MODIS Science Team

Meeting Minutes

October 12 - 14, 1994

Prepared by Science Systems and Applications, Inc.

MODIS SCIENCE TEAM MEETING MINUTES
October 12 - 14, 1994

TABLE OF CONTENTS

MODIS SCIENCE TEAM MEETING MINUTES

October 12 - 14 1994

LIST OF ATTACHMENTS

Note: Below is a list of the handouts distributed at the MODIS Science Team Meeting. They are stored in MODARCH. If you have questions, contact David Herring at Code 920, NASA / GSFC, Greenbelt, MD 20771; call (301) 286-9515; or e-mail herring@ltpsun.gsfc.nasa.gov.

ATTACHMENTS

1. MODIS Science Team Meeting Agenda	David Herring
2. MODIS Software Implementation Review	Vince Salomonson
3. Ocean Color Remote Sensing with MODIS	Robert Frouin
4. EOS Mission Profile	Michael King
5. Earth Observing System Data & Information System (EOSDIS) Project Status	John Dalton
6. Science Operations Concepts for EOSDIS Part I - Data Products Resource Allocations	Steve Wharton
7. SDST Presentation	Ed Masuoka & Al Fleig
8. Brief Status Summary of MODIS Project	Dick Weber
9. MODIS Hardware Development Status	Tom Pagano
10. MODIS Optical and Electronic Effects Characterization	Bruce Guenther
11. Current Status of Global Imager (GLI)	Teruyuki Nakajima
12. VEGETATION Onboard SPOT 4: A Mission for Global Study of the Biosphere	Gilbert Saint
13. VEGETATION Preparatory Programme Call for Proposals	Gilbert Saint
14. Discriminating Clear Sky from Cloud with MODIS	Paul Menzel
15. Satellite Imagery Visualization System (SIVIS) Basic Functionality	Bryan Baum
16. MODIS Vegetation Indices	Alfredo Huete
17. Validation in the MODIS Atlantic Test Site	Frank Hoge

18. SCAR-C Preliminary Results	Yoram Kaufman
19. IR Tri-Spectral Cloud Phase Delineation	Kathy Strabala
20. Cirrus Cloud Properties and Detection	Kuo-Nan Liou
21. Detection and Correction of Thin Cirrus Effects Using the 1.375-µm MODIS Channel	Bo-Cai Gao & Yoram Kaufman
22. MODIS Level 3 Gridding: The ISSCP Grid	Robert Wolfe
23. MODIS Engineering Model Update	Jim Young
24. Lessons Learned from GOES 8	Jim Bremer
25. MODIS Flight Operations	Ed Knight
26. Total and Spectral Solar Irradiance	Ann Mecherikunnel
27. SRCA Status Update	Nianzang Che & Harry Montgomery
28. FPAR/LAI	Alfredo Huete
29. BRDF Algorithm Development	W. Wanner
30. BRDF/Albedo and DEM	Jan-Peter Muller
31. Land Cover Issues	Alan Strahler
32. EDC FY95 Activities	Dave Carneggie
33. MODARCH Status Report	Mike Heney
34. MCST Status Briefing	Bruce Guenther
35. CERES Status Report	Bryan Baum
36. The Earth Scan Laboratory of the Coastal Studies Institute	Oscar Huh
37. Calibration Working Group Report & Action Items	Phil Slater
38. Atmosphere Group Report	Yoram Kaufman
39. MODLAND Plenary Report	Chris Justice
40. MODIS Oceans Topics	Wayne Esaias

MODIS SCIENCE TEAM MEETING MINUTES

October 12 - 14, 1994

LIST OF ATTENDEES

The following persons attended the MODIS Science Team Meeting. Those flagged with "™" are MODIS Science Team Members.

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MODIS SCIENCE TEAM MEETING MINUTES

October 12 - 14, 1994

GLOSSARY OF ACRONYMS

ADEOS	Advanced Earth Observing Satellite
AGU	American Geophysical Union
AIRS	Atmospheric Infrared Sounder
APAR	Absorbed Photosynthetic Active Radiation
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
BCS	Blackbody Calibration Source
BOREAS	Boreal Ecosystem Atmospheric Study
BRDF	Bidirectional Reflection Distribution Function
CAR	Cloud Absorption Radiometer
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)
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	Defence 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
_PDR	Delta Preliminary Design Review
ECS	EOS Core System (part of EOSDIS)
Ecom	EOS Communications
EDC	EROS Data Center

EDOS	EOS Data and Operations System
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-2	ESA Remote Sensing Satellite
ESA	European Space Agency
ESTAR	Electronically Steered Thinned Array Radiometer
FIFE	First ISLSCP Field Experiment
FOV	Field of View
FTP	File Transfer Protocol
FY	Fiscal Year
GAC	Global Area Coverage
GCM	Global Climate Model; also General Circulation Model
GE	General Electric
GIFOV	ground instantaneous field-of-view
GLAS	Geostationary Operational Environmental Satellite
GSFC	Goddard Space Flight Center
GSOP	Ground System Operations
HAPEX	Hydrological-Atmospheric Pilot Experiment
HDF	Hierarchical Data Format
HIRS	High Resolution Infrared Radiation Sounder
HQ	Headquarters
HRIR	High Resolution Imaging Radiometer
HRPT	High Resolution Picture Transmission
HRV	High Resolution. Visible
I & T	Integration and Test
IDS	Interdisciplinary Science
IFOV	Instantaneous field-of-view
IGBP	International Geosphere-Biosphere Program
IPAR	Incident Photosynthetic Active Radiation
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
JPL	Jet Propulsion Laboratory
JRC	Joint Research Center
JUWOC	Japan-U.S. Working Group on Ocean Color
LAI	Leaf Area Index
LARS	Laboratory for Applications of Remote Sensing
LTER	Long-Term Ecological Research
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
NE_L	Net Effective Radiance Difference
NE_T	Net Effective Temperature Difference
NESDIS	National Environmental Satellite, Data, and Information Service
NIR	near-infrared
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NPP	Net Primary Productivity
NPS	National Park Service
NSF	National Science Foundation
OBC	On-Board Calibration
OCR	optical character recognition
OCTS	Ocean Color and Temperature Scanner
OSC	Orbital Sciences Corporation
OSTP	Office of Science and Technology Planning
PDR	Preliminary Design Review
PFM	Protoflight Model
PGS	Product Generation System
POLDER	Polarization and Directionality of Reflectances
QCAL	calibrated and quantized scaled radiance
RAI	Ressler Associates, Inc.
RDC	Research and Data Systems Corporation
RMS	Room Mean Squared
RSS	Root Sum Squared
SAR	Synthetic Aperture Radar
SBRC	Santa Barbara Research Center
SCAR	Smoke, Cloud, and Radiation Experiment
SCF	Scientific Computing Facility
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
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
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)
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
VAS	VISSR Atmospheric Sounder
VIRSR	Visible/Infrared Scanning Radiometer
VIS	visible
WAIS	Wide-Area Information Servers
WWW	Worldwide Web

MODIS Science Team Meeting
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1.0 DAY 1 PLENARY SESSION

1.1 Welcome and MODIS Overview

The MODIS Science Team Meeting was chaired and called to order by Vince Salomonson, Team Leader. Salomonson reported that EOS Project has received the results of the ATBD review, which he feels was a useful exercise.

Salomonson announced that the MODIS software implementation review is planned for next month (see Attachment 2). During the review, the phasing and readiness plans of data products will be examined; and resource requirements continue to be a challenge. Also, the development status of external interfaces—such as data dependencies, toolkits, network requirements, etc.—will be reviewed, as well as test and quality assurance plans, plans for receiving and integrating team members' software into the Team Leader Computing Facility, and plans for integration into EOSDIS.

1.1.1 Concern Over SBRC Reorganization

Salomonson stated that the MODIS Team is very concerned that the Santa Barbara Research Center (SBRC) reorganization may negatively impact MODIS development. Hughes is relocating SBRC facilities and personnel to their El Segundo facility near Los Angeles Airport. Specifically, the MODIS Team fears that certain vital SBRC personnel working on the MODIS project may decide not to relocate, which could possibly put development behind schedule. Salomonson drew up a letter (see Attachment 2), which will be sent to the CEO of Hughes, expressing the Science Team's concerns.

1.2 Headquarters Perspective

Diane Wickland, MODIS co-program scientist, reported that there has been a third NASA HQ reorganization in as many years. The Science Division director is Dr. Robert Harriss. In that division, the Atmosphere Branch Head is Bob Shiffer, the Oceans / Solid Earth Branch Head is Miriam Baltuck, and Tony Janetos is the Head of the Global Modeling and Ecology Branch. Wickland stated that the goal at HQ is to integrate interdisciplinary science with research and analysis.

1.2.1 New MODIS Co-Program Scientist

Salomonson introduced Dr. Robert Frouin, the new MODIS co-program scientist replacing Frank Muller-Karger. Frouin discussed briefly some concerns he perceives for ocean color remote sensing. For example, he said the optical properties of absorbing aerosols are not known, so they are hard to correct for. Also, there are currently no algorithms with which to correct for stratospheric aerosols. Frouin recommends that atmosphere correction experts over land and oceans should work together in producing MODIS' atmosphere correction algorithm (see Attachment 3).

1.3 EOS Project Science Report

Michael King, EOS Senior Project Scientist, gave an overview of the rebaselined EOS mission profile (see Attachment 4). King noted that there will be much greater reliance to place EOS instruments on flights of opportunity in the future. For example, largely as a result of Mark Abbott's and Chuck McClain's efforts, EOS Color is being considered to fly on Landsat. Schedules for the altimeter missions are still not clear.

1.3.1 EOS Science Budget

King briefly discussed the EOS science budget, which is projected to reduce due to rescopes and rebaselines. He reported that science funding is no longer rigidly earmarked for its particular Unique Project Number (UPN). Principal investigators may now allocate funding as they deem appropriate for algorithm development, science computing facilities, and scientific research. They must, however, continue to report funding disbursements in their regular (533Q) financial reports.

1.3.2 ATBD Revisions

King reminded the Science Team that the deadline for submission of revised ATBDs is Nov. 1, 1994. ATBDs must be submitted to the EOS Project Science Office electronically for HTML (Hypertext Mark-up Language) mark-up and inclusion in the World Wide Web (WWW). Authors should also make their ATBDs available for anonymous FTP (File Transfer Protocol) from their respective computers.

1.3.3 EOS Project Science Office Updates

King reported that the EOS Interdisciplinary Working Group (IWG) e-mail distribution lists are available for use and include iwg-atmospheres, iwg-biogeochem, iwg-climate_and_hydrology, iwg-data_quality, iwg-eosdis, iwg-land, iwg-sec, iwg-management, iwg-mission_design, iwg-swamp, iwg-modeling, iwg-oceans, iwg-payload, iwg, and iwg-cryo_working_group. To distribute a message to one of these lists, enter one of these names in the TO: field of your message; e.g., *iwg-atmospheres*@ltpsun.gsfc.nasa.gov.

King announced that an updated EOS Directory has been printed and will be distributed soon. The EOS Educator's Package is in the final stages of review and will be distributed in late October. The EOS Poster series is also being reviewed and will be distributed in late November. The EOS Science Strategy Document was recently printed by the American Institute of Physics.

1.4 EOSDIS Status Report

John Dalton, ESDIS Project Manager, delivered a status report on ESDIS (Earth Science Data and Information System) (see Attachment 5). The EOSDIS Core System (ECS) design review was held in June. The second release of the PGS (Product Generation System) Toolkit was delivered to investigator teams.

Dalton reported that the EOS Data and Operations System (EDOS) contract was awarded to TRW. The EOS Communications (Ecom), which will form communications links between DAACs (Distributed Active Archive Centers) is being developed in-house by contractors. The Preliminary Design Review is scheduled for January 1995.

Dalton stated that beta delivery of software will be 2 years before launch, so that there will be an early warning if there are any problems. Salomonson asked if there are any worries regarding MODIS beta software development. Dalton responded that he currently has no concerns.

Regarding Independent Verification and Validation (IV&V), Dalton announced that the contract was awarded to Intermetrics in June. Intermetrics is examining and evaluating Version 0 against the IV&V functional requirements. Dalton noted that ESDIS has decided to eliminate 24-hour turnaround in the production of data products. He said there were never any clear requirements for quick-look data. If the MODIS Team needs quick-look data, as well as health and safety data on the instrument, we can still rely on direct readout.

Regarding storage and processing requirements, Dalton stated that ESDIS is relying on team member estimates. Dalton stated that soon a cost estimate for ECS will be made and then resource bounds for instruments and data products must be established. The objective is to put together a decision flow so that EOSDIS will know when to lock down at-launch data products. Salomonson emphasized to the Team the importance of providing information on their processing needs to EOSDIS in a timely manner. He stated that allocating processing and storage for data products will take careful orchestration of EOSDIS' resources.

Esaias asked if these allocations apply only to the ECS and not the TLCF. Salomonson responded that if the EOSDIS allotment doesn't satisfy team members' processing needs, then we will try to in the TLCF. Dalton stated that even if the data products are produced in the TLCF, they will still need to go into ESDIS and will still take up resources. It was generally agreed that this issue needs further discussion.

Jan-Peter Muller stated that currently, data processing and storage is center-specific. He asked what plans ESDIS has to ensure that there will be more capabilities to combine searches. Dalton responded that ESDIS doesn't currently have specific plans for implementing query commands for complex sensor searches where users want to look at data in a particular range—such as cloud-free data.

1.4.1 Data Products Resource Allocation

Dalton introduced Steve Wharton, EOSDIS Project Scientist, to present the science operations concepts for EOSDIS (see Attachment 6). Wharton reported that all data interdependency information has been submitted to EOSDIS and the system is being modeled by Hughes. He said Hughes will have a preliminary understanding of the system's cost by Nov. 15. Wharton stated that EOSDIS needs to introduce evaluation criteria for reducing the complexity and operational cost of standard data products. Then, resource allocations can be made and requirements can be managed within that capacity. He proposed that allocations be revisited on an annual basis because there will be changes in requirements and technology. (Here, Wharton's presentation has been glossed over because he provided such a detailed summary in Attachment 6. Please refer to it for more details.)

1.5 SDST Status Report

Ed Masuoka, MODIS Science Data Support Team leader, announced that SDST has a new supporting contractor—GSC/SAIC. (See Attachment 7.)

Masuoka told the Team that they must eliminate any TBDs on their lists of data product processing allocations because Hughes is now determining EOSDIS' processing requirements and TBDs will be counted as zeros. Matt Schwaller, of Hughes, stated that he needs to know the Team Members' requirements for external data products. Specifically, he needs a file name on a server or archive. Masuoka reported the estimates for MODIS processing and storage requirements; the current estimates are 3.5 GFLOPS and 490 GB, respectively.

Masuoka introduced Robert Lutz as the quality assurance manager for MODIS data products. He stated that there is a need to develop a quality assurance plan for MODIS products in order to revise the MODIS data management plan in early November. In early December, Dixon Butler will conduct a software readiness review. The half-day review will focus more on status than on algorithms, science, or software design.

1.5.1 MODIS Simulation Data Workshop Summary

Al Fleig summarized the Simulation Data Workshop at Flathead Lake, MT. The purpose of the meeting was to discuss data to be used to test the MODIS processing algorithms. Fleig said all MODIS groups were well-represented. At that meeting it was generally agreed to conduct two types of tests: tests for the scientific validation of algorithms and tests to ensure that the code is functioning correctly. Fleig stated that global testing will be a problem. SDST plans to use the SeaWiFS global data set to test MODIS' algorithms.

Fleig told the Team that SDST will develop a MODIS Validation Plan. Soon, SDST will distribute a strawman among the Science Team and they will fill in details wherever necessary. SDST needs to know from the Team how they should validate the algorithms before launch and what kind(s) of test data they will need.

1.5.2 Beta Software Delivery

Masuoka reported that while the January 1994 beta software delivery consisted of one delivery of heritage code from each of the MODIS software developers, the second beta delivery which began in October 1994 will consist of software to produce every science product. By June 1995, SDST hopes to have fully integrated MODIS beta software undergoing testing in preparation for the January 1996 beta delivery to EOSDIS. He asked team members to provide SDST with flow diagrams showing their actual models and interdependencies. Specifically, SDST needs to understand what code will be encapsulated and where.

Masuoka announced that SDST now has a library for reading and writing scan cube data, which will be sent to each Science Team member's software development team later this month. The scan cube was put together by Tom Goff and Virginia Kalb.

Masuoka noted that the MODIS scan cube data structure can be complex to handle due to differences in spatial resolution between bands and a commandable number of Science and Calibration frames. SDST also developed a utility library to simplify input/output with the scan cube.

Masuoka stated that the libraries were produced in an Oceans Group format; he hopes Land and Atmospheres will also be able to use it. The utilities are written in C—SDST will need to develop a wrapper for team members submitting code in FORTRAN 77 or FORTRAN 90.

1.5.3 MODIS Gridding

Masuoka reported that SDST, based on recommendations from Robert Wolfe, has decided to use the ISCCP (International Satellite Cloud Climatology Program) grid for MODIS. MODIS' grid will be an 18-km grid for producing MODIS Level 3 products. Finer resolutions down to 250 m will be nested within each 18-km cell. Tools for converting this nested ISSCP grid to user desired projections will be developed by MODIS or ESDIS and run at a DAAC or end user site to produce the desired research product.

1.5.4 DAAC Activities with SDST

Masuoka said the Goddard DAAC is considering distributing MODIS Airborne Simulator (MAS) data, which would save SDST some work. The EDC DAAC will soon establish an Asynchronous Transfer Mode (ATM) link from the TLCF to EDC to provide access to global AVHRR data at 1 km.

1.6 MODIS Project Report

Richard Weber, MODIS Project Manager, reported that SBRC will have the MODIS Engineering Model (EM) built in 2 months. The beryllium mainfram survived vibration testing with no problem. EM system-level tests will continue from January 1995 to March 1995. (Refer to Attachment 8 for more details.)

Weber announced that Lee Tessmer has replaced Lloyd Candell as program manager at SBRC. Weber attended SBRC's 2-day Quarterly Management Review in September. Hughes is creating Hughes Aerospace & Electronics Company (HAEC); SBRC will be closed and personnel relocated to the facility in El Segundo, CA. He reported that the Hughes reorganization, scheduled to take place within the next 18 months, will probably put MODIS development at some risk. In the long-term, the reorganization should improve the cost structure, but in the short-term it could have a negative impact on cost and schedule. Some of the key SBRC MODIS team members may refuse to move to Los Angeles.

Weber stated that in terms of mass, power, and data rates, SBRC is well within specifications. Both the EM and the Protoflight Model are on schedule for delivery. The radiative cooler has been tested, and it performed excellently. NASA GSFC has authorized SBRC to begin working on flight model 2 for the EOS AM-2 mission.

Weber said stray light—scattered light off of the mirrors, contamination, spectral band registration, and detector crosstalk—is still a concern. He noted that SBRC wanted to develop some new detectors, but the costs could not be borne. Long-term tests on the current detectors are underway. A number of old concerns have been eliminated. For example, the ghosting fixes will be implemented on the protoflight model; Weber would also like to implement the fixes on the EM.

Weber reported that GSFC has been an active participant in the development of MODIS and has conducted work parallel to SBRC. He listed some of the areas of effort and presented a list of his top concerns.

Chris Justice, MODIS Land Group Leader, said he is very concerned about the impact the move will have on development. He is concerned that continuity and quality may suffer. Tom Pagano, SBRC, assured the Team that everyone on the MODIS Team at SBRC will be offered a job at the El Segundo facility. He pointed out that Hughes management is sensitive to the personnel on the MODIS Team who need to be preserved. Justice asked Pagano if he feels that a letter of concern from the MODIS Team to Hughes management would be appropriate. Pagano responded that a letter would be very helpful; such a letter should be carbon copied to Lee Tessmer. Salomonson took it as an action item to produce the letter and make it available for signature by the MODIS Science Team.

1.6.1 MODIS Hardware Development Status

Pagano began the SBRC presentation by emphasizing that although the Hughes reorganization was a surprise and is a concern, MODIS will remain intact and will be properly moved. He feels that most of the MODIS personnel will move to El Segundo—including himself.

Pagano reported that most MODIS subassemblies are complete, and are being integrated and tested (see Attachment 9). The afocal telescope assembly is complete and the entire optical bench is assembled. The onboard calibration blackbody hand polishing is complete; the next step is anodization. Pagano said SBRC had a problem earlier when they heated the blackbody to 380K and some of its panels cracked (the anodization was too thick).

Pagano reported that the detector responses look good for the EM; additional data will be available in January 1995. SBRC received the prototype filters for the VIS and NIR bands and in during analysis discovered some discrepancies in edge ranges and bandwidths of those filters. They asked NASA to relax the specifications for those filters. The MODIS Science Team will likely agree to relax the specs, but Ed Knight, of MCST, stated that MCST plans to conduct further study on Bands 13, 14, and 19 before making a decision.

Pagano showed an SBRC-produced video on the EM assembly.

1.7 MCST Status Report

Bruce Guenther, MCST Leader, announced that MCST presented its Calibration ATBD scenario yesterday and received positive feedback. He discussed MCST's and SBRC's efforts to characterize the scattering / diffraction, ghosting, and optical and electronic crosstalk on MODIS, which could potentially limit radiometric accuracy in mixed scenes. SBRC is devising a strategy which includes design changes for the protoflight model (PFM) and detailed modeling of optical effects such as ghosting. MCST is producing an end-to-end high fidelity model. (See Attachment 10.)

Guenther explained that MCST must first characterize MODIS and then propose software corrections, if necessary. The matter requires further study, but if software corrections are necessary, then MCST will present recommendations to the Science Team for approval. Guenther stated that MCST will also perform qualitative comparisons of the optical and electronic artifacts within MODIS with those of its heritage instruments.

1.8 Global Imager Overview

Teruyuki Nakajima, of Japan's National Space Development Agency, presented an overview of the Global Imager (GLI) (Attachment 11). Nakajima stated that GLI is a MODIS-like spectroradiometer, and is an extension of the EOS Ocean Color sensor. GLI has 34 channels, in different locations than MODIS', ranging from 0.380 µm to 11.95 µm. Fabrication of the GLI engineering model will begin soon. GLI is designed for a minimum life span of 3 years, but will fly with 5 years worth of fuel. It will fly in a sun-synchronous orbit at an altitude of 800 km, and an inclination of 98.62 degrees. GLI uses a whisk-broom scan mirror with a viewing swath width of 1600 km.

Nakajima stated that the science objectives of GLI are to help scientists gain a better understanding of global energy and water circulation, the global carbon cycle and biomass production, and to observe global change.

1.9 SPOT VEGETATION (VEGN) Overview

Gilbert Saint, SPOT Program Scientist, presented an overview of SPOT VEGN (Attachment 12). Saint said the main mission objective of VEGN is to observe and measure surface parameters in order to describe spatial and temporal distributions of radiative properties. Another objective is to monitor vegetation resources—agriculture, forests, and grasslands—globally. Also, VEGN will measure biosphere processes to help scientists understand and model ecosystems. Specifically, the SPOT team is interested in the effects of human activities on biospheric processes, as well as biospheric interactions with the atmosphere. (See Attachment 13 for additional details on the SPOT VEGN instrument.)

Saint reported that the mission requirements are to provide a long-term data set with high site revisit capaibilities. VEGN will have a wide field of view and zoom capability. The instrument will have four channels ranging from 0.43 µm to 1.75 µm. VEGN will have a spatial resolution of 1 km at nadir and can view off-nadir up to 50°. Data will be transmitted to ground receiving stations at L band, S band, and X band.

Jan-Peter Muller asked if there are any plans for SPOT VEGN to generate a Digital Elevation Model (DEM). Saint responded that VEGN doesn't need a highly accurate DEM due to the stability of the platform.

1.10 Cloud Mask Discussion

Paul Menzel led a discussion on the development of the cloud mask algorithm, on which he is working closely with Bryan Baum and the CERES Team. He noted that his presentation is only a modification of the one he presented at the last Science Team Meeting. He presented his definition of a cloud mask (see Attachment 14), which remains the same, except that he omitted reference to aerosol product generation, as was suggested by the ATBD review panel. Menzel showed the MODIS channels that will be used to generate the cloud mask.

Menzel reported that the outputs for the mask have evolved—there will be a 32-bit word for each field of view. He said the infrared threshold of the mask has two problems: it must calculate surface emissivity over land and it must perform moisture corrections. Menzel feels that MODIS will perform so well that it can quantitatively describe the field of view.

To validate the cloud mask, Menzel is planning two ER-2 campaigns using the MODIS Airborne Simulator (MAS). There will be a winter deployment over the Great Lakes / Hudson Bay areas during which image data will be taken over areas of sea and lake ice. There will also be a summer deployment over ocean, mountains, and the desert in the Gulf of Mexico region. Menzel cautioned that the cloud mask will not make everyone happy; he wants the Team to make sure they understand *why* it doesn't make them happy so that they can correct for it in their algorithms.

1.10.1 Satellite Imagery Visualization System (SIVIS) Basic Functionality

Bryan Baum, CERES Team Member, presented an overview of SIVIS, a validation software tool for cloud algorithm development (Attachment 15). Baum stated that he is working with many teams on the problems of visualization of cloud data. SIVIS allows imagery from up to three different channels to be overlaid in 24-bit color. Among its features, SIVIS provides image processing and mophological functions, spatial coherence information, brightness temperature differences, temperature and humidity profiles, and cloud classification and masking modules.

Baum stated that the MODIS / CERES cloud mask will borrow heavily from the International Satellite Cloud Climatology Project (ISCCP), CLAVR (Clouds from AVHRR), SERCAA (Support of Environmental Requirements for Cloud Analysis and Archive), and the University of Wisconsin's global cirrus climatology efforts. MAS, AVHRR, HIRS, Landsat, and GOES-8 data sets will be used in developing the cloud mask.

1.11 MODIS Vegetation Indices

Alfredo Huete reported on the development of MODIS vegetation indices (see Attachment 16). The Group's global objective is to monitor the Earth's photosynthetic

vegetation (phenologic and interannual), to make precise and consistent spatial and temporal comparisons of vegetation conditions, and to detect change. The global vegetation index will be biome independent.

According to Huete, the biophysical objective is to measure leaf area indices (LAI) and the fraction of absorbed photosynthetically active radiation (FPAR). Huete reported that Chris Justice and he have developed Level 2 and Level 3 algorithms. Their validation approach will be similar to those used by MAS, ASAS, TM, SeaWiFS, and AVHRR. Initially, they will establish and characterize the relationships between the vegetation indices and physical parameters, they will use data from precursor sensors to test their algorithm, and they will use test site to gather test data. Huete and Justice plan to participate in a number of upcoming field campaigns, including BOREAS, SCAR, and LAMBADA.

Huete said two indices are planned for development—NDVI and MNDVI (MODIS normalized difference vegetation index). MNDVI will include soil and atmospheric corrections.

1.12 Validation in the MODIS Atlantic Test Site (MATS)

Frank Hoge offered to lead or participate in MODIS validation efforts. He cited his background experience of conducting ship and aircraft operations in the Atlantic Test Site for the past 17 years. He noted that the first MODIS validation product doesn't require a ship, but if access to one is provided, he would certainly use it. Hoge suggested using an airborne laser to validate data on chromophoric dissolved organic matter (CDOM). (Refer to Attachment 17 for more details.)

1.13 Ocean Productivity

Wayne Esaias, MODIS Ocean Group Leader, presented his work in developing the MODIS ocean productivity algorithm. He stated that error analysis for ocean productivity algorithms is difficult. He plans to have ready at launch annual empirical types of algorithms. He plans to use SeaWiFS data to help resolve differences in analytic approaches to compute daily productivity at any given pixel size.

Mark Abbott reported on his efforts to produce the MODIS primary productivity algorithm. He said that estimating primary productivity depends upon the scale of the map to be produced. Abbott's objective is to develop an algorithm for deriving the photoadaptive state of phytoplankton. He explained that phytoplankton absorb incoming solar radiation and convert it into heat or carbon, or re-emit it as fluorescence. These processes depend upon the spectrum of light, the efficiency of the light-energy delivery, and the speed at which the light moves through the system. Ultimately, Abbott wants to use the variability of fluorescence to learn about phytoplankton's photoadaptive state.

Abbott's algorithm has two sources of error—analytic error and sampling error, which is the dominant source of error. He plans to use drifter buoys to gather test data. These

buoys will have spectroradiometers onboard looking downward to measure upwelling radiance. (No attachments were provided for Esaias' and Abbott's presentations.)

1.14 Day 1 Plenary Closing Statements

Salomonson brought the day 1 Plenary Session to a close. On day 2, the group divided into four Discipline Group sessions: Atmosphere, Calibration, Land, and Ocean. Salomonson instructed the Groups to focus part of their discussions on ATBD revision, interdependencies of data products, and data software delivery.

2.0 ATMOSPHERE DISCIPLINE GROUP

The Atmosphere Discipline Group meeting was called to order at 10:30 am. Michael King requested that Yoram Kaufman preside. Present were Paul Menzel, Bo-Cai Gao, Piers Sellers, Didier Tanré, Bryan Baum, Kathy Strabala, Robert Wolfe, Kuo-Nan Liou, Si-Chee Tsay, Menghua Wang, Teruyuki Nakajima, Irina Mel'nikova, and Steve Platnick. Portions of the meeting were attended by Diane Wickland and Al Fleig. The minutes were recorded by Michael Heney and David Shirey.

2.1 Introduction and ATBD Review

2.1.1 Aerosol ATBD

Yoram Kaufman led off with the Aerosol ATBD. Overall, the ATBD received an "A". A general comment was made by the reviewers concerning remote sensing and atmospheric correction over the ocean. Kaufman suggested that retrieval of aerosol over the ocean and foam reflection may need to be addressed. He stated that there were no major concerns due to the review process in the short term.

In the long term, he expressed concern about the non-existence of an aerosol climatology. He stated that there did not seem to be much work being done in combining satellite and aircraft observations on a large scale. There is a need for stabilization in the ground-based aerosol data collection network—many people are buying instruments, data network access and network costs will be an increasingly important question.

2.1.2 Water Vapor ATBDs

Bo-Cai Gao followed with comments on the Water Vapor algorithm. This is a simpler algorithm, with no big holes in it. There is still a need to work on improving agreement with microwave data.

Michael King discussed his meeting with NIST regarding their calibration facilities and capabilities. Their instrumentation includes a shadowband radiometer and a Brewer ozone spectrometer. They are doing aerosol measurements from their rooftop in Gaithersburg. Ambler Thompson is the contact person at NIST.

Teruyuki Nakajima discussed the network of aureole sensors in place in Japan. They now have more than 1/2 year's data from continuous observation, which includes yellow sand dust from the Chinese mainland. They have their own data network under development.

Also, aureole inversion code version 2 is about completed, and will be coming out soon. This code incorporates a new inversion technique, with a result that the aerosol distribution becomes more realistic.

Menzel suggested that the water vapor product should combine both the near-IR and IR algorithms. It was agreed at the outset that this is a good idea, but that there are difficulties because the algorithms and resulting products are different. The ensuing discussion focused on the individual strengths of each algorithm, the differences between them which would make integration difficult, and the question of correspondence between the results of the two algorithms. Another consideration was the status of Menzel's work as a research ATBD, versus Kaufman/Gao's as a production ATBD. Updating the Kaufman/Gao ATBD might have more of an impact on data processing in other areas. The discussion concluded with an agreement that water vapor products should be available in one place, and accepted Kaufman's suggestion that Gao send one or two pages from the NIR Water Vapor ATBD to Menzel for incorporation into Menzel's Atmospheric Profiles ATBD in order to accomplish this goal.

Al Fleig brought up a point concerning algorithms ready "at-launch" versus "phased implementation" over the course of the first year after launch. He expressed the opinion that phased implementation is not a good idea, and that algorithms planned for at-launch should really be ready at launch time, and not phased in.

There was a brief discussion, initiated by Gao, concerning water vapor column measurements over ocean cirrus. Kaufman suggested that from a radiative balance perspective, water vapor absorption above a reflective surface could be a useful product. King touched on the difficulties of doing this and expressed his feeling that this would be a complicated undertaking. There was no further discussion of this topic.

2.1.3 Cloud and Cloud Mask ATBDs

Paul Menzel discussed the status of his three (3) ATBDs. The Atmospheric Cloud Properties ATBD was treated gently during the review, as it is based on heritage instruments. The Cloud Properties ATBD is the focus of most of Menzel's effort. The algorithm will become more global in the ATBD re-write. Both ATBDs got good grades, and there is not much concern about them.

2.1.3.1 Masking, Cirrus Clouds, and Stratospheric Aerosols

The Cloud Mask ATBD did not receive as good a grade, but the reviewers were appreciative of the work done on relatively short notice. The revised ATBD will include more data, including GAC and LAC, and MAS 50-channel data. Validation will be from heritage instruments.

On how to define an obstructed field of view, a view is obstructed if clouds are present. If the radiance is different than expected for a clear field of view, it is designated as obstructed. A dialogue between Kaufman and Menzel ensued concerning aerosol detection. Menzel indicated that they were guided away from incorporating aerosols in the cloud mask. Using 13.9 versus 1.38 μm data to distinguish between cirrus and stratospheric aerosol was discussed. Menzel commented that he could provide a crude estimate when a lot of stratospheric aerosol is present, and could provide that to Kaufman, but doesn't feel it's necessary to make it available to everyone. He is concerned about masking out too much of a scene. He suggested that the algorithm is good for getting thick cirrus, but that a separate "thin cirrus" indicator may be needed. King made the comment that the cloud mask is a front-end process, and shouldn't use up all the processing time. If it saves computation time later, it's a good thing. Menzel noted that the changes to the cloud mask algorithm were getting smaller and smaller, although the possibility of changes after global data sets become available exists.

Both Menzel and King noted that the reviewers indicated that coordination with each other's ATBD work would be appropriate. King also mentioned that the next versions of the ATBDs would be made available via WWW.

2.1.3.2 Simulated Data

A discussion of simulated data followed. Menzel stated that synthetic data sets for science tests would not be constructed, as they are difficult to build. Software engineering tests may use synthetic data, but Science (algorithm) testing will be done using AVHRR, HIRS, MAS 50-channel, etc. data. Menzel will provide small data sets with cloud masks for use by others to test their algorithms; he will not build cloud masks based on Thematic Mapper data, as there are not enough spectral channels there to do a good job.

Michael King discussed his ATBD, indicating that he would be cross referencing it with Menzel's cloud top properties ATBD. His ATBD includes algorithms for deriving cloud optical thickness, effective particle radius and discriminating water clouds from ice clouds. He suggested that Strabala could work on an at-launch thermodynamic phase algorithm (involving thermal data) and that he would add his near-infrared approach post-launch. This is not yet decided, however, and may change following acquisition and analysis of more MAS data.

2.1.3.3 Use of TRMM Data

Bryan Baum offered to make AVHRR-3/HIRS-3 data available to the MODIS team. With launch in December 1994, he will need a global data algorithm by summer 1995. He noted that he will be using the MODIS cloud mask algorithm in his work.

Menzel noted that Baum's data would be different, and used the fact that MODIS does not use CO_2 slicing as an example, but did state that a data set with the cloud mask should be available. Kaufman asked if AVHRR global data would be used; Menzel replied that 1.6 μm data will be available for daytime scenes, but that the 3.9-μm channel would replace it at night.

Piers Sellers inquired about cloud detection using composite clear-sky maps. Fleig discussed using a Land group gridded product of cloud free fields of view as data sanity checks. Baum discussed TRMM plans for composite clear-sky maps, producing 10-minute clear-sky maps, updating either every 1 or 3 hours. He is interested in data that would suggest how often to update, and whether to save VIS and IR albedos. Menzel stated that it would be useful to have radiance data. Baum discussed the tradeoffs in spatial vs. temporal fineness in a 2.5 degree grid, and the fact that it is difficult to come up with just one number that describes what is going on in a grid cell.

A discussion followed on using the 0.936 and 0.94 μm channels to help with warm-water clouds, as well as the ratio of 0.94 to 0.86 μm reflectance to take advantage of a correlation between higher reflection and less water vapor.

2.1.4 Spatial Resolution of Products

King stated that the last topic with respect to ATBDs would be the spatial resolution of products. He is sampling every 5 km rather than every pixel in his ATBD. MODIS will have 250m / 500m / 1km resolution; for producing data sets with MAS data, the plan is to use one resolution (50 m), then degrade it to simulate coarser resolutions. King hopes to avoid radiometric averaging, given a 12-bit digitizer and 0.3 degree resolution, although Menzel plans to use it, as he won't have a good enough signal / noise ratio on the long wavelength side if he doesn't. King plans to archive his MODIS data products at 1 km resolution; Menzel's data products will be at 5 km resolution.

Kaufman stated that for water vapor, resolution could be 1km since overlap should be good. On aerosols, 50 ∞ 50 km will be used over land, due to the number of pixels that may not have aerosol information. A geographically-oriented grid, perhaps 9.2 km or 5 ∞ 9.2 km, would be good. Over oceans, a 5 ∞ 5 pixel sampling, ignoring overlap, is planned.

King noted that the different gridding strategies were all based on valid research approaches, but for purposes of data archiving, it is good that MODIS is not launching next year.

King indicated that he is removing cloud cover from his ATBD. He stated that it is difficult to understand cloud cover from a radiative transfer point of view, and suggests that cloud cover will be a level 3 product. He is at this point unsure how gridding of overlapping clouds will be done.

2.1.5 Non-Atmosphere ATBD Status

Kaufman reported briefly on two ATBDs that he is working on that are not Atmosphere research ATBDs—Fire Products and Atmospheric Correction. On fires, the algorithm uses a moving 10 ∞ 10 pixel algorithm to determine the total amount of energy emitted, number of fires in a given class (defined by total energy emitted), and the ratio between smoldering and flaming fires. He stated that this is more useful than performing a temperature and size analysis, and can help the aerosol and trace gases communities have a better estimate of emissions from fires.

The Atmospheric Correction ATBD is a collaboration between the Atmosphere and Land groups, with Kaufman and Eric Vremote developing the ATBD. The ATBD received a "B" grade by the Project Science Office. Current work includes work on the radiative transfer code, working to improve Liam Gumley's code to make it more accurate over land. There has been no correction for atmospheric effect in the past for land products (e.g., vegetation indices); prototyping work for these corrections is underway. Stratospheric aerosol is a concern, plans are underway to work with AVHRR and SCAR data to establish corrections for tropospheric aerosols. Non-sphericity in backscatter also has an effect. The ATBD review commented on validation and operational concerns, the lack of aerosol climatology, and a need to decouple ground and atmospheric BRDF. Kaufman commented that you can't validate a correction, but that consistency checks could be done.

2.2 MODIS Science Team "Holes"

King moved on to the topic of "holes" in the MODIS science team. Suggested areas for added expertise or help included cloud masking, cloud physics and cloud modeling, non-spherical ice crystal modeling, validation, and remote sensing of finite clouds. King noted that the Atmosphere group consists entirely of remote sensing and retrieval specialists, with no modeling or global data people on board. He stated that a new member need not add a new data product, but could instead offload work from others. The need to weigh the potential contributions of additional team members against the project's finite resources was touched upon.

2.3 MAS Update

An update on the MAS 50-channel digitizer followed, with delivery expected in the December time frame. A discussion ensued on modifying MAS to add 1.38 and 0.42 µm channels. For the 1.38 µm channel, it should be relatively easy to do, and a discussion of the relative benefits between a 1.38 µm channel and the existing 1.88 µm channels followed. The 0.42 µm (blue) channel would be harder to add, due to fitting the hardware (diffraction grating) in, given the existing 0.96 µm channel previously requested and in place. Kaufman stated his opinion that the 1.38 µm channel would be nice to have at some point, but that he considered the 0.42 µm channel more important. Menzel suggested that it would be nice to have the instrument available for a year to gather data rather than have it unavailable due to continuous upgrades and changes.

A report on the status of the MAS instrument spectral characterization was presented by King. MAS flight schedules for the first half of 1995 were discussed.

2.4 SCAR-B / Brazil Campaign Status

The SCAR-B campaign was discussed. A go-no go from Brazil is needed by December 31; the Brazilians are sensitive about remote-sensing flights over Brazil, and it is quite possible that approval for flying the ER-2 will not be given. Kaufman would be interested in going down with just the University of Washington's C-131A; it is unclear whether NASA HQ would continue to support the UW plane through the internation memorandum of understanding process. Alternative sites that were considered include South Africa, Mexico, and Australia (perhaps near Perth); NASA international affairs

does not feel that a memorandum of understanding with South Africa or Mexico could be put into place in time. Kaufman questioned the utility of data from Australia, wanting to make observations that have effects on climate—he is not sure that Australia holds any advantage over Oregon. Menzel is also more interested in Brazil, with its extensive biomass burning. Given that he needs top-of-atmosphere measurements, Menzel is not interested in a mission with the C-131 alone—he needs the ER-2.

2.4.1 SCAR-C Preliminary Results

Kaufman gave a presentation on the SCAR-C mission, focusing on fire data. His overheads are available as Attachment 18. Fire images from the 21 September 1994 flight were displayed, which was located in California, Idaho, and Washington. Data acquired on this mission are necessary for the development of the fire products algorithm. Data are available from MAS, AVIRIS, and the Radiation Measurement System (flux measurements) on this flight, as well as from the GEOS-8 3.9-µm band. This will be used to determine aerosol size distribution, artificial changes in humidity, albedo, and black carbon measurements. Smoke measurements from sun photometers will be used to help build a smoke / aerosol model, along with black carbon.

2.5 Tri-Spectral Phase Indicator

Kathy Strabala gave a presentation on a tri-spectral technique for determining cloud phase. Her overheads are available as Attachment 19. The technique involves using 8, 11, and 12 µm data, and plotting the difference between 8 and 11 µm data against the difference between 11 and 12 µm data. Details of the algorithm and an example of its application to a cloud scene were shown. The algorithm was developed using over-water scenes; work on extending the algorithm to work over land is planned.

2.6 Cirrus Update on Optical Properties and Radiative Transfer

Kuo-Nan Liou gave a presentation on work being done on remote sensing of cirrus clouds. His overheads are available as Attachment 20. His work includes a description and modeling of ice crystal shapes. Scattering and polarization is correlated to ice crystal shape and size distribution. Satellite and balloon data used in developing this model were presented.

2.7 Atmospheric Correction for Thin Cirrus

Bo-Cai Gao gave a presentation on atmospheric correction for thin cirrus clouds, using the 1.375 µm channel. His overheads are available as Attachment 21. He presented AVIRIS data acquired over North Carolina and Monterey, California, and showed correlations between 4 bands over land and water. The equations used to compute the corrections were presented, and a set of pre- and post-correction images were displayed.

2.8 Gridding for Level 3

Robert Wolfe gave a presentation on Gridding for Level 3. His overheads are available as Attachment 22. He proposes using ISSCP gridding, which is an equal area grid, and provided an overview of that gridding strategy. He then provided a possible specific implementation for use with MODIS data, based on a 9.28 km grid size. He covered the number of grid cells at different latitudes, column alignment, nesting grid cells for

different resolutions, and area errors from several different factors. In the course of the discussion during the presentation, it was generally agreed that this would be workable as a Level 3 storage and archiving format, given that mapping functions exist to convert to other (specifically, equal angle) formats, and that the Level 1 and Level 2 data products remain accessible.

2.9 Archive Needs

Michael Heney requested input on the MODARCH system. Most comments centered on a desire to have documents available in an electronic format, either via World Wide Web or ftp, as opposed to the bitmapped page format.

3.0 CALIBRATION DISCIPLINE GROUP MEETINGS

The Calibration Working Group met on Tuesday, Oct. 11, prior to the actual Science Team Meeting. The meeting was chaired by Phil Slater. Present were Peter Abel, Paul Anuta, Phil Ardanuy, Joan Baden, John Barker, Wayne Boncyk, Jim Bremer, Ken Brown, Tom Bryant, Kendall Carder, Lloyd Carpenter, Nianzeng Che, Gerry Godden, Tom Goff, Bruce Guenther, Fred Gunther, Marghi Hopkins, Doug Hoyt, Mike Jones, Kirsten Parker, Ed Knight, Dan Knowles, Geir Kvaran, Dan LaPorte, Al McKay, Harry Montgomery, Tom Pagano, Shi-Yue Qiu, Mike Roberto, Ken Schaffer, Will Snyder, Steve Ungar, Zhengming Wan, Robert Wolfe, and Tim Zukowski. Minutes of the proceedings were recorded by Jim Butler.

3.1 MODIS Engineering Model

The first speaker was Jim Young of SBRC. Young presented an update of the MODIS Engineering Testing model (Attachment 23).

Slater began with a question to Young concerning the schedule of the planned move by SBRC to El Segundo and what specifically is planned before and after the move. Young stated that the schedule for the move has not been finalized. The move will take place following the completion of the engineering model (EM) but before the protoflight model (PFM) in the April to June 1995 timeframe. Actual EM measurements will start in December 1994 and will continue through March 1995.

3.1.1 MODIS Dedicated Calibration Facility

Concerning the Dedicated MODIS Calibration Facility (DMCF), Tom Pagano stated that the facility should be completed in December 1994 with testing slated for January 1995.

Young stated that all calibration equipment used in the EM will be used in the PFM. Young also pointed out that the SSMA has been divided into two components: the SpMA (Spectral Measurement Assembly) and the ScMA (Scatter Measurement Assembly). Young stated that the near field response measurement is a difficult one. He also stated that far field stray light tests are not planned for the EM. Slater inquired on what is exactly meant by far field stray light. Young stated that far field stray light is light from sources beyond 3 to 4 degrees and is simulated using a 21 by 21 pixel hole in

a bright background. This approach was adopted as a result of time and money constraints. Young added that based on the modelling of stray light to date, he is more concerned with near field stray light out to 10 degrees.

With respect to critical EM testing which has been preserved, Young stated that the spherical integrating source (SIS) window is silicon dioxide which absorbs in the mid wave infrared (MWIR) and long wave infrared (LWIR). The integration and alignment collimator (IAC) window is calcium fluoride which absorbs in the LWIR. The Specrtoradiometric Calibration Assembly (SRCA) will provide spectral band registration for all bands in MODIS. However, Young did remind the group that no SRCA is planned for the EM.

3.1.2 Ambient Test Flow

Young presented information on the planned ambient test flow. Guenther inquired whether enough data will be captured to determine the exent of the fixed pattern noise. Young stated that 20 percent of the scan line will be filled by the SIS. When the nadir aperture door is closed, these measurements will be able to be performed at 0 radiance. It was recommended that SBRC take an action on this to see if they will be able to do a complete scan line but not a number of scan lines. SBRC might have to dump data to accomplish this. Also it was requested that SBRC examine the effect of doing single scan lines to characterize the fixed pattern noise.

3.1.3 Radiometric Characterization Tests

With respect to the radiometric and performance characterization tests in the reflectance (MWIR and LWIR) bands, Young presented compliance matrices that showed all the specs were being met. SBRC requested comments from the meeting attendees on these matrices to ensure that the performance specs are indeed being met.

Young also presented matrices showing the radiometric and performance characterization tests for system spatial performance. John Barker inquired whether the out of band response will not be a spectral response. Young stated that will be partially true. He also stated that the slit widths are limited and therefore the signal to noise for spectral out of band measurements is low. The MODIS signal to noise will be at the 0.1 percent level.

3.1.4 Inflight Calibration Requirements

With respect to the inflight calibration requirements, the on-board calibration blackbody will be on the EM and will enable MODIS to be used as a transfer radiometer. Guenther inquired whether an electronics calibration will be done on the EM. Young stated that a test will be done. Slater inquired what the extent of the far field is for MODIS. Young stated that at 10 degrees there is a portion of MODIS that does not see any baffles. Ed Knight inquired if there will be a check of stray light on the solar diffuser for the EM. Young stated that there is no structure on the EM to do this and the test is no longer planned. Eric Johnson at SBRC estimated the cost to build a solar simulator would be roughly $20K. SBRC thinks this potential problem will be able to be dealt with through modelling on the EM and will be actually measured on the PFM. Young expressed

some concern on solar diffuser/SRCA scattering because SBRC does not have as much information as they would like at this stage. Young also stated that there is no way to get solar diffuser structures in the EM at this time. Guenther inquired what is the status of the plan to shorten the transfer mirror snout on the SRCA. Young stated that the study is included. Pagano added that Eric Johnson said shortening the snout cannot be done because the view factors are all full.

With respect to the EM vacuum timeline, Barker inquired whether it is planned to return to the initial temperature before removing MODIS from thermal/vacuum. Young stated that he hopes so. Biggar inquired on the curious jog in the cool temperature curve at days 13 and 21. SBRC stated that they will investigate this.

Concerning the PFM thermal/vacuum timeline, SBRC stated that they will need all the time they can get to do this.

Young reported that the super polished spherical mirror in the ScMA is a 7 Angstrom or better surface on a glass substrate. Slater inquired whether scatter from the filter will be a problem. Young stated that scatter will occur in the along track direction but not in the along scan direction. SBRC is aware of this. Slater inquired why an off axis parabolic mirror was not used. Young stated that it is much more important to have a smooth mirror here than a good imaging optic.

With respect to the ScMA design parameters, the mirror is 0.02 percent in total integrated scatter (TIS). The calculated MODIS scan mirror smoothness is 8 to 10 Angstroms RMS from the BRDF data. The initial spec for the mirror was 0.15 percent TIS which leads to a 20 Angstrom smoothness. Young does not believe the 24 Angstrom number obtained from TMA Technologies. Slater inquired why SBRC needs 36 filters in the ScMA design. Young stated that the problem is more complex given the bands and the dynamic ranges. Ghosting also presents additional problems than just scatter. Additional filters will provide a good way of separating cross talk and transient response when it is an electrical effect. Near field scatter and ghosting will be combined.

3.1.5 Near Field Response

Young reported that the MODIS near field response approaches technological limits. Knight inquired how the specification line of 0.4 percent Lcld for a 21 by 21 km hole was arrived at. Young stated that there are currently two interpretations of this line. The first is that the line represents the MODIS response change in seeing the 21 by 21 km hole in having it surrounded and then not surrounded by Lcld. The second interpretation is a transient response specification in which it is assumed that the transient response refers to all phenomena that contribute to MODIS performance. Then within 2 km of a cloud the spec level is 0.5 percent of Ltyp. Young stated that if you apply interpretation 2 to this spec you will never meet it. Pagano added that the transient response interpretation does not specify a cloud size. Guenther inquired if special calibrations will be done in the water vapor bands. Young stated that measurements with the large integrating sphere will require a purged optical path.

Guenther requested information on the calibration of band 21-the fire channel. Young stated that SBRC will use the large aperture blackbody source. Young believes that 10 percent accuracy is achievable on this channel. Similar problems are anticipated in calibrating the high levels of bands 31 and 32. Biggar inquired on the range of operating temperatures of the blackbody calibration source (BCS). Young stated that the BCS range is 170 K set by the calibration of the platinum resistance thermocouples (PRTs) to 350 K. SBRC has reported a crazing problem in the BCS above 350 K. The BCS will be heated no higher than 350 K.

3.2 GOES 8 Lessons Learned

Jim Bremer of Swales presented information on lessons learned from GOES 8 (Attachment 24). Bremer stated that GOES 8 is a 3 axis stabilized satellite as opposed to previous GOES satellites that were spinners. Interestingly, GOES 8 sees space hotter at 50 degrees incidence angle than at 40 degrees incidence for the long infrared wavelengths. In some cases space appears to be 150 degrees. In the course of one day, the scan mirror is sometimes non-uniformly illuminated. The single thermistor on the scan mirror does not help in analyzing this problem. According to Bremer, a cassegrain telescope pointing at the sun at midnight satellite local time poses large radiometric problems. This overall problem was traced to polarization effects of the mirror. The p polarization appeared not to be well behaved while the s polarization was fine. To correct for this effect, use was made of the onboard blackbody with a 45 degree view followed by a 40 to 50 degree view of space. Earth is viewed at 41 to 49 degrees. Currently work is being done to correct for these effects using algorithms. It is hoped that a 10 times reduction of these effects will be realized by this approach. A complete correction is prohibited by the 5 to 7 degree gradients on the mirror. It is anticipated that these effects will be seen on GOES J and K also. The GOES mirror substrate is similar to the mirror that will be used in MODIS. Bremer noted that the thermal environment of MODIS will be milder than that experienced by GOES, but the angular range of the MODIS mirror is larger. SBRC plans to calibrate for these effect before the launch of MODIS.

3.3 Level 1B Calibration Algorithm

The next speaker was Geir Kvaran who presented material on the Level 1B Calibration Algorithm, Beta 2 delivery. Concerning the level 1B software milestones, Slater inquired where vicarious calibration appears in the scheme. Kvaran stated that vicarious calibration enters through the Team Leader Computing Facility (TLCF) calibration parameters. Kvaran pointed out that there is a lot of room to tweek the system there. Slater emphasized that the role of preflight and vicarious calibration should be spelled out in this material. Additionally, fallback positions should be outlined clearly. For example, what happens if the onboard calibrators fail. Biggar recommended that exceptions handling should be designed at the gound level and that it cannot be implemented after the fact.

3.4 Calibration Peer Review

Bruce Guenther presented an overview of the status of the Calibration Peer review and the ATBD review. Guenther stated that both reviews had fundamental concerns. Sixty

one requests for information were received from the calibration peer review alone. Answers were provided within 4 to 6 weeks. The ATBD was considered not held and the ATBD document not delivered. Guenther stated that at this Science Team meeting the architecture of the ATBD will be presented. Guenther also stated that the chairman of the calibration peer review panel requested another review in the fall of 1994. Guenther hoped that the information presented in this meeting will satisfy that requirement.

3.5 Calibration ATBD

It was stated that the EM testing would be completed by the end of February 1995. Slater asked when analyses will be finished on the EM test data. Pagano answered that SBRC will analyze the data to make sure it meets specs. This should be finished one month after the tests are completed.

3.5.1 Calibration Algorithm Architecture

The next speaker was Peter Abel who presented information on the architecture of the algorithm. Concerning the absolute radiance calibration of MODIS for wavelengths less than 2.3 microns, Young stated that the SRCA will carry an absolute radiance scale into orbit through the SRCA subsystem. According to Young, the silicon detectors are not being designed to be stable from prelaunch to orbit, however it is hoped that the lamps will be stable. Abel asked Young if the lamps will be operated in constant current or radiance mode from pre to post flight. It was agreed by all parties that this issue must be examined in more detail.

Concerning the spatial calibration of MODIS, Young pointed out that +/-20 m is the limit of the prelaunch measurement accuracy, and this is not entirely guaranteed at this time. Slater pointed out that a radiometric standard is not available for the infrared calibration. MODIS will use temperature standards with no clear traceability to radiance. Slater recommended that a statement along these lines be made in the ATBD.

Abel concluded his presentation with information on verification of MODIS level 1B radiances. Abel pointed out that when the uncertainty curves cross between the MODIS calibration using on board calibrators and that using verification methods, the verification methods could very well become more reliable than the on board methods.

3.6 Emissive Band Verification

The next speaker was Paul Menzel who presented some of his work on emissive band verification. Menzel presented some concerns and outlined an approach in comparing the emissive band measurements from different instruments. Menzel recommended that total system spectral response and determination of the infrared calibration coefficients under thermal vacuum conditions should indeed be characterized preflight. However, Menzel also pointed out that these might also be able to be determined post-flight. Menzel also presented some interesting work on cross calibration between sensors on a postflight basis. He showed the example of calibrating Meteosat 3 against the GOES 7 onboard blackbody. Menzel did caution that this approach is not a substitute for a good prelaunch calibration.

3.7 Level 1B Algorithm

The next speaker was Harry Montgomery who briefly spoke on risk, status, and future activities in the generation of the MODIS level 1B algorithm. Slater expressed a bit of concern on the fact that the move of SBRC to El Segundo will possibly eliminate a solar calibration of MODIS.

3.8 Thermal Calibration

Dan Knowles presented his work on the thermal calibration of MODIS. With respect to the overview of the thermal calibration as presented by Knowles, Menzel inquired whether the list of temperatures used as input in the calibration are limited. Pagano stated the the foreoptics temperatures will be available and these data may be used to troubleshoot any problems. Pagano added that the master curve calibration approach presented here will be verified on the EM.

Concerning the universal MODIS infrared calibration curve, Biggar stated that he is not convinced that the complete master curve will be able to be characterized using only two baseplate temperatures at 290 and 310 K. Young stated that the PFM will be needed to fully model and understand this approach. Young also added that it is SBRC's intent to measure the reflectivity of the scan mirror as a function of angle prelaunch. Menzel then added that if the telescope optics are at one temperature and the space, earth, and blackbody are at another temperature, you will not see a uniform source. Pagano stated that SBRC does not plan to do a far field response characterization in the infrared. Pagano also stated that the radiance of space should be assumed not to be equal to zero.

Concerning the current absolute error analysis, Biggar inquired how the detector biases will be set. Pagano stated that these will be set prelaunch and problems will arise if the detector resistances change. Biggar also inquired how well will the mirror directional reflectance will be measured. Young stated that the mirror reflectance cannot be measured absolutely to the uncertainty stated on the chart. Slater asked if out of band rejection has been considered. Pagano stated that out of band is scene dependent. Knowles added that he has not considered out of band rejection in his work yet.

3.9 Solar Diffuser Radiometric Calibration

Paul Anuta presented his work on the solar diffuser radiometric calibration. With respect to the SD/SDSM Calibration Summary, Slater inquired whether the quoted 2.4 percent BRDF accuracy is with respect to the sun. Anuta stated that the actual spec is 2 percent. In the error analysis for the solar diffuser calibration mode, Young asked why BRDF appears twice in the error budget. Anuta stated that 1 percent is the accuracy that the SDSM will track the solar diffuser over time while 1.53 percent is the measurement accuracy of the diffuser at time=0. Slater pointed out that the messiest part of this approach is the problem of not doing a solar based calibration of the system. Pagano asked if MODIS could be used to calibrate the transmission of the screen. Young stated that this could be done on-orbit. The presentation concluded with Biggar firmly stating that 1 percent radiance calibration using the moon is not achievable.

3.10 Spectroradiometric Calibration Assembly (SRCA) Update

The final speaker in this session was Nianzeng Che who presented his work on the SRCA. Concerning the use of the SRCA in the radiometric mode, Pagano stated if the transfer uncertainty is 4.6 percent and 3 percent relative to the sun, maybe this transfer should be revisted. In addition, Che presented his summary graphs on the SRCA in the spectral calibration and spatial registration modes.

3.11 Calibration Discipline Group Meeting

The MODIS Calibration Discipline Group met again on Thursday, Oct. 13. The meeting was chaired by Phil Slater, and was attended by the same persons attending the Calibration Working Group. Minutes of the proceedings were recorded by Jim Butler.

3.11.1 MODIS Flight Operations

Ed Knight presented information on the MODIS flight operations (Attachment 25). Knight reported that as of October, MCST learned that information must be supplied to the spacecraft integrator (ie. Lockheed Martin) concerning any anticipated commands and controls to the instrument and any housekeeping data needed to monitor instrument safety. This information is sent to the EOS Operations Center three weeks in advance for review and implementation. John Barker stated that in the past, all data were monitored. He stated that what is being offered here is a toolkit but no computer. Since only 1 of 16 orbits will be monitored by the ground system per day, Barker expressed concern that something could go wrong with the instrument and might not be caught until the next day. Guenther asked how will we recover if the instrument fails on-orbit. Guenther stated that we need to examine those failure mechanisms that will not be caught in either the state check or the processing of the level 0 data in the Science Computing Facility (SCF).

3.12 Action Item Review

The next speaker was Mike Roberto who reviewed the list of action items from the previous MODIS Science Team meeting held on May 4 - 6, 1994.

Action item 1 concerned the emissivity of the blackbody calibration source (BCS). Guenther asked if the BCS surface is the same as the on-board blackbody calibration source. Jim Young answered that problems and questions seen with the BCS exist for the the on-board blackbody also. Roberto pointed out that emissivity is a strong function of geometry with these blackbody designs. Biggar asked at its lowest temperature, can the BCS and the instrument see anything that is greater than 300 K on a single reflection or bounce. Young answered that Hughes El Segundo did realistic simulations of the BCS. A non-black source is seen if you look at the BCS at an angle off from that viewed by the MODIS. Young stated that simulation data of the BCS can be made available. Slater inquired whether SBRC plans to make measurements of the reflectance or emissivity of this source. Young stated that no plans exist for making those measurements on the BCS but measurements will be made on the on-board blackbody. Young added that it might be useful if a source with a temperature greater than 300 K is brought in while the MODIS and BCS are in thermal/vacuum. Young

thought that some useful information may be gained from that exercise. Tom Pagano added that perhaps out of field effects should be modelled using the situation of a cold blackbody accompanied by a warm out of field target. An action item was taken for SBRC to look at this situation to see what possible measurements could be done to get a handle on this. A simple measurement would be ideal. SBRC will collect all information on this and also all information available to date on BCS stray light modelling. GSFC will assemble the information they have by Nov. 22, 1994. Young stated that on the on-board blackbody, SBRC will do a measurement of the total integrated scatter using a laser illuminating the blackbody at the geometry of MODIS. Emissivity will be equal to 1 minus the total integrated scatter.

Action item 2 concerned the polish of the spherical mirror in the SSMA. Slater asked if some determination or measurement could be made on the magnitude of the the stray light introduced by the filter in the SSMA. An action item was taken for SBRC to examine the magnitude of the stray light introduced in the along slit direction by the filter. Pagano did point out that there is no transient response specification in the along slit (ie. track) direction.

Action item 4 concerned the question of earthshine on the on-board blackbody calibrator. SBRC is to analyze why the MSAP model is not handling this correctly. GSFC must also look at the magnitude of the earthshine error by Nov. 14, 1994. Gerry Godden also recommended that the specular reflection off the edge of the scan mirror be examined.

Action item 5 concerned the measurements of the emissivity of the on-board blackbody calibration source. Young stated that polarization and angle depenedent changes will be examined. He also stated that it is necessary to determine if a polarization component is present in the emissivity.

Action item 6 concerned the availablity of sufficient light from the integrating sphere to perform the stray light test. Pagano stated that making the linearity measurement to 0.5 percent may be difficult in that it could be hard to distinguish non-linearities in the sphere versus those in the MODIS. Young presented a technique to measure these effects. This technique scans the MODIS entrance aperture while masking the MODIS aperture and the integrating sphere opening. An action item was taken for SBRC to produce a study of this technique in the next three weeks. Slater added that it might be good to do a quick calibration of the integrating sphere before and after lamp changes using a transfer radiometer.

Action item 7 concerned the timeline for thermal/vacuum testing. Barker stated that an equal amount of time should be allocated during the thermal/vacuum testing at the two temperatures. Guenther inquired whether the EM testing includes elevating the on-board blackbody temperature. Young stated that he would like to see that done, but it will require time. The blackbody will be heated after installation but no detectors will look at it. Biggar inquired whether two temperatures on the baseplate will be sufficient to establish the universal curve. Barker stated that there may be a risk in using only two

temperatures. There also may be a problem in not verifying that the universal curve approach works before the PFM.

Action item 8 concerned the effect of scan angle on the magnitude of the stray light problem. Pagano stated that the knowledge of the scan mirror temperature is better than 1 degree K using a tested radiative transfer method.

Action item 9 concerned whether SBRC actually will measure the transmission of the diffuser screen. Biggar asked if the question of changing BTDF of the screen has been addressed with respect to illumination geometry, hole size, and hole thickness. Young stated that he would like to see more modelling on this. An action item was taken for SBRC to procure an additional screen following the completion of their modelling. Pagano pointed out that a screen will not be built until the PFM.

Action item 10 concerned the magnitude of the effect on radiometric error when sunlight hits the internal side of the sunshade and then is reflected onto the blackbody. SBRC is modelling this, and Pagano thinks this modeling could be extended to the aperture door. An action item was taken on this for SBRC to continue their modeling with a parallel effort by GSFC to be undertaken following approval by the MODIS Engineering Team.

3.13 MODIS Near-Field Response

Slater led a discussion on the MODIS near field response. Pagano further explained the chart he presented previously showing that the near field response approaches technological limits. Pagano stated that the chart is meant to show that SBRC is doing as well as possible on this. The real problem is that SBRC sees the transient response specification as defining an electrical requirement that defines overshoot and ringing. This is still an area of major disagreement between SBRC and NASA. SBRC stated that test equipment will be designed to quantify the near field response. However, SBRC thinks that the specification as interpreted by GSFC will not be met. NASA modelling on this will be done in parallel with the SBRC effort.

3.14 Total and Spectral Solar Irradiance

The next speaker was Ann Mecherikunnel who presented information on total and spectral solar irradiance (Attachment 26). Mecherikunnel presented an overview of the solar irradiance data sets and an idea of the irradiance variation as a function of time and wavelength. Mecherikunnel ended her presentation with recommendations on the best solar irradiance data sets.

3.15 Modelling the Solar Diffuser Screen

The next speaker was Paul Anuta who presented some information on his modelling of the solar diffuser screen. Anuta presented an error model which projects the solar diffuser screen onto the solar diffuser.

3.16 SRCA Overview (Continued)

The next speaker was Nianzeng Che who continued his presentation on the SRCA. Concerning the use of the SRCA in an absolute radiometric calibration mode for wavelengths less than 2.3 microns, Slater asked if the 3.8 percent error assumes that the detector being used is the transfer mirror detector and that the calibration is transferred in-flight. Slater further asked if the silicon photodiode detector in the secondary mirror can be used in the radiometric mode. Young stated that there may be some lamp levels where the silicon detector could be used in the radiometric mode. At high lamp levels in broadband operation mode, this detector could saturate. The detector is an 8 bit detector. A higher gain would be needed to enable the silcon detector to be used in the total radiometric mode. An action item was taken for SBRC to determine if there is any radiometric level at which the silicon detector in the secondary transfer mirror could be used as a radiometric monitor. Young added that since there is no temperature control on this detector, SBRC will also have to examine any operational constraints on this detector.

With respect to the SRCA operating in spectral mode, Young pointed out that in at least three other monochromator calibrations that he has experienced, if you have access to measured data you can use a least squares method to home in on the monochromator parameters. Pagano stated that depending on the field angle of the band, the SRCA aperture walks along the filter with a definite cone angle. Pagano asked if this has been taken into account.

Nianzeng Che and Harry Montgomery then led a discussion on several questions concerning the SRCA (Attachment 27). Question 1 concerned the ability to do radiometric monitoring of the SRCA output using the reference detector. It was pointed out by SBRC that all silicon photodiode detectors are 12 bits, the spectral detector is 1nm wide, and in the radiometric mode will experience a 100 x increase in its signal level. Radiometric monitoring by this detector may be able to be performed using the 1 Watt lamps. Changing the gain on this detector to accomodate high signal levels is not trivial.

Question 2 concerned the stray light levels out of the SRCA effecting radiometry. SBRC reported that a stray light APART model was done on the SRCA to determine problem areas. This model did not give SBRC a system level knowledge of stray light. It was not SBRC's intent to do stray light measurements on the SRCA. It was considered a poor use of resources by SBRC.

Question 3 concerned the stepping strategy during spectral calibration. An action item was taken for Eric Johnson at SBRC to give the details on this strategy.

Question 4 concerned the reticle being out of focus during spatial calibration mode. SBRC answered that modelling of this has not been done for the SRCA. However, this modelling has been done for full aperture illuminators and the effect is negligible. An action item was taken for SBRC to locate the report(s) on this and furnish them or any additional information to GSFC. Abel asked with respect to stray light when the SRCA is filling 20 percent of MODIS, what is the remainder of MODIS looking at? Young

stated that MODIS will look at the surrounding areas of the SRCA. This mode could be most effectively used at night.

3.17 Action Items

1. *SBRC and GSFC*: Determine what measurements can be performed to determine the emissivity of the blackbody calibration source (BCS). In addition study the effects on emissivity induced when a warm out of field target (ie. greater that 300 K) is introduced while MODIS is in thermal/vacuum. SBRC will gather all information they have on this to date. GSFC will assemble their information by Nov. 22, 1994.
2. *SBRC*: Examine the magnitude of the stray light effect in the along slit (ie. track) direction introduced by the filter in the SSMA.
3. *SBRC and GSFC*: Determine why the MSAP model is not handling earthshine effects on the on-board blackbody. GSFC will look at earthshine error also by Nov. 14.
4. *SBRC*: Examine the effects and magnitude of the specular reflection off the edges of the scan mirror.
5. *SBRC*: Produce a study of Jim Young's masking/aperturing approach to measuring the non-linearity in the MODIS versus that in the integrating sphere by Nov. 14.
6. *SBRC*: Con tinue modelling of diffuser screen transmission including effects such as changing BTDF with hole size, illumination geometry, and hole thickness. Following modelling, produce an additional screen for testing.
7. *SBRC and MODIS Engineering Team*: Extend APART/ASAP modelling to sunlight hitting the internal side of the sunshade door. The MODIS Engineering Team will determine if GSFC should persue a parallel modelling study of this.
8. *SBRC*: Determine if there is any light level at which the silicon photodiode detector in the secondary transfer mirror of the SRCA can be used for radiometric monitoring. Determine how the possible operational cycle of this detector will be effected by its lack of temperature control.
9. *SBRC*: Report on the details and techniques for stepping during spectral calibration.
10. *SBRC*: Gather all information on the effects of using an unfocussed reticle in the spatial registration mode of the SRCA.
11. *SBRC*: Check to see if a full scan line can be filled using the spherical integrating source in order to characterize fixed pattern noise. SBRC will report the effect of using single scan lines in characterizing fixed pattern noise.
12. *SBRC*: Provide information on Eric Johnson's study of shortening the snout of the SRCA.
13. *SBRC*: Identify the reason for the slight temperature jog in the EM vacuum timeline that appears on days 13 and 21.
14. *SBRC*: Report whether the optical path for the irradiance transfer of the standard lamp to the spherical integrating source will be purged to eliminate water vapor.
15. *SBRC and GSFC*: Examine and arrive at a mutual understanding on exactly how the SRCA will carry an absolute radiometric scale into space using its sphere-imbedded silicon photodiode detectors in feedback mode.

4.0 LAND DISCIPLINE GROUP

The MODIS Land Group Meeting was chaired by Chris Justice. Present were Dorothy Hall, Alfredo Huete, Jan-Peter Muller, Steve Running, Alan Strahler, Vern Vanderbilt, Zhengming Wan, David Carneggie, Al Fleig, Ed Masuoka, Dave Meyers, Ranga Myneni, Rama Nemani, Piers Sellers, Phil Teillet, Robert Wolfe, Steve Ungar, Eric Vermote, and W. Wanner. Minutes of the proceedings were recorded by David Toll.

4.1 ATBDs and MODLAND Products

MODLAND (MODIS Land) is making significant changes based on the ATBD reviews. Under consideration are plans for subcontracting specific tasks to broaden the participation in MODLAND and bring in specific expertise. In addition, MODLAND welcomes the recommendations of the ATBD review panel of adding new team members to augment and strengthen their current activities. Justice said MODLAND would welcome a closer relationship with components of the NASA Research and Applications Program as suggested by D Wickland (HQ) in her plenary presentation. Justice stated that MODLAND needs a stronger computing capability to deal with the data volume necessary for prototyping the MODIS products and the associated validation related issues recommended by the ATBD review.

4.1.1 FPAR and LAI

Based on the ATBD review, R. Myneni is contributing to the program of Running, Nemani, and Strahler on the FPAR (fraction of absorbed photosynthetically active radiation) and LAI (leaf area index) MODIS products. They will examine a suite of canopy radiative transfer models in a versatile approach augmented with "look-up generated tables" to estimate FPAR and LAI. In addition, their work will be closely coupled with the Vegetation Index and BRDF (bidirectional reflectance distribution function) products. Running will also look in to the availability of an EOS produced IPAR (incident photosynthetic active radiation) product that is required for all photosynthesis related models. Sellers offered to push for a community product through the SWAMP. Nemani provided a summary of the FPAR/LAI algorithm development (Attachment L-1). Sellers plans to coordinate a Swamp/ISLSCP, MODIS/MISR, BRDF/LAI/FPAR meeting this spring to work Community Product issues.

4.1.2 NPP

Running will continue development of a net primary productivity (NPP) product and will collaborate closely with other investigators working global land NPP issues. They feel strongly that a global land NPP will significantly add to MODIS activities. Running will actively pursue the ancillary data inputs to their models and report at the next MODLAND meeting. Climate data at a suitable resolution for use in MODIS NPP product generation remains an outstanding issue.

4.1.3 Vegetation Index

Huete said in response to the ATBD review he will work closer with Running and Myneni to relate the MODIS vegetation indices to the LAI/FPAR product (See Attachment 28). His work will emphasize semi-empirical algorithms and will augment the physically based models used by the Running group for FPAR and LAI. In addition, in response to the ATBD review, the relationship between the atmospherically resistant

component of the MODIS vegetation index and the atmospherically corrected data will be further examined .

4.1.4 Fire Product:

Justice said the ATBD review for the fire product was encouraging with no major changes recommended. The fire group are currently using various existing sensors to prototype the MODIS Fire product. These will include examination of the global 1-km data set for algorithm development and regional evaluation, the use of the MAS for monitoring controlled burns (SCAR C) and Thematic Mapper data. Luke Flynn from the Mouginis Mark - IDS project is assisting in the algorithm development and participated in the SCAR-C experiment.

4.1.5 Snow & Ice

Hall said the ATBD review recommended improvements on validation planning and sea ice algorithm development. Hall said they are currently addressing these issues. They added Ann Nolan and George Riggs to assist on sea ice research. They are further pursuing the use of microwave data with Al Chang to augment their data analysis approach. They will hold a small community snow / ice MODIS meeting with the major players in the next six months.

4.1.6 BRDF & Albedo

Strahler said the ATBD review indicated the BRDF product is too complex and risky and recommended that the BRDF be an experimental product. Other MODLAND products plan to use BRDF as an input to their production. In response to the ATBD recommendations they are now emphasizing a semi-empirical approach for an at-launch product. The semi-empirical method is more readily invertible to provide BRDF estimates. W. Wanner gave a presentation on the BRDF MODIS product (Attachment 29). The surface albedo will be derived from BRDF modeling. They will use the semi-empirical method to derive hemispherical reflectance estimates in albedo estimation. Additional work is planned for the number of MODIS looks used to estimate albedo and interactions with the MISR multi-angle derived reflectivities. Strahler said they will interact closely with nvestigators working on validation planning on other products. Muller is also assisting with BRDF albedo algorithm development (Attachment 30). Scaling of the validation data sets remains a key issue because of the variation in BRDF with scale size. Sellers stated that he will try to coordinate the albedo products (temporal, spatial, etc.) for the EOS AM platform.

4.1.7 Land Cover

Strahler said there are three concerns from the ATBD review on the land cover product (refer to Attachments 31 and 28). First, the thresholding using surface temperature and NDVI is considered too simple. Next, the ecosystem classification required by many investigators will not be adequately represented by a satellite based classification. Last, the validation plan should be improved. MODLAND is planning on going research to explore the use of neural net classifiers. MODLAND is interacting closely with the EDC IGBP 1-km land cover classification, a modified version of which will be used as the at-launch product. MODLAND plans to use LTER global sites to augment and strengthen

the global 1km land cover validation. In addition, they are working closely with other groups on developing a "community accepted" land cover classification scheme.

4.1.8 Surface Temperature

Wan said they need an adequate at-launch land surface emissivity map. They are planning to derive land emissivities using MODIS multispectral (optical and thermal) data. In addition, they will work with the ASTER investigators to address spatial and temporal emissivity variations. Wan said they will investigate the use of microwave data to estimate surface temperature during cloudy sky conditions.

4.2 Validation Planning

Running is close to submitting a joint proposal with 12 (of 17) LTER investigator groups for joint funding from NSF and NASA. They are proposing to provide vegetation structural data on land cover, NPP and LAI for 100 square km areas. The data collection will start during the summer of 1996. Running also said the wildlife habitat work under the "GAP" Program could provide reference data for MODLAND validation. Gap analysis will be completed within two years for most of the western states. Justice said MODLAND would like to work closer with the NASA R & A program to assist with validation efforts. In addition, Running suggested that MODIS should consider working with "GLOBE" to have school children assist with collecting Earth science data.

Ungar will try and have MAS BOREAS data available to MODLAND by December 1994. MODLAND is currently waiting on BOREAS to make available satellite imagery for algorithm development and testing.

4.3 Related Satellite Sensors

MODLAND would welcome a closer link to the SPOT 1 km vegetation instrument currently under design. Discussions were held with Gilbert Saint concerning areas of mutual interest. MODLAND recommended a presentation by ATSR 2 for the next MODIS Science Team Meeting.

4.4 Data & Information Issues

4.4.1 DEM

Justice stated that thanks to Martha Maiden (NASA HQ), digital elevation models (DEMs) are now on the EOS agenda for the at-launch instruments. A 1km initiative is now underway to generate a product for use by the EOS AM instruments. MODLAND will support the initiative and will evaluate higher resolution post-launch requirements for the BRDF product. Strahler and Muller will be responsible for justifying a higher resolution (<1-km horizontal) DEM for use in radiometric related corrections. (See Attachment 30 for a summary of DEM work by Muller.)

4.4.2 Gridding and SDST

Wolfe of the MODIS SDST gave a presentation to MODLAND on Level 3 Gridding (Attachment 22). He is recommending the ISSCP grid based on equal area as the baseline for current TLCF development work. He said the grid is being used for the

Pathfinder / SeaWiFS ocean products. The scheme is similar to a sinusoidal map projection and is efficient on computer memory space since only points on Earth are used. The SDST wants the science team to consider their gridding requirements as well as grid cell sizes and nesting issues for MODIS Level 3 Products. MODLAND wants the SDST to produce a white paper on gridding for land products over the next six months. The EDC DAAC was asked to provide inputs.

MODLAND wants to play a key role in the specification of a land-water mask for a Community At Launch Products. MODLAND needs to work closely with SDST over the next year to work issues associated with Beta Delivery. MODLAND and the SDST are planning a workshop for Spring '95 in Tucson. MODLAND and SDST need to develop improved networking among the science team to be able to share data and to work as a team.

4.4.3 EDC DAAC Activities

Carneggie summarized the EDC FY95 DAAC activities (see Attachment 32). He gave updates on Version 0 data set preparations, and their EOS-AM support activities. They will continue to contribute to the Global DEM strategy. Additionally, they will address current issues on new Land Products, IDS derivative products, ASTER processing, and Version 0, 1 and ECS data migrations.

4.4.4 IDS

Wood said EOS should work better to ensure the instrument data products meet the IDS investigator data requirements.

4.5 ACTION ITEMS

1. *P. Sellers* (SWAMP) to develop a coordinated effort for an EOS-am albedo product.
2. *R. Wolfe* with MODLAND to develop a MODIS white paper on gridding.
3. *E. Masuoka* to prepare a new SDST organization chart associated with the new staffing.
4. *J.P. Muller, A. Strahler and C. Justice* to make the case for the DEM requirements for EOS radiometric corrections.
5. *D. Hall* to organize a snow / ice MODIS meeting of a small community of researchers in the next six months.
6. *A. Huete* to organize a SDST and MODLAND meeting for this spring '95 in Tucson.
7. *S. Running/P. Sellers* (SWAMP) to investigate an EOS AM IPAR product.
8. *S. Running* to specify the climate and weather data requirements for the NPP product and to evaluate the suitability of the existing data.
9. *D. Herring/V. Salomonson* to organize a presentation on the ATSR2 for the next science team meeting.
10. *S. Ungar* to provide MAS BOREAS data to MODLAND by December 1994.
11. *P. Sellers* (SWAMP / ISLSCP) / Huete / Running to coordinate a vegetation index, BRDF and FPAR / LAI meeting in 95.

5.0 OCEAN DISCIPLINE GROUP MEETING

The MODIS Ocean Discipline Group Meeting was chaired by Wayne Esaias. Present were Howard Gordon, Frank Hoge, Kendall Carder, Bob Evans, Mark Abbott, Dennis Clark, Lisa Vanderbloemen, Patricia Rosten, Teruyuki Nakajima, Diane Wickland, Robert Frouin, Bob Lutz, and Al Fleig. Angela Li, Robert Wolfe, and Oscar Huh attended portions of the meeting. The minutes were recorded by David Herring.

5.1 Introduction and ATBD Revisions

Esaias began the meeting with an overview of key topics to discuss. He reminded the group that revisions of ATBDs receiving grades of A or B are due to the EOS Project Science Office in November 1994. Revisions of ATBDs receiving a C or D are due by the end of December 1994. Hoge and Abbott said there are factual errors in the comments made by their ATBD reviewers, so they are not sure how to respond. Esaias advised them to include comments to the reviewers' comments along with their revisions.

5.2 MODIS Data Dependencies

Esaias briefly summarized the MODIS Simulation Data Workshop held recently at Flathead Lake, MT. He told the group that SDST needs to know precisely who is producing which products and who needs what input(s) and/or output(s). At that meeting SDST reported that there are major inconsistencies in their current understanding of MODIS' processing needs that must be clarified.

Several members pointed out that the "MOD" numbers on SDST's list of MODIS data products don't match the numbers for the same products on the ATBDs. This was a source of confusion. Moreover, the Ocean Group unanimously agreed that the wiring diagram for the MODIS ocean data products needed to be reworked. This was done in real time during the meeting with considerable help from Herring and Rosten.

5.3 Summary of the *Ad Hoc* Working Group Meeting

Evans reported on the deliberations of the *Ad Hoc* Working Group. He said that for Ocean products there will be two sets of numbers for every pixel of image data, for both clear and cloudy conditions. He suggested at Level 2 computing each parameter with 4 bytes of information. Then, at Level 3, remaining consistent with SeaWiFS' parameters. In short, MODIS will keep 2- to 4-byte words per parameter and carry fields for quality information.

Lutz interjected that no one knows the cost of data products. He stated that not all products will be ready at launch; in fact, few will. Fleig disagreed (as did the Oceans Group), stating that research products will have to be produced at launch in order to be ready (as standard products) a year after launch. "Not ready at launch" does not mean "not produced at launch". Fleig felt that the idea of a phased plan for producing data products is flawed and dangerous.

Lutz asked, What is the use of storing data at the DAACs if they are not for scientific use? Fleig responded that the data will be used for scientific investigations. Where will the data be stored if not at the DAACs, he asked rhetorically.

Evans stated that the Oceans Group's SST and ocean color products are based on a rich heritage. He asserted that MOCEAN products will be ready at launch, and added that the Group will also need calibration and validation so that they can distribute and evaluate their products. If this is not possible within the DAAC framework, he concluded, then MOCEAN needs to find another.

Abbot agreed with Evans, stating that to minimize risk, MOCEAN should explore the option of setting up their own Science Computing Facility for storage and distribution. He is concerned that given their current cost model estimates, the DAACs won't provide adequate storage and distribution capabilities.

Esaias gave an action item to the Oceans Group to look over the list of input products and make sure it is correct so that a sensible wiring diagram can be drawn. He asked Rexrode to solicit inputs from each MOCEAN member.

Evans and Abbott were viewed has having represented the group interests very well in a very rapidly developing and important area of concern. They will try to communicate their efforts to the group as a whole via email, when necessary.

5.3.1 Headquarters Perspective

The group was pleased to have Dr. Robert Frouin, newly-appointed Ocean Biology Program Manager, and Diane Wickland, MODIS co-Program Scientist, present for much of their discussion. Wickland stated that MOCEAN has raised an important issue (status of archive and distribution of research products), one to which she is sympathetic. However, she cautioned the Group against "going it alone" because that would be ill-taken politically. She urged MOCEAN not to give up on EOSDIS and to try a few more rounds of getting their point across. Additionally, she said it is important that representatives from EOSDIS regularly attend the Science Team Meetings. She envisioned much greater need for coordination of the Research and Applications programs with EOS in the future, and was very optimistic that this would happen.

Esaias agreed with Wickland that the Science Team must continue to work with EOSDIS, but voiced his concern that EOS Project may one day deselect products from the product list based on the inaccurate assumption that the cost of producing, storing, and distributing individual data products is driving the cost of EOSDIS. The point was made that there is not a linear relationship between the cost of data products and the cost of EOSDIS.

5.3.2 Forum and Agenda for Next MODIS Meeting

Esaias said he would suggest a change in the focus of the next MODIS Science Team Meeting from discipline-centric to topic-centric. In short, he feels we have reached the point where we need more cross-disciplinary discussion of topics, and more group business needs to occur in separate meetings. Herring took it as an action item to recommend an appropriate forum for more effective, efficient Science Team Meetings. Esaias said one topic for the next meeting should be "How to Handle Data Products".

5.4 Cloud Masking

Regarding development of the cloud masking algorithm, MOCEAN agreed that there is a need to use several years of Pathfinder data to test the cloud mask. There are questions about how MODIS' radiance thresholds will compare with SeaWiFS and AVHRR. Evans and Menzel have discussed this and have developed a good course of action. Menzel will provide his software to Evans, and Evans will do the necessary comparison and develop MOCEAN's cloud mask approach. Evans indicated that some of the comparisons with AVHRR could be ready by mid-winter, and, provided SeaWiFS is launched in the May time frame, applications of Menzel's scheme with the visible channels could be done by late summer. Evans was optimistic that the coordination would result in a very useful ocean cloud mask, perhaps implemented shortly after launch.

5.5 Beta Software Delivery Schedule

Esaias reported that it was determined at the Flathead Lake meeting that there were some discrepancies between Atmosphere and Land Data Products; e.g. how to test the algorithms in each group's beta software.

Evans stated that SeaWiFS software should be delivered to SDST before the launch of SeaStar. After launch, Evans will set up a parallel version of the SeaWiFS program to replace SeaWiFS' versions of products with MODIS'. In short, there will be a SeaWiFS code base with which to implement SeaWiFS algorithms, and another for implementing MODIS algorithms. Then, Evans explained, when we can show that we can take SeaWiFS data and make MODIS data correspond to SeaWiFS, we will deliver our beta software to SDST, so that they can take the SeaWiFS Level 1 data reader into the MODIS Scan Cube reader. Evans said he will work more closely with Ed Masuoka to gain a better understanding of MOCEAN's input needs.

5.6 MOBY/MOCE Update

Esaias reported that Dennis Clark's instrumentation aboard an oceanographic research vessel was accidentally damaged when 220 volts were sent through the neutral system. Clark and Stan Hooker have procured a power conditioning system to minimize future occurrances, new slip rings for the winch, and have replaced other damaged electrical components. The system should be operating at full capability for the MOCE cruise in October-November.

MOBY is scheduled for redeployment in February 1995. Esaias reminded the Group that SeaStar is scheduled to launch in April-May time frame of 1995. Discussions with Paul Menzel are occuring regarding the possibility of conducting some joint validation and initialization activities tentatively scheduled for August 1995. It might be appropriate to include overflights with the MODIS Airborne Simulator.

5.7 Validation

Esaias announced that Michael King, EOS Senior Project Scientist has succeded in establishing a new funding line for validation, and in removing the distinction between

SCI and SCF funds. (Gordon stated that the University of Miami would need a letter from King to that effect.) Esaias said the EOS-wide validation effort will be coordinated through the EOS Project Science Office. It will build slowly, and complement the validation efforts of various instrument team members.

MOCEAN agreed upon some general objectives for a global ocean validation plan—it should define error fields and indicate how they vary spatially and temporally for science applications, and it should help define research areas in terms of parameter processes and geographical region/time scales. The validation plan should begin with individual product plans (algorithm validation) and then identify which parameters need to be validated; e.g. which can be addressed with ships, buoys and models, and which can only be left as assumptions. The plan should identify any aspects or attributes missing from individual principal investigator plans, and any aspects to be included in an overall MODIS or EOS plan. The plan should also identify the MODIS interface with other ocean sensors, and should therefore address multiple sensors. MOCEAN supports extending the sun-photometer network; additional sun-photometers are needed at sea.

Frank Hoge's offer to take the lead in assembling inputs from MODIS Team Members was accepted.

5.8 Gridding

Robert Wolfe visited the Group Meeting to present SDST's proposal for adopting the International Satellite Cloud Climatology Project (ISCCP) Grid for the MODIS Level 3 global grid. Wolfe explained that the ISCCP Grid is based on the spherical Earth model and is space efficient. He further explained that SDST will provide a multi-resolution grid—they can either provide the grid at different resolutions and worry about lining up the cells later; or they can provide the grid at one resolution and then break the cells up into quarters, 16ths, 32nds, etc. SDST calls the latter approach a "nested" grid.

Esaias felt that the proposed ISCCP Grid would meet the Ocean Group's needs and has the recommendation of the group, and would probably serve the needs of the other disciplines as well; however, the other discipline groups need to reach their own conclusion. The scientific needs of the discipline groups should weigh heavily in any decision to have a single (vice multiple) standard grid. Wolfe cautioned against having multiple grids. He said that in terms of storage and data analysis, there are a lot of benefits to having a common grid. He noted that the Atmosphere Group has accepted the ISCCP Grid, but that the Land Group hasn't thought it through yet and so is still uncertain of the best approach.

5.9 Level 1 Product ATBD Review

Esaias showed copies of the presentation material for the Level 1 product review, which he attended only briefly. Carder reported that he is unsure how much MCST will rely on the solar diffuser versus onboard lamps versus vicarious calibration methods for MODIS. He said the sensor itself is probably more stable than the lamps. Carder will look over the review materials and get back to MCST and the group if he has concerns.

Esaias said he wants MOCEAN to participate more in the Calibration Group's efforts. He would like more than one representative from MOCEAN to attend future Calibration ATBD Reviews. Evans indicated that the recent progress may mean that the Level1B could be an acceptable starting point for most ocean algorithms.

5.10 MODARCH and Document Distribution Options

Herring solicited feedback from the Ocean Group on MODARCH, as well as their ideas on setting up a document distribution system to operate in parallel. The Group was in favor of establishing a robust distribution system for a small subset of MODIS documents on an "as required" basis. Such a system would allow for document-oriented browsing, instead of a page orientation, much faster copy and print capabilities, and the ability to retrieve and manipulate documents electronically in various formats. MOCEAN was also in favor of MAST distributing format templates to Team members wishing to submit documents for general distribution.

5.11 PGS Allocations

The Ocean Group unanimously agreed that the current metric for allocating processing flops for data products is not rational. There is concern that EOSDIS will arbitrarily allocate a processing budget that is not adequate for the Group's needs. The Group understands that EOSDIS is trying to scale back their system, however there doesn't seem to be rational thinking as to how best to do so.

MOCEAN will try to help EOSDIS by providing more information on data dependencies, their own estimates of flop requirements, and ideas on the levels of service they need.

There was major concern that research product generation and distribution be robustly maintained, both within MODIS and across EOS. The MODIS Team as a whole must consider how it will accommodate research product generation and distribution, as well as some current standard products if allocation comes about. Moreover, MOCEAN feels that research data products need to be readily accessible. Inputs to research products need to be readily accessable. There is concern that PI's alone may not have adequate resources to access such data, produce it, or make it available. The Group recommends that the Interdisciplinary Working Group and Data Panel discuss the issue further.

5.12 Next MOCEAN Meeting

The MODIS Ocean Group tentatively scheduled their next meeting for Jan. 23 - 25, 1995, in Miami, Florida.

5.13 Action Items

1. *Science Team Members:*: Revisions of ATBDs receiving grades of A or B are due to the EOS Project Science Office in November 1994. Revisions of ATBDs receiving a C or D are due by the end of December 1994.

2. *Herring:* Recommend a more effective, efficient forum for the next Science Team Meeting.
3. *King:* Write a letter to each Science Team member stating that there is now no distinction between SCI and SCF funds.
4. *Hoge:* take the lead in assembling inputs from MODIS Team members for a validation plan.
5. *Abbott:* Work with D. Chelton to estimate temporal and spatial resolution scale dependence.
6. *MOCEAN:* Participate more in the Calibration Group's efforts and, if possible, attend the Calibration ATBD Review.
7. *MOCEAN:* Provide Rexrode with updated data dependency information.
8. *Esaias:* Collate data dep. info and draw up consistent flow diagram.

6.0 FINAL PLENARY SESSION

Salomonson began the Final Plenary Session with the announcement that a letter to Hughes has been written expressing concern about relocating SBRC personnel to El Segundo and the possible impact on MODIS. The letter will be sent to Michael Smith, chairman of Hughes Aircraft. Carbon copies will be sent to George Speak, and Lee Tessmer. He encouraged any Science Team member interested in signing the letter to do so.

Salomonson noted that the move will likely occur shortly after completion of the engineering model. He also noted that the move will collocate SBRC personnel with Hughes Department of Defense personnel, which Salomonson feels will be beneficial to MODIS in the long run. In the short run, Salomonson said he hopes Hughes will take action to preserve the SBRC MODIS Team.

6.1 MAST Reports

Locke Stuart, acting head of the MODIS Administrative Support Team (MAST), reported that Janine Harrison, former MAST head, resigned. Stuart stated that efforts are underway to find a successor for Harrison. He acknowledged the excellent job Harrison did for MAST and observed that she will be sorely missed.

Stuart introduced Teresa Mautino, Financial Analyst, who thanked the Science Team members for their timely submission of 533Q reports. She asked the Team members to include explanations any time they deviate from their planned expenditures. If the Team fails to include an explanation, then she must do so, possibly without full understanding of the Team's intentions.

Steve Running asked if the Team must provide monthly 533Qs once they cross the $500,000 annual budget threshold. Mautino responded that she will let team members know when they need to report monthly.

6.1.1 MODARCH Status Update

David Herring, MAST Technical Manager, briefly summarized the results of Discipline Group discussions on the MODIS Document Archive (MODARCH). He stated that the Team is interested in establishing a more robust document distribution system to operate parallel to MODARCH. There is still some frustration regarding MODARCH's page range printing facility.

Herring introduced Michael Heney, MODARCH System Administrator, who presented the MODARCH status overview (see Attachment 33). Heney announced that the system has been upgraded to PixTex/EFS version 3.5, so Macintosh and PC DOS users must also upgrade. Heney told the Team that printing utilities are now available for PC and Macintosh users to enable page range printing. The utility does not, however, speed up Postscript printing. UNIX printing service remain available.

Heney reported that the MODARCH CPU has been upgraded to a Sun SparcStation 10 and now runs Solaris 2.3 system software. The CPU now has 128 MB of RAM, whereas there was previously 16 MB. The increased processing capability has resulted in significantly faster searches. Storage capacity was increased 18 GB, and now exceeds 20 GB.

He stated that MODARCH is also available as an ftp (file transfer protocol) site. The MODIS logos—color and black and white—are now available, or the Team may use the site for submitting documents for distribution.

Heney announced that MAST has established the MODIS Home Page on the World Wide Web. The Uniform Resource Locator (URL) for the page is http://ltpwww.gsfc.nasa.gov/MODIS/MODIS.html. He encouraged the Team to browse the page and forward comments. Heney stated that MAST is exploring options for using WWW for document distribution. He noted that WWW will not replace MODARCH, but will be used synergistically with it.

6.2 MCST Status Report

Bruce Guenther, MCST Leader, summarized the Team's progress since his last update (Refer to Attachment 34 for more details). He stated that MCST is restructuring its management approach to a smaller, more skilled staff of personnel.

Regarding Beta-2 algorithm delivery, Guenther reported that the top level design was frozen in July. Delivery is scheduled for the end of October. The Calibration ATBD has been revised; Guenther hopes to write the ATBD for delivery before the end of this year. Guenther reported that he has instituted a weekly electronic newsletter/status report on MCST's activities.

Guenther reported participating in the reflected solar round-robin measurement comparisons at JPL. He feels MCST is making significant progress in this area. The SeaWiFS round-robins are done, and comparisons are being made. Guenther hopes to meet with SBRC within the next 6 months to make some calibration comparisons. MCST is also addressing water vapor contamination problems.

Guenther is discussing with EOS Project possibilities for maneuvering the AM spacecraft to view the moon—this maneuver is called a pitch-hold arrangement. A lunar view can be obtained with a 25-degree spacecraft roll, which as minimal risks. He estimates that each maneuver will cost about 1/3 of an orbit's worth of Earth data. Kendall Carder asked if Hugh Kieffer, University of Arizona, is responsible for characterizing the moon under these scenarios. Guenther responded that the EOS Project Science Office is responsible for characterizing the moon, but presumes that the Senior Project Scientist will support Kieffer's work. Salomonson said that he has made a formal request to EOS Project that they recognize MODIS' requirement to look at the moon some way.

Guenther showed a chart of GOES 8 scan mirror test data showing reflectance as a function of wavelength. Guenther said the data imply that there is a 2 percent calibration difference across the GOES mirror. This is a concern in that the design specifications for the GOES mirror are virtually the same as the MODIS mirror specs, except that the GOES mirror scans 10 degrees and MODIS scans 55 degrees. Guenther said it is essential that MCST characterize the reflectance of the mirror as a function of incidence. He pointed out that GOES validates their data by looking at cold space periodically; he believes that this will be necessary for MODIS too. Current understanding suggests that the mirror will not change with time in orbit, so he will request a one-time large-angle spacecraft roll early in the mission to determine the mirror's infrared reflectance on orbit.

Guenther reported that reflectance, scatter, and image quality continue to be concerns to MCST. Currently, no one at SBRC or GSFC is capable of making spectral measurements into the infrared to verify the performance of the scan mirror.

6.3 CERES Instrument Update

Bryan Baum reported that development of the CERES instrument remains on schedule (See Attachment 35 for more information). The CERES Team recently completed a successful review of ground and space-based CERES calibration methodologies.

All CERES ATBDs received an A or B. CERES is reducing the number of Atmospheric levels of radiative fluxes to four, and the number of instantaneous cloud layers to two. CERES continues to work closely with MODIS on developing cloud masking and cloud properties products.

Salomonson asked why CERES' data requirements (40 GFLOPS) are so much larger than MODIS'. Baum responded that 40 GFLOPS seems to be a magic number and doesn't know how it was derived. He estimates that CERES' actual processing requirements will be several times smaller than that.

Menzel asked what MODIS radiance data does CERES need. Baum replied that CERES will need the ten 1-km channels for cloud properties and cloud retrieval. He stated that there is no great rush to receive the data—if they were sent on tape that would be fine.

Salomonson reminded the MODIS Team that Bruce Barkstrom has requested summary abstracts of their data products. Yun-Chi Lu added that MODIS is the only EOS team that has not provided abstracts.

6.4 Using MODIS to Study Coastal Environments

Salomonson introduced Oscar Huh, coastal ecologist from Louisiana State University, who gave a presentation on how MODIS will help researchers study the dynamics of coastal and marine environments (Refer to Attachment 36 for information on the LSU Coastal Studies Institute). Huh noted that it is commonly held that, given its resolution, MODIS cannot contribute to studies on a coastal scale. On the contrary, Huh pointed out, MODIS can make significant contributions to studies of deltas and estuaries. He showed image data of the Mississippi River delta taken by a number of MODIS heritage instruments. He concluded that 1-km data is quite adequate for studying river deltas, and 250-m resolution is excellent for studying estuaries. Huh stated that air-sea interactions are critical in coastal environments; he feels there is a need for all discipline groups to team up to study these interactions.

Huh asked, what is the potential for real time access of MODIS data? Salomonson responded that MODIS will transmit data in X-band, so it is possible to get a direct readout.

6.5 Calibration Group Meeting Summary

Phil Slater summarized the Calibration Group's discussions (see Attachment 37). Slater said the revised MODIS Calibration ATBD should be an improvement over earlier versions; however, suggestions for further improvements have been given to Guenther. Specifically, the Group feels that more work is needed on the inclusion of vicarious calibration, error budgets, and validation.

Regarding the Engineering Model (EM) test plan and schedule, Slater said he is concerned that the far-field stray light will not be tested. The Calibration Group feels that the two temperature plateau levels presented are insufficient for EM thermal vacuum testing—there should be five temperature plateau levels. Also, the Group is unsure of the effect on calibration accuracy of the new temperature maximum of 350K for the onboard blackbody. The Group is concerned about the stray light modeling for MODIS, as well as the calibration and characterization equipment. They feel more than one model should be used.

It has been determined that the space offset measurement done at both ends of the Earth scan in the longer thermal channels of GOES 8 differ. The offset is caused by a physical condition which is very similar to the design of MODIS' scan mirror. Slater is concerned that MODIS may experience different stray light problems depending upon which port it looks through.

Slater presented a list of past and new action items for the Calibration Group.

6.6 Atmosphere Group Meeting Summary

Yoram Kaufman summarized the deliberations of the Atmosphere Group (see Attachment 38). The Group discussed ATBD updates, integration of products, and delivery of beta software. For the validation of water vapor products, Kaufman said the Group plans to compare their results with those of the sun photometer network—specifically, they will intercompare near infrared and infrared products.

Kaufman told the Team that the ATBD reviewers requested that validation and aerosol climatology be taken into consideration for the MODIS atmospheric corrections. These issues will be addressed in the revised ATBD. Kaufman noted that aerosol climatology is a major problem, so the Group will need to obtain additional data to address it.

Regarding the MODIS fire algorithm, Kaufman stated that there is a problem simulating wildfires because they don't always look the same in the real world. The SCAR-C campaign was a success in that it provided the Group with the database needed to make progress in this area. Kaufman reported that discussions are still ongoing as to whether there will be a SCAR-B campaign in Brazil.

Kaufman said progress is being made in developing the algorithm for aerosol correction over oceans. The Group compared the assumptions made in both Howard Gordon's and Didier Tanre's algorithms, and feels that there is the possibility that they can optimize and use the best features of each, combined into one approach. Additional measurements of black carbon, aerosol absorption, and phase function is needed. However, Kaufman pointed that although there may be some convergence between the Ocean and Atmosphere Groups' atmospheric correction algorithms, there are still different objectives—Gordon is interested in clear conditions and Tanre is interested in hazy conditions. There will be a separate algorithm for atmospheric corrections over land.

6.7 Land Group Meeting Summary

Chris Justice summarized the Land Group Meeting (see Attachment 39). He reported that ATBD revision is underway; significant changes have been made based on the panel reviewers' comments. Justice stated that the reviewers' recommendation that the Land Group could be strengthened with additional members is welcomed. The Group is considering 1) adding new team members to augment ongoing activities on existing products, 2) subcontracting specific short-term development tasks to "experts" within the community, and / or 3) building a computing facility. Justice emphasized that adding new team members will not be at the expense of the resources needed for existing team members to fulfill their commitments.

Justice said the Group would also welcome closer alignment of the R&A program with the Group's activities. He recommends that the Group hold a snow-ice meeting within the next 6 months. Justice announced that Piers Sellers has proposed holding a SWAMP / ISLSCP meeting in the spring of 1995 to discuss issues related to development of BRDF, LAI, FPAR, and land cover products.

Justice reported that Digital Elevation Models (DEMs) for EOS AM-1 instruments are being developed through an initiative headed by Martha Maiden at NASA HQ. The Land Group will play an active role in this initiative. Justice said the Group needs to examine the specific requirements for the post-launch BRDF product and to work towards a product which will meet the team needs.

Justice stated that the Land Group is working to deliver beta software according to SDST's schedule. He conceded that more work is needed internally to clarify data interdependencies and produce a more thorough wiring diagram. Justice said he wants to ensure that the phased implementation suggested by EOSDIS allows for product dependencies and for full evaluation of products prior to DAAC dissemination.

Regarding the MODIS land water mask, Justice stated that he wants the Land Group to play a role in its development. Specifically, he wants MODLAND to be involved in the decision concerning the Community Products proposed for land water masks.

Justice said the Land Group needs to further review options for gridding. He asked Robert Wolfe to help them generate a white paper on the subject, keeping in mind the entire EOS community and its wide ranging needs. Justice feels that the Group's ancillary climate data needs will need to be addressed at some point. He suggested that SDST host a workshop on the subject in the Spring of 1995 in Tucson. The Land Group is now trying to access image data from the BOREAS campaign.

Justice feels there is a need to interact with the Long-Term Ecological Research (LTER) sites in reviewing the MODIS validation plan. The Group also welcomes more input from the SPOT team and would like to establish stronger, more formal ties between the two teams. Moreover, they would like to request a presentation by the ATSR (Along Track Scanning Radiometer) team at the next Science Team Meeting.

6.8 Ocean Group Meeting Summary

Wayne Esaias presented a summary overview of the Ocean Group's meeting (see Attachment 40). He announced that the Group's ATBD revisions are underway and on schedule. The Group iterated on the data dependencies diagram and presented the current version. Esaias pointed out that configuration control on the data product numbers needs to be standardized.

Esaias stated that the Group has major concerns regarding the suggested PGS allocations. He pointed out that the metric for the allocations is not rational and that the PGS should not be flop limited. The numbers of products and flops required per product must balance with the service provided by EOSDIS. The process by which EOSDIS estimates cost per flop required is not clear. Esaias emphasized that research product generation and distribution must continue, both within MODIS and across all of EOS.

Esaias sees no problems in meeting the Group's beta software delivery schedule, especially if SeaWiFS launches on its current schedule. However, the Group needs to

know what formats are needed, as well as MODIS' plan for gridding. Esaias stated that the gridding plan, as proposed by Robert Wolfe, is acceptable to MOCEAN. He recognized, however, that it may not meet MODLAND's needs, so perhaps more than one gridding approach is needed.

Esaias feels that MODARCH is still growing well. He encouraged establishing a file transfer protocol (ftp) site for more robust document distribution. Also, the MODIS Specifications should be made available on WWW.

Regarding validation, Esaias stated that the MODIS plan objective should be to define error fields and characterize how they vary spatially and temporally for science applications. MOCEAN supports extending the sun photometer network.

Esaias plans to have a representative attend future OCTS/GLI meetings. Additionally, the Group agrees to strive to be more responsive to messages and requests for information. At the next meeting, Esaias would like discussions to be focused on key topics, rather than discipline-centric. He feels MODIS will benefit from more cross-disciplinary interaction. The Ocean Group will meet Jan. 25 - 27 at a separate meeting to address discipline issues.

6.9 Closing Remarks

In bringing the meeting to a close, Salomonson reminded the Science Team to sign the letter to SBRC. He announced that the next Science Team Meeting is scheduled for May 3 - 5, 1995.

Salomonson said next week's IWG needs to address the Teams' allocation concerns, and well as concerns regarding EOSDIS. The gridding issue must also be studied further, and perhaps discussed at the next SWAMP meeting.

Wickland added Earth science R&A programs must continue in closer accordance with the EOS program. Additionally, she cautioned the team against adopting an "us against them" perspective on EOSDIS.

6.10 Action Items

1. *Science Team*: Provide a summary abstract of your data product(s) as requested by Bruce Barkstrom.
2. *MCST*: determine the implications for changing the maximum temperature of the onboard blackbody from 380K to 350K.
3. *Herring*: Invite a representative from the ATSR team to deliver a project overview at the next Science Team Meeting.
4. *Stuart & Herring*: Make sure EOSDIS representatives attend group discussions at the next Science Team Meeting.