submitted.

◊ The MODIS Science Team has been working on algorithm refinement and Algorithm Theoretical Basis Document (ATBD) revisions in recent months.

◊ As part of overall efforts to define future spaceborne SAR programs, NASA has published a National Research Council report titled, "Spaceborne Synthetic Aperture Radar: Current Status and Future Directions."

◊ As part of a comprehensive status report on Landsat-7, Darrel Williams, the Landsat-7 Project Scientist, asked the Panel to consider endorsing the concept of placing an X-band receiver at Fairbanks, Alaska by early 1998 for real-time downlink of Landsat data and as a back-up capability for EOS AM-1 data.

Earth Science Data and Information System (ESDIS) DAAC System Manager, Greg Hunolt, reported on ESDIS Project activities and issues. He reported that efforts are underway to develop a consistent set of user statistics across all DAACs, reflecting end-to-end Version 0 (V0) activities such as overall system

Information Management System (IMS), local IMS, data distribution, etc. Work plans submitted by the DAACs for FY 1996 are due July 1 and will be reviewed by the EOSDIS Data Panel. EOS data access and pricing policy is still evolving, and it is not clear just when a final policy will be announced. It is not yet clear what the anticipated $5 billion to $8 billion cut in the NASA budget for the FY 1996-2000 period will mean for EOSDIS or for the DAACs. One way of dealing with budget reductions may be increasing the synergy between NASA and NOAA in areas of technology infusion and co-location of data centers.

Wednesday, April 12

EDC DAAC Project Scientist, Bryan Bailey, led the Panel in a short discussion aimed at bringing increased attention to the topic of DAAC interaction with, and support of, the EOS IDS investigations. Among Panel members, there exists differing opinions about what the relationship between the DAACs and IDS teams should be in terms of the generation, archiving, and distribution of products developed by those teams. Clarification of roles and responsibilities is needed, and the Panel directed the DAAC to seek such clarification, as well as clarification about the fundamental relationship between the DAAC and the Science Computing Facilities (SCFs).

Moshe Pniel, the ASTER Science Project's Product Generation System Technical Manager, provided the Panel with an overview of ASTER standard product generation software development. He described the objectives of and overall approach to the effort, as well as the fundamental goals for the Beta, Version 1, and Version 2 software releases. He characterized the scope of the effort in terms of the specific products being developed and the corresponding estimated lines of code, and he described the project's management approach and testing philosophy.

ECS contractor staff reviewed recent activities and future plans as they relate to development of the EOSDIS Core System. Topics and activities discussed included ECS Science Office objectives and responsibilities; the near-term ECS development schedule, particularly as it relates to the EDC DAAC; a summary of the "Evaluation Package Four" experience; user modeling, the Ad Hoc Working Group on Production; and plans for data migration. Also, the EDC DAAC Manager, Lynn Oleson, described to the Panel the DAAC's strategy for enhancing its interactions with the ECS contractor.

Lynn Oleson and DAAC Group Leaders for Engineering & Development, Data Set Acquisition and Ingest, Mission Support, and Data & Information Services reviewed the status of DAAC activities and presented preliminary plans for FY 1996. Points of note from the presentations follow.

Efforts to establish a new DAAC organizational structure are partially complete. Technical groups have been established with designated leaders and growing numbers of dedicated staff, and the formal process to establish an EOS Systems Branch at EDC has been initiated. The DAAC Data Distribution System (DDS) is taking shape. The operational system uses a new digital linear tape (DLT) jukebox, Silicon Graphics server, and an AMASS file management system. Interim electronic distribution capabilities have been implemented for distribution of some data sets.

The DAAC is beginning to seriously address V0-to-V1 transition with the ESDIS Project and ECS. Progress with data set ingest since the last meeting was less than anticipated due to a number of factors, including staffing delays and extended learning curves. Ingest of all the Landsat Pathfinder data sets is expected to be complete in FY 1995, however. 46,000 scenes of global land 1-km AVHRR data have been acquired and archived. Seven global composites and 36 North American composites have been produced by the DAAC.

Tangible progress has been made toward the release and utilization of the Defense Mapping Agency's Digital Terrain Elevation Data, and 1 km DEMs for Africa and Japan have been staged on Internet. Efforts continue on schedule for transitioning operational processing of AirSAR data from JPL to the EDC DAAC in FY 1996. SIR-C Survey data are now available from the DDS via FTP and the DAAC home page.

Science algorithm integration and test planning activities are increasing with the hiring of new DAAC staff and increased interaction with the ASTER and MODIS teams. The DAAC User Support Office has been processing about 20 requests per month for DAAC data sets submitted through the IMS and off-line sources. However, requests for AVHRR 10-day global composites, SIR-C Survey data, and 30 arc-second Digital Charts of the World DEM data from the DDS via the DAAC home page have averaged, respectively, about 80, 500, and 50 per month. The user profile on these latter requests shows that 29% are foreign, 25% from academia, and 21% from the private sector.

Thursday, April 13

The Panel spent substantial time reviewing its recommendations and the action items that had been assigned during the meeting. In addition, Panel members discussed the overall direction and long-term goals of the DAAC, and offered constructive observations and suggestions. Lynn Oleson summarized the status of the DAAC's FY 1995 budget and offered preliminary projections for FY 1996. A Panel member for one of the IDS teams summarized recent and evolving plans to hold a workshop, probably late this year, to address a variety of issues related to DAAC/SCF responsibilities and relationships.

The following is a selection of Panel recommendations and meeting action items summarized prior to adjournment:

1. The ESDIS Project should establish a mechanism, e.g., a "technical series," whereby papers written by DAAC personnel, including DAAC-related USGS publications, could be published in HTML format via the DAAC home page.

2. A broader community of Earth scientists than just those affiliated with ASTER should be able to submit ASTER data acquisition requests (DARs).

3. Installation of the X-band receiver at Fairbanks, currently planned for 2000, should be moved ahead to 1998 for use as a real-time Landsat data downlink and EOS AM-1 back-up.

4. Landsat-7 data acquisition policy should include provision for submission of DARs by the general user community.

5. Panel to send a letter to the EOS Program asking for "bottom-up" direction concerning DAAC responsibilities for producing, archiving, and distributing IDS team data products. Include reference to need to address fundamental issue of the relationship between SCFs and the DAACs.

6. The DAAC and ECS contractor to report to the Panel, at the next meeting, on past and current prototypes; include a proposal for an end-to-end ECS prototype for land-related data.

7. The DAAC to present a "strawman proposal" for EDC DAAC data set migration at the next meeting.

8. DAAC to increase involvement in the Science Working Group for the AM Platform (SWAMP) sub-group on gridding and report to the Panel on issues and activities.

9. Building on the revised outline and incorporating meeting discussion, the DAAC to complete a draft of the EDC DAAC Science Support Plan that provides a vision of where the DAAC wants to be at launch of AM-1.

The period September 18-20, 1995, was selected as the tentative date for the next meeting.

Meeting Summary: Atmospheric Science Observations from the Space Shuttle

— **Jack A. Kaye** (jkaye@mtpe.hq.nasa.gov), Office of Mission to Planet Earth, NASA Headquarters, Washington, DC 20546

1994 was the busiest year ever for atmospheric science observations from the Space Shuttle, with five of the eight shuttle flights having atmospheric science measurements as their primary or strong secondary goals. This flurry of activity marks the beginning of a transition period to a new era, however, as current plans for NASA's Mission to Planet Earth (MTPE) call for significantly reduced use of the Space Shuttle for atmospheric science measurements in the future. Furthermore, reduced budgets and a very busy Shuttle manifest place strong constraints on possible implementation of expanded use of the Space Shuttle by MTPE for atmospheric science measurements in the coming years.

To help assess the results from atmospherically-oriented Shuttle missions in the past few years and to provide recommendations to MTPE management concerning possible future use of the Space Shuttle for atmospheric science, a meeting on "Atmospheric Science Observations from the Space Shuttle" was held March 21-23 in Washington, DC. This article provides a summary of the motivation behind, and outcome of, this meeting.

Some fifty scientists from the U.S., France, Germany, and Belgium participated in the meeting. Participation at the meeting was invited from a broad cross-section of the atmospheric science community, including many principal investigators (PIs) and co-investigators associated with atmospheric science instruments and modeling efforts associated with the EOS program, as well as members of MTPE's Earth System Science and Applications Advisory Committee (ESSAAC).

The specific goals of the meeting were threefold. First, results of atmospherically-oriented observations were presented by principal investigators associated with the instruments that have flown aboard the Space Shuttle this past year. Second, a "customer assessment" was obtained from scientists associated with measurement and modeling programs that make use of data from the Shuttle-borne instruments. Third, scientists with interests in using the Space Shuttle as a platform for additional flights of existing instruments, or for initial flights of modified or new instruments, presented their wishes.

Among several questions which were asked of speakers at the meeting were how instrument development efforts and measurements obtained from Shuttle-borne instruments would feed into the EOS program. A particular question was what role Shuttle-based instruments could play in bridging gaps between currently operating and planned EOS instruments. Another focus was how results of Shuttle-based instruments could help in providing calibration information for satellite-based instruments.

The measurement programs for which results were presented at the meeting include the Measurement of Air Pollution from Satellites (MAPS) instrument (Vickie Connors, NASA/LaRC, PI), which flew twice on the Space Shuttle in 1994 as part of the Space Radar Laboratory (SRL) missions, the Lidar-in-Space Technology Experiment (LITE) instrument (M. P. McCormick, NASA/LaRC, PI), the third Atmospheric Laboratory for Applications and Science (ATLAS-3) payload (Timothy Miller, NASA/MSFC, Mission Scientist), the Shuttle Backscatter UltraViolet (SSBUV) instrument (Ernest Hilsenrath, NASA/GSFC, PI), which, like MAPS, flew twice in 1994 (once as part of a microgravity mission and once together with ATLAS-3) and the joint German/U.S. Cryogenic Infrared Spectrometers and Telescopes for the Atmosphere/ Shuttle Pallet Satellite (CRISTA/SPAS) payload (Dirk Offermann, Univ. Wuppertal, CRISTA instrument PI). Results from each of these programs were presented, although in many cases data were very preliminary.

Where individual programs included several instruments, scientists associated with each instrument made presentations. This included the ATLAS-3 payload, which consisted of six instruments, and the CRISTA/SPAS, which contained both the German CRISTA and the American Middle Atmosphere High Resolution Spectrographic Investigation, or MAHRSI instrument, with Robert Conway of the U.S. Naval Research Laboratory (NRL) as PI. For ATLAS-3 this included Michael Gunson, Jet Propulsion Laboratory (JPL), for the Atmospheric Trace Molecule Spectroscopy (ATMOS) instrument, Richard Bevilacqua from NRL for the joint German-Swiss-U.S. Millimeter-Wave Atmospheric Sounder (MAS) instrument, Michael VanHoosier, also of NRL for the Solar Ultraviolet Spectral Irradiance Monitor (SUSIM) instrument, Gerard Thullier of CNRS, France for the Measurement of the Solar Spectrum from 180 to 3200 nm (SOLSPEC) instrument, Richard Willson of JPL for the Active Cavity Radiometer Irradiance Monitor (ACRIM), and Dominique Crommelynck of the Royal Belgian Institute of Meteorology for the Measurement of the Solar Constant (SOLCON) instrument. Timothy Miller made a presentation on behalf of the Colorado Space Grant Consortium's Experiment of the Sun Complementing the ATLAS Payload and Education (ESCAPE II) instrument, which co-manifested with the ATLAS-3.

Measurement and modeling programs that gave "customer assessments" on the usefulness of Shuttle data included the Upper Atmosphere Research Satellite (Mark Schoeberl, NASA/GSFC, project scientist), the NASA/NOAA Solar Backscatter Ultraviolet (SBUV/2) program (Walter Planet, NOAA), the NASA Total Ozone Mapping Spectrometer (TOMS) program (P. K. Bhartia, NASA/GSFC, project scientist), the recently inaugurated Stratospheric Tracers of Atmospheric Transport (STRAT) aircraft campaign (Paul Newman, NASA/GSFC, project scientist), and assessment modeling efforts (Malcolm Ko, Atmospheric and Environmental Research, Inc. and Ross Salawitch, JPL). Particular attention was given to the role of the ATLAS payload relative to UARS, as a primary goal of the ATLAS series was to obtain coincident measurements with UARS, for which there are instruments which are either similar in objectives and technique, or in some cases, nearly identical (ACRIM and SUSIM instruments are on both UARS and the ATLAS payload). Additionally, the role of SSBUV in providing calibration information for the SBUV/2 instruments was a focus, as the SSBUV program was explicitly designed to help maintain calibration of the SBUV/2 instruments.

The final round of formal presentations at the meeting included ideas for future Shuttle instruments and reflights of existing instruments. These included ideas for continued flights of the ATLAS, SSBUV, CRISTA, and LITE payloads (with special mention of the need for an ATLAS flight in the late 1995-96 timeframe to help capture solar data during the time of the solar minimum—Guenther Brueckner of NRL presented this), as well as ideas for several modified or new instruments. Dominique Crommelynck discussed the possibility of flying a modified version of the SOLCON instrument independent of ATLAS. Philip Schwartz of NRL discussed the possibility of modifications to the MAS instrument to measure ClO and HCl simultaneously through addition of channels in the 600 GHz region. Kelly Chance of the Harvard-Smithsonian Center for Astrophysics discussed a concept for the OH Interferometric Observation (OHIO) instrument, which is being designed as a balloon instrument but could be adapted for the Space Shuttle. Herbert Pickett of JPL discussed a possible Shuttle-based heterodyne OH instrument, which could provide a test of 2500 GHz band detection of space-based OH. Richard McPeters of NASA/GSFC discussed plans for the Shuttle Ozone Limb Sounder Experiment (SOLSE), which is currently under development at GSFC for a possible flight as a Get Away Special or Hitchhiker payload.

Possible constraints on Shuttle use associated with the manifest were discussed by Lou Caudill of MTPE's Flight Systems Division, while Mark Sistille of NASA's Office of Life and Microgravity Science and

Applications discussed accommodations for science instruments which will be available on the International Space Station.

There was a half day of discussion at the meeting in three subgroups—Solar Science (G. Brueckner, NRL, subgroup leader), New Science Opportunities from the Shuttle (Mark Zahniser, Aerodyne Research, Inc., subgroup leader), and Additional Science Opportunities using Existing Instruments (Jae Park, LaRC, subgroup leader). The outcomes of the subgroup deliberations were presented to the full group in the final morning of the meeting. Based on the presentations made at the meeting, MTPE management is considering its options for use of the Space Shuttle.

Readers desiring further information about the meeting should contact the author, who served as organizer of this meeting. Contact may be made electronically (see above e-mail address), by phone at 202-358-0757, or by fax at 202-358-2770.

EOSDIS Version 0

—Greg Hunolt (gregh@ulabsgi.gsfc.nasa.gov)

Under the banner of EOSDIS Version 0, the EOS Distributed Active Archive Centers (DAACs) are actively engaged in providing a full suite of data and information services to the science community. In March, there were roughly 62,000 accesses to Version 0 (V0) services by 9,700 distinct users, resulting in just over 10,000 requests for data, and—the true bottom line for Version 0 and the DAACs—1.96 terabytes of data were provided to users. (Many of the 62,000 accesses were casual WWW accesses.)

V0 is the complete end-to-end ingest, processing, archiving, cataloging, and distribution system used by the DAACs to serve the community. One component of the V0 system is the V0 Information Management System (IMS), which provides the user whose interests cross DAAC or discipline boundaries the V0 capability to obtain, at "one stop," a coherent view of data sets available across the V0 system as a whole, search for data that meet common criteria, e.g., spatial and temporal coverage, and to order whatever combination of data from whatever combination of DAACs that meets his or her needs, without having to know in advance what data sets are available or what their source may be. The V0 IMS, operated now by all of the DAACs, complements DAAC-specific services tailored to the needs of each DAAC's individual user community.

Today the V0 IMS features both graphical user interfaces (GUI) and character-based user interfaces (ChUI) accessible from each DAAC. Two important improvements to the system will be available in the near future. A World Wide Web (WWW) interface to the V0 IMS has now been demonstrated by the end of June and will be available for use later in the summer. (DAACs now provide some WWW-based services.) Porting of the V0 IMS client software to user workstations (which improves performance by localizing screen generation and thus minimizing network traffic involved in the use of the system) was started in June. Users will soon (no later than September) be able to freely download copies of the client software from an ftp site.

Until the V0 IMS client software becomes available from an ftp site, users may request a copy of the client by contacting any DAAC User Services office or me, Greg Hunolt (E-mail: gregh@ulabsgi.gsfc.nasa.gov, phone 301-286-0653). We will respond on a first-come, first-served basis, gradually at first, but as quickly as we can. I also invite you to bring to my attention any concerns or problems anyone has with any aspect of the overall V0 system (DAACs, local DAAC services, etc., including the V0 system level IMS). I welcome constructive criticism, I guarantee a reply, and I also don't object to hearing about aspects of V0 that users are pleased with!

Image Processing in the Alaskan Classroom

—**Gary Cooper** (fygisg@aurora.alaska.edu), Jr. High Science Teacher, Ft. Greely School, Delta Junction, Alaska

Only a few years ago, high-powered graphical computing was limited to research institutions. Over the past few years, however, that computing power has reached many classrooms and opened up exciting new doors for computer use by teachers and students. One of the most exciting uses for this new technology falls under the broad category of image processing. In its simplest sense image processing involves the manipulation and interpretation of images to help teach a variety of concepts to students. These images come from a wide variety of sources, such as biomedicine and planetary, and can help teach a similar wide variety of science topics.

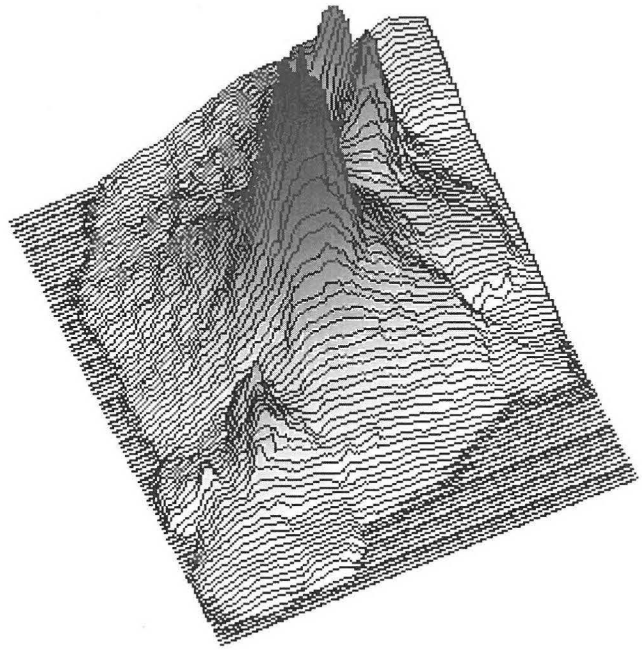
After attending an NSF-sponsored institute several years ago on image processing at the University of Arizona, I began using this technology with my students and saw its potential. There is a large amount of data available from planetary missions and more is becoming available all the time. One of the difficulties is sorting through these data and turning them into meaningful activities that students can use. After using image processing with classes, I became interested in trying to incorporate some of the geographical features of Alaska into activities that my students could use. One of the best sources for images in this area is the Geophysical Institute at the University of Alaska-Fairbanks, which is also a SAR (Synthetic Aperture Radar) facility.

I was able to get funding through the Alaska Space Grant to work with Ken Dean, a remote sensing scientist at the Geophysical Institute, to put together several activities. One of these involves looking at the Mt. Spurr eruption of 1992 and writing an activity for students to calculate the size of the ash cloud, the speed of the ash cloud movement, and the altitude of the cloud. During the summer of 1994 there was a large fire about 15 miles from Delta Junction. I was able to obtain the data credit necessary to generate before-and-after SAR images of the fire area, along with AVHRR images taken during the fire, so students could calculate the size of the fire and differences in its intensity.

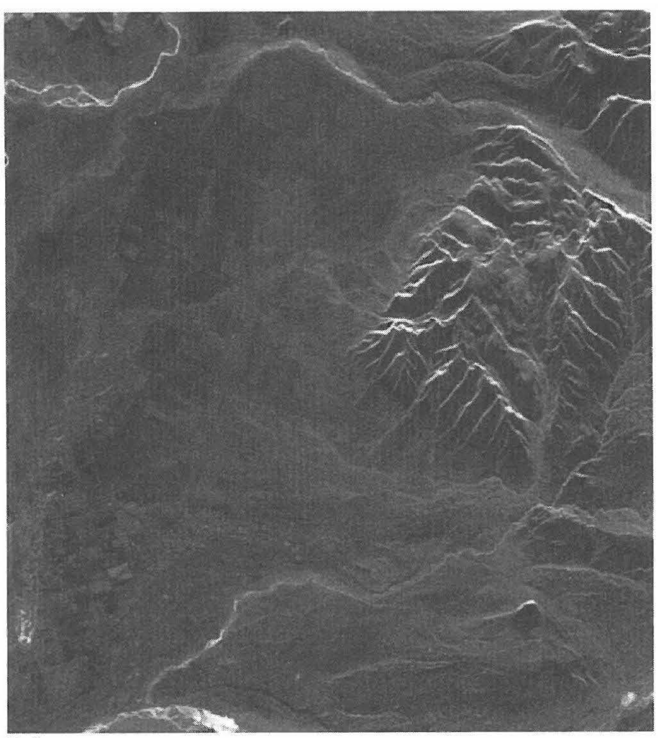
Last year the Alaska SAR facility put out a SAR sampler CD-ROM containing a number of different images of glaciers, volcanoes, ice floes, etc., and having the potential for a number of useful student activities.

It has been said that good ideas take up to 20 years to reach the classroom. It's been nearly 5 years since image processing was introducted into schools. My colleagues and I have observed that there is a tremendous interest by teachers in getting the training to use this technology in their classrooms. With so many sources of images becoming available on CD-ROM and on the Internet, it would be great to see them find their way into the hands of students and teachers. That way we can use technology in a meaningful way to help teach science and math concepts.

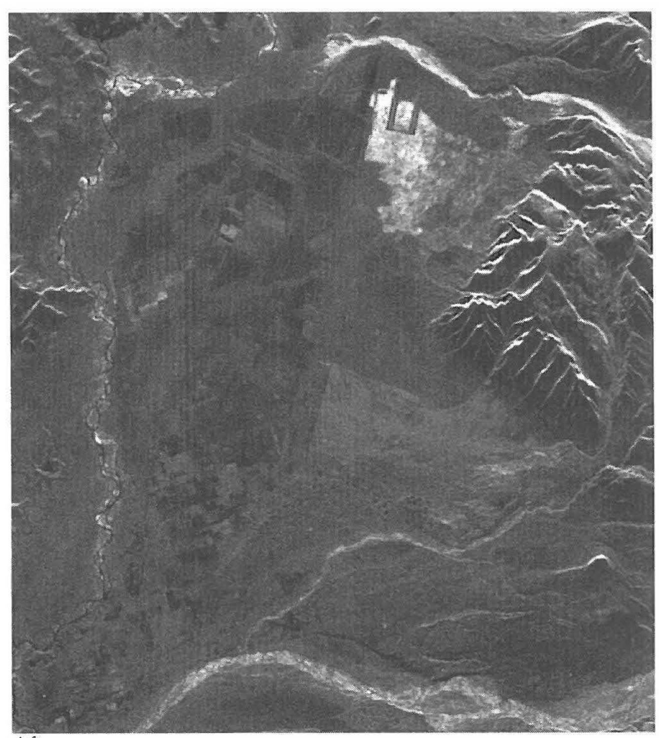
The image shows DEM (Digital Elevation Model) data of Mt. Edgecumbe near Sitka, Alaska. By doing a surface plot of Mt. Edgecumbe you can get more of a three-dimensional view of the area.



These two SAR images show the fire scar from a fire during the summer of 1995 close to milepost 1400 of the Alaska Highway. By using known features on the images you can set the scale, then calculate the area burned. Also notice the two different shades of gray in the fire scar. This corresponds directly to the intensity of the fire in those two areas. In the lighter area it burned to the soil and in the darker area the overburden was left intact.



Before



After

How Will We Choose Which Quality Flags and Constraints to Report for MISR Level 2 Data?

Ralph Kahn (kahn@jord.jpl.nasa.gov), **David Diner, John Martonchik, James Conel, Robert Vargo, Daniel Wenkert, Robert West, Carol Bruegge, Wedad Abdou, Earl Hansen, Susan Paradise, Kathleen Crean, Brian Rheingans, and Duncan Mc Donald**, MISR Level 2 Aerosol/Surface Retrieval Algorithm Development Team, Jet Propulsion Laboratory, Pasadena CA 91109

As members of the MISR instrument team responsible for contributing data to the EOS project, we have been asked to develop a "Data Quality Assessment" plan for our Level 2 products. We have begun to develop an approach to creating what we hope will be a useful Quality Assessment (QA) product. We view this note as a contribution to the discussion about how EOS instrument teams will choose which quantities to report as Quality Flags.

The main goal of the MISR Level 2 retrieval algorithms is to obtain, as accurately as possible, the physical meaning of the Level 1 MISR radiances. An important tool in achieving this goal is to apply tests and external constraints to the data at various stages of processing, and to report the results in the form of "quality indicators." Some constraints may be applied as pre-processing steps, such as choosing a processing path based on surface terrain type, or rejecting cloudy areas. Others may affect post-retrieval analysis, such as our "ClimLikely" aerosol climatology data used to select among those aerosol models that have the lowest residuals in the fits between models and the measurements. Some will simply be passed as ancillary data without further action, in anticipation that they may prove to be of value for future analysis of the data.

For practical reasons, these constraints will be applied within the standard processing data stream for MISR Level 2 data. The resulting indicators will then be reported routinely as an aid to science users of the standard data product and for convenient monitoring at the DAAC for production control and quality assurance purposes.

Note that data often will be useful even if a quality flag is set to a non-optimal value. In some cases, such occurrences may help identify important discoveries. In developing these constraints, we found it useful to organize our effort around situations arising in at least four areas:

Instrument Performance

The instrument performance area is largely a matter of tracking the instrument behavior indicators that affect spectral, radiometric, and geometric performance. These are monitored for engineering purposes as well, and to effect updates to the instrument calibration parameters. As part of the Level 2 data stream, some subset of the Level 1 indicators will be compared with sets of limits, and the relevant performance implications encoded into data quality flags. A few examples of instrument performance areas relevant to the MISR Level 2 data are: up-to-date radiometric uncertainty estimates, dropped lines, and missing pixels.

Physical Constraints

There are many physical constraints that can be applied to the retrieval results, some of which can be used as indicators of the data quality. Some examples are: the requirement of non-negative radiances, albedo within the range of zero to one, an upper bound on the total aerosol optical depth based on the darkest pixel in the scene, etc.

Algorithmic Constraints

Since keeping track of the assumptions and numerical behavior of the algorithm is part of the development effort anyway, these constraints are relatively easy for us to identify. They include such items as: (1) performance bounds on the convergence characteristics of numerical methods (residuals and number of iterations), (2) the limits of intrinsic assumptions made in the parameterizations used (such as an ocean surface roughness model that is meaningful only within a certain range of wind speeds), (3) case limitations (such as treating pixels that may cross radically different terrain types, e.g., coasts, if the algorithm is designed to assume an "average" terrain type), and rejecting pixels that are too cloudy or with terrain too rough for the retrieval to work.

Climatological Constraints

Climatological data provide statistical constraints that could result in "warnings" rather than "errors". An "unlikely" result may mean a misinterpretation of the data, or a discovery. Flags based upon such constraints will be very helpful for the first-order analysis of the MISR Level 2 results. The ClimLikely aerosol data, for example, may indicate that it is more likely to find biomass burning particles than mineral dust particles over a tropical rain forest. Placing climatological constraints on other MISR-retrieved physical parameters (surface albedo and view-dependent reflectances, cloud cover, etc.) would require obtaining similar "climatologies" for these quantities.

The matter of anticipating which indicators will be most valuable to users once scientific analysis of the Level 2 data begins seems to warrant further discussion. Clearly we can not plan for all contingencies, and storing every conceivable parameter at every stage of data processing is impractical. We are currently planning a modest but reasonable selection of indicators in each of the four categories, but we welcome further discussion of this subject.

Acknowledgments: We thank our colleagues Lucien Froidevaux and Lee Elson of the Upper Atmosphere Research Satellite/Microwave Limb Sounder Team for useful discussions.

USGS Releases Data in Spatial Data Transfer Standard (SDTS) Format

Geological Survey, Reston, VA 22092

Technical Announcement
For release: May 10, 1995 (prepared May 3, 1995)

The U.S. Geological Survey (USGS) announced today that its 1:100,000-scale vector data are available in Spatial Data Transfer Standard (SDTS) format. The announcement was made in the National Spatial Data Infrastructure Town Meeting of the 1995 National GeoData Forum in Crystal City, VA. The USGS released its entire data base of 1:100,000-scale transportation and hydrography digital cartographic data in SDTS format. The data can be downloaded free of charge from the EROS Data Center in Sioux Falls, S.D.

The SDTS is defined by Federal Information Processing Standard (FIPS) 173. The standard specifies a model and format for moving spatial data between computer systems without information loss. Federal spatial data producers, such as the USGS, are obligated to begin supplying their data in the SDTS format. Widespread use of this standard format will reduce the problems of moving geographic information system (GIS) data between different computer systems.

The SDTS was designed by a broad cross-section of government, academic, and industry experts. It is therefore more general than formats, such as the USGS digital line graph (DLG), created by individual agencies. The SDTS holds attributes as text in relational tables, eliminating arbitrary attribute code numbers. In addition, SDTS data sets include a data quality report specific to scale and theme and a data dictionary that defines the feature and attribute terms.

Several major GIS vendors are currently working on SDTS translators. Environmental Systems Research Institute of Redlands, CA., satisfied a contractual obligation to the USGS by delivering an SDTS translator in ARC/Info Version 7.

The USGS will convert all of its digital cartographic data to SDTS format during the next several years. The first data to be converted are the hydrography and transportation layers of the 1:100,000-scale DLG-3 series. Complete coverage of the continental United States will be available sometime in July. These data will also continue to be available in regular DLG formats.

The data in SDTS Format can be retrieved from the following anonymous ftp and World Wide Web sites:

FTP: edcftp.cr.usgs.gov
cd/pub/data/DLG/100K
WWW: http://edcwww.cr.usgs.gov/doc/edchome/ndcdb/ndcdb.html

In the near future, the data can also be purchased on CD-ROM by contacting any USGS Earth Science Information Center, including:

Earth Science Information Center
EROS Data Center
Sioux Falls, SD 57198
(605) 594-6151; FAX (605) 594-6589
E-mail: custserv@edcserver1.cr.usgs.gov

For general information about the Spatial Data Transfer Standard contact:

Phone: (314) 341-0856
E-mail: sdts@usgs.gov or esic@mcdgs01.cr.usgs.gov
Web: http://mcmcweb.cr.usgs.gov

Science Calendar

September 8	SEC Meeting, Chicago O'Hare International Airport, Chicago, IL. Contact Eric Barron at (814) 865-1619 (eric@essc.psu.edu).
September 20-22	CERES Science Team Meeting, NASA/Langley Research Center. Contact Bruce Barkstrom at (804) 864-5676 (brb@ceres.larc.nasa.gov).
November 14-17	ASTER Science Team Meeting, Tokyo, Japan. Contact H. Tsu (tsu@ersdac.or.jp) or Anne Kahle (anne@lithos.jpl.nasa.gov).

Global Change Calendar

September 3-9	17th Cartographic Conference, Barcelona. Call for papers. Contact David Sanchez Carbonell, ICC '95. Conference Secretariat, Institut Cartografic de Cataluyna, Balmes, 209-211, E-08006 Barcelona. Tel. (+34) 67-15-99-00, FAX (+33) 3-2128-89-59.
September 4-6	15th Symposium of the European Association of Remote Sensing Laboratories (EARSeL), University of Basel, Switzerland, and workshops on hydrology and meteorology, September 6-8. Contact EARSeL Secretariat, Attn: M. Godefroy, Bureau B-418, 2 avenue Rapp, F-75340 PARIS Cedex 07, France. Tel. (+33)1-45 56 73 60; FAX: (+34) 1-45 56 73 61.
September 18-20	Third Thematic Conference on Remote Sensing for Marine and Coastal Environments: Needs, Solutions, and Applications, Westin Hotel, Seattle, Washington. Sponsors: ERIM, MSRC, EPA. Contact Robert Rogers at (313) 994-1200, ext. 3453; FAX: (313) 994-5123.
September 25-29	Global Analysis, Interpretation, and Modelling (GAIM), The First GAIM Science Conference, Garmisch-Partenkirchen, Germany. Contact: IGBP Secretariat, Institut für Meteorologie, Freie Universität Berlin, Carl-Heinrich-Becker-Weg 6-10, 12165 Berlin, Germany or Dr. Dork Sahagian, GAIM Task Force Officer, Institute for the Study of Earth, Oceans and Space, U. of New Hampshire, Morse Hall, 39 College Road, Durham, NH 03824-3525, U.S.A. Tel. (603) 862-1766; FAX: (603) 862-1915; e-mail: gaim@unh.edu.
October 10-13	Environmental Technology '95 "Demonstrating the role of computers and information technology in environmental information management." Contact Tobi Aclaro at (703) 683-8500, ext. 308; FAX: (703) 836-4486, e-mail: ntpmktg@clark.net.
October 23-26	International Conference on Image Processing, Washington, DC. Contact Billene Mercer, 2553 Texas Avenue South, Suite C-283, College Station, TX 77840, Tel. (409) 696-6596, FAX: (409) 696-6653. WWW URL: http://www.ee.princeton.edu/-icip95, ftp: ftp.ee.princeton.edu/pub/ICIP95.
December 4-5	Sustainable Development and Global Climate Change, Arlington, VA. Contact Center for Environmental Information, 50 West Main Street, Rochester, NY 14614-1218, Tel. (716) 262-2870, FAX: (716) 262-4156, e-mail: ctrenvinfo@igc.ape.org.
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February 27-29	Eleventh Thematic Conference on Geologic Remote Sensing, Las Vegas, Nevada. Contact Robert Rogers, ERIM, Box 134001, Ann Arbor, MI 48113-4001. Tel. (313) 994-1200, ext. 3453; FAX: (313) 994-5123; e-mail: raeder@vaxc.erim.org.
August 20-22	William T. Pecora Memorial Remote Sensing Symposim, "Human Interaction with the Environment—Perspective from Space," Sioux Falls, SD. Call for papers will be issued in September. For preliminary program information, contact Gary Johnson, Technical Program Chair, at pecora13@edcserver1.cr.usgs.gov.

Code 900
National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

The Earth Observer

The Earth Observer is published by the EOS Project Science Office, Code 900, NASA/Goddard Space Flight Center, Greenbelt, Maryland 20771, telephone (301) 286-3411, FAX (301) 286-1738, and is available on World Wide Web at Uniform Resource Locator (URL) http://spso.gsfc.nasa.gov/spso_homepage.html. Correspondence may be directed to Charlotte Griner (cgriner@ltpmail.gsfc.nasa.gov) or mailed to the above address. Articles, contributions to the meeting calendar, and suggestions are welcomed. Contributions to the Global Change meeting calendar should contain location, person to contact, telephone number, and e-mail address. To subscribe to *The Earth Observer*, or to change your mailing address, please call Hannelore Parrish at (301) 441-4032, send message to hparrish@ltpmail.gsfc.nasa.gov, or write to the address above.

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Printed on Recycled Paper