MODIS Science Team Meeting Minutes

May 1 - 3, 1996

Prepared by: David Herring, Science Systems and Applications, Inc.
Mike Heney, SSAI
Dave Toll, NASA GSFC
Locke Stuart, NASA GSFC

MODIS SCIENCE INTEREST GROUP
November 15 - 17, 1995

GLOSSARY OF ACRONYMS

ADEOS	Advanced Earth Observing Satellite
AFGL	Air Force Geophysical Lab
AGU	American Geophysical Union
AHWGP	*Ad Hoc* Working Group Panel
AIRS	Atmospheric Infrared Sounder
AO	Announcement of Opportunity
APAR	Absorbed Photosynthetic Active Radiation
API	Application Programmable Interface
ARVI	Atmospherically Resistant Vegetation Index
ASAS	Advanced Solid State Array Spectrometer
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
ATBD	Algorithm Theoretical Basis Document
ATMOS	Atmospheric Trace Molecule Spectrometer
ATSR	Along Track Scanning Radiometer
AVHRR	Advanced Very High Resolution Radiometer
AVIRIS	Advanced Visible and Infrared Imaging Spectrometer
BAT	Bench Acceptance Test
BATERISTA	Biosphere-Atmosphere Transfers / Ecological Research / In situ Studies in Amazonia
BATS	Basic Atlantic Time Series
BCS	Blackbody Calibration Source
BOREAS	Boreal Ecosystem Atmospheric Study
BRDF	Bidirectional Reflection Distribution Function
CAR	Cloud Absorption Radiometer
cc	cubic convolution
CCB	Configuration Control Board
CCN	Cloud Condensation Nucleii
CCRS	Canadian Center for Remote Sensing
CDHF	Central Data Handling Facility
CDR	Critical Design Review
CEES	Committee on Earth and Environmental Sciences
CEOS	Committee on Earth Observation Satellites
CERES	Clouds and Earth's Radiant Energy System
CIESIN	Consortium for International Earth Science Information)
CNES	Centre National d'Etudes Spatiales (French Space Agency)
CPU	Central Processing Unit
CZCS	Coastal Zone Color Scanner
DAAC	Distributed Active Archive Center
DADS	Data Access and Distribution System
DCW	Digital Chart of the World
DEM	Digital Elevation Model
DIS	Data Information System or Display and Information System
DMA	Defense Mapping Agency
DMCF	Dedicated MODIS Calibration Facility
DoD	Department of Defense
DOE	Department of Energy
DPFT	Data Processing Focus Team
DPWG	Data Processing Working Group

DTED	Digital Terrain and Elevation Data
ΔPDR	Delta Preliminary Design Review
ECS	EOS Core System (part of EOSDIS)
Ecom	EOS Communications
EDC	EROS Data Center
EDOS	EOS Data and Operations System
EDR	environmental data record
EFS	Electronic Filing System
EM	Engineering Model
EOS	Earth Observing System
EOSDIS	EOS Data and Information System
EPA	Environmental Protection Agency
ER-2	Earth Resources-2 (Aircraft)
ERS	ESA Remote Sensing Satellite
ESA	European Space Agency
ESDIS	Earth Science Data and Information System
ESIP	Earth Science Information Partners
ESTAR	Electronically Steered Thinned Array Radiometer
FIFE	First ISLSCP Field Experiment
FM	Flight Model
FOV	Field of View
FPAR	fraction of photosynthetically active radiation
FTP	File Transfer Protocol
FY	Fiscal Year
GAC	Global Area Coverage
GCM	Global Climate Model; also General Circulation Model
GCOS	Global Change Observing System
GE	General Electric
GIFOV	ground instantaneous field-of-view
GLAS	Geoscience Laser Altimeter System
GLI	Global Imager
GLRS	Geoscience Laser Ranging System (now GLAS)
GOES	Geostationary Operational Environmental Satellite
GOOS	Global Ocean Observing System
GSC	General Sciences Corporation
GSFC	(NASA) Goddard Space Flight Center
GSOP	Ground System Operations
GTOS	Global Terrestrial Observing System
HAPEX	Hydrological-Atmospheric Pilot Experiment
HDF	Hierarchical Data Format
HIRS	High Resolution Infrared Radiation Sounder
HOTS	Hawaii Ocean Time Series
HQ	Headquarters
HRIR	High Resolution Imaging Radiometer
HRPT	High Resolution Picture Transmission
HRV	High Resolution. Visible
HTML	Hypertext Markup Language
I & T	Integration and Test
ICD	Interface Control Document
IDS	Interdisciplinary Science
IFOV	Instantaneous field-of-view
IGBP	International Geosphere-Biosphere Program
IORD	Integrated Operational Requirements Document
IPAR	Incident Photosynthetic Active Radiation

IPO	Integrated Program Office
ISCCP	International Satellite Cloud Climatology Project
ISLSCP	International Satellite Land Surface Climatology Project
IV&V	Independent Validation and Verification
IWG	Instrument Working Group
JERS	Japanese Earth Resources Satellite
JGR	Journal of Geophysical Research
JPL	Jet Propulsion Laboratory
JRC	Joint Research Center
JUWOC	Japan-U.S. Working Group on Ocean Color
K	Kelvin (a unit of temperature measurement)
LAC	Local Area Coverage
LAI	Leaf Area Index
LAMBADA	Large-scale Atmospheric Moisture Budget of Amazonia / Data Assimilation
LaRC	NASA Langley Research Center
LARS	Laboratory for Applications of Remote Sensing
LBA	Large-scale Biosphere-Atmosphere experiment in Amazonia
LCD	Liquid Crystal Display
LTER	Long-Term Ecological Research
LUT	look-up table
MAB	Man and Biosphere
MAS	MODIS Airborne Simulator
MAT	MODIS Algorithm Team
McIDAS	Man-computer Interactive Data Access System
MCST	MODIS Calibration Support Team
MERIS	Medium Resolution Imaging Spectrometer
MFLOP	Mega FLOP, or a million floating point operations
MGBC	MODIS Ground Based Calibrator
MISR	Multiangle Imaging Spectro-Radiometer
MOBY	marine optical buoy
MODARCH	MODIS Document Archive
MODIS	Moderate-Resolution Imaging Spectroradiometer
MODLAND	MODIS Land Discipline Group
MOPITT	Measurements of Pollution in the Troposphere
MOU	Memorandum of Understanding
MPCA	MODIS Polarization Compensation Assembly
MSS	Multispectral Scanner (LANDSAT)
MST	MODIS Science Team
MTF	Modulation Transfer Function
MTPE	Mission to Planet Earth
NASA	National Aeronautics and Space Administration
NASDA	National Space Development Agency of Japan`
NASIC	NASA Aircraft Satellite Instrument Calibration
NDVI	Normalized Difference Vegetative Index
NEΔL	Net Effective Radiance Difference
NEΔT	Net Effective Temperature Difference
NESDIS	National Environmental Satellite Data and Information Service
NIR	near-infrared
NIST	National Institute of Standards and Technology
NMC	National Meteorological Center
nn	nearest neighbor
NOAA	National Oceanic and Atmospheric Administration
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NPP	Net Primary Productivity

NPS	National Park Service
NRC	National Research Council
NSF	National Science Foundation
NSIDC	National Snow and Ice Data Center
OBC	On-Board Calibration
OCR	optical character recognition
OCTS	Ocean Color and Temperature Scanner
ONR	Office of Naval Research
OSC	Orbital Sciences Corporation
OSTP	Office of Science and Technology Planning
PAR	Photosynthetically Active Radiation
PDQ	Panel on Data Quality
PDR	Preliminary Design Review
PFM	Protoflight Model
PGS	Product Generation System
PI	Principal Investigator
POLDER	Polarization and Directionality of Reflectances
QA	quality assurance
QC	quality control
QCAL	calibrated and quantized scaled radiance
RAI	Ressler Associates, Inc.
RDC	Research and Data Systems Corporation
RFP	Request for Proposals
RMS	Room Mean Squared
RSS	Root Sum Squared
SAR	Synthetic Aperture Radar
SBRC	Santa Barbara Research Center (changed to SBRS)
SBRS	Santa Barbara Remote Sensing
SCAR	Smoke, Cloud, and Radiation Experiment
SCF	Scientific Computing Facility
SDP	Science Data Processing
SDSM	Solar Diffuser Stability Monitor
SDST	Science Data Support Team
SeaWiFS	Sea-viewing Wide Field of View Sensor
SIS	Spherical Integrator Source
SNR	Signal-to-Noise Ratio
SOW	Statement of Work
SPDB	Science Processing Database
SPSO	Science Product Support Office
SRC	Systems and Research Center
SRCA	Spectroradiometric Calibration Assembly
SSAI	Science Systems and Applications, Inc.
SSMA	Spectral/Scatter Measurement Assembly
SST	Sea Surface Temperature
STIKSCAT	Stick Scatterometer
SWAMP	Science Working Group AM Platform
SWIR	shortwave-infrared
TAC	Test and Analysis Computer
TBD	to be determined
TDI	time delay and integration
TDRSS	Tracking and Data Relay Satellite System
TIMS	Thermal Imaging Spectrometer
TIR	thermal-infrared
TLCF	Team Leader Computing Facility

TM	Thematic Mapper (LANDSAT)
TOA	top of the atmosphere
TOMS	Total Ozone Mapping Spectrometer
TONS	TDRSS On-board Navigation System
TRMM	Tropical Rainfall Measuring Mission
UARS	Upper Atmosphere Research Satellite
UPN	Unique Project Number
URL	Uniform Resource Locator
USGS	United States Geological Survey
UT	Universal Time
VAS	VISSR Atmospheric Sounder
VC	vicarious calibration
VISSR	Visible / Infrared Spin Scan Radiometer
VIS	visible
WAIS	Wide-Area Information Servers
WVS	World Vector Shoreline
WWW	Worldwide Web

MODIS Science Team Meeting

May 1 - 3, 1996

ATTACHMENTS

Note: the box above is a hyperlink to a World Wide Web list of the handouts that were distributed at the MODIS Science Team Meeting. The URL for the list of Attachments is `http://modarch.gsfc.nasa.gov/TEST/attachtest.html`.

If you are unable to access any of the attachments or have questions, contact David Herring at Code 920.2, NASA/GSFC, Greenbelt, MD 20771; call (301) 286-9515; or e-mail herring@ltpmail.gsfc.nasa.gov.

MODIS Science Team Meeting

May 1 - 3, 1996

1.0 PLENARY DISCUSSIONS

1.1 Welcome and Meeting Overview

The MODIS Science Team Meeting was called to order and chaired by Vince Salomonson, team leader (see Attachment 1 for the meeting agenda). Minutes during the plenary sessions were taken by David Herring. Salomonson told attendees that the emphases for this meeting are reviewing progress on the development of data products, preparing for Version 1 delivery of code, and re-examination of validation plans.

Salomonson introduced and welcomed the new Science Team Members—Janet Campbell, University of New Hampshire; Bo-Cai Gao, U.S. Naval Research Labs; Ranga Myneni, University of Maryland; John Townshend, University of Maryland; and Eric Vermote, University of Maryland.

1.2 EOS AM Platform Status Report

Chris Scolese, EOS AM Project Manager, announced that significant progress has been made in the last 6 months by the AM Project (see Attachment 2). The first CERES instrument was delivered and installed on TRMM, the primary structure of the AM-1 spacecraft has been built and static testing is complete, and many of the spacecraft components have been delivered. Additionally, many significant hardware issues have been resolved. The EOS AM-1 launch vehicle vibration requirements were resolved and a launch site has been established, the ASTER, TIR, and MOPITT cooler vibrations were resolved, MODIS vibration and mirror interaction was resolved, and MODIS parts problems at SBRS were mostly resolved. SBRS now has in house enough parts to complete the protoflight model (PFM); and the flight model 1 construction begins soon. Scolese told the team that the launch vehicle chosen for EOS AM-1 is the Atlas Centaur (AC-141) rocket.

Scolese said he is pushing hard to accelerate the fabrication and delivery of the EOS AM-1 spacecraft, in order to save time and cost. He pointed out that the Valley Forge facility is shutting down and he is concerned about the potential for loss of personnel there in the interim. He feels that the best way to resolve potential problems arising from the loss of personnel is to complete the spacecraft integration and testing and get it out of Valley Forge as quickly as possible.

Scolese reported that good progress is being made on developing the science software for each instrument. He is concerned that MODIS' processing requirements appear to be driving the cost of the data system—a problem that he feels needs addressing. He said the general feeling among instrument teams is that processing and computer support is costing too much.

Scolese listed his top concerns, which include: the federation of the EOS DIS, adequacy of support for MODIS beyond AM-1 and PM-1, definition of MODIS for the AM-2 and later era, and the relationship of MODIS to NOAA missions. Salomonson asked Scolese to expand upon his concerns for the future of MODIS. Scolese responded that he is currently reviewing options—particularly cost and risk factors associated with redesign—facing MODIS. He is also exploring with NOAA the possibility of any common ground between their missions and MODIS' capabilities. There is the possibility that NOAA will eventually take over responsibility for MODIS. However, he stated frankly that support for MODIS outside of the MODIS team is currently not strong. He feels it is very important to reduce the size and cost of follow-on MODIS sensors if it is to continue.

Guenther proffered that MCST has consistently indicated a need for on-orbit maneuvers to provide the required calibration accuracy. He asked if the AM Project has made a decision regarding spacecraft maneuvers. Scolese responded that Project is working with Lockheed and Codes 500 and 700 to add on-orbit maneuver capability. However, he questioned the need to do a substantial roll in order to view the moon. He is concerned that when doing such a roll, a deliberate command would have to be sent for MODIS to keep its aperture doors open. But during such a roll, it would also view the sun, thereby changing thermal conditions in the instrument. He feels that there are better alternatives to lunar view maneuvers, such as doing a partial maneuver to view cold space.

Esaias said that he is concerned that if MODIS delivers 55 days ahead of schedule, as the AM Project is advocating, then SBRS and the MODIS Team loses 55 days that could be used for testing the instrument. Scolese responded that he wants to ensure that there is plenty of time for integration and testing of the entire spacecraft. But, he said, if everything goes smoothly and there is still some slack time left, then that time may be used for additional tests.

1.3 EOS Project Science Report

Michael King, EOS senior project scientist, presented a brief status report on recent EOS concerns (see Attachment 3). He announced that TRW Space & Electronics has resumed work on the EOS PM-1 spacecraft contract. That spacecraft is now scheduled for launch in December 2000.

During the last week in April, the FY96 budget was signed by President Clinton. King reported that $535.3 million was allocated for EOS flights, $241.2 million for EOSDIS, and $248.2 million for science (including IDS and R&A budgets). The proposed MTPE FY97 budget was submitted to Congress on March 19 and is now under consideration. King feels that there is still too much annual "uncosted carryover" by MTPE principal investigators. King presented a list of recent relevant Congressional actions. He stated that in FY97 there will be no "subsidized" flight hours available, so investigators must budget according to "full cost" of flight hours (i.e., the cost for the NASA ER-2 is $3,500 per flight hour).

King announced that EOS instrument team members must update their ATBDs by Aug. 16, 1996. This deadline also applies to new science team members to submit their first ATBDs.

King announced that Jim Hanson, of the Goddard Institute for Space Studies, was elected to the National Academy of Sciences. Also, Piers Sellers, EOS AM program scientist, was recently selected to join the NASA Astronaut program. Sellers will report to Johnson Space Center on Aug. 12, 1996.

1.4 EOSDIS Project Status Report

John Dalton, ESDIS project manager, reported that ESDIS recently held a successful critical design review (CDR) of their science data processing and communications system. The Interim Release-1 (IR-1) system has been deployed at GSFC, LaRC, and the EDC DAAC to support early algorithm integration and testing. (Refer to Attachment 4 for more details.)

Dalton announced that the SCF Release A Science Data Processing (SDP) Toolkit was delivered to ESDIS on April 30, and is scheduled for delivery to the EOS science software developers by the third week in May. The toolkit contains new tools for EOS-HDF (hierarchical data format) and metadata access. The SCF Release B SDP Toolkit is scheduled for delivery in the December 1996/January 1997 timeframe.

Dalton reported that the ECS Flight Operations software development is continuing on schedule. Version 2 coding is complete and the Version 3 design is in progress.

<u>1.4.1 ESDIS Active Issues</u>

Dalton listed the issues and concerns currently facing ESDIS. Foremost, the EOSDIS requirements for processing and storage hardware exceed its current budget. He feels that more integration between the MODIS programmers and ECS is needed for optimization of MODIS algorithms. He proposed initiating MODIS/ECS/DAAC/Project tiger teams to identify peak resource demands and perform algorithm and system tuning.

Dalton said a strategy is needed for sufficient testing of MODIS algorithm data flow with ECS data staging and archive elements. Dalton want to ensure that the data archive is not a bottleneck to consumers—he expects consumers to pull out twice the volume of data that is produced per day. To support that load, more robots, pickers, and readers are needed. Dalton noted the MODIS Team's concern that ECS is buying its computer equipment too early. The issue is if ECS buys sooner, then they can better test their system; if it buys later, then the equipment will be cheaper and, presumably, more robust. Dalton hopes to compromise by dividing the system into elements and buying those elements that must be tested sooner, but delaying buying the whole system as long as possible.

1.5 Headquarters Science Reports

Diane Wickland, MODIS co-program scientist, briefly discussed the review and selection procedures for the new MODIS Science Team members. Wickland listed eight themes that were taken into consideration in the review and selection process (see Attachment 5). According to Wickland, the EOS review panel recommended that EOS begin thinking about and preparing for the "next generation" of data products. She has asked the EOS Program and Project Scientists to explore the possibility of getting the EOS IDS climate and cloud modeling investigators more involved in early assessments of MODIS aerosol and cloud data products.

Nancy Maynard presented new changes and current themes in NASA's Mission to Planet Earth (MTPE). She stated that all MTPE technologies must decrease their costs by 30 percent in the out years of the mission. Heavy emphasis will be place on developing commercial partnerships in order to promote practical applications of MTPE data. Maynard listed five priority areas for research and application of MTPE resources: 1) land cover change and global productivity, 2) seasonal to interannual climate prediction, 3) long-term climate variability, 4) atmospheric ozone, and 5) predicting and monitoring natural hazards.

1.6 DAAC Federation Overview

H.K. Ramapriyan (or "Rama"), EOSDIS project manager, presented an overview of the new DAAC Federation (see Attachment 6). Rama reported that the National Research Council (NRC) Board on Sustainable Development made two key recommendations for EOSDIS: 1) retain and streamline components for flight control, data downlink, and initial processing; and 2) transfer responsibility for product generation, as well as publication and user service, to a federation of partners selected through a competitive process.

The proposal suggested that the new federation be developed in phases. Phase I involves immediately forming a working prototype federation—comprised of ESIPs, or Earth Science Information Partners—which will work to meet EOSDIS' immediate goals. Among the goals in Phase I are defining governance and allocation of powers within the federation, and outreach to educate and prepare the broader community for federation implementation. Also, the ESIPs will begin aggressively pursuing cost efficiencies to enable flexibility in the expansion of the federation.

Phase II will build upon the results of Phase I to form the full federation under which EOSDIS will operate into the future. During this phase, competition for new products services will be held.

1.7 MODIS Project Scientist Remarks

Robert Murphy, MODIS project scientist, stated that the team needs to develop plans and increase efforts in the three following areas: 1) validation, 2) an advanced technology MODIS, and 3) outreach.

Murphy announced that a first draft of the MODIS Validation Plan is complete—it was submitted to Dave Starr, EOS validation scientist, in four separate pieces, one from each discipline. Over the next 3 months those drafts will be revised and integrated into a single document. Murphy encouraged the team to step up its participation in aircraft campaigns and begin putting more intellectual energy into the next stage of the MODIS validation effort.

Regarding plans for the advanced technology MODIS, Murphy reported that the EOS Program Office is discussing options for handing off future MODIS technologies to NOAA. He said that we need to find ways of reducing the size and weight of MODIS. However, we need to also preserve and build upon the science of the current MODIS. Murphy asked the team to consider what lessons it has learned so far in the design and development of the current MODIS. Which specifications should be relaxed, and which ones tightened? He called for the formation of a science working group to offer suggestions in an organized manner.

Murphy said there is a need for the MODIS Team to step up its outreach efforts. Specifically, it must work more closely with the general scientific community to help define needs for its data products. He is concerned that the scientific community at large may perceive MODIS as irrelevant.

1.8 MODIS Project Reports

Richard Weber, MODIS project manager, reported that the integration and testing of the MODIS Protoflight Model (PFM) is underway. All optics and focal planes are assembled. By June 1996, SBRS will have the SRCA, the SDSM, and instrument electronics assemblies in place. Weber stated that he expects the PFM to be delivered in December 1996; however, this assumes an “optimistic” schedule, with no major problems.

Weber announced that the MODIS Flight Model-1 (FM-1) components are also being prepared now. For example, the FM-1 focal planes are complete and the new, low-scatter near infrared optics are in house. The FM-1 radiative cooler is being assembled now and Weber expects it to be complete by June 1996. The mainframe will be complete in October 1996. (The PFM will fly on EOS AM-1 and the FM-1 will fly on EOS PM-1.)

Weber presented his list of top concerns (see Attachment 7). Cost and schedule continue to present significant challenges to SBRS. Also, recently there have been problems with some of the connectors, but those are mostly behind us. Several key people have left SBRS over the last year, and it costs time to find new people and bring them up to speed. Weber reported that the tests on the scan motor have been ongoing for 2 years now without any failures. It has been running at three speeds and the 60 rpm test set already exceeds the number of revolutions in the projected mission lifetime.

1.9 SBRS Status Report

Tom Pagano, of SBRS, showed the MODIS PFM integration and test schedule through completion and delivery of the instrument (see Attachment 8). He announced that SBRS now has a fully-functional MODIS; however, the subsystems are still not assembled. Remaining is the integration of the onboard calibrators, electronics modules assembly, and system tests.

Pagano stated that some major events took place on the PFM since the last MODIS Science Team Meeting. SBRS realigned the optical system, completed vibration testing and has almost finished integrating the onboard calibrators. Pagano proffered that the MODIS focal planes are the most sophisticated focal planes for radiometry ever built in the remote sensing industry. (There may be detectors with higher resolution, but not with the combined dynamic range and sensitivity.) SBRS is currently working on characterizing the bidirectional reflectance distribution function of the solar diffuser.

Salomonson asked if SBRS had determined the emissivity of the blackbody. Pagano answered that the blackbody emissivity is better than 0.992. The specification calls for 0.1K temperature uniformity and SBRS' test show a uniformity of better than 0.05K. Pagano stated that the blackbody performance is important for the infrared detectors because they will probably drift in orbit.

Pagano reported that the PFM signal-to-noise ratio meets specifications for all bands. However, the dynamic range is a concern for the near infrared detectors—their throughput is higher than spec and will affect the dynamic range. Additionally, there is concern for bands 1 and 2. SBRS is planning special tests next month to better characterize those bands.

Pagano reported that the PFM meets spec for radiometric accuracy, onboard blackbody and instrument internal temperature. He said that when the internal temperature is cold, radiometric accuracy degrades due to knowledge of center wavelength. He said that it is better to have a warm blackbody then a cold blackbody when the instrument is cold.

Registration of the optical system and coregistration of pixels look very good. Pixel alignment is 3 or 4 µm, and distortion is less than 0.1 percent. Pagano thinks SBRS will meet the goal for the visible and near infrared bands, but the infrared bands will be more challenging.

Pagano stated that the near field response of MODIS compares very favorably with that of SeaWiFS, CZCS, and AVHRR. MODIS has an intermediate field stop that reduces far field response over and beyond what its heritage sensors could do. Pagano stated that stray light analyses show that contamination dominates at level 400; however, MODIS must maintain a clean room condition at level 300.

1.10 SDST Status Reports

Ed Masuoka, SDST Leader, reported that the MODIS beta software delivery was made by the January 1996 deadline. He congratulated the team for meeting the schedule; as well as submitting code that meets ESDIS and MODIS software standards. Masuoka listed those team members who have delivered code and those with upcoming delivery deadlines (see Attachment 9). Focus has now shifted from integrating the software into the DAACs, to science integration—the code's ability to handle ancillary data is now a concern.

Masuoka told the Team that the deadline for submission of Version 1 code is January 1997. The goals for that submission are to have the science algorithms implemented according to plans given in the ATBDs. Also, the code must use ancillary and LUT (Look-up Table) data, and employ realistic resource usage, timing, and operations algorithms.

Masuoka stated that EOSDIS cost growth is a concern—it is currently $75 million over budget. Most of the extra cost is attributed to the cost of hardware for the "pull side"; i.e., robotics and storage media to support the user community. Masuoka hopes that better characterization of the "pull side" requirements will enable ESDIS to cut costs in areas where there will be lower demand. Also, SDST is working with ESDIS on ways to optimize MODIS code to improve its performance and lessen its processing requirements. Additionally, SDST is helping ESDIS test its ECS system using MODIS code.

<u>1.10.1 MODIS Software Overall Test Program</u>

Al Fleig, of SDST, stated that it is the Science Team's responsibility to test the science content of their code, as well as perform its implementation. He stressed that not all testing will be done by SDST; most will be done by the Science Team members themselves. When the code is delivered to the DAAC, SDST will make sure that it runs properly in the DAAC environment.

Fleig stated that SDST will write the software test plan, but it will need input from each Science Team member. The idea is to test all features of the science algorithms as an integrated process and as a total processing system.

Fleig proffered that the quality assurance (QA) effort after launch will consume 20 to 50 percent of each algorithms processing resource requirements. He said that the QA algorithms must available at launch, so development is needed now. Fleig recognized that the QA effort will tremendously impact funding, and reminded the Team that the MODIS QA Plan is due this fall.

Fleig reported that SDST has improved its synthetic data set. He hopes it will be of assistance to the Team. He ask the Science Team to let him know their synthetic data requirements.

1.11 MCST Status Reports

Bruce Guenther, MCST Leader, reported that Version 1 of the Level 1B software has been delivered, and Version 2 will be delivered in early 1997. The file specification was updated on April 8 and is now frozen. The new file specification for Version 2 is in progress and will be frozen in December 1996, which Guenther feel will remain until launch. (Refer to Attachment 10 for more details.)

Guenther stated that at the Calibration Working Group Meeting yesterday, discussion focused on the testing program as a primary concern. One issue was reflectance versus radiance calibration techniques. Guenther said that reflectance will be the most likely path taken.

Guenther told the Team that there will be some measurements taken in the scan cavity. Additionally, calibration accuracy will be improved by using lunar measurements on orbit. However, he stated that the previously-planned solar diffuser test will not be conducted.

1.12 Development of Algorithms and Strategies for Monitoring Chlorophyll and Primary Productivity in Coastal Ocean, Estuarine and Inland Water Ecosystems

Janet Campbell, a new Science Team member from the University of New Hampshire, presented an overview of her proposed research efforts (see Attachment 11). Her goal is to develop the scientific and statistical basis for monitoring algal pigments and primary productivity in coastal, estuarine, and inland ecosystems using satellite data and complementary surface measurements.

Campbell's primary research objective for MODIS is to establish a protocol for developing and validating regional or site-specific algorithms for estimating surface chlorophyll-a concentration and primary productivity while accounting for the optical variability of other water constituents. She hopes to demonstrate this protocol by developing chlorophyll and productivity algorithms for near-shore coastal ocean areas and for major estuaries and inland bodies of water in the northeastern United States.

1.13 Correction of Thin Cirrus Effects and Characterization of Cirrus Radiative Properties from EOS/MODIS Data

Bo-Cai Gao, a new MODIS Science Team member from the U.S. Naval Research Laboratory, stated that his proposed research includes thin cirrus detection and correction, radiative transfer modeling, and airplane contrail cirrus studies. Gao stated that his research on atmospheric corrections is primarily of interest to the MODIS Ocean and Land Discipline Groups.

Gao showed sample image data taken over Coffeyville, KS (see Attachment 12). He pointed out that in the 1.375-μm channel you see cirrus clouds and not surface features. MODIS will have the 1.375-μm channel for cirrus corrections. Gao proposes developing techniques for the operational removal of thin cirrus from MODIS data acquired over both ocean and land. He also proposes developing theoretical models to simulate radiative transfer properties of thin cirrus clouds, as well as contrail cirrus.

Gao told the Team that Congress recently authorized NASA to study aircraft contrails and their impact on atmospheric radiation. He feels that MODIS will have a better capability to detect contrails than GOES or AVHRR.

1.14 Radiative Transfer Based Synergistic MODIS/MISR Algorithm for the Estimation of Global LAI/FPAR

Ranga Myneni, of the University of Maryland, told the Team that he has been at GSFC doing research for the last 6.5 years. He showed a 1995 data plot of average normalized differential vegetation index (NDVI) anomaly as compared to biospheric carbon and sea surface temperature (see Attachment 13). Myneni stated that globally, there is some correlation between the three variables up until about 1990; afterwards, they do not appear as closely correlated. He hopes to perform more intensive calculations of these variables using MODIS data, rather than produce more data plots. Specifically, he said, he plans to derive leaf area index (LAI) and fraction of photosynthetic active radiation (FPAR) absorbed by green vegetation.

Myneni will then develop a look up table algorithm for estimating LAI and FPAR for a given MODIS scene. Ancillary data layers will include biome type, such as grasses and cereal crops, shrubs, broadleaf plants, needle forests, etc. His algorithm assumes that surface spectral BRDF will be given, and that illumination and viewing geometry will be defined.

1.15 Enhanced Land Cover and Land Cover Change Products

John Townshend, new MODIS Science Team member from the University of Maryland, stated that he is interested in land cover characterization and monitoring land cover change. He noted that the current MODIS land cover data set is based on multispectral and multitemporal data using a neural net approach. He proposes to enhance this product by making an at-launch product available using AVHRR data, and by creating additional planes of land cover characterizations depicting continuous fields all based on the AVHRR sensor’s data. Therefore, land cover change results will be available shortly after EOS AM-1 is launched, rather than during the second year after launch as was originally planned. (Please refer to Attachment 14 for more details.)

Specifically, Townshend plans to monitor land cover change, showing where the change occurs, and what sort(s) of change(s) it is, at a frequency of every 1 to 2 months. He expects his product to be relevant to local, regional, and global studies, particularly for users such as natural resource managers.

Townshend said that timeliness is a concern, as he will have a tight schedule in getting up to speed to produce at-launch products. He said that funding is also a concern; he asked when will resources arrive so that he can begin doing the work.

Regarding the MODIS instrument, Townshend is concerned that geometric registration and pointing knowledge be within spec.

1.16 A Global Land Surface Reflectance Product for use in MODIS Land Algorithms

New Science Team member Eric Vermote, also from the University of Maryland, presented an overview of his proposed land surface reflectance product to be used by the land algorithms (see Attachment 15). Vermote said his algorithm will be used for atmospheric corrections; in turn his products are heavily dependent upon the aerosol product.

Vermote stated that data processing and ECS (EOSDIS Core System) modeling are areas of concern. He is interested in seeing early end-to-end testing performed at the DAACs. Additionally, instrument performance and meeting specification are concerns.

1.17 University of Wisconsin's MODIS Synthetic Data Set

Paul Menzel told the Team that he would like to take advantage of MODIS' 36 spectral bands but there is currently no adequate data set. So, his team at the University of Wisconsin-Madison is working to simulate MODIS using MAS (MODIS Airborne Simulator) data. The purpose is produce a synthetic data set to facilitate and enhance MODIS algorithm development. Menzel explained that the synthetic data sets will be used for testing algorithms and strings of algorithms. He plans to use real data where possible and approximate the co-registration of MODIS. Output data will be Level 1B and geolocated, and will provide the best possible radiometric calibration.

Menzel listed the MODIS channels and their MAS equivalents, where applicable (see Attachment 16). Of the 36 channels, 22 are a decent match, 9 have no match, and 5 could match after performing a first order correction. He noted that MAS has no water vapor absorption channels, which is a problem.

Menzel explained that the synthetic data set is being put together as if the 50-m MAS footprint equals a 250-m MODIS nadir footprint. In the first quarter of 1996, a data set of clear sky over water scenes was produced. In the second quarter, cloudy scenes over water will be produced and in the third quarter, clear scenes with limb-corrected infrared data will be produced at true MODIS spatial resolution. Production in the fourth quarter is still to be determined.

1.18 Cloud Mask Update

Steve Ackerman, of the University of Wisconsin-Madison, presented an update on the MODIS Cloud Mask algorithm (see Attachment 17). He said the cloud mask will provide a confidence flag for each pixel indicating how certain the algorithm is that that pixel is clear. Ackerman stated that real time execution, computer storage (5.25 Gb per day), and comprehension are restrictions on currently impacting the cloud mask. The cloud mask confidence level is temperature dependent—the threshold is around 270K for the 13.7-μm channel.

Ackerman reported that inputs into the cloud mask were increased from 32 to 48 bits in order to include results from individual tests and provide better interpretation of results, as well as the requirement to go to a non-cloud obstruction bit and to have spare bits as contingency.

Ackerman told the Team that the development data sets being used for the Cloud Mask are global collocated GAC AVHRR and HIRS data, regional LAC AVHRR data, and regional MAS data.

Ackerman listed the following as outstanding problems in refining the MODIS Cloud Mask: ecosystem dependence, cloud shadows, polar cloud detection, defining "thin cirrus", aerosol flagging, sun glint, and infrared only techniques.

1.19 SDST Comments on Testing and Validation

Fleig told the Team that as it moves into the version 1 software delivery and test phase, emphasis will change from what it did for version 0. For version 0, the idea was to ensure that the data sets delivered to the DAACs worked. Also, version 0 code was designed to demonstrate understanding of the interfaces with the DAACs. Fleig stated that SDST did not try to test version 0 code thoroughly, it only wanted to ensure that it worked the way it was supposed to as a training and learning experience. (Refer to Attachment 18 for more details.)

On the other hand, version 1 code is a precursor to version 2, which will be the launch code. Version 1 will be much more important in terms of robustness and cross communication of processes. More testing will be done by SDST, which will provide more feedback to principal investigators on problems encountered. Additionally, Science Team members themselves will be expected to do more testing, which doesn't stop with delivery to SDST. Fleig said SDST plans to send the Science Team data sets that will stress their code in some ways. For instance, a data set will be provided in which each detector (there are 430 detectors on MODIS) is periodically labeled as a "bad detector". Algorithms will need to check for this label and decide what to do to compensate.

Fleig pointed out that MCST plans to flag "noisy" detectors. So, in another of its test data sets, SDST will label some detectors as noisy, to which the version 1 code will be expected to be able to respond. With bad and noisy detectors on MODIS, the plan is to calibrate the information that is received from MODIS and put out that value. In short, the algorithms will need to look at the metadata for each detector and see if any given detector is failed or noisy.

Moreover, as quality assurance (QA) flags are defined, SDST expects each algorithm to read them and figure out its own QA. Fleig said he is concerned that each process is thoroughly tested in version 1. He expects version 1 code to read real ancillary data. He wants to ensure that there are no surprises at launch. He pointed out that SDST is not staffed to do complete testing of anyone's algorithm, so each Science Team member will have to do his or her own testing. However, SDST will help however it can. For example, SDST will provide synthetic data sets for testing processing flow. Ki Yang, of SDST, will be the main contact if anyone is interested in obtaining a customized synthetic data set.

Ackerman asked if SDST plans to supply ancillary data readers. Fleig responded negatively because the task is too specific as to how it should be done for each algorithm and, therefore, it is better done by each Science Team member. Joe Glassy, of the University of Montana, stated that all Science Team members will need ancillary data readers, and suggested that a single person or group be designated to solve this problem for everyone.

1.19.1 Data Quality Assurance

Fleig said SDST expects each Science Team member to put QA indicators in each of their products, either at each pixel, or as metadata. Basically, the QA indicator should include a brief summary for pull side data users as to whether or not those data are useful.

1.20 Overview of MODIS Validation Plan

Robert Murphy, MODIS project scientist, proffered that all MODIS products must be validated. He reported that four non-integrated draft Validation Plans were submitted to the EOS Project Science Office in April 1996. He said there will be a partial integration of plans between MODIS and ASTER. MCST is accelerating development of its validation plan of Level 1B.

Murphy reminded the Team that there will be a MODIS Validation Workshop next week at which he hopes to get input as to how to write the integrated MODIS Validation Plan by the end of summer 1996. He proposed that MODIS prepare an Integrated Calibration/Validation Plan by that same date. Murphy showed a list of responsibilities for cal/val planning (see Attachment 19).

1.20.1 Atmosphere Group Validation Plans

King presented the Atmosphere Group's validation plan. Their strategy include field experiments for pre- and post-launch validation of their data products. These experiments will be coordinated with ground-based networks to optimize on available resources. King listed the campaigns, their responsible principal investigators, and the primary sensors to be used (see Attachment 20). The overall approach will be to collocate ground-based data with higher aircraft and satellite data.

1.20.2 Land Group Validation Plans

Chris Justice, Land Group Leader, stated that the Land Group's validation focus is to push *in situ* data measurements associated with EOS test sites. He noted that an in-depth article on EOS test sites will be published by Tim Suttles, of Hughes, *et al.*, in the next issue of *The Earth Observer*.

Justice stated that MODLAND's pre-launch validation activities will focus on radiative transfer models that compare satellite data to modeled outputs, compare simple parameterizations to complex models, and perform angular extrapolation and interpolation for BRDF. Additionally, field correlation measurements—such as LAI, FPAR, net primary productivity, surface temperature and emissivity, and BRDF—will be obtained at EOS test sites. Aircraft data will also be obtained for surface reflectance, vegetation indices, BRDF, snow and land cover, and fires. MODLAND plans to use existing satellite data, as well as data from future platforms like SeaWiFS, POLDER, SPOT Vegetation, and GLI.

MODLAND plans to use the EOS Validation Test Site Hierarchy with emphasis on 50 - 60 globally distributed test sites. Also, MODLAND plans to participate in international intensive field campaigns (see Attachment 21 for more details).

1.20.3 Calibration Group Validation Plans

Phil Slater, Calibration Group Leader, reported that he plans to use multiple calibration paths for MODIS, and suggests three dependent methods for validating vicarious calibration results. Once the vicarious calibration methods are validated, then they can be used to validate the onboard calibrators. He said there are three validation criteria to be met: 1) self-consistency of results over a given time, 2) agreement with predicted uncertainty budgets, and 3) agreement between the various vicarious calibration methods.

Slater is planning a joint field campaign involving representatives from MODIS, MISR, and ASTER. He plans to use Lunar Lake and Railroad Playa as the site at which to conduct this campaign to best facilitate comparison of top of the atmosphere (TOA) radiances.

1.20.4 MCST's Validation Plans

Guenther stated that MCST's task is to validate the Level 1B product, the baseline product of which is based upon calibration testing. He noted that MCST doesn't intend to use the solar diffuser or the SRCA autonomously right after launch. However, it needs to be prepared to update and improve the on-orbit performance of the baseline product. To address this need, MCST will create a test data set that will be distributed to selected principal investigators producing Level 2 products sensitive to the instrument's calibration. Then, before implementing the baseline product into an operational product, MCST will determine which test data sets infer or imply realistic sensor or scene physics. Then MCST will hold a workshop to evaluate and revise the baseline product. Guenther said MCST plans to work with Level 1B and all validated top-of-atmosphere (TOA) radiances or reflectances.

Guenther told the Team that MCST does not currently plan to participate in any field campaigns. (See Attachment 22 for more details.)

1.20.5 Level 2 Products for Calibration / Validation

Howard Gordon, Ocean Discipline Group member, stated that the Level 2 products can assist in and can constrain sensor calibration if their accuracy and sensitivity to calibration change is demonstrated by modeling and field measurements. (Refer to Attachment 23 for specific details.) The Ocean Group plans to look at water leaving radiance, which he believes will, at most, be about 10 percent of the TOA radiance over open ocean. He observed that water leaving radiance is extremely sensitive to sensor calibration and constrains it. For this reason, he plans to compare MODIS data to those of MOBY, the Marine Optical Buoy.

Gordon said he expects feedback from the Atmosphere Group on aerosol optical thickness over ocean scenes. He noted that looking at dense dark vegetation over land is also sensitive to sensor calibration, as is remote sensing of high altitude lakes. He said that the far field scatter problem is a concern.

1.20.6 Ocean Group Validation Plans

Wayne Esaias, Ocean Group leader, reported that the Ocean Group's validation approach was developed in 1990. The approach is consistent with that of SeaWiFS, consisting of visible, high precision continuing mooring system (MOBY). Additionally, ship initialization cruises will be made in selected waters shortly after launch to gather *in situ* data. Esaias presented the schedule for the group's validation activities and the planned validation sites (see Attachment 24). He pointed out that the group needs to add more activities to include the southern oceans.

1.20.7 General Validation Discussions

Robert Wolfe, of SDST, noted that geolocation validation was not discussed at all by the Team. He feels that this is a significant hole in the MODIS Validation Plan.

2.0 REMOTE SENSING OF PRIMARY PRODUCTIVITY OVER LAND AND OCEANS

Moderator: Y. Kaufman; **Panelists:** A. Huete, W. Esaias, S. Running, M. Behrenfeld, K. Arrigo, R. Myneni, and J. Campbell.

2.1 Overview

The primary objective of the session was to discuss and compare the methods for estimating primary productivity between the Land and Ocean Discipline Teams. Kaufman said the meeting is to provide a cross fertilization of ideas that may strengthen the model development. Attachment 25 outlines the structure of the session: 1) magnitude; 2) atmospheric correction; 3) time scales; 4 fluorescence; and 5) saturation. Esaias summarized the Ocean primary productivity products and model (Attachment 26).

2.2 Magnitude of Productivity

The magnitude of the productivity was difficult to define and was discussed primarily in terms of primary productivity. The groups emphasized methods to estimate primary productivity. There were several important differences noted between the Ocean and Land Groups. Esaias and others said estimating ocean productivity has problems associated with depth below surface of the productivity, rapid rates of consumption, and movement of production. Behrenfeld summarized ocean related science issues and discussed the ocean model development (Attachment 27). Huete and Nemani reported productivity over land is most difficult for forests and for below ground roots. Land scientists typically use a single efficiency parameter in their model to account for several environmental variations including light, nutrients, water, plant physiology, consumption, etc.

2.3 Atmospheric Correction

Currently the Land Group uses the blue band for atmospheric correction and the red and near-IR bands for model development. The Land Group is evaluating the use of vegetation indices that are less sensitive to atmospheric effects. The Ocean Group uses red and near-IR for correction and the blue and green bands for their model development. Kaufman reported the SW mid IR (1.3-4.0 mm) may be under utilized for atmospheric corrections, especially for analysis of aerosols.

2.4 Time Scales

The land versus ocean time scales are significantly different. Over land the targets are stationary and are estimated over a longer temporal period (e.g., vegetation growing season). Ocean productivity has significant movement and has a shorter time scale. In addition, consumption of productivity over a short time period is a significant problem when using remote sensing. Ocean productivity related models are used to approximate consumption and other factors such as depth. Nemani and Huete report land productivity is estimated using temporal composites with both empirical and ecosystem modeling.

2.5 Fluorescence

Abbot said fluorescence over oceans is an important part of ocean model development and is related to both productivity and stress. The Land Group indicated fluorescence is not used much over land for productivity. Previous research work has indicated surface temperature is a better indicator.

2.6 Saturation

Land has a significant saturation in the red band with changing vegetation density. Oceans have a similar problem in the blue band. The Land Group with the Atmosphere Group is investigating the use of other bands such as the SW mid-IR.

3.0 MODIS Data Quality Assurance Plan

Moderator: A. Fleig; **Panelists:** B. Guenther, P. Menzel, A. Strahler, B. Evans, D. Tanre, J. Townshend, B. Gao, and K. Strabala.

3.1 Introduction and Overview

Fleig opened the session with a suggested classification of QA and validation activities. He divided these activities into two groups: 1) Whatever will be done in-line with science software on a per-pixel basis and in metadata, both of which go into production software; and 2) Things that will be done after the product is generated—post-production analysis, or comparing your results to what you'd expect or to other sensors (truth data).

Fleig suggested that in order to plan for QA and validation needs, the Science Team members would need to address several issues:

- access to data (both instrument data and ancillary data),
- access to truth data,
- what sort of software will need to be written, and
- what sort of staff will be needed.

Fleig noted that this should be topic in the discipline group breakout meetings, and indicated that the a draft QA plan from MODIS should be drawn up by Sept. 1 in preparation for an EOS AM-1 QA meeting in October 1996.

3.2 QA Versus Validation

The panel took up the question of what is QA and what is validation. There was a good discussion and exchange of viewpoints. The general consensus was that QA done on all of the data during processing or reprocessing is integral to the production of the data products, and is an ongoing process. QA can be done at any time, either before or after products are released.

Validation is done on localized subsets on the data outside of the product generation environment, requiring outside support (e.g., a field campaign) and is an episodic process. Validation is more of an algorithm-level or product-level process. Validation data may be integrated into the QA process; if validation ("truth") data become available as a regular data stream, they may become an ancillary data source.

Guenther agreed that there is a need to be careful about changing definitions; but noted that the team will need to do QA and validation regardless of the definitions. He emphasized the need to make sure that QA is built into the process.

3.3 Direct Broadcast

Salomonson asked how direct broadcast data is handled. Guenther replied that direct broadcast will feed the Level 1B product; what comes to the ground is converted to radiances. They will carry one orbit's worth of QA for a given day on the WWW. In general, users of direct data will not have the benefit of QA done on the data. They will have general instrument performance information, but not DAAC-level QA.

3.4 Required Resources for QA

Fleig turned the discussion to resources needed to do QA. He suggested putting together a strawman set of requirements for moving data across the network, noting that the current network should be able to move 10 percent of the data. There was some discussion about whether 10 percent was a sufficient number, with Reber noting that people typically make initial requirements for large amounts of data, later discovering that what they asked for is more than they need or can handle. Strahler noted that network performance in general seems to be degrading as it becomes more congested, and suggested that it is important to get the networks in place as soon as possible.

It was suggested that putting staff at the DAACs to do QA would be an alternative to shipping data across the Net. Bob Lutz (ESDIS) noted that it is the responsibility of the SCFs to do Science QA; they would need to provide funding for any staff they want in place at the DAAC. ESDIS is planning to do non-science QA such as verifying file formats, attached metadata, etc.

3.5 Ancillary Data

The discussion turned to obtaining the ancillary data needed to do QA and produce the data products, especially from ASTER and MISR. Simon Hook outlined ASTER's QA strategy, carrying the QA information as an extra "band" for each telescope on the instrument. Lutz indicated that other instruments would be able to accommodate MODIS QA needs if the requests are made early enough.

Guenther discussed the need for planning for QA needs, and for developing a strategy for incorporating QA results from the TLCFs and SCFs back into the processing system, hopefully with support from the PGE staff.

Menzel noted that there is a suite of ancillary products that they assume will be accessed by or available through the DAAC, including NMC data sets. He noted that they also need access to these data at the TLCFs, and highlighted a need for a good data visualization system. MacIDAS was suggested as a possible visualization package.

3.6 Reprocessing Strategies

Townshend asked what the purpose of QA really was—a flag for users, or something that allows you to fix the data down the line. This led to a discussion of reprocessing strategies and requirements, including system loads and the impact reprocessing will have on downstream products. Fleig noted that early on, the team will be learning things about the instrument quickly, so it doesn't make sense to reprocess every time you learn to do something better. He noted that the planned hardware would be enough to process the data once and reprocess it twice; the amount of reprocessing desired will drive the cost of the system.

Justice noted that the TLCFs and SCFs would need sufficient capacity to run several different versions of the code, in order to make sure that it is running right. Vermote wondered how the DAACs were going to manage requests for reprocessing from 26-28 SCFs; Fleig suggested this be taken up in the discipline group meetings.

3.7 Future Considerations

Strahler noted that the revised ATBDs are due August 15, 1996, and suggested that this could impact the QA plans due on September 1. Fleig noted that the driver on this is the EOS-wide QA discussion in October. Guenther added that the need to have QA in the Version 2 software is also a major consideration.

It was recommended that MODIS develop a strawman QA position by June 1, including reprocessing requirements and addressing the impact of QA issues in one product on products that depend on it. It should also address data transfer issues. Experience from other teams should be taken into account, Lutz provided a reference to the MISR QA page on the WWW as an example.

3.8 Action Items

- Provide a strawman reprocessing scenario
- Produce a strawman set of goals for QA processing by June 1
- Generate a strawman top-down view of QA
- Need to connect QA to driving events
- Need to talk to folks about network plans and requirements.
- Have QA Plan in place by Sept. 1.

4.0 FOLLOW-ON MODIS SENSOR CONSIDERATIONS

Moderator: W. Barnes. **Panelists:** V. Salomonson, R. Taylor, P. Westmeyer, S. Neeck, W. Esaias, C. Justice, M. King, P. Slater, B. Guenther, R. Weber, R. Murphy, and S. Ungar.

4.1 Overview

Salomonson said NASA’s goal is to have science, not engineering solutions, drive new issues and sensors. He said there is a scientific need to provide long term data sets. NASA likely will join with NOAA for long term data issues. The main goal for a follow-on MODIS is to retain the existing capabilities and to live within the projected resources. Specifically, the plan is to get MODIS as close as possible to the box size, weight, and power of the NOAA AVHRR. Scolese said the space to ground data rate may be that of the present MODIS or greater. Scolese reported there are several unresolved issues. We need to plan for MODIS related requirements beyond the PM-1 platform. There needs to be a budget input for the next MODIS.

4.2 National Polar-orbiting Operational Environmental Satellite System

Stan Schneider of the Integrated Program Office (IPO) gave an overview of the National Polar-orbiting Operational Environmental Satellite System (NPOESS) (see Attachment 28). The primary goal of IPO is to provide a single national remote sensing capability. IPO is attempting to achieve cost savings through convergence of DoD and NOAA meteorological satellite programs and where appropriate incorporate technology from the NASA EOS program. The convergence should be in place by 2006 to 2008, giving NASA and MODIS people time for planning. NASA may or may not place a satellite sensor on NPOESS, depending on research issues and cost requirements. If NASA does add a sensor to NPOESS, NASA will provide copy(s) of the instrument for flight on the NPOESS platform at no unit cost to IPO.

Currently, IPO is developing an Integrated Operational Requirements Document (IORD-1) that establishes twelve system parameters and reflects seventy environmental data records (EDRs). An EDR is a product-level definition of a parameter. There will be critical parameters identified with a requirement that failure to meet would result in a system reassessment or termination. EOS investigators are reviewing the IORD to identify common measurements.

4.3 Trade Space Issues for Post AM-1 MODIS Missions

Paul Westmeyer (EOS-AM Project) presented a brief presentation on Trade Space Issues for Post AM-1 Instruments (Attachment 29). He said more processing will occur on the ground versus on the instrument. There will be smaller launch vehicles that will make packaging difficult. AM-2 will be more volume limited and not data limited. NASA plans to provide detailed performance specifications to the contractors to allow the contractor more freedom with the implementation approach.

4.4 Follow On MODIS Sensor Characteristics for EOS AM-2

Steve Neeck (EOS AM Project) presented a summary of the Follow-on MODIS activities (Attachment 30). He reported that there have been a number of options explored in the past year. The MODIS follow-on activities arose from Pre-Phase A studies to assist in planning and costing for EOS AM-2 options. Several concepts have been presented (see MODARCH for copies). There are several considerations about science requirements, risk, instrument approach, etc., that have to be evaluated. Neeck said we need to develop scenarios in the next 6 to 12 months for AM-2.

4.5 Micro-MODIS

Bill Barnes summarized an Orbital Sciences Corporation presentation on a Micro-MODIS given previously (April 3, 1996) to members of the MODIS Technical Team. Attachment 31 summarizes the Micro-MODIS design of 36 spectral bands in the visible and infrared regions using pushbroom technology. The instrument uses three separate Wide Field-of-View Imaging Spectrometers (VIS / NIR,SWIR and LWIR); each is modular with “reduced” size and weight . The field of view is 120 degrees. Barnes said MODIS asked OSC to review the MODIS specifications in reference to the proposed instrument and then return.

4.6 MODIS Light: Option for Low Risk EOS Cost Reduction

Carl Schueler (Santa Barbara Remote Sensing-SBRS) summarized the Hughes SBRS MODIS Light plans (Attachment 32). The MODIS Light removes some of the subsystems (e.g., SRCA and SDSM) but preserves the Optical Bench Assembly necessary to retain the MODIS spectroradiometry. The scan angle is reduced from +/-55º to +/-45º and the sensor is repackaged to reduce mass, volume and power. Schueler said MODIS Light maintains the 36 MODIS bands with the same IFOV's, spectral definitions, and SNR's, thereby minimizing impacts to MODIS processing algorithms.

4.7 MODIS Specifications

Barnes summarized the advanced MODIS specifications under development (Attachment 33). He plans to place these MODIS follow-on specifications onto the World Wide Web. Barnes said the MODIS team wants to insure data continuity by starting with present specifications. The attachment summarizes the reduced specifications from the current MODIS. Possible enhancements include the option of selecting new (different) bands by the science team and adding more 250 m spatial resolution bands.

5.0 TEMPORAL COMPOSITING PERIODS & SPATIAL GRIDS

Moderator: R. Wolfe; **Panelists:** A. Strahler, S. Running, A. Huete, P. Sellers, A. Fleig, B. Evans, D. Tanre, J. Townshend, B. Gao, and K. Strabala.

5.1 Introduction

The overheads used during this roundtable can be found as Attachment 34. Wolfe opened the session and indicated that he planned on separating the discussion into two separate parts—temporal and spatial, in each case starting with an overview, then moving to the panel discussion.

Wolfe noted that there are several considerations in selecting periods for temporal compositing, particularly

- the need for a short enough period to avoid masking changes over time,
- the need for a long enough period to,
    - minimize errors through multiple observations, and
    - handle missing observations due to cloud cover and orbit coverage patterns, and
- using similar time periods for all products to allow for intercomparisons.

5.2 "Data Day"

Wolfe also touched on the topic of a "data day", which is a method for handling data on scans which cross the International Date Line. In this scenario, on the orbit with the ascending (or descending) node closest to the date line, data points on scans which cross the date line are assigned to different "data days" depending on which side of the line they are on. This is the method used by SeaWiFS. Land and Atmospheres plan to go by UT at the time of the scan.

5.3 Compositing Period

Noting that typical compositing periods included 7 days, 10 days (3 periods per month), 30 days, quarterly, and annual, Wolfe opened the discussion of compositing periods to the panel. Fleig stated that having the compositing period makes sense with the observing period—a 16-day repeat cycle in MODIS' case—would be preferable. He was concerned that the varied observing geometry with an out-of-synch compositing period might introduce artifacts. He noted that the geometry almost repeats itself in 8 days, which would be a good approximation of a week.

There was some discussion of the historical reasons for 10- and 20-day periods. It was noted that using a similar compositing period for MODIS would make data comparisons with other data sets easier. Huete indicated that he felt that the science should drive compositing and gridding.

5.3.1 Resynchronizing Compositing Periods

Some time was spent discussing re-synching the compositing periods, so they would start on the first of the month, quarter, or year. It was generally agreed that re-synching on an annual basis is a good idea and is necessary; there was no strong consensus on synching on a monthly basis. It was noted that a 16-day composite would lend itself to a two-periods-per-month strategy; an 8-day cycle could either be four periods per month, with an abbreviated fourth period each month, or 45 periods per year, with a 5- or 6-day 46th cycle , re-synching annually. The latter strategy will be used by SeaWiFS.

Strabala noted that Atmospheres planned on producing 1-day, 10-day, and monthly products, and would come to a decision on that at the Atmospheres Discipline Group meeting the following day.

5.4 Spatial Gridding

Wolfe moved on to Spatial Gridding. He noted that all standard products will be produced in the Integerized Sinusoidal Grid for Beta. He reviewed the spatial resolutions to be used by each group with the panel, both for the daily products (Level 2) and for the Climate Modeling Products (Levels 3/4).

Fleig noted that IDS wants an equal-angle grid, regardless of what MODIS does internally. In the case where other grids are required, such as Lambert Azimuthal Equal-Area for the polar regions or Goodes Homolosine for some land applications, the data would need to be reprocessed into those grids. Tile formats and aggregation methods were discussed briefly; Wolfe then adjourned the session.

6.0 ATMOSPHERE DISCIPLINE GROUP MEETING

The Atmosphere Discipline Group Meeting was chaired by Michael King. Minutes of the meeting were taken by David Herring.

6.1 Data Products and Processes

Rich Hucek, of SDST, gave a status report on the MODIS software definition process. He showed a table listing the Atmosphere Group's data products and information on how they will be processed (see Attachment 35). Hucek also listed the CPU performance estimates (in megaflops) and volume estimates (in gigabytes per day) for each Atmosphere data product. He asked to group to verify that the information in the tables is correct. He told the group that the Atmosphere beta software was sent to an independent company for optimization and this company found that there weren't any simple solutions for optimizing it. The company recommended reducing the load by totally revising the algorithms. However, Hucek said that optimization activities are still ongoing within SDST.

There was some discussion regarding the relationship between MODLAND's and Atmosphere's need for ancillary data. Hucek feels that this relationship is unclear and stated that Robert Wolfe has not indicated a need for any special ancillary data for MODLAND. King asked Hucek to approach MODLAND to see of they want to collaborate on ancillary data.

Hucek questioned whether all Atmosphere processes should be routine. King said he still has questions on stability and lifted index, as well as temperature and moisture profiles. He views those products as being done for science purposes on local areas, not for global use. Hucek pointed out that several MODLAND developers want to use those profiles and if they are not to be produced routinely as standard products then MODLAND needs to know. He stressed that the Atmosphere Group needs to consider how it will handle files coming out of process number 7.

Regarding the Level 3 daily aerosol product, Hucek asked which temporal grid would be used. Discussion focused on using an 8-day versus a 10-day grid. Kaufman said he prefers an 8-day grid, but agreed that the grid should be consistent among all of the science disciplines. He feels this issue should be worked with the other disciplines.

Hucek reminded the Group that SDST plans to flag "noisy" data. He asked the Group how they plan to respond to the "noisy" data flag. Ackerman feels that it is ridiculous and CPU-intensive for everyone to check for noisy data in their algorithms. He feels that SDST should address this problem in a single algorithm.

Hucek showed the delivery schedules for Level 2 and Level 3 code. The only Level 2 code not already delivered is the "MOD_PRANC" process, or "Atmosphere Ancillary Data Preprocessing". It is due later this month. Additionally, the file specifications for all Level 3 code is also due at the end of this month. Level 3 software is due later this year.

King said he plans to address the Group's near- and long-term schedules and begin developing a template for its Quality Assurance Plan at the Atmosphere Group Meeting, tentatively scheduled for July 17 - 18. That meeting will be held at Chincoteague, VA, as many Atmosphere members will be attending the TARFOX campaign at that time.

6.2 CERES Cloud Algorithm Integration Process

Bryan Baum, of CERES, presented the CERES top level data flow diagram and discussed how his team integrates cloud property products with other CERES data products (see Attachment 36). Baum listed the components of the CERES version 1 algorithm for Subsystem 4, which includes cloud, convolution, inversion, and surface flux algorithms. The CERES team has developed a special toolkit for integrating all of its Subsystem 4 algorithms. He said an ATBD is available for Subsystem 4.

Baum stated that after running a 15-day test, he discovered that most problems in the CERES algorithms came from ill-conditioned trigonometric functions. In short, he said, more than 99 percent of the problems that he found in the CERES code came from bad arguments. Most of these problems have been solved and he is now obtaining much more consistency in his results.

6.3 Validation Opportunities in Australia

King introduced Merv Lynch, a remote sensing professor at the Curtin University of Technology in Perth, Australia. Currently, Lynch is a visiting scientist at the University of Wisconsin. Lynch discussed in detail the meteorological conditions and research facilities located around Perth and throughout southwestern Australia. He told the group that personnel and facilities are available there to support validation campaigns in the following areas: calibration, sea surface temperature, cloud masking, cirrus heights, atmospheric profiling, land surface temperature, and normalized differential vegetation index.

6.4 Announcements

King announced that revisions to all ATBDs are due to the EOS Project Science Office by Aug. 16, 1996.

King reported that Kaufman, Tanré, and he attended the recent International Aerosol Workshop. He felt that the workshop was an excellent forum for scientific presentations and discussions on remote sensing of aerosols and plans to coordinate a cloud workshop along similar lines next Spring.

6.5 Action Items

1. *Hucek:* pursue the ancillary data issue with MODLAND and determine if they wish to collaborate with the Atmosphere Group on ancillary data.
2. *Atmosphere Group*: Establish plans for handling files coming from process number 7.
3. *Science Team*: Determine the temporal resolution grid—8-day or 10-day?

7.0 OCEAN DISCIPLINE GROUP MEETING

The Oceans Discipline Group meeting was chaired by Wayne Esaias, and attended by Mark Abbott, Ken Carder, Howard Gordon, Frank Hoge, Ian Barton, Dennis Clark, (team members), and Peter Minett (representing Otis Brown), Maria Vernet, Barbara Putney, Gerry Goddin, and Locke Stuart. Esaias presented a strawman agenda (see Attachment 37).

7.1 Validation Plan

Carder felt that any validation plan should discuss field experiments and stray light. Gordon is concerned that stray light is being ignored. Esaias is also concerned about corrections -- more effort is needed. Spatial and optical variability validations are important. Hoge mentioned the need for airborne lidar. Gordon agreed that there is a need for shipborne lidar, to measure aerosols, plumes, dust: there is a need to build up a climatology to do atmospheric correction. Minnett mentioned a group at Los Alamos which wants to collaborate on lidar.

A draft plan was distributed (Attachment 37). The next steps in preparation were discussed. Water-leaving radiance needs to be reviewed. Surface validation off Hawaii, in the Mid-Atlantic bight, and off west coast of Africa should be discussed. Post-launch cruises need to be considered. Esaias showed a surface experiment schedule (Attachment 37). Esaias stressed the need for a focused MODIS field effort, to justify funds and bring other investigators into the action. Ship time budgetary concerns were discussed. There is a need to start now in developing a plan to reserve ships. Clark announced the likely availability of a Spanish Class 1 vessel. Carder stressed the importance of small regional cruises, which can furnish some seasonally sensitive data. Minnett suggested that interagency cruises need to be considered opportunistically. The Group addressed the possibility of ocean satellite launch delays; Carder thinks there are sufficient currently active satellites that cruise schedules should not be changed. Clark mentioned that there are plans for the MODIS Airborne Simulator to overfly MOBY. David Starr is interested in using Hawaii for validation studies in all three disciplines. Clark expressed concern over the cost for both ships and aircraft flights. Carder perceives a need to consider a site for stray light bright target characterization.

7.2 Instrument Scattering

Issues were presented by Esaias (Attachment 37). He illustrated how water detail is affected by near-field effects. Chlorophyll is substantially affected by far-field (dirty mirror). Barton wanted to know if it is possible to backward continue, to correct; Gordon thinks not. Esaias believes the effect needs to be known to 1 percent. The possibility of using SeaWiFS and MODIS, particularly in the near IR, to characterize the effect was discussed. Validation of Level 1 radiances is considered critical, and MCST is expected to provide adequate knowledge. Validation of Levels 2 & 3 is up to Oceans. Gordon mentioned a novel method for assessing scatter on-orbit: pointing close to the sun. Minnett wondered if the moon will do. Gordon proffered that the moon is not bright enough. Esaias characterized the scattering effect as serious, but tractable. Hoge wanted to assure that the MODIS follow-on will address scattering problems substantially, and in the early design phase.

7.3 Ocean Test Sites

Esaias presented his views on the role of, and what constitutes, an ocean test site. For calibration purposes the ocean is pretty well behaved. There is a need for extended operations in support of ocean color studies. Abbott included the Monterey Bay Mooring. Carder added Tampa Bay, and expressed a need to add sun photometers at test sites.

In response to a question from Campbell, Esaias presented his views on what constitutes a test site (Attachment 37). Esaias then showed his list of MODIS Ocean "Highlights". Gordon added open ocean whitecap reflectance measurements.

7.4 Next Meeting

The Group decided on 17-19 July, at Goddard. The NASA Satellite Ocean Primary Productivity Workshop (11-13 June) preliminary agenda was distributed; also a July meeting addressing MODIS PM was mentioned.

7.5 QA Plan

Any quality assurance plan has to deal with stray light. Gordon, Hoge, and Carder will work with Esaias on the plan.

7.6 Research Products

7.6.1 Phycoerythrin (Maria Vernet—Scripps Inst.)

Vernet discussed pigment types, and what can be done with remote sensing (Attachment 38). She showed spectral peaks. Cruise data off the California coast, featuring cyanobacteria, were presented. Further data were presented on extracted phycoerythrin, chlorophyll, seasonal variability, vertical variability, fluorescence properties, and absorption properties for the coastal waters of Antarctica, northern part of the Indian Ocean, and the coast of North America. Esaias wanted to know how long the surveys will continue. Vernet responded that she expects the surveys to continue on a seasonal basis for the next several years. Esaias mentioned the development of a formal relationship between Goddard and Scripps. The discussion was concluded with Esaias voicing concerns about the NASA aircraft moving to the west coast—there will be a mid-Atlantic problem, and the Ocean Team may have to depend on California data.

7.6.2 Thermal IR (Peter Minnett)

Minett described a combined sensor cruise from Samoa to New Guinea to Hawaii. The cruise objectives and instrument compliment was presented (Attachment 39). Minett described the impressive array of instruments, which may be unique. Long transect (Over 3000 km) skin and bulk temperature measurements were made, covering the area from 150 to 180 East. High resolution diurnal studies were conducted, and Minett showed preliminary results. Some discussion followed on the use of Coast Guard vessels. They can accommodate up to 30 scientists, but are very expensive. Vernet mentioned that NOAA ships cover a wide range as well. Minett mentioned that the Japanese are active in the W. Pacific. Minnett concluded by mentioning the need to engage ships of opportunity.

7.7 Follow-on MODIS

Minnett pointed out a need to change the mirror, so that the angle of incidence is constant, to remove polarization. Along with polarization, stray light is a concern. Band ratios have to be typical. It was perceived that there is a need to design a Follow-on MODIS that will be congruent with the New Millennium Program's advanced technology.

7.8 Action Items

1. *MCST*: provide adequate knowledge of Level 1 radiances.
2. *Ocean Discipline Group*: Provide Murphy with appropriate oceans program documentation, as a tutorial.
3. *Gordon, Hoge, and Carder*: work with Esaias on the quality assurance plan.

8.0 FINAL PLENARY SESSION

8.1 Quality Assurance Discussion Summary

Fleig proffered that the Team needs to generate a Quality Assurance (QA) Plan by September 1996 so that it can send representatives to the QA Workshop in October prepared to discuss an organized approach. Fleig has agreed to produce a draft document stating the purposes and objectives of the MODIS Quality Assurance Plan, as well as how QA will be used.

Fleig emphasized that the Team's version 1 software should check the QA flags of inputs, as well as generate QA flags in its outputs. Fleig stated that the September QA Plan will be congruent with the MODIS Validation Plan.

8.2 Temporal Compositing Periods and Spatial Grids

Wolfe reported that progress has been made toward establishing the temporal compositing periods for MODIS data—consensus was for an 8-day period. There was some question as to whether the Team should simply resynchronize at the beginning of each month, or each year. Wolfe announced that the majority of Team members favored resynchronizing each year. That way, data users can compare the same date periods for each year over a given region.

Esaias proffered that the Ocean Group favors the 8-day compositing grid, but it doesn't want the grid resynchronized ever. After a brief discussion, it was agreed that the issue is still not closed and requires further discussion. Wolfe asked the Science Team to let him know the final set of products to be produced in the 8-day grid; he needs to present that list to the SWAMP.

8.3 Follow-On MODIS Sensor Considerations
Barnes told the Team that there is a push to build a smaller, lighter version of MODIS for future missions. In scoping the new MODIS, he stated that emphasis will be on maintaining all of the requirements for the current MODIS. Barnes said he is putting together a specification for the follow-on MODIS sensor. This specification will include the same channels, radiometric requirements, and calibration requirements as the current MODIS; the difference will be in size and weight constraints.

8.4 Remote Sensing of Primary Productivity over Land and Oceans
Kaufman noted that the methods for remote sensing of primary productivity differ between the Land and Ocean Discipline Groups. He reported that discussions during this session focused on the magnitude of primary productivity and the methods for estimating it. The question was raised should the two groups try to homogenize their assumptions; and the answer was basically no because most of the attendees agreed that it is too early to homogenize. It was generally agreed that the groups should wait until after launch before attempting to homogenize.

Regarding temporal scales, oceanic primary productivity has a strong dependence on nutrient cycling, as well as the consumption rate by higher organisms. On land, obviously the vegetation doesn't move, so time dependence is much slower and it is possible to do composites. Composites are more challenging over oceans because of the current dynamics and the relatively short lifetimes of phytoplankton.

Also, fluorescence and saturation were discussed in this session. Kaufman observed that fluorescence saturates over land in the red channels, and over oceans it saturates in the blue channels.

8.5 Calibration Discipline Summary Statements
Phil Slater, Calibration Discipline Group leader, summarized discussions at the Calibration Working Group meeting (see Attachment 40). He stated that he is concerned about the truncated test and calibration schedule at SBRS. He suggested that they should endeavor to use any opportunities to study the long-term stability of MODIS in the pre-flight phase. He also feels that they should re-expand the thermal vacuum testing that was cut back to 15 days.

Slater said that MCST is concerned about thermal radiation contamination from the nadir aperture door, as well as the sun shade and spaceview port. He suggested that the effects, on the scan mirror and blackbody, from these possible contamination sources be simulated in thermal vacuum tests.

Slater recommended halting the work on the solar radiation test at SBRS due to inadequacy of the heliostat mirror.

He said there is a need to accurately determine the BRDF of the solar diffuser. He pointed out that this test was canceled at SBRS, but feels that there is still a need to characterize the solar diffuser. Slater requested that SBRS' measurements of BRDF be compared to those of other institutions.

Slater recommended that SBRS study the feasibility of measuring far-field stray light effects to validate a basis for determining Level 1B radiometric uncertainties. For the ocean color bands, Slater noted that Esaias' study shows that about 56 percent of "clear" ocean pixels will have a scene-dependent error greater than 1 percent. Slater suggested that MCST should study, in consultation with the Science Team, the provision of an estimate of the radiometric error for the Level 1B product.

Slater feels that SBRS should employ the SRCA more frequently during testing and calibration activities to check the long-term stability of the SRCA and MODIS as a whole. He said SBRS should also perform system-level tests of stray light when the SRCA is in use.

Slater announced the upcoming first joint vicarious calibration field campaign, to be conducted at Lunar Lake and Railroad Playa, Nevada, from May 30 to June 7. The purpose is to compare TOA radiances predicted by the various participating groups when measuring the same playa area at the same time. Up to three such estimates will be made each day to simulate the acquisition times of the AM-1 platform sensors at the solstices and equinoxes. MODIS, MISR, and ASTER calibration scientists will participate in the campaign.

8.6 Atmosphere Group Summary Statements

King reported that the Atmosphere Group discussed extensively the algorithm code delivery schedule and its Level 3 data products. He noted that some team members prefer an 8-day temporal composite whereas others prefer a 10-day composite.

He reminded the Team that the revised ATBD delivery deadline is August 1996.

The Atmosphere Group will hold its first independent splinter meeting July 17 - 18 to discuss near- and long-term schedules and templates for QA plans. The meeting will be held at Chincoteague, VA, because many of the group members will be there participating in the TARFOX campaign.

King briefly recounted Brian Baum's presentation on the CERES cloud algorithm integration process. He noted that one day of CERES data take three days to process. (Refer to Attachment 41 for more details of King's presentation.)

8.7 MOCEAN Summary Statements

Esaias briefly reported that there will be a MOCEAN Meeting July 17-19, at GSFC, in which the group will work on its QA Plan, validation schedule, product configuration, test data, and ATBD revisions. Additionally, there will be an Ocean Primary Productivity Workshop on June 11-13 at GSFC.
Esaias listed MOCEAN's requirements for the New Millennium Program (NMP) and MODIS "wannabes". They request a constant incidence angle on the scan mirror. Regarding scatter and relative calibration of the bright target response, they suggest writing the spec in terms of band ratios. They recommend trading polarization insensitivity with characterization and onboard monitoring. They advocate monitoring changes in the point spread function, as well as other scatter effects. The also encourage optimizing band sensor performance at ± 45° scan angle.

Esaias listed MOCEAN's upcoming validation campaigns (see Attachment 42).

8.8 MODLAND Summary Statements

Regarding its version 1 delivery schedule, Justice announced that MODLAND is on schedule and will meet its target delivery dates. He pointed out that MODLAND needs a version 1 end-to-end test to be conducted by ECS. He requested a report from ECS, or SDST, on how that test will be conducted.

Justice said MODLAND feels that geolocation is an issue that needs more MODIS-wide attention, particularly with respect to instrument performance, ATBD revisions, and MCST's validation plans.

He stated that MODLAND representatives will attend the upcoming EOS Cal/Val Meeting. The focus of that meeting will be on test sites and IDS interaction.

Justice reported that the Land Group's Level 2G code is under development. Currently, processing volumes and loads are being refined. A decision will need to be made soon as to whether to retain Level 2 or 2G data levels and to assess the impact on volumes and loads. He listed MODLAND's currently pending action items (see Attachment 43).

Justice called for a new reporting mechanism to be implemented for the MODIS Team which maximizes information flow while minimizing the management burden. He challenged the management to offer a proposal, to which the Team can then respond.

Justice proffered that as test data become available later this year there need to be mechanisms in place for data preparation and rapid response from the science discipline groups. Justice requested that a schedule for engineering test data generation be developed by MCST with an indication of what analyses will be performed and when the team can expect to receive the results from the various MCST analyses.

8.9 Team Leader Summary Statements

Salomonson said that the report from SBRS on MODIS' development was exciting and positive. He thanked SBRS and MODIS Project for their efforts. He noted that algorithm development is going well and that the beta and version 1 code delivery experience has been positive. He told the Team to expect challenges in data processing and storage requirements in the coming months.

Salomonson announced that the dates for the next MODIS Science Team Meeting are Oct. 9 - 11, 1996.