MODIS SCIENCE TEAM

MEETING MINUTES

October 27 - 29, 1992

NASA / Goddard Space Flight Center
Greenbelt, Maryland 20771

Prepared by: Science Systems and Applications Inc.

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October 27 - 29, 1992

TABLE OF CONTENTS

MODIS SCIENCE TEAM MEETING MINUTES

October 27 - 29, 1992

LIST OF ATTACHMENTS

(Note: The following attachments were selected to complement this summary of the MODIS Science Team Meeting Minutes—they are only part of the full set of attachments presented at the meeting. In the following list, the letter "V" indicates that that attachment was presented as a viewgraph and "D" indicates that attachment was presented as a document. Copies of the full set of Minutes or full set of Attachments are available in the MODIS Archive and can be obtained by contacting: David Herring; Code 920; NASA/GSFC; Greenbelt, MD 2077; or calling (301) 286-9515.)

1. Meeting Agenda and Meeting Objectives	V	Vince Salomonson
2. EOS Project Status	V	Michael King
3. EOS AM-1 Spacecraft Milestone Schedule	V	Chris Scolese
4. MODIS Descope Candidates	V	Dick Weber
5. MODIS Level-1 Code Development Schedule	D	Al Fleig
6. MCST Report on Possible MODIS Instrument Changes	D	John Barker
7. MODIS Reflective and Emissive Bands	D	John Barker
8. MOCEAN Group Report	V	Wayne Esaias
9. Atmosphere Group Report	V	Michael King
10. MODLAND Group Report	V	Chris Justice
11. Calibration Group Report	V	Phil Slater
12. Summary of Main Topics of Discussion	V	Vince Salomonson

MODIS SCIENCE TEAM MEETING MINUTES

October 27 - 29, 1992

LIST OF ATTENDEES

The following persons attended the MODIS Science Team Meeting. Those flagged with "**" are members of the MODIS Administrative Support Team (MAST). (Telephone numbers could now be outdated.)

Attendees	Affiliation	Phone Number
1. Mark Abbott	Oregon State University	503-737-4045
2. Steve Ackerman	University of Wisconsin	608-263-3647
3. Russ Abbink	Sandia National Labs	505-845-8351
4. Vern Alferd	SBRC	
5. Carol Andrews		
6. Paul Anuta		301-286-9412
7. Phil Ardanuy		
8. Ros Austin	San Diego State University	
9. Joe Banacho	SBRC	
10. John Barker	NASA GSFC	301-286-9498
11. Bill Barnes	NASA GSFC	301-286-8670
12. Stuart Biggar	Optical Sciences Ctr.	602-621-8168
13. Francesco Bordi		
14. Jim Butler **		301-286-4606
15. J. Campbell		
16. Lloyd Candell	SBRC	
17. Kendall Carder	University of South Florida	813-893-9148
18. Dave Carneggie	Department of the Interior	605-594-6059
19. Moustafa Chahine	JPL	818-354-6057
20. Edward Chang		
21. Dennis Clark	NOAA/NESDIS	301-763-8102
22. Titus Clay	San Diego State University	
23. Barbara Conboy **	NASA GSFC	301-286-5411
24. Bob Curran		
25. John Davis		
26. Dave Diner	JPL	818-354-6319
27. Rod Durham	SBRC	
28. Andy Endal		

29. Wayne Esaias	NASA GSFC	301-286-5465
30. Bob Evans	University of Miami	305-361-4799
31. John Figoski	SBRC	
32. Larry Fishtahler		
33. Al Fleig	University of Maryland	301-286-7747
34. Bo-Cai Gao		
35. Howard Gordon	University of Miami	305-284-2323
36. Bruce Guenther	NASA GSFC	301-286-5205
37. Liam Gumley	RDC	301-982-3748
38. Dorothy Hall	NASA GSFC	301-286-6892
39. Joann Harnden	NASA GSFC	301-286-4133
40. Janine Harrison **	NASA GSFC	301-286-5324
41. Patricia Henderson **	SSAI	301-286-9291
42. David Herring **	SSAI	301-286-9515
43. Simon Hook	JPL	818-354-0974
44. Paul Hubanks		
45. Alfredo Huete	University of Arizona	602-621-3228
46. Tony Janetos	NASA HQ	202-358-0274
47. Chris Justice	NASA GSFC	301-286-7372
48. Anne Kahle	JPL	818-354-7265
49. Yoram Kaufman	NASA GSFC	301-286-4866
50. Michael King	NASA GSFC	301-286-8228
51. Okada Kinya	JPL	
52. Brian Krupp		
53. Tom Mace	EPA HQ	202-260-5710
54. Jim Maslanik		
55. Ed Masuoka	NASA GSFC	301-286-7608
56. Paul Menzel	NOAA/NESDIS	608-264-5325
57. Jim Muller	San Diego State University	
58. Frank Muller-Karger		
59. Evlyn Novo		
60. Harold Oseroff **	University of Maryland	301-286-9538
61. Tom Pagano	SBRC	805-562-7343
62. J.J. Pan		
63. John Parslow	CSIRO, Australia	61-02-206202
64. Samuel Pellicori	SBRC	
65. Lisa Rexrode		301-286-6614
66. Steve Running	University of Montana	406-243-6311
67. Vince Salomonson	NASA GSFC	301-286-8601
68. Carl Schueler	SBRC	
69. Chris Scolese	NASA GSFC	301-286-9694
70. Yosio Shimabukuro		55-123-229977
71. Phil Slater	University of Arizona	602-621-4242
72. Alan Strahler	Boston University	617-353-5984
73. Locke Stuart **	NASA GSFC	301-286-6481

74. Didier Tanre	Laboratoire d'Optique Atmospherique	33-20-434532
75. Phil Teillet	Canada Centre for Remote Sensing	613-952-2756
76. C. Trees		
77. Si-Chee Tsay		
78. Steve Ungar		
79. John Vampola	SBRC	
80. Eric Vermote		
81. Michel Verstraete	CEC Joint Research Ctr.	39-332-785507
82. Zhengming Wan	University of California	805-893-4541
83. Dick Weber	NASA GSFC	301-286-5992
84. Jim Young	SBRC	

AGENDA

MODIS SCIENCE TEAM MEETING

October 27-29, 1992; Santa Barbara, CA

Tuesday, Oct. 27:

0800: Registration
0830: Welcome & MODIS Overview---------------------------------V. Salomonson
0850: Headquarters' Perspective --- A. Janetos
0930: EOS Project Status--M. King, C. Scolese
1000: BREAK
1015: SBRC Perspective & PDR Summary------------------L. Candell & T. Pagano
1200: LUNCH
1300 - 1730: Descope Discussions --------------D. Weber, V. Salomonson, SBRC
(These discussions will center on the instrument and product descopes.)
1730: CLOSE DAY 1 PLENARY
1930 - 2200: Discipline Group Meetings (optional)

Wednesday, Oct. 28:

0800: MAST Report---L. Stuart
0830: MCST Report and Algorithm Status---------------------------------J. Barker
0945: BREAK
1000: SDST Status Report-- A. Fleig
1100: Peer Review and Interdisciplinary Interactions-------------V. Salomonson
(Merging IDS investigators and other Team leaders w/MODIS Team.)
1200: LUNCH
1300 - 1730: Discipline Group Meetings ------------------------------ All Afternoon
Groups meet in assigned conference areas. Discussions should center on Descope/Instrument and Descope/Products.
1530-1700: Tour of Santa Barbara Research Center (Optional) ------------- SBRC
(MODIS Science Team members only)
1800: SOCIAL - Catered
1930 - 2200: Discipline Group Meetings (optional)

Thursday, Oct. 29:

0800 - 1200: Discipline Group Meetings (continued) ---------------- All Morning
Groups meet in assigned conference areas. Discussions should center on Peer Review/Future Meetings and Interdisciplinary Interaction.
1200: LUNCH
1300: Plenary Discussion — Peer Review and Future Meetings -------- Panel of
1345: Plenary Discussion — Interdisciplinary Interaction --------- Team Leaders
1430: Plenary Discussion — Instrument Descope ------------------ and Discipline
1530: Plenary Discussion — Product Descope --------------------------------Leaders
1700: ADJOURN SCIENCE TEAM MEETING

MEETING OBJECTIVES
(in Priority Order)

- Review MODIS instrument descope plans and assess the impact on science. Determine the implications for your discipline area.

- Review the data product list, form priority groups, make substitutions to optimize the at-launch selection, and carefully justify any additions.

- Complete and approve an algorithm peer review plan. Specifically, schedule peer review. Recommend a format for future Plenary Meetings and suggest possible agenda items.

- Determine the appropriate level of interdisciplinary interaction and cooperation.

MODIS SCIENCE TEAM MEETING MINUTES

October 27 - 29, 1992

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
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
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
CERES	Clouds and Earth's Radiant Energy System
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
ECS	EOS Core System (part of EOSDIS)
EDC	EROS Data Center
EOC	EOS Operations 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
FPA	Focal Plane Assembly
FTP	File Transfer Protocol
FY	Fiscal Year

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
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
GSOP	Ground System Operations
HAPEX	Hydrological-Atmospheric Pilot Experiment
HIRIS	High Resolution Imaging Spectroradiomter
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
IR	Infrared
ISLSCP	International Satellite Land Surface Climatology Experiment
IWG	Instrument Working Group
JERS	Japanese Earth Resources Satellite
JPL	Jet Propulsion Laboratory
JRC	Joint Research Center
LAI	Leaf Area Index
LARS	Laboratory for Applications of Remote Sensing
LTER	Long Term Ecological Research
LWIR	Longwave Infrared
MAB	Man and Biosphere
MAS	MODIS Airborne Simulator
MCST	MODIS Characterization Support Team
MISR	Multiangle Imaging Spectro-Radiometer
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
MWIR	Midwave Infrared
NASA	National Aeronautics and Space Administration
NASIC	NASA Aircraft Satellite Instrument Calibration
NDVI	Normalized Difference Vegetative Index
NEΔL	Net Effective Radiance 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

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
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
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
SRCA	Spectroradiometric Calibration Assembly
SSAI	Science Systems and Applications Inc.
SST	Sea Surface Temperature
STIKSCAT	Stick Scatterometer
SWIR	Shortwave Infrared
TBD	to be determined
TDI	time delay and integration
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
VIRSR	Visible/Infrared Scanning Radiometer
VIS	visible

MODIS Science Team Meeting
October 27 - 29, 1992

SUMMARIES OF THE MINUTES

1.0 PLENARY SESSIONS

1.1 Welcome and MODIS Overview

Vince Salomonson, MODIS Team Leader, welcomed the attendees to the MODIS meeting and reported that MODIS is doing well. He showed a viewgraph of the Meeting Agenda which he briefly discussed (Attachment 1). He tasked the meeting attendees to work together to ensure that all tasks on the agenda are accomplished.

1.2 Headquarters' Perspective

Tony Janetos, EOS Program Scientist, reported that originally EOS was cut back from $16 billion to $11 billion, and has now been reduced again by Congress by 30 percent to $8 billion. He commented that there is no guarantee that there will not be further reductions. He cited the loss of HIRIS (High Resolution Imaging Spectroradiometer), the reduction in the number of at-launch science / data products, the loss of contingency funds which puts instrument development at a much higher risk, and the serious possibility of descopes as examples of cost constraining measures.

Janetos stated that it is critical for each Instrument Science Team within EOS to decide as soon as possible how to proceed in developing their algorithms based upon the designs of their respective instruments. They must understand and be able to explain how their instrument characteristics affect their data products. They must identify ways to save money without significantly impacting their science. Each team must have a plan laid out for descoping if a budgeting worst-case scenario happens; and they must be prepared to show how those descopes impact their science products, other instrument products, and IDS (Interdisciplinary Sciences) investigations.

He also stated that it was critical for the Science Team to undertake of full analysis of the scientific impacts of any potential descope prior to acceptance. He stated the need to compare MODIS instrument capabilities with those available on other sensors (eg. AVHRR).

1.3 EOS Project Status

Salomonson introduced Michael King as the new EOS Senior Project Scientist. According to King, Congress has stated that funding for EOS shall not exceed $8 billion; nor shall it fall below that figure. Therefore, all instruments under EOS are interconnected; for example, if MISR overruns on its budget, it could cause MODIS' budget to be reduced. King raised the possibility of adopting a common spacecraft for all EOS instruments to save on platform development costs. Attachment 2 gives details of the overall EOS Project Status.

King discussed other EOS programs which have been lost or reduced due to diminishing funding. He noted that MODIS, however, has not been mandated to descope beyond the elimination of MODIS-T in an earlier budget reduction.

Regarding the development of the EOS Data and Information System (EOSDIS), King stated that there was a delay in the process of selecting the core system contractor; however, Len Fisk, Associate Administrator for Space Science and Applications, has now selected Hughes Information Technology Division with whom to negotiate the contract.

1.4 EOS Platform Status

Chris Scolese showed a viewgraph of the EOS AM-1 Spacecraft milestone schedule (Attachment 3). He noted that CERES and MODIS have already successfully completed their Preliminary Design Reviews (PDR) and the other EOS instruments' PDRs are coming soon.

Scolese reported that the Red/Blue Team developed a Charter for EOS in May of this year. The Charter places the following commitments on the EOS program:

- The EOS AM-1 Spacecraft must be launched in June of 1998;
- EOS' instrument complement and science identified through the restructured program must be maintained to the maximum extent practicable;
- The measurement capabilities must be equal to or greater than those provided during phase 1 of MTPE (Mission to Planet Earth).

The Charter also included the following objectives:

- Reduce the EOS Budget through the year 2000 by $3 billion (from $11B to $8B);
- Reduce the FY 1994 budget request by 30 percent;
- Reduce the total cost from FY 1995 through FY 2000 by an average of 30 percent.

Scolese pointed out that the budget is not being cut across the board. There are three areas to reduce the budget, without seriously affecting the science behind the instruments: the AM platform bus, the data system, and contingency. So, for the early years of the developmental phase, contingency will bear the brunt of the budget cuts, which will increase the instruments' developmental risk. Scolese reported that major savings were realized by minimizing non-recurring costs, implementing a common spacecraft approach, and adopting a cost-driven approach—all of which reduced cost and contingency with minimal impact on science or risk. However, achieving the full 30 percent budget reduction will eventually require an impact on science and risk.

Scolese explained a new NASA-wide policy that has been established: if the cost of an instrument grows to greater than 115 percent of its negotiated price, the deputy administrator will step in and assume control of that instrument. And if the cost grows to more than 125 percent, that instrument gets cancelled. This gives added incentive to find ways to keep instruments within budget.

1.5 SBRC Perspective and PDR Summary

Salomonson introduced Lloyd Candell, MODIS Manager for Santa Barbara Research Center (SBRC), who spoke on the overall status of MODIS and potential descope items—detector operability, registration, and calibration. Candell prefaced his presentation by stating that SBRC considers the MODIS contract a national trust. He gave a brief overview of SBRC and cited its three-decade history of delivering instruments that meet and/or exceed requirements, such as the signal-to-noise ratio (SNR) requirements for the Thematic Mapper (TM). He also discussed how the changing marketplace is affecting contractors' abilities to meet technical requirements.

1.6 Instrument Status and Descope Options

Candell introduced Tom Pagano, SBRC's chief systems engineer for MODIS and MODIS Science Team interface. Pagano stated that MODIS covers 36 bands at frequencies ranging from 0.407 µm to 14.385 µm; hence, it demands a wide range of spectral and rediometric requirements. Also, it has a prime location on the EOS AM Spacecraft which allows for a clear view of the sun and outer space for cooling the detectors and electronic modules. MODIS has a continuously rotating mirror and a Solar Diffuser Stability Monitor (SDSM).

However, Pagano reported that registration is affected by the fact that there are twelve different modules to be assembled. He discussed the MODIS Calibration Management Plan as outlined by Jim Young, SBRC, stating that linkage between preflight and in-orbit calibration is required. He said that the thermal vacuum test configuration is established so they can accurately characterize any changes in MODIS.

Pagano stated that the Spectroradiometric Calibration Assembly (SRCA) provides a radiometric calibration check, spectral band calibration, band registration check, and self calibration.

He noted that the electronic phase delay allows SBRC to re-register the focal planes on a focal plane assembly (FPA)-to-FPA basis. Salomonson interjected that this delay affords the Science Team a window of opportunity to prioritize the bands to get the best registration arrangement. Pagano added that there are 640 possible combinations of band arrangements for MODIS.

Pagano reported that SBRC has used detailed filter models to predict performance and tolerance of the MODIS instrument. They have found that the modulation transfer function (MTF) exceeds specs, which will give a better understanding of remotely-sensed images. He stated that SBRC will meet SNR spec goals.

Pagano presented a reprioritized list of risk items, ranking as follows:
1) Spectral Band registration
2) PV HgCdTe Detector "Operability"
3) PC HgCdTe Detector Performance
4) Achievement of Spectral Requirements
5) IR Filters Radiation Degradation

6) Scan Mirror Drive Bearing Life
7) Focal Plane / Filter Stray Light
8) Program Performance to Schedule and Cost
9) MODIS Instrument Mass
10) Filter Assembly Tolerances

1.6.1 Filter Status

John Figoski, SBRC, said that filters are a concern, but are within state-of-the-art. The relationship of the bandwidth to the center wavelength is critical: the narrower bandwidths at longer wavelengths present an increasingly greater difficulty in registering channels. Although there is no concern regarding filter polarization, dichroics are a definite concern. According to Figoski, the dichroics show considerable transmittance structure and a large polarization contribution and variation. The spectral structure will be within specification, he noted, but is close to the limit. The prototype filters for bands 27 through 31 are complete. However, Figoski said, the edge range requirement was not met. He also cautioned that the dichroic beamsplitter design shows areas to watch and will have to be carefully controlled during manufacture. All filters should be delivered by February 1993.

1.7 Risk Items

Weber recounted SBRC's reprioritized list of risk items. He stated that SBRC has spent beyond their original plan on registration, development of filters and detectors, ground support equipment (GSE), and on MODIS' beryllium mainframe.

Pagano emphasized that spectral band registration and operability is a challenging task—SNR is driving the task. Currently, SBRC feels that the registration budget can be met, but it is statistically a high risk. Pagano said that a mitigation plan needs to be devised wherein we know the most important bands in terms of registration and we determine which bands need re-work. He said that there is a 95 percent probability that specs for registration within each focal plane will be met within cost. Relaxation to 0.2 pixel between focal planes would improve the probability of success. Pagano concluded that the Science Team needs to define the bands to be used together so that SBRC can provide individual readouts on critical band registration.

1.7.1 Detector Operability and the MTF

Pagano stated that the midwave infrared (MWIR) detectors need to be reduced to 1/4 of their present size in order to improve the MTF and meet noise spec. The longwave infrared (LWIR) photovoltaic detectors are reading out at 100 percent efficiency, using a serpentine configuration, which passes MTF requirements.

Pagano commented that there are operability problems in the LWIR and MWIR detectors. He recommended changing to sub-pixel detectors because sub-pixels give tight profiles. Candell added that the baseline is to use a segmented detector. However, the smaller pixel improves MTF, and improves correlation between bands. SBRC recommends going with the smaller detectors clustered together to produce the required specifications of the larger detector.

Pagano presented the current descope option, which allows failure of one detector per band, and less than or equal to two detectors per FPA (but not both in the same band). This relaxation would also considerably reduce risk. Salomonson commented that we need to plan on having some dead detectors.

1.8 Descope Options
Salomonson showed a vugraph of Weber's list of descope options (Attachment 4). As a subset of that descope list, Salomonson told the Science Team to consider the segmented detector option that Pagano offered. Salomonson also instructed the Team to prioritize the registration requirements among the bands. He reminded the Team of SBRC's recommendation to relax the registration requirement from 0.1 pixel to between 0.15 and 0.2 pixel.

1.9 SDST Status Report
Fleig presented a processing flow diagram of MODIS data products (Attachment 5). He stated that there are 195 products associated with MODIS. He recommended removing all Level 3 products and combining scales and products when they're the same, which he says will reduce the number of products substantially.

Fleig requested the Science Team to notify the Science Data Support Team (SDST) if they will need a mask for a certain products. He also asked the Team to make sure the processing flow is correct for each product and to notify SDST if they can make their products with the products selected.

1.9.1 Science Data Management Plan
Fleig mentioned the Science Data Management Plan, and noted that only nine Team members have returned the Plan; sixteen have not. Regarding Level 2 products, Fleig reported that SDST is recommending making simplifications, so that the total number of products has been reduced from 195 to somewhere between 77 and 61 prior to launch and 16 post launch. Fleig told the Science Team that SDST has included a series of questions on their list of products asking whether SDST's recommendations are acceptable. He instructed the Team to mark up the list of questions and products however they wish and return it to SDST.

1.9.2 Science Computer Facility Plan
Regarding the Science Computer Facility Plan, Fleig stated that the Team members must deliver to SDST a list of the hardware they want to buy, when they want to buy it, and the cost through the year 2000. They must also explain how they plan to buy the hardware and what it will do. Their assessment must be reasonably accurate.

1.9.3 MODIS Prototypes
Kendall Carder asked if a tool kit would be available to address transmissivity of filters versus incoming solar spectra.

Fleig suggested that Barker would produce utilities and support functions, and that some prototypes will be available before Christmas. He said SDST will develop a tool kit that will make the DIS transparent.

1.9.4 Algorithm Development

Fleig expects to receive code from the Science Team members within one year. This code need not represent the same physics that is expected in the final algorithm, but should be detailed enough to provide a rough estimate of the computing size. It will also enable Project to run large pieces of code and get experience. SDST must be able to compile the code and execute it on their computer, Fleig explained. It must be accompanied by input, output, and operational instructions.

1.9.5 MODIS Duty Cycle

Fleig discussed the MODIS instrument duty cycle, currently defined as "on" 40 percent of the time. The requirement is for MODIS to provide continuous daytime coverage, plus some night coverage. Fleig noted, however, that 40 percent coverage does not allow full daytime coverage. In order to achieve full global daytime coverage only, the instrument must be "on" from 44 percent of the time—at the solstices—to 50 percent of the time—at the equinoxes.

Moreover, Fleig said that, at 40 percent, no data will be collected over the North Pole during the winter and no data will be collected over the South Pole during the summer. At summer solstice, a surfeit of data would be collected over the North Pole and at winter solstice an excess of data will be collected over the South Pole.

1.10 Summary Statements

Salomonson summarized the day's deliberations and identified some issues for future consideration: 1) placing the P.M. Platform in an ascending or descending node orbit; 2) direct broadcast; and 3) Yoram Kaufman's 1.375 µm proposal.

1.11 Further Descope Discussions

The Day 2 Plenary Session began with a discussion of additional descope concerns regarding the Spectroradiometric Calibration Assembly (SRCA). Additionally, based upon some new information on budget risk factors from SBRC, Scolese defined four other major problem areas:

1) Optical Design. This is a FY 93-94 problem driven by the registration requirement. Scolese said that the Science Team needs to identify descope positions now.
2) Mechanical Design. This is being worked by SBRC; the Science Team's interaction is not required.
3) Ground Calibration; which is costing considerably more than planned and therefore, according to Scolese, needs to be scaled back.
4) Contract Rate Increase. An increase in the contract rate is expected for FY93 retroactive to FY92. According to Scolese, about $10 million needs to be saved in FY93 and FY94, with the peak year being FY93.

Scolese stated that the descope priorities to look at are as follows:
1) Registration
2) Detector Operability
3) SRCA / Ground Calibration

1.11.1 Ground Calibration
Weber adressed the ground calibration problem, warning that it is out of reasonable financial bounds and needs to be worked in the next few weeks. Salomonson instructed the Calibration Group to take the lead in understanding the problem and in making a recommendation to the Team. Candell promised to have SBRC calibration experts meet with the Calibration Group to help reach a conclusion.

Salomonson further mandated that the Calibration Group, which should include one representative from each discipline group, should take a radical approach of considering *either* the ground calibrator *or* the SRCA. In other words, can the Team make do with just one or the other? Barnes asked Candell to scope the cost of various descopes, so that the Team will have an understanding of the cost distribution of different options.

1.11.2 Registration and Operability Descope
Salomonson also gave the discipline groups a mandate to consider relaxation of requirements to 0.2 pixel, and to consider individual band relationships. Salomonson also identified detector operability as a major issue and asked the discipline groups to determine whether they can tolerate two dead detectors per focal plane.

1.11.3 Parts Quality
Salomonson stated that the Science Team would accept Grade 2 parts.

1.12 MCST Status Report
Barker presented the MODIS Characterization Support Team (MCST) status report; MCST's priorities are as follows:

1) Instrument-related characterization / calibration—this includes a) pre-launch and at-launch characterization and b) calibration and post-launch characterization;
2) Algorithms, software, and hardware for EOC / MCST monitoring of in-orbit data;
3) MODIS Cloud Masking Utility Product;
4) Algorithms for simulated MODIS imagery; and
5) Discipline-related product sensitivity to calibration, in cooperation with Team members.

He showed a viewgraph of potential EOS AM-1 cost reduction measures (Attachment 6).

1.12.1 Pre-launch and At-Launch Characterization

Barker discusssed the old versus the currently recommended specifications for MODIS' spectral bands. MCST is preparing a document stating why they decided to include certain spectral bands.

Barker reported that MCST has developed an asymmetrical model of MODIS' detectors and is currently doing simulations to examine relative sensitivity of SWIR detectors.

1.12.2 Calibration and Post-Launch Characterization

Barker showed a flow diagram of the MODIS Level-1 calibration algorithm. He said the delivery schedule is based on when the engineering, flight, and protoflight models will be available. He also showed a viewgraph of the calibration peer review schedule; he said peer review should occur every six months.

Barker showed a list of MODIS Level-1B calibration products which have been condensed into a single image product/Calibration Product #3646. He also presented the algorithm and ancillary data development schedule. He reported that MCST will have calibration data at Level 1A and 1B for both the AM and PM Platforms; and they will include real or simulated MODIS data sets. Also, math and error models will be available in a more compact form, and non-radiometric accuracy information will be provided.

1.12.3 Approach to Calibration Documentation

Barker gave overviews of the MODIS Mission Calibration Plan (which provides a comprehensive review and integration of all methodologies used to calibrate the MODIS instruments), the MODIS Level-1B Calibration Algorithm Plan (provides a plan for MCST's algorithm production activities), and the MODIS Science Calibration Handbook (provides a stand-alone scientific user's guide containing all one needs to know about calibration of MODIS data throughout the lifetime of the EOS mission).

The algorithm plan, he noted, will be organized by radiometry, spectral algorithms, and geometric algorithms.

1.12.4 On-Orbit Instrument-Based Calibration Methodology

Barker reported that in-flight calibration and radiometric accuracy and stability are driving the requirements for MODIS calibration. The final MODIS design configuration will feature a solar diffuser assembly, the SDSM, an SRCA, and a blackbody. He listed the requirements for the onboard calibrators.

Barker listed MCST's calibration strategy, the first step of which will be to use alternative calibration methodologies to provide an "offical" calibration algorithm and to allow for its validation by independent methods. Within two to six months, MCST will conduct post-launch quantitative characterization and monitoring of the precision with which MODIS at-satellite radiances are measured by various methods. MCST will characterize and monitor the accuracy of MODIS at-satellite radiances for three to five years. Over the fifteen-year lifetime of the EOS mission, MCST will validate the components of the predictive radiometric math models for each MODIS instrument. Barker stated that the math model is a deliverable.

Barker also discussed MCST's schedule for producing hardware and software to monitor MODIS spacecraft-level integration and testing.

1.12.5 Cloud Masking

Barker discussed the major issues surrounding the MODIS cloud masking utility products. He explained that the utility product generation will start with the masks from the MODIS/MCST utility algorithm. Discipline scientists will participate in the development and review of the algorithm. The requirements for masking for land cover products in each category in the mask will be statistically and spectrally defined so that it can be input to the approriate MODIS products. Attachment 7 lists MODIS' bands and gives details such as bandwidth, IFOV, and purpose.

Barker said he is trying to develop, in conjunction with Jan-Peter Muller, an end-to-end model of the system, which he feels is still six months to a year from completion. However, as a precursor, Photon Research software is due in a month which will provide a UNIX shell for initial simulation efforts.

Salomonson wanted assurance that the Team wants to invest the resources in an end-to-end simulation. He stated that the core job of calibration comes first.

1.13 Algorithms for Simulated MODIS Imagery

Barker reported that transforming Landsat Thematic Mapper (TM) data to MODIS format will entail selecting TM data for the MODIS Analog Band, filtering asymmetrical MODIS MTF in the frequency domain, converting to TM radiance and adjusting for MODIS band characteristics, and resampling to 250-, 500-, and 1000-meter pixel size.

1.14 Direct Readout

Ed Chang reported that all direct readout data will come down via x-band in real time. He explained that there are two direct broadcast (DB) bands, one each supporting MODIS and ASTER. A 3-meter antenna will receive one band; a 10-meter antenna is needed to receive both. Chang stated that EOS probably will not provide software support to receiving stations.

1.15 MODIS Orbits

Menzel presented Ron Muller's analysis of an EOS 3 P.M. descending orbit. As opposed to the ascending orbit, the descending orbit provides more uniform coverage of both hemispheres. One option is to have same-day viewing of the same area from both the AM and PM platforms. Southern hemisphere coverage is radiometrically improved by the P.M. descending orbit, in that higher latitudes approach a local noon crossing time.

1.16 Proposed Cirrus Cloud Band

Kaufman presented his proposal to include a 1.375-μm band for identification of cirrus clouds. Kaufman and Bo-Cai Gao wrote a paper explaining that the 1.375-μm band shows cirrus definitively against a black background, which is important for land and ocean temperature measurement; and it is important for remote sensing of reflectance and aerosols. Kaufman suggested merging the fire channel with Bands 20 or 23, and moving the fire detector from 700°K to 500°K (the absolute minimum limit is 400°K). Kaufman pointed out that this movement would release Band 21, and would reduce the dynamic range of 20 or 23 only slightly for fire detection.

Gao presented AVIRIS data taken over Coffeyville, KS, as an example of how well the utility works.

1.17 AIRS Status Report

Moustafa Chahine, AIRS Team Leader, described the current status of the AIRS (Atmospheric Infrared Sounder) instrument. He gave details of that instrument's descope and discussed details of its technical and scientific capabilities. Chahine stated that AIRS has not yet established calibration requirements—they hope to adapt theirs from MODIS'. Co-registration of all "visible" channels has been proposed at 1.5 percent. These channels are a "bridge" between MODIS' 36 channels and AIRS' 2,200 channels. Kaufman expressed some concern about the transfer of calibration from MODIS to AIRS.

1.18 MISR Status Report

Dave Diner, MISR principal investigator, reported on the changes in the design of MISR (Multi-Angle Imaging Spectro-Radiometer). Diner emphasized that MISR and MODIS must speak with a unified voice on platform pointing and positioning knowledge. He noted that ASTER is currently driving platform jitter requirements. Relative motions (distortions) within the platform are a concern.

Diner commented that calibration cross-checks with MODIS would be interesting.

(At this time on the second day, the Science Team separated into discipline groups. The following reports trace the deliberations of each group up to the time of the final plenary session.)

2.0 OCEANS DISCIPLINE GROUP

2.1 Data Products

Some products need to be added, and the Oceans Group needs to consider some that have disappeared. The Group determined that products derived from different algorithms should not be assigned under the same name.

2.2 Descope Priorities

The Oceans Group expressed a willingness to delete the high resolution bands (first 250 meters, then 500 meters), and all radiometric calibration except that furnished by the SRCA. Polarization (#16) should not be so high on the descope list.

2.3 Registration

Relaxation of registration to 0.2 pixel is likely acceptable. Special attention was called to the registration of certain bands, particularly across focal planes. The attached Esaias report (Attachment 8) addresses this recommendation in some detail.

2.4 Commandable Registration

The Oceans Group strongly recommends that the electronic alignment not be changed in orbit. Such changes are considered detrimental to the interpretation of global data sets.

2.5 Full versus Sub- versus Segmented Detectors

The Oceans Team felt that the improved MTF would offset any disadvantages derived from dividing up a full detector into smaller units. Brown recommended that the MTF of adjacent detectors abut one another to ≥ 5 percent. The Oceans Group assumes that choosing the sub–detector or segmented detector baseline eliminates the need to consider the descope option of two dead detectors per focal plane assembly (FPA).

2.6 Fire Bands

Bands 22 and 23 should not be modified for use as fire bands. Possibly band 20 could be used, providing the 265°K to 320°K range quantization and SNR are not compromised. Then the 1.375-µm band could replace channel 21. The Oceans Group felt that this is desirable.

2.6.1 MCST Masking Algorithms & Calibration

Evans mentioned the urgent need to normalize the intra-band detector gain, since there are ten spatial detectors per spectral channel. There will also be a substantial need to collect discipline group-generated utility masks into synoptic masks. In a consideration of calibrated radiances, if Barker does Level 1A, can Oceans do their own 1B?

2.6.2 Surface Truth Data

The Oceans Group agreed that Clark's data need to go into some kind of program that automatically updates MODIS calibration.

2.6.3 Simulated Data Sets

Gordon has a simulated data model that can be used to develop a simulated data set. Parslow and Esaias mentioned that SeaWiFS can serve as a simulated data set. Abbott emphasized the need to do real-time interaction with the simulated data set, and that this would require faster networking to tweak parameters in real time. Evans felt that Oceans should develop an off-the-record internal simulation set to be used only by the Oceans group so they can avoid project-style documentation.

2.6.4 Ground Calibrator
Gordon felt that the SRCA could be the main source of pre-launch calibration.

2.6.5 FPA Readout Redundancy
Each FPA will have A and B readouts, with the capability to shift from A to B in case of catastrophic failure. Oceans needs to know which detectors are affected by the shift.

2.6.6 Peer Review
A two-page "white paper" presentation per algorithm is recommended. SeaWiFS-related algorithms will be reviewed by whole Group next January.

2.7 Action Items

1. *Stuart*: Revise the data product list, based on inputs from the team members, and distribute the revised list to the Oceans Group members.
2. *Evans, Carder, and Brown*: Prepare inputs to the SeaWiFS "white paper" and forward to Esaias.
3. *Parslow*: Review above-mentioned white paper.
4. *Barker*: Discuss Radiometric calibration with Howard Gordon— can the MODIS Characterization Support Team (MCST) do Level 1A, and Oceans (Gordon) do Level-1B?
5. *Clark*: Work with Oceans Discipline Group members to develop a plan for the use of *in-situ* buoy data as surface truth and calibration for Oceans data products.
6. *Esaias*: Develop a plan for development of a MODIS simulated data set. Explore the possibility of budgeting for a T3 communications line between OSU and Miami.
7. *Barnes*: Clarify to the Oceans Group the redundant operation of the A and B readout for each FPA. Which detectors are affected by the shift from A to B, and *vice versa*.
8. *Oceans Discipline Group*: Produce a two-page "white paper" for each algorithm.

3.0 ATMOSPHERE DISCIPLINE GROUP

3.1 Instrument Issues

At the previous Plenary Session, Bo-Cai Gao recommended implementing the 1.375-µm channel for remote sensing of cirrus clouds based on the following conclusions:

•The 1.375-µm (Δl = 30 - 50 nm) channel can sense thin cirrus clouds undetectable otherwise during the day.

•The 1.375-µm channel provides very good separation between cirrus clouds and clear surface areas due to the strong water vapor absorption in the lower atmosphere, and it has small sensitivity to mid-level clouds between 4 and 6 km.

The Atmospheres Discipline Group decided to recommend including the 1.375-µm band in the SWIR / MWIR focal plane. They are considering splitting the gain on channels 20, 22, or 23 to include fire detection, thereby enabling channel 21 to be used. Or, alternatively, they recommend substituting 1.375 µm for either band 24 or 26.

3.1.1 IFOV Spatial Characteristics

At the MODIS Plenary Session, Pagano proposed changing the MODIS detectors to either segmented or sub-pixel. Menzel is in favor of changing to sub-pixel detectors on as many channels as possible.

King raised the possibility of having a fairly high number of dead detectors on MODIS at launch.

The Atmosphere Discipline Group concluded that it prefers sub-pixel detectors to segmented detectors. The Group also concluded that increased MTF is advantageous—both to the Atmosphere and other Discipline Groups—because it offers cloud / no cloud detection, and improved characteristics of blending 250-, 500-, and 1000-m bands. The along track and cross track FOV responses should be well matched.

3.1.2 Resampling to Achieve Registration

Menzel reported that from a cloud imaging perspective, 0.2 FOV is not adequate because it introduces a huge error. He said that we should avoid these areas or resample. However, resampling becomes a problem if you are trying to find something between samples—you have to use sophisticated programs to compensate and the MODIS Science Team is unwilling to do that.

The Atmosphere Group prefers to relax the specs on band-to-band registration from 0.1 to 0.15 or 0.2 pixels (as long as 0.1 is still a goal), with some optimization of layout on focal planes. The Group feels strongly that onboard calibrators should be further developed and maintained. Moreover, the Group asserts that onboard calibrators are more important than the extensive ground support equipment (GSE) calibration effort, with the exceptions of MTF characterization, filter characterization (vacuum vs ambient), and radiometric calibration.

3.2 Principal Investigator Reports

King stated that the AM Project is planning to baseline solid state recorders in lieu of mechanical tape recorders on the EOS AM satellite. In order to increase capacity on the recorders, the Project is planning to use data compression. The MODIS data are presently being configured by SBRC to be recorded for all 36 channels of a single pixel before going to the next pixel. This will likely limit the effectiveness of data compression. In order to gain a greater data compression efficiency, there would be some advantage to recording all 2330 km of the swath width at a single channel, before going to another channel. The scientists generally find this solution, dictated largely by data compression arguments, as undesirable.

Menzel is focusing his work on three areas: 1) MODIS Airborne Simulator (MAS) reconfiguration, 2) Using the tri-spectral techniques as suggested by Steve Ackerman, and 3) improving the CO_2 splicing to perceive cloud layers.

King reported on his MAS flights and showed viewgraphs containing bidirectional reflectance images of the Kuwait oil fires. He was particularly interested in the backscatter and rainbow (oilbow) features that showed that the oil fire smoke contained a considerable quantity of oil drizzle droplets. He also showed the first analysis of the optical thickness and effective particle radius derived from MAS data over marine stratocumulus clouds near the Azores (ASTEX).

Kaufman reported that he is trying to derive aerosol optical thickness by looking at images over very dark, dense targets. He said that he has found a high correlation of AVIRIS data in the reflectance of underlying surfaces and NIR. He is studying the atmosphere over the Amazon Jungle.

Didier Tanre reported that he is conducting aerosol remote sensing over land surfaces.

Si-Chee Tsay reviewed his study of the link between cloud microphysics and remotely sensed radiance fields. He said that he needs input from the Science Team. He proposed developing a model in the area of thermodynamics and microphysics to examine radiances.

3.3 MAS Update

Menzel reported that TOGA-COARE will fly the same instrument configuration as ASTEX. However, he said, 1.375 µm cannot be done because that is not an option for MAS.

Menzel also reported that a new dichroic has been ordered in preparation for TOGA-COARE. The configuration will fly from Guam to Townsville, Australia and throughout TOGA-COARE (based in Townsville) and CEPEX (based in Nadi, Fiji) from early January to mid-March 1993.

3.4 Software Prototype Delivery for MAS Processing

Liam Gumley reported that the SDST has MAS data at Level 1B. Eventually, when MODIS is launched, SDST will get the algorithms from the Science Team members and begin processing them into the Level 1B shell. Currently, SDST is determining how the shell will work.

Gumley said that it seems reasonable to use the MAS dataset to simulate MODIS data. At the same time, useful products that are scientifically valid could be produced. He reminded the Group that by January 1993 Fleig would like to receive some code from the Science Team members that allows some processing. He noted that it is okay if the code works on AVHRR. Also, Fleig wants Team members' Science Data Management Plans—which is a contract requirement— and their Science Computer Facility plan, which is a statement of their future plans to procure computers.

3.5 Action Items

1. *Atmosphere Discipline Group*: forward your Science Data Management Plans and your Science Computer Facility Plan to Al Fleig by January 1993.

4.0 LAND DISCIPLINE GROUP

4.1 MODLAND Calibration Review

Zhengming Wan reported on thermal calibration issues. Wan is concerned that the radiometric accuracy of the MODIS thermal bands (29, 31 and 32) may not meet the required goal. Wan recommended an evaluation of signal-to-noise levels at lower temperatures than investigated by SBRC. Wan has to have a high registration accuracy (between bands and scene to map) to implement emissivity corrections in heterogeneous areas.

Huete, as the MCST Land Group representative, reported on MCST activities from an optical perspective. He said land radiometric calibration specifications should be reported as absolute and not relative. Huete reported that the 0.1-pixel registration requirement by land is frustrating the MODIS sensor design. The MCST wants additional background information on the land registration accuracy requirements. The MCST would like the Land Discipline Group (MODLAND) to study the effects of MTF, radiometric calibration, misregistration effects, focal planes, etc. more rigorously.

4.2 Peer Review

Justice discussed the Land Peer Review Strawman. The MODLAND Team envisions two components to the peer review process, informal and formal. The informal process should consist of regular contacts with IDS groups, other instrument teams, other agencies, and international scientists who either plan to use the MODLAND data or generate compatible algorithms. The formal process should consist of a series of peer review scientific papers in the open literature. In addition, peers from the EOSDIS and the international communities should be selected to attend periodic thematic meetings on MODLAND Products.

4.3 Test Sites

Justice reported the MODLAND Group is developing worldwide test sites over which comprehensive satellite data sets (primarily AVHRR, TM, and MSS) exist, and over ongoing and retrospective experimental/ground sites. The focus for the site selection is land cover. The MODLAND Group's needs are being integrated with the Landsat Pathfinder test site project. Justice said sites are being selected for the Americas, Asia, Africa and will include Long-Term Ecological Research (LTER) and International Geosphere-Biosphere Project (IGBP) sites. However, sites need to be selected for Europe. Any MODLAND test site requests should be given to Justice as soon as possible. He said he will distribute information of MODLAND sites to EOS and IDS investigators for joint collaboration. Justice will coordinate the MODIS test site initiative with the Landsat Pathfinder Test Site activity. David Carneggie gave a presentation to MODLAND on the Land DAAC status.

4.4 IDS Links

The MODLAND team gave an update on their cooperative efforts with IDS investigators. The MODLAND group will continue their close cooperation.

4.5 Surface Temperature and Snow/Ice Work

Wan summarized his work to date on deriving global surface temperature. He is searching for surface temperature reference data for preparation of a journal paper. He said the proposed 1.375-µm band may not derive cirrus optical depth but will only detect the presence of cirrus clouds. Dorothy Hall summarized her snow and ice work. She has made significant progress in deriving snow and ice cover and spectral characteristics. Additional research is needed to address the cases of snow in dense forests. Follow-on work will further evaluate multi-temporal relationships.

4.6 Descope Options

Alan Strahler reported on MODIS Land bands registration. Justice said the Land bands have the most stringent geometric requirements. They are requesting all the Land bands to 0.1 pixel. Preliminary studies show the negative impact of misregistration on EOS spectral issues. The bands within focal planes could be prioritized for maximizing registration precision. The surface temperature bands 29, 31 and 32 should be placed for optimal band-to-band registration. MODLAND supports the proposed 1.375-µm band. In addition, the land bands should be grouped on the focal plane to provide optimal band to band registration (1 & 2; 3 & 4; 5, 6 & 7; and 29, 31, & 32). The MODIS 3.75 µm needs reevaluation. If possible, a move to 3.95 µm is recommended to reduce water vapor absorption. Wan and Hall will assist MODLAND with prioritizing band-to-band registration accuracy between focal planes. Strahler expressed concern over the interpretation of the spec which addresses registration between the 250-m and 500-m bands.

4.7 Data Product List

Justice reported the MODLAND primary products are vegetation indices, snow/ice cover, land cover, albedo, bidirectional reflectance distribution function (BRDF), surface temperature, leaf area index, net primary productivity, and fire characteristics. All the MODLAND products assume certain input parameters such as a radiometrically corrected radiance, atmospheric correction, topographic correction, geometric correction, BRDF correction [This may be an “endless loop” situation: BRDF is defined as a product, and defined as being needed in producing the product], hemispherical reflectance conversion, and cloud, snow mask [For snow mask, see the above “endless loop” statement]. The Land Group recommends starting the data product list from scratch. The MODLAND team should complete the Data Product list within three months. Revised product flow diagrams should be generated for each MODLAND product within the same time frame. In addition, each Land member should define their ancillary data requirements and show them in the flow diagram format.

Fleig was asked to summarize the status and capabilities related to platform, instrument, and ground processing that affect scene to scene registration accuracy.

4.8 Planned MODLAND Meetings and Activities

Tanre, Muller, Huete, and Strahler will hold a meeting next year on an albedo product. Michael Verstraete may host the meeting.

Steve Running will coordinate a Leaf Area Index (LAI) / Net Primary Productivity (NPP) Product meeting and initiate the peer review process. In addition, Running should consider coordinating a meeting with other IDS investigators.

Strahler provided a summary of the September '92 land cover meeting. The next land cover meeting should occur approximately a year after the previous one. Hall should come to the next meeting to provide information on the snow / ice product from a land cover perspective. Hall should also develop plans for a peer review of her snow / ice data products.

Wan should coordinate a surface-temperature product meeting and a peer review with 2-3 people in FY 93.

4.9 Action Items

1. *Wan and Hall*: Assist MODLAND with prioritizing band-to-band registration accuracy between focal planes.
2. *Land Group Members*: Define your ancillary data requirements and show them in the flow diagram format.
3. *Fleig*: Summarize the status and capabilities related to platform, instrument, and ground processing that affect scene to scene registration accuracy.
4. *Running*: Coordinate a meeting with other IDS investigators.

5.0 CALIBRATION WORKING GROUP

The meeting of the MODIS Science Team Calibration Working Group convened the morning of Oct. 26 with introductory comments delivered by the meeting chairman, Philip Slater of the University of Arizona. Slater quickly reviewed the agenda for the meeting and set a number of meeting goals.

5.1 MCST Report

John Barker of GSFC followed with a presentation on the MCST report. Barker urged all meeting attendees to pick up and offer comments on the MODIS calibration and algorithm handbooks and plans provided at the meeting. Barker led several discussions on a multitude of items such as: the revised MCST product list, the MCST approach to calibration documentation, on-orbit calibration of MODIS, platform overlap implications, and the development schedule for MODIS Level 1B data products. The subject of on-orbit calibration was quite extensively discussed, with each component of the onboard calibration (i.e. the Spectroradiometric Calibration Assembly, the Solar Diffuser / Solar Diffuser Stability Monitor, the On-board Blackbody, and the use of the Space View Port) being examined closely with respect to design and calibration functionality.

5.2 SeaWiFS Update

Bill Barnes of GSFC presented an up-to-date overview of the SeaWiFS instrument. Barnes reviewed the scope of the project and announced that the instrument is still on schedule to be designed and delivered in less than two years. Barnes also reported some interesting stability test results on the reflective solar filters used in SeaWiFS.

5.3 MODIS Calibration Management Plan

Jim Young, of SBRC, followed with a review of the MODIS Instrument Calibration Management Plan. Young outlined the proposed SBRC approach to preflight and inflight calibration of the MODIS instrument. Young stressed the importance of maintaining the math model of the instrument and encouraged the use of vicarious calibrations in characterizing the in-flight behavior of MODIS. Young also reviewed the SBRC plans for subsystem and system level testing of the MODIS onboard calibrators and reviewed exactly how each calibrator functions. He reviewed the specifications for the GSE used as preflight stimuli for MODIS.

5.4 Preflight Calibration

Stuart Biggar, of the University of Arizona, followed with a presentation on the status of the development of a set of traveling radiometers which will be used in the preflight calibration of MODIS and other EOS instruments. Biggar has made progress on the VIS / NIR radiometers and work has begun on a shortwave infrared radiometer. Biggar also identified several potential problem areas which arose from presentations and discussions at the MODIS Calibration Peer Review.

5.5 Descope Options

John Barker then led a discussion on the MCST-proposed descope options. During this presentation, Barker presented spectral sensitivity data on the MODIS instrument and band-to-band registration data. It was generally agreed by the group that a tradeoff study of registration, MTF, calibration accuracy, and aliasing be done as soon as possible. During Barker's presentation, Tom Pagano of SBRC presented the results of his study of registration / MTF effects on radiometric accuracy. Pagano stated that he believes that a slight relaxation of the registration requirement would not cause information loss. Concerning the on-orbit registration measurement capability of the SRCA, Jim Young stated that SBRC believes that, in flight, the SRCA should be able to measure registration to 0.1 FOV along track and even better cross track. Tom Pagano asked for a prioritization of bands according to science products in order to permit SBRC to optimize the band positions and to determine if any bands can live with a slightly relaxed registration requirement.

During this descope discussion, the idea of eliminating the SRCA was quickly dismissed. Dick Weber of GSFC used the opportunity, however, to list a number of potential problems in the SRCA design, including the effect of heat on the integrating sphere source and the effect of temperature rise on the radiometric output and operability of the lamps. In addition to examining the SRCA, the SDSM , solar diffuser, and MODIS filters were discussed.

The final task in this descope discussion was to place a priority on the onboard calibrators. The group placed an equal importance on the SRCA and the SDSM. A high priority was also placed on the blackbody, despite its seemingly many design and functional questions.

5.6 Cross Calibration

Guenther presented his current plans for calibration and cross calibration both at the instrument builders' facilities and at GE. Guenther urged all instruments to attend the Data Product Validation Meeting in Las Vegas, January 20-22. He requested that the instrument Teams come to the meeting with ideas on cross calibration.

5.7 VIS/NIR Calibration

Towards the close of the afternoon, Barker was given the opportunity to cover the items in the MCST report that he was not able to cover in the morning. Barker examined VIS/NIR calibration of MODIS under a wide variety of scenarios. Barker concluded his presentation by reviewing his ideas on platform overlap implications and initial inflight tests leading up to production of a Level 1B-calibrated product.

5.8 MODIS Data Products

The Calibration Group reconvened in the evening of Monday, Oct. 26. Guenther led the Group in an examination of MODIS data products with respect to the resolution of the products necessary to do meaningful science. Representatives from the various working groups present indicated which of their data products and corresponding MODIS bands required the tightest registration. Pagano presented data from his study of MTF/misregistration on radiometric accuracy. Pagano also exhibited data on the use of sub-pixel geometries on radiometric error.

6.0 CALIBRATION DISCIPLINE GROUP

The Calibration Discipline Group met Wednesday afternoon, October 28, 1992, to identify potential areas of cost savings in the calibration of the MODIS instrument. The group examined all aspects of the MODIS preflight and inflight calibration hardware and the proposed preflight tests. With respect to hardware, the group concluded that many of the functions performed by the ground calibrators could potentially be performed by an improved, robust, well tested SRCA.

Additionally, it was concluded that the cooled detectors in the SDSM could possibly be eliminated and the approach to the solar test source should be re-examined. With respect to instrument requirements, the group identified several system-level thermal vacuum tests to be re-examined and proposed an examination of relaxation of the registration requirement. The group agreed that SBRC should construct a strawman report/study of the items identified by the Calibration Group with respect to capability and performance characteristics, and submit this report to GSFC for extensive review.

7.0 FINAL PLENARY

7.1 Oceans Discipline Group Presentation

(See Attachment 8)

7.1.1 SeaWiFS Status

Esaias reported that SeaWiFS is 44 weeks away from launch—tentatively scheduled for Aug. 31, 1993. However, he is concerned over the lack of knowledge of science funding. He said the next SeaWiFS Science Team meeting is tentatively scheduled for Jan. 12-14, 1993.

The MODIS Oceans Group reviewed with the SeaWiFS contingent the outline and two sections of a white paper, detailing how to handle the SeaWiFS / MODIS transition to maintain data products, scientific continuity, etc. The white paper is in conjunction with the Ocean Color Strategy and Implementation Plan. The first draft will be completed and available by mid-December for review at the next SeaWiFS Science Team meeting.

7.1.2 Overall Review of Descopes and Products

Esaias stated that the Oceans Group is concerned that there is still no mechanism at the EOS Program level to balance instrument, science, and EOSDIS capabilities with respect to a cost-constrained system.

7.1.3 Descope Prioritization

Esaias reported that Oceans would like polarization to be put lower on the list of descope priorities; the Group recommends retaining some kind of specification.

Esaias stated that the SRCA gains importance for radiometric calibration if ground calibration is deselected, so it should be included. He said keeping the SDSM is essential; however, it should be made a low priority item on the descope list. The filters in the SDSM need to be tested for vacuum shift effects in the same way as the focal plane filters.

7.1.4 Registration

Esaias reported that most ocean color heritage is with the CZCS (Coastal Zone Color Scanner), which had nearly full registration due to its spectrometer design. Experience with AVHRR is more relevant to MODIS and some problems are experienced in high gradient regions due to misregistration.

SeaWiFS registration is expected to be about 0.1 pixel, with 0.3 pixel spec. Relaxation of MODIS pixel registration to 0.2 pixel is reluctantly acceptable to the Oceans Group in order to meet cost constraints, given the point spread function and the generally low within-scene variability at the top of the ocean atmosphere. However, good registration is important, so the Oceans Group offers the following guidance for alignment of specific bands and regions of focal planes:

•Visible and NIR focal planes should be given greatest attention. Specifically, alignment of Bands 9, 12, 13, and 14 are most important for ocean color;
•Rotations should be minimized because ratios of Bands 8-10 to 11 and 12 form the primary geophysical relationships of interest;
•Alignment of Bands 15 and 16 with Bands 8-10 is also important for atmospheric corrections;
•Reverse the positions of Bands 11 and 12, if possible;
•Relative alignment of Bands 20, 22, 23, 31, and 32 is most important in the thermal for SST (sea surface temperature);
•Commandable along-scan registration is potentially bothersome. If it does make difference to more than one data set, then changing it will affect the time series accuracy.

Esaias stated that registration to 0.5 pixel is unacceptable.

7.1.5 Operability

For Channels 22 and 23, Oceans prefers the sub-pixel approach because it gives better sampling. Esaias added that if there is a choice in the size of the sub-pixel he would like to see a 5 percent overlap at the band edges of the sampling areas.

7.1.6 The 1.375-µm Band

According to Esaias, the 1.375-µm Band is highly desirable, but he is concerned that such a change might affect the operating characteristics of Bands 22 and 23, which cannot be tolerated. He also cautioned that the 1.375-µm change may add cost.

He stated that Channel 20 is also of interest in determining SST to retain the 15-year heritage of AVHRR. Provided the detector could work up to 500K, and that there is no decrease in characteristics of the SNR and data within the environmental range 265 to 320K, necessary changes to Channel 20 would be considered.

7.1.7 PM Orbits

Esaias said it is essential that a more complete suite of studies be performed, which include windspeed-dependent glint patterns, to select optimal phasing between AM and PM platforms as well as nodal crossing times. The studies need to consider actual water-leaving radiance levels, attaining global coverage rapidly outside of glint-impacted areas, and climatological wind fields.

7.1.8 Duty Cycle

Esaias reported that the duty cycle for daylight mode of the AM platform should be increased to allow collection of data to the terminators at equinox and to the terminator in the northern hemisphere at winter solstice and likewise for the summer solstice and southern hemisphere.

7.1.9 Direct Broadcast

Direct broadcast at L-band (HRPT-like) of a selected subset of MODIS bands would be a very useful way to take advantage of the considerable worldwide ground station capability.

7.1.10 Masking Algorithms

According to Esaias, the Science Team depends on MCST's capabilities to perform essential calibration and characterization studies (i.e. normalizing all elements in a given band). He feels the best people to develop utility masks are the ones that are developing the science algorithms.

He suggested, following development of the algorithm-dependent masks, collating these masks under a single product listing, as well as including them in the individual science products.

7.1.11 Level-1B Products

Esaias reiterated that the Oceans Group feels that the heritage of CZCS and SeaWiFS coefficients are most appropriate leading into MODIS. He said that Level-1A data is preferred over Level-1B; however, he asked for a better definition of what -1B data products are. All calibrations will be done retrospectively, he said, necessitating recalculation of Level 1B products, probably several times per year, in contrast to providing new calibration tables.

7.1.12 Simulated Data Models

Esaias stated that the capability exists to produce highly realistic simulated data sets to generate algorithms to explore certain geometries, atmospheric conditions, surface conditions, and water bio-optical characteristics. Additionally, real SeaWiFS data is expected in a year. He said connectivity is a factor in handling large models in near real time on computers. If greater network bandwidth existed between Miami and the OSU CM-5, the Group would be able to perform the sensitivity studies required to utilize the much more complex algorithms required for MODIS ocean color atmospheric and foam correction. Esaias would like for EOS Project to explore the connectivity problem further.

7.1.13 Peer Review

Esaias reported that work continues on the ocean algorithm document, with revisions derived from the most recent revision of product listings and research findings. The SeaWiFS-relevant algorithms and in-water validation program developed by MODIS Team members will be presented to the 50-member SeaWiFS Science Team meeting in January. Alternate arrangements will be made to cover the non-SeaWiFS algorithms (e.g. SST, fluorescence).

The CZCS vicarious calibration article is in manuscript form, he reported. Additionally, the MODIS algorithms are being documented in a series of technical reports and peer-reviewed articles.

7.1.14 Data Products
Esaias said the Group took a fresh look at SDST's list of data products—particularly at each product's connectivity. He said they grouped some, broke some out, and added a couple of new ones. The list will be included in the algorithm peer review document.

7.2 Atmosphere Discipline Group Presentation
(See Attachment 9)

7.2.1 The 1.375-µm Channel Option
On behalf of the Atmosphere Group, King strongly recommended the inclusion of the 1.375-µm band in the SWIR/MWIR focal plane. He said the Group explored a number of options to see which would have the least impact on the instrument. They recommend replacing either Band 24 or 26 with 1.375 µm—a decision to be specified the next week after further review by Paul Menzel.

7.2.2 Detector Operability
The Atmosphere Group prefers sub-pixel to segmented detectors because sub-pixels will improve their ability to blend the channels that they intend to use.

7.2.3 Descope Options
King recognized that striving to meet the current registration specs of 0.1 pixel could be a financial "black hole" for SBRC. Therefore, he recommends relaxing spec requirements to 0.15 IFOV within and between focal planes, yet maintaining 0.1 IFOV as a goal.

He said that the segmented versus sub-pixel discussion offers the opportunity to rearrange the focal planes. He noted that detectors located closer to the center of a focal plane should be the ones likely to be used together. He recommended rearranging the SWIR/MWIR and LWIR focal planes. The Atmosphere Group would like to see Channel 31 and 32 in the center of the focal plane. King also noted that Channel 29 is the 8.8-µm window for SST; he would like it to be close to the center also. The 1.375-µm band should also be close to the center; Channels 24 and 26 can be farther out toward the sides.

Evans stated that 22, 23, 20, and 21 in that order together is the most desirable arrangement.

7.2.4 Software Development Plan
King reported that the Atmosphere Group will provide SDST with their Version beta software by January of 1993.

7.2.5 MODIS Calibrators
King would like to maintain and develop onboard calibrators, with the blackbody getting the least attention. The onboard calibrators are more important than the extensive GSE calibration effort, with the exceptions of MTF characterization, filter characterization (vacuum vs ambient), and radiometric calibration.

7.3 Land Discipline Group Presentation

(See Attachment 10)

7.3.1 Misregistration

Justice reported that the Land Group is most concerned with misregistration. They want to keep the required specs at 0.1 pixel for Land bands. Justice said they have stated which bands are most important and then prioritized them by focal plane. Justice conceded that SBRC could relax Band 7 because it is not critical to the product they are generating. Justice said the Land Group requires registration to within 50 meters between the 250 and 500 meter bands.

Barnes pointed out that, under the current unrelaxed specifications, four 500-meter pixels fit into the 1000-meter band within 100 meters registration; and sixteen 250-meter pixels fit into the 1000-meter band to within 100 meters registration.

7.3.2 Optimization of Detectors

Justice said Land prefers the segmented detector over the sub-pixel. He noted, however, that segmented detectors may have problems at lower temperatures. He also said they would need better SNR characterization.

7.3.3 The 1.375-µm Band

Justice reported that the Land Group supports the 1.375-µm band as long as it does not negatively affect Land's bands. He observed that 1.375 µm trade-offs may shift the fire band, which will need adjustment to saturation at 500°K rather than 700°K.

7.3.4 End-to-End System Simulation

Justice said the Group anticipates future descope / spec issues with rapid response time. They advocate MCST giving a high priority to end-to-end system simulations. Justice said the sooner the Team gets end-to-end simulation, the easier the decision will be on descope tradeoffs.

7.3.5 Scene-to-Scene Registration

Justice stated that scene-to-scene registration is critical to the Land Group because they want to register images at different dates as accurately as possible. Justice feels this issue is not being given enough attention. They recommend MODIS, MISR, and ASTER getting together to talk about location, accuracy, topographic data requirements, and commonality. Justice asked Al Fleig to summarize the scene-to-scene registration status and options.

Guenther interjected that EOS AM is converting to a geocentric rather than geodetic coordinate system. He noted that star tracking requires a geocentric system, whereas horizon sensors require a geodetic system.

7.3.6 Peer Review

Justice said he considers peer review to be a continuous process—those who want to use our algorithms and have input into our product should have input into peer review.

He recommended having the Interdisciplinary Science groups involved in the peer review process. The Science Team members' articles should also be peer reviewed in refereed jounals. Justice suggested inviting focussed peer attendees (outsiders) to write a report to the Team Leader stating their opinion of the algorithms and the progress being made.

Fleig added that he doesn't think it is appropriate for Science peers to review code. He said SDST will try to review the code.

7.3.7 Plenary Meetings

Justice proferred that MCST members should move among MODIS Science Team discipline group sessions because they enhance interdisciplinary interaction.

Justice reported that product definition refinement is underway and each product will be considered at meetings next year. He said he would like to keep the meetings small.

7.3.8 Action Items

1. *Fleig*: Summarize the scene-to-scene registration status and options.

7.4 Calibration Group Presentation

(See Attachment 11)

7.4.1 Calibration Working Group Meeting Action Items

Slater reviewed the action items from the Calibration Working Group's meeting on Monday, Oct. 26:

1) The Calibration Group would like the Science Team members, who represent calibration for their respective groups, to comment in writing on the Calibration Handbook drafts by Nov. 11, 1992, to ensure that everyone agrees on its contents.
2) The Group suggests the need for a contamination monitor. Slater said it is a simple device which can provide useful information to help the Team decide when to open MODIS for taking images. Slater said he would like the Science Team to endorse this suggestion and then present it to Project as an action item.
3) Slater recommended a study of the interaction beteen registration accuracy, MTF, aliasing, re-sampling, and calibration accuracy for typical scenes.
4) Slater recommended prioritization of band registration.
5) He would like MODIS to view the moon on a monthly basis near every full moon.
6) Slater suggested improving the stability of the SDSM for possible use as an absolute calibrator.
7) Slater said there needs to be a discussion of MCST's peer review plan. He would like to meet more frequently—preferably quarterly—in a setting separate from the MODIS Science Team meetings.

7.4.2 Calibration Descope Discussions

Slater reported on the Calibration Group's descope discussions. Regarding the budget problem, he said the GSE use for pre-flight calibration characterization and test equipment has risen in cost. The Group's solution is to do away with the GSE and enhance the SRCA—including adding a photodiode to the SRCA's output and providing a stability check on it. Slater said that these are not costly enhancements. He felt that the required specs for registration could be relaxed from 0.1 to 0.2 pixel, but would rely on the Science Team's reaction to that.

Steve Ungar interjected that relaxation of registration results in an MTF problem. Registration, he said, is analogous to precision— you cannot trade a decrease in accuracy with an increase in precision. Slater responded that improving MTF will not necessarily give rise to improvement of radiometric accuracy.

Regarding implementation of the Calibration Group's solution, Slater reported that Spectralon is good enough to eliminate the three cooled SWIR detectors in the SDSM.

Jim Young said registration could be 0.2 pixel along-track, and that along-scan would be significantly better. Pagano added that SBRC will need to do spot checks outside of the SRCA. Young said that they will not rely on the SRCA for integration.

Slater stated that rigorous tests at GE are not necessary because the MODIS instrument will be moved from GE to Cape Canaveral, and then into orbit. Such moves will likely negate any precise calibration and characterization attempts. He reported that descope item 1 (Specification Paragraph 3.1.4) has been modified and simplified. There will be no thermal vacuum MTF measurement, reliance will be placed on the SRCA. Radiometric tests will not be affected by the descope modifications, nor will the ambient scan mirror tests. Transient response will be tested on the subsystem level. Stray light tests, polarization and cross talk tests, and pointing knowledge tests will all be simplified.

Slater stated that because the in-flight calibration will be of improved design, with more redundancy built in, the SRCA will provide more self-consistent comparisons and will be the main source of calibration information.

<u>7.4.3 Action Items</u>

Slater listed the following as action items as a result of the Plenary and Discipline Group meetings:

1) SBRC should develop a two-level descope list. The first to reflect, in general, the items discussed thus far and their budgetary impact. The second, to the extent possible, to indicate extreme measures but still preserving the perceived MODIS science requirements, and to estimate their budgetary impact.
2) SBRC should forward the results of Action Item 1 to GSFC as soon as possible.
3) SBRC and GSFC should negotiate the specification changes required to permit these descopes.

7.5 Final Plenary Summary Statements

Salomonson summarized the main points of the Science Team meeting (See Attachment 12). He observed that there has been a subtle shift in philosophy among MODIS Science and Technical Team members from a ground-based to an in-orbit capability of calibration.

Esaias said he agrees with Slater in that there should be more reliance on the SRCA in thermal vacuum tests.

Young replied that SBRC had not planned to do thermal vacuum characterization tests of the SRCA. SBRC has a rather large complement of tests at the subsystem level, but not one in thermal vacuum. He said they will have to re-think that.

7.5.1 Polarization

Salomonson stated that maintaining polarization specifications should be a high priority, but polarization should be kept on the descope prioritization list because there is now more reliance on the SRCA.

7.5.2 Registration

Salomonson stated that the spec requirement for registration would be relaxed to 0.2 pixel, with a goal of 0.1 wherever possible. Barnes added that SBRC will meet the 0.1 pixel goal on the same FPA.

Ungar interjected that rather than relaxing the registration spec to 0.2 pixel across the board, why not have a combination of 0.1- and 0.2-pixel requirement, depending upon the importance of the band? Lloyd Candell responded that requirements of 0.1 versus 0.2 determines how many times SBRC disassembles and reassembles the instrument. He pointed out that SBRC's philosophy on how to build MODIS will not be changed by relaxing the spec to 0.2 pixel. However, the amount of money GSFC saves will be impacted.

Justice asserted that the Land Group needs 0.1-pixel registration on certain bands. He suggested relaxing the specs between Ocean and Land bands.

The land bands are the most difficult to register to 0.1 pixel, Pagano countered. If SBRC can achieve 0.1 pixel registration, he asked, could it either be all in the scan direction or along-track?

Justice replied that he would like to review that idea with MCST to ensure that he makes the right decision.

7.5.3 Operability

Salomonson summarized the Science Team's preferences regarding detector operability—Oceans and Atmosphere prefer sub-pixels and Land prefers segmented detectors.

Wan is concerned that the SNR will drop if the sub-pixel detector is adopted. Pagano commented that the difference in SNR between the sub-pixel and segmented detector is about 10 percent. Wan wants reassurance that the transfer curve at 250°K is okay.

Esaias stated that Bands 22 and 23 are most important in high water vapor areas. He would like to use sub-pixel detectors for those bands because it puts MTF equal across-track and along-track.

7.5.4 The 1.375-µm Band

Salomonson reported that the Team decided to adopt the 1.375-µm Band.

7.5.5 Duty Cycle

Salomonson stated that the PM orbits will be worked by Project and that the duty cycle needs to be increased.

7.5.6 Direct Broadcast

Regarding direct broadcast, he said that the Science Team needs to consider HRPT (High Resolution Picture Transmission)-like possibilities.

7.5.7 Masking Algorithms

Salomonson stated that the Team members will do their own utility masking algorithms.

7.5.8 The Fire Channel

Justice asked if Salomonson had considered the request to place the fire channel on 22 instead of 20. Salomsonson said that fire will be on 22.

7.5.9 Future MODIS Meetings

The next MODIS Science Team meeting will be held in Greenbelt, MD—possibly off site—late in March . The MODIS Critical Design Review (CDR) will be held about one year from now—sometime around October 1993.

8.0 ACTION ITEMS

1. *Stuart*: Revise the data product list, based on inputs from the team members, and distribute the revised list to the Oceans Group members.
2. *Evans, Carder, and Brown*: Prepare inputs to the SeaWiFS "white paper" and forward to Esaias.
3. *Parslow*: Review above-mentioned white paper.
4. *Barker*: Discuss Radiometric calibration with Howard Gordon— can the MODIS Characterization Support Team (MCST) do Level 1A, and Oceans (Gordon) do Level-1B?
5. *Clark*: Work with Oceans Discipline Group members to develop a plan for the use of *in-situ* buoy data as surface truth and calibration for Oceans data products.

6. *Esaias*: Develop a plan for development of a MODIS simulated data set. Explore the possibility of budgeting for a T3 communications line between OSU and Miami.
7. *Barnes*: Clarify to the Oceans Group the redundant operation of the A and B readout for each FPA. Which detectors are affected by the shift from A to B, and *vice versa*.
8. *Oceans Discipline Group*: Produce a two-page "white paper" for each algorithm.
9. *Atmosphere Discipline Group*: forward your Science Data Management Plans and your Science Computer Facility Plan to Al Fleig by January 1993.
10. *Wan and Hall*: Assist MODLAND with prioritizing band-to-band registration accuracy between focal planes.
11. *Land Group Members*: Define your ancillary data requirements and show them in the flow diagram format.
12. *Fleig*: Summarize the status and capabilities related to platform, instrument, and ground processing that affect scene to scene registration accuracy.
13. *Running*: Coordinate a meeting with other IDS investigators.
14. *Science Team*: Consider the need for a contamination monitor. Phil Slater would like the Science Team to endorse this suggestion and then present it to Project as an action item.
15. *Science Team*: Discuss MCST's peer review plan. Phil Slater would like to meet more frequently—preferably quarterly—in a setting separate from the MODIS Science Team meetings.
16. *SBRC*: Develop a two-level descope list. The first to reflect, in general, the items discussed thus far and their budgetary impact. The second, to the extent possible, to indicate extreme measures but still preserving the perceived MODIS science requirements, and to estimate their budgetary impact.
17. *SBRC*: Forward the results of Action Item 16 to GSFC as soon as possible.
18. *SBRC and MODIS Science Team*: Negotiate the specification changes required to permit these descopes.