Earth Observing System

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In this issue . . .

EDITOR'S CORNER

Michael King
EOS Senior Project Scientist

I'm pleased to report that the President has approved the Appropriations Conference Committee bill that provides funding to the Veterans Administration, Department of Housing and Urban Development, and Independent Agencies (including NASA) for FY2001. The bill appropriates $14.285B for NASA for FY 2001. This is $250M above the President's budget request, and $633M more than the FY 2000 level. The bill fully funds the President's program for NASA, and allocates $1.498 billion for the Earth Science Enterprise, $82.1M more than the President's request (prior to allocation of Earth Science's share of the $49.1M general reduction to the Science, Aeronautics and Technology account).

The Earth Science budget for FY 2001 is divided into three categories: Major development, Research and Technology, and Operations. Within the R&T budget, NASA has restructured the Earth Science budget into three categories: Program Science, Applications Commercialization and Education (ACE), and Advanced Technology. These resources will allow advancements in our understanding of the global environment, the vulnerability of the environment to human and natural forces of change, and the provision of numerical models and other tools necessary for understanding global climate change. Of NASA's Earth Science budget for Major Development, $399.1M is for the Earth Observing System (EOS), $277M is for EOSDIS, and $164.9M is for Earth Probes. Within R&T, $351.4M is for Earth Science Program Science, including both the research and analysis program and the EOS Interdisciplinary Science (IDS) investigations. The Applications, Commercialization and Education program's budget is $114.4M, the Advanced Technology program is $115.2M, and Operations is $55.6M.

Plans are progressing nicely for the next EOS Investigators Working Group (IWG) meeting to be held January 30 – February 1 in Ft. Lauderdale, Florida. The agenda is being formulated at this time, but the primary focus of the meeting will be to learn of exciting new science from recently launched missions including Terra, QuikScat, ACRIMSAT, and Landsat 7, and to assess plans for the EOS program over the next few years. We are

also soliciting presentations on the new EOS Interdisciplinary Science (IDS) investigations, Federation partners, and EOSDIS data processing status. Several science team meetings will also be held. See the article on the IWG meeting on page 3 of this issue for more information.

EOS Science Teams have been very active recently, with several team meetings having been held in the past few weeks. The Science Working Group for the AM Platform (SWAMP) was held September 6-8 at the University of Toronto. At the meeting, the advantages and disadvantages of a deep space calibration maneuver (currently scheduled for late January 2001) were extensively discussed. A charter is also being formulated for the Science Working Group for Data. EOSDIS Project Scientist, Skip Reber, and Jon Ranson, Terra Project Scientist, are involved in this effort.

The Aqua Science Working Group met on September 12 at Goddard Space Flight Center, with major discussion topics including data processing issues, validation efforts, and coordinated flying with other satellites in the EOS afternoon constellation. Concerns were discussed over the ability to handle the increased data flow when both Aqua and Terra are operating simultaneously. Scientists discussed the need for validation efforts within the first six months after launch. The discussion of coordinated flying concentrated on concerns over risks and fuel costs.

The Aura Science Team meeting was held October 17-19 in Easton, MD. An Aura Validation document has been drafted, but its priority has not yet been established. Positive discussions during the meeting should result in Version 1.0 of the Aura Validation document.

Approximately 140 people attended the Tropical Rainfall Measuring Mission (TRMM) Science Team meeting in Greenbelt, Maryland. Several presentations were given on papers published previously in *Science* and *Nature* periodicals. Many of the presentations centered around validation of TRMM data. Other topics included the life expectancy of the satellite, which is expected to provide about three more years of data.

A new ground receiving station for Terra has begun operating in Moscow, Russia, bringing the number of EOS Direct Broadcast stations to 18. The Direct Access System for the EOS spacecraft provides a means of transmitting some, or all, of the EOS science data directly via X-band to ground. The R&D center, ScanEx, has developed the EOScan Direct Broadcast station for acquiring MODIS data transmissions for most of eastern and central Europe. It joins 17 other Direct Broadcast stations already operating in the U.S., Australia, Europe, U.K., and Japan.

10 additional stations will be operational soon in Sweden, U.S., China, Brazil, Italy, Thailand, India, France, and Russia. These stations and others will also acquire data from Aqua after its launch which is scheduled for no earlier than July 12, 2001. More information on EOS Direct Broadcast can be found at http://rsd.gsfc.nasa.gov/eosdb/.

Finally, it is with both regret and congratulations that I report the transition of Deputy Project Scientist for ICESat, Dr. Waleed Abdalati, to his new position as the Polar Program Scientist at NASA Headquarters. Dr. Abdalati was recently presented with the Presidential Early Career Award for Scientists and Engineers. I wish to thank him for his significant contributions to the EOS Project Science Office, and I'm confident that he will continue his outstanding performance in his new position.

KUDOS to Dr. Yoram Kaufman

Dr. Yoram Kaufman, former Terra Project Scientist, and Senior Physical Scientist in the Laboratory for Atmospheres, Goddard Space Flight Center, was awarded the William Nordberg Memorial Award for Earth Science at a ceremony November 3, 2000. The Nordberg Award is given annually to an employee of the Goddard Space Flight Center who best exhibits those qualities of broad scientific perspective, enthusiastic programmatic and technical leadership on the national and international levels, wide recognition by peers, and substantial research accomplishments in understanding Earth system processes which exemplified Dr. Nordberg's own career. Kaufman was honored for his outstanding leadership in EOS Terra, and his scientific contribution to remote sensing of aerosols, their optical properties, and their radiative forcing of climate.

The Earth Observer staff and the EOS community congratulate Dr. Kaufman on his outstanding accomplishments.

Overview of the Upcoming EOS Investigators Working Group Meeting

— Jim Closs (jim.closs@gsfc.nasa.gov), EOS Project Science Office, NASA Goddard Space Flight Center

The next EOS Investigators Working Group (IWG) meeting will be held January 30 to February 1 at the Wyndham Resort and Spa in Ft. Lauderdale, Florida. The IWG meeting is the primary and most comprehensive forum for sharing EOS program activities and scientific studies.

The meeting is held nominally every nine months, and the location usually alternates between eastern and western U.S. venues. This year's meeting location is 20 minutes from the Ft. Lauderdale International Airport.

The primary focus of the meeting will be to learn of exciting new science from recently launched missions including Terra, QuikScat, ACRIMSAT, and Landsat 7, and to assess plans for the EOS program over the next few years. Presentations are also planned on the new EOS Interdisciplinary Science (IDS) investigations, Federation and International partners, and the EOSDIS data processing status. Several science and instrument team meetings will also be held. Numerous posters on diverse EOS topics will be displayed for the duration of the meeting.

The specific agenda for the Ft. Lauderdale meeting is being formulated, but the meeting will begin with a programmatic session on the Earth Science Enterprise (ESE) and the EOS Program chaired by EOS Senior Project Scientist, Michael King. Ghassem Asrar, NASA Associate Administrator for Earth Science, will present the current status and future of the Earth Science Enterprise. Jack Kaye, Director of the Research Division, Office of Earth Science, NASA Headquarters, will discuss the ESE Science implementation strategy, and Chris Scolese from the EOS Program Office at Goddard Space Flight Center will give an update on the EOS flight program along with an overview and status of the Earth System Sciences Pathfinder (ESSP) Program by the new ESSP Project Scientist, Marc Imhoff. There will also be a presentation on EOSDIS data processing and data system status, as well as European space program updates from the European Space Agency. Overviews by Earth Science Information Partners (ESIPs) and Regional Earth Science Application Centers (RESACs) are also being planned.

A two-hour working lunch is planned for the first day, with various science working groups and instrument teams meeting in separate locations in the hotel. The first day of the meeting will end with a session on Landsat 7 and ACRIMSAT mission performance and new science results.

The second day of the meeting will bring a plenary science session highlighting instrument performance and new science results from Terra and QuikScat. Principal Investigators or Instrument Team Leaders will give overviews of each sensor's capabilities and performance, which will be followed by two or three presentations on exciting new research being conducted using data from the instruments. With the extremely active mission launch activity over the past year, this session will fill the agenda for the entire day.

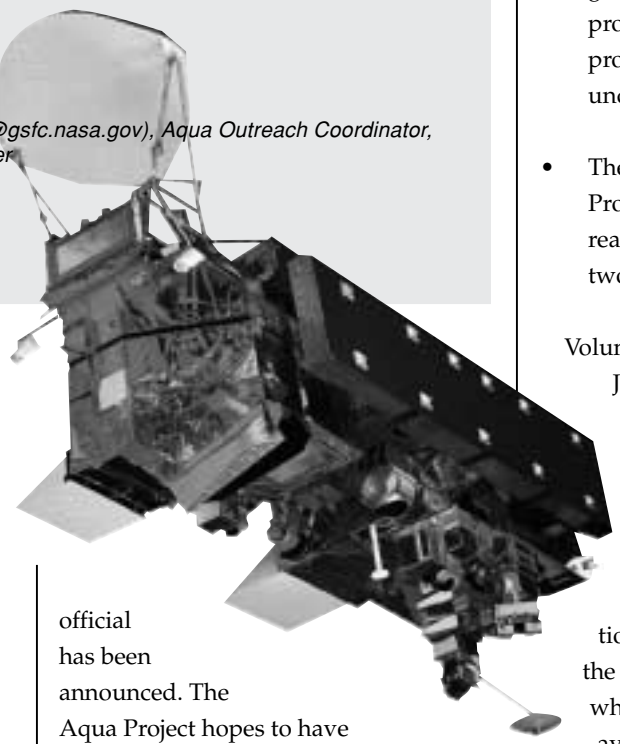
A social event is planned for Wednesday evening. Specific information will be broadcast in the near future. All meeting attendees are invited to attend.

A collection of new and interesting research activities from the newly selected EOS IDS investigations will be presented on Thursday morning. Research studies in Atmosphere, Land and Ocean disciplines will give a comprehensive sample of the latest EOS scientific studies. These talks promise to be very informative, and indicative of future research directions for the Enterprise.

The meeting will end Thursday afternoon. Registration and hotel information, along with a detailed agenda are available on the Calendar page of the EOS Project Science Office web site at eos.nasa.gov.

Minutes of the Aqua Science Working Group Meeting

—Steve Graham (steven.m.graham.2@gsfc.nasa.gov), Aqua Outreach Coordinator, NASA Goddard Space Flight Center



The Aqua Science Working Group met at the Goddard Space Flight Center (GSFC) on September 12, 2000, and was chaired by Claire Parkinson, the Aqua Project Scientist. Parkinson opened the meeting at 8:30 a.m. by welcoming the attendees and then introducing Steve Cole of the EOS Project Science Office Science News and Information Team. Cole stated that the EOS Science News and Information Team has helped to get information about EOS research into the news media that has reached an audience of more than six million in its first year. The EOS News Team facilitates responsible and balanced science reporting in the mass media, and that team works closely with EOS researchers and their institutions' public information staffs to write press releases, arrange press conferences, and publish media guides on NASA Earth Science missions. Cole encouraged all in attendance to make use of his team to improve and expand public understanding of global change research. Early next year, Cole will be working with Parkinson and Aqua scientists on a "Science Writers Guide" to Aqua.

Following Cole's remarks, Parkinson presented an update on the status of the Aqua mission, noting that the Aqua launch will most likely occur no earlier than May 7, 2001, although nothing official has been announced. The Aqua Project hopes to have a firm launch date in place by the end of October 2000. *[Ed. Note: The offical date is now no earlier than July 12, 2001.]* Other status updates from Parkinson included:

- Spacecraft electrical integration has been completed.
- The second review of the Integrated Mission Timeline (IMT) took place on July 13-14, 2000, with the next IMT scheduled for October.
- The Comprehensive Performance Test (CPT) was completed on August 23, 2000.
- Planning is underway for a gain change in two MODIS circuit boards in order to improve the accuracy of MODIS-derived sea surface temperatures.
- The first and second stages of the launch vehicle are completed.
- The NASA Research Announcement (NRA) for Aqua Validation generated a large number of proposal submissions. The review process for these proposals is now underway.
- The second volume of the EOS Data Products Handbook should be ready for printing within the next two weeks.

Volume 2 covers ACRIMSAT, Aqua, Jason-1, Landsat 7, Meteor 3M, QuikScat, QuikTOMS, and Vegetation Canopy Lidar (VCL) and will provide descriptions of the standard and research data products, file sizes, spatial and temporal resolutions, and information on where the products can be obtained and whether or not a browse product is available.

Concerning Aqua outreach initiatives, the first installment in the Aqua Series of NASA Fact Sheets has been completed. Titled "The Water Cycle" and written by Steve Graham, Claire Parkinson, and Mous Chahine, this fact sheet gives an overview of Earth's water cycle and how the Aqua mission will contribute to an increased understanding of its role in global change. Those EOS and Aqua parties interested in obtaining hard copies of the fact sheet are encouraged to contact Steve Graham, e-mail: steven.m.graham.2 @gsfc.nasa.gov. It can also be found online at earthobservatory.nasa.gov/ Library/Water. Work has begun on the second fact sheet in the series, titled "Weather Forecasting," as well as the Aqua brochure. The AMSR-E brochure is in press.

Following Parkinson's Aqua update,

Bruce Barkstrom, the CERES Team Leader, provided an update on the CERES investigation. He noted that all major activation activities are completed on Terra CERES, with the exception of the deep space maneuver. To date, the Terra instruments have performed exceptionally well, with reasonably good fixes on geolocation and coastline navigation.

Barkstrom then moved on to the science impact on CERES of Earth Science Data and Information System (ESDIS) capacity limitations. He reiterated that the CERES Science mission provides a peer-reviewed science investigation in five areas:

- The continuation of the Earth Radiation Budget Experiment (ERBE) measurements of the Earth's radiation budget and cloud forcings.
- Improvement of scene identification of radiation budget with simultaneous and collocated imager data (VIRS and MODIS).
- Provision of new angular distribution models to cut instantaneous Earth radiation budget (ERB) flux errors in half.
- Provision of empirical surface radiation budget fluxes.
- Provision of atmospheric flux profiles (shortwave and longwave).

Barkstrom noted that the last four bullets are new areas of major scientific improvement.

There has been a major investment in the CERES instrument, validation, and software. Five instruments have been developed and are flying or will fly on three platforms. The CERES team has invested three years of work in the scientific validation of TRMM data. The investment in CERES production code is large, with about 600,000 lines of scientific code and about 45,000 lines of production scripts.

Regarding the CERES effort to reduce hardware capacity requirements, Barkstrom provided a number of instances:

First, ingest is down six times from the original estimates. The original ESDIS/EOSDIS Core System (ECS) ingest rates included one MODIS stream for each CERES instrument. CERES recommended not only reducing to one MODIS stream per satellite but also subsetting to only one third of channels.

Second, the CERES Surface and Atmospheric Radiation Budget (SARB) algorithms have reduced central processing unit (CPU) needs by a factor of 10.

Third, personal efforts by Barkstrom on the Ad Hoc Working Group on Production (AHWGP) resulted in reducing 19 ESDIS/ECS working groups to one working group that produced a preliminary summary of needs in two weeks using e-mail and that provided final capacity estimates within six months. This work reduced the uncertainty and cost of the total EOSDIS system.

Fourth, the CERES team is considering the impact of using reduced imager resolution data in its cloud algorithms, although this reduction may increase spatial noise.

Fifth, the team is considering the possible removal of clear-sky reflectance history in the same algorithms, which may reduce cloud detectability.

It is clear that reducing hardware capacity carries a substantial scientific risk for these algorithms.

Commenting on the current state of CERES data production, Barkstrom noted that the TRMM ERBE-like data products have been available from the Langley Research Center (LaRC) Distributed Active Archive Center (DAAC) for some time and that Terra ERBE-like data products have been available in beta form since very shortly after the covers opened late in February. The CERES Team expects to release an "Edition 1" version of the Terra ERBE-like data products shortly along with TRMM instantaneous cloud properties. Owing to the TRMM instrument failure, only about one year of TRMM data will be available. On Terra, EOS Data and Operations System (EDOS)/ECS problems have been hampered as intermittent dropouts have prevented producing daily and monthly data products.

The current CERES approach to capacity estimation involves improving the data production schedule to cover TRMM, Terra, and Aqua. CERES has developed software to tie the production schedule to hardware capacity needs and production workforce. The standard NASA approach based on Level 0, Level 1, Level 2, and Level 3 data does not describe the phased validation and production approach CERES uses. In the CERES schedule, there is a need to reprocess some data products before validating others. In addition, CERES will begin to use a "non-delay" schedule as a baseline and examine schedule slips and associated cost increases as a function of capacity reduction. CERES

primarily needs a three-fold CPU increase over the ESDIS profile.

The science impact of a reduced hardware capacity critically lowers the ability of the EOS program to reduce uncertainty in cloud-radiation interaction. This effectively lessens the ability of EOS to (1) provide improved long-term cloud properties, (2) reduce the uncertainty in angular distribution models and top of atmosphere (TOA) fluxes, (3) improve the surface radiation budget, and (4) provide new information on the atmospheric budget. In addition, there would be a probable reduction in the EOSDIS user community. Also, a reduced capacity would slow improvements in commercial data products used by solar energy and home-building industries, and reduce the ability to provide timely data to students who participate in the CERES outreach program called Students' Cloud Observations On Line (S'COOL).

Next, Bob Murphy of the MODIS Science Team presented sample Terra MODIS results and provided an Aqua MODIS update on behalf of Vince Salomonson, who was unable to attend the meeting.

Murphy began by stating that MODIS is working well, and in general, signal to noise ratios (SNR) and noise equivalent delta temperatures (NEDT) are better than pre-launch. Band-to-band registration is good and most early striping problems have been resolved. The team is still adjusting focal plan biases to optimize performance, as optical cross-talk in medium wavelength infrared (MWIR) and short wavelength infrared (SWIR) persists. Also, the noise injection into analog to digital conversion (ADC) problem results in 10-11 bit long wavelength infrared (LWIR) bands, so they need to switch to the MODIS B side electronics. Because of this problem, a resistor swap has been requested for the Aqua MODIS. (Note: The resistor swap was approved on October 2.) A deep space maneuver for the Terra spacecraft is planned for January 2001.

Next, Murphy showcased a series of MODIS images including Enhanced Vegetation Index (EVI), cloud mask, water vapor, thin cirrus, cloud top pressure, cloud optical thickness, cloud particle effective radius, aerosols (African dust), and sea surface temperature.

A current issue being worked is the timeliness of ephemeris data. Murphy noted that the Tracking and Data Relay Satellite System (TDRSS) On-board Navigation System (TONS) on Terra provides real time orbit data needed for geolocation. For Aqua, these data must come from the post-processed ephemeris that is not available for 40 hours after the first data collection for each day. ESDIS estimates that more frequent ephemeris data would involve a one-time ECS software costs of approximately $150K and that yearly cost would vary depending on desired frequency (2 ephemera per day - $52K, 4 ephemera per day - $112K, 6 ephemera per day - $172K). At the present time, the processing chain from EDOS through the Goddard Earth Sciences Distributed Active Archive Center (GES DAAC) and to the MODIS Adaptive Processing System (MODAPS, a MODIS Principal Investigator-led processing system) takes more than a week so it is not necessary to provide the more frequent ephemeris updates. Ultimately the entire system must be optimized so that data can move from EDOS through the GES DAAC and into MODAPS in 48 hours. To achieve that requirement, it will be necessary to provide the ephemeris updates more frequently. The target for reaching this timeliness should be launch plus 6 months.

Following Murphy, Kathy Amidon, from the Aqua Instrument Planning Group Support, provided a summary of the Integrated Mission Timeline (IMT). Amidon noted that the second IMT Review was held on July 13-14 and was attended by members of the Aqua Project, TRW, Instrument Operations Teams, and the Flight Operations Team. The current version of the IMT is based on previous IMT reviews from March and July 2000. She noted that MODIS yaw maneuvers previously planned for days 26-27 and 30-31 have been rescheduled to days 29-30 and 36-37. This is because MODIS elects to wait until day 15 to begin its outgassing procedure. Since MODIS activities stay in the same order, the first set of yaw maneuvers slips out to days 29-30.

A table was included that summarizes all planned instrument modes during spacecraft maneuvers. It is still the preference of the AIRS team not to perform deep space constant pitch maneuvers, so the question remains which calibration activities would need to be repeated. If all calibration activities need to be repeated, then AIRS would not complete activation checkout until approximately day 85.

Next, Amidon noted that CERES yaw maneuvers appear to be incompatible with MODIS yaw maneuvers. CERES solar calibrations probably cannot piggyback on MODIS yaw maneuvers because of the orbital timing of the yaw maneuvers, the duration of attitude hold at the yaw offset attitude, and the yaw angle sequences. MODIS wants to maneuver to a yaw-offset attitude, hold

for approximately five minutes, and return to nominal attitude once per orbit. These yaw maneuvers would be centered roughly over the orbital South Pole, which is approximately 10-15 minutes after the spacecraft experiences sunrise. Each orbit will have a different (incremental) yaw offset currently varying from 16.5° to 0°. CERES, on the other hand, wants to maneuver to a yaw offset attitude of approximately 15° and hold attitude for roughly 35 minutes before returning to nominal attitude of 0° yaw. The beginning of the maneuver would be at approximately sunrise minus two minutes, so the maneuver back would be at approximately sunrise plus 33 minutes. CERES first wants an orbit sunrise at 0° yaw, followed by an orbit sunrise at 15° yaw, followed by an orbit at 0° yaw, and wants to perform this sequence twice. The MODIS sequence does not allow for 0° yaw orbits between their incremented yaw offsets and does not want to sit in the yaw offset attitude for 35 minutes. Consequently, an additional maneuver sequence has been proposed to satisfy CERES solar calibration requirements and is currently under evaluation.

Lastly, Amidon noted that the next Aqua IMT Review is currently scheduled for October 17-18, 2000.

After a short break and guided tour of the Aqua Flight Operations Facility (narrated by Fran Wasiak), the meeting reconvened with presentations by Ed Masuoka of the MODIS Science Data Support Team and Bruce Barkstrom of the CERES Team on Terra and Aqua Data Processing Issues. Masuoka presented first on MODIS lessons from Terra regarding data systems and product release. He noted that a spacecraft design flaw has resulted in bit-flips in high data rate instrument Level 0 data, and that the ground system lost capacity and robustness due to budget constraints. In July 2000, EDOS had hardware failures and capacity bottlenecks followed by difficulty processing Level 0 with bit-flips in August 2000.

From a science perspective, six months to a year are required to get releasable products after initial data acquisition. The performance of MODIS on orbit required calibration software changes and there were on average 10 science algorithm changes per higher level product (Level 2 and Level 3 products.) The performance of the data system and bit-flip problems resulted in days with large data gaps, and since products are now being released to the public, solid data days are very important. Additional problems with data ordering have been encountered, as ordering data using the EOS Data Gateway (EDG) is cumbersome, slow, and intermittent, and frequently leaves the user with the impression that no products are in the archive. Another flaw in product ordering is that large data orders (15 GB) do not get filled, but do not fail either, so it is only later that the end-user is notified via email from DAAC user support. The Quality Assurance metadata update tool (QAMUT) needs substantial work to improve its efficiency in handling the updating of a large number of data sets.

Next, Masuoka commented on the current status and issues related to MODIS data production at the GSFC DAAC. He noted that some two-hour Level 0 data sets are truncated due to file transfer protocol (FTP) problems, and they are unable to achieve robust processing of Level 1 products in the GSFC DAAC as production problems in the EOSDIS Core System (ECS) release 5B are being manifested as gaps in the Level 1 data products.

MODAPS is processing the data that arrive from GSFC, and is currently running 10-30 days behind acquisition. MODAPS data production is exceeding A+ baseline (the average daily product volume and average daily number of files that MODIS is allowed to store in each of the MODIS DAACs) for delivery and the MODIS Science Team is working closely with them to prioritize production. Currently, the science team is making trades between keeping production near current day and processing complete days for time series. Delays in acquiring complete days (95% of Level 1) from EDOS/GDAAC is an issue and it is taking up to a month to fill holes in a day when EDOS reprocessing is required.

Impacts of the current problems include having not processed all of the MODIS Level 0 data that has been acquired. There exist a large number of days that haven't been produced due to system inefficiencies. The system is unable to produce consistently, even at 96 A+ levels, mainly due to the incomplete delivery of Level 1 products to MODAPS, greatly hampering higher-level product generation and validation efforts. Masuoka noted that they have lost as many clear views of validation sites to "bit flips" and EDOS problems as to cloud cover. In addition, increased archive capacity is needed above the 96 baseline to store higher level MODIS science products. Estimates were developed before any code was completed and is now inadequate to store these MODIS products.

A delay in production of complete Level 0 products for data days has held up downstream production at GDAAC and

MODAPS. The production backlogs have resulted in having to move data from online storage to tape archive with associated overhead of retrieval and further delays in producing Level 3 composite products (8-, 16-, and 32-day products). Reprocessing is a high priority due to large gaps in the data record and the beta quality of the science algorithms that produced the products. Currently there is no capacity to reprocess and keep up with the current production at the same time. The MODIS team needs significantly more reprocessing and ingest capacity at the DAACs to reprocess the science data and insert reprocessed products into the archives.

Barkstrom then continued this theme by giving an overview of the EOS data issues workshop held on June 1-2, 2000 at GSFC. The gathering constituted the inaugural meeting of a Science Working Group on Data (SWGD). Participants included (1) Terra instrument team representatives from CERES, MISR, MODIS, MOPITT, (2) EOS Project and ESDIS Project representatives, (3) EOS Project Science Office representatives, including the Terra and Aqua Project Scientists, and (4) DAAC and Science Investigator-led Processing System (SIPS) representatives.

He noted that the immediate EOSDIS situation appears to have improved as early EDOS problems are being solved, although EDOS remains backlogged. The Working Group formed because the system remains unstable and appears to be systematically under-sized. There is concern that the lack of hardware will delay the scientific validation effort by 2-3 years minimum. The SWGD hardware appraisal needed to deal with validation and reprocessing shows a need of about $15 million in computer hardware in FY01 and FY02 to solve the problems, with small additions in later years (~$2M).

During the workshop, the participants discussed the current operating status of EOSDIS, and in particular the lower than expected throughput and how it should be addressed. They noted that the February 1996 baseline sizing used to implement EOSDIS is not adequate to support the science data needs. Because that baseline was established before the algorithms were developed and could be run in the production environment, it did not have a clear empirical basis. In addition, the 1996 baseline does not appear to have been based on previous NASA experience in validating and producing Earth science data. Terra instrument team representatives presented revised system sizing estimates based on current experience and improved understanding of the EOS production environment. The group noted that the current performance of the system has yet to meet an operational level of production equivalent to the Option A+ first year capacity of 1x (product generation executable rate equals the input data rate from the satellite) of Level 1 products and .5x (product generation executable rate is .5 of the input data rate from the satellite) of Level 2 and higher products as volumes specified in the 1996 baseline.

The primary finding from the working group meeting was the need for a marked increase in the system capacity to generate data products. The current budget situation is difficult on all sides. It is clear that there will need to be frank and open discussions between all of the parties involved in EOSDIS regarding possible options. One area of concern is the impact of the rapid evolution of information technology on the obsolescence of the current system. This impact suggests that we may need to move rapidly from the current system to the more distributed system being envisioned for the new Data Information Systems and Services (NewDISS).

[Ed. Note: See article on page 32 for progress in the performance of the EOSDIS system since this meeting.]

The next topic of discussion was possible formation flying amongst the EOS afternoon constellation of satellites. As introduced by Parkinson, Al Chang, the Aqua Deputy Project Scientist, will be representing Aqua scientists at upcoming meetings this fall on the issue of formation flying amongst Aqua, PICASSO-CENA, Cloudsat, Aura, and PARASOL (French micro-satellite containing POLDER), the set of upcoming EOS satellites taking measurements in the afternoon. Chang outlined the issues involved, including fuel expenditure, mission risks, and measurement enhancements, and solicited from the audience any concerns or support for formation flying. Ed Macie of the Earth Science Missions Operations (ESMO) Project presented more detail on the Constellation Coordination of the Afternoon Train. Macie said the ESMO at GSFC has been designated as the focal point for coordination of the Earth Science morning and afternoon constellations. Their charter is to design and implement a constellation plan to maximize the science return, minimize operations, demonstrate various formation-flying technologies, and provide a focal point for communication and coordination between missions.

The Morning Train includes Landsat 7, Terra, EO-1, and SAC-C and the Afternoon Train includes Aqua, PICASSO-CENA, CloudSat, Aura, and

PARASOL. Barkstrom noted that the ESMO needs to have a clearer picture of the PICASSO-CENA/CloudSat precession across the swath, and that the PICASSO-CENA team should follow up on this with GSFC. In addition, the point was brought up that in the forward scattering direction near the equator, MODIS sees a lot of sun glint in clear skies. The major concern on formation flying right now is the gap in time needed between Aura and Aqua since they use the same polar ground stations. This is not a problem for Terra/Aqua since they will be rarely overhead at the same time, and PICASSO-Cena/CloudSat since different ground stations will be used. The current philosophy of the train constellation is that Aqua leads and other satellites respond to any Aqua orbital changes in elevation or inclination.

There will be a Morning Constellation Working Group meeting at NASA Headquarters on September 15, 2000 and an Afternoon Constellation Working Group Meeting sometime in late October. *[Ed. Note: the afternoon constellation meeting was changed to November 28, 2000.]* Current plans and activities call for:

- establishing Missions Operations Working Groups and Charters;
- developing a Mission Implementation Plan (morning constellation draft being reviewed);
- prototyping a web-enabled Earth Science Collaborator tool for the Morning Constellation for dissemination of information, analysis, and coordination of constellation activities;
- a system demonstration in January 2001;
- reviewing and updating the Flight Dynamics and Network studies as needed, and maintaining insight for identification and resolution issues; and
- defining and developing agreements between missions and services as required.

After returning from lunch, the group heard from Akira Shibata, the Japanese AMSR-E Team Leader, who presented a National Space Development Agency of Japan (NASDA) AMSR-E Science Team Update. Shibata noted that the AMSR-E data will be available after 24 hours following the collection of data. Shibata also showed sea surface temperature maps from the TRMM Microwave Imager (TMI), and he discussed the merits of the inclusion of 6 GHz channels on AMSR. These merits include more accurate sea surface temperature, soil moisture, sea surface wind speed and precipitation data.

Shibata noted that main efforts for validation are concentrating on making match up data sets. Operational data on water vapor, sea surface winds, sea surface temperatures, precipitation, and snow depth have been collected through the global telecommunications system (GTS), the internet, and JMA. Experimental data will be collected by field campaigns and automatic stations maintained by the PIs and NASDA. These data will include water vapor, cloud water, precipitation, sea ice, snow depth, and soil moisture.

Data distribution from the Earth Observation Research Center (EORC) (for PIs and authorized persons):

Level 1B	6 hours online, tape
Level 2	24 hours online, tape
Level 3	1.5 days online, tape
Subsetting	6 hours online
Matchup data	2 days online

Reports of Japanese scientific activities on the usefulness of 10 GHz data of TRMM Microwave Imager (TMI) have been prepared on sea surface temperature (SST) by Shibata and Murakami, precipitation by Aonashi, sea surface wind speed under rainy conditions by Shibata, and soil moisture by Koike.

Shibata also commented on the merits of 6 GHz of AMSR/AMSR-E by saying that more accurate SST, soil moisture, sea surface wind speed, and precipitation measurements will be available. In addition, some new applications are anticipated for snow and sea ice. Concerns for 6 GHz include interference from artificial sources like the 10 GHz of TMI.

Following Shibata, Roy Spencer, the NASA AMSR-E Team Leader, offered an update on NASA AMSR-E progress and issues. Spencer noted that all algorithm software has been handed off to SIPS (except sea ice) and that SIPS interface testing with Remote Sensing Systems (RSS) and National Snow and Ice Data Center (NSIDC) is progressing normally. Regarding passive microwave calibration, the TMI calibration bias has been traced to a probable loss of all vacuum deposited aluminum (VDA) coating on the main reflector, due to atomic oxygen in its 350 km orbit. Also, a passive microwave rainfall mystery exists in that various estimates of tropical ocean rainfall change during El Niño Southern Oscillation (ENSO) (+10% during warm phase) is at least double that inferred from surface energy and atmospheric radiation balance considerations (possible explanations for these observations include rainfall efficiency and drop

size distribution change). The TRMM radar actually shows a decrease during the warm phase (may be due to drop size distribution change).

Spencer also noted that there will be an AMSR-E workshop in Kyoto, from October 30 to November 1, 2000.

After Spencer, George Aumann, the AIRS Project Scientist, offered a status update on the AIRS/AMSU/HSB program. Aumann began by stating that the scientific objectives of the AIRS/AMSU/HSB instrument suite are to improve operational weather forecasting and study the weather and climate related processes related to temperature and moisture profiles, surface temperature and emissivities, and cloud properties.

Aumann noted that the instrument suite passed the warm Comprehensive Performance Test (CPT) at TRW, and the cold Thermal Vacuum (TVAC) is the next scheduled test.

Version 2 product generation software (PGS) has been installed at the GSFC DAAC and Level 1b software performance is being verified using flight model data from the TVAC tests. Based on these tests, the instrument is demonstrating excellent radiometric and spectral performance.

The instrument team continues to work on the implementation of the Validation Plan. The validation processing system is being prepared at JPL with the goal of having fully characterized Level 1b data at launch +7 months and T(p) (temperature profile as a function of atmospheric pressure), q(p) (water vapor profile as a function of atmospheric pressure), and T_surface (surface skin temperature) products at launch +12 months.

For routine global meteorological observation support, plans include the use of 100 co-located atmospheric truth sets from worldwide routine radiosondes (expect about 10 to be cloud free) and 300 "surface reports" from ocean buoys and ships per day for sea surface temperature validation (expect about 30 to be cloud free, 15 of these at night). In addition, a routine meteorological data set will be used for operational quality assurance.

For dedicated temporary support, plans include the use of 16 atmospheric state truth periods per day from the U.S. and five other countries for three months coordinated with EOS Aqua overflights.

Concerning the NASA Research Announcement for EOS Aqua validation support, 36 proposals were received related to AIRS/AMSU/HSB and they expect to have funding for approximately 8 of the proposals. The funded proposals are expected to support the validation effort with an additional 50 research-type radiosonde launches per year, many of them with chilled mirror hygrometers, and 40 special floating buoy measurements per day, for the three-year proposal period.

Next, Aumann spoke about the new task of AIRS data forecast impact assessment. There is a letter of agreement between NOAA and NASA (James Baker and Dan Goldin) to assess impact of AIRS data on operational forecast by launch +12 months. NOAA understands what information is needed to improve weather forecasts and sees the AIRS instrument as the way to provide this important information. The National Centers for Environmental Prediction (NCEP) and the European Center for Medium-range Weather Forecasting (ECMWF) have determined that achieving a major positive forecast impact requires satellite data that provides:

- lower tropospheric sounding with minimal surface mixing;
- accurate surface temperature and emissivity;
- mid-tropospheric and higher water vapor sounding channels; and
- accurate (and scene independent) error characterization.

Currently, none of these data is provided by infrared or microwave sounders, but will be provided by AIRS.

Aumann noted that NCEP and ECMWF have great expectations for AIRS to have a high impact on weather forecasting. They are currently working with NOAA/NESDIS to expedite AIRS data transfer within three hours of receipt on the ground. Operational forecast systems (NCEP, ECMWF) have switched from Level 2 data assimilation to Level 1b data assimilation. The initial impact assessment will be based on the evaluation of specific forecast "bust" cases over North America and Western Europe.

Lastly, Aumann commented on an Aqua instrument inter-instrument cross comparison. There is significant Level 1b spectral and spatial overlap between MODIS/AIRS/CERES and AMSU/HSB/AMSR-E. Also there is significant Level 2 product overlap between MODIS/AIRS/AMSR-E for sea surface temperature, MODIS/AIRS for cloud height, cloud fraction, and cloud top temperature, and AIRS/AMSU/AMSR-E for cloud liquid water and total water column. Aumann then displayed an example comparing an SST product for

a single AIRS footprint and corresponding MODIS field of 15 x 15 footprints. AIRS SST claimed an accuracy of 0.5K root mean squared (RMS) for a single footprint, while MODIS SST claimed an accuracy of 0.2K RMS. He clarified that successful inter-instrument cross-comparison does not constitute validation, but if simple uniform areas are picked, this could be an important step in the development of multi-instrument data products, or at the least, the products could contain information that could be used for new products.

Following Aumann, Peter Hildebrand, the Deputy Aqua Project Scientist for Validation, provided an update on Aqua validation activities. Hildebrand discussed areas of concern for Aqua validation, which include the scheduling of validation field efforts. Hildebrand noted that flexibility needs to be built into the planning of field efforts and critical validation campaigns should be delayed until the time is right (i.e., everything is working). Also, there exists the need for development of alternative modes of data collection for use during start-up so initial calibration and validation needs can be met.

Other areas of concern are the expectation of supporting measurements from other instruments and the cooperation of common validation efforts.

There are also concerns about the data system, ground stations, and data delivery planning. Terra has a complete direct downlink data path that is unavailable for Aqua. Concerning the archival of validation data sets, the model appears to have individual teams/sites do the archival. This will be facilitated using standard data formats and planning for eventual migration to a DAAC.

Other validation impacts noted by Hildebrand are the needs for deep space looks for calibration, the scheduling of validation efforts due to time lost following launch due to getting to the proper orbit, and the effects of re-competition on the science teams.

Action items suggested by Hildebrand included increasing communications by holding validation meetings on the day prior to the Science Working Group Meeting and having regular validation meetings and telecons. Finally, he suggested the creation of an Aqua validation document that identifies the planned validation activities and sources of validation data.

The meeting concluded at 4:00 p.m. with a guided tour of the Goddard DAAC facilities narrated by Steve Kempler, the Goddard DAAC Manager.

The next Aqua Science Working Group meeting is scheduled for Thursday, February 8, 2001 at Goddard.

Software tool being distributed by NASA's Jet Propulsion Laboratory

— Linda A. Hunt (l.a.hunt@LARC.NASA.GOV), NASA Langley Research Center

A software tool for visualization of MISR and AirMISR data files, misr_view, is now being distributed by NASA's Jet Propulsion Laboratory.

misr_view is an IDL-based and graphical user interface-driven display and analysis tool for use with many types of MISR and AirMISR data. It is specificially designed for use with those MISR and AirMISR files that use the HDF-EOS "grid" interface. These include MISR L1B2 georectified (map-projected) radiance, MISR L1B3 radiometric cloud masks, all MISR Level 2 geophysical products, the MISR Ancillary Geographic Product, and AirMISR L1B2 georectified radiances. For MISR data, the user interface provides data selection for specified orbits, paths, or observation dates, and enables translation between these modes of identification. The interface to AirMISR data is simplified. The display and analysis tools include simultaneous display of several data planes through color assignment, contrast enhancement, data value query, image rotation, creation of stereo anaglyphs, zooming, and linked analysis and view windows.

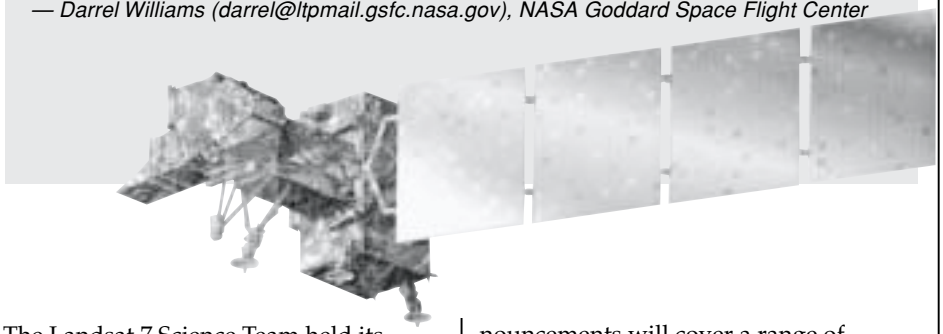
misr_view has been developed by the Visualization and Earth Science Applications Group of the Image Processing Applications and Development Section at the Jet Propulsion Laboratory. Version 3.3 of misr_view, which includes a User's Guide, is available for download free of charge from JPL, upon completion of a misr_view license agreement:
URL: osa.jpl.nasa.gov/MISR_SW_LICENSES/license.visualization

MISR and AirMISR data are available from the Atmospheric Sciences Data Center at NASA Langley Research Center:

Science User and Data Services Office
Atmospheric Sciences Data Center
NASA Langley Research Center
MS 157D
Hampton, VA 23681-0001
Phone: (757) 864-8656
Fax: (757) 864-8807
Internet: larc@eos.nasa.gov
URL: http://eosweb.larc.nasa.gov

Landsat 7 Science Team Meets in Boulder Colorado

— Darrel Williams (darrel@ltpmail.gsfc.nasa.gov), NASA Goddard Space Flight Center



The Landsat 7 Science Team held its eighth bi-annual team meeting May 12-15, 2000, at the University of Colorado, in Boulder CO. Landsat 7 Project Scientist Darrel Williams (NASA GSFC), Science Team Leader Samuel Goward (University of Maryland), and Alex Goetz (University of Colorado) chaired the meeting.

The gathering offered Landsat team members the opportunity to review the success of the Landsat 7 mission, and present initial analyses of the data. Landsat 7 was launched successfully in April, 1999, and has performed superbly during the subsequent year. The presentations at the team meeting confirmed that Landsat 7 has met or surpassed expectations regarding data acquisitions and image quality.

The meeting began with a briefing from Garik Gutman (NASA HQ), NASA Landsat Program Manager. Gutman noted that NASA was moving away from instrument science teams, and that consequently the Landsat Science Team would not be renewed during the coming fiscal year. However, team members would have the opportunity to bid on disciplinary Announcements of Opportunities during the next 12 months to continue their projects. These announcements will cover a range of terrestrial science processes, including the global carbon cycle, hydrology, and land-use/land-cover change. Gutman also outlined plans for a Landsat computational facility to ease the burden of conducting large-area analyses using Landsat ETM+ data.

Representatives from NASA and USGS then gave short presentations on Landsat operations during the previous six months. David Lorenz (NASA GSFC) indicated that both the instrument and spacecraft continued to perform well, with only a few recent glitches. Most of the recent problems had to do with operations of the solid-state recorder, although none was particularly serious or resulted in significant loss of data. Jay Feuquay (USGS EROS Data Center) noted that sales of Landsat data at EDC had increased to 40-50 scenes/day in recent months. [*Note: at the time of writing (summer 2000), data sales have further increased to 70-80 scenes/day.*] Landsat 7 ETM+ scenes may be purchased from EDC for $600 each (or $475 for "raw" Level 0R data). Feuquay also noted that EDC was introducing a new, more intuitive Web interface for browsing Landsat 7 images (http://earthexplorer.cr.usgs.gov).

Terry Arvidson (Lockheed Martin) gave an overview of the Landsat 7 Long-Term Acquisition Plan (LTAP). The LTAP schedules global image acquisitions using a cloud-avoidance algorithm and knowledge of seasonal vegetation cycles in order to optimize data collection. At the time of the meeting, Landsat 7 had acquired over 75,000 scenes for the U.S. archive, with ~36% of these scenes "cloud-free" (<10% cloud cover). As a result, by early 2000, the EDC held complete, nearly cloud-free coverage of the world's land and coastal areas. The science team agreed that the LTAP was a major success of the Landsat 7 mission, and that the time-space coverage of Landsat 7 acquisitions was considerably better than on past missions. The team also expressed a desire to see the LTAP updated and improved in the future, with regular, objective assessments of its effectiveness.

John Barker, Brian Markham, and Jim Storey (NASA GSFC) were joined by Ron Morfitt (USGS EDC) to present the latest update on ETM+ data quality and calibration. To date the ETM+ has performed superbly, with the signal-to-noise ratio of individual detectors >100, and less than 1 DN in per-pixel noise. In addition, the calibration appears to be stable through time and within 5% of actual at-sensor radiance. These metrics either meet or exceed pre-launch specifications. Geodetic accuracy of ETM+ scenes was improved by implementing definitive (post-pass) ephemeris processing in April 2000. Scene corner coordinates are now accurate to ~50 meters, a factor of 5 better than the original Landsat 7 specification (+/- 250 meter 1 sigma error). Thus, for many applications (including change detection), ETM+ scenes can be used directly in a GIS environment without registering them by hand.

The Landsat 7 mission was designed to share a common orbit with the NASA Terra platform, which was launched in December 1999. Vincent Salomonson (NASA GSFC), principal investigator for the Terra MODIS instrument, presented an update on MODIS operations and processing. The instrument appears to be functioning well, although the processing and distribution of some higher-level geophysical data products may not occur until later in the year.

The Tuesday afternoon and Wednesday morning sessions were devoted to reports from individual team members, who gave overviews of their scientific findings. Descriptions of individual projects, as well as recent results from team members, can be found on the science team Web site: www.geog.umd.edu/landsat/.

Wednesday afternoon began with a presentation from Phillip Teillet (CCRS/NASA GSFC) on efforts to cross-calibrate Landsat 5 TM and Landsat 7 ETM+. In May 1999, while Landsat 7 was ascending to its final orbit, it underflew Landsat 5. This presented an opportunity to acquire simultaneous images from ETM+ and the older Landsat 5 TM sensor, whose calibration was not rigorously maintained during the EOSAT/commercialization era. Teillet showed results from the underfly experiment, and indicated that a new, more accurate calibration for Landsat 5 TM should be released later in 2000.

The afternoon finished with two splinter sessions, one dedicated to the details of the cross-calibration experiment, and one dedicated to a more detailed look at the Long-term Acquisition Plan.

Recommendations from each group were forwarded to Darrel Williams and Samuel Goward.

The bulk of the last day was concerned with outreach activities and the long-term future of the Landsat program. Lynn Chandler (NASA GSFC) and Steve Cole (NASA GSFC) discussed recent efforts to publicize both the Landsat 7 mission as well as science results derived from ETM+ data. Stephanie Stockman (NASA GSFC) presented new educational efforts to teach remote sensing to K-12 students. She noted that "Echo the Bat", an elementary school lesson plan to teach principles about remote sensing, had been extremely well received and that a follow-up was being prepared.

James Irons (NASA GFSC) discussed the current status of the Landsat 7 follow-on mission, which is currently in the planning stages. The current choice of NASA Headquarters is to implement a follow-on mission as a commercial data buy, in which a private company would build and launch the spacecraft, and NASA would purchase the data. A science-data specification has been prepared for such a mission, and forwarded to NASA headquarters. Team members expressed some concern at the slow pace of decision-making and, given the clear success of Landsat 7, the lack of consideration for a government-sponsored mission.

The next (and possibly last) Landsat Team meeting will be held at the Airlee Conference Center, located between Gainesville and Warrenton, Virginia, November 7-9, 2000. Those interested in participating should contact Jeffrey Masek (jmasek@geog.umd.edu).

Following are paragraphs extracted from a letter to Darrel Williams, the Landsat Project Scientist, and members of the Landsat Project, from Samuel Goward, Landsat Science Team Leader.

On behalf of the Landsat Science Team I would like to congratulate you and the diverse members of the Landsat Project with your exceptional accomplishments in the development and deployment of Landsat 7 mission. Your leadership in this joint NASA/USGS mission has implemented a new vision for the Landsat series. Specifically, Landsat has now become a truly global observing mission. Through your efforts, NASA has begun a new era in which high spatial resolution multispectral studies are possible at global scales.

We are now on the verge of realizing the long-held dream of Landsat as the observatory that permits us to understand the land component of the Earth system, specifically the role of human activities both as a source and sink for global change. We would not now be in this exceptional position of discovery if it were not for the heart-felt dedication of all members of the NASA and USGS Landsat Team.

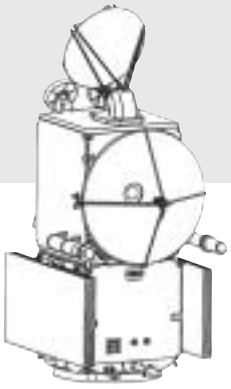
The Landsat Science Team congratulates you and applauds you on this success. Your long-term commitment to the Landsat mission has reaped rewards far beyond our expectations if not beyond our greatest dreams.

A note from Al Diaz, Director of Goddard Space Flight Center, to Darrel Williams:

I know how satifying this recognition from the Landsat Science Team must be for you. You have done a terrific job for your community and the nation. You should feel proud. Congratulations!

Jason-1 Calibration/Validation

— Bruce J. Haines (Bruce.J.Haines@jpl.nasa.gov) Jet Propulsion Laboratory, California Institute of Technology, USA
— Yves Ménard, Centre National d'Etudes Spatiales, France



Jason-1 is the first in a series of planned radar altimeter missions designed to extend the remarkable TOPEX/POSEIDON (T/P) sea-level record into the new millenium [*Ménard et al*. 2000]. Clearly, the Jason-1 measurement system must be held to the same performance standards established by its highly successful predecessor. In recognition of this, the Jason-1 measurement requirements were derived directly from estimates of errors in the current T/P geophysical data products. These performance requirements are shown in Table 1, expressed in terms of an error budget for the determination of sea-surface height (SSH), and ancillary wind/wave parameters. The overall requirement on the single-pass accuracy of the definitive SSH measurements (final product produced within 30 days) is 4.2 cm root-mean-square (RMS), commensurate with the current estimated performance of T/P. Note that Jason-1 will also feature operational wind/wave (3-hr latency) and interim geophysical (3-day latency) data products to support near real-time applications (Table 1).

Also given in the error budget table are a set of goals that elevate the expectations of Jason-1 performance to a new level. To achieve the goal for SSH accuracy (2.5 cm RMS), radial orbit errors must be reduced to 1 cm (RMS). Significant advances in the development of the correction terms for the altimeter range (e.g., sea-state and tracker effects) will also be needed. An additional goal (not listed) states that the measurement-system drift should not exceed 1 mm/yr. These goals have been developed in response to the challenge of "millimeter altimetry," driven by the unparalleled success of T/P. Meeting this challenge will enable new insight into subtle variations in the basin- and global-scale sea level which, despite their small magnitude, can bear significantly on the understanding of long-term climate change.

Table 1: Jason-1 Geophysical Data Product Accuracy as a Function of Latency

Measurement	3 hours (requirement)	3 days (requirement)	30 days (requirement)	30 days (goal)
Range to sea surface (cm, corrrected)	4.5	3.3	3.3	2.3
Radial orbit height (cm)	3.0	4.0	2.5	1.0
Sea-surface height (cm)	NA	5.0	4.2	2.5
Significant wave height (m)	0.5	0.5	0.5	0.25
Wind speed (m/s)	2	1.7	1.7	1.5

A principal objective of the Jason-1 CALVAL program is to verify that the post-launch performance of the measurement system meets or exceeds the standards set forth in the error budget requirements. An equally important goal is to calibrate the various component measurements in order to maximize the overall performance. To address these objectives, the CALVAL program is building on the successful T/P model by involving participants from the Jason-1 Science Working Team (SWT), as well as the CNES and NASA project offices. CALVAL efforts will peak during the six-month verification phase, which will begin when Jason-1 reaches its operational orbit approximately one month after the planned Spring 2001 launch. During this phase, Jason-1 and T/P will fly in a tandem arrangement to enable ultra-precise cross-calibration of measurements from the two satellite systems. At the end of the verification phase, the CALVAL team will issue a revised error budget as well as estimates for the bias and drift of the measurement system in an absolute sense and in relation to the T/P system. Recognizing the importance of ongoing validation to achieving the measurement goals of the mission, many of the CALVAL activities will continue for the duration of the mission. This continual monitoring

will be essential to our quest to achieve "millimeter altimetry."

CALVAL Implementation

The Jason-1 CALVAL program embraces a wide variety of activities ranging from engineering assessments of the sensor data to *in situ* validation of the overall measurement system. CNES will monitor engineering and science data from the POSEIDON-2 altimeter (POS-2) on an ongoing basis to ensure that all performance requirements (e.g., noise, range drift) are being met. Like its predecessors on T/P, the POS-2 altimeter has two internal calibration modes: one provides a measure of the point target response of the instrument, and the other measures the altimeter transfer function. CNES will monitor how output from these calibration modes evolves in the long term, and the results will be factored into routine science data processing. Jason-1 science team investigators from NASA Wallops Flight Facility, responsible for monitoring the TOPEX radar altimeter, will also participate in the POS-2 internal calibration exercise. Science team investigations will target improvements in the sea-state and electromagnetic biases, which corrupt the altimeter range measurements. Finally, the dual-frequency ionosphere correction from POS-2 will be validated using estimates derived independently from the the U.S. Global Positioning System (GPS) and French Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) system.

The three-frequency Jason microwave radiometer (JMR) provides an estimate of the columnar water-vapor delay used to correct the altimeter range. When operating nominally, the JMR does not employ a "cold-sky" calibration mode; rather it relies on triple-redundant (noise-diode) temperature measurements on each of the three operating frequencies. The JMR engineering team at the Jet Propulsion Laboratory (JPL) will monitor and ensure the integrity of the noise-diode and antenna temperatures on an ongoing basis. Jason-1 science team investigators will perform intensive post-launch calibration of the JMR brightness temperatures and path-delay retrieval algorithms using ground truth as well as comparisons with data from other spaceborne radiometers and global models. The path-delay measurements will be monitored throughout the mission to detect potentially subtle drifts, such as the 1 mm/yr trend experienced by the TOPEX microwave radiometer [*Keihm et al*. 2000].

In situ validation of the overall measurement system will be performed using dedicated verification sites, as well as distributed tide gauges. The principal objective of these programs is to use observations from tide-gauges directly on (or near) Jason-1 ground tracks to calibrate the SSH measurement made by the satellite as it passes overhead. Dedicated verification sites offer the advantage of a direct overflight geometry, and an absolute tie to the geocenter. In addition, they typically feature several collocated sensors (e.g., tide gauges, radiometers, GPS, and SLR) to help discriminate between different sources of error. The prime CNES verification site is located on the island of Corsica [*Exertier et al*. 2000]. Established in 1996, the Corsica experiment is currently delivering ground-truth data to support calibration of T/P, which traces out the same ground track as that planned for Jason-1. Pelagic GPS techniques have been recently used to measure the geoid slope between the locations of the open-ocean altimeter measurements and the coastal tide gauges at the principal Cape Senotosa site. An extension of this program to Capraia Island, located between Corsica and Italy, will provide an additional verification opportunity along the same satellite track. The prime NASA verification site for T/P is located at the Harvest Oil Platform off the coast of central California [*Christensen et al*. 1994]. A T/P calibration time series dating back to the satellite's 1992 launch has been formed from the Harvest data, and the potential systematic *in situ* error sources have undergone extensive evaluation. The calibration program for Jason-1, which will also fly directly over the platform, will benefit significantly from the occupation history at this site [*Haines et al*. 1998]. Successful T/P altimeter calibration sites in the Bass Strait [*White et al*. 1994] and English Channel [*Murphy et al*. 1996] will also continue to provide data for the Jason-1 CALVAL effort. Finally, plans are under way to develop additional sites in the Mediterranean and Gulf of Mexico to support calibration of multiple altimeter missions, including ENVISAT and Geosat Follow-On in addition to Jason-1 and T/P.

While the information from the absolute calibration proved invaluable for detecting biases in the T/P measurement systems, the most reliable external information on system drift was afforded by the global tide-gauge network. Cooperating tide gauges in this network are rarely found along the satellite's ground track; moreover, relatively few are currently colocated with GPS or DORIS to provide information on vertical land motion. When determining the stability of the altimeter measurement system; however, these limitations can be overcome by combining calibration time series from the

many distributed tide gauges into a single ensemble result [e.g., *Mitchum* 1998]. The resulting drift estimate provides information that is complementary to the calibration estimates from the dedicated sites. The significance of this complementary information was amply demonstrated with the discovery in 1996 of a T/P algorithm error which introduced both a global bias (13 cm) and slow drift (8 mm/yr) in the sea-surface heights. While the effects of the mean component of the error were readily observed by the dedicated calibration sites soon after launch [*Christensen et al*., 1994; *Menard et al*. 1994; *White et al*. 1994], a multi-year calibration time series from the global tide-gauge network was needed to convincingly detect the slow drift [*Mitchum* 1998]. In retrospect, the combined results provided a remarkable portrait of the total effect of the algorithm error on the sea-surface height. This experience helped spur efforts to further enhance the global network by identifying 30 selected tide gauges where vertical land motion measurements are needed to support improved altimeter stability estimates [e.g., *Neilan et al.* 1997]. The use of the tide-gauge network in this capacity has also been a significant agenda for GLOSS [*Woodworth* 1998], leading to the identification of a subnet known as GLOSS-ALT. As part of a Jason-1 science team investigation, the University of Hawaii Sea Level Center has embarked on a program to provide continuous GPS at 11 of the 30 gauges comprising the altimeter calibration network. Some of the remaining stations are already instrumented with GPS or DORIS; thus a major component of the enhanced network will be in place for the Spring 2001 launch of Jason-1.

In addition to the external (*in situ*) calibrations, the CNES and NASA project elements will be performing routine, global evaluations of data generated by the science data processing systems for both Jason-1 and T/P. Such statistics (e.g., histograms, spectra, multi-variable mapping, cross-over residuals, multi-satellite comparisons) are essential to quickly check the quality and consistency of geophysical products. They will be generated every ten days (one repeat cycle of the ground track) and sent to experts for further analysis. Science working team members will participate in more specialized characterizations of these global data sets.

Significant efforts will also be devoted to verifying the precise estimates of the radial orbit positions. A precise orbit determination (POD) verification team—led by the University of Texas and consisting of selected members of the science team and CNES/NASA representatives—has been formed to evaluate and exchange existing models and iterate on recommendations for standards to be used by CNES in computing the orbits. Extensive post-launch validation will be performed by comparing orbits determined by various contributing groups using different data and strategies (e.g., reduced-dynamic GPS, short-arc laser, DORIS). On going verification and continuous improvement will be essential if the goal of 1 cm for the radial orbit accuracy is to be attained.

Concluding Remarks

The CALVAL plan for Jason-1 will involve many project- and science-team experts who share the motivation to characterize and improve Jason-1 system performance. The TOPEX/POSEIDON experience has highlighted the benefit of wide participation in CALVAL activities spanning engineering assessment through scientific evaluation. The Science Working Team, in particular, plays an essential role in these efforts.

Coordination of the CALVAL activities and synthesis of results will require close interaction among the participants of the Jason-1 CALVAL team. The first dedicated meeting of this team was held in May 2000 in Washington D.C. Over 40 participants were in attendance and reviewed plans for the Jason-1 CALVAL effort. This "kickoff" meeting also provided an opportunity for the members of the CALVAL team to present individual plans for their Jason-1 investigations, and to review relevant T/P results. Finally, the meeting provided a forum to address specific issues related to the following topics: 1) CALVAL contributions to quick-look/outreach activities; 2) CALVAL standards to be used by the team; and 3) methods for exchanging and reporting CALVAL data/results using a Web site and other means. A meeting dedicated to verification will be held a few months after the Spring 2001 launch. In addition, results and analyses will be presented at regular SWT meetings. These meetings will also provide a forum for issuing recommendations that will serve as the basis for updating the post-launch error budget and the algorithms underlying the science data processing.

In addition to monitoring the performance of the measurement system, the CALVAL team will attempt to refine the error budget in such a way as to characterize long-term sea-level changes (inter-annual to secular) to within a few millimeters per year. Achieving the error-budget goals, measuring the bias

and drift of the measurements at the millimeter level, and ensuring a precise connection with previous and future altimetric missions are the keys to meeting this "millimeter challenge."

An electronic copy of the full Jason-1 CALVAL plan is available on the Web at gipsy.jpl.nasa.gov/jason1, or from the EOS validation Web page at eospso.gsfc.nasa.gov/validation/valpage.html.

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Oregon Museum to Bring EOS to a Neighborhood Near You with Travelling Exhibit: Eyes on Earth

— Jim Closs (jim.closs@gsfc.nasa.gov), EOS Project Science Office, NASA Goddard Space Flight Center

The Oregon Museum of Science and Industry (OMSI) was awarded a grant under the 1999 Earth Science Enterprise Education Research Announcement (OES 99-2) to develop an interactive EOS exhibition that will tour science centers and museums around the United States during an eight-year period. The exhibition features hands-on, engaging, educational activities focusing on Earth Observing System (EOS) missions. The exhibit, titled Eyes on Earth, is projected to be viewed by more than four million people during its eight-year life.

OMSI is an established industry leader in the development of interactive science exhibits. This exhibition is intended to present science center visitors with a suite of hands-on exhibits that will convey the value of observing the Earth from space as well as the means by which scientists are studying our home planet.

The conceptual approach is to highlight the various EOS missions as they help us understand the Earth. This would involve a blending of a variety of research areas such as meteorology, oceanography, biology, and atmospheric science. The exhibit concepts represent NASA missions that support these fields. The exhibits will be interactive, providing opportunities for the visitor to learn about EOS at their own level and pace. Mission scientists Michael Freilich and Dudley Chelton from Oregon State University serve as content advisors for OMSI's project manager, Ray Vandiver.

SAFARI 2000 Dry-Season Airborne Campaign

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One of the largest and most aggressive coupled ground, air, and remote-sensing environmental field campaigns ever conducted in Africa was conducted recently in Southern Africa. From August 13 to September 25, the Southern African Regional Science Initiative's (SAFARI 2000) dry-season airborne campaign studied the complex interactions between the region's ecosystems, air pollution, atmospheric circulation, land-atmosphere interactions, and land use change.

The field campaign was timed to coincide with the annual winter fire season in Southern Africa. It appears that SAFARI 2000 observed an unusually large fire season, especially in western Zambia, southern Angola, northern Namibia, and northern Botswana.

The multidisciplinary effort involved nearly 200 participants from 18 countries, including Canada, Germany, the United Kingdom, the United States, and several Southern African nations. This challenging campaign, which coordinated ground-based measurement teams, multiple research aircraft, and satellite overpasses across nine African nations, was headquartered at the Pietersburg International Airport in South Africa's Northern Province. The study region included Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia, and Zimbabwe.

The SAFARI 2000 airborne campaign began with an open house at Pietersburg International Airport, South Africa. EOS Senior Project Scientist, Michael D. King, was one of the project organizers who welcomed the public and government officials to the event. King was also principal investigator for NASA's ER-2 aircraft (background). Photo by Jim Ross, NASA Dryden Flight Research Center.

During the dry-season campaign, unique coordinated observations were made of the evolution of massive, thick haze layers produced by industrial emissions, biomass burning, marine and biogenic sources and the intricate structure within it; the interactions of the haze with local and distant cloud fields; and the detailed structure of different vegetation types and the associated underlying geology. Many of the measurements collected during the campaign will provide extensive validation of new data products from NASA's Terra satellite, which was launched in December 1999.

Project Overview

The dry-season field campaign was the latest in a series of field experiments in

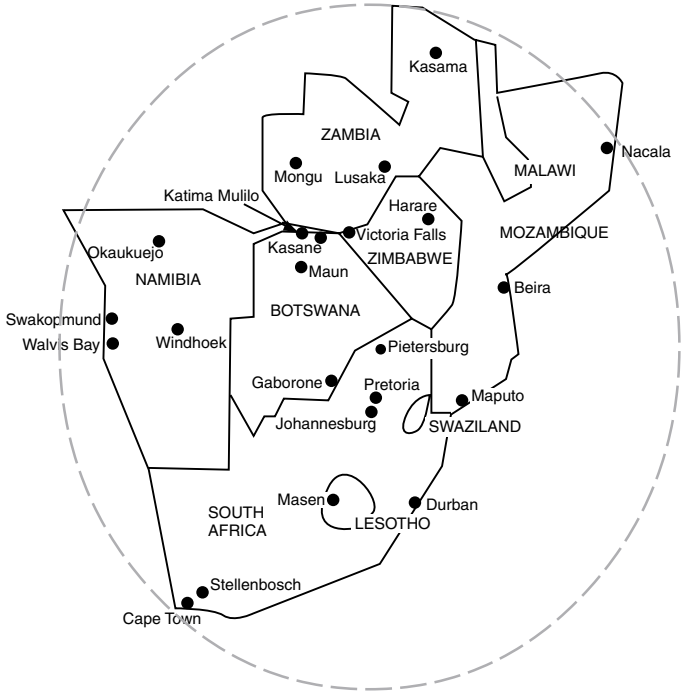
this three-year project. The goal of SAFARI 2000 is to understand the processes driving the different sources of emissions and their transport and chemical transformations in the atmosphere; identify where, when, and how these emissions are deposited and what their impacts are on ecosystems; and lay a foundation for long-term monitoring of the consequences of these processes on climate, hydrology, and vegetation.

SAFARI 2000 incorporates continuous research efforts employing regional observation networks to capture as much of the changes in the physical and biological systems as possible, as well as intensive measurement campaigns involving both airborne and expanded ground-based observations. The strategy is to contrast the wet season with the dry season. The observations range in size from plot-scale to landscape to regional, and across time periods of hours, weeks, and seasons.

Undertaking a project of this scale is only feasible because there is already a reasonable level of relevant knowledge of the subcontinent and there are existing regional scientific networks. The core ground sites that anchor this network are Mongu, Zambia; Skukuza, Kruger National Park, South Africa; Maun, Botswana; and Etosha National Park, Namibia. SAFARI 2000 is an organizational umbrella for diverse environmental studies, some of which are long-term monitoring efforts.

Data collection began in the second half of 1999 with the first dry-season land characterization campaign primarily at ground sites at Skukuza and Mongu. The Kalahari Transect wet-season mobile campaign in February-March 2000 examined ecosystem structure, functioning, and processes at peak biomass growth along a transect from Botswana to Zambia. Each successive intensive field campaign drew increased international participation and increased the scope of scientific questions addressed.

▲ Detailed ground, air, and satellite observations of prescribed burns were a central focus of SAFARI 2000. This fire in South Africa's Kruger National Park was timed to coincide with an overpass of NASA's Terra spacecraft. Photo by Jim Ross, NASA Dryden Flight Research Center.



◀ The study area for the dry-season campaign covered much of Southern Africa from a base of operations in Pietersburg, South Africa. NASA's ER-2 high-altitude aircraft gathered remote-sensing data over the entire region (within circle).

This year's dry-season campaign was the most intensive of SAFARI 2000. Four research aircraft were stationed at Pietersburg: NASA's high-altitude ER-2, the University of Washington's CV-580, and two South African Weather Bureau

Aerocommander 690-As. The United Kingdom Meteorological Office C-130 operated from Windhoek, Namibia, during the later half of the campaign. The ER-2, 2nd the University of Washington CV-580, carried *in situ* & remote sensing instruments, and the other aircraft conducted *in situ* sampling of aerosols and trace gases.

Many of the air and ground observations were coordinated with the extensive satellite observations of Southern Africa during the campaign. Comprehensive environmental observations were obtained with the five instruments on NASA's Terra satellite. High-resolution views of land-cover change were also made with Landsat 7 and broad regional views were provided by SeaWiFS. Regional views of aerosol and ozone concentrations were provided daily by the Total Ozone Mapping Spectrometer (TOMS). Daily weather forecasts were aided by observations from Europe's METEOSAT.

Intensive ground-based activities, many of which focused on Terra validation, took place in several different countries, including Botswana, Namibia, South Africa, and Zambia. These SAFARI 2000 participants operated under many difficult logistical situations in setting up and maintaining their equipment and made the types of observations needed to tie the *in situ* and remote-sensing observations to the processes on the ground.

Daily flight planning was facilitated in Pietersburg by the strong in-region support of the SAFARI 2000 Operations Center for Flight Planning as well as the information and in-field support received by the operations center from key field sites. The South African Weather Bureau coordinated a network of enhanced meteorological soundings for the campaign and provided an on-site weather forecaster who gave daily weather briefings. The provision of a real-time geospatial data server at the operations center aided greatly in planning this intensive campaign. In addition, the Web site developed and maintained at NASA Langley Research Center by Louis Nguyen and Pat Minnis was an extremely valuable aid to flight planning. Likewise, strong support in the extremely quick handling of NASA remote-sensing data in North America greatly aided the project.

An Intensive Six-Week Campaign

The dry-season campaign officially began on August 12 with a public "open day" that attracted more than 5,000 visitors to the Pietersburg airport. Government officials and the general public viewed the aircraft and many educational displays throughout the day. Subsequent outreach activities conducted throughout the six-week campaign focused on smaller groups of students, from primary through graduate school, government agencies, non-government organizations, and the interested public.

Science flights began on August 15. The first synchronized observations with the airborne Terra instrument simulators aboard the ER-2 and the Terra spacecraft took place on August 17. A 1,000-hectare prescribed grassland fire in the Madikwe Game Reserve in South Africa's Northwest Province was the focus of "stacked" aircraft flights and satellite observations on Aug. 20. The data collected will be used to perfect the ability of Terra's MODIS instrument to see fires, the optical properties of smoke, "burn scars" on the ground, and the optical thickness of aerosols in the air.

During the first three weeks of the campaign observations concentrated on the eastern half of the region, including

Members of the local community inspect the University of Washington's CV-580 during the "open day" in Pietersburg. The CV-580 was one of the *in situ* research aircraft that flew throughout the dry-season campaign. Photo by Jim Ross, NASA Dryden Flight Research Center.

the industrial belt of South Africa and the associated continental outflow region into the Indian Ocean; the inflow region along the coast of Mozambique; the Okavango Delta; and the western province of Zambia. Efforts to achieve a more in-depth coverage of some of the sectors were hampered by problems with over-flight clearances.

By September 2, there had been 9 ER-2 science flights, 17 CV-580 flights, and approximately 20 flights for each of the two South African Weather Bureau planes. Accomplishments during this half of the campaign included extensive observations of biomass burning, both from flaming and smoldering fires; industrial emissions, primarily power generation and metallurgical industries; and biogenic emissions from different types of vegetation. Several ground sites related to the Terra validation (MODIS and MOPITT) and the AERONET network were also imaged.

In early September, the project emphasis shifted to the western side of the subcontinent for the second half of the campaign, including Namibia, South Africa's Western Cape and Karoo regions, and the Kalahari Desert in Botswana. Subcontinental outflow along the west coast into the Atlantic Ocean and the interactions of aerosols and trace gases with the Namibian stratus cloud deck over the Atlantic were the primary focus.

The ER-2 conducted remote-sensing missions over this region from its base in Pietersburg while coordinating with Terra overpasses. The CV-580 joined the UKMO C-130 based in Namibia to conduct *in situ* studies in support of Terra validation as well as to obtain fundamental understanding of radiative and chemical interactions of aerosols, trace gases, and clouds within that region.

By the end of the campaign on September 24, the aircraft had accumulated an impressive record of observations. The ER-2 and the CV-580 flew for approximately 120 research hours each. The two South African Weather Bureau Aerocommanders flew a combined total of nearly 200 hours, and the UKMO C-130 flew nearly 80 research hours on the western side of the subcontinent.

Observation Highlights

From initial analyses, it appears that SAFARI 2000 will have observed the effects of an unprecedented fire season in Southern Africa, especially in western Zambia, southern Angola, northern Namibia and northern Botswana. Burning was especially widespread during the later half of the campaign. Many of these were extremely large fires, with fire fronts often exceeding 30 km and lifetimes of days.

Integrated airborne and ground-based activities coupled with remote-sensing data acquisition from Landsat 7 and Terra enabled the thorough observation of at least four prescribed fires in South Africa and three in Zambia. We were able to characterize the land surface and the atmosphere before, during, and after such fires. The thick haze layer produced by these extensive fires, particularly during the period of August 20-September 7, produced atmospheric conditions that campaign participants had not seen in previous field studies, including campaigns in the Amazon Basin and the Kuwati oil fires.

SAFARI 2000 obtained some exciting *in situ* and remote-sensing information. For the first time, comprehensive physical characterization of aerosols from primary industrial sources in Southern Africa have been obtained over the full spectrum range from primary condensation particles upwards. Together with the detailed gas chemistry measurements collected during the campaign, researchers will now be able to evaluate the relative importance of industrial and other natural and human-induced emissions. This information will contribute to the development of both national and regional air quality management policies.

SAFARI 2000 included the first concentrated study of marine stratocumulus clouds off the southwest African coast and the aerosol environment in which they form. This type of cloud system, which typically forms off the west coast of the major continents, plays an important role in the Earth's climate. Previous work on the marine stratocumulus regimes off of Namibia and Angola have been limited to a single *in situ* effort and two remote-sensing studies.

Normally the biomass burning smoke plumes of central Africa are carried toward the Atlantic Ocean by the tropical easterlies. But during the campaign the easterlies interacted with the subtropical system producing a river of smoke that moved from northwest to southeast over the subcontinent, causing heavy haze and reduced visibility over Botswana and South Africa for about 10 days in early September. For the first time, we were able to track this annual spring haze from the source, understand the meteorological transports, and determine the fate of the aerosol. The resulting quantification of carbon transfers (gases and particles) in such events are likely to add important pieces

to balancing global carbon budgets.

Several times during the campaign the *in situ* aircraft encountered extremely clean layers of air, 500-800 feet thick, sandwiched between very hazy layers. The origins and mechanisms that produced these pristine layers will likely be a fascinating study.

The campaign's combined, interdisciplinary data set of ground-based, *in situ*, and remote-sensing data is rapidly approaching the order of a terrabyte. Much of this information is currently accessible on the campaign's Web site (www.safari2000.org). The Geospatial Database on this site contains many types of detailed information, including the AVHRR quick-look fire products from NASA Goddard, satellite orbital predicts (Landsat 7, Orbview2, TOMS, AVHRR, and Terra), and post-flight descriptions of aircraft flight paths and times.

To archive and distribute field campaign data, the SAFARI 2000 project has established a data information system and an associated data policy. Data will be shared over the Internet using the Mercury metadata search and data retrieval system. Large volumes of data will be exchanged on CD-ROMs and science-team selected "golden day" data sets will be prepared. The data information system provides tools for documenting, storing, searching, and distributing data and images. The SAFARI 2000 data policy is designed to ensure that participants have access to data in a timely manner, that intellectual property rights are protected, and that co-authorship, acknowledgements, or credits are given to data originators and principal investigators.

Data generated by SAFARI 2000 will be permanently archived in Southern Africa. About 18-24 months after data collection, data will be considered in the public domain, except for restricted or copyrighted data. SAFARI 2000 acknowledges that some investigators may be required by their funding agencies to follow established agency guidelines for the distribution of project data (e.g., NASA EOS-funded investigators must release their data sooner than required by SAFARI 2000). Further details on the SAFARI 2000 Data and Information System and Data Policy are available at http://mercury.ornl.gov/safari2k/.

The field component of the three-year SAFARI 2000 project concludes after the completion of an airborne wet-season campaign and the Miombo Transect campaign in February-March 2001. The Miombo Transect involves a research caravan comprised of scientists with the Miombo Network, the Southern Africa Validation of EOS (SAVE), and SAFARI 2000. The caravan will travel east from Mongu to Mozambique to characterize vegetation in the world's largest dry tropical forest during the height of biomass growth. The airborne campaign involves observations from two South African Weather Bureau aircraft and data from two main ground sites (Skukuza and Mongu) to quantify major wet-season sources of emissions.

The next step for the project will be the intercomparison and calibration of data and the presentation of first results. A data comparison/calibration workshop is tentatively scheduled for late summer of 2001 in Lusaka, Zambia. We will be proposing a special session on initial results from the campaign at the American Geophysical Union meeting in December 2001. A final wrap-up workshop and planning session for a *Journal of Geophysical Research* special issue is planned for the summer of 2002 in Southern Africa.

◀ Deputy President of South Africa, Jacob Zuma, receives a MODIS image of his country from EOS Senior Project Scientist, Michael D. King, following a speech to the South African cabinet on the SAFARI 2000 project. Project organizers Robert Scholes, CSIR Environmentek (far left), and Harold Annegarn, University of the Witwatersrand (far right), also made presentations to the cabinet. Photo by Stuart Ralph, Capetown.

The Social Driving Forces of Land Use Change in the Northern Province, South Africa: Illustrations from the Household and Community Level

— *Brent McCusker (mccuske1@msu.edu) Department of Geography, Michigan State University*

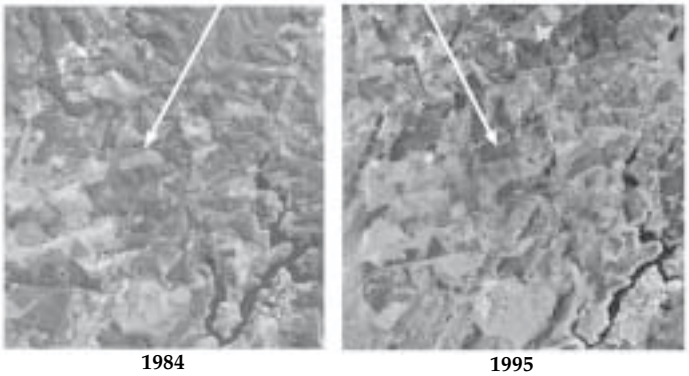
1. Introduction[1]

Land-use and cover change has largely been addressed as a bio-physical issue. Social driving forces of change are not well understood, especially at the household level. This paper is a first attempt both to incorporate a structure/agency perspective into the discussion of land use change and to identify the social driving forces of such change. I will focus on identifying the social driving forces of change drawing on case studies and preliminary analysis of satellite imagery and begin by examining theoretical issues in the study of land use and cover change with relevance to South Africa. Key aspects of the study of land use and cover change are highlighted and critical questions are raised in the second section. The third section sets the scene, describing the study area and the data collected. Section four examines the social driving forces of land use change. I conclude by re-examining the usefulness of such an analysis and provide challenges for future work.

2. The Study of Land Use Change in South Africa

Land use and cover change in South Africa is neither unique nor more important than in other areas. I will not set land use and cover change in South Africa apart as somehow special or different. I will argue, rather, that South Africa is representative of *a broad range of land use and cover changes*. I focus here on two types of change, structural and agentist. Structure is that which constrains, such as through a legal system or societal norms (Giddens 1984). This represents known, readily identifiable and predictable changes manifest largely in land use plans and management documents. Timber plantations are the largest contingent of such change in the northeast South Africa. The scope and spatiality of such change is known in timber company documents, town and regional land use plans, etc. The second type of change, and the focus of this study, can be described as agentist change. Agency is the freedom individuals have to act upon their own will (Giddens 1984). This category represents less structured change spurred by individuals and groups in society where outcomes are neither easily measured nor planned, and often come into direct conflict with structured forms of land use.

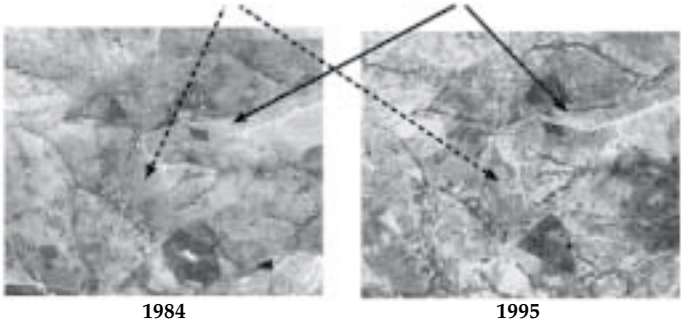
Forest Regrowth in Timber Plantations



1984 **1995**

Figure 1. Structural Land Use Change – Rotation of Timber Stands in the Escarpment Region

Land Fragmentation **Settlement Expansion**



1984 **1995**

Figure 2. Agentist Land Use Change – Land Fragmentation and Settlement Expansion around Platklip Control Farm, Nebo District.

[1] This paper represents research undertaken as part of NASA's Earth System Science Fellowship and the NSF's Doctoral Dissertation Improvement Award. The material presented here represents the first phase of that research. Follow-up work will focus on satellite-derived temporal analysis of land cover change.

Change in South Africa is neither exclusively structuralist or agentist. That the South African state (structure) seeks to alter the landscape makes the country a good case study. The state as a force of change is clear and can be evaluated and analyzed as a factor of total change. Institutions in South Africa, such as the Department of Land Affairs, seek to strongly influence change (Department of Land Affairs 1997). Rural households represent one of the largest contingents of agentist change. South Africa, then, serves as a good candidate for the testing of models of the socio-economic drivers of land use and cover change and for integrating socio-economic and remotely sensed data.

3. The Study Area and Data

Figure 3. Map of the Study Areas in the Northern Province

The Northern Province is similar to many other areas of rural South Africa in its history and agrarian structure. The residents of the rural Northern Province face many of the same constraints and opportunities as their counterparts across South Africa. However, more than in any other province, people rely on their own production for sustenance (Lipton 1996). The Northern Province is also one of the drier provinces of the country and is prone to drought, especially during periods of El Niño Southern Oscillation (ENSO) events. With an average annual precipitation of 381mm-635mm, only the Northern Cape and Northwest Provinces are dryer (Tyson 1987).

Having contained three of the former homelands[2], the Northern Province is the poorest in South Africa (Levin 1996). Demographic pressures include the highest population growth rate in South Africa, high rates of infant mortality, and strong out-migration to the mining sector (Levin 1996). Further, nearly 70% of the population lives below the poverty level (Kirsten 1996). Income is derived from a range of sources, including the sale of crops, remittances, non-farm activities, and pensions (Baber 1996).

Land and tenure reform has recently been undertaken in the Northern Province. The democratic government elected in 1994 implemented a program of land reform that includes land redistribution, land restitution, and land tenure reform. At the time of field research, the central government had initiated in the Northern Province 18 redistribution projects. One restitution claim had been settled and 5,640 claims had been lodged on 9,644 portions of land (Regional Land Claims Commission, 2000). Figure 4 represents verified land claims on rural farms[3]. Land reform is clearly a component of overall land use and occupation change and in the future will figure even stronger in analyses of land use and occupation change.

Figure 4. Verified Land Claims on Rural Farms in the Northern Province

This research focuses on several issues including 1) the scope of land use change; 2) identifying the key indicators and perceptions of land use change; and 3) investigating possible agentist forms of land use change.

Study Data: Remote Sensing (and GIS)

Initial analysis of the scope of land cover change was undertaken in early 1999 using imagery from 1984 and 1995. Through collaboration with South African counterparts at the University of the North, seven TM images and two SPOT image sub-scenes were geo-rectified and classified. A basic land cover change map was created for the two study areas. The most recent topo-cadastral sheets (1:50,000) for the entire Northern Province were digitally captured. All farm boundaries were digitized from 1:250,000 map sheets. All enumerator areas (for census data), district councils, other sub-province political units were obtained from outside sources. Digital Elevation Models have been obtained for sub-scenes relevant to the farms under study. Further, the list of pending land claims in

[2] Prior to 1994, South Africa was divided between white areas and black areas called homelands. The homelands of Lebowa and Gazankulu and the so-called 'independent' Republic of Venda were all incorporated into the Northern province in 1993.
[3] Many land claim applications are incomplete or imprecise and, therefore, unable to be verified.

the Northern Province has been obtained and digitized. These data were used to perform initial assessments of land cover change in the study areas.

Study Data: Household Interviews

Household level investigation of the social forces of land use and cover change is rare, especially in South Africa. Larger scale aggregate variables are more prominent because of their ease of collection and use. Variables such as population, population pressure, number of cattle, amount of fields per capita, etc. are most often used to estimate change. Due to problems in dis-aggregating such data, I have chosen to examine household-and farm-level dynamics first, in order to build up as well as reach down in the search for the social driving forces of change. Targeted questions were asked on seven farms through the central and southern regions of the Northern Province. Participants were queried on their livelihood system and their recent land use patterns. Questions on perceptions of land use and occupation change and the importance of land were included.

Two groups were surveyed. The first group (n= 306) owned land that had been redistributed by the central government under a comprehensive land reform programme. These participants were part of Communal Property Associations (CPA). Under the Reconstruction and Development Programme a once-off R15,000 (~ $2140) social grant is provided to each historically disadvantaged citizen. Finding white farms far too expensive for individuals or even communities to purchase out-right, the Department of Land Affairs facilitated the land redistribution through the CPA programme by encouraging Africans interested in farming to pool their resources in order to purchase productive farms.

The second group of participants (n=101) interviewed resided on the Platklip farm in the Nebo magisterial district in the former Lebowa homeland. They have experienced no land redistribution, rather have had continual access to land under communal arrangements. This group served as a control group. If there is such a thing as a 'typical' rural farming area in the Northern Province, the Platklip Farm might be considered such. The area is under both communal and freehold land tenure systems, thus represents many other rural areas in that it has overlapping land rights. In addition to uncovering the driving forces of land use change in the Northern Province, utilizing a control group allows finer assessment of the impact of land reform on land use change. In fact, it may be spurious to assume that land reform drives the majority of land use changes.

4. Social Driving Forces of Land Use and Cover Change

Land Use Patterns among Members of CPA's

The original intention of this research was to document and explain patterns of land use change among farms that had been redistributed from white owners to black associations under the Department of Land Affairs Communal Property Association (CPA) program. From the onset of field research it became clear that few actual land use changes had occurred. The primary change was the transfer of the land from white to black owners. It was expected that production would intensify due to pressure from the membership for access to the land. In all but one of the CPA's, production was reported to be less than before the transfer. The reasons ranged from lack of membership commitment to unclear division of authority between the chief and the CPA chairperson. The smallest CPA, in fact, was the most productive. CPA's range is size of membership based on the price of the farm the committee wishes to purchase. The larger and/or more potentially productive the farm, the more expensive it becomes. As a result, more individuals are needed to pool their grants to purchase the farm. The largest CPA in the study is located outside of Seshego and has a membership of 396. The farm was used to raise approximately 500 cattle and 200 chickens. No farming had been undertaken.

At a second large CPA near Pietersburg, the land was used for farming and herding. This CPA, however, suffered from conflicts between the committee of the CPA and the traditional chief. The chief, for instance, led a meeting with the community to discuss my work on land use and livelihoods on CPAs. Normally, the chairperson of the committee would fill this role. It is the chief, not the chairperson, who makes land use decisions. As evidenced from this CPA, community level politics factor strongly in land use decisions. This represents one of the most pressing problems in rural South Africa—overlapping claims to community authority. When explaining community level forces of land use change, it is impossible to make clear statements on the role of community authorities, as they themselves are overlapping and often in conflict.

The smallest (and most productive) CPA visited had a membership of 40. This CPA, near Potgietersrus, had a small

irrigation system and raised corn, beans, and melons. A higher proportion of farm members was regularly present on the farm. The chairperson reported that he had fewer problems in getting the membership to participate in farm activities than did the chairpersons of the larger farms.

Land Use Patterns in the Control Group

The Platklip control farm allowed for testing of hypotheses regarding the role of traditional authority on land use and allocation. The Communal Property Associations' have an elected chairperson and committee rather than a chief. As a result, CPAs tend toward greater democracy than under a traditional authority, although the chieftancy should not be viewed as exclusively anti-democratic.

When queried, only 49% of respondents said that their chief instructed them on where to farm. The traditional authority controls fewer land use and occupation decisions than expected. The overwhelming majority of respondents noted that they have always farmed the same fields (93%) and only 39% have ever let their land go fallow. The amount of land a household controls has been stable in the period since 1990 as evidenced by the fact that 86% of participants have neither gained nor lost land to others, however, a significant degree of farm-land to range-land conversion has occurred. One-fifth of participants have stopped farming a piece of land previously under cultivation. Land use change appears to be strong in the study area as 87% of respondents have grazed cattle on land that they previously cultivated, but 90% have never farmed land in which they had previously raised cattle, indicating a shift out of farming.

These findings indicate that farmland is being abandoned for better land or used for more extensive purposes such as raising cattle. At first this would indicate an incredible amount of land use change. Under further investigation, it was discovered that this was intra-annual change rather than inter-annual change and the practice is common in South Africa, in fact all of Africa. When the crops are harvested, cattle are allowed to graze on the stubble to provide fertilizer to enhance the next season's crops. Land designated for raising cattle is considered not suitable for farming, therefore, no cultivation would occur.

Household and Community Driving Forces: Perceptions

Participants' perceptions of land use are rooted in a more traditional system of societal and tenure arrangements. Members of the Community Property Associations differed slightly from participants on the control farm in the "typical" rural area. When queried if farming (for one's own consumption and trade) was still important to them, 91% of CPA participants and 92% of the control group responded positively. However, far fewer (49%-CPA; 21%-Control Farm) agreed with the statement "Do you think that even if people can't farm or don't have the money to farm that they should still have access to land?" The primary reason for the strong disagreement with this statement among both groups was that those without money would have a difficult time raising the necessary capital to undertake farming. Simple possession of land does not explain the widespread push for land reform and can be ruled out as a possible social driving force. I distinguish here between simple land hunger as the desire for land regardless of what is the intended use and land hunger that assumes active use of the land. It would be logical to expect that communities feel their land should be returned to them regardless of how they would or would not use it since it was alienated from them (often brutally) under apartheid. However, these communities view land as a productive asset *first* and a social asset *second*. Simply put, land must be used. The social value of land (our ancestors lived here, we have relatives buried here) has been subsumed by the production ethic. Under apartheid, subsistence farmers were often viewed as unproductive and inefficient, therefore, many rural people still fear that "unused" land might be taken from them. The difference between the two groups stems from the fact that many of the CPA members have experienced acute landlessness and are more willing to grant access to those in need.

The importance of land for food production is highlighted by the fact that the majority of respondents in both groups noted that the primary reason they farm is to grow food for their own consumption (65%-CPA; 71%-Control Farm). Farming for income generation was a distant second (26%-CPA; 28%-Control Farm). Thus, subsistence farming can be considered a social driving force.

Heritage and lineage are strong societal forces in African society. When queried, the overwhelming majority of participants responded positively to the statements "Do you think it is important to farm because your ancestors farmed?" (95%-CPA; 98%-Control Farm) and "Do you think it is important to farm because not many young people are farming anymore?" (93%-CPA; 98%-Control Farm). These strong *cultural*

perceptions are likely drivers of change.

Researchers often note that apartheid skewed the system of land distribution, leaving Africans landless and unable to farm. Accordingly, the majority of respondents agreed with the statement "Do you think it is important to farm because the land was taken from people under apartheid and it is now their right to farm?" (90%-CPA; 97%-Control Farm). The return of land alienated under apartheid also drives change. People all over the province wait for their land and plan how they will make use of it.

Household and Community Driving Forces: Livelihood Systems

A range of questions were asked that were intended to uncover how livelihood choices might influence land use patterns and land use change. While the majority of respondents (84%- CPA; 94%-Control Farm) practiced subsistence agriculture, the degree to which farming contributed to household income was remarkably less. In both cases, the largest response to the query "How much of your income is derived from farming?" was "very little" (46%- CPA; 56%-Control Farm).

Cattle are generally an important source of both wealth and social standing in northern South Africa. As discussed above, no notable increase in herd size was detected and slight decreases were observed. Other sources of significant income included pensions (13%-CPA; 30%-Control Farm), petty commodity sales (37%-CPA; 27%-Control Farm) and remittances (16%-CPA; 26%-Control Farm). Employment in government either as teachers or other civil servants is a notable source of income for 24% of CPA members, but only 13% of respondents on the control farm.

To summarize, the strongest social driving forces of land use change in the study area are:

1. the desire to continue practicing subsistence farming;
2. perceptions of cultural heritage and legacy;
3. the degree of income diversification; and
4. conflict between local authorities.

Simple land hunger and for-profit farming were not shown conclusively to contribute to decisions regarding land use. The clearest social driving force of land use change emanating from livelihood choice is the mix of income sources. Agriculture does not provide the sole, nor the dominant, means of income generation. Subsistence farming is more widely practiced than for-profit agriculture, and accordingly, takes much less land area. Land use change under subsistence farming will be confined to much finer spatial and temporal changes. Respondents noted that when they lack employment, or remittances fail, they often undertake cultivating more fields than normal. As the local and regional economies fluctuate, so too would the land area under cultivation.

Perceptions of cultural heritage and legacy compel people to farm. Many respondents, especially the elderly, reported feeling the "need to farm" because "we have always farmed." Others feared that farming would collapse unless they were involved due to the lack of involvement of the youth. This results in land remaining under production that in other circumstances might go abandoned or be turned over to others for more intensive use.

Income diversification within the household affects the amount of land used. Those households with more diverse income sources, or more reliable income sources, are less reliant on their own food production, and therefore can produce less. A more diverse income also results in less time for agriculture. Respondents heavily involved in other economic activities reported having very little time to devote to farming their fields. In areas where a wider range of income opportunities is available, we can expect to see less agricultural activity and quite possibly, less change.

Conflict between local authorities over the administration of land leads to uncertainty. Individuals are fearful of choosing to abide by one authority over another in fear of retribution. This instability leads to confusion over land rights and lack of willingness to engage in labor intensive activities that might subsequently prove to be in vain. Only where clear authority exists can people be sure of the stability necessary to invest in the production of crops and raising of livestock.

Structural and Agentist Land Use Change in the Study Area

Manifestations of both structure and agency are illustrated in the farms under study. The state, through its land reform program, attempts to improve rural livelihoods by stimulating agricultural production. The expected result of this process is land use change, however, only one farm changed land uses from the previous (white) owner. Local authorities, also considered a structural force of change, had a limited ability to direct change on both the CPA farms and the Platklip Control Farm.

Agentist expressions of change were noted primarily on the Platklip Farm. The majority of respondents made their

own decisions on where to farm, not relying on the chief to decide for them. The preliminary analysis of satellite imagery showed areas of agentist change (see Figure 2). One of the most dominant forms of agentist change, however, has little to do with agriculture. Settlement expansion is much more obvious on the imagery than changes that could be attributed to shifts in cultivated or ranched areas.

5. Conclusion

I began this paper by attempting to broaden our understanding of land use and cover change. The study data have shown that it is possible to understand some of the social forces that drive change at the household level. The distinction between structural and agentist land use change will help deepen our understanding of change that does not fit into current models.

This paper is a first attempt at both quantifying the social forces of land use change and identifying the differences between structural and agentist change. As such, it has several shortcomings. First, a broader range of questions needs to be addressed regarding the upward and downward linkages between the different scales of analysis. How do agentist expressions of change filter up to national and regional scales? Second, more work is needed at clarifying exactly what are the social driving forces of change. Little work has been done at the household level on identifying the range of social forces influencing change. This paper, like others, has limited the number of social variables. Finally, more work must be conducted on the exact nature of the link between livelihood systems and land use change. I have inferred the impacts of livelihood systems on land use change based on quantitative interview data that was followed-up with qualitative discussions. Although tentative, this work can help evoke questions that may lead us to a more complete understanding of land use change.

Acknowledgments

Funding for this project was provided by the National Aeronautics and Space Administration Earth System Science Grant (NGT5-30340) and the National Science Foundation (NSF99-2). I sincerely wish to thank all of my South African collaborators, especially Prof. Paul Fouche, Marubini "Octo" Ramadzuli, Stephanie Dippenaar, and Parvin Shaker of the University of the North. At Michigan State University I extend my thanks to David J. Campbell, David Lusch, David Skole, and the Basic Science and Remote Sensing Initiative for their generous support and constant help.

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(Continued on page 34)

The CEOS Global Observation of Forest Cover Boreal Forest Initiative Summary of August 28 - September 1 Workshop

— Eric Kasiscke, University of Maryland
— Garik Gutman (ggutman@hp.nasa.gov), Land Cover Land Use Change Program, NASA Headquarters
— Tim Perrott, GOFC Project Office, Canada Centre for Remote Sensing

Introduction

The Global Observation of Forest Cover (GOFC) is a panel of the Global Terrestrial Observing System (GTOS). It was originally developed as a Committee on Earth Observing Satellites (CEOS) pilot project as part of their Integrated Global Observing Strategy. GOFC's overall objective is to improve the quality and availability of satellite observations of forests at regional and global scales and to produce useful, timely and validated information products from these data (together with *in situ* observations) for a wide variety of users. Details are available on www.gofc.org.

Background

In March 1999, a workshop on Regional Networks for Implementation of the GOFC Project in the Tropics was held in Washington, D.C which was followed by regional coordination *tropical* workshops during 2000. In August 2000, a group of scientists and forest data users gathered in Novosibirsk Akademgorodok, Russia, to discuss issues specific to the *boreal* forest, with the goal of developing recommendations for the eventual development of GOFC data sets specific to the boreal forest region and the information networks required to distribute them. The workshop location enabled a large participation by the Russian forestry community.

Workshop Objectives

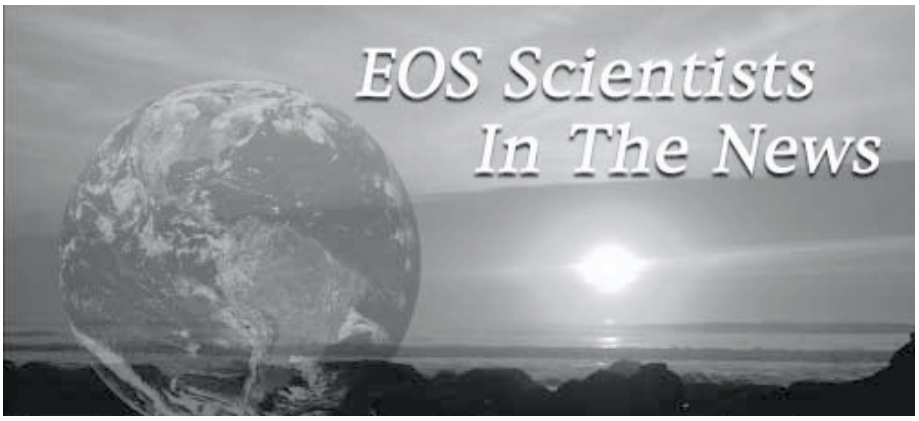
The goal of the GOFC Boreal Forest workshop was to promote a coordinated effort among scientists towards building an observational boreal forest network which would result in operational monitoring of forest cover and forest cover change on a continental scale, and to make data and information on forests usable and accessible.

Workshop Summary

The workshop was organized into six plenary, two poster and three breakout sessions. On Day 1 of the meeting, an overview of GOFC was presented in Plenary Session 1, and information requirements for the boreal forest were reviewed from the perspective of resource managers and researchers in Plenary Sessions 2 and 3. These requirements were then reviewed and prioritized by the workshop participants based on regional perspectives (North America, Western Russia/Fennoscandia, and Eastern Russia/Far East) in Breakout Session 1. On day 2, the variety of remote-sensing data products that are potentially available for the boreal forest region were reviewed during Plenary Sessions 4 and 5 and Poster Session 1, with a particular focus on products that are being generated for specific purposes, such as fire monitoring. The utility of these products with respect to the information requirements identified during Day 1 were evaluated during Breakout Session 2. Day 3 of the meeting focused on information networking requirements in Plenary Session 6, Poster Session 2, and Breakout Session 3. Specific attention was paid during this last Breakout Session on the need for regional networks in the boreal forest, and how these networks should be created from the different regions that comprise the boreal forest.

Plans for the Future

While the Novosibirsk GOFC Boreal Forest Workshop represented a good first step in implementing GOFC in the boreal forest region, it is clear that much work remains. First and foremost, the recommendations derived from this workshop need to be circulated and reviewed by the broad group of users who comprise the boreal forest management and research community. A report from the workshop is under preparation and should be published in early 2001. Next, a series of more focused workshops need to be convened within specific regions of the boreal forest. Two such regional workshops are recommended for the next 18 months, one for the Western Russia/Fennoscandia region and a second for the Eastern Russia/Far East region.



Attention EOS Researchers:
Please send notices of recent media coverage in which you have been involved to:

Rob Gutro, EOS Project Science Office
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E-mail: rgutro@pop900.gsfc.nasa.gov

Major EOS hotspots in the news this period ranged from the controversial report on greenhouse gases to the melting polar ice cap and record ozone hole.

"Hot News on Warming," (August 28) The Washington Post.
An editorial cites both bad news and good news on global warming, from open water at the North Pole to James Hansen's (NASA GISS) report stating "It may be more practical to slow warming than is sometimes assumed."

"North Pole Melting May Rest on Thin Ice," (August 28) The Dallas Morning News.
Mark Serreze (National Snow and Ice Data Center/DAAC) and Drew Rothrock (University of Washington) concur with other polar researchers that open water at the top of the world isn't evidence the North Pole is melting, and its likely just a temporary opening.

"Get the Easy Greenhouse Gases First," (August 29) The New York Times.
"New Cause of Global Warming Uncovered," (August 30) Fox News, Los Angeles Times.
James Hansen's (NASA GISS) study of greenhouse gases says reforms could be more practical and affordable, and methane and other gases may have played a greater role than carbon in warming Earth's surface.

"Satellites Let Scientists Better Understand Global Warming," (August 30) Foxnews.com.
Mark Serreze (National Snow and Ice Data Center/DAAC) said satellites are an effective way to observe sea ice thicknesses with very high resolution.

"El Niño Not So Bad," (September 1) ABCnews.com.
James O'Brien (Florida State University) noted that El Niño is good for the United States, and La Niña events are worse because they increase tornadic and hurricane activity and spread over a larger area.

"The Big Arctic Meltdown," (September 4) Time Magazine.
North Pole ice may continue to melt. Richard Alley (Pennsylvania State University) contends that more melting may shut off the Gulf Stream and cool the Northern Hemisphere. Meanwhile, politicians are still struggling with the controverisal study by James Hansen (NASA GISS).

"Up in Smoke," (September 4) The Philadelphia Inquirer.
Bob Swap (University of Virginia) and Michael King (NASA/GSFC) were two of several NASA researchers and scientists from 13 nations looking at the atmosphere of southern Africa during fire season.

"Climate Change Expert Stirs New Controversy," (September 7) Nature.
James Hansen's (NASA GISS) controversial research that appears to give carbon dioxide less blame in global warming has been welcomed by opponents of the Kyoto Protocol.

"Trouble in the Greenhouse," (September 7) Nature.
John Seinfeld (California Institute of Technology), Yoram Kaufman (NASA GSFC), and V. Ramanthan (Scripps Institution of Oceanography) point out that modeling the effects of aerosols on the Earth's climate includes a great deal more than their influence on clouds.

"NASA Spies Largest-Ever Antarctic Ozone Hole," (September 8) Reuters.
This year's ozone hole at the South Pole covers over 11 million square miles, according to Paul Newman (NASA GSFC).

"New Drought Index Takes Volcanic Eruptions into Account," (September 18) Space News.
Compton Tucker's (NASA GSFC) new multi-spectral drought index compensates for volcanic dust and aerosols in its search for drought.

(Continued on page 34)

Earth Science Education Program Update

Earth Science Competitions In NASA's Student Involvement Program

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

The NASA Student Involvement Program (NSIP) is a national program of investigations and design challenges. NSIP links students directly with NASA's diverse and exciting missions of research, exploration, and discovery.

NSIP Earth science-related competitions include:

Watching Earth Change (grades 5-8 and 9-12) — Students may focus on any type of change in the Earth's surface or atmosphere, whether natural or human-induced. Participants will define a research question related to this change, and use satellite images, data, and maps to answer their question. A $4,000 independently-funded scholarship will be awarded to a selected grade 9-12 NASA Center winner in this category.

My Planet Earth (grades 3-4) — This competition involves the entire class, who will select, observe, and describe a study site that is near their school, using an Earth systems approach. This is an excellent project for teachers doing an environmental science unit, or if you are already using environmental education resources such as the GLOBE Program (Global Learning and Observations to Benefit the Environment), URL at: www.globe.gov/

Aeronautics and Space Science Journalism (grades 3-4, 5-8, and 9-12)— Students develop a news report in one of the following media: print, cassette audio tape, or VHS videotape. The topic of the news report can cover any one of NASA's many stories, from space or Earth sciences or aeronautics.

Other NSIP competitions include: Design a Mission to Mars and Space Flight Opportunities. Visit the newly redesigned NSIP Web site at: education.nasa.gov/ to download the 2000-2001 program announcement and educator resource guides.

Entries for Space Flight Opportunities are due January 19, 2001. Entries for all other competitions are due February 1, 2001.

Organizations Selected To Promote Climate Variability And Change Education

The Institute for Global Environmental Strategies has announced that it will provide five organizations with grants to promote the use of IGES-developed, K-12 classroom activities to increase the understanding of climate variability and change. These organizations were selected from more than 27 innovative proposals to encourage the use of peer-reviewed learning activities. The activities are available online at: http://www.strategies.org/. Grant funding is provided by NASA's Earth Science Enterprise and the Environmental Protection Agency's Office of Environmental Education. For more information contact: Stacey Rudolph, e-mail: stacey_rudolph@strategies.org

OEOS Education Project At University Of Montana

The Earth Observing System (EOS) Education Project at the University of Montana disseminates Earth system science imagery and supportive curriculum to the global kindergarten through undergraduate level (K-16) educational community. The project provides Internet-based and on-site training for the K-16 education community in the interpretation, utilization and relevancy of NASA EOS mission imagery. They investigate how EOS information can enhance existing interdisciplinary curriculums that explore the diverse and changing landscapes of the world.

With the western Montana fires in the news, more attention has been paid to satellite images of the fires. Images posted on www.eoscenter.com have received media recognition, encouraging unprecedented numbers of visitors to the site since the start of this year's forest fires. Visitors range from those in the general public interested in the movement of the fires to educators planning to show their classrooms the ecological effects of the fires.

ESRI's ArcIMS Geographic Information System software was used to develop

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Current Status of EOSDIS

— *Vanessa Griffin (vanessa.griffin@gsfc.nasa.gov), ESDIS Project Office*

Significant progress has been made in the performance of all aspects of the EOSDIS system since the time of the Aqua Science Team Meeting. EOSDIS is currently meeting the A+ specifications (based on the February 1996 requirements baseline), although as noted in the above article, those specifications do not meet the full needs identified by the Science Working Group on Data.

Since September, the EDOS performance has been nominal. EDOS has successfully processed over 99% of the science data from Terra, with over 95% of the Terra science data processed within 24-hours of receipt of the data at the ground station. However, the operational system lacks sufficient margin to accommodate system outages and accomplish adequate reprocessing of the Level 0 data. To date a large backlog of data still needs to be reprocessed (primarily data prior to September 2000). The next version of EDOS, Release C4.1, has been installed and is undergoing final operational testing. Release C4.1 has sufficient capability to support both Aqua and Terra, with additional margin for reprocessing of data in a timely manner.

The stability problems experienced with the ECS system in July and August have also been corrected and processing of Terra science data has been increased substantially. The GSFC DAAC has been processing MODIS Level 1B data at better than "keep-up" rates for the past two months. GSFC has consistently demonstrated the capability to process eight days of MODIS data to Level 1B in seven days. The GSFC DAAC and the MODAPS team have collaborated in processing streamlining that ensures complete (no data holes) weeks are being processed. As a result, many, complete MODIS 8-day products are now available from the GSFC, EDC, and NSIDC DAACs.

CERES processing on the Langley TRMM Information System (LaTIS) at the LaRC DAAC has also been nominal with the exception of a six-week outage due to system problems and algorithm modifications. The CERES team recently began processing using a new version of their Level 1B algorithm and has already reprocessed the data for September and October that resulted from the outage. The CERES team is working with EDOS to get key data sets reprocessed that are needed to fill holes in the June and July data prior to producing the monthly CERES products.

ASTER Level 1a and Level 1b data are produced by the ASTER Ground Data System (GDS) in Japan. The ASTER GDS sends the Level 1 data to the EROS Data Center (EDC) DAAC. EDC recently began receiving ASTER data products certified for public release and began distributing the Level 1b data on Friday, November 10th. The ASTER science team is nearing completion of their calibration and validation efforts on the Level 2 and 3 ASTER science products and EDC plans to begin processing higher level products in December.

The MOPITT and MISR science products have recently been made available. As we gain experience with the new MISR instrument which requires new techniques for obtaining the science products, we have identified system inefficiencies and increased resource requirements of the MISR algorithms, as a result the LaRC DAAC has only been able to process about 70-75% of the MISR data to Level 1B. The MISR, LaRC and ESDIS teams are working to enhance overall system performance and have accelerated the purchase of hardware planned for MISR reprocessing in order to get production up to the 100% mark.

The MOPITT Science Investigator-led Processing System (SIPS) at the University of Colorado is processing the science data products for the MOPITT instrument. Modifications to the MOPITT Level 1 and Level 2 processing algorithms required more time than expected due to data receipt problems created by the EDOS system anomalies. Recently the MOPITT SIPS delivered more than 60 granules of MOPITT science data to the LaRC DAAC for distribution to the public. MOPITT plans to begin routine production of Level 1B data at the LaRC DAAC soon

While we have been making the system improvements, EOSDIS has been delivering unprecedented volumes of Terra science data to the Instrument Teams and to the general science community. The EOS Data Gateway (EDG) has been modified to be more user-intuitive, enabling first-time users to more easily locate and order Terra science data. In addition, the EOSDIS Project Scientist, Skip Reber, has developed a simplified web-based interface that allows general users to quickly find Terra data products using both the EDG and DAAC specific search and order systems. This interface can be found on the web site: eosdatainfo.gsfc.nasa.gov/eosdata/terra/terra_dataprod.html.

MISR Level 2 Preview Products

The Earth Observing System Data Information System (EOSDIS) NASA Langley Atmospheric Sciences Data Center (Langley DAAC) announces the release of preview Multi-angle Imaging SpectroRadiometer (MISR) Level 2 data. These preview products include two Level 2 Aerosol and Land Surface product granules, and two Level 2 Top-of-Atmosphere/Cloud Stereo product granules. Within known limitations, all analyses performed to date indicate that these preview products are of very good quality. They are not intended, however, for use in scientific investigations but to familiarize users with the product content and format, and to illustrate the performance of the "first generation" of MISR geophysical retrieval algorithms. These data sets are available through the Data Center's home page at eosweb.larc.nasa.gov

MISR is part of NASA's Terra spacecraft, launched into sun-synchronous polar orbit on December 18, 1999. MISR measurements are designed to improve our understanding of the Earth's environment and climate.

Viewing the sunlit Earth simultaneously at nine widely spaced angles, MISR provides radiometrically and geometrically calibrated images in four spectral bands at every angle. New algorithms for the retrieval of atmospheric aerosol, cloud, and surface geophysical properties have been implemented to capitalize on this unique observational capability.

HOW TO CONTACT US

For information regarding NASA Langley Atmospheric Science Data Center data or for assistance in placing an order, please contact:

NASA Langley Atmospheric Sciences Data Center
Science User and Data Services
Mail Stop 157D, 2 S. Wright Street
Hampton, VA 23681-2199
Phone: 757-864-8656
Fax: 757-864-8807
E-mail: larc@eos.nasa.gov

KUDOS

Dr. Mark Schoeberl, Aura Project Scientist, has been awarded the NASA Distinguished Service Medal for his outstanding contributions to Earth Science and for developing the Earth Science Vision (ESV), a new approach to communicating Earth Science research to the public.

Dr. Darrel Williams, Landsat Project Scientist, has been awarded the NASA Distinguished Service Medal for ensuring the scientific integrity of the Landsat 7 mission by serving as the Landsat Project Scientist.

Dr. Yoram Kaufman, former Terra Project Scientist, has been awarded the Exceptional Scientific Achievement Medal for his outstanding scientific creativity and leadership that has revolutionized remote sensing of atmospheric aerosols and will firmly establish their role in global climate forcing.

Dr. Richard Rood, former Head of the Data Assimilation Office (DAO), has been awarded the NASA Outstanding Leadership Medal for his contributions to the modeling of advective processes in the atmosphere and his leadership in the formation of the Data Assimilation Office.

Dr. Hugh Christian, Principal Investigator for the LIS instrument, has been awarded the NASA Exceptional Scientific Achievement Medal for his contributions to atmospheric electricity and lightning research that have not only advanced scientific understanding, but have directly contributed to a number of NASA missions.

The EOS community and The Earth Observer staff wish to congratulate these scientists on their outstanding achievements.

(Continued from page 28)

The Social Driving Forces of Land Use Change in the Northern Province, South Africa: Illustrations from the Household and Community Level

Tyson, P., 1987: *Climatic Change and Variability in Southern Africa*. Cape Town: Oxford University Press.

(Continued from page 31)

EOS Scientist in News

"Uncovering Storms," (September 20) ABCnews.com.
Timothy Liu (NASA JPL) said that Quikscat and TRMM are used to identify the early signs of swirling in the tropics, almost two days before previous data.

"Scientists Focus on Africa's Burning Environmental Problem," (September 29) Chronicle for Higher Education.
Christopher Justice (University of Virginia), Bob Swap (University of Virginia), and Peter Hobbs (University of Washington) were on the SAFARI 2000 project, assessing the sub-continent's air quality, ecosystems, and the human impact on the landscape.

"Debate Rises Over a Quick(er) Climate Fix," (October 3) The New York Times.
James Hansen's (NASA GISS) study is again mentioned one month before 150 countries meet to follow up on the Kyoto Protocol, as scientists are still debating what the main target of climate change should be: carbon dioxide, methane, ozone, or soot.

"Cracking Up: The Ross Ice Shelf," (October 5) ABCnews.com.
Robert Bindschadler (NASA GSFC) notes that the ice shelf on the western Antarctic coast has been shedding icebergs, and the latest one, named "B-15," is the size of Connecticut.

"Clouds' Role in Global Warming Studied," (October 9) CNN.com and ENN.com.
David Rind (NASA GISS) and Anthony Del Genio (NASA GISS) were interviewed about this recent study that indicates that warmer temperatures lead to thinner clouds that reflect less sunlight and may add to warming.

"Sun Studies May Shed Light on Global Warming," (October 9) The Washington Post.
James Hansen's research (NASA GISS) is still a big discussion topic as a new theory suggests that changes in the sun's magnetic field alters the amount of cosmic rays that strike Earth, and directly affect cloud formation and warming.

"Record Ozone Hole Refuels Debate on Climate," (October 10) The New York Times.
Paul Newman (NASA GSFC) said the ozone hole will continue to be large until the year 2010 or so.

(Continued from page 31)

Earth Science Competitions In NASA's Student Involvement Program

the new interactive map service, located at www.lewisandclarkeducationcenter.com. EOS images can be viewed at the base layer. Queries can then be made by clicking on other layers of provided information (for example: states, rivers, major highways, federal lands, watersheds). By layering these data on top of one another, one can learn more about an area than information gathered from a simple map or image.

Lewis and Clark Trail Fire Effects Maps are posted on the map server to show the extent of the fires along the famed trail. One of the main focuses of EOS Education Project's National Lewis and Clark Education Center is to study the changes that have occurred in the ecology surrounding the trail from the start of the expedition (1803) to present. These fire maps are one of many ways such changes can be studied.

EOS Science Calendar

January 4-5
ORNL DAAC User Working Group, Albuquerque, NM. Contact: Bob Cook, ORNL DAAC, e-mail: cookrb@ornl.gov, tel. 865 574-7319.

January 8-11
Sixth Meeting of the the Federation of ESIPs, Tucson, Arizona. Contact Martha Maiden, tel. (202) 358-1078, e-mail: mmaiden@hq.nasa. gov.

January 24-26
MODIS Science Team Meeting, Sheraton Columbia Hotel, Columbia, MD. Contact: Barbara Conboy, e-mail: barbara.conboy@gsfc.nasa.gov, tel. (301) 614-6068.

January 30-February 1
EOS Investigator Working Group Meeting, Wyndham Resort and Spa, Ft. Lauderdale, FL. Contact: Mary Floyd, tel. (301) 345-3211 x107, URL: eos.nasa.gov.

February 8
Aqua Science Team Working Group Meeting, GSFC. Contact Steve Graham, tel. (301) 441-4169, e-mail: smgraham@pop900.gsfc. nasa.gov.

February 14-15
ICESAT/GLAS Science Team Meeting, UCSD, La Jolla, CA. Contact Bob Schutz, tel. (512) 471-4267, e-mail: schutz@csr.utexas.edu.

February 15-16
SEDAC User Working Group, Arlington, VA. Contact: Bob Chen, tel. (845) 365-8952, e-mail: bchen@ciesin.columbia.edu.

February 27-March 2
AVIRIS Earth Science and Applications Workshop, Jet Propulsion Laboratory. Contact Robert O. Green, e-mail: rog@spectra.jpl.nasa.gov, URL: makalu.jpl.nasa.gov.

Global Change Calendar

January 14-19
American Meteorological Society, Albuquerque. tel. (202) 682-9006, fax: (202) 682-9298, e-mail: ams@ametsoc.org.

April 2-4
International Conference on Information Technology: Coding and Computing (ITCC2001), Las Vegas, Nevada. Contact Pradip K. Srimani, e-mail: srimani@cs.clemson.edu; URL: www.cs.clemson.edu/~srimani/itcc2001/cfp.html.

April 3-5
Oceanology International Americas, Miami, Florida. URL: http://www.oiamericas.com/
e-mail: oiamericas@spearhead.co.uk
tel: +44 (0) 20 8949 9222
fax: +44 (0) 20 8949 8186/8193.

April 8-11
GWXII: The XIIth Global Warming International Conference & Expo, 2001 Annual Conference: KYOTO Compliance Review, Cambridge University, UK. Call for Papers. URL: www.GlobalWarming. Net; tel. (630) 910-1551; fax: (630) 910-1561; e-mail: gw12@GlobalWarming.Net.

April 23-27
ASPRS: The Imaging and Geospatial Information Society, St. Louis. See URL: www.asprs.org, e-mail: wboge@aol.com, tel. (410) 208-4855, fax: (410) 641-8341.

May 14-18
Environmental Risks & the Global Community, Argonne, IL. Contact Joan Brunsvold, tel. (630) 252-5585, e-mail: jbrunsvold@anl.gov.

July 9-13
International Geoscience and Remote Sensing Symposium, Sydney, Australia. Call for Papers. URL: www.IGARSS2001.org, tel. 61.2.6257.3299; fax: 61.2.6257.3256; e-mail: igarss@ausconvervices.com.au. Global.

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

Correction to Minutes of the Sixteenth Earth Observing System (EOS) Investigators Working Group (IWG) Meeting, March/April 2000, Vol. 12, No. 2, pp 3-10, 20

The report presented by Paul Simon, ESTEC/ESA should read as follows:

Paul Simon (Institute for Aeronomy of Belgium) gave the ESA Earth Science Program Status Report. Current elements in ESA's Earth science program are classified according to whether they fall within the Earth Observation Envelope Programme or whether they are funded by a separate "optional" programme. Elements currently falling in the latter are ERS-2, ENVISAT, MSG (Meteosat Second Generation) and METOP (the latter two with EUMETSAT).

The Earth Observations Envelope Programme covers instrument development and data exploitation as well as the Earth Explorer Missions (science driven). It also encompasses the preparation of the Earth Watch Missions (applications driven).

Paul Simon briefly reviewed the various missions, noting in particular that METOP included both a METEO package and an ESA package (ASCATT and GOME-2) plus an Announcement of Opportunity instrument called IASI. The Earth Explorer Envelope Programme includes funding for two types of Earth Explorer Missions, namely core missions (major) and opportunity missions (smaller). Currently four of these missions are approved for implementation:

Core Missions

GOCE - a gravity-field mission from which it is intended to derive the Earth's geoid. It will exploit gradiometry to measure the full tensor of the geoid. ADM - a Doppler wind lidar mission for measuring globally 3-D winds in clear air to improve climate and weather models.

Opportunity Missions

Cryosat - will determine variations in the thickness of polar ice sheets as well as observing the thickness of sea ice. It will use a radar altimeter operating in Ku band in three operational modes. SMOS - will measure soil moisture and ocean salinity using an L-band 2D interferometer. It will use a passive microwave radiometer operating at 1.4 GHz.

In reserve (as an Earth Explorer Opportunity Mission) is ACE which will use GPS soundings to determine temperature and humidity profiles. Other reserves include SWARM - measuring Earth's magnetic field; and SWIFT - determining stratospheric winds by Doppler interferometry.

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