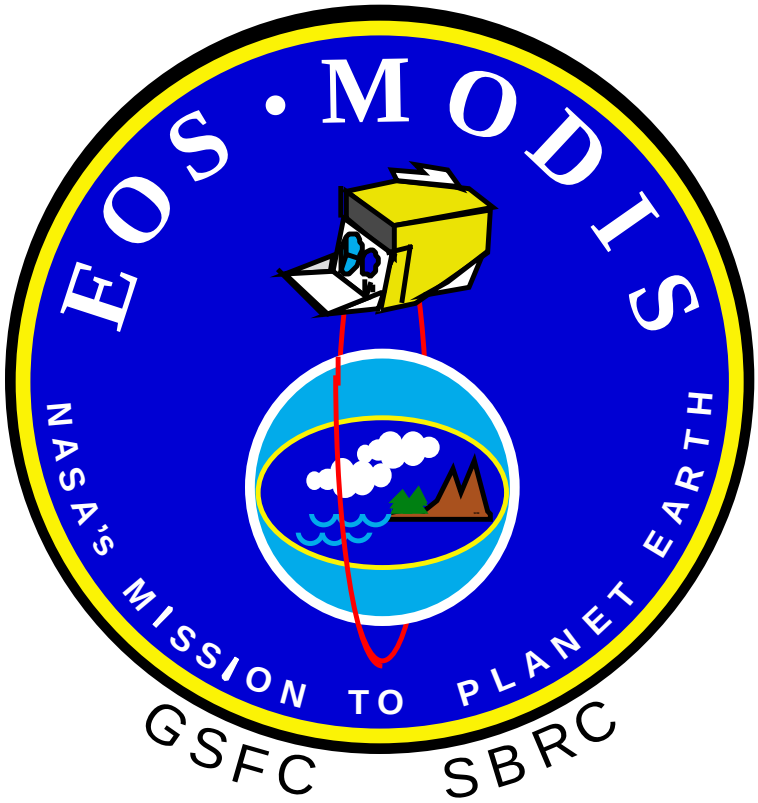
MODIS SCIENCE TEAM

MEETING MINUTES



Sept. 29 - Oct. 1, 1993
NASA / Goddard Space Flight Center
Greenbelt, Maryland 20771

Prepared by: Science Systems and Applications, Inc.

MODIS SCIENCE TEAM MEETING MINUTES
Sept. 29 - Oct. 1, 1993

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Sept. 29 - Oct. 1, 1993

LIST OF ATTACHMENTS

(Note: Below is a complete list of attachments for the MODIS Science Team Meeting Minutes; however, most are not included in the condensed hardcopy and can be obtained only from MODARCH. Two different numbering schemes were used to distinguish the two sets of attachments; those included here are numbered 1-11 and those found only in the MODARCH are numbered X1-X25. If you have questions, contact David Herring; Code 920; NASA/GSFC; Greenbelt, MD 2077; or call (301) 286-9515); or e-mail me at herring@ltpsun.gsfc.nasa.gov.

ATTACHMENTS: Abbreviated Set

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8 MODARCH Presentation Viewgraphs	David Herring & Michael Heney	
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10 MODIS Land Group Plenary Summary	Chris Justice	
11 MOCEAN Report	Wayne Esaias	

ATTACHMENTS: All Remaining

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X3 SBRC MODIS Instrument Update	Tom Pagano
X4 Land Group Science Presentation	Alfredo Huete
X5 Remote Sensing of Cloud Optical Thickness and Effective Particle Radius	Michael King
X6 Inferring Cloud Properties	Paul Menzel
X7 Aerosol Effect on Climate	Yoram Kaufman
X8 SeaWiFS Status Report	Wayne Esaias
X9 MODARCH Presentation	David Herring & Michael Heney

X10	SDST Presentation	Ed Masuoka & Al Fleig
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X12	MCST Report	John Barker
X13	Calibration Working Group Agenda	John Barker
X14	SBRC Calibration Presentation	Jim Young
X15.1	MODIS Calibration & Characterization Report: Introduction	John Barker
X15.2	Status of Calibration-Related Action Items	John Barker
X15.3	Reflective Band Spectral Sensitivity Studies	John Barker
X16	On-Board Calibration Algorithms	Harry Montgomery
X17	MODIS Scan Edge Geometry	Steve Ungar
X18	Preflight Solar-Radiation-Based Calibration of SeaWiFS	Stuart Biggar
X19	Inclusion of the F_0 Error	Howard Gordon
X20	Infrared Calibration	Paul Menzel
X21	MODIS NIR Water Vapor Algorithm	Bo-Cai Gao
X22	Use of the Moon as a Calibration Source	Hugh Kieffer
X23	MODIS Level-1 Geolocation and Calibration	Zhengming Wan
X24	LPDAAC Status: Test Sites	Dave Meyers
X25	MISR Status Report	Dave Diner

MODIS SCIENCE TEAM MEETING MINUTES

Sept. 29 - Oct. 1, 1993

LIST OF ATTENDEES

The following persons attended the MODIS Science Team Meeting. Those flagged with "**" are MODIS Administrative Support Team (MAST) personnel.

	NAME	AFFILIATION	PHONE NUMBER
1.	Mark Abbott	Oregon State U.	(503) 737-4045
2.	Michael Abrams	NASA JPL	(818) 354-0937
3.	James Acker	NASA GSFC	(301) 286-1444
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7.	Ken Anderson	NASA GSFC	(301) 286-6845
8.	Paul Anuta	RDC	(301) 286-9412
9.	Philip Ardanuy	RDC	(301) 982-3714
10.	Ghassem Asrar	NASA HQ	(202) 358-0259
11.	John Barker	NASA GSFC	(301) 286-9498
12.	Bill Barnes	NASA GSFC	(301) 286-8670
13.	Robert Barnes	Wallops Flight Facility	(301) 286-0501
14.	Celso Barrientos	NOAA / NESDIS	(301) 763-8102
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20.	Ken Brown	NASA GSFC	(301) 286-3296
21.	Otis Brown	U. of Miami	(305) 361-4018
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27.	Dave Case	ARC / Hughes ECS	(301) 925-0754
28.	Hyo Chang	Hughes STX	(301) 794-5280
29.	Judy Chen	GSC	(301) 953-2700
30.	Ruiming Chen	RDC	(301) 982-3754
31.	Leslie Cheng	Hughes STX	(301) 794-5411
32.	Eric Chipman	CSC	(301) 286-7764
33.	Barbara Conboy**	NASA GSFC	(301) 286-5411
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36.	Dave Diner	NASA JPL	(818) 354-6319

37.	Wayne Esaias	NASA GSFC	(301) 286-5465
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39.	Larry Fishtahler	CSC	(301) 464-3385
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41.	Stan Freden	CSC	(301) 572-3530
42.	Hajime Fukushima	Tokai University	81 559-68-1211
43.	Bo-Cai Gao	NASA GSFC	(301) 286-5818
44.	Zibordi Giliseppe	JRC/CEC-ISPLE	0332-785902
45.	Jerry Godden	SAIC	(703) 318-4785
46.	Tom Goff	RDC	(301) 982-3700
47.	Howard Gordon	U. of Miami	(305) 284-2323
48.	Renny Greenstone	Hughes STX	(301) 513-1619
49.	Bruce Guenther	NASA GSFC	(301) 286-5205
50.	Liam Gumley	RDC	(301) 286-8789
51.	Dorothy Hall	NASA GSFC	(301) 286-6892
52.	Joann Harnden	NASA GSFC	(301) 286-4133
53.	Janine Harrison**	NASA GSFC	(301) 286-5324
54.	Yukio Haruyama	NASDA HQ	81 3-5470-4252
55.	Patricia Henderson**	SSAI	(301) 286-9291
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57.	David Herring**	SSAI	(301) 286-9515
58.	Frank Hoge	Wallops Flight Facility	(804) 824-1567
59.	Doug Hoyt	RDC	(301) 982-3700
60.	Paul Hubanks	RDC	(301) 982-3700
61.	Alfredo Huete	U. of Arizona	(602) 621-3228
62.	Ed Hurley	GSC/SAIC	(301) 953-2700
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66.	Mike Jones	SAIC/GSC	(301) 953-2700
67.	Chris Justice	NASA GSFC	(301) 286-7372
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69.	Susan Kaltenbaugh	Hughes STX	(301) 513-7749
70.	Yoram Kaufman	NASA GSFC	(301) 286-4866
71.	Kiyoshi Kawasaki	Nat. Res. Inst. of Far Seas Fisheries	81 543-34-0715
72.	Yann Kerr	LERTS	011 33-61274472
73.	Jeffrey Key	U. of Colorado	(303) 492-3450
74.	Hugh Kieffer	USGS	(602) 556-7015
75.	Michael King	NASA GSFC	(301) 286-8228
76.	Motoaki Kishino	Inst. of Physical & Chemical Research	81 48-462-1111
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80.	Shun Lin Liang	U. of Maryland	(301) 405-4070
81.	Yun-Chi Lu	NASA GSFC	(301) 286-4093

82.	Thomas Mace	EPA	(919) 541-2710
83.	Martha Maiden	NASA HQ	(202) 358-0759
84.	Ed Masuoka	NASA GSFC	(301) 286-7608
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88.	Paul Menzel	U. of Wisconsin	(608) 264-5325
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92.	Frank Muller-Karger	NASA HQ	(202) 358-0238
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94.	Rama Nemani	U. of Montana	(406) 243-4326
95.	Kiyoshi Ono	RESTEC	81 493-31-1090
96.	Harold Oseroff**	U. of Maryland	(301) 286-9538
97.	Tom Pagano	SBRC	(805) 562-7343
98.	J.J. Pan	RDC	(301) 982-3700
99.	Claire Parkinson	NASA GSFC	(301) 286-6507
100.	Fred Patt	GSC	(301) 953-2700
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103.	Myneni Rangia	NASA GSFC	(301) 286-5554
104.	Lorraine Remer	SSAI	(301) 286-8235
105.	George Riggs	RDC	(301) 982-3700
106.	Mike Roberto	NASA GSFC	(301) 286-4004
107.	Jon Robinson	NASA GSFC	(301) 794-6164
108.	Jean-Claude Roger	NASA GSFC	(301) 286-2091
109.	Steve Running	U. of Montana	(406) 243-6311
110.	Toshiro Saino	U. of Tokyo	81 3-5351-6456
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113.	Shahin Samadi	NASA GSFC	(301) 286-8510
114.	Ted Scambos	U. of Colorado	(303) 492-1113
115.	Francis Schiffer	CSC	(410) 338-1213
116.	Carl Schueler	SBRC	(805) 562-7155
117.	Stan Scott	NASA GSFC	(301) 286-8817
118.	A.K. Sharma	NASA GSFC	(301) 286-6165
119.	John Sharman	NOAA	(301) 763-4626
120.	Phil Slater	U. of Arizona	(602) 621-4242
121.	Larry Smith	Cornell U.	(607) 255-6329
122.	Peter Smith	NASA GSFC	(301) 286-8255
123.	Carl Solomon	Hughes STX	(301) 794-5493
124.	Jim Storey	Hughes STX	(301) 794-5382
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126.	Alan Strahler	Boston U.	(617) 353-5984
127.	Locke Stuart**	NASA GSFC	(301) 286-6481
128.	Anand Swaroop	Hughes STX	(301) 794-5409

129.	Yoshio Tange	NASDA HQ	81 3-5401-8663
130.	Philippe Teillet	Canada Centre for Remote Sensing	(613) 947-1251
131.	Gilberto Tisnado	NASA GSFC	(301) 286-4009
132.	Dave Toll**	NASA GSFC	(301) 286-9256
133.	Si-Chee Tsay	NASA GSFC	(301) 286-9710
134.	Kazuo Umezawa	NASDA HQ	81 3-5470-4233
135.	Steve Ungar	NASA GSFC	(301) 286-4007
136.	Michael Van Woert	NASA HQ	(202) 488-5150
137.	Vern Vanderbilt	NASA ARC	(415) 604-4254
138.	Eric Vermote	NASA GSFC	(301) 286-6232
139.	Michel Verstraete	CEC Joint Res. Ctr.	011 39-332-785507
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143.	Richard Weber	NASA GSFC	(301) 286-5992
144.	Oscar Weinstein	SBRC	(805) 562-7185
145.	Trish Weir	NASA GSFC	(301) 286-1453
146.	Ron Welch	SD School of Mines & Technology	(605) 394-2291
147.	Steve Wharton	NASA GSFC	(301) 286-3175
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AGENDA

MODIS Science Team Meeting

Sept. 29-Oct. 1, 1993, at GSFC Bldg 8 Auditorium

Wednesday, September 29:

0800: Registration
0830: Welcome & MODIS Overview / Meeting Goals----------V. Salomonson
0845: Headquarters Perspective----------G. Asrar, F. Muller-Karger
0915: EOS Project Science Report----------M. King
0945: BREAK
1000: EOSDIS: Status Report---------- H.K. Ramapriyan, S. Wharton
1030: Global Imager (GLI) Report ----------T. Moriyama
1100: Project Report: Ghosting and Issues----------D. Weber, T. Pagano
1200: LUNCH
1300: Land Science Presentation----------C. Justice, S. Running
1430: BREAK
1445: Atmosphere Science Presentation---------- M. King / Y. Kaufman
1615: Oceans Science Presentation----------W. Esaias

Thursday, September 30:

0900: MAST: Status & MODARCH Reports J. Harrison, D. Herring, M. Heney
0945: BREAK
1000: SDST: Data Review----------E. Masuoka, A. Fleig
1100: MCST: ATBD and Cal Plan----------J. Barker
1200: LUNCH
1300: Discipline Group Meetings
Groups meet in assigned rooms. Discussions should address Data Products and MODIS Science w / Discipline Leaders reporting back tomorrow on key products (eg., aerosols, vegetation indices, and sea surface temperature)
1830-2130: SOCIAL

Friday, October 1:

0800: Discipline Group Meetings Continue
1000: BREAK
1015: EOS Instrument & Interdisciplinary
Investigator Comments ---------- To Be Determined
1200: LUNCH
1300: Calibration Discipline Summary Report----------P. Slater, et. al.
1315: Atmosphere Discipline Summary Report----------M. King, et. al.
1330: Land Discipline Summary Report---------- C. Justice, et. al
1345: Oceans Discipline Summary Report ----------W. Esaias, et. al.
1400: Action Items and Closing Remarks ----------V. Salomonson
1430: ADJOURN SCIENCE TEAM MEETING

Sept. 7 1993

Objectives for Discipline Group Sessions

- Review currently approved data products and comment on appropriateness & interactions / interconnections / accuracies
- Review status & completeness of ATBD's
- Prepare topical report on an essential product / algorithm & present to Plenary

MODIS SCIENCE TEAM MEETING MINUTES

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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
BOREAS	Boreal Ecosystem Atmospheric Study
BRDF	Bidirectional Reflection Distribution Function
CAR	Cloud Absorption Radiometer
CCB	Configuration Control Board
CCRS	Canadian Center for Remote Sensing
CDR	Critical Design Review
CEES	Committee on Earth and Environmental Sciences
CEOS	Committee on Earth Observation Satellites
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
DEM	Digital Elevation Model
DIS	Data Information System or Display and Information System
DoD	Department of Defense
DOE	Department of Energy
DPWG	Data Processing Working Group
ΔPDR	Delta Preliminary Design Review
ECS	EOS Core System (part of EOSDIS)
EDC	EROS Data Center
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
GE	General Electric
GIFOV	ground instantaneous field-of-view
GLAS	Goddard Laser Altimeter System

GLI	Global Imager
GLRS	Goddard Laser Ranging System (now GLAS)
GOES	Geostationary Operational Environmental Satellite
GSFC	Goddard Space Flight Center
GSOP	Ground System Operations
HAPEX	Hydrological-Atmospheric Pilot Experiment
HIRS	High Resolution Infrared Radiation Sounder
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
ISLSCP	International Satellite Land Surface Climatology Experiment
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
MCST	MODIS Calibration Support Team
MISR	Multiangle Imaging Spectro-Radiometer
MOBY	marine optical buoy
MODARCH	MODIS Document Archive
MODIS	Moderate-Resolution Imaging Spectroradiometer
MODIS-N	MODIS-Nadir
MODIS-T	MODIS-Tilt (this instrument has been cancelled)
MODLAND	MODIS Land Discipline Group
MOU	Memorandum of Understanding
MPCA	MODIS Polarization Compensation Assembly
MSS	Multispectral Scanner (LANDSAT)
MST	MODIS Science Team
MTF	Modulation Transfer Function
MTPE	Mission to Planet Earth
NASA	National Aeronautics and Space Administration
NASDA	National Space Development Agency of Japan`
NASIC	NASA Aircraft Satellite Instrument Calibration
NDVI	Normalized Difference Vegetative Index
NEΔL	Net Effective Radiance Difference
NEΔT	Net Effective Temperature Difference
NESDIS	National Environmental Satellite Data Information System
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
PGS	Product Generation System
QCAL	calibrated and quantized scaled radiance
RAI	Ressler Associates, Inc.
RDC	Research and Data Systems Corporation
RSS	Root Sum Square
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
SNR	Signal-to-Noise Ratio
SPDB	Science Processing Database
SPSO	Science Processing Support Office
SRC	Systems and Research Center
SRCA	Spectroradiometric Calibration Assembly
SSAI	Science Systems and Applications Inc.
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
TRMM	Tropical Rainfall Measuring Mission
UARS	Upper Atmosphere Research Satellite
UPN	Unique Project Number
VIRSR	Visible/Infrared Scanning Radiometer
VIS	visible
WAIS	Wide-Area Information Servers
WWW	Worldwide Web

MODIS Science Team Meeting
Sept. 29 - Oct. 1, 1993

SUMMARIES OF THE MINUTES

1.0 PLENARY SESSIONS

The MODIS Science Team Meeting began at 8:30 a.m. on Sept. 29 in the GSFC Building 8 Auditorium. Vince Salomonson, MODIS Team Leader, welcomed attendees and began the meeting with a brief overview of discussion topics. Salomonson noted that for the first time each Discipline Group will report on the science behind their work during the Plenary Session. He asked members to indicate after the Meeting if they like the new agenda (See Attachment 1).

Salomonson also reminded the Team that the deadline for first delivery of code is January, 1994.

Salomonson introduced Janine Harrison as the new MODIS Administrative Support Team (MAST) Leader; she is succeeding Locke Stuart. Harrison introduced the MAST members and briefly discussed the logistics for the meeting. She announced that Dr. George Smoot will be the guest speaker for the MODIS Banquet. Smoot is credited with discovering the "ripples" in space—using NASA's Cosmic Background Explorer (COBE) satellite—as evidence in support of the Big Bang Theory.

1.1 EOS Project Science Report

Michael King, EOS Senior Project Scientist, gave a brief report on the EOS and MODIS budgets (See Attachment 2). He stated that there are no changes in the budget from the last Science Team Meeting. The total EOS budget is $8 billion and the total MODIS budget allocated through FY93 is $827.6 million. The budget projections for MODIS in 1994 are still accurate.

1.1.1 SCI versus SCF Funds

King recalled that in FY92 funding was split into two different UPNs (Unique Project Number)—SCI and SCF. SCI includes funds for all scientific research, programmers devoted to the development of algorithms and software for data processing, data validation experiments, etc. SCF includes hardware and software devoted to support of data visualization and processing, including Team Member and Team Leader Computing Facilities (lease, maintenance, and purchase), workstations, operating systems, software, and computer operators.

1.1.2 New EOS Organization

King showed the new EOS Organization Chart and introduced Piers Sellers as the new EOS AM Project Scientist and Les Thompson as the AM Deputy Project Scientist.

1.1.3 EOS IWG Report

King summarized the EOS IWG (Instrument Working Group). He said the focus of that meeting was on development of each instrument's list of data products. At that meeting each instrument team presented their strawman list for discussion. King stated that the lists will help Yun-Chi Lu size the storage and processing requirements for the data products.

Bob Evans asked if Lu's sizing activity will be ongoing. He stated that the system needs to be flexible so that new science can be incorporated as the Team learns and technology improves over the next few years. King responded affirmatively; there will be a continual need to update and evaluate the sizing for some of the products; however, some products are firm as specified in the EOS Project Plan.

King reported that there are currently 132 routine at-launch EOS products. Mark Abbott asked if ocean color is currently listed as a MODIS product. King responded negatively.

1.1.4 Executive Phase Project Plan

King announced that Shelby Tilford and John Klineberg have signed the Executive Phase Project Plan. Because this is a top-level document, configuration control is quite high. The plan contains a description of the history of the EOS project; overviews of EOS AM, PM, and DIS; responsibilities of the EOS Project and Program offices; and details of the Level 1 requirements. King explained that the Level 1 requirements represent a subset of the planned at-launch data products.

Abbott asked if the Team needs approval at the Tilford level to add new products. King said that the process for adding new products has not yet been fully defined, but it is clear that new products must be approved by the Team Leader.

1.1.5 Senate Funding Appropriations

King reported that Congress is still deliberating over funding appropriations for FY 95; the House of Representatives has already passed its appropriations. King explained that Congress feels that each individual instrument's expenditures should be monitored year-by-year. King is concerned that this will lead to micromanagement of the EOS instruments and will reduce the teams' flexibility.

Another Congressional concern, according to King, is that EOS should not be seen "as all things to all people".

King reported that funding for CIESIN (Consortium for International Earth Science Information) was deleted. However, King feels that funding for that project will resume at some level, but not what was originally asked for. Funds will no longer be awarded to non-NASA organizations for construction of facilities, such as the EDC DAAC (Eros Data Center Distributed Active Archive Center).

1.1.6 EOS Project Science Office Reports

King reported that a series of seven posters are being developed which illustrate the EOS theme. Also, an EOS brochure has been printed. A 10-minute animation video was produced showing the operation of MODIS' optics. Each MODIS Team Member will receive a copy of the video.

King said the Science Office also plans to explore mechanisms for making EOS information available on-line electronically. Some of the applications he is exploring are Worldwide Web, WAIS (Wide-Area Information Servers), and Gopher.

1.1.7 EOS Color Mission

King stated that EOS Color will provide 1-km global data. The mission will be managed within the GSFC Earth Science Directorate under Vince Salomonson. King said that manpower and funding logistics have not yet been resolved.

1.1.8 Tilford Succeeded by Cannell

Salomonson announced that on Jan. 1, 1994, Shelby Tilford will be succeeded by Charles F. Kennel, a member of Physics Department at UCLA since 1972. Prof. Kennel specializes in plasma physics. Salomonson thanked Dr. Tilford for bringing EOS this far.

1.2 Headquarters Perspective

Frank Muller-Karger presented lasted data from Keeling on Mauna Loa (See Attachment X1). He presented data illustrating the global increase in the ratio of CO_2 to oxygen over the last 30 years. The reason(s) for the increase is currently not understood.

1.2.1 ADEOS Plans

Muller-Karger welcomed the Japanese OCTS team members. The Japanese announced their plans to build and launch ADEOS (Advanced Earth Observing Satellite). They expect proposals to be submitted by Dec. 24, 1993. They will make their selection by March, 1994.

Muller-Karger explained that the Japanese want to learn how relations work within the EOS remote sensing community. They would like to work closely with EOS, especially on cross referencing and calibration.

1.2.2 Mission to Planet Earth Reorganization

Muller-Karger stated that there will be three divisions under the new MPTE office: 1) Flight Systems, under the direction of Mike Luther; 2) Science, under the direction of Bob Watson; and 3) Data Processing, under the direction of Dixon Butler.

1.2.3 MODIS Team Accomplishments Recognized

On behalf of NASA HQ, Muller-Karger praised the MODIS Team for its accomplishments to date. He said MODIS' handling of the stray light problem was particularly impressive. He commended the Land Group on its LTER (Long-Term Ecological Research) site selection and the Ocean Group in implementing its SeaWiFS

field calibration scheme. According to Muller-Karger, the Oceans Group will be invited to participate in EOS Color.

Muller-Karger said that because the cost is high Headquarters is trying to avoid excessive requests for funds for airborne campaigns, both within and outside EOS. HQ feels there needs to be a strategy to address these costs while still collecting airborne data. He said Team members must work w / Instrument Team Leaders to help carry the burden of cost for airborne campaigns.

Chris Justice pointed out that Team Members are not given advance notification of approaching airborne campaigns. If they were given flight schedules in advance, they could develop plans themselves to participate. Muller-Karger said he will work to facilitate dissemination of airborne campaign schedules.

1.3 MODIS Data Products

Salomonson showed simplified flow diagrams of the MODIS Data Products. He stated that the list of data products is under Configuration control (See Attachment 3). The Team wants to ensure that their list includes enough products to be substantive and detailed, but not so many as to be a burden. Salomonson stated that products could be added, but the decision to do so must be made carefully as it must be approved by the Associate Administrator.

Salomonson observed that in the Oceans flow diagram, the Group may want to consider designating the "Pigments and Chlorophyll_a" product as the Level 1 requirement rather than "CZCS Pigments".

1.4 EOSDIS Status Report

H.K. Ramapriyan gave an update on EOSDIS activities (See Attachment 4). The ECS SRR (EOSDIS Core System System Requirements Review) was held Sept. 14-15. EDOS proposals were received at the end of March and they are under evaluation. An award is planned for December, 1993. The Independent Validation and Verification (IV & V) contract will be awarded in February, 1994. The ECOM design is scheduled to be completed in December, 1993.

1.4.1 Information Management System

Rama reported that the Information Management System prototype is the main priority of version 0. Version 0 is serving as a good feasibility study. The current emphasis is on facilitation of the system by independent people. For example, inventory systems are being developed independently through a collaborative effort between the DAACs and EOS Project.

1.4.2 EOSDIS Focus Teams

Rama reported that the Focus Teams have had several meetings. Team membership listings are available electronically from Rama.

1.4.3 EOSDIS Core System Status

Rama announced that the ECS contract was awarded to Hughes Applied Information Systems, Inc. in March. Otis Brown asked what is the process for commenting on the PGS Toolkit. Rama responded that the Toolkit was sent to Ed Masuoka. Masuoka added that he sent out a request for comments in mid-September and hopes to receive them by mid-October. He will then relay those comments to EOS Project.

1.4.4 Processing and Storage Requirements

Rama showed a viewgraph comparing previous and current processing and storage requirements—there has been a significant increase in the size of the estimates. Between May and September of this year the estimates for the AM platform increased by a factor of 5. EOSDIS is now taking those numbers and feeding them into their cost model to determine whether they can afford the hardware to support the increase in processing and storage.

Steve Running interjected that if we're getting to the point where our products requirements are bigger than the available software support, then the Science Team needs to hear that. The Team hasn't received any guidance as to what their processing limits will be. Rama responded that that's why EOSDIS is emphasizing feedback from the Science Team at this time, so that EOSDIS can in turn provide feedback to the Science Team.

1.4.5 EOSDIS Status

Steve Wharton stated that his current objective is to facilitate communication between EOSDIS Developers and the EOS science community (See Attachment 5). Specifically, he plans to interact with the science teams, science committees, DAACs, and the focus teams. His initial focus will be to promote the development of an implementation plan for end-to-end data product support. He also plans to expand the scope of the Science Data Plan to incorporate all EOS data products.

Wharton said he will also review the functional and performance requirements from the SRR. He will examine the allocation of processing capacity and input/output bandwidth for ingest, processing, reprocessing, and distribution.

1.5 Global Imager (GLI) Report

Muller-Karger introduced Dr. Y. Haruyama, NASDA senior engineer, who stressed the importance of cooperation between the United States and Japan in the global change initiative. Haruyama said his team is preparing ADEOS—an important part of EOS—for launch in 1996.

Haruyama introduced Mr. Tange who gave an overview of GLI (See Attachment X2). According to Tange, GLI will have a lifetime of 3 years. The instrument has 34 spectral bands (22 of which are under 1 µm) ranging from 375 NM to 14.45 µm, a bandwidth of 10 NM, 250-m resolution, a field-of-view of ±50°, and an NEΔT of 0.1°K. The instrument will have 10-bit quantization on 250-m bands; all others will have 12-bit quantization. Tange stated that the signal-to-noise ratio on 1,000-m bands is greater than 800; SNR on 250-m bands is greater than 200.

1.6 MODIS Project Report

Dick Weber gave a MODIS contract status update (See Attachment 6). He reported that cost caps are currently being met by SBRC, but the schedule is slipping some. For example, they are 2 1/2 months behind on the engineering model and will be about 10 percent over budget at the end of the project. They currently have a manpower of 174.

Weber announced that SBRC conducted a major exercise to "exorcise" the ghost image problem in MODIS and their results are better than was expected. SNR specs are being met in all but one band. The Team first learned of the problem at the last Science Team Meeting when Wayne Esaias presented SeaWiFS test data. Weber said Lloyd Candell (SBRC) spent a great deal of time spearheading the effort to analyze the problem, with a great deal of input from Gene Waluschka (GSFC). SBRC evaluated the options and presented several different approaches and cost schedules to the MODIS Team, one of which has already been selected. Weber pointed out that the cost of fixing the ghost image problem is not insignificant.

Regarding the MODIS subsystem overview, Weber reported that the engineering model focal plane assemblies (fpa) have been built. However, there are some problems in the thermal cycling. Weber explained that the structure is made primarily of beryllium, which a different material than is typically used—it is very stiff and can crack under duress.

MODIS' mainframe is built, tests on the scan mirror are underway, the PDR (preliminary design review) was held recently, most of the wiring boards are designed, and SBRC has received the cooling parts. Weber stated that the calibration accuracy looks good and the ground support equipment (GSE) is processing well.

Weber showed a list of future MODIS meeting dates.

1.7 SBRC Reports

Tom Pagano began his presentation by introducing Oscar Weinstein as SBRC's new deputy program manager. Pagano said his job is to make sure that SBRC meets all MODIS performance requirements, even in the engineering model.

1.7.1 MODIS Status Summary

Pagano reported that some of the major MODIS subsystem hardware assembly has been completed on the engineering model (See Attachment X3). The aft optics platform has been fabricated and delivered to SBRC; all dichroic beamsplitters are in hand and the detector arrays are working (except for the LWIR which is having minor problems); all four focal planes are ready for filter assemblies, final tests, and delivery; the electronics module design is complete; and the scan mirror motor controller is assembled.

1.7.1.1 Onboard Calibration

Pagano stated that fabrication of the SRCA (Spectroradiometric Calibration Assembly) is nearly complete and the SDSM (Solar Diffuser Stability Monitor) is in the final stages of design. The Solar Diffuser design has been determined and will be drawn when the SDSM is finished. The blackbody design is complete.

1.7.1.2 MODIS Performance

Pagano reported that MODIS' power and data rates are within spec. SBRC has reduced the stray light problem so that the instrument is very close to meeting specs for radiometric accuracy in the presence of clouds. Pagano assured the Team that SBRC has a good understanding of MODIS surface budget on the AM platform, as well as the instrument's pointing accuracy requirements.

1.7.1.3 Ghost Image Problem

Pagano explained the ghost image problem on MODIS: if a lens doesn't have a good anti-reflection coating then any incoming out-of-band energy will be reflected back onto the focal plane so that a detector may "see" an image even after it is no longer in the MODIS' field of view. Based on their "worst-case scenario" testing, SBRC feels that ghosting shouldn't be a problem in the VIS and NIR focal planes; in other words, they may meet specifications on those focal planes without making dramatic changes. However, the lenses in the SW / MWIR and LWIR focal planes do not have adequate anti-reflection coatings, therefore intermediate filter assemblies may have to be implemented. Pagano also suggested optimizing the coatings for those lenses, as well as the lenses' curvature. In the LWIR, SBRC will include a reflecting dichroic and in the MWIR the intermediate filter windows will be tipped to deflect reflections.

Pagano said that implementing these solutions will benefit transient response.

1.7.1.4 Ground Support Equipment Development, Integration, and Test

Pagano reported that the collimator is nearly complete, the blackbody calibration source is completely designed, and the MODIS ground-based calibrator is completely designed.

SBRC is building a MODIS-dedicated calibration facility, which is almost complete. Pagano explained that the facility is a B32 class 10,000 clean room. This facility will house a complete thermal vacuum and calibration equipment.

1.7.1.5 Risk Assessment

Pagano presented a prioritized list of risks to MODIS instrument performance. Ultimately, he said, SBRC has mostly good news regarding development of MODIS:

- the engineering model hardware is proceeding rapidly,
- all performance requirements are being satisfied,
- their ghosting solutions meet the transient response specs, and
- the ground support equipment designs are near completion.

1.8 Land Group Science Presentation

Since this is the first meeting at which the discipline groups gave presentations on their science, Chris Justice began the Land Group presentation with a brief introduction (See Attachment 7). He explained that the group leaders requested time at the Science Team Meetings to discuss the broad scientific aspects of MODIS. He encouraged attendees to suggest topics for science presentations at future Science Team Meetings. Justice made the following topic suggestions:

- How could MODIS data and derived products contribute to the U.S. and international Global Change Research Agenda?
- What are the science and policy questions that MODIS could be used to address?
- What are the science questions that the MODIS Science Team will address?
- How do the science requirements drive the MODIS instrument and data system specifications?
- What is the theoretical basis behind the MODIS products?

Justice introduced Steve Running, who began his presentation with an EOS-wide perspective on MODLAND products. Initially, he said, the two central objectives of the MODIS Land Group were to provide data on greenhouse gases, and primary productivity and the water cycle.

Running said the Land Group is developing algorithms to provide global land cover and vegetation overviews. He hopes to be able to identify classes of plants globally through remote sensing—first simply to classify them, later to discern more complex qualities about them. He hopes to be able to determine whether plants are perennial or annual; whether their leaves are coniferous or deciduous; whether they are broad-leafed, needle-leafed, or simply grass.

Running showed an image of the border between Canada and the United States which illustrates the difference in the two countries' use of the land. He stated that land cover is a dynamic variable that we can observe in near real time and continuously update.

Running is interested in working beyond two-channel NDVI (Normalized Difference Vegetation Index). Along with spectral detail, MODIS will provide seasonal timing data. It will also use thermal IR data to perform land discrimination.

Running said there is a need to exploit technological improvements in measuring bidirectional reflectance. This will make it easier to detect land cover classes. Wharton asked if neural networks are being used. Alan Strahler responded that the Land Group will use some simple neural network classifiers, but they want to keep them as simple as possible.

Muller-Karger asked about 1-km data versus those data at higher resolutions. Strahler responded that MODIS provides three resolutions. The Land Group will work at the 1-km level, but will use higher resolutions as well.

1.8.1 Validation

Alfredo Huete stated that the Land Group is not just working on NDVI; they feel they can do better by relying on more recent research (See Attachment X4). He said there is a need to validate the product scheme. Although MODIS' NDVI will be the most sophisticated index of its kind, and will reduce noise to a minimum, there are still some problems to address. NDVI, he explained, is very sensitive to ground-based and atmospheric contamination problems and, theoretically, can't be validated.

Justice pointed out that it is difficult for the Land Group to obtain a dataset because they are constrained by cost at the moment. They are interested in accessing aircraft data taken by MAS; also, they are interested in working with other groups to share data.

1.8.2 Algorithm Improvements

Running said that the Science Teams' algorithms are continually improving so he hopes EOSDIS will be flexible enough to not "freeze" algorithm development until the last possible moment.

Running showed LAI (leaf area index) and NDVI field data, which he said he wants to map globally across different surfaces. The Land Group is also exploring newer canopy radiation models. Net primary production (NPP) is another land product essential to EOS.

Running explained that land cover classes are needed to identify biomes—there are six biome models corresponding to each of the land cover classes. Then, with epsilon values and vegetation indices, scientists can calculate NPP and hydrologic balance.

1.9 Atmosphere Group Science Presentation

Michael King gave a presentation on his work with remote sensing of cloud optical thickness and effective particle radius (See Attachment X5). He announced that he finished his ATBD on the subject. King began with a status update on MAS. The objectives of MAS are to simulate the majority of atmosphere and land channels of MODIS prior to launch, obtain measurements of reflected and emitted radiation with a single instrument under a wide variety of earth-atmosphere conditions, compare retrievals of atmospheric and surface properties with nearly simultaneous in situ aircraft and surface observations, and perform calibration inter comparisons during MODIS overflights.

King gave an overview of the instrumentation used on the SCAR-A (Sulfates, Clouds, and Radiation) campaign. MAS, flown aboard the ER-2, has 50 channels and "sees" a spectral range of 0.55-14.2 μm on 11 of 50 possible bands. The Airborne Visible and Infrared Imaging Spectrometer (AVIRIS) was also flown aboard the ER-2. AVIRIS has high spatial resolution and has 224 bands between 0.4 and 2.5 μm.

King showed images taken over the Dismal Swamp during the SCAR-A experiment. He also showed images of St. Louis taken during the Mississippi River flood. He said

the SCAR campaign was a major experiment by the Atmosphere Group involving himself, Yoram Kaufman, and Paul Menzel.

King stated that the following are outstanding problems facing the Group requiring future work: incorporate Rayleigh and aerosol corrections into retrieval algorithms, look into the influence of boundaries on atmospheric retrievals, incorporate multiple channels into retrieval (including 1.64, 2.13, and 3.75 μm), examine multiple layer clouds using data collected during TOGA-COARE and CEPEX, and study the impact of ice and mixed phase clouds on atmospheric retrievals of optical thickness and effective radius.

Muller-Karger asked of what interest will MAS data be to the Oceans Group. King responded that Otis Brown wants to use some of the MAS NIR data taken both during the day and night. They also plan to use the data to help in the development of their cirrus cloud correction algorithms.

Muller-Karger asked King to compare MAS to AVIRIS. King stated that AVIRIS costs $52K per flight to fly. It has no channels beyond 2 μm and provides no quick look data. There are no user's fees for MAS; and it provide thermal IR data. King also pointed out that MAS is funded in-house—HQ provided none of the funding. Documents are available detailing the technical capabilities of MAS.

1.9.1 Paul Menzel's Science Presentation

Menzel gave a presentation on inferring cloud top properties from MODIS observations (See Attachment X6). Menzel explained that clouds are a strong modulator of shortwave and longwave components of the Earth radiation budget—knowledge of cloud properties and their changes in time and space are crucial to studies of weather and climate. Menzel is developing an algorithm to use on MODIS data, but is practicing the algorithm using HIRS (High Resolution Dynamics Limb Sounder) data taken over high, semi-transparent thin clouds. He said MODIS' good NEΔT is needed to detect thin cirrus clouds. Menzel explained that since the eruption of Mt. Pinatubo there has been an increase of cirrus clouds globally, according to HIRS 4-year global statistics. He said, however, that the effects of Mt. Pinatubo and El Nino are not well understood.

Menzel reported the following conclusions from the HIRS cloud study: globally, clouds are found in 76 percent of all observations, 67 percent over land and 79 percent over oceans. The global preponderance of semi-transparent high clouds is 42 percent on the average between June 1989 and May 1992. There are large seasonal changes in the storm belts at mid latitudes and little seasonal change in cirrus between 45 - 75 degrees latitude. There is more cirrus in the summer than in the winter in each hemisphere.

Menzel stated that MODIS will offer the atmospheric science community high spatial resolution data with a good signal-to-noise ratio. It will also enable scientists to better determine cloud properties.

1.9.2 Yoram Kaufman's Science Presentation

Kaufman presented his work toward understanding how aerosols affect climate (See Attachment X7). Specifically, he is interested in direct and indirect aerosol forcing and the potential for aerosol to counteract greenhouse warming. Kaufman is also interested in the remote sensing of aerosol from present satellites and using these data to study how aerosol interacts with clouds. Kaufman stated that MODIS will be better equipped to gather these data than AVHRR—MODIS has better channels, better resolution (on some bands), measures water vapor, and retrieves surface parameters better.

In summary, Kaufman stated that aerosol can affect climate by directly reflecting sunlight to space and indirectly by increasing cloud reflectance. Satellite data can be used to analyze cloud-aerosol relations on large scale. MODIS can sense clouds and aerosols better than its heritage instruments due to its superior spectral and spatial resolution and radiometric performance. Kaufman feels that a network of sun/sky radiometers on representative geographical locations is very important to assess the aerosol optical properties and for ground truth to MODIS.

1.10 Oceans Group Science Presentation

Wayne Esaias gave a status report on SeaWiFS (See Attachment X8). He stated that at the next Science Team Meeting the Oceans Group will give a multimedia presentation on sea surface temperature (SST) data.

Esaias reported that the target launch date for SeaWiFS is still July 22, 1994. The second SeaWiFS Science Team Meeting is planned for March 14-18, 1994 at a site near Goddard. The focus of that meeting will be algorithms, software use, validation, and the DAAC. Esaias pointed out that all MODIS Oceans Group members are also on the SeaWiFS Team.

1.10.1 Bright Target Recovery and Ghosting

Esaias reported that the SeaWiFS Team has successfully addressed the bright target recovery and ghosting problems; contract modification was completed Aug. 27. Esaias said that sensor modifications and cloud flags are underway. SBRC has improved SeaWiFS' electronic response, tilted the filters, and modified the bilinear gain function and all other associated gains. In the following weeks they will resurface the polarization scrambler, perform instrument characterization, and attempt an onboard cloud flag for GAC (Global Area Coverage) data. Esaias said there is a need to study correction routines for LAC (Local Area Coverage) and mask for GAC for very bright targets in the NIR bands.

1.10.2 Personnel Update

Esaias reported that sensor characterization test data has been prepared by Bob Barnes. Filter response data will soon be available electronically via ftp (file transfer protocol).

According to Esaias, the next review of Mission Operations will be held Nov. 17, 1994, at GSFC. A simulated data set, prepared by Watson Gregg, is available via ftp. Greg is also making significant progress on navigation procedures.

End-to-end system testing will be conducted by P. Coronado in December and January. The local HRPT (High Resolution Picture Transmission) antenna and pad are finished—a report on HRPT hardware requirements is available. Also, the decoder box prototype is complete.

The algorithm and calibration / validation efforts are being lead by Chuck McClain. McClain will give a Cal / Val Element status review on Oct. 19, a bio-optical workshop on Nov. 8-10 at GSFC, and a primary productivity workshop in late January. Esaias reported that the SeaWiFS atmospheric correction procedure is already coded and running, for which testing is now underway.

SeaWiFS' data processing requirements are being met under the direction of Gene Feldman. The processing formats will be "frozen" at HDF (Hierarchical Data Format), developed by the National Center for Supercomputing Applications (NCSA), this fall. Regarding software availability, Esaias stated that all SeaWiFS software will be available, but some will be unsupported. The processing software will be bundled as SeaDAS (SeaWiFS Data Analysis System), which will be supported for Sun and Silicon Graphics computers by McClain. Esaias is concerned that SeaWiFS has under scoped its processing requirements. He feels they may need to do a spatial reduction and process every other pixel.

A marine optical buoy (MOBY) will be moored off the coast of Lanai, HI to help calibrate and validate SeaWiFS. Dennis Clark is heading the MOBY efforts, funded by both SeaWiFS and MODIS. MOBY is about 17 meters long and is equipped with sensors for measuring upwelling and downwelling radiance. MOBY will provide a time-series data base for bio-optical algorithm development for SeaWiFS and MODIS.

1.11 Day 1 Closing Remarks

Salomonson concluded the Day 1 Plenary Session with a request for feedback on the Discipline Groups' science presentations. He felt that it will be helpful for the Team to discuss and evaluate the atmospheric / aerosol correction procedures for land, oceans, and atmosphere. Salomonson also urged the Team to discuss the challenges in atmospheric correction. He said the idea of studying the global radiation balance is important.

1.12 MODARCH Presentation

Janine Harrison, MAST Team Leader, introduced David Herring and Michael Heney, who gave a presentation on MODARCH, MODIS' new electronic document archive (See Attachments 8 and X9). Herring discussed the events leading up to the procurement of MODARCH. Beginning almost 1 year ago, Paul Baker, a Presidential Management Intern working in the Goddard Library, and Herring collaborated to define the MODIS Team's requirements for an archive. They evaluated MODIS' paper archive in operation at that time, surveyed the Team to determine their preferences, evaluated other archives in operation by other agencies both on and away from Goddard, investigated new electronic archiving technologies available commercially,

and then recommended the system they felt would best meet the Team's needs based on their research.

Baker and Herring determined that in 10 years a paper archive would consume about 85 filing cabinets. Also, given that the paper system is distributed over at least four different locations at Goddard, the time and effort needed to retrieve information is excessive and is becoming progressively worse.

However, there will always be a large volume of incoming hardcopy that must be archived, hence any electronic archiving system must be capable of ingesting these documents via a scanner and then performing optical character recognition (OCR) on the resulting bit-mapped image. As no OCR software is perfect, the system must be able to compensate for OCR errors.

Additionally, because the MODIS Team operates in a heterogeneous computing environment, any system procured must be flexible enough to accommodate everyone—it must be accessible from Macintosh, PC, and UNIX computers. Ultimately, any electronic system procured must be fast, easy to use, and retrieve relevant information approaching 100 percent of the time. Moreover, it must be flexible and expandable.

Based on these criteria, Baker and Herring recommended procuring Excalibur Technologies' PixTex/EFS (Electronic Filing System) software. On July 1, 1993, MAST procured a Sun Sparcstation IPX (to house the archive), a Fujitsu scanner (for hardcopy ingest), a Calera TruScan board and software for OCR, a PC (to run the scanner and OCR process), optical and tape drives (for mass storage and system back-ups), a Hewlett-Packard LaserJet Printer, and the EFS software. Collectively, for simple reference and in order to assign it an internet address, this system was named "MODARCH".

Heney gave an actual online demonstration of MODARCH. He explained that tens of documents were entered into the system in order begin the pilot phase of MODARCH in which the system was tested by select members of the MODIS Team. Using a Macintosh PowerBook running the EFS client software, Heney was able to access MODARCH from Building 8 over the internet, type in a search "clue", and in seconds retrieve information.

Heney explained that MAST is completing the MODARCH pilot and is ready to begin the full operation of the archive—MAST is now distributing EFS client software to the entire MODIS Team. Questions/comments regarding MODARCH should be addressed to Michael Heney either via e-mail at mheney@ltpsun.gsfc.nasa.gov, or phone (301) 286-4044; or David Herring at herring@ltpsun.gsfc.nasa.gov, or phone (301) 286-9515. Or, you may e-mail directly to the system at modarch@modarch.gsfc.nasa.gov.

Heney stated that MAST is exploring future enhancements to the system; such as electronic document distribution, on-line conferencing, and serving as an interface or front-end for EOSDIS.

Alan Strahler asked if EFS allows Boolean searches. Heney responded affirmatively.

Steve Running stated that he likes the idea of putting science research papers in MODARCH, which would have helped him greatly in developing his ATBD.

Howard Gordon asked if the Science Team may satisfy their contractual requirement by submitting their monthly, quarterly, and semi-annual reports through MODARCH. Herring responded affirmatively.

1.13 SDST Reports

Ed Masuoka discussed the MODIS beta software development objectives and presented the development schedule (See Attachment X10). He reminded the Team that beta software is due to be delivered in January, 1994. He expects to receive the beta toolkit soon. He said there is a need to work out SDST interactions with ECS soon. Foremost, however, there is the need to learn from and teach the Science Team members how their algorithms will work together. He said SDST is developing a data interdependency chart. SDST is also beginning to provide sizing information to EOSDIS.

1.13.1 Software and Data Management Plan

Masuoka stated that all Science Team members are developing prototype algorithms; they need to determine how fast their code will run. SDST is working on their Software Data Management Plan. Eventually, Masuoka explained, the Team will go from developing simple code using a few bands, to multiband data. Moreover, he expects the Team to begin using simulated data in testing their code.

The integrated beta toolkit will become available in 1995—Masuoka hopes to begin testing the integrated code in April of that year. Salomonson asked the Team if they know what is needed from them, and when. Masuoka said he needs test data for input so that they can see what the output will look like. He said SDST will provide a schedule of when simulated data will be available. Masuoka asked John Barker if he feels he can provide simulated data in 1995. Barker responded that he can provide some simulated data, but not a total simulation.

1.13.2 MODIS Prototyping

Masuoka introduced Al Fleig to address the bowtie effect which will be seen in MODIS' scan geometry. Fleig stated that he has been working with Paul Hubanks to study the location accuracy and errors on location. Fleig explained that at nadir a MODIS pixel will "see" a 1-km by 1-km area, and at the edges of the swath a pixel will see an area 2 km by 5 km. Moreover, Fleig explained, there will be a 50 percent overlap of the swaths out toward the edges of the cross-track coverage.

Fleig stated that the Science Team members must compensate for this bowtie effect in their texture algorithms if they intend to do visual quality control checks of their data. In short, he said, they shouldn't plan to show unregistered Level 2 images in journal articles because they will look funny. He pointed out, however, that the data will not be wrong—the geolocation will be correct, the image will simply not look like what is actually on the ground. The data will need to be resampled.

Fleig said SDST will work with the Science Team on ways to present their data in journals and presentations, etc. He encouraged Team members to share their ideas with SDST. Otis Brown said that he has never published an un-remapped image, he has always had to re-grid the data. However, he said, SDST shouldn't automatically resample all Level 2 data. In short, he feels the Team shouldn't try to find a single common solution to this problem. Fleig responded that SDST simply wants to help the Science Team develop tools for making the images presentable for presentations, not for doing science.

Brown stated that sizing for Level 2 products must now be reconsidered because there will be a dramatic increase in storage requirements. He feels we should either define other ways to store Level 2 products or we should discuss other ways to process image data because the system will no way of describing two-dimensional objects. Fleig disagreed that storage will be a problem because, he said, the images will be compressed for transmission. Brown replied that he is more concerned about latitude and longitude values and quality assessment parameters. Fleig responded that location parameters are only stored once, different parameters will not be assigned to different products.

Brown said he is concerned that 3/4 of the data taken will be over the ocean, which is what will drive the size of the data. Fleig said lossless storage compression will be used so no data will be lost. However, he agreed that the storage format needs to be discussed further.

1.13.3 Volcano Alarm on MODIS

Fleig presented a letter from Peter Mouginis-Mark requesting that MODIS be used as a volcano alarm. Fleig said this could be done quickly and easily without impacting MODIS' data or resources. It would, however, impact EDOS because the data must be transmitted and processed quickly 100 percent of the time. Mouginis-Mark concedes that he will be happy with transmission and processing 70 percent of the time.

One attendee pointed out that there are other possible alarms, such as red tide. If MODIS agrees include a volcano alarm, then there may be additional requests for other alarms. Fleig agreed that that is possible, but he pointed out that the objective behind the MODIS alarm is to get ASTER to point at the volcano whenever possible. He explained that when the criteria for an alarm is met, that information will be put in a file and sent to Mouginis-Mark—MODIS will not send commands to ASTER.

Brown recommended developing the alarm, but not making it a linear part of the MODIS database. That way, if there is a problem, MODIS' official position is that a volcano alarm is not part of their data.

1.13.4 Data Validation and Quality Checks

Masuoka presented the communications requirements for data validation and quality checks (See Attachment X11). He stated that the Software and Data Management Plan will be delivered one time only within the next 6 months.

Masuoka introduced Larry Kline, of Hughes Applied Information Systems, who is working with him on data validation. Masuoka said they are using the ATBDs to determine the relationships between products for sizing and ancillary data requirements. He stated that the Goddard DAAC is responsible for generating all ancillary data.

1.14 MCST Reports

John Barker began his presentation with a discussion of the MODIS Level 1 characterization and calibration algorithm (See Attachment X12). He said their strategy is to use a single calibration algorithm because it must be operative for more than 15 years, for six MODIS instruments. Several calibration methodologies will be implemented throughout the 15-year mission to provide a robust calibration algorithm that can be validated by independent methods.

Barker reported that MCST will use time-dependent radiometric calibration of MODIS' reflective bands to determine the instrument's precision. The solar diffuser will be used several times per month until MCST learns how best to use it. Barker stated that MODIS must have lunar looks, which is not currently funded. He noted that EOS Project is considering adding a roll maneuver capability, but that maneuver will not allow for a direct look at the moon, which is needed for cross calibration of MODIS with ASTER or MISR.

1.14.1 Utility Masks

Barker reported that standard Level 1B utility masks will be used for all bands. These will help the Team process their data. This utility mask will be developed by MCST in collaboration with members of the Science Team. There will be three 64-bit Level-1B images, one for each of the different 250-, 500-, and 1000-m MODIS spatial resolutions. The bits in these images are each masks which will contain either binary or fractional information on each pixel.

1.14.2 Characterization and Calibration Sources

Barker presented MODIS' calibration requirements for radiometric calibration, spectral characterization, and geometric characterization. Barker also discussed MODIS' stability requirements. He introduced Stephen Ungar and Brian Markham as taking the lead on MODIS system performance simulations. The primary purpose of this exercise, he said, is to validate the Level 1 products. MCST concludes that the Ocean Group has

the highest radiometric requirement and the Land Group has the highest spatial requirement.

1.14.3 Bowtie Effect

Barker explained the bowtie effect which will be seen toward the edge of the swath at a 55° slant angle from nadir. Barker stated that this effect may actually improve MCST's ability to do histogram equalization—they may be able to equalize after only a few scans, rather than requiring a full orbit as was originally thought.

1.14.4 Band 29 Study

Based on MCST's studies of Band 29, Barker reported that wafers A and B show similar sensitivity to potential after-launch wavelength shifts. However, wafer B was deemed acceptable and both can provide spectral sensitivity curves.

2.0 ATMOSPHERE DISCIPLINE GROUP MEETING

The MODIS Atmosphere Discipline Group met in two sessions during the Science Team meeting. The meeting was chaired by Michael King. Present were Liam Gumley, Si-Chee Tsay, Mike Abrams, Nahid Khazenie, Paul Menzel, Bruce Wielicki, Anand Swaroop, Steve Platnick, Yoram Kaufman, Ron Welch, Kathy Strabala, Paul Anuta, Bo-Cai Gao, Brian Baum, David Herring, Patricia Henderson, Dave Diner, Ken Brown, and Howard Gordon.

2.1 Flight Requests for Field Campaigns

King reported that he has received more aircraft flight requests than can be funded by EOS. He explained that the cost to use AVIRIS (Airborne Visible and Infrared Imaging Spectrometer) is $52K per flight, in addition to flight fees. MAS (MODIS Airborne Simulator) differs from AVIRIS in that it is funded primarily by the MODIS Atmosphere Discipline Group.

King stated that Kaufman and Menzel's flight requests will both be approved. They will each receive 10 flight hours for a total of 20. Kaufman pointed out that he would like to have more than 10 hours in order to accommodate the Land Group.

Welch asked if he could change his request from using AVIRIS to MAS. King responded affirmatively.

2.1.1 Documenting MAS Features and Uses

King reported that the EOS Program Manager, Frank Muller-Karger, asked the Atmosphere Group to write a document describing all of the features of MAS as well as its uses.

The Group briefly discussed the MAS configuration and the gains on the 3.75-μm channel.

2.2 Technical Reports and ATBDs

King reminded the Atmosphere Group members that they have a contractual obligation to submit monthly, quarterly, and semi-annual reports.

King distributed copies of his ATBD and reminded the Group that they are due. Everyone in the Atmosphere Group reported completing their ATBD. Menzel asked how often Science Team members are expected and allowed to update ATBDs. Kaufman suggested making all ATBDs available in MODARCH.

2.2.1 MODIS Processing and Storage Sizing Estimates

Menzel said he would like to receive feedback on the Teams' sizing exercise. He asked what will be done with the sizing estimates. Kaufman responded that the numbers have already been incorporated into Ed Masuoka's estimates; 25 percent was added to the total number.

2.2.2 Peer Review

King announced that there will soon be an algorithm peer review of all EOS AM instrument teams plus LIS (TRMM) and SeaWinds (ADEOS II). ATBDs will be the basis of the peer review process. King stated that Ghassem Asrar has already conducted peer reviews of each of the 29 IDS investigations. Asrar will report his findings at the next IWG.

King reported that Dixon Butler is also interested in conducting an internal review of the algorithm development process and who is in charge of each step of the process in November of this year. MODIS Team members (with the exception of Salomonson and King) will not be involved in this meeting.

2.2.3 EOS Science Plan

King announced that he will work with the EOS investigators and the Project Science Office to begin to develop the EOS Science Plan this fiscal year.

2.3 MODIS Poster

King announced that SBRC is about to begin a final iteration on their MODIS Poster. He encouraged the Group to review the poster and comment on it.

2.4 MODARCH

King stated that he saw the demonstration on MODARCH (MODIS Document Archive) this morning during the Plenary Session. He said the system looks good and will be useful to the Team.

2.5 Cloud Masking/Screening

King introduced Ron Welch, South Dakota School of Mines and Technology and a member of the CERES, HIRIS and ASTER Teams, who gave a presentation on cloud masking/screening. Welch prefaced his presentation by stating that the cloud masking algorithm should be kept as simple as possible—both for cost and processing. He plans

to use neural networks and fuzzy logic for complex analyses, especially in polar regions.

Welch said his algorithm will require calibrated and navigated data. He was surprised by Al Fleig's talk during the Plenary Session that showed the overlapping of pixels on subsequent scan lines—Welch would like to see geometrically located pixels. He would also like the data to be corrected for geographical location. He explained that not correcting the data will present a problem in doing texture analysis. He concluded that this issue needs further discussion because it will affect the algorithms for all EOS instruments, not just MODIS and CERES.

Welch stated that the DEM (digital elevation model) toolkit presents a problem when trying to produce ecosystem maps. He said he wants ecosystem maps to distinguish surface features.

Welch discussed a number of possible features to be built into the MODIS cloud mask algorithm. The MODIS Team—specifically the Atmosphere Group—needs to communicate to him what features they want. Welch suggested King send him an official letter stating precisely what they need in the cloud mask algorithm.

Kaufman asked if the Group should consider doing atmospheric corrections for cirrus clouds. Bruce Wielicki interjected that before the Group takes on that job, they must determine if they can do it.

Welch asked if dust storms and volcanoes should be incorporated into the cloud mask. King responded that the Land Group and the SWAMP working group are interested in those features. It was agreed to discuss the issue directly with the Land Group during their meeting. Kaufman also expressed an interest in discussing the SCAR-C experiment with the Land Group.

King stated that the Atmosphere Discipline Group must decide how to proceed with the cloud mask algorithm. He noted that John Barker proposed that MCST develop the cloud mask. However, the Atmosphere Group recommends that a group be established to develop the cloud mask, which would include John Barker and Paul Menzel from MODIS and Ron Welch and Brian Baum from CERES.

2.6 Thermal IR Calibration

Menzel briefly discussed his work on the IR mask, which relies on knowledge of SST (sea surface temperature). He said the mask is reliable over oceans, but there are problems with it over land.

Menzel is very concerned about the Thermal IR calibration—he feels it is not being addressed adequately by MCST or SBRC. Wielicki observed that thermal IR calibration should be incorporated into the MODIS design. Ken Brown, of MCST, responded that calibration is done mostly in the reflective bands. He stated that this is not a concern because SBRC is meeting the ghosting requirements of the calibration devices in

MODIS. He explained that MODIS doesn't have the same problems typically associated with thermal IR calibration. All of the reflective technologies used in MODIS are new engineering approaches to reflective calibration.

Menzel referred to the list of concerns on the last page of the handout he distributed during his presentation at the MODIS Calibration Working Group. He asked that those concerns be addressed because they are essential to his products.

The Atmosphere Group concluded early in order to attend the Land Group Meeting to present their ideas regarding development of the cloud mask.

2.7 Cirrus Cloud Detection

At the start of the second Atmosphere Group Meeting, Si-Chee Tsay gave a presentation on his work on radiative transfer in non homogeneous cloud layers. His objective was to assess the impact of horizontal in homogeneity in the remote sensing of cloud optical properties, especially cirrus clouds. Tsay explained that it is extremely difficult to quantitatively infer optical properties of cirrus clouds because the particles are non spherical (hexagonal and other irregular shapes). He also discussed the fact that scattering phase functions of realistic non spherical ice crystals are nonexistent from measurements. Tsay concluded that atmospheric scientists do not understand cirrus clouds very well and further study is needed. King observed that it is possible to measure the shadows of the cirrus clouds. Kaufman stated that he would like to find a way to measure the particles in order to better perform atmospheric corrections.

2.7.1 Thickness of Cirrus Clouds

Kaufman complemented Tsay's presentation with a discussion of his view on measurements of surface reflectance of the solar bands. He advised the Group to prepare for the possibility of having a large fraction of pixels with some cirrus contamination.

Howard Gordon suggested taking the radiance in the 1.38-µm band, converting it into reflectance and then subtracting it from other channels. Kaufman added that more often you see shadows of cirrus than you see cirrus itself. King stated that the Team needs a clear articulation of what Kaufman wants the 1.38-µm band to do.

2.8 Action Items

1. *Atmosphere Group:* At the request of the MODIS Program Scientist, write a document describing all of the features of MAS as well as its uses.
2. *King*: Send Ron Welch an official letter stating precisely what the MODIS Team needs in the cloud mask algorithm.
3. *MCST*: Address the concerns listed by Paul Menzel in his handout distributed during his presentation at the MODIS Calibration Working Group.

3.0 CALIBRATION WORKING GROUP

The Calibration Working Group meeting was chaired by Phil Slater. Present were John Barker, Jim Young, Harry Montgomery, Steve Ungar, Joann Harnden, Al Fleig, Stuart Biggar, Howard Gordon, Bo-Cai Gao, Hugh Kieffer, Paul Menzel, Zhengming Wan, Al McKay, Eric Vermote, Zia Ahmad, Bill Barnes, H.H. Kim, Suraiyer Ahmad, Jean-Claude Rogers, Phil Ardanuy, Tom Goff, Carl Solomon, Lalit Wanchoo, D. Case, Bob Barnes, Ken Anderson, Tom Bryant, P. Smith, John Burelbach, Denise Heller, Dick Weber, Mike Roberto, Ed Hurley, Lloyd Carpenter, Tom Ake, Doug Hoyt, Jon Smid, Marvin Maxwell, Bruce Guenther, Oscar Weinstein, Tom Pagano, Stan Rfeden, Ed Knight, Paul Anuta, Gerry Godden, Bill Bandeen, Glen Schneider, Francis Schiffer, Charles Braun, Jerry Cantril, Geir Kvaran, Ed Masuoka, Ken Brown, and Larry Fishtahler.

3.1 Introductory Remarks

Phil Slater stated that the Calibration Working Group would be conducted in two parts: SBRC and MCST reports in the morning and MCST reviews and Working Group presentations in the afternoon. He said Hugh Kieffer would discuss EOS instruments' requirements for lunar calibration.

Slater said he wants the Working Group to develop a schedule for the Science Team for review of ATBDs, resolve the contamination monitor issue, and the issue of the operating mode for the SRCA.

3.2 MODIS Hardware and Algorithms

Jim Young, of SBRC, reported that SBRC is using multiple calibration approaches (See Attachment X13). He stated that calibration and characterization of MODIS will be done with traceability to NIST (National Institute of Standards and Technology) standards. He stated that pre-launch to on-orbit linkage will be achieved via the SRCA and Solar Diffuser.

Young reported that integration of the engineering model will take place in early 1994. Testing will be conducted late in 1994, and the instrument will be delivered early in 1995.

3.3 Pre-flight Calibration Plan

Young reported that the VIS, NIR, and SWIR detectors are being calibrated using an integrating sphere with respect to NIST. The along-track modulation transfer function (MTF) will be calibrated using the internal alignment collimator and the MODIS ground-based calibrator. He noted that the polarization test does not use normal mirror incidence, for which SBRC will try to compensate. The polarization spec is 2 to 4 percent for MODIS; the source will have less than 1 percent polarization.

3.4 Test Matrix

Guenther asked where SBRC is using their bench test cooler. Young responded that the bench test cooler will be used for every ambient test outside of the thermal vacuum. Spectral characterization will be done by the MODIS ground-based calibrator and monochromator.

Young stated that transient response is a function of crosstalk, ghosting, and the transient response of the instrument's electronics.

3.5 Band Registration Measurement

Young stated that there are three methods for making band registration measurements available: centroid, knife edge, and full width maximum. He noted that for the Thematic Mapper SBRC used the centroid of the line spread function. Therefore, they chose the centroid method for MODIS.

3.6 SRCA

Young reported that the SRCA SIS radiance problem has been solved. Originally, SBRC suspected that the low radiance values were due to spectralon contamination. This was later determined to be false. He noted that the SRCA has three functions: radiometric, spectral, and geometric calibration.

Young pointed out that the quartz-halogen lamp color temperature values were tested at 2700°K, not 2900°K as was advertised. He also noted several design modifications. This change caused a reference change of 1 percent. Barnes asked if there is transmission through the wall. Young responded affirmatively.

3.7 Integration

Young stated that ghosting is measured at the non-scanning level with all MODIS optics in the path. Slater asked why stray light was not discussed. Young responded that SBRC made a change in the MWIR and LWIR focal planes because they need a 5 by 5 pixel illumination centered in a 20 by 20 surrounding for Lmax and Ltypical. In short, they couldn't get full illumination so they got permission to go to 11 by 11.

Young reported that an internal CDR was held at SBRC on Aug. 19, 1993. Their blackbody procurement is complete, assembly of the BCS and SVS has started, and software development for computer control of the blackbody system is progressing to near completion.

3.8 MCST Calibration and Characterization Report

Barker stated that image data may not be used for calibration, but it will be used for characterization (See Attachment X14.1-X14.3). He noted that the vicarious calibration effort is being led by the University of Arizona contingent of the Calibration Group. Integration methods will be developed over time.

Barker stated that Level 1-A and 1-B products will have fixed radiance ranges from Lmin to Lmax for each band. Pagano asked if 1-B data will be corrected for spectral shifts. Barker said no, because no method exists to do so. Pagano suggested taking out the solar change. He stated that SBRC is carrying a term in their error budget for spectral change in solar input and blackbody.

3.9 On-Board Calibration Algorithms

Harry Montgomery gave a presentation on MODIS' on-board calibration (OBC) algorithms (See Attachment X15). He stated that the SRCA will provide spectral, radiometric, and spatial calibration; the solar diffuser, SDSM, and blackbody will provide additional radiometric calibration.

3.10 Implications of Image Scan Geometry

Stephen Ungar discussed the "bowtie" effect of MODIS' image scan geometry (See Attachment X16). He stated that at the edges of a scan MODIS will have twice the look distance for edge pixels than for nadir pixels. Ungar reported that the edge distortion in the along-track direction is due to the doubling of the satellite distance from the target at a slant angle of 55 degrees. The along-scan distortion is further exaggerated by obliqueness of view and curvature of the earth.

3.11 Level-1 Calibration Algorithm

Bruce Guenther gave a brief discussion of the Level-1 Calibration Algorithm. He stated that by December, 1994, the Level-1 Calibration core algorithm will be delivered. He pointed out that the image-based calibration will not be available in the core algorithm, but will be used for characterization. As MCST's confidence in image-based calibration grows they will include it in their core algorithm.

3.12 Level-1 Geolocation Algorithm

Jim Story, SDST, gave a presentation on the Level-1 Geolocation Algorithm. He stated that SDST would like to see an implementation plan, quality assurance plan, prototyping plan, and post-launch analysis plan developed for the geolocation algorithm.

3.13 SeaWiFS Pre-Launch Solar Radiation-Based Calibration

Stuart Biggar stated that the Calibration Group plans to calibrate SeaWiFS on the ground yet duplicating solar conditions in orbit (See Attachment X17). He stated that the solar diffuser is important because it is the only on-board system that can provide a calibration that is full aperture, full field, end-to-end, and at the appropriate radiance distribution and level. The preflight calibration of the sensor/diffuser is important because it is desirable to associate the in-flight calibration with an SI-based preflight calibration. Any sensor with a solar diffuser can be calibrated preflight using the sun as the source, Biggar explained. He also discussed ways to minimize errors in their calibration method, as well as advantages and disadvantages.

3.14 Inclusion of the F_0 Error

See Howard Gordon's presentation (Attachment X18).

3.15 Pre-launch IR Calibration Information

Paul Menzel stated that for MODIS cloud applications, radiances must be accurate to better than 0.25 $mW/m^2/ster/cm\text{-}1$ in the LWIR and 0.004 in the MWIR. He discussed his ideas on in-orbit calibration for IR bands (See Attachment X19).

3.16 NIR Water Vapor Algorithm

Bo-Cai Gao reported that there is a water vapor error in MODIS due to an error in the three-channel ratio. He explained that a 1 percent error in the channel ratio results in a 2.5 percent error in water vapor retrievals. Gao used AVIRIS data to conduct his analyses. (See Attachment X20.)

3.17 MODIS Lunar Calibration

Hugh Kieffer discussed the advantages in using Lunar Calibration: the moon is a source of solar radiation, it is stable and uses no gadgets, and it is accessible by everyone. The primary disadvantages are varying radiance levels and platform attitude. (See Attachment X21.)

3.18 Thermal Calibration

Zhengming Wan noted that NOAA-12 AVHRR Channel 4 is subject to errors of a few degrees Kelvin where sun glint occurs because of its out-of-band response. He stated that the reflected solar beam radiation in the 8 to 13-µm spectral range is almost negligible. The VIS solar radiation may be 10^2 larger than thermal radiation at 300°K in MODIS bands 31 and 32, and 10^3 larger than the thermal radiation in band 20.

Additionally, Wan stated, there are uncertainties in AVHRR geolocation which may be up to 30 km cross track; variability depends upon scanning angle, spacecraft height and attitude, and surface elevation.

Wan recommends including the VIS and NIR ranges in the system level out-of-band response of thermal IR bands to assure that radiometric accuracy requirements are met. He also urged the Calibration Group to find ways to calibrate the thermal IR bands for fire detection in the high temperature range. (See Attachment X22.)

3.19 Action Items

See Phil Slater's handout (Attachment 9.)

4.0 LAND DISCIPLINE GROUP

The Land Group Meeting was chaired by Chris Justice. Present were Alan Strahler, Alfredo Huete, Steve Running, Dorothy Hall, Vern Vanderbilt, Philip Teillet, Dave Diner, Tom Mace, David Toll, Dave Meyers, David Shirey, Edward Masuoka, Eric Vermote, Steve Ungar, Piers Sellers, John Barker, Michael King, and Yoram Kaufman.

The MODLAND (MODIS Land) Group met during the afternoon of Thursday, Sept. 30 and the morning of Friday, Oct. 1. The session recorder was David Toll. The primary issues discussed were radiometric calibration, geolocation, test sites, and algorithm development.

4.1 Radiometric Calibration

Wan expressed concern that the MODIS 3.95 mm band at high temperatures may saturate and requested a complete calibration before launch. In addition, Wan said the "visible and near-IR for the system level out of band response" of the thermal bands

should be included to assure meeting the radiometric accuracy requirements. E. Vermote requested the MCST to address issues associated with vicarious calibration procedures using off-nadir sensors. The AVHRR could be used to develop and test these procedures.

4.2 Geolocation

Justice said that MODLAND requires a 0.1 of a 1 km pixel (2 sigma) registration specification. Fleig is to produce a geolocation requirement document for coordination with MISR (Diner) at the next SWAMP Meeting (Nov. 15, 1993). The MODIS contribution to the SWAMP report will be reviewed by John Townshend (UMd). Diner would like to have as much geolocation correction at the sensor and platform level and reduce the amount of correction required in ground processing. In addition, he stressed the need for a close cooperation between ASTER, MISR, and MODIS on geolocation requirements. Fleig also will provide static versus dynamic requirements for the PM-1 platform. Justice requested Weber to have SBRC examine the cost and feasibility of angular displacement sensors on MODIS and EOS-AM.

4.3 Test Sites

Running reported on the MODLAND links to LTER sites discussed at the NSF LTER Meeting. He is coordinating inputs from LTER groups to submit a proposal to NASA HQ for funding directly to LTER investigators. The LTER groups (perhaps four to eight) will collect data useful for MODLAND science. MODLAND will assist Justice to prepare a plan for Wickland (NASA HQ) and NSF regarding potential LTER data coverage (e.g., aircraft data and Sun photometer network). Justice will coordinate possible MODLAND/LTER over-flights and contact NASA HQ (Wickland) for possible MODLAND piggyback flights associated with the planned Sept. 1994 SCAR-California experiment (includes MAS).

Tom Mace said he would provide MODLAND input on EMAP test site activities and access to EMAP newsletters. Steve Ungar reported on the limited capability to provide MAS coverage for BOREAS, if there is not a modification to convert the sensor to fly on the NASA C-130 plane instead of the high altitude and limited land sensing capability of the ER-2 plane. Running, Hall, and Strahler will attend the next BOREAS meeting and coordinate MODLAND inputs to the experimental design.

Dave Meyers from EDC gave a presentation on EDC DAAC activities. MODLAND requested a review of their raw 1-km data needs and data costing with EDC. Muller said MODLAND is concerned about ASAS data availability constraints through GSFC and recommends the data come from a DAAC. NASA HQ is asked to give the current plans for integration of ASAS data in the DAAC system. (See Attachment X24.)

4.4 Algorithm Development

Welch and King gave a presentation to MODLAND on cloud utility algorithm development. MODLAND recommends Barker and King to develop and integrate plans for the cloud mask utility program. MODLAND would like a dialogue with MCST regarding utility algorithm developments.

MODLAND will provide an internal review of each others ATBDs in the next three months. Sellers said MODLAND should emphasize data links with other sensor products when doing the ATBDs.

Muller will coordinate MODLAND DEM related activities in the context of the SWAMP DEM group. He should contact Bailey at EDC regarding MODLAND input.

MAST should consider using MODARCH to include critical on-line reference papers.

4.5 MODIS Future Activities

MODLAND will have a land cover focus meeting on March 28-29, 1994 in Tucson, Arizona. Wan will attend the next ASTER system design review in Japan this November. Sub-group meetings are also planned for MODLAND members to further develop research strategies for the vegetation index, BRDF and atmospheric correction products.

4.6 Action Items

1. *Running*: Coordinate MODIS LTER test site land cover activities and related proposals. Chris Justice and Eric Vermote will coordinate LTER Sun photometer and atmospheric correction initiatives for MODLAND.
2. *Tom Mace*: Provide MODLAND with EMAP test site activities and access to EMAP newsletters.
3. *MODLAND (esp. D. Hall, A. Strahler and S. Running)*: Coordinate MODLAND and BOREAS interactions, including MAS needs.
4. *MODLAND*: Develop a MODLAND plan for LTER data utilization. Justice will contact Diane Wickland and NSF regarding coordinating potential LTER airborne and satellite coverage.
5. *Ungar*: Pursue with Michael King to evaluate possibility of modifying the MAS for placement on C-130 to significantly increase data collection of MAS data at BOREAS.
6. *MAST*: Provide MODLAND a copy of ATBDs for internal review. MODLAND to review each others ATBD in the next three months.
7. *D. Meyer*: Report to EDC on MODLAND requirements for raw global 1-km data archive for test site algorithm development.
8. *P. Muller*: Coordinate MODLAND DEM related activities in the context of the SWAMP DEM group and contact Bailey (EDC) regarding MODLAND input.
9. *MODLAND*: Determine if Ethernet is suitable for data transmission volume, and if not develop alternatives with SDST for enhanced communications. Also, SDST should examine links to international stations (e.g., J-P Muller).
10. *Barker and King*: Discuss role of MCST in developing the cloud masking utility algorithm.
11. *Weber*: Evaluate the implications for angular displacement sensors on MODIS and EOS-AM.
12. *Justice*: Provide inputs on science rationale for 0.1 pixel geolocation accuracy (science rationale) to Al Fleig. Fleig will provide a geolocation requirements document

for coordination by MISR (Diner) at the next SWAMP Meeting. Fleig will also provide static versus dynamic requirements for the PM-1 platform.
13. *Wan*: Attend ASTER (system design review) meeting in Japan.
14. *MCST*: Interact with MODLAND regarding utility algorithm developments.
15. *MODLAND*: Review ATBDs associated with joint products.

5.0 OCEANS DISCIPLINE GROUP MEETING

The Oceans Discipline Group meeting was chaired by Wayne Esaias, and attended by Mark Abbott, Ken Carder, Robert Evans, Howard Gordon, Frank Hoge, and Otis Brown (team members), Frank Muller-Karger (HQ), Chuck McClain, Bill Barnes, Lloyd Carpenter, and Locke Stuart (Executive Secretary).

Esaias went over a proposed agenda for approval by team members. Wayne noted that several investigators will be missing, or only around for a limited time tomorrow.

5.1 Continuity of SeaWiFS Funding through MODIS

Otis Brown requested a discussion of the MODIS / SeaWiFS transition—particularly the continuity of support funding. Esaias asserted that the current budget posture will make it doubly hard to do both. Requirements for additional funding need to be recommended to NASA Headquarters. Chuck McClain agreed that the budget drops precipitously next year. Substantive discussion ensued about the transfer radiometer, and the Round Robin calibration procedure. While neither should be tied exclusively to MODIS, both should be fully supported by NASA, for SeaWiFS, MODIS, and COLOR. Various approaches to sources of funding were discussed, including interaction with NASA Headquarters and the MODIS Calibration Group.

5.2 SeaWiFS

5.2.1 Kieffer Problem

Kieffer has no funds in FY94, however, the Oceans Group depends on his lunar calibration work. HIRIS has supported Kieffer, but funding for HIRIS disappears after FY94. Some discussion addressed the value of lunar calibration to oceans work, and it was generally agreed that it was not needed for SeaWiFS. Esaias felt that there was a definite need for in-orbit lunar calibration for MODIS, to map long-term changes. Esaias wants the Oceans Group to go on record as being supportive of Kieffer's efforts.

5.2.2 Recommendation on Repeating Solar Observations

There was a group consensus that solar observations *via* the solar diffuser are important in the pre-launch environment. SBRC should be encouraged to repeat their measurements.

5.2.3 Approach to Hosting Correction / Masking

Barnes has started an out-of-band ghost image study. Ten-pixel clouds show ghosting effect. Forty counts at five pixels away from the cloud edge is determined to be the worst case. The nominal case is five counts at five pixels away. It is not currently clear

how much time will be available to exercise further correction before launch. One possibility is to build a crude, conservative mask, and correct through ground processing after launch. Gordon is concerned that a single pixel cloud cannot be mapped. Muller-Karger felt that there would not be too much contamination from a single pixel cloud. Brown wanted to know the point spread function, and Gordon felt it imperative to have that information before launch. Looking at small (1 pixel) clouds gave ambiguous results. Esaias suggested looking at small clouds after launch, and making any necessary correction in the ground data processing.

5.2.4 Algorithm Implementation Review Date

The algorithm implementation review date will probably be coupled to MCST's ATBD review, so team members won't have to travel to GSFC on two separate occasions. The date will be set as soon as MCST sets their ATBD review date.

5.2.5 Data Products

There is still a need for a reflectance-related product. McClain hopes to resolve the issue in early November. Are archivable products the best SeaWiFS can provide? McClain is not convinced that water-leaving radiance at 443 NM is the best that can be archived. All agreed that archiving water-leaving radiance was absolutely necessary. McClain explained that the data quantity issue is not at Level 2; but at Level 3. Esaias identified this as more than just a SeaWiFS issue, and related its effect to the DAAC. Further discussion followed on the group's perception of the most critical products, and their data volume requirements.

5.3 MODIS Data Products & Algorithms

Otis Brown felt it important that MODIS data products show a substantial improvement over previously available products. Ken Carder felt that SeaWiFS Case 1 Chlorophyll_a will transition nicely to MODIS. Esaias mentioned several other products, including sea surface temperature and photosynthetically active radiation, that could be reasonably upgraded to MODIS. Frank Muller-Karger mentioned that dissolved organics should be included. All felt that Level 1 products would be delivered. While CZCS pigments were considered crude, it was felt necessary to do the product, in order to be able to compare MODIS to CZCS. Fluorescence and productivity are also planned above Level 1. There was a general agreement to delete backscattering coefficient, since it would be used only for coccolith concentration.

5.4 Quality Analysis Data Requirements

Masuoka requested to know what datasets were needed for quality evaluation. Brown stressed the need for interteam network data transfer, which Esaias felt needs to be couched in an ATBD.

5.5 Interteam Network Data Transfer

Generally the meaning of "quality analysis" is poorly understood. In the past it has been usual to archive data, and warn the user that the data have not been quality evaluated. It is suspected that this caveat will initially hold for MODIS as well. Some discussion of SeaWiFS quality analysis ensued, wherein it was determined that it is the

responsibility of each investigator to put together the requirement. Running global climatology, such as is being done by Pathfinder, is considered a good comparison for quality check. It was agreed that speed is important—a pixel-by-pixel check seems unlikely and impossible.

5.6 ATBD Schedules

Gordon and Abbott averred that they had submitted their ATBDs, Brown is close, and Evans is writing his. Esaias took this opportunity to discuss peer review, which will be a formal review of all instrument team members' algorithms. Current planning calls for such a review In the Spring. Esaias is open to suggestions; he wants a uniform procedure. Each team member will be invited to discuss his ATBD. Mike King wants to formalize the process. Carder was concerned with the requirement in light of the heavy SeaWiFS activities. On the other hand, Brown saw some advantages to peer review. Gordon wanted to understand the purpose of the peer review Esaias suggested that review comments be directed to king@climate. Gordon stressed the importance of a peer review; he wants to present to those who are knowledgeable. Abbott felt that each team member should be responsible for setting up his own review committee—each individual knows best who's right to judge. Brown suggested scheduling a meeting with King to discuss plans and procedures.

5.7 Comments on Barker's MODIS Level 1 ATBD

Substantial discussion ensued, with the heart of discussion centering on the value of the planned correction procedures to Oceans. It was generally felt that Land and Atmospheres benefit to a much greater extent than Oceans, that calibration costs are excessive and that a portion of the money could be better devoted to a transfer radiometer. Infrared calibration methodologies were disputed, and the need for non-linear correction emphasized. Integer scaling from 12 to 16 bits, striping, and histogram equalization were discussed in light of understanding the precision of sensor measurements. Esaias saw resampling to 1 km as a problem and does not want fill for dead detector. Brown reminded the group that picture use is minor and that good, unbiased estimates are needed to fill in data, according to reasonable mathematical principles. Evans questioned the assumption that emissivity of the black body remains constant. Esaias stressed the need to concentrate on converting counts to radiance.

5.8 Atmospheric Correction Comments

Esaias felt that correction could be applied on an every other pixel basis. Gordon felt that processing power was sufficient to handle full scene correction.

5.9 EOS COLOR Issues

COLOR was addressed as the follow-on to SeaWiFS. As such, the project should be funded beginning in FY95, with a planned launch in 1998. Chuck McClain, Project Scientist, talked about several issues. He put together a proposal to do COLOR within the Laboratory for Hydrospheric Processes and presented it to Dr. Klineberg. McClain requested that a project manager and deputy (data systems person) be appointed quickly. This is a problem since so much of management is tied up in EOS and SeaWiFS. The SeaWiFS project would transition into COLOR as SeaWiFS phased down.

McClain addressed some of the characteristics of the COLOR mission, and contrasted it to SeaWiFS. As is the case with SeaWiFS, COLOR will be a data buy. A 1-km resolution, 12-bit system is recommended, but it was understood that NASA Headquarters is reluctant to approve the 12-bit system on the basis of the increase in data quantity. Bilinear gain is recommended, and should make the mission attractive to non-ocean users. The ghosting problem will be addressed by tightening up the RFP specifications, and a "tight" stray light specification will be written when we go out with the RFP, to reduce ghosting. Larger recorders are in the offing, and the total spacecraft may end up being too large for a Pegasus launch. It is hoped that COLOR data collection will overlap SeaWiFS by 6 months. Muller-Karger noted that a benefits and needs study is important.

There was some concern that the source of funding for SeaWiFS and MODIS complementary products had not yet been determined. It was felt that this was an issue which Management has avoided, and that the viability of the SeaWiFS mission, and subsequent value to MODIS and COLOR, is being handicapped.

McClain noted that the COLOR Announcement of Opportunity would support a small (6-7 researchers) instrument team. Muller-Karger noted that this is not a science team, but rather an inst. team in the fashion of MODIS. If a MODIS team member wants to compete, he will have to give up MODIS, according to Ghassem Asrar. Muller-Karger further expounded that the COLOR team would address calibration / validation issues, and maybe some algorithm development. The Oceans Discipline Group decided that they should offer a formal statement that they are failing to see expected progress on allowances for data and project management.

Finally, it was felt that COLOR would have to rely heavily on MODIS' algorithm development and calibration / validation experience, and that products should be compatible with MODIS.

5.10 MODIS Ocean Interaction with Foreign Missions

The NASA relationship with Japanese Research Announcement was explored. Should SeaWiFS / MODIS members respond jointly, or individually? Muller-Karger responded that all SeaWiFS team members want data from OCTS, GLI, and MERIS.

There was some discussion on the source of Japanese data: should it be obtained directly by team members from Japan or should the DAAC provide data in accordance with descriptions set forth in team members' ATBDs. While there was some disagreement, it was generally felt that obtaining data through the DAAC was more efficient.

Regarding MERIS, Mike Brass would like Vince Salomonson to designated an official representative between MODIS and MERIS. There is an Oct. 17 MERIS meeting. No MODIS liaison has been appointed. It was conceded that someone from the MODIS Science Team should attend and report back to the MODIS team.

5.11 Payload Panel Inputs

A SeaWiFS Payload Panel meeting is scheduled for next week. The Oceans Group will be represented there.

5.12 Surface Truth Calibration

Gordon asked how Clark's data would be used. The Oceans Group agreed that a firm plan is needed and that Clark's data need to go into some kind of program that automatically updates calibration. Evans noted that all calibrations will be done retrospectively, if Clark's data are used.

5.13 White Paper

Australia has responded in reviewing the paper. Abbott now needs to review it. Muller-Karger stated that he would like to see a discussion of high resolution spectrometry in the paper. Operational needs of other agencies show a need for good spectroradiometric data. Brown stated the need for a full spectral sensor of some sort, which can really do color in an objective, non-manual way. Hoge felt that spectral resolution is much more important than spatial resolution: spectral diversity demands it. Carder averred that all sensors are being driven by land requirements, to high spatial resolution. Oceans researchers need an opening into hyperspectral resolution.

5.14 Talks

Brown was designated as the presenter at the next MODIS Science Team meeting and will address sea surface temperature.

5.15 Action Items

1. *Salomonson*: At Mike Brass' request, designate an official representative between MODIS and MERIS.

6.0 FINAL PLENARY

Salomonson announced the dates of the next MODIS Science Team Meeting—April 13-15, 1994. The Calibration Working Group will meet April 12; both meetings are at GSFC.

6.1 MISR Reports

Dave Diner announced that the MISR PDR (Preliminary Design Review) was held in May, during which their calibration peer review was conducted. MISR is a nine-camera instrument with a pushbroom scan direction. Diner showed a list of the instrument's parameters and showed an illustration of its camera and calibration photodiode layout (See Attachment X24). The engineering model is currently being built at JPL. Diner explained that the MISR design enables flexible science by providing two operating modes: global and local. The global mode includes any combination of averaging configurations in the 36 channels which can operate continuously without violating data rate allocation. The local mode includes sequential inhibition of averaging in the four bands of all nine cameras to provide high-resolution data in all 36 channels for

selected ground targets. Diner said he is putting together a database of local mode targets which he can share with the MODIS Team.

Diner showed a list of MISR's top of atmosphere (TOA), cloud data products, and aerosol data products. He stated that MISR may use MODIS' cloud altitude data, and MODIS may want to use MISR's stereo capability to measure cloud altitude. He showed sample data from Howard Gordon's work on aerosol retrieval over oceans.

Diner asked for input from MODIS on the EOS AM platform's requirements for image geolocation, pointing, and registration. He said MODIS' requirements are similar to MISR's. He feels that putting a tighter specification on the platform is not needed. According to Diner, to meet the 100-m geolocation knowledge, the pointing knowledge must be around 10 arc-seconds. Currently, the spec is around 15 arc-seconds.

Diner stated that MISR cannot generate Level 2 products until it is geographically registered, which is not a requirement for MODIS. Salomonson asked how resampling will affect the instrument's radiometry. Diner responded that MISR is only promising 2-km products. The finer the resolution, the greater will be the impact of misregistration.

Salomonson asked how MISR is proceeding on coding. Diner responded that MISR has just begun simulation exercises; they expect to have simulated datasets by the end of this year.

6.2 ASTER Reports

Mike Abrams gave an update on ASTER in Simon Hook's absence. He feels that ASTER and MODIS need to work more closely together in developing their datasets.

Abrams stated that the American contingent of the ASTER Team has no control over the instrument's calibration because the instrument is being built by the Japanese. He said there have been problems in dealing with the Japanese due to cultural differences, which they are working to overcome. He said ASTER consists of three different instruments integrated as one, to which the American ASTER Team was opposed.

Abrams reported that ASTER has a good working relationship with the MODIS Land Group. They are collaborating on their test site efforts to ensure there is no redundancy.

6.3 Calibration Group Summary Report

Phil Slater gave the Calibration Group's Final Plenary report (See Attachment 9). He requested that GSFC and SBRC review and respond to the various issues raised in the handouts presented at the Calibration Working Group by Paul Menzel and Zhengming Wan. He discussed the list of Calibration action items.

Salomonson asked if the Calibration Group has evaluated the risks involved with lunar viewing. Slater responded negatively, stating that this topic will be explored further. Salomonson added that the lunar viewing capability must be weighed against the risks

of reorienting the platform. Slater responded that there are other issues to consider as well; for example, cooling may be a problem. Esaias interjected that no decision should be made until SeaWiFS data become available.

Slater said there is considerable interest in including contamination monitors on the AM-1 platform both to determine the initiation, frequency and duration of solar-diffuser and scan-mirror door deployment, and also to help diagnose the degradation and change in calibration of the various optical sensors. Slater feels that contamination should be monitored at all times on MISR and ASTER as well.

The Calibration Group recommends that the system-level specification be rewritten for the out-of-band (OOB) response of some filters that presently have a 5 percent requirement. The latter is inconsistent with the radiometric calibration uncertainty specification.

Slater stated that the present round-robin cross calibration activities for SeaWiFS will conclude this year. He feels that MODIS should adopt a similar cross-calibration strategy.

6.4 Atmosphere Group Summary Report

King announced that the Atmosphere Group will collaborate with CERES on producing cloud mask algorithms. He said that particularly Bruce Wielicki, Brian Baum, and Ron Welsh will be asked for their input. He said there was a meeting last week in Denver on how the two teams will interface their algorithms. At that meeting Piers Sellers assigned Wielicki the task of coordinating the cloud masking efforts.

King said that IR calibration is a concern. Paul Menzel will work closely with the MODIS Calibration Group on this issue.

King stated that the scattering properties of cirrus clouds are a major uncertainty in understanding cloud-radiation interaction. He explained that there are no good measurements of size distribution of the non-spherical ice crystals in cirrus clouds. He feels that the 1.38-µm channel will help gather these data, but the algorithm used will be state-of-the-art.

All Atmosphere ATBDs have been completed, but have not all been distributed yet. He explained that ATBDs were first done by the UARS (Upper Atmosphere Research Satellite) Team, which had their software generated 5 years before launch. King stated that all teams within EOS will be asked to produce ATBDs. He said there will be an EOS-wide software and science review within the next fiscal year.

King reminded the MODIS Team that code is due to SDST in January, 1994. The Atmosphere Group is on schedule to deliver prototype code during the first quarter of 1994.

King stated that the Atmosphere Group is committed to participating in the SCAR-C field campaign next year. He reported that the flights have already been approved. There will be some cirrus experiments during SCAR-C. The MAS instrument will be enhanced prior to SCAR-C—it will have 50 channels.

6.5 EOSDIS Rapid Processing

Piers Sellers briefly discussed quick look requirements for EOS data. He explained that the idea is to allow EOS data users to shop through small segments of data shortly after it is acquired; however, he said, adding this capability will be very expensive. He observed that the Land and Atmosphere Group don't need quick look capability. Esaias state that as long as there is some quick readout capability for locating and tracking anomalies, the Oceans Group doesn't need quick look data. Dave Diner added that some quick look capability is required for MISR. They need access to data within 1-2 hours of the satellite's scan.

Barker stated that he had assumed quick look data was a flight operations issue because it is not a cost issue; there is, however, a transmission issue. Fleig added that there were constant requests for quick look data from the Nimbus Team. Moreover, he said, quick look capability will add relatively little cost.

6.6 Land Group Summary Report

Chris Justice reported that all Land ATBDs are completed and will undergo internal review and revision by MODLAND within the next 3 months, prior to external distribution. (See Attachment 10.)

Justice stated that the Land Group is concerned with the pre-launch calibration of the 3.95-µm channel. Also, they are soliciting ideas on calibrating MODIS after launch. He feels MCST should address the issues associated with vicarious calibration using off-nadir sensors.

Regarding geolocation, Justice stated that MODIS' will be better than AVHRR. However, the Land Group wants to explore options for improving geolocation accuracy through ground processing. MODLAND requires 0.1 of a 1-km pixel. Justice asked SDST and MCST to develop options and associated budgets for ground processing to meet their registration requirement. Additionally, he feels that angular displacement monitors on instruments should be evaluated to address high frequency jitter.

Salomonson asked if there is funding for sun photometers to be used in the Land Group's LTER (Long-Term Ecological Research) test site initiative. Justice responded that the National Science Foundation has offered to fund four initiatives for LTER sites. Justice feels that a global network of sun photometers is necessary to provide precursor data.

Justice reported that the Land Group plans to use MAS data taken over California in February, 1994. Currently, only 10 flight hours are allocated. The Land Group would like to fly MAS aboard the C-130.

Justice stated that data access is a concern—the Land Group has had problems getting data from the DAAC due to the considerable cost. Justice said he would like to see a comprehensive bibliography in MODARCH of all MODIS-related journal articles. Janine Harrison said that including copyrighted materials prepared by non-MODIS Team members in the archive presents a legal concern which she is pursuing.

6.7 Oceans Group Summary Reports

Regarding data products and ATBDs, Wayne Esaias reported that the Oceans Group has changed its CZCS Pigment product to Chlorophyll_a concentration and has deleted the backscatter product. He explained that Howard Gordon will concentrate on his whitecap corrections and aerosol effects algorithms. He announced that the Ocean ATBDs are progressing. (See Attachment 11.)

Esaias commended MODIS Project and SBRC for resolving the ghost image problem. He is looking forward to reviewing the test data on their ghosting solutions.

Regarding the Level 1 Radiance Calibration ATBD, Esaias stated that the Oceans Group will produce a list of comments which they will forward to Bruce Guenther and John Barker. He stated that there needs to be some non-linear terms in the thermal bands.

He reminded the Team that the SeaWiFS launch is only a year away; funding for SeaWiFS will decline drastically after this year. Additionally, the round-robin calibration / validation efforts decline after 1994. He said the Ocean Group will work to ensure that there is continuity in their algorithm development from SeaWiFS to MODIS. Esaias feels that MCST should take the lead in incorporating recent improvements in calibration technologies.

Esaias stated that EOS Color remains an essential component of EOS; however, not much progress has been made in determining how its data will be handled or how the mission will be approached since the last Science Team Meeting. For example, Color doesn't even show up in any EOSDIS data charts—there is a need to begin management and data processing planning for that mission.

Esaias said there needs to be more interaction with non-United States GCI missions. He feels that the Japan-U.S. Working Group on Ocean Color (JUWOC) initiative is working well. Also, the OCTS interactions have been well-coordinated—agreements have been made on data and software exchange, as well as cal / val interactions.

Esaias stated that some quick look data is required for effective planning of cruises to obtain calibration data. The Oceans Group will need some quick look data within 24 hours of acquisition, and they will need it on several bands. Fleig observed that Level 0 data arrives during processing 21 hours after acquisition, and Level 1 data is available another 24 hours later.

6.8 Closing Comments

Dick Weber stated that he is pleased with the progress being made by the MODIS Team overall. His primary concern is watching costs.

Salomonson said he wants to make the Science Team Meetings as efficient as possible and encourage attendees to offer suggestions. He also encouraged the MODIS Team to access MODARCH now that it is on-line and will be steadily inputting new MODIS documentation, such as ATBDs.

Salomonson also reminded the Team that ATBDs are due and should be submitted as soon as possible for peer review. The next MODIS Science Team Meeting will be held April 13-15, 1994, at GSFC.

6.9 Action Items

1. *Masuoka*: provide a schedule of when simulated data will be available and work with Barker on software development for data simulation.
2. *GSFC and SBRC*: review and respond to the various issues raised in the handouts presented at the Calibration Working Group by Paul Menzel and Zhengming Wan.