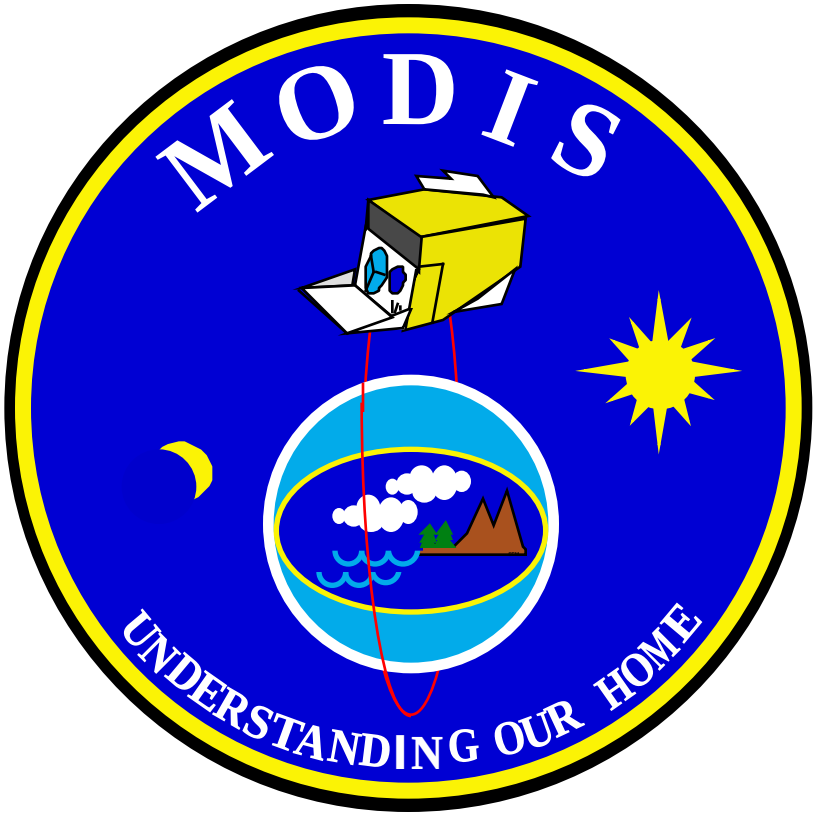
# MODIS SCIENCE TEAM

# MEETING MINUTES

**April 13 - 16, 1992**




**NASA / Goddard Space Flight Center**
**Greenbelt, Maryland 20771**

Prepared by: Science Systems and Applications Inc.

**MODIS SCIENCE TEAM MEETING MINUTES**

**April 13 - 16, 1992**

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| 1.5 COLOR (SeaWiFs II) Team Leader Contract | D | Vince Salomonson |
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| 1.9 Algorithm Development & Peer Review | V | Michael King |
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| 1.12 Peer Review: A Suggestion | D | Otis Brown |
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| 1.16 Radiative Transfer in the Atmosphere for Correction of Ocean Color Remote Sensors | D | Howard Gordon |
| 1.17 Atmospheric Correction of Second Generation Ocean Color Sensors: A Preliminary Algorithm | D | Howard Gordon |

## MODIS SCIENCE TEAM MEETING MINUTES

## April 13 - 16, 1992

# LIST OF ATTENDEES

The following persons registered at and attended the MODIS Science Team Meeting. Those flagged with "*" are secretarial staff and support personnel. Telephone numbers were obtained from previous Science Team Meeting Minutes and could now be outdated.

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| 10. Tom | Arnold | | |
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| 12. Miriam | Baltuck | | |
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| 16. William | Barnes | 301-286-8670 | GSFC |
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| 19. Rick | Berry | | |
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| 30. Ed | Chang | | |
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| 35. George | Daelemans | | |
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| 37. Jeff | Dozier | | NASA/EOS |
| 38. Rod | Durham | | |
| 39. Frank | Eden | | |
| 40. Wayne | Esaias | 301-286-5465 | NASA/GSFC |
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| 46. Brij | Gambhir | 301-731-9300 | SSAI |
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| 48. Thomas | Goff | 301-982-3704 | MSDST |
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| 50. Watson | Gregg | 301-286-3464 | GSFC |
| 51. Barbara | Grant | 301-286-9412 | MCST/925 |
| 52. Bruce | Guenther | 301-286-5205 | GSFC |
| 53. Liam | Gumley | 301-982-3700 | RDC |
| 54. Dorothy | Hall | 301-286-6892 | GSFC |
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| 56. Patricia | Henderson * | 301-286-9291 | SSAI |
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| 58. Simon | Hook | | |
| 59. Doug | Hoyt | 301-982-3700 | RDC |
| 60. Ann | Hsu | | |
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| 73. Ed | Masuoka | 301-286-7608 | GSFC |
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| 77. Paul | Menzel | 608-263-4930 | NOAA/NESDIS |
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| 80. Aaron | Moody | | |
| 81. Peter | Mouginis-Mark | | |
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| 93. Lorraine | Remer | 301-286-8235 | SSAI |
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| 108. Anand | Swaroop | 301-513-1607 | STX |
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| 120. Lalit | Wanchoo | | |
| 121. Richard | Weber | 301-286-5992 | GSFC |
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| 127. Dot | Zukor | | |

# *AGENDA*

## MODIS SCIENCE TEAM MEETING

### April 14 - 16, 1992; Building 8 Auditorium

**Tuesday, 14 April:**

0800: Registration
0830: Welcome & MODIS Overview---------- V. Salomonson
0845: Headquarters' Perspective----------A. Janetos, G. Asrar
0915: EOS Platform Status----------J. Dozier
1000: Project Science Office Report (Funding Status)---------- D. Zukor
1030: BREAK
1045: MODIS-N - Instrument Status----------J. Young, T. Pagano / SBRC

**1200: LUNCH**

1300: Electronic Formats, Communications, and Reporting ---------J. Harrison
1330: Algorithm Development Schedule and Peer Review----------M. King
1430: Data Sets & Algorithm Information ----------A. Fleig
1500: EOS Data Products & Requirements ----------Y.-C. Lu
1515: Discipline Group Meetings ---------- All Day

Groups meet in assigned conference areas. Issues center on selection of algorithms in light of the disappearance of MODIS-T, the advent of SeaWiFS, and the current funding scenario. Required ancillary data sources should be tied into the discussion.

**Wednesday, 15 April:**

0800: Discipline Group Meetings ---------- All Morning

Groups meet in assigned conference areas. Discussions should center on group-specific utility and "common" algorithm requirements, and mainly on the current state of the scientific algorithms, and (proposed) peer review plans.

**1200: LUNCH**

1300: **Plenary Discussions**: Peer Review Plans----------M. King
1400: Texture, Masking, and Error Utility Algorithms----------J. Barker
Instrument-related Scene Simulation Activities ----------J. Barker
1500: Atmospheric Correction----------Y. Kaufman, H. Gordon
1700: Simulated Data Sets----------A. Fleig

1800: **SOCIAL - Catered**

**Thursday, 16 April:**

0800 - 1130: Discipline Group Meetings (continued) ---------- All Morning

**LUNCH**

1230: Plenary Session: Algorithm Status Reports ----- Discipline Group Leaders
1630: Next Meeting Plans & Closing Remarks ---------- V. Salomonson

## MODIS SCIENCE TEAM MEETING MINUTES

## April 13 - 16, 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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. |
| 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
# April 15 - 16, 1992

# PLENARY MEETING 1
# SUMMARY

**Welcome and Agenda Presentation**
Vince Salomonson began the Plenary Session by setting the agenda, the first item of which was a status review of the MODIS-N instrument. Salomonson noted that Santa Barbara Research Center (SBRC) would suggest changes in a variety of MODIS bands, some of which (e.g. the ocean color bands) would be controversial. The second item on the agenda was progress on algorithm development, and the third item involved decisions on peer review. Also, Salomonson told team members to determine how they would handle validation of data products. Finally, he noted that Jeff Dozier is leaving EOS in September.

**Headquarters Perspective**
Salomonson introduced Ghassem Asrar, EOS Program Scientist, who briefed the Science Team on his duties and responsibilities within EOS. Asrar interacts with the interdisciplinary investigators and the science team members, oversees the review process for all EOS science activities, and is responsible for the EOS science budget. He is also planning new activities, such as documenting the EOS science strategy and updating the EOS Handbook. Asrar wants to establish a uniform enforceable strategy for aircraft usage by EOS team members so that principle investigators will be treated fairly.

Tony Janetos, the MODIS Program Scientist, addressed four points: 1) Science products provided by the MODIS team will now appear in individual and team leader contracts / agreements; 2) The schedule is tight so there is an urgent need for timely completion of the algorithm development tasks; 3) He is excited about planned MODIS science activities, especially cross-science topics; 4) He is available to assist with science and budget issues needing help from NASA HQ.

Asrar then further commented that he would like the level 1 requirements to be more specific, because it is easier to track instrument capabilities and there is less loss of science.

**EOS Platform Status**

Jeff Dozier discussed the EOS Platform configuration presented to Congress by Admiral Truly. The 25-page report is part of the president's FY 1993 budget and was well received by Congress. However, the required 1994-95 ramp up in the budget is still controversial. Moreover, the House Subcommittee on Space has proposed restructuring the NASA budget into three components: 1) core programs (i.e. shuttle and space station), which would receive steady funding, 2) lower priority groups (i.e. EOS and advanced solid rocket motor program), and 3) miscellaneous. This proposal would force EOS to compete for leftover funding, which is cause for concern. Dozier agreed that specific level 1 requirements is a good idea because well-defined requirements make it easier to explain why simplification of instrumentation or flight configuration is not necessarily better.

**Funding Status Report**

Dot Zukor, head of the EOS Project Science Office, presented the budget for FY 1993 through FY 2000, which contains a significant ramp-up necessary to accomplish a 1998 launch. Because the EOS budget doubles during that time, it has a very high attention profile. To protect the budget against future manipulations, more detailed level 1 requirements will be requested from team leaders.

Additionally, Zukor reported that Project Scientists for other missions, like the chemistry and altimeter missions, will be selected at a later date. Project is also working alleviate communication problems and to enhance EOS' public visibility. For example, a 15-minute video for lay persons is being produced.

**Instrument Status Report**

Tom Pagano, of Santa Barbara Research Center (SBRC), reviewed an earlier presentation that was made in 1990. (See Attachment 1.7 containing detailed view graphs for the most critical information presented by Pagano.) He noted that the filter bands have been changed slightly from original specs and that custom tailored filters will be employed for every band. Pagano then provided a system overview, noting the features designed by SBRC, such as Main Instrument Assembly, In-flight Calibration Assemblies, System Performance Predictions, and Spacecraft and Data Interface information. In short, Pagano reported that all aspects of instrument development are going well.

**Filter Status Report**

Weber noted that there are problems with the filter requirements and procurement, and that SBRC has made recommendations to alleviate those problems. According to Young, the problems are due to the filters' very stringent tolerances. He provided lists of requested changes, both general and specific, in the filter requirements.

**MODIS Communications**

Locke Stuart introduced the MODIS communications personnel: Barbara Conboy, communications officer; Donna Hollar, assistant to Conboy; and Janine Harrison, who is being trained to take over MODIS administrative duties in the future.

Harrison reported that MODIS support groups have standardized on Macintosh three pieces of software: Microsoft Word 5.0, Microsoft Excel 3.0, and MacDraw Pro 1.0 (or a later version). The MODIS Administrative Support Team (MAST) also plans to implement an electronic archive—enabling a full text search capability—so incoming documents should be in electronic format. Additionally, Harrison reported that general communications have been switched from GSFCMAIL to EUDORA, which uses Internet. However, for members that cannot use EUDORA, Conboy still regularly reads GSFCMAIL. Also, EUDORA can send to GSFCMAIL.

**Algorithm Development Schedule and Peer Review**

Michael King, MODIS Deputy Team Leader, reported that according to the new statement of work, launches have been moved up, funding will be delayed, and two MODIS instruments (AM and PM) will be flown. To prepare for the scheduling changes, King suggested that SDST develop a software management plan as template. King also discussed the Science Computing Facility Plan, Data Processing Software, the Calibration Plan (to be prepared by Barker and Slater), Software Review Status, meeting attendance, and monthly and quarterly status reports.

Additionally, King reported that Project requires all instrument algorithm development efforts, including MODIS, to undergo annual peer reviews. He presented his concept of the peer review process as a strawman proposal to the Team. However, there were conflicting views of how the peer review process should be handled, scheduled, and achieved.

**EOS Data Product Database**

Stuart introduced Hyo Duck Chang, who presented and demonstrated the EOS Data Product database, called the Science Processing Database. It is a completely interrelated database of all instrument and PI data products. The Science Processing Database allows investigators to find a data product to suit their requirements and to see how changes in the algorithm or specifications for one data product might impact a variety of other data products.

**Science Data Processing Software**

Fleig discussed the science data processing software being developed for MODIS. The software is in the primitive stages of development and will be operational (or a prototype) in about two years. Fleig stressed that the software will be developed through a process of iterative convergence between the scientists and the software team.

# MODIS SCIENCE TEAM MEETING
# 15 - 16 April, 1992

# PLENARY MEETING 2
# SUMMARY

**Discussion of Peer Review**
Each Discipline Group presented its thoughts on the peer review process. According to King, the Atmosphere members disliked the words "peer" and "review" in the title. They suggested having an informal advisory panel meet between October 1992 and January 1993 to discuss MODIS concepts and ideas before presenting anything to the general community.

The Calibration Discipline Group, according to Slater, had already derived a panel, similar to that suggested by Atmosphere, almost a month ago. Their list includes one or two members from each Discipline Group and two non-MODIS remote sensing authorities.

Brown reported that Oceans is in favor of peer reviewing, but they prefer a hierarchical process rather than a single committee review. They recommended that a three-tier Discipline-Team-Community review process be conducted annually. Brown explained that community awareness and approval are important to the peer review concept.

Justice stated that Land has not yet discussed the peer review issue. Personally, he felt that King's proposal was inappropriate for Land and preferred Brown's proposal. However, because of the diverse nature of land-oriented algorithms, Justice was unsure whether Brown's proposal would work for the Land Group. Land, he said, has already taken measures to ensure community review and interaction.

Salomonson recommended that the Ocean Proposal for peer review should be adopted as the strawman proposal, but that each group should modify or adapt the proposal to fit its individual needs.

**Discussion of Simulated Data Set**
Fleig reported that, to test the MODIS data analysis system, Unger and Barker will generate "synthetic" data sets. Fleig's group will then modify the data to look like a MODIS data stream. The synthetic data, however, do not adequately exercise all algorithm paths through the processing software. It

was recommended that the simulated data be tied to actual measurements to expose any possible future problems in real data not revealed in a synthetic simulation.

**Texture, Masking, and Error Utility Algorithms**
Barker reviewed MCST's current activities (see Attachment 1.13 and Handout 1.14), including Calibration Data Products and the MCST Calibration Plan. It was agreed that the accuracy of MODIS data could be characterized within twelve months after launch. Currently, however, there are no platform calibration data products. Barker concluded with a summary of his simulated data set activity.

**Atmospheric Corrections**
Gordon's and Kaufman's presentations encouraged more open and direct communication of scientific ideas and concepts among the Discipline Groups. Gordon reviewed the first order correction algorithm and noted its shortcomings. He proposed a second-order algorithm, to be used by both SeaWiFs and MODIS, which employs a term for Rayleigh aerosol scattering. He reviewed plans for testing and improving the algorithm.

Kaufman reported that calculating the atmospheric correction over land is more difficult than for over oceans because there is more and highly variable surface reflectance over land—especially when the effects of vegetation are factored into the equation. He discussed molecular scattering, vegetation indices, effects of aerosols, and methods for deriving path radiance.

Eric Vermote discussed the codes whereby radiative transfer is used to apply atmospheric correction. Brent Holben detailed experiments in which his group used sun photometers to measure aerosol properties, precipitable water, ozone, and sky radiance. He presented data collected at GSFC, stations in Africa, the Amazon Basin, and the Dead Sea.

**Filters: The Great Debate**
This session was intended to be a status review of the Science Team members' responses to the relaxations in the filter specifications which were requested by SBRC. Rather than a series of presentations, the session evolved quickly into a heated discussion of the filter specs.

Richard Weber encouraged Team members to resolve the filter specifications issues immediately due to scheduling and cost containment concerns. He urged Team members to make band-by-band changes, stressing that even a single relaxation in a single band would help the filter manufacturer. Weber proposed that relaxation of the edge-range specs would offer relief. Jim Young reinforced Weber's remarks.

Otis Brown pointed out that a list of specifications changes was distributed in January and that Oceans is prepared to respond to it. Brown noted inconsistencies between the two lists and said that responding to the new list would take weeks of analysis. He requested SBRC and William Barnes to provide the study results and software to clarify the effects of the filter changes. Brown was supported by Howard Gordon.

# MODIS SCIENCE TEAM MEETING
# April 15 - 16, 1992

# PLENARY MEETING 3

# SUMMARY

Vince Salomonson introduced the proposed MODIS logo and asked that comments be addressed to L. Stuart. He also recommended referring to MODIS-N as just MODIS, because MODIS-T is no longer an active instrument. Salomonson then asked for the Discipline Group Status Reports.

**Calibration Group**

Algorithm Status Report

Phil Slater reported that the MCST algorithms require review. He noted that the principal source of algorithms and calibration is the SBRC preflight data, which will not be available until October, 1992.

Calibration Working Group Action Items and Prompts

Slater discussed the nine action items resulting from the Calibration Group's meeting, listed in Attachment 1.21. Richard Weber will contact Bob Schowengart for a computer program to simulate data retrieval. Also listed in Attachment 1.21 are the four prompts resulting from the Calibration meeting. Prompt 2 arose because there is lingering disagreement on the use of the Solar Diffuser Stability Monitor (SDSM).

Action Item 3 resulted from discussion of the various interrelated filter procurement needs and calls for Slater to tell Guenther what costs are involved. Kieffer needs to test the filters; and there is a need for monochromator testing.

Contamination Meeting Conclusions

There is a 50 Å contamination build-up on the MODIS mirror that is non-uniform, therefore it is field angle dependent. The contamination results in a 1% reflection diffraction across the mirror surface, which can affect signal-to-noise in some bands. These effects cannot be accurately math modeled or lab simulated. Slater presented four possible solutions to the problem.

Radiance Calibration

Slater stated that the lunar observations noted in Item 3 are for radiance calibration, but they also serve as a backup check of the stability of the solar diffuser. C. Scolese said that if these lunar-related observations are purely operational then he sees no reason to get involved in the issue. However, Guenther cautioned that MODIS should not presume the proof will be handled elsewhere until we know what SeaWiFS and DoD find.

Comments and Concerns

Slater stressed the need for more representation by Science Team members at Calibration meetings. He remarked on the cross-calibration visible-infrared radiometer, which is under development, and on the interest that exists in using it with SeaWiFS. He expects the radiometer to be ready on time and has discussed the possibilities with Wayne Esaias. He is eager to work out the filter problems because the expected price jump of an order of magnitude caused by a delay will have a severe impact.

## Atmosphere Group

Filter Recommendations

King stated that only those recommended filter changes that could be easily assessed would be accepted. The effect on planned research of manipulating four filter parameters (location, width, edge slope, signal-to-noise) was not apparent. Many recommended changes would severely impact the Atmospheres objectives.

MODIS AIRBORNE SIMULATOR (MAS):

A review of current specifications was provided, along with a history of the instrument and its use. Mention was made that the instrument has been returned to the manufacturer for modification, in preparation for ASTEX (Azores), TOGA-COARE (6 weeks of intensive field effort), SCAR (Brazil -- hopefully 1993) and other upcoming field experiments.

ALGORITHM DEVELOPMENT STATUS:

P. Menzel has reported considerable progress in algorithm development; other team members are relying heavily on aircraft and field campaigns to provide the necessary input data. It was acknowledged that A. Fleig has considerable interest in receiving some initial preliminary ("place-holder") algorithms, and hopes they will be supplied soon.

## Land Group

Justice highlighted the Group's activities in a summary statement:

- **Products:** There are no major changes; a few post-launch products are missing.
- **Budgetary Constraints:** 93-94 field campaigns will depend on the promised level of funding.

•**General Observations:** 1). Response on a greater number of issues burdens team members, and funding levels are insufficient to employ help; 2). More Land Discipline Group meetings are required, and possibly team plenary meetings could be reduced to two days.

Topographic Requirements

EOSDIS has not responded to Justice's request that they address the overall EOS topographic requirements, and their plan to meet those requirements. At the next Instrument Working Group meeting, Justice will request that the Project and Program Scientists consider the high priority of topographic data.

Inter-Instrument Liaison Structure

The Land Group felt it critical that a working liaison be formed with other instrument teams, to develop a unified approach on issues of common concern. Examples of this need are evident in the pointing accuracy and topographic problems, wherein it is assumed that several teams carrying recommendations forward would carry more weight than a single group.

Test Sites

Determination of satisfactory test sites continues at the discipline group level. The concept of multi-use test sites, involving many elements of EOS, is important, and will be addressed at the June EROS Data Center DAAC Advisory Board meeting. F. Hoge invited other team members to take advantage of the mid-Atlantic P-3 mission.

## Ocean Group

O. Brown reported on the highlights of the Group's meetings, which covered the following topics: filters, peer review, data products, algorithm delivery & data management plans, ATSR calibration, infrared black body calibration, in-situ observations, and Oceans Meetings reports and future plans.

Filter Recommendations

The Oceans Group presented a plan, wherein they would receive software from SBRC/GSFC to study the impact of the requested changes, would furnish preliminary comments within a week after receipt of the software, and would furnish their "final" comments in two to three weeks.

Data Products Lists

V. Salomonson asked where the new forms of the product names came from. W. Esaias responded that they came from the attempt at uniformity in the renaming of products to fit a word search plan. Salomonson commented that any proposed changes to products need to be discussed *before* the changes are made.

SeaWiFS

R. Evans commented that the relationship of SeaWiFS to MODIS needs to be clearly defined. He noted that the two programs combine research teams, but maintain separate projects—with some overlapping on algorithm development and funding—which has caused some tension. There is no clear delineation of authority on budgets and contractual obligations. Salomonson said that support for SeaWiFS follow-on is embedded in the MODIS contract, but that the current SeaWiFS and MODIS contracts must be kept separate and discrete so that SeaWiFS research and development will be ready on time.

# MODIS SCIENCE TEAM MEETING
## April 15 - 16, 1992

# ATMOSPHERE DISCIPLINE GROUP
# SUMMARY

Present were Michael King, Yoram Kaufman, Paul Menzel, Tom Arnold, Kenneth Brown, John Cooper, Philip Dabney, Liam Gumley, Janine Harrison, Brent Holben, Lorraine Remer, Vince Salomonson, Eric Vermote, Richard Weber, and Jim Young. David Rosten was executive secretary.

**Resolution of SBRC Filter Issues**
M. King stated that there is some confusion as to which of the requested filter spec changes in MODIS-N is the most recent. The Atmosphere Group studied the changes band-by-band and then approved or disapproved the requests. However, the Group was impeded by not knowing the cost/performance tradeoff between bandwidth tolerance and edge range.

**MODIS-N Algorithms**
Because the data product list was first distributed with the meeting packet, King stated that, as a group, they must update the atmosphere product list and, as individuals, each scientist must describe the status of algorithm development for the MODIS-N products. P. Menzel presented his algorithm development plans and schedule, which listed algorithm delivery dates to SDST.

At Wednesday's meeting, the Group determined that the MODIS science data products need to be limited so that the system is not overloaded. Y. Kaufman stated that nothing should be entered into or changed in the database without prior approval from the investigators. The Science Processing Support Office (SPSO) database will be the means by which scientists—both inside and outside of MODIS—can identify future sources of data products, based on current MODIS expectations.

**MODIS Peer Review**
Although the group conceded the importance of peer review, Menzel pointed out that the term implies a "yes"/"no" response to a funding proposal, which is not what MODIS wants to accomplish. Peer review, he said, should be an interactive discussion that checks the strength of the investigator's work and suggests changes if it falls short. Kaufman suggested an advisory/review to

take place twice—once in 1992 and again just before release of a product. All agreed that an oral presentation is better for interactive discussion than a written distribution.

Kaufman asked King if he intended to use MISR cloud data in his algorithms. Kaufman explained that, in its high resolution mode, MISR generates optical thickness better than MODIS. King would rather see MODIS products self-contained.

**MODIS Airborne Simulator Status**

King presented status information on MAS and reported on its configuration: four channels record as 10 bits each and the other seven are 8 bits each, one of which is in the visible. He showed an image taken over the Gulf of Mexico in which he pointed out an optically thin section and some high level cold cirrus clouds. Menzel reported that the preliminary MAS data were very good; however, he also demonstrated the need for some higher resolution data. Once they are calibrated, he said, the FIRE data are quite useful.

K. Brown reported that MAS has significant problems on the ER-2 aircraft which result because the contractor is unfamiliar with the hostility of the aircraft environment. Moreover, Brown explained that the current data system for the instrument is ill-suited. P. Dabney discussed an alternative data system, currently being prepared for ASAS (Advanced Solid-State Array Spectroradiometer). According to Dabney, the new data system is superior and will be inexpensive and easy to integrate into MAS.

According to Brown, revisions to the instrument were made to educate the contractor on the hostility of the aircraft environment. But three major problems persist: 1) temperature causing gain changes, 2) humidity in the aircraft causing condensation on the optics and electronics, and 3) 400 Hz noise arising from the pod heaters surrounding the data system. Despite its problems, Group members expressed a positive reaction to MAS.

## April 13 - 16, 1992

# CALIBRATION DISCIPLINE GROUP

# SUMMARY

**• The following is a summary of a series of MODIS Science Team Calibration Working Group Meetings. The first meeting was held Monday, April 13, 1992, at NASA/GSFC in Building 22, Room 365. This session was chaired by Phil Slater of the U. of Arizona. Present were Peter Abel, John Barker, Bill Barnes, Stuart Biggar, Ken Brown, Bruce Guenther, Joann Harnden, Brian Markham, Jan-Peter Muller, Tom Pagano, June Tveekrem, and Jim Young. Jim Butler was executive secretary.**

**EOS Calibration/Data Product Validation Meeting Major Issues**
Phil Slater presented a review of three major issues examined at the EOS Calibration/Data Product Validation Meeting held the week of April 6 in Boulder, Colorado. These issues were important to the MODIS Science Team Calibration Working Group and included the following: 1) the acquisition of sets of filters for preflight calibration activities, 2) the assimilation of the calibration PDR into the instrument level PDR, and 3) the plans by GE to permit calibration before environmental testing.

**MODIS/MCST and Calibration Working Group Report**
John Barker (NASA/GSFC) presented the MODIS/MCST and Calibration Working Group Report. Barker pointed out that the calibration strategy for MODIS is an evolving one. Barker reviewed plans for Level 1, 2, and 3 calibration data products. Barker indicated that he is planning to provide data users with a scheme for automated quality assurance of MODIS data along the lines of the system used for Landsat. Comparison of MODIS and CERES Level 2 products was also discussed. Barker requested input and feedback on a distributed version of the MODIS/MCST Calibration Plan and Handbook. Barker concluded his presentation with a review of the flow of MODIS Level 1B radiometric data processing as presented in the Appendix to the MODIS/MCST Calibration Working Group Report.

**EOS Calibration/Data Product Validation Report**
Bruce Guenther (NASA/GSFC) presented an overview of the issues discussed at the EOS Calibration Data Product Validation Meeting held April 7-10 in Boulder, CO. Discussions included the issue of spacecraft contamination, the nature of the calibration PDR and the algorithm review process, and data

product validation. Guenther announced that the next EOS Cal/Val Meeting will take place in Logan, Utah, September 14-18.

**Calibration of the MODIS Instrument**
Jim Young (SBRC) presented information on MODIS calibration. Young reported that for the most part the calibration requirements and performance predictions for MODIS remain unchanged. SBRC anticipates the use of their own and other vicarious methodologies in calibrating MODIS. Young carefully reviewed the in-flight calibration of MODIS. The Spectroradiometric Calibration Assembly (SRCA) and Solar Diffuser Stability Monitor (SDSM) were extensively examined with respect to SBRC-proposed modifications to these subsystems. In addition, the issues of scan mirror contamination, SBRC ambient and vacuum radiance calibrations, and cross-comparison at GE was examined.

**MODIS Radiometric Math Model**
Tom Pagano (SBRC) presented the current status of the MODIS radiometric math model. He discussed the effect of glint on the diffuser and the ability of the math model to predict its potential effect. The treatment of polarization and radiometric accuracy by the model were also examined in this presentation. Pagano expressed a need for additional data from the MODIS Science Team (MST) to be input to the math model.

**MODIS Calibration/Characterization Plan**
John Barker presented an overview of the MODIS Calibration/Characterization Plan. Barker plans to address more extensively the reflectance based calibration of MODIS. The importance of a study to examine misregistration and geometric effects on the instrument Modulation Transfer Function (MTF) and radiometric error was emphasized by the MST and SBRC.

**EOS Cross Calibration Radiometers**
Stuart Biggar (U of Arizona) presented his ongoing work on EOS cross calibration radiometers. He discussed the issues of vacuum, or ambient operation of the traveling radiometers, the anticipated instrument radiance levels needed for calibration, and the anticipated scheduling of the radiometers.

**Simulated MODIS Imagery**
Brian Markham (NASA/GSFC) presented his work on simulated MODIS imagery from TM. The role of this work in the development of the utility algorithm was presented.

**Math Model of MODIS Sensors**

Jan-Peter Muller (U. College London) presented his work in developing a math model for the MODIS instrument sensors. Muller requested information on the MODIS camera geometry. The orthophoto generation of images from the linear array sensor and the MODCAL 1992 work plan were reviewed.

**MODIS Aircraft Simulator**
Ken Brown (NASA/GSFC) presented a summary of work on the MODIS Airborne Simulator (MAS) and the successful role it played in the recent FIRE campaign. Areas for improving the operation of the MAS and its usefulness with respect to MODIS were examined during the presentation.

**NASA Aircraft Satellite Instrument**
Peter Abel (NASA/GSFC) presented ongoing and future plans to improve the NASA Aircraft Satellite Instrument Calibration (NASIC) instrument with the goal of providing vicarious calibration for MODIS using aircraft underflights.

**Sea Wide Field of View Spectrometer (SeaWiFS)**
Bill Barnes (NASA/GSFC) presented an overview of the SeaWiFS instrument scheduled to be launched in August, 1992.

**• The MODIS Science Team Crosstrack Calibration Meeting was held Tuesday, April 14 in the Building 8 Auditorium. The meeting was chaired by Phil Slater (U. of Arizona). The following topics were discussed in this session.**

**MODIS Contamination Model**
June Tveekrem (NASA/GSFC) presented information on the MODIS contamination model. Tveekrem presented the assumptions which are used in the contamination modeling. The calculated 19 Å upper limit for contamination thickness was reported to be a bit pessimistic. Tveekrem indicated that the GE plans for contamination control during integration and test need to be closely examined and understood.

**Proposed SBRC Crosstrack Calibrator**
Jim Young (SBRC) presented information on the SBRC proposed crosstrack calibrator. His model predicted a large polarization induced by 50Å carbon contamination of the scan mirror at 0.7 microns. This polarization effect was ascribed to a possible interference phenomenon produced by the scan mirror contamination.

**NASIC**
Peter Abel (NASA/GSFC) presented information on the role of the NASIC instrument in monitoring MODIS scan mirror contamination through simultaneous views of ground targets.

**Crosstrack Calibration Analysis**
Joann Harnden presented the results of her contamination analysis. She proposed crosstrack calibration techniques for time series analyses of MODIS imagery over the same target, and yawing the spacecraft to acquire along-track data.

The main conclusions of the meeting were that the best approaches to all the polarization and contamination problems are the vicarious methods, which look as promising as the hardware solutions. Therefore, the ER-2 experiment must be made as stable as possible and a bore-sighted camera must be flown with the experiment in order to solve the registration problem.

**Discussion**
The session was concluded with a discussion on which crosstrack calibration method to recommend. The Group concluded that none of the proposed on-board hardware solutions were effective in addressing the problem. The recommendation made was that the best approaches to polarization and contamination problems are the vicarious methods. The specific recommendation was made that the ER-2 NASIC experiment must be made as accurate and stable as possible.

**• The MST Calibration Discipline Group met Wednesday, April 15. Phil Slater chaired the session, and the following items were discussed.**

**SBRC Radiometric Math Model**
Tom Pagano (SBRC) presented details on the radiometric math model for MODIS. Items examined included the referencing of radiances to tungsten lamp irradiances, diffuser BRDF, and the SBRC assumption of uniform scenes in computing in-flight radiometric accuracies.

**Action Item Review**
Phil Slater presented a draft list of action items from the meeting. Slater also presented some information on the algorithm status report, wherein he reported that the basic algorithms supplied by the Science Team have been peer reviewed in the literature, and that a detailed review is needed.

**MCST Presentation on Schedules**
John Barker (NASA/GSFC) presented information on MCST schedules. He recommended that interdisciplinary investigators be contacted now for participation in the PDR, that the PDR must be in place by October, and that the calibration plan be seriously reviewed before the next MST meeting.

**• The MST Calibration Discipline Group met on Thursday, April 16. Phil Slater again chaired the meeting.**

In this session, discussions were held on SBRC's planned in-flight use of the solar diffuser monitor, the proposed preflight calibration filter procurement, the ability to access aliveness data imbedded in the engineering housekeeping data stream after the instrument is buttoned up, stray light on the diffuser, and the ability to monitor inflight changes to the diffuser using lunar calibration. The session ended with the announcement of the MODIS quarterly review at GSFC on June 22.

# MODIS SCIENCE TEAM MEETING
# April 14 - 16, 1992

# LAND DISCIPLINE GROUP
# SUMMARY

**General Issues**
Chris Justice reported that the Land Group needs calibration and sensor-related information on: (1) the 3.75 µm band calibration; (2) the difference in modulation transfer function (MTF) between bands 1 & 2; and (3) the impact of the proposed changes to the filter specifications on land sensing and atmospheric corrections.

Vince Salomonson reported that the listing and documentation of the data products by each individual investigator is important in the planned revision of contracts.

**Justice Research Summary**
Justice reported on his work related to four MODIS "At-Launch" data products: 1) Atmospheric Corrected Radiance with D. Tanre and Y. Kaufman; 2) Vegetation Index with Alfredo Huete; 3) Land Cover with Alan Strahler; 4) Fire product with Yoram Kaufman. He then briefly discussed his work with three "Post-Launch" products: 1) Vegetation growing season length; 2) Regional trace gas emission from biomass burning; 3) Land cover change.

**Huete Research Activity**
Alfredo Huete reported on his Vegetation Index-related work, which includes the effects of atmosphere, background (understory), directional reflectance on vegetation index, and temporal compositing techniques. Additional work is planned with Alan Strahler on temporal spectral mixtures, with Steven Running on vegetation stress, and with Zhengming Wan on thermal inertia.

**Running Research Activity**
Ray Hunt summarized his and Running's work on Net Primary Productivity (NPP) and their use of MODIS input products of vegetation index, land cover, APAR, and incident photosynthetic active radiation (IPAR). They are working on growing season length and vegetation stress.

**Geometric Considerations**

John Barker presented MODIS geometric considerations. He recommended a minimum goal of registration at 250 m and not 480 m for MODIS bands 1 & 2. The Land Group is most interested in the final registration accuracy and the Project should decide whether the Land Group's geometric specifications are met by using either Ground Control Points or a spacecraft configured system.

**Utility Algorithms**

Barker gave an overview of MCST's Utility Data Products, which include a texture product and a classification / mask overlay. The classification overlay includes clouds, water, snow-lines and vegetation. Work on the Utility Products should be the third priority for the MCST, behind instrument characterization and calibration, and algorithms and work related to monitoring MODIS in orbit.

**Muller Research**

Jan-Peter Muller gave a presentation on misregistration effects from variations in topography. He recommended a grid spacing of 0.5 km. He is studying effects of slope, aspect, grid size on shading, topographic requirements for low resolution, for moderate resolution, and for high spatial resolution. Additionally, he is working on a peer review paper regarding the misregistration effects on MODIS data caused by not incorporating topographic effects.

**EDC DAAC**

June Thermosgaard gave a presentation on Distributed Active Archive Center (DAAC) activities. Their work on misregistration effects from a terrain displacement is up to 2 AVHRR pixels, and up to 3 pixels for large scan angles. She said that they have completed examining 1990 and 1991 data from SPOT and JERS-1, and are near finishing validation using the 1989 and 1992 daily AVHRR data.

David Carneggie highlighted Version 0 Activities—they are working on System Level activities, including work on catalog, user interface, data formats and a science processing library. EDC is also working with IGBP-DIS on an 18-month AVHRR global land database, starting with mid-year 1992 data, to provide global coverage of High Resolution Picture Transmission (HRPT) network data. EDC is also procuring Multispectral Scanner (MSS) and AVHRR data for MODIS, which they sell for the cost of reproduction.

**Global Land Data Set Requirements**

John Townshend reported on requirements for a global 1 km AVHRR data set, and presented a proposal for a high resolution data set from the Land Cover Working Group of the IGBP-DIS.

**Land Surface Temperature**

Zhengming Wan summarized his work on land surface temperature in which he is examining accuracy of selected radiative transfer models. He will examine pre-launch ground, aircraft and satellite data to study problems when estimating surface temperature.

**BRDF, Albedo, Spatial Structure, and Land Cover**
Alan Strahler's work on these topics included MODIS-T and MISR evaluations with Muller, and BRDF work with Barnsley. His group is examining spatial structure at the spatial resolutions of MODIS using 30 m TM data. Currently, Strahler is evaluating classification procedures and satellite data temporal compositing problems.

**Topographic Correction, Global BRDF, Surface Roughness, Land Cover for Climate, Spectral Albedo, Scene Simulation, and Camera Model**
Jan-Peter Muller reported on his work to date. Muller is looking at NS001 type data. M. Barnsley is evaluating MISR/BRDF work. Muller and Barnsley are studying how many pixels of a location are needed to estimate surface albedo. They are also planning to develop a DEM database. Justice said that because of the uncertainty in both Muller's and Tanre's funding level, their MODIS data products may be at risk.

**Polarization Vegetation Index**
Vern Vanderbilt is modifying the vegetation index for polarization effects. He is examining the use of polarization data from ADEOS, to be launched in 1986, to modify MODIS data.

**MODIS Airborne Simulator**
Michael King summarized the MAS. They used only one visible band for their November FIRE flight. They are planning a Brazilian flight in September, 1993. Paul Menzel reported that the 3.75 μm band has a 1.7°C rms error and the 8.8 μm band has a 0.3°C rms error. Justice intends to employ MAS in future Land field campaigns.

**Smoke, Cloud, and Radiation (SCAR) Experiment**
Y. Kaufman reported on the Smoke, Cloud, and Radiation Experiment planned for Brazil. The experiment's objective is to study the radiative and physical effects of biomass burning on the atmosphere, and to prepare a comprehensive data set for the evaluation of remote sensing procedures from ground and air measurements of the optical and physical properties of aerosol particles, cloud drops, and the surface reflectance.

Lorraine Remer, of SSAI, presented her work to characterize the land surface reflectance for many parts of the world using a Hasselblad camera and digitization techniques.

**NDVI Correction**

Michael Verstraete presented his work on the development of a spectral vegetation index algorithm that corrects for atmospheric effects.

**Snow & Ice**
Dorothy Hall summarized her work on snow, sea ice, and glaciers. She discussed plans to use MODIS and MISR to measure albedo. Her team also plans to provide global mapping of snow and related watershed areas with MODIS. They are investigating adverse effects on the mapping caused by fog and vegetative cover. They plan future work in Ontario, BOREAS sites, and Glacier National Park.

The BOREAS work, according to Ray Hunt, will permit the MODLAND Team to develop and test algorithms. He wanted figures on the proposed algorithms and input/output products from the MODIS Team.

**Test Sites**
Justice reported on the MODIS Team considerations of global test sites. The plan was to select land cover test sites by biome throughout the global land surface. A selection of MSS scenes was identified for FY91 through EDC. EDC is preserving world-wide historical Landsat data with a goal of three scenes a year.

Huete summarized the MODIS request for EDC to purchase 50 MSS scenes to be used for algorithm development and validation. EDC is paying to register 200 Landsat MSS scenes in the Southwestern United States and Mexico and will consider registering those scenes purchased for MODIS.

**ASTER**
Wan summarized information on the ASTER Science Meeting. He said that for the ASTER thermal bands (8-12 mm), the signal to noise is low at cold temperatures. He cannot attend the ASTER meeting in Japan during June, 1992.

**MISR**
Strahler reported that MISR is considering tradeoffs between spatial resolution, bands, and camera angles when determining their local and global model test sites. MISR is working on three different cloud screening approaches. MISR data will be managed through the Langley DAAC.

**Radiometric Calibration**
Huete reported that Ken Brown gave a pessimistic portrayal of MAS—it was never tested for environmental temperature changes. However, Huete said, most of the MAS problems are correctable. Huete said the MCST will need to consider special calibration requirements and sensitivities to satisfy the Land Group. In addition, any specific topographic requirements should be emphasized.

Jon Burelbach said the snow group is examining MODIS simulated data, which includes scanner and detector effects.

**Interdisciplinary Science**
Justice wants to determine how MODLAND can provide information on data products to the IDS investigators and to determine what the investigators expect from MODIS.

Peter Mouginas-Mark gave a presentation on volcanic eruption effects on the atmosphere. He wants continuous collection of the SW and LW infrared channels; also, he needs an absolute calibration of the thermal bands. He plans to use TOMS data to measure ozone and sulfur dioxide. Additionally, for his purposes, MODIS will be merged with MISR, ASTER, GLRS-A, and AIRS.

# MODIS SCIENCE TEAM MEETING
# April 15 - 16, 1992

# OCEAN DISCIPLINE GROUP
# SUMMARY

Present were Wayne Esaias, Ian Barton, Otis Brown, Frank Hoge, Mark Abbott, Robert Evans, Ken Carder, Howard Gordon, and Greg Mitchell. A number of other guests, including technical team members, were occasionally in attendance. Locke Stuart acted as executive secretary.

**Filters**
Much of the group's deliberations were concerned with possible relaxation of spectral filter requirements. In summary, it was decided that there was insufficient time and information at the meeting to make fully rational decisions on modifications to the previously carefully crafted specifications. There was some stress in the propriety of the filter review request: previously a set of proposed modifications had been sent to team members by Santa Barbara Research Center, then a wholly new (and in some cases conflicting) set was presented on the first day of the Science Team meeting. A week's deadline for response was allowed by Project; inappropriate for a fully defined filter review, but possible on a selected basis with a concentrated effort by certain members of the Oceans group, led by Howard Gordon. Gordon will work particularly closely with O. Brown and P. Slater to complete the recommendations on schedule.

**Peer Review**
In general, the concept of algorithm peer review was well received by the Oceans Group. While there was some concern that it was a bit early to institute reviews (before algorithms are sketched or drafted), it was felt that current peer review could prove valuable in considering the scientific concept. Internal reviews (within the Group) are initially preferred, followed by MODIS Science Team review, and then regular publication / presentation of algorithms and concepts in an appropriate forum.

**Data Products**
A substantive review of data products was made, in view of the demise of MODIS-T. Generally, Oceans data products were not eliminated by the disappearance of MODIS-T; in fact, the product list may be complicated by the advent of both an A.M. and P.M. MODIS. The importance of interim data

products was discussed, and the relationship of IDS and other instrument requirements was recognized.

**Other Discussions**

Other MODIS issues were addressed, and a forum for the initiation of tutorials on team member's research was informally established. The MODIS issues addressed covered instrument specifications, science team plans and schedules, and SeaWiFS and its Follow-on (called COLOR). I. Barton gave a status report on the Along Track Scanning Radiometer (ATSR). Research tutorials were presented by I. Barton (Structure of the Top Meter of the Ocean), K. Carder (Solar Stimulated Fluorescence), and F. Hoge (Phycoerithryn Modeling).

Instrument discussions stressed the need for MODIS' thermal accuracy to be comparable to ATSR. Science Team schedules stressed the need for more than 2 discipline group meetings per year -- probably 4 meetings are required under the presently required level of effort. Most of the SeaWiFS and COLOR concerns addressed data availability and distribution, the relationship between SeaWiFS and MODIS algorithms, and the coordination of calibration and data validation.

Highlights of ATSR instrument performance were its thermal measurement precision and accuracy. Barton's presentation on the ocean structure stressed an *in situ* measuring device, which is towed and gives vertically stratified measurements. Carder's fluorescence tutorial stressed the output region from the ultraviolet to the far red. Hoge stressed the need for absorption meter measurements to add precision to his modeling efforts.

# DAY 1 - MORNING PLENARY SESSION

## 1. WELCOME AND AGENDA PRESENTATION

Vince Salomonson welcomed the audience to the MODIS Science Team meeting. He presented a copy of the meeting agenda and objectives, Attachment 1.1, and offered an interpretative summary of the three most important elements of the agenda.

The first critical agenda element is a status review of the MODIS-N instrument. Salomonson stressed the need to bear down on filter specifications in particular. Santa Barbara Research Center (SBRC), the instrument manufacturer, would be offering suggested changes in a wide variety of MODIS bands. Although he felt that many would be acceptable, some were certain to be controversial. Salomonson identified the ocean color bands as a possible area of contention. He asked team members to respond to the SBRC recommendations if at all possible by the end of the meeting. Filter costs have already proved to be larger than expected, and further delay would be coupled to increased costs for other budget items.

The second important element of the agenda is to make progress on algorithm development. The schedule dictates that there is a need to show substantive progress from this meeting. The third important element involves making decisions on how to do peer review.

Salomonson also remarked that team members should consider how they would handle validation of data products. He noted in relation to this topic that there will be updates to team member contracts, primarily in the level 1 requirements. Attachment 1.2 was offered as an example. There are also some inconsistencies that need to be clarified and details that require increased specificity. Such changes are merely tune-ups that will make the contracts more logical, and which are likely to reoccur at various times during MODIS's lifetime due to changing boundary conditions.

Team member reporting has been going well. Salomonson considers many of the one-month reports on E-mail to be quite valuable contributions, and he is looking forward to the six-month reports.

It was noted that Jeff Dozier will be addressing the team for the final time. He is leaving EOS in September after 2 $^{1}/_{2}$ years of service. An announcement is being circulated to advertise the position, and team members were advised to

consider candidates to take over the position. Salomonson suggested that team members speak with Dozier himself if they were interested in more details of the duties involved.

Salomonson noted the MODIS social on Wednesday and the proposed logo (Attachment 1.3) for the MODIS group. The logo was a surprise presentation to the Science Team from the MAST group. While it is a good idea to have a logo, Salomonson wants to be sure that the team has had ample opportunity to critique it and that they are comfortable with it before adopting it for the group. Salomonson also reminded the audience that Michael King has been designated the MODIS Deputy Team Leader. This is a challenging position that will supply Salomonson with some badly needed task sharing.

## 2. HEADQUARTERS PERSPECTIVE

**INTRODUCTION:**
Salomonson noted that NASA Headquarters was represented by Ghassem Asrar, the EOS Program Scientist, by Tony Janetos, the MODIS Instrument Scientist, and by Diane Wickland of the Ecosystem Dynamics and Biogeochemical Dynamics Branch.

**ASRAR PRESENTATION:**
Salomonson introduced Ghassem Asrar, the new EOS Program Scientist who took over for Stan Wilson approximately two months ago. Asrar's opening remarks make note of the presence of ASTER and MISR representatives, which pleased him because an interdisciplinary effort is needed for a successful EOS program. Asrar commented that he has had to maintain a very busy schedule in order to come up to speed on past EOS activities.

Asrar briefed the Science Team on his duties and responsibilities within the EOS Program Office. There is a triumvirate of responsible management, with Asrar overseeing the science component, Ray Roberts the hardware, and Dixon Butler acting as the head of the data and information systems. Asrar's first function is to provide direction to interdisciplinary investigators as well as to the science team members of the various instruments. Another function is to set up a review process for all of the EOS science activities. He has been working to this end with Jeff Dozier and other members of the Project Science Office in a very productive collaboration. Asrar has overall responsibility for the EOS science budget and the apportionment of resources. To perform these duties, Asrar feels he needs to rely heavily on support from many groups; therefore, he considers communication among these groups as a major and continuing challenge.

Asrar discussed some of the new activities which have been started by the Program Office. He plans to document the EOS science strategy, and hopes to have something ready for the IWG meeting in July. He anticipates an update

of the EOS handbook, and requests input from the team members. Establishing criteria for evaluation of progress will also be an issue. Asrar wants to establish a uniform enforceable strategy for aircraft usage by EOS team members, leaders, and interdisciplinary investigators. Current practice identifies money from the principle investigators (PI) funding allocation for aircraft usage. It is his opinion that this is an unfair way to treat PIs; however, the alternative is to have NASA completely subsidize aircraft expenses. Asrar wants the status quo changed to a compromise position somewhere between these two extremes.

In summary, Asrar stated that his goal is to help the EOS program achieve a position where it can take a proactive role, rather than only react to many varied inquiries. In order to achieve this goal, it is necessary to clearly articulate the EOS science.

**ASRAR QUESTION-AND-ANSWER SESSION:**
Q1: *Vince Salomonson* - Is there a need for more frequent reporting than the 3-month and 6-month reports which are now required?
A1: *Asrar* - It is not yet clear how the instrument team members will be involved in the reporting loop. He is trying to streamline the process, and has opened a dialog between the Project and the Program Science Office in order to establish what is expected.

Q2: *Vince Salomonson* - Do you envision anything much different administratively than the current flow of information channeled through the MODIS Project Scientist?
A2: *Asrar* - Current sentiment among NASA Headquarters program scientists is that they are not adequately involved in the loop. It is unclear if they have a desire to have more input into the budgets, daily decision making processes, or something else entirely. It is clear that, generally speaking, the various components of the program are disconnected and that internal communication needs improved. Current MODIS reporting procedures might be adequate, but he has not yet been able to evaluate them. There is a requirement for consistency in whatever the evaluation process is for all instrument groups. To this end Asrar expressed his need to rely heavily on his colleagues at Headquarters because he cannot monitor everything personally. Tony Janetos will be relied upon heavily, and Team Members are encouraged to go through him with their concerns.

Q3: *Vince Salomonson* - You have specifically addressed aircraft usage, but how does ship time enter into the resource allocation process?
A3: *Asrar* - Funding and resources for ship time is one of many urgent problems that needs to be addressed. Ship time will be addressed, but he is unsure of how at this time.

Q4: *Wayne Esaias* - Esaias stated that he wanted to encourage incorporation of SeaWiFs and SeaWiFS2 (COLOR) into the overall EOS resource allocation process. This would help minimize time involvement for experimenters involved in both programs. Esaias inquired about the current status of SeaWiFs involvement.
A4: *Asrar* - Asrar noted that he needs to devote more thought and discussion to the subject, and that in particular he needs to dialog with Greg Mitchell before attempting an answer.

**JANETOS PRESENTATION:**
Tony Janetos succinctly addressed four points to the audience.

1. Science products to be provided by the MODIS team will now appear in individual and team leader contracts / agreements. The additional specificity of the products has been included to be sure no one can be unjustifiably held accountable for products for which they are not responsible.
2. There is a renewed sense of urgency on timing of algorithm development tasks. The schedule is very tight (roughly equivalent to 1 grant period).
3. He conveyed a personal sense of excitement about planned MODIS science activities, especially in the areas of cross-science topics. His interests run beyond the ecology program he administers. As an example, he cited the aircraft campaign planned for Brazil.
4. Janetos made it known he is available to assist with science and budget issues needing help from NASA Headquarters. His intent is not to interfere with daily management decisions, but to guarantee that those issues which require extra attention will receive it.

**ASRAR FOLLOW-UP:**
Asrar made a follow-up comment that he would like the level 1 requirements to be more specific if possible. If requirements are specifically stated, then it is easier to track instrument capabilities and there is less likelihood of loss of science. The MODIS plan was thought to have the best presentation.

Salomonson commented that MODIS requirements were made more specific than most instruments for just that reason. In addition, funding losses imply a ripple effect that causes changes in many areas. The more specific the contracts are, the easier it becomes to show what impacts are to be expected due to a budget change.

## 3. EOS PLATFORM STATUS

**DOZIER PRESENTATION:**
Jeff Dozier reminded the audience that this would be his last appearance as Project Scientist. He has found the position to be scientifically rewarding and challenging.

His presentation centered on the EOS Platform configuration as presented to Congress. Admiral Truly presented a 25-page report that was generally well received, and has been described as a readable explanation of EOS that is responsive to earlier criticisms. The package was presented as part of the president's FY 93 budget. Attachment 1.4 presents an overall summary of the United States' contributions to the EOS instruments. These include:

Platform AM-1, June 1998 launch

| | |
|---|---|
| MODIS | surface imaging |
| ASTER | surface imaging |
| CERES | radiation budget |
| MOPITT | tropospheric chemistry |
| MISR | bi-directional properties of surface and atmosphere |

Platform PM-1, December 2000 launch

| | |
|---|---|
| MODIS | surface imaging |
| CERES | radiation budget |
| MIMR | atmospheric sounding |
| AIRS / AMSU | atmospheric sounding |

SeaWiFS2 (COLOR), 1998 launch - ocean color measurements

SAGE, 2000 launch - chemistry mission

Altimetry mission, 2002 launch - revamped version of GLRS (GLAS)

Chemistry mission, 2002 launch

Dozier noted that this program requires a 1994-5 ramp up in the budget, which is still somewhat controversial. Other presented material included a revised artist's configuration of the AM Platform and a "wiring diagram" depicting the interplay between the NASA components of the EOS mission.

The current funding climate within the Congress was another important topic addressed by Dozier. There have been disturbing rumblings coming from the House Subcommittee on Space, chaired by Representative Hall. The Hall Committee has proposed restructuring the NASA budget into three components. The first consists of core programs like the shuttle and space station, which would be granted the status of a steady funding profile. The second group consists of lower priority programs like the advanced solid rocket motor program. The third is a miscellaneous category. EOS would be placed in the second group, which would have to compete for leftover funding which is above the inflation rate. This approach is troubling because it brands EOS as being "below the line" or non-essential. EOS is in better shape in the Senate due to the support of Senators Mikulski and Gore, but there is still room for concern.

Dozier expressed the opinion that Asrar's request for specific level 1 requirements is an excellent idea. Project is often called on to defend and explain the MODIS configuration. Having well-defined requirements makes it easier to justify why simplification of the instrument or its flight configuration is not necessarily better. Dozier conceded that EOS is likely to remain as a high profile program and be susceptible to attempted diversion of funds.

**DOZIER QUESTION-AND-ANSWER SESSION:**
Q1: *Mark Abbott* - What is the status of ESA plans for MERIS?
A1: *Asrar* - It is his understanding that ESA still plans to fly MERIS.

Q2: *Mark Abbott* - Tilford has made statements that implied budget problems are casting doubt on MERIS.
A2: *Asrar* - There seems to be some justification coming from the standpoint of ocean color measurements.

Q3: *Eric Young* - What is the budget priority given to planetary missions like Cassini?
A3: *Dozier* - Planetary missions come under the grouping of core science, which covers a wide range of scientific activity.

Salomonson added the comment that in the past, we used to tout the idea of concurrent, simultaneously derived measurements; however, this has generally been lost as a compromise to the realities of the budget. In MODIS we still have some vestiges in one instrument of the concept of interdisciplinary congruent observations. This is a strength which gives MODIS an added programmatic advantage.

Q4: *Mark Abbott* - What is Headquarters current thinking on SeaWiFs data distribution rights?
A4: *Dozier* - Headquarters is still very enamored of the concept of the data bucket. The intention seems to be to do away with the waiting period. Dozier felt that everyone at Headquarters is very enthusiastic about this new way to do business, and expects SeaWiFs data to have the same availability as the rest of the EOS data.

Salomonson offered Attachment 1.5 as additional information relevant to the question. It is a copy of a section of his Team Leader contract that shows the level 1 wording relevant to SeaWiFs II. He suggested that this contract needs further detail, particularly with regard to financial arrangements, to be in the team leader contract, and Project seems to agree.

# 4. FUNDING STATUS REPORT

**ZUKOR INTRODUCTION:**
Salomonson introduced Dot Zukor of the Earth Sciences Directorate Staff. She is also the Associate Director for Projects Engineering and assists Jeff Dozier with the logistics of managing the EOS Science Office. Additionally, the Science Office consists of the AM Platform Project Scientist (headed by Bruce Guenther), the PM Platform Project Scientist (headed by Les Thompson), and EOSDIS (headed by Bob Price). Zukor helps to coordinate the activities of these groups, and is expected to perform the same function when other EOS groups become sufficiently well organized to have a project scientist.

**ZUKOR PRESENTATION:**
Zukor presented Attachment 1.6, a proposed funding runout for Science Team members. She reported that the remaining FY92 funding should be available sometime in May, and that the Project will visit Team Leaders within the next two weeks for detailed budget discussions. The budget in Attachment 1.6 contains a significant ramp-up in FY93 through FY96. The ramping is necessary to accomplish a 1998 launch; however, the EOS budget doubles in that time period, lending it a very high attention profile.

A new and more detailed statement of work containing level 1 requirements for data products will be issued to all team leaders. It will solidly document intended at-launch deliverables as well as help protect against future budget manipulations. A new phasing plan that will have greatest impact in the out years can be expected. Team members were cautioned not to count too heavily on the budgets outlined for the out years because changes often occur.

The Project Science office will be involved in the selection of Project Scientists for other missions like the chemistry and altimeter missions at a later date. The Project has also been continuing to work to alleviate the EOS communication problems and to provide public visibility for the EOS program by attending conferences and school events, and by assisting with informative brochures and displays. A task is underway to produce an EOS video geared toward the layman.

**BUDGET QUESTION-AND-ANSWER SESSION:**
Salomonson recalled intense budget discussions some months back. The budgets derived at that time emphasized the time period through FY94, and are not changed. The ramifications for budget changes for FY95 and beyond are still being sorted out.

Q1: *Wayne Esaias* - Is funding for SeaWiFS2 included in the budget or will some addition be necessary?

A1: *Salomonson* - Salomonson restated the opinion that it is not possible to do SeaWiFS2 work with the existing MODIS funding as has been represented in the strawman contract. Extra funding will have to come from somewhere if SeaWiFs2 is to be added.

Q2: *Mark Abbott* - Who is responsible for data products common to the two MODIS instruments or involved with other satellites like SeaWiFs?
A2: *Salomonson* - When MODIS-T disappeared, and the AM and PM platforms were created, responsibility for forming interfaces between the two was placed on the initial AM platform.

Q3: *Mark Abbott* - What will the responsibilities be for handling of data products within EOSDIS and the subsequent implications for the budget?
A3: *Salomonson* - EOSDIS will not be broken up. An easy way to remember the domain of responsibility is that the platforms are responsible for the data until it hits the ground, at which point the EOSDIS responsibility kicks in. The interplay between data products has fiscal implications. For example, even though we saw MODIS-T go away, a simple deletion of its funding is not appropriate. The algorithm development looks the same and costs the same or more because some algorithms now need to be pieced together from other data sources. Having two of what was known as MODIS-N also implies added work and increased strain on the budget.

## 5. INSTRUMENT STATUS REPORT

**PAGANO INTRODUCTION:**
Salomonson reminded the team that a subject of discussion during the meeting would be when to hold the next meeting. The next meeting is scheduled for late October, and there is a probable interaction with the timing of the PDR which is also scheduled in the same time frame. If the PDR is held after the Team meeting, it will not be possible for SBRC personnel to attend the team meeting. It may also be possible to hold the team meeting at Santa Barbara in conjunction with the PDR; however, this option is logistically stressful on the limited GSFC travel budget. Some decision is desirable before the end of the current meeting.

After these initial remarks, Salomonson introduced Tom Pagano of SBRC, the assistant engineer for development of the instrument.

**PAGANO PRESENTATION:**
Pagano began by noting that his presentation was first presented in 1990. SBRC has been working on MODIS for five years, and the basic design has not changed much. Changes would be noted during the course of the presentation. He also noted that today's presentation would be a top level presentation only, but that it is supported by significant detailed design currently being carried out in Santa Barbara. Pagano reviewed an outline of

his presentation, and noted that Jim Young would be speaking afterwards on the spectral filters.

Pagano presented his talk in conjunction with Attachment 1.7, which is a complete and detailed set of view graphs. The reader is referred to these view graphs for the most critical information presented in Pagano's talk. A brief outline will be presented here, with Pagano's additional comments and the comments and questions from the audience interspersed.

***REQUIREMENTS REVIEW*** - Pagano noted that there are a few minor changes in the filter bands since the original presentation, and that custom tailored filters will be employed for every band.

***SYSTEM OVERVIEW*** - There are four spatially coregistered focal planes stacked on top of each other in the object space. A passive radiative cooler is employed. SBRC makes full use of the 360 degrees of rotation of the scan mirror by filling the non-sensor views of the mirror with calibration equipment.

***MAIN INSTRUMENT ASSEMBLY -*** All sub-assemblies attach to the instrument mainframe; therefore, it needs structural and thermal stability. SBRC is currently performing studies related to the stability. The 100% duty cycle for MODIS represents a significant mechanical engineering challenge. All optics have been placed on the aft optics assembly in order to facilitate meeting the registration requirements. Using an individual preamplifier for every detector allows SBRC to custom tailor dynamic ranges of the detectors, which in turn helps meet S/N requirements. Detector arrays and the focal plane layout are configured to minimize optical distortions. There is a discrete filter for every spectral band, except for 13 and 14 which are duplicated. A time delay and integration is utilized to receive the signal from these channels. The cooler operating temperature has been changed from 88 degree Kelvin to 85, but there is still a 5 degree margin for error.

Q1: *Peter Mouginnis-Mark* - Can you elaborate on the processing for bands 13 and 14?
A1: *Pagano* - We wait for band 13' to reach 13 so that the line spread functions overlap. The signals are then averaged to double the signal strength and reduce the noise by the root-sum-square (RSS). This has little affect on the line spread function, it just improves the S/N. Salomonson further noted that these are the fluorescence bands, and that a similar time delay is utilized on the SeaWiFs instrument.

***IN-FLIGHT CALIBRATION ASSEMBLIES*** - The SDSM alternates views between the sun and the solar diffuser. The SRCA does not have a full aperture; however, one is not required for stability monitoring. The

mainframe has a port that allows the sun to hit the solar diffuser. The blackbody assembly has a specular black coating to provide an effective emissivity of 0.992. The blackbody design has changed since the original presentation, and the view graphs reflect the current design.

Q2: *Vince Salomonson* - Could you comment on the provision that has been made to provide a few calibration points.
A2: *Pagano* - It is possible to heat the blackbody to 320 degrees Kelvin and thus to allow several temperature calibration points to be measured. A few additional charts in the handout show the sensor dynamic range needed to accommodate these calibrations. (These charts are included in Attachment 1.7, but were not included in the original distribution made at the meeting)

Q3: *Yoram Kaufman* - Is it possible to extend the solar calibration chart to visible wavelengths?
A3: *Pagano* - Pagano agreed that this a good idea, but does not currently have solar data in that wavelength range. It was agreed that he would try to get that data from Phil Slater.

Q4: *Michael King* - Why are the screen holes small?
A4: *Pagano* - The screen holes need to be small to avoid scattering.

Q5: *Vince Salomonson* - Is there a way to control degradation of the solar diffuser plate?
A5: *Pagano* - A cover door closes over the blackbody to minimize the degradation.

Q6: *Yoram Kaufman* - Do you have plans to simulate the deterioration rate?
A6: *Pagano* - SBRC has drawn on the LDEF experience to estimate the deterioration rates. SBRC will also use the best materials available to minimize radiation effects. Slater further noted that activities are currently in progress to study materials for the solar diffuser. A plate with holes in it has been selected as the best approach.

Q7: *Howard Gordon* - What is the fail-safe mechanism for the screen operation?
A7: *Pagano* - That mode is with the screen down, so there is a 10% transmittance level.

The SDSM started out as a grating system design, but was later changed to allow monitoring in infrared. The current design uses an integrating sphere and is much simpler in concept. The SDSM is located in the mirror's object space, and will subtend a selected solid angle on the focal plane. Monitoring of the short-wave infrared bands is performed. The system performs spectral band registration with a reticule pattern, so it has the ability to perform an internal calibration.

***SYSTEM PERFORMANCE PREDICTIONS*** - SBRC has developed radiometric sensitivity models, which were discussed extensively at yesterday's calibration session. Pagano expressed optimism that performance can meet or exceed specifications for all 36 bands, although there is some minor concern over a few of the bands with the very longest wavelengths. The detectors have very high sensitivities, such that no other instrument has achieved comparable sensitivities in orbit. Calibration target accuracy is the major contributor to radiometric accuracy. Data shown in the presentation is for single scene samples, and scene averaging is expected to improve accuracy.

Q8: *Otis Brown* - Will it be possible to meet the goal accuracy of 0.3%?
A8: *Salomonson* - This is expected to be a very difficult task.

Q9: *Ian Barton* - AVHRR has an approximate calibration accuracy of 0.3%. Absolute accuracy of the on-board calibration is the key to achieving a good overall accuracy. Should MODIS not be capable of doing significantly better?
A9: *Salomonson* - A study performed by RAI has implied that MODIS should be able to achieve 0.3% accuracy. Pagano expressed doubt that the AVHRR system was capable of the quoted performance.

Pagano noted a very low error margin in polarization sensitivity in the blue which is where the mirror is most polarization sensitive. The information provided was calculated using TM data. The short-wave infrared has not been checked yet, but no problems are anticipated. Some variability is seen in the modulation transfer function (MTF), which is a measure of the degree of blur that is seen. The MTF is different in the scan and track directions, and even different from pixel to pixel; however, much effort has gone into making the functions uniform. Approximately 0.07 spectral band pixel registration is expected from modeling; however, a number of factors may influence this so it should be considered as a preliminary estimate.

Q10: *Otis Brown* - A question was raised with respect to registration of the bottom pixels of a scan.
A10: *Pagano* - SBRC is required to register corresponding pixels of a band, but not required to register to another band. The bottom pixels are expected to be approximately the same as the rest of a scene because of the uniformity.

Q11: *John Townshend* - Townshend noted that the Land Group has some concerns regarding the pointing error budget.
A11: *Pagano* - Pagano expressed the opinion that there remains a good margin for error.

Q12: *Chris Justice* - Justice noted that the Land Discipline Group would be discussing the pointing error budget during its Tuesday afternoon session, and inquired if someone could attend to participate in the discussions.
A12: *Pagano* - Pagano agreed to try to attend.

***SPACECRAFT AND DATA INTERFACE INFORMATION*** - The instrument dimensions are within the envelopes required by the specifications. Pagano noted the location of the mounting cube on MODIS. Pixels are registered relative to the cube and thence to the spacecraft. Supplied measurements are in meters. MODIS is a TM class instrument both in complexity and size. MODIS has more bands and better calibration, but less resolution. Pagano skimmed through the data format and rate information with little comment.

***SUMMARY -*** In his summary, Pagano stated that all aspects of instrument development are on track and going well. There are a few isolated cases where things do not yet meet specifications; however, almost all specifications are currently expected to be met, and in most cases the goals (which are more stringent) will also be met.

Q13: *Phil Slater* - Slater inquired about the status of the instrument filters.
A13: *Rod Durham* - They are in the process of selecting a vendor, have already written the specifications, and expect to place the order very soon.

Q14: *Peter Mouginnis-Mark* - An inquiry was made about how the quick-look data segments are processed.
A14: *Pagano* - SBRC has been told to identify packets as quick look data, then key a flag to tell the information processing systems what happens to the data after it is telemetered down. There is no on-board processing of the data.

Q15: *Yoram Kaufman* - What is the pessimistic side of instrument development?
A15: *Pagano* - Pagano made an effort to clarify the optimism that has been expressed about MODIS instrument development. Even though things like the radiative cooler work has been done before, much of the package represents a state-of-the-art challenge. There are some development areas where they are really pushing the limits of the technology and the budget, as for example the registration issue. It should be expected that some problems will be encountered; however, SBRC's 20 years of experience is expected to overcome those problems.
A15: *Bruce Guenther* - Guenther elaborated on Pagano's answer by adding a "sales pitch" for calibration. They're very interested in top level system requirements, an issue partially covered by Kaufman's questions. Guenther invited Kaufman to attend calibration sessions to see more detail and provide feedback.
A15: *William Barnes* - Barnes also elaborated by noting that a significant amount of failure analysis has been performed to minimize the effects of any failures that might be encountered. Three or more days at the instrument PDR will be devoted to covering these types of problems. All Science Team members are invited to attend and hear the details.

# 6. FILTER STATUS REPORT

**WEBER INTRODUCTION:**
Richard Weber prefaced this presentation by noting that there are problems associated with the filter requirements and procurement. SBRC has made recommendations to alleviate those problems. Weber expressed the view that those recommendations should be considered acceptable unless specific objections are raised. Although he did not expect complete acceptance of the recommendations, he did express a hope that closure on the filter specifications could be reached by the end of the meeting.

**FILTER PRESENTATION:**
Jim Young reiterated that there are some problems with the filters due to the very stringent tolerances, but stressed his desire to alleviate the problems in a cooperative effort with the Science Team. Even with modifications to requirements, implementation will be complex. The difficulty is not any single characteristic or specification, rather it is the collective set of specifications for most single filters. Young noted the effects of the mirror f-number on the filter response. The bandpass filters, even without the filtering needed for blocking other spectral regions, will require on the order of 50 layers to achieve. The worst case filter at 1.2 microns is expected to require as many as 200 total layers to construct, which provides significant opportunity for filter suppliers to encounter errors. Young presented lists of general and specific changes to the present filter requirements, with the areas of concern highlighted.

**FILTER DISCUSSIONS:**
Salomonson presented a personal-view summary of the filter status to help focus discussion. Bands 9, 10, 13, 14, and 15 require discussion. Gordon has strongly stipulated that there be no changes for band 15. Kaufman has some reservations about changes to the long-wavelength surface temperature bands. Most of the difficult problems are expected to be found in ocean color bands. From band 2 on down the list (see Attachment 1.7), there should be few changes that are not tolerable.

Q1: *Yoram Kaufman* - How do we compare what the instrument specifications in space are compared with what we see on the ground?
A1: *Salomonson* - The SRCA should significantly help with this question.
A1: *Young* - Young was in agreement, and further specified that we can do 1 nm measurements on the instrument spectral response for visible, near infrared, and short-wave infrared bands. Measures are not possible for midwave and long wave infrared.

Q2: *Yoram Kaufman* - How will you know if the filters have changed once the instrument is in orbit?

A2: *Young* - A pre-flight measurement of all instrument performance parameters at fine-resolution is made under ambient conditions and thermal vacuum conditions. This should verify that there is no shift between the two sets. The external monochromater and onboard monochromater will measure the filter sensitivity curves simultaneously so they can be correlated. After launch there is not as much capability for measuring the full curve, but it should still be possible to locate the center wavelength to 1 nm. Whole band shifts rather than changes in band shapes are expected.

Q3: *William Barnes* - Are the requirements given the full-up requirements for in-vacuum performance?
A3: *Young* - Yes.

Salomonson noted that the cost quotes are now estimated optimistically to be twice the original estimate. One vendor described the filter requirements to be the most difficult set they had ever seen.

Otis Brown expressed the opinion that it will be necessary to carefully examine repercussions of any proposed changes to most bands in general, and to bands 22 and 23 in particular. The positioning of these two bands is very tricky. Relaxation may be possible, but it isn't possible to tell without a careful examination.

Q4: *William Barnes* - Are the changes given in the same format as the previous set of recommended changes?
A4: *Young* - The changes are listed in percentages and in nanometers.

Gordon observed that for bands 13 and 14 there is minimal room to insert anything. There is also significant concern for band 15 which is situated between two absorption features of water vapor in the atmosphere.

Q5: *Howard Gordon* - If the filters are so hard to make, what is the risk assessment of using such a filter?
A5: *Young* - There may be some risk, but it has not previously been flagged as a problem. Filters are expected to be durable, in that layers will not strip off.

Q6: *Howard Gordon* - Is it possible that some previously unexplored combination of parameter changes will produce a more easily manufactured filter?
A6: *Young* - It is possible and SBRC is willing to work toward an appropriate compromise, but tolerances are already tightly boxed and the development is very time-critical.

Ian Barton noted that some groups of bands should be treated as a matter of principle as groups, and that individual changes to make the filters easier to manufacture should not be an option. The filters are designed to work as a

unit. As an example, he noted the atmospheric temperature sounding bands in filters 33 through 36.

Q7: *Nancy Roman* - What is the expected stability of the filters in a cosmic ray environment?
A7: *Young* - Young knew of no literature reference with direct bearing on the problem. Effects from radiation during classified experiments has been noted, and no problems were reported.

Q8: *William Barnes* - Was total radiation dosage due to the environment included in the specifications?
A8: *Young* - He is unsure, but noted that it should have been. It is known to be an issue for some of the optics.

Q9: *William Barnes* - At the end January 1992, a memorandum was distributed asking for changes to 18 of 36 MODIS bands. Now we see SBRC asking for changes to 30 of 36 bands. Are you classifying the 18 original changes as top priority? Are you asking for feedback on all bands on such short notice or just on the original 18 bands?
A9: *Young* - Young felt that the original 18 are probably higher priority, but was unsure. The newer changes are generic changes, and the older set of changes are more specific. Relaxation for the newer changes are also being requested at this time.

Q10: *Vince Salomonson* - What tables of requested relaxations should we use? Are there differences in the two lists?
A11: *Young* - The most recent tables which have been presented today should be used. There are differences in the two lists.

Weber suggested that the Science Team needs to define parameters band-by band rather than with a broad brush approach. No simple answers are expected. Young can come to individual discipline sessions to further discuss the issues. Salomonson reminded the audience that some of these bands are interdependent, making a strictly one-at-a-time approach to the relaxations impossible.

Q12: *Howard Gordon* - Why is the final filter design nearly impossible to manufacture?
A12: *Barnes* - This design process has been worked on for a couple of years. The scientists have pushed the limits of the technology very hard. The filter designers have talked to manufacturers, who replied that the filters could be done but were difficult.

Weber reminded the audience that Project is already having discussions about descoping MODIS. He expressed the opinion that this is unlikely to happen if we can show our ability to deal with real-world problems. Bruce

Guenther commented that letters have been sent to the five AM Platform instruments requesting updates to their descope plans. The last descope plan dates from January 1990, and some facets of that plan are no longer appropriate. Input from the investigators will be required.

Q13: *Chris Justice* - Is a presentation planned on Project's ideas on descoping?
A13: *Weber* - No presentation is planned.

Q14: *Wayne Esaias* - At what level does the tradeoff of holding a goal of 36% error margin relate to changing the filter specifications?
A14: *Young* - There is only a very loose relationship.

Esaias commented that the current approach assures the difficult bands will have a small S/N, and the easy bands will have a high S/N.

Salomonson closed the morning session by requesting that the Science Team take this problem into their group sessions. The support personnel will reconfigure the problem as the meeting progresses.

# DAY 1 - AFTERNOON PLENARY SESSION

Stuart opened the session by reminding the audience that the agenda calls for afternoon discipline group sessions starting at 3 p.m. The audience was also invited to attend the MODIS social on Wednesday evening. Some difficulties with the room acoustics were noted in that those in the rear of the room have had difficulty hearing questions addressed to the speakers. Stuart asked that questioners wait for the portable microphone to reach them before starting their questions. This will help the audience as well as those taking minutes of the meeting.

## 7. MODIS COMMUNICATIONS

**STAFF INTRODUCTION:**
Stuart introduced the MODIS communications personnel. Barbara Conboy has been involved in supporting MODIS for several years. She is the communications officer and also receives MODIS reports. These functions are expected to become more complex as MODIS activities ramp up. Donna Hollar has been engaged to assist her with these duties. Janine Harrison is part of the Presidential Management Intern Program. At the end of her internship she will take over Stuart's MODIS administrative duties. She plans to work with Ghassem Asrar at Headquarters during her next training rotation.

**HARRISON PRESENTATION:**
Janine Harrison presented a report (Attachment 1.8) covering various aspects of MODIS communications. MODIS support groups have standardized on three pieces of Macintosh software: Microsoft Word 5.0, Microsoft Excel 3.0, and MacDraw Pro 1.0 (or later versions). These are used heavily locally at GSFC, but are applicable to Macintosh users only. MAST is striving to get as much of its incoming documentation as possible in electronic format. One of the primary motivators for doing electronic reporting is a planned MODIS document archive with a full text search capability. Hard copy inputs are still acceptable, but they will require that an OCR scan be run on the document in order to insert it into the archive system. Harrison solicited examples of information that Team members would like to see in the archive, and supplied examples of documentation that are currently expected be included. Harrison showed the distribution list and schedule for technical reports which are required under MODIS contracts. In general the technical reporting has gone well, although there are a few Science Team members that have been tardy or have not complied.

General communications have been switched from GSFCMAIL to a software package called EUDORA. EUDORA uses the Internet addresses supplied in the information packets to initiate communication. Harrison solicited comments on the formatting and information content of the list, and asked that Conboy be notified of any changes. EUDORA has several advantages: it automatically checks your mail and notifies you, documents can be attached, and the editing function is easier than GSFCMAIL. Its largest restriction is that it can only be used on Macintosh computers. Harrison solicited suggestions for a mail program for PC users. EUDORA requirements are provided in Attachment 1.8. The software and user manuals are available, and can be obtained by signing the distribution list being kept by the meeting receptionist. For the benefit of members that cannot use EUDORA, Conboy still regularly reads GSFCMAIL. She can forward and distribute communications via EUDORA if they are received in GSFCMAIL. Members that are in the field or unavailable for extended periods were asked to notify Conboy.

**COMMUNICATIONS QUESTIONS:**
Q1: *Jan-Peter Muller* - Is it possible to reduce the page of addresses at start of a mailing? His system's mailings have eliminated the problem.
A1: *Barbara Conboy* - Each name in a group mailing appears as part of the header on the mailing. Eudora cuts down on some of the extraneous information, but it seems to be an artifact of the communication software.
A1: *Otis Brown* - The extra names can be eliminated, but it requires some programming on the server work station to set things up.

Q2: *Jan-Peter Muller* - Are there problems with sending journal articles via electronic mail due to copyright infringements? Such articles characteristically have the copyright assigned to the journal.
A2: *Locke Stuart* - Stuart is unaware of the problems, but will check on the legalities of the situation.
A2: *Howard Gordon* - Gordon suggested that the copyright problem might not apply if MODIS pays for the article, because the government retains the copyright.

Q3: *Howard Gordon* - Is it acceptable to send preprints electronically in Postscript format?
A3: *Harrison* - Yes.

Ed Masuoka suggested that those with Internet addresses might wish to obtain the most recent copy of the EUDORA software from the FTP national supercomputer center in Illinois.

# 8. ALGORITHM DEVELOPMENT SCHEDULE AND PEER REVIEW

**ALGORITHM DEVELOPMENT SCHEDULE:**

Michael King addressed the deliverables contained in the statement of work (Attachment 1.9). Team members are very aware of the requirement for quarterly reports; however, additional items are specifically called out.

1. *Software and Data Management Plan* - King noted that although this is an EOS Project level requirement and due June 1992, he expressed doubt anybody has started it yet. The new statement of work reflects that the launches have been moved up, funding has been moved back, and two MODIS instruments will be flown. Annual updates to the plan are called for. King suggested that the SDST group should try to develop a template software management plan.
2. *Science Computing Facility Plan* - The first draft is also due in June 1992. It addresses the team member's individual facilities. It also has not yet been prepared.
3. *Data Processing Software* - King thought this would be more challenging than a mere planning document. It must express to what level each team member is going to conduct and deliver their data products. The schedule reflects the reality of having MODIS selected for two spacecraft. Three versions of software are desired.
4. *Calibration Plan* - This will be prepared by Barker and Slater, and will not be written by team members. They will be expected to be supported in development of the plan with consultations and review.
5. *Software Review Status* - This is performed annually.
6. *Meetings* - Attendance is required in the contracts.
7. *Status Reports* - The monthly, quarterly, and semiannual reports were discussed previously.

**DISCUSSION OF ALGORITHM DEVELOPMENT:**

Q1: *Chris Justice* - Justice inquired if King expected to meet the deadline for the software management plan.
A1: *Michael King* - No.

Stuart noted that a request has been made to Project for relief from the June 1992 deadline for the data management plan. MODIS leadership is sympathetic to the problem, and has requested a three month delay to October 1992. No answer has been received.

Q2: *Chris Justice* - Justice expressed the opinion that all team members will have their own ideas, and that several iterations will be needed to achieve a uniform format. He suggested that the issue might be addressed at the Science Team meetings.
A2: *Locke Stuart* - Project has stressed that this first deliverable is a draft. It is a place from which to start, and convergence will come later.

Howard Gordon and Michael King expressed the scientist's viewpoint that such deliverables take time away from doing science. Otis Brown favored the idea of strawman software management plan. Stuart noted that Al Fleig intends to produce such a strawman plan.

**PRESENTATION OF ALGORITHM SCHEDULE:**
King presented Attachment 1.10, the most recent SDST schedule from Al Fleig. The schedule reflects the beta version start date and the iterative refinements of the software. The beta dates are essentially a date on calendar rather than a definition of software capabilities. The schedule reflects the software annual reviews, which are analogous to the instrument reviews.

Q3: *Otis Brown* - Does the schedule specify when coding guidelines will be made available to Team members?
A3: *Michael King* - Fleig's group is working toward that goal. They are currently dealing with the system shell which contains the interface routines. Fleig is the next speaker and will deal more with that issue.

**PEER REVIEW CONCEPT PRESENTATION:**
King summarized that Project has issued a requirement that calls for all instrument algorithms, including MODIS, to undergo annual peer reviews. The requirement is very loosely defined; no specifics have been issued regarding how the peer reviews should be handled. In Attachment 1.9, King presented a set of assumptions regarding the peer review process. With these assumptions, he presented his concept of the peer review process as a strawman proposal to the Team. The offering is intended to promote discussion. He asked that the proposal be considered in depth in the discipline groups. King asked members to bear in mind that the path that MODIS chooses is often adopted as an EOS standard.

**PEER REVIEW DISCUSSION AND QUESTIONS:**
After the proposal, there was a brisk discussion that accented the fact that there were generally conflicting views of how the peer review process should be handled, what type of schedule should be maintained, and the goals to be achieved.

Chris Justice commented that two different topics are involved in the peer review process: the technical details of the algorithm and whether the algorithm satisfies the platform requirements. He expressed the opinion that this strawman fails to fulfill the need to address both issues. Michael King further commented on the need to look for implications of the data processing structures.

Q4: *Yoram Kaufman* - Is the proposed October review the only one?
A4: *Michael King* - King expressed the hope that this would be the only formal review of this nature. Some review is required annually, but a

formally structured review every year is undesirable. In his view, the panel review occurs only once. He thinks Jeff Dozier may have envisioned the annual reviews to be similar to the paper which was written by the Atmosphere Group or to the one which is being drafted by the Land Group.

Ken Carder commented that as disciplines, the team members haven't merged their algorithms. He expressed the opinion that it will not be possible for individuals to specify what they are doing in 10 years without knowing how their algorithms interact with others of their own Discipline Group.

Howard Gordon expressed concern that the peer review process would result in the algorithms being frozen in 1992, allowing no flexibility for innovative ideas. He branded this approach as a mistake. Otis Brown echoed a similar sentiment. He noted that the visible band algorithms are unlikely to gel until software version 2 or beyond and that the infrared algorithms are expected to undergo major reprocessing. Brown expressed the opinion that the peer review panel would be of little scientific value if it is done merely to satisfy a requirement. King tried to allay their concerns by noting that the process is not fixed or rigid and that change and new ideas are easy to implement.

Ed Masuoka commented that the beta level 1 requirements exist primarily as a sizing thing. Project gets to scope the software cycles, but no real substance exists until level 2. Phil Ardanuy offered the observation that this review approach borrows from the UARS experience. The beta software establishes the ability to test interfaces and to size the CPU. It just gets you a start on the algorithm development process.

King and Justice concurred that the issue should go to discussion within the Discipline Groups. After they arrive at a separate consensus, it will be revisited in plenary session.

## 9. EOS DATA PRODUCT DATABASE

Locke Stuart introduced Hyo Duck Chang, who was substituting for Yun Chi Lu. Chang presented and demonstrated the EOS Data Product database, called the Science Processing Data Base, a completely interrelated database of all instrument and PI data products. Its function is to allow investigators to find a data product to suit their requirements and to see how changes in the algorithm for one data product might impact a variety of other data products.

The database was developed in Building 28 by the Science Processing Support Office (SPSO). The software uses Oracle running in a UNIX environment, and runs as an on-line interactive program. The database program supports VT100 class terminals. It can be accessed via network or by dial-up modem on IBM PC or Macintosh computers running the proper emulator. Access requires a password and user id. The interface has been designed to be user

friendly and easy. Users have the ability to make and store on-line comments to note errors in the database. Users cannot make changes in the data base (these need to go through a CCB), but can suggest changes. Contact information for each of the 560 investigators is stored within the data base. The 1991 EOS Reference Handbook is the primary source of information in the data base. The one notable capability that the system lacks is the ability to list all of the input data required for each instrument, a characteristic that will be changed in a future version of the software.

The database demonstration was an interactive computer session, hence no view graphs or slides are available. Attachment 1.11 provides a quick reference guide to the system. Chang demonstrated a short walk-through of the system. He touched on the welcome screen, tutorial, user profile entry, the main menu screen, and the data product query screen. Queries can be unconstrained or constrained according to eight limiting data fields. Using Salomonson's snow cover data product as an example, Chang showed some of the ways to make selections. At the end of the demonstration, Stuart noted that the demonstration computer terminal would be available at the back of the Building 8 auditorium for team members to use to become acquainted with the system.

## 10. SCIENCE DATA PROCESSING SOFTWARE

Al Fleig presented a discussion of the current status of the science data processing software which is being developed for MODIS. He referred again to Attachment 1.10 and discussed the various software items and their scheduling rationale. The algorithms are developed and delivered in a phased series of events, each of which is paced according to events that have been scheduled by Project.

Fleig described the beta version software as a very early developmental stage. Final science algorithms are not really expected for about two years. Fleig stressed that the software will be derived through a process of iterative convergence between the scientists and the software team. He hopes to react quickly to directives from the Science Team, with faster turnarounds and lessening effects on the code with each iteration.

Coding guidelines have been derived through consultation with a variety of local experts. Copies of the current guidelines will be supplied to Team members in their informational envelopes, which will be distributed at the Discipline Group meetings. Revisions to the guidelines are expected as we get closer to operational software. Fleig requested feedback on the standards, and noted that the current guidelines still lack coding examples .

Q1: *Howard Gordon* - At what point will fundamental changes in algorithms no longer be accepted?

A1: *Al Fleig* - Even though it is not a Project-endorsed answer, Fleig expects some changes will continue after launch. An answer more in line with official expectations is that mathematical changes in the algorithms will stop being accepted somewhere in the version 2 software.

Q2: *Howard Gordon* - When is it expected that the software should be capable of providing realistic values of computer run-time and CPU usage?
A2: *Al Fleig* - Version 1 should supply a reasonable version of our processing needs.
A2: *Ted Meyer* - It is important to understand as much as possible about the computer needs in the planning process, so users should try to flag uncertainties in algorithms that might cause large deviations in processing requirements estimates. The risk areas should be identified by the end of the version 1 software, even if the usage itself cannot be decided.

Fleig posed the question: What constitutes a delivered algorithm? It is his expectation that an algorithm would consist of a set of information:

- Code
- Mathematical description of algorithm
- Input data set
- Output from scientist's test runs
- Internal code documentation
- Operating procedures and operational documentation

Fleig strongly intends not to change fundamental scientific algorithms. He wants the input data set to exercise all rational paths through the algorithm. Scientists will be asked to deliver code in whatever language is prescribed by the EOS standards for PGS.

Some concern exists about where to get a complete simulation of the whole MODIS data stream that is totally self-consistent. Fleig solicited guidance and help on formulating a source for such a data set, and asked the Team members to consider the issue during Discipline Group meetings.

Fleig noted that copies of the data product database for individual investigators are included in the Team informational packets. He requested that these be reviewed for accuracy and returned to him by the end of the Science Team meeting. He expects Project to put the data products under configuration control in the near future.

Q3: *Jan-Peter Muller* - After a sneak preview of the information packets, Muller noted that data product descriptions are provided by first named author only. Other authors are not listed. Can this be altered to include all authors?
A3: *Al Fleig* - Fleig expressed a willingness to modify the system to incorporate the other authors for each data product. The data base will reflect

whatever the scientists want, and the identification of responsibility for a product belongs with the Science Team.
A3: *Chris Justice* - Project prefers that only one experimenter be officially accountable for the data product to avoid confusion.

Q4: *Jan-Peter Muller* - Muller noted that previous changes in the data products have not been made. He requested a revised list within a few months after end of meeting.
A4: *Al Fleig* - Fleig expressed confidence that the changes will get implemented. He agreed that a repeat mailing in the same format as has been distributed at today's meeting can be done.
A4: *Hyo Duck Chang* - Chang agreed that the data base can be modified.

Lloyd Carpenter noted that for team members' convenience there is also a complete data product list in the packet in addition to the personal list. Stuart closed this session with directions to break into individual Discipline Groups, and called for the next Plenary Session in the afternoon. He reviewed the schedule for following days.

## **Action Items**

Harrison / Conboy - Check if there is a way to eliminate the extraneous information at the beginning of an electronic mailing.

Stuart - Check with legal personnel about mailing journal articles via electronic mail.

# DAY 2 - PLENARY SESSION

## 11. DISCUSSION OF PEER REVIEW

Each of the Discipline Groups presented their thoughts on the peer review process which emerged during their individual sessions on Day 1.

**ATMOSPHERE DISCIPLINE GROUP:**
Michael King referred to Attachment 1.9, the strawman peer review proposal that he devised and presented during the plenary session on Day 1. The Atmosphere members disliked the title, in particular the connotations implied by the words "peer" and "review". They suggested having an informal advisory panel meet between October 1992 and January 1993 to discuss MODIS concepts and ideas before presenting anything to the general community. The panel could then revisit the issues in an autumn 1995 time frame to see how the ideas have evolved. At that time a formal peer review could be conducted. King felt there was strong support for specific personnel to be asked to sit on the panel, and that it represented an opportunity for the reviewers and reviewed alike to learn. Suggested members included the following representatives:

Calibration - Phil Slater
Oceans - Howard Gordon
Land - Chris Justice
AIRS / AMSU team - Bill Smith, Moustafa Chahine, or Alan Chedin
CERES - Dave Randall or Ramanathan
MISR - Tom Ackerman or Roger Davies
Interdisciplinary- Bob Dickinson, John Eric, Ben Herman, or Pat McCormick
UARS - unnamed representative suggested by Salomonson

**CALIBRATION DISCIPLINE GROUP:**
Phil Slater provided input from the Calibration Discipline Group. Slater and Barker met approximately a month ago and derived a peer review group similar to that suggested by the Atmosphere Group. They also included two non-MODIS remote sensing authorities, Carol Johnson (NIST) and Hugh Kieffer (USGS). They feel that one or two members from each Discipline Group should be included. Overall, the group should be limited in membership to just 7 or 8 members. Slater noted that the non-MODIS members have a problem in that they will require financing to get them to the meetings. Calibration differs from other discipline groups because it depends heavily on SBRC. Most of Calibration's work requiring peer review would be that which originates from MCST.

**OCEAN DISCIPLINE GROUP:**
Otis Brown presented the views of the Oceans Discipline Group on the peer review process with Attachment 1.12. Oceans is fully in favor of doing peer review, but prefer a hierarchical review process rather than a single committee-like reviewing entity. Their view graphs presented three review levels and provided suggestions for who should participate, when meetings should be held, the review objectives, and the output product. They recommended a three-tier Discipline-Team-Community review process that should be conducted annually.

The Discipline Group Overview document would include a summary of the integrated observing and processing approach. A few paragraphs would be included on how algorithms are expected to be generated, a brief discussion of algorithm dependencies and interdependencies, and a brief review of the output data products to give an annual focus of priorities. Brown postulated that some comments on possible relations to the Calibration/Validation plan could be included. There would also be an appendix with a few pages covering a current description of each algorithm. The format is expected to evolve each year.

During subsequent discussion Mark Abbott added that the Oceans' approach tries to address the question of why peer review is done. This process will achieve greater visibility to the whole community, and will more effectively distribute information than a single panel. Guenther expressed the opinion that many members of the scientific community think that data algorithms and products will not be available until launch, and there is a need to make the ideas available much earlier. A strength of the Oceans proposal is that it satisfies this need. King agreed that the need for open and early communication has been realized all along by Project, and that the Science Team members were selected in part because of their ties to and their ability to communicate with their affiliated science community.

Brown elaborated that the issues of community awareness and community approval are cardinal to the peer review concept. The capability for community interaction must be an innate part of the process. The non-EOS community has not yet been provided adequate information to allow them to see how the pieces of the big picture fit together. A reason behind having a discipline level coordination meeting is that it would allow individual disciplines to formulate a coordinated view of their processing plans, a technique that has worked well in the past. The three-tier review then provides a mechanism that allows the processing plans to filter out to the community and to interactively change over the multi-year lifetime of the peer review process. The desired objective is to initially achieve community consensus on the general approach, and then later to achieve consensus on specific algorithms.

**LAND DISCIPLINE GROUP:**
Chris Justice reported that the Land Group has not yet had opportunity to properly talk through this issue, but he offered several opinions based on off-line conversations he has had with some members. He felt that the original strawman proposal from King was inappropriate for the Land Group, and that a process of increasing involvement more like the Ocean proposal would be preferred. He expressed uncertainty whether the specific details of their plan would work for the Land Group because of the very diverse nature of land-oriented algorithms. Land has already taken measures to ensure community review and interaction. The Adjunct Team members serve as external sources of advice and guidance on algorithms. The Land Product meetings are Land's forum for involving external experts, as is the initiatives made through the IGBP, the surface temperature workshop and the fire algorithm workshop. Land's publication being drafted by Steve Running will make the existing structure of processing algorithms known to the appropriate readers. Justice commented that Land has its own interdisciplinary liaisons, but that a panel review might be acceptable in this case. He promised to have the Land Group examine the issues in an upcoming discipline group session and report back with a consensus.

**SUMMARY:**
Salomonson proposed that the Ocean Proposal for peer review should be adopted as the strawman proposal, and that each group should modify or adapt the proposal to fit its individual needs. Stuart agreed to distribute copies of the new strawman proposal to all groups for afternoon discussions.

## 12. DISCUSSION OF SIMULATED DATA SET

Al Fleig led a discussion of how to formulate a simulated data set for testing of MODIS software. His purpose was to share his thoughts on what has been done, what function the data set would serve, and how to devise such a data set, and then to solicit feedback from Science Team members on how they think the simulated data set should be addressed.

**CURRENT SUMMARY:**
Fleig summarized that a source of data is needed as input to the integrated set of algorithms to enable testing of the MODIS data analysis system. Steve Unger and John Barker intend to generate "synthetic" data sets by defining a set of physical situations, setting values for reflectance, and working backwards to generate the radiances. Fleig's group will then modify the data with instrument and telemetry artifacts to make it look like a MODIS data stream. This data set will provide an adequate test vehicle for beta testing of characteristics like input/output formats and processing speed; however, it has limited application for testing individual algorithms. It is necessary to have some other data set that can adequately exercise all reasonable algorithm

paths through the processing software. Fleig then inquired if there were any suggestions on how to get appropriate data sets.

**DISCUSSION AND OPINIONS:**

*Yoram Kaufman* suggested several data sets, including:

1. MAS data - King multi-channel
2. AVHRR 1 km data set under development by Land
3. Modified TM images

These could be taken together to generate a full MODIS data set. Fleig agreed that these are good sources for data to use to test the science behind individual algorithms, but they were not really adequate to test the programming correctness of an integrated suite of operational algorithms. Fleig noted that something is needed that is self-consistent, so it looks real.

*Jan-Peter Muller* suggested that existing scene simulation software systems (e.g. those constructed by Photon Research associates) could be enhanced and extended. Fleig responded that even though all inputs are known in such a system, it is difficult to judge how close to reality the product simulations might be. A large number of parameters must be simultaneously measured *in situ* in order to characterize a correct scene, and the simulation software might not properly model the interactions between parameters. Fleig noted that Barker already has a scene simulator available.

*Steve Unger* agreed that the appropriate use of other data sets is for verification by realistic data. They give strong clues to what should be seen. Unger noted the radiometric correspondence principle, which calls for consistency when synthesizing data. In order to generate any synthetic scene, one must first assume some characteristics that are not real but which are characteristic of possible physical variations.

*Yoram Kaufman* expressed the opinion that simulated data should be tied to actual measurements whenever possible because there may be problems in real data you won't see in a synthetic simulation. As an example, he suggested using MAS data in concert with TM data to produce TM scenes possessing MAS statistics. In this fashion it would be possible to provide a complemented TM image which was manufactured with minimal possible intervention. Fleig agreed, noting that he was eager to see King achieve full-channel MAS capability so that data very close to real measurements could be used in a scenario similar to that suggested by Kaufman.

*Steve Unger* also remarked that Kaufman's point was quite valid. His models currently use more ingenuity than physical data, even though he would much prefer to start with ground observations and work backwards. It isn't necessary to fully characterize the ground, so the geometry can be simplified; however, an envelope of observations is needed to exercise the data

processing system and to permit an understanding of how the algorithms behave.

*Ian Barton* cited his experience of modeling an along-track scanning radiometer. The physical scene characteristics often proved easier than modeling the instrument housekeeping characteristics. There are many variations and the problem is horrendous. It is essential to work closely with the instrument builders. Fleig agreed, noting that he is depending on Barker for help with the instrument calculations.

*Wayne Esaias* seconded Barton's comments regarding the difficulty and complexity of the simulation activities. He noted that Watson Greg has done a backward modeling for SeaWiFS based on the ocean color model, and has simulated SeaWiFS swaths. Implicit in the modeled data set is current understanding of the physics involved in the imaged ocean-system; therefore, the system response to real data is not fully predictable. Fleig agreed with Esaias, noting that it will be several years after launch before it is possible to extract all possible test cases from the data. Assuming final algorithms until after years of data have been collected is illogical. Fleig's concern at this point lies only with the data processing system.

*Wayne Esaias* expressed the opinion that the simulation approach can be simplistic if Fleig just sticks to the goal of testing the software. Otherwise significant resources might be expended in producing a simulation. Fleig agreed, noting that the simulation data set is not intended to become a black hole for MODIS funding.

*Michael King* remarked that the simulated data set is a Project requirement. Project is using the UARS experience as a model. The approach of using a simulated data set is more appropriate for UARS than for MODIS because the UARS physical system is easier to model than MODIS. Nevertheless, there still exists a mandate to produce the data set. We need to test obvious traps without overextending resources.

*Ian Barton* stated that Australian investigators did a complete ATSR simulation. They intentionally removed the simulation software group from the instrument software group to avoid building in simulation errors matched by a counter error in the hardware or data processing software. Use of the same fallacious assumption in both places is avoided by this precaution.

*Steve Unger* provided a summary of the issue of manufacturing a MODIS simulated data set. The procedure of making a simulated data set has been done before with some degree of success. Even though some aspects did not work well, it was a substantial aid for TM processing software. There is also the favorable UARS experience. The alternative approach is to have no

representative data set. This is generally not desirable, but it would be preferred in the case where only a misleading representation is possible. At this point the simulated data set seems to be required as an initial start-up crutch, and it should be as reasonable a simulation as possible; however, it should not be permitted to become resource intensive.

## 13. TEXTURE, MASKING, AND ERROR UTILITY ALGORITHMS

John Barker began his presentation with a review of MCST and its current activities. His presentation closely followed Attachment 1.13, with additional backup material distributed in Attachment 1.14. A variety of questions were posed throughout the presentation rather than at the end.

Barker reviewed the MCST priorities, introduced the MCST civil service and contractor support personnel, the calibration strategy being followed by the MCST group, and the current conception of time scales which apply to the calibration. During the presentation, Otis Brown noted that there will be 40 missions over the next 9 years that can be used to compare the data for accuracy. Brown contended that it should be possible to characterize the accuracy of the MODIS data within 12 months after launch, to which Barker concurred.

Barker reviewed the MCST Calibration Data Products. Barker asked whether there are any unique AM or PM platform calibration data products because he is not aware of any yet. Al Fleig recommended that other instrument teams should be posed the same question. Jan-Peter Muller suggested that bi-directional reflectance might be a good example of just such a product.

Q1: *Wayne Esaias* - Is it possible that some of the MCST At-launch Calibration Data Products can be moved up?
A1: *Barker* - Yes. Even though the algorithms are not expected to be stable at launch date, there will be no holding of the data. It will be made available as it becomes available.

Barker reviewed the MCST Calibration Plan, and reminded the Science Team that a copy of the preliminary Calibration Plan was included in their handouts. He also discussed the Calibration Handbook, the SBRC instrument delivery schedule, and the SBRC systems analysis overview and MCST's involvement in that overview. The MODIS Utility Data Products were reviewed, of which there are only two--the Texture Products and the Classification Overlay Map. The overlay has not changed much in recent years, except for the recent addition by the Land Group of glint. Muller reminded the audience that the "hot spot" as well as glint were important.

Q2: *Peter Mouginis-Mark* - Are you defining types of clouds, e.g. volcanic clouds, using the overlay map?

A2: *Barker* - MCST is not intending to define types of clouds; however, they do intend to manufacture cloud masks for different groups and different functions. Cloud masking is an activity designed to help the various disciplines. In a sense, the different cloud masks represent different definitions of clouds.

Q3: *Jan-Peter Muller* - Muller warned of the danger of compositing sub-pixel clouds, and inquired if it would not be wiser to estimate the percentage of such clouds.
A3: *Barker* - Barker agreed that this might be necessary, and gave determination of snow cover as an example where the percentage of sub-pixel clouds must be known.

Q4: *Robert Evans* - Will you give us your definition of what is a cloud?
A4: *Barker* - Barker declined to address the issue in this forum, but agreed to do it later. He noted that this is likely to be an iterative process.
A4: *Vince Salomonson* - Salomonson reminded the group that it is not certain how much of the masking work can be done let alone how it should be done. Barker will start at the level 1b product, and start iterating with the various discipline groups to go as far as resources permit.

Barker summarized the simulated data set activity which he is pursuing in cooperation with Steve Unger. The requirements, properties, and approach to the data sets were addressed. He noted that of the variety of desirable properties, it may not be possible to achieve all of them. He also noted that Muller has requested that Barker compare his software for the simulations to Muller's own. LOWTRAN7 output and LANDSAT TM imagery were provided as examples of how simulated data sets might be achieved. Barker requested that the team members provide feedback on the Handbook and Calibration Plan on the forms provided at the end of Attachment 1.13.

Q5: *Kendall Carder* - Can the MCST spreadsheet model data be made available to the various discipline groups?
A5: *Barker* - Yes. Barker agreed to look into it.

The MCST presentation was followed by several brief announcements. Ghassem Asrar announced through Michael King that Asrar and Jeff Dozier have a bulletin board called EOS.NEWS which is available on OMNET, GSFCMAIL, and INTERNET, and which is updated weekly on Thursdays. Likewise, Asrar announced that the first EOS tropical workshop on biosphere-atmosphere interactions will be held in June, with Piers Sellers as the principle contact. Barker also announced that MCST maintains a bulletin board on GSFCMAIL under MCST.BB.

# 14. GORDON: ATMOSPHERIC CORRECTIONS

Michael King introduced Howard Gordon, who presented the Ocean Discipline Group's plans for atmospheric corrections for SeaWiFs and MODIS. King noted that the presentation by Gordon and the subsequent presentation by Kaufman represent an attempt to respond to the Science Team for more open and direct communication of scientific ideas and concepts.

**PRESENTATION:**
Howard Gordon presented a detailed mathematical and scientific discussion which closely followed the information presented in Attachment 1.15. Gordon also distributed Attachments 1.16 and 1.17, recent papers he has authored on the subject of atmospheric corrections for ocean imaging. He reviewed the first order correction algorithm, as derived from the CZCS (Coastal Zone Color Scanner), and presented a set of slides of the Mississippi River delta to help demonstrate the function of the algorithm and the atmospheric aerosol content. The shortcomings of this algorithm and its errors were reviewed as a prelude to a discussion of SeaWiFS. Both SeaWiFS and MODIS are expected to use the same proposed second-order algorithm, which employs a term for Rayleigh aerosol scattering. Different color bands than those utilized by the CZCS are employed to solve for the atmospheric corrections. Gordon sketched the new algorithm and discussed the modeling activities done so far to test the algorithm performance and its performance relative to the CZCS algorithm. The new algorithm is expected to have a significantly enhanced performance over the old algorithm. Gordon completed his presentation with a review of future plans for testing and improving the algorithm, and for extending and applying it to MODIS.

**QUESTION-AND-ANSWER SESSION:**
Q1: *Kendall Carder* - For epsilon extrapolations, do you plan to use 667 nm to stabilize the epsilon extrapolation process?
A1: *Gordon* - Gordon felt this might be a viable approach if the chlorophyll is low enough, but he hasn't really thought it through yet.

Q2: *Kendall Carder* - Is the Scripps approach reasonable?
A2: *Gordon* - Yes, it is viable. The approach he will adopt after SeaWiFS launch is to use clear water to achieve a calibration, and then to use some of those representative values. Before launch, he will use models like LOWTRAN to calculate epsilon from the geometry and other factors.

Q3: *Paul Menzel* - What data are used to characterize the wind field?
A3: *Gordon* - We use the Cox model. For CZCS we assume the wind speed is zero. For MODIS, wind speed is derived from surface pressure and numerical models. If a scatterometer were still available, it would help the calculation significantly.

Q4: *Jan-Peter Muller* - Is it possible to use glint in the central 400 km of the MISR swath to estimate surface wind speed?
A4: *Gordon* - Gordon was unsure if multiple views would be available with MISR. MODIS-T had been involved in the sun glint calculation, but it's gone now. Gordon expressed strong doubts that the glint could be used for wind speed.

Q5: *Michael King* - In the pictures showing spectral reflectance of surface chlorophyll, were there absorption features of the oxygen A band?
A5: *Gordon* - Yes. If there is no light getting into the water, then absorption should take place.

Q6: *Michael King* - Does the water leaving radiance reflect the attenuation of sunlight?
A6: *Gordon* - Yes. If you measure reflectance directly at the surface, the bands disappear.

## 15. KAUFMAN: ATMOSPHERIC CORRECTIONS

**KAUFMAN'S PRIMARY PRESENTATION:**
Yoram Kaufman presented a discussion in significant detail of atmospheric corrections and to the sensing of aerosol properties. The presentation very closely parallels Kaufman's handout, included as Attachment 1.18. Portions of his presentation come from Didier Tanre, who was unable to attend the meeting. Complementary presentations by Brent Holben and Eric Vermote were included as part of the total presentation on atmospheric corrections.

Kaufman discussed the overall problem. Calculating the atmospheric correction over land is more difficult than for over oceans because the surface reflectance over land varies more than over oceans. This is especially true when the effects of areas of vegetation are factored into the equation. Kaufman developed the case for the minimum correction that is easy to achieve, during which he discussed contributions from molecular scattering, understanding vegetation indices, and effects contributed by aerosols. Techniques of predicting path radiance at one wavelength from a known path radiance at another wavelength were presented. Kaufman presented specific strategies heavily based on empirical relations for deriving path radiance, the best values for which will contribute to the atmospheric correction.

Contributions from Lorraine Remer of SSAI in the analysis of NDVI for dense dark vegetation were noted. Kaufman showed a variety of data analyses providing specific examples of the application and testing of the proposed atmospheric correction for a LANDSAT MSS scene of the Chesapeake Bay, corrections over Maniwaki, Hawaii, over the Eastern United States, over the water near Peterborough, and at Gao, Mali. Kaufman also

spoke about a planned paper on the alternative approach of using an atmospherically resistant vegetation index (ARVI), which is more stable than NDVI.

**VERMOTE ON RADIATIVE TRANSFER:**
Once the form of the atmospheric correction is decided upon, radiative transfer is used to apply the correction. Eric Vermote spoke on the various codes that have been developed and are currently used for applying a radiative transfer function (Attachment 1.19). He spoke briefly on the important parameters which must be considered for the operational atmospheric correction code for MODIS radiative transfer activities, the most important of which is the error budget. His presentation included a list of relevant reference material.

**HOLBEN ON FIELD EXPERIMENTS:**
Brent Holben presented details of past and planned field experiments done using sun photometers (Attachment 1.20). These instruments can measure aerosol properties, precipitable water, ozone, and sky radiance. They have previously been employed primarily in a hand-held mode, but Holben's group is working to develop a fully automated instrument. He presented examples of data derived from sun photometers, including aerosol optical thicknesses measured from GSFC, a network of stations in Africa, the Amazon basin, and at the Dead Sea in Israel. Very few observations with coincident satellite observations are available--a problem which the automatic recording sun photometer should rectify. A prototype instrument was made available for inspection at the meeting. Holben reviewed the results which he has obtained from the sun photometers.

**KAUFMAN SUMMARY:**
Kaufman briefly summarized the three presentations. He noted the need for quality data sets for many types of measurements, and reviewed the types of measurements needed as precursors to MODIS. He also reviewed the field campaigns he is involved with, including those with MAS. In concluding, he summarized his strategy for applying atmospheric corrections and suggested a field campaign for 1994.

**QUESTION-AND-ANSWER SESSION:**
Q1: *Ian Barton* - With the 6 S radiative transfer program, what is the wavelength range it operates over and what is its spectral resolution?
A1: *Kaufman and Vermote* - It is similar to the 5 S code, and operates over the entire solar spectrum. It is only valid in the visible because it takes no account of blackbody emission. Its upper range is approximately 2.5 microns, or 5 wave numbers--very similar to the new LOWTRAN.

Q2: *Jan-Peter Muller* - What is the sensitivity of your atmospheric correction schemes to *a priori* knowledge of BRDF?

A2: *Kaufman* - Kaufman noted that a paper published several years ago shows that the assumption of small direct reflectance is usually pretty good. An iterative approach should be considered, using the model for radiative transfer.

Q3: *Jan-Peter Muller* - What is the sensitivity to topography, elevation and slope?
A3: *Kaufman* - Kaufman noted that topography is important for molecular scattering, and intends to use the best topography available.

Q4: *Dennis Clark* - Clark requested clarification of the components of the vegetation index. He noted what he felt was a large disparity, and was interested in what the driving sensitivities involved were.
A4: *Kaufman* - As an artifact of choosing the highest vegetation index, one also chooses days with low optical thickness. An optical thickness of 0.12 was chosen as a compromise position.
A4: *Michael King* - King requested that what was mounting into a very detailed scientific discussion be taken off-line.

## 16. FILTERS: THE GREAT DEBATE

This session was intended to be a status review addressing the issue of the Science Team members' responses to the relaxations in the filter specifications which were requested by SBRC. Rather than a presentation or series of presentations, the session evolved quickly into a spirited discussion. A significant number of critical arguments and issues were raised. An approach was hammered out regarding how the team would make their response based on information presented at this session and in off-line sessions that followed. Rather than present a chronological representation of this very active debate, a summary is presented of the viewpoints of the major players.

**RICHARD WEBER:**
Weber briefly reviewed the status of the filter specifications issue. He expressed a strong hope that final feedback from the team members could be obtained by the end of the meeting, thus resolving the issue. He informed the team that a final resolution would be required by the end of the week, if not by the end of the meeting on Thursday. The pressure for resolution of the issue is driven by the schedule. SBRC's reasons for requesting the relaxations stem from cost containment concerns. The cost of manufacturing the filters is already well in excess of the original estimates. The MODIS contract is a cost-plus contract, meaning that cost overruns caused by a delay in completing the filters implies EOS funding would be drawn from other sources--possibly even from investigator's budgets. Weber emphasized that what was sought today was not all possible relaxations in the specifications, just those that were easily recognized (i.e. the "easy takes"). He acknowledged

that more extensive relaxations might be possible given more time, but reminded the team of the importance of keeping on schedule. Many of SBRC's requests are made as blanket relaxations, which Weber conceded may be impractical. Team members were urged to make band-by-band changes if that was in the best interests of MODIS science, and stressed that even a single relaxation in a single band would be most helpful in reducing the filter manufacturer's level of effort. Weber conceded that some filter changes cannot be judged without an extended analysis. Weber noted that the edge-range specifications were areas where, in his opinion, relief would be easiest to find.

**JIM YOUNG:**
Jim Young reiterated most of what was expressed by Dick Weber. He further elaborated on the extremely difficult task involved in manufacturing the filters as they are currently specified. Of the eight suppliers that were approached, only four provided a cost bid on the job. No one has been willing to brand any of the filters "impossible", but all have remarked on the difficulty. Even SBRC has only recently realized the true difficulty, which is why they are requesting any and all relief that will not substantially affect the science. He estimated that 95% of the filters can be manufactured to the current specifications, but that some of them may take so long as to render their manufacture impractical. Young stressed that even if no relaxation is forthcoming, SBRC will still do everything possible to meet the filter manufacturing specifications; however, he was pessimistic of the overall outcome. Timing remains critical. An order for the optical filters must be placed within one month or it will not be possible to complete the instrument engineering model on time. In response to Team member requests for a more refined gauge of the costs involved in any specific relaxation, Young responded that the information was unavailable. Young noted that although many of the requested changes are expressed as blanket recommendations, it was never intended to bind Team members to blanket changes. They can feel free to make specific relaxations.

**OTIS BROWN:**
Brown served as the principal spokesman for a united and notably perturbed Oceans Discipline Group. Brown pointed out that a list of specifications changes was distributed in January, and that another quite different list was distributed at the current meeting. Oceans has examined the January list and is prepared to respond to it, but they cannot in good conscience respond to the new list of requested changes. Many inconsistencies have been noted in a line-by-line comparison of the two lists, both in specifications being tightened as well as loosened. Brown expressed the opinion that the spirit of collegiality had been breached by SBRC in insisting on a response to such a critical issue with so little notice. Oceans expressed a strong desire to be helpful and to respond, but noted that it is not possible to do in hours an analysis task that requires at least weeks. They were displeased with this turn of events and

refused to provide the on-the-spot feedback requested by SBRC. Instead, Oceans requested that SBRC provide them with some rational means of understanding the scientific ramifications of the proposed changes. They formally requested that SBRC and William Barnes provide them the results of a study and software that would clarify the effects of the filter changes, and volunteered to respond with relaxations within one week after the study is made available. Brown noted the existence of Fraunhofer lines in the visible spectrum that are essential to avoid. There are also infrared bands near 2 microns that give significant cause for concern.

**HOWARD GORDON:**
Gordon solidly backed Otis Brown. In particular, he also flatly refused to provide the feedback requested on such short notice. Gordon acknowledged there may be a few changes that are easy to judge, but filter bands near the atmospheric oxygen bands, fluorescence bands, and Fraunhofer lines need careful evaluation. A hasty answer based on insufficient information would severely impact ocean color studies for the next thirty years. Gordon expressed a preference to have his research funds curtailed rather risk causing such an impact. He noted that there is little focus by the collective support groups on this issue other than pressure for an answer, when it should be everyone's principal focus to assist the Science Team in seeking a solution.

**KENDALL CARDER:**
Carder reiterated the opinions of his Ocean Discipline colleagues. He expressed a willingness to provide quick feedback when required information becomes available. He asked to see the filter functions overlaid on at-satellite Fraunhofer lines on the solar spectrum, a task he felt should be possible to complete in a rather short time.

**YORAM KAUFMAN:**
Kaufman expressed the opinion that the judgments the team was being asked to make would be far easier if there was a relative sense of the dollar value associated with various requested changes. In addition, he lamented that SBRC typically only provided one direction that a filter characteristic could be moved to reduce costs. Kaufman noted that a range of directions would be easier to deal with.

**MICHAEL KING:**
King noted that the Atmosphere Group was expecting to respond to the January information and they have identified some easy takes on the strictly atmosphere bands. He also commented that many proposed changes are not so easy because of the unknown price tradeoffs. There is some inconsistency and confusion regarding the January memorandum, but problems in the thermal bands may be justified.

**CHRIS JUSTICE:**
Justice reported that the Land Group had not yet dealt with the issue. There has generally been confusion in the Land Group on this issue, but the discussions have clarified it. He supported the Ocean position, and recommended that the month available should be used to see what other information can be obtained to ease the decision making process.

**VINCE SALOMONSON:**
Salomonson's primary concern appeared to be how MODIS got into this squeeze, considering that Phase B planning was done in such a careful and deliberate fashion. When he inquired what changed, he was informed by King that the line specifications were added in Phase C.

**PHIL SLATER:**
Slater reported that Calibration has responded to the January requests, but have not dealt with the new ones. He recommended that he discuss the issues further by telephone with Gordon and Young. This would allow him time to do further analysis.

**WILLIAM BARNES:**
Barnes agreed that the new list is unfair. He also fielded a few specific inquiries regarding stability of the filters if placed in storage.

## Action Items

Barnes - Work with SBRC to prepare an at-satellite spectrum covering the MODIS band wavelengths, and provide a program for showing the effect of filter relaxations.

# DAY 3 - PLENARY SESSION

In his opening remarks, Vince Salomonson asked that any comments on the proposed MODIS logo be addressed to Locke Stuart. Because MODIS-T has been deselected and is no longer an active instrument, Team members were asked to consider adjusting the name of MODIS-N to just MODIS, standing for Moderate Resolution Imaging Spectroradiometer. He asked the Discipline Group leaders to present their status reports.

## 17. CALIBRATION GROUP: SUMMARY REPORT

**ALGORITHM STATUS REPORT:**
Phil Slater presented the algorithm status report for the Calibration Discipline Group, employing the slides shown in Attachment 1.21. The main body of work that will require review are the MCST algorithms. Although they are derived from many sources, the principal source of algorithms and calibration is the SBRC preflight information, which will not be available until October, 1992. John Barker's algorithms will come mostly from work by Peter Abel with the ER-2, by Howard Gordon on ocean data and sea glint, by Yoram Kaufman on desert areas , by Paul Menzel and Zhengming Wan in the thermal bands, and by the University of Arizona group. The basic algorithms have been peer reviewed in the literature. The Calibration Group has not reviewed algorithm status in detail due to other pressing issues. Slater has talked to other discipline group leaders to derive a preliminary list of members for the MCST peer review panel. Of the members shown in Attachment 1.21, he noted that Carol Johnson and Hugh Kieffer require financial support.

**CALIBRATION WORKING GROUP ACTION ITEMS:**
Slater reported on the nine action items derived from the MODIS Calibration Working Group meeting, which he listed in Attachment 1.21. Item 3 asks SBRC to characterize the preflight memory effect in the imaging hardware, a request resulting from problems with transient image areas in TM data. Item 4 calls for designating a single standard solar spectrum for EOS work. Different models of the solar spectrum have been used in recent calculations, yielding different results. Item 7 arises from SBRC's concern over band-to-band image registration. Richard Weber will be asked to contact Bob Schowengert for a computer program to simulate data retrieval. Item 9 has already been somewhat further defined. Jan-Peter Muller requires the photogrammetric properties of MODIS.

Q1: *K. Carder* - Do we still define a pixel as 1 km? This is a question that was addressed previously.

A1: *Slater* - I don't know.
A1: *William Barnes* - The 1 km value comes from band-to-band registration.

**CALIBRATION WORKING GROUP PROMPTS:**
Slater reported on the 4 prompts derived from the MODIS Calibration Working Group meeting, which he listed in Attachment 1.21. These are distinguished from the action items because they are deemed less critical. He commented further on some of the prompts. Prompt 2 arose because there is some lingering disagreement on the use of the Solar Diffuser Stability Monitor (SDSM), especially its use in the errors involved in the radiometric math model. Prompt 3 states that there is a need to determine if the polarization used by SBRC is realistic. Several aerosol models and many wavelengths have been examined, but no conclusions drawn. Prompt 4 asks that we determine to what extent we need understand the operation of cross-calibration radiometers in vacuum.

**SCIENCE TEAM MEETING OUTPUTS:**
Slater reported on three action items and one prompt resulting from the Science Team meeting. Item 1 results from an inquiry by Yoram Kaufman. Item 3 is the result of a significant amount of discussion of the various interrelated filter procurement needs. The action calls for Slater to tell Guenther what costs are involved. Slater noted that Kieffer needs to test the filters under various f-number conditions; and there is a need for monochromator testing.

**CONTAMINATION MEETING CONCLUSIONS:**
A 50 Å contamination build-up on the MODIS mirror was considered. It is non-uniform and, therefore, it is field angle dependent. Recent update information by June Tveekrem implies that the contamination is thinner than expected, and only results in a 1% reflection diffraction across the mirror surface. This changes the transmission amount from 98% to 99%; however, it is still an appreciable amount. Barker's study has shown that the contamination can affect signal-to-noise in some bands. Meeting participants concluded that the effects can't be accurately math modeled or lab simulated. It is not expected that the contamination will really be a problem, but if it is, there isn't anything that can be done about it. There are other solutions to the problem, and Slater presented four possibilities. From the Cal/Val meeting, it was learned to the group's consternation that test conditions at General Electric lend themselves to other types of contamination. Slater noted that we may want to consider cleaning the optics afterwards. B. Guenther added from the audience that most people bag their instruments during tests, so it isn't too much of a problem.

**TODAY'S ACTION ITEMS:**
Slater presented four action items derived from today's Calibration Group meeting. Slater stated that the lunar observations noted in item 3 are for

radiance calibration, but they also serve as a backup check of the stability of the solar diffuser. SeaWiFS and DoD flights are expected to use the lunar calibration techniques before MODIS. In answer to his inquiry, Guenther was informed that the request for the memorandum being drafted by Barnes originated with Project. Guenther noted that C. Scolese has said that if these lunar-related observations are purely operational then he sees no reason to get involved in the issue. Guenther cautioned that MODIS should not presume the proof will be handled elsewhere until we know what SeaWiFS and DoD find. It may be premature to say we don't need it, especially if there is an involvement with design issues.

**COMMENTS AND CONCERNS:**
Slater stressed the need for more representation by Science Team members at Calibration meetings. He remarked on the cross-calibration visible-infrared radiometer, which is under development, and on the interest that exists in using it with SeaWiFS. He expects the radiometer to be ready on time and has discussed the possibilities with Wayne Esaias. He is eager to work out the filter problems because the expected price jump of an order of magnitude caused by a delay will have a severe impact.

Q2: *Vince Salomonson* - Were there any concerns about thermal calibration?
A2: *Slater* - It was reviewed very briefly, with no significant issues being discussed.

Q3: *Vince Salomonson* - Salomonson suggested to Slater that there is concern, especially regarding the 3.75 µm bands used for sea surface temperature. There is concern about the accuracy contributed by the blackbody. It is apparent that MODIS will not meet what you can do with AVHRR. Salomonson recommended that this be added to the list of concerns.
A3: *Barton* - Barton volunteered that he had discussed absolute accuracy of the thermal channels, and they are not state of the art. He intends to make a presentation to the EOS Cal/Val group, and to let them know he is not happy with the current status.

**NOTE: Due to a change in contracts, the Executive Secretary for the meeting departed before completing the minutes. Only summary statements and references are provided for the remainder of this document.**

## 18. ATMOSPHERE GROUP: SUMMARY REPORT

M. King presented the summary statement for the Atmosphere Group (Attachment 1.22).

**FILTER RECOMMENDATIONS:**
King stated that there was only time during the meeting to give a cursory review of the recommended filter changes, and that only those changes which could be quickly and easily determined were accepted. With four parameters to manipulate, the total effect on planned research was not readily apparent. Many recommended changes would severely impact the Atmospheres objectives.

**DATA PRODUCTS:**
The Atmospheres Group had little use for MODIS-T, consequently the data product list will change very little from the atmospheric viewpoint.

**MODIS AIRBORNE SIMULATOR (MAS):**
A review of current specifications was provided, along with a history of the current instrument and its use. Mention was made that the instrument has been returned to the manufacturer for modification, in preparation for ASTEX (Azores), TOGA-COARE (6 weeks of intensive field effort), SCAR (Brazil—hopefully 1993) and other upcoming field experiments.

MAS data over the Gulf of Mexico was shown. It was pointed out that the 8.8 µm and 11.95 µm channels highlight the colder cirrus clouds. Brightness temperature differences in clouds were described through ratioing the 8 µm and 11 µm bands.

A Menzel-processed flight line of MAS data clearly showed a river running through the image—an excellent feature for monitoring degradation as the resolution is decreased. The next visual showed the same area successively degraded from 50 meters through 250 and 500 to 1 km resolution. The river disappears at <250 meters resolution.

The MAS instrument performance was detailed, and mention was made of the potential value of the data to Land studies.

Q1: *Vince Salomonson* - Can the Land Group -- particularly Z. Wan -- use the data effectively?
A1: *Wan* - Yes.

Q2: *F. Hoge* - What is the shortest available MAS wavelength? Hoge is interested in a 415 nm band for ocean color.
A2: *King* - That wavelength is not available.
Q3: *V. Salomonson* - What is the potential value of MAS for Oceans?
A3: *King* - The instrument may be of some use for sea surface temperature work, so long as the 50 m pixel size is satisfactory. However, considering the schedule for the ER-2 and the MAS, it is questionable if the instrument can be scheduled for any extensive oceans work.

**ALGORITHM DEVELOPMENT STATUS:**
P. Menzel has reported considerable progress in algorithm development; other team members are relying heavily on aircraft and field campaigns to provide the necessary input data. It was acknowledged that A. Fleig has considerable interest in receiving some initial preliminary ("place-holder") algorithms, and hopes they will be supplied soon.

## 19. LAND GROUP: SUMMARY REPORT

C. Justice presented the meeting report for the Land Group (Attachment 1.23).

**SUMMARY:**
Justice highlighted the Group's activities in a summary statement:

**Products:** There are no major changes; a few post-launch products are missing.

**Algorithms:** The status of algorithm development was reviewed by team members.

**Budgetary Constraints:** 93-94 field campaigns will depend on the promised level of funding.

**General Observations:** 1). Response on a greater number of issues burdens team members, and funding levels are insufficient to employ help; 2). More Land Discipline Group meetings are required, and possibly team plenary meetings could be reduced to two days.

Q1: *Vince Salomonson* - should we tackle more issues with telemail?
A1: *Justice* - if it helps to reduce team meetings to 2 days.

Salomonson stated that the team should consider a new way to do team meetings, wherein telemail and teleconferencing play major roles.

**INSTRUMENT GEOMETRY:**
This issue is of increased concern to the Land Group—so much so that the lack of response to the previous October's request for improved pointing accuracy was revisited. Salomonson mentioned that there is a Project expert in this area, and recommended that Justice contact him.

**TOPOGRAPHIC REQUIREMENTS:**
Justice commented on the lack of EOSDIS response to his request that they address the overall EOS topographic requirements, and their plan to meet those requirements for EOS, and particularly MODIS. This issue was addressed to EOSDIS also after last October's Science Team meeting. Justice plans to make a strong plea at the next Instrument Working Group meeting, in concert with MISR and ASTER, that the Project and Program Scientists consider the high priority of topographic data.

**TEAM LEADER COMPUTING FACILITY (TLCF):**
Justice was concerned that the TLCF step up to being the Miami equivalent for Atmospheres and Land. Pathfinder data storage and availability, in support of data simulation and algorithm development, is essential.

**ANCILLARY DATA NEEDS:**
The issue was addressed and it was noted that considerations were evolving. Ancillary requirements will be a focus of the next Science Team meeting.

**CALIBRATION GROUP INTERACTION & ACTIVITIES:**
Appropriate calibration is recognized as critical to the success of the MODIS data analysis effort. Support of the Calibration Panel is essential, with A. Huete and Z. Wan playing key roles. J.-P. Muller and V. Vanderbilt are expected to serve as advisors. Barker mentioned that, insofar as external interactions are concerned, he has had some discussions with CERES. It is important that the Calibration Group carefully define its priorities: for example, some utility algorithms (i.e., cloud masking) are key to the success of land products. The cost of calibration, in the perspective of the accuracy it provides, must be carefully controlled. V. Salomonson averred that this would be done.

**REPORTING:**
Justice finds it very important that each member of the group be kept informed of the activities of every other member. The group agreed that the regular progress reports would be circulated among other group members.

**PEER REVIEW:**
The Land Group did not feel prepared to offer definitive comments or plans for setting up peer review standards at this time. Defining external review processes is considered premature. It is planned to address this issue at the next discipline group meeting. V. Vanderbilt and J.-P. Muller are expected to lead the effort.

**INTER-INSTRUMENT LIAISON STRUCTURE:**
The Land Group felt it critical that a working liaison be formed with other instrument teams, to develop a unified approach on issues of common concern. Examples of this need are evident in the pointing accuracy and topographic problems, wherein it is assumed that several teams carrying recommendations forward would carry more weight than a single group.

Q2: *V. Salomonson* - Can you give an example of the top-down approach?
A2: *C. Justice* - Critical people, like the Team Leaders of MISR and MODIS, need to meet to discuss these issues.

B. Guenther noted the further need to have liaisons to Interdisciplinary Science (IDS) investigators, and that they should be extended personal invitations to attend the MODIS meetings.

**ELECTRONIC COMMUNICATIONS:**
C. Justice made a plea that MODIS go electronic in its documentation / modifications, where possible, on things like data products and test sites.

**TEST SITES:**
Determination of satisfactory test sites continues at the discipline group level. The concept of multi-use test sites, involving many elements of EOS, is important, and will be addressed at the June EROS Data Center DAAC Advisory Board meeting. I. Barton volunteered that the issue also should be brought up at the Committee on Earth Observation Satellites (CEOS) meeting in May. The discussion broadened into test sites in general, with F. Hoge mentioning a mid-Atlantic test site as part of his algorithm development program. He invited other team members to take advantage of this P-3 mission, and fly other instruments / take other measurements where practicable. Hoge will be flying at 150 meters altitude.

**SPECIFICATIONS:**
The changes most recently proposed by SBRC need time to evaluate. Teams of Tanre / Kaufman (Atmosphere), Slater / Huete (Land Bands), and Wan (Thermal) will evaluate and report. Kaufman will take particular consideration of the high-gain bands, in consideration of the non-linear gain proposal. The modulation transfer function (MTF) on bands 1 and 2 are different, and help from the Calibration Support Team was requested.

## 20. OCEAN GROUP: SUMMARY REPORT

O. Brown presented the Oceans Discipline Group report (Attachment 1.24). The report was well-structured and covered the highlights of the group meetings:

**Filters**
**Peer Review**
**Data Products**
**Algorithm Delivery & Data Management Plans**
**ATSR Calibration**
**Infrared Black Body Calibration**
**In-situ Observations**
**Oceans Meetings Reports and Future Plans**

**FILTER RECOMMENDATIONS:**
The Oceans Group presented a plan, wherein they would receive software from SBRC / GSFC to study the impact of the requested changes, would

furnish preliminary comments within a week after receipt of the impact study, and would furnish their "final" comments in two to three weeks.

**PEER REVIEW:**
The peer review plan presented by the Oceans Group was highly regarded, and considered a "guideline" from which other groups and instrument teams could operate. Indigenous to the plan is the request that Science Team meetings be held at locations other than Goddard, to which V. Salomonson responded that perhaps two meetings a year would continue to be held at Goddard, and two other meetings at different locations. The two meetings at Goddard would be "business" oriented, while the two meetings away would be more discipline / algorithm / research focused.

**DATA PRODUCTS LISTS:**
The algorithm ID field was discussed, with representatives from the Science Processing Support Office (SPSO) present. This is a documentation which describes the algorithm, and ties the algorithm to specific data products. Grouping of products by algorithm therefore becomes possible.

Q1: *V. Salomonson* - Where did the new, and sometimes unrecognizable, forms of the product names come from?
A1: *W. Esaias* - from the attempt at uniform renaming of the products to fit a word search plan.

Salomonson commented that any proposed changes to products need to be discussed *before* the changes are made. SPSO reported that any changes would be traceable, and that an appropriate approval chain, set up at the team's discretion, would be implemented *before* the changes are official. B. Guenther also made a comment that changes would affect the Interdisciplinary Science (IDS) investigators, and that they should somehow be included in change deliberations.

**ALGORITHM DELIVERY and DATA MANAGEMENT PLANS:**
The Oceans Group determined that they will be meeting in Miami in May, and that draft plans will be developed at that time. They expressed willingness to develop a "best guess" draft plan, in the absence of any suggested format from Project or other source. The June delivery date for a draft plan does not seem reasonable.

**ATSR CALIBRATION/VALIDATION (Cal/Val):**
I. Barton reviewed the ATSR Cal / Val data, and is convinced that the data are accurately portrayed, and the instrument will perform at the advertised specification level.

**ALGORITHM REVIEWS:**
While not formally initiated, an early and *ad hoc* trial effort was made to begin the algorithm review procedure. F. Hoge and I. Barton reported in the Oceans Discipline Group session on the status of their research.

**MEETINGS:**
A discussion of future meeting requirements and commitments led to considerable discussion of the current and expected responsibilities of Oceans Group members. In general, they agree with the Land Group that mounting requirements on contract business, documentation, and algorithm development are not compatible with the current level of financial support. There is a need for Ocean-specific meetings, and the first of these will be in May.

**SeaWiFS:**
R. Evans commented that the Ocean Group Highlights failed to include discussions on the relationship of SeaWiFS to MODIS. He noted that tension has resulted from this bifurcated program, which combines research teams, but maintains separate projects, but with some apparent overlapping assumptions on algorithm development and funding.

W. Esaias noted that the Oceans Group has continually growing SeaWiFS responsibilities, and that it is not clear what the full level of obligation will be.

Others noted that there is also no clear delineation of authority on budgets and contractual obligations. The question was raised on how potential funding cuts to MODIS would be managed, in light of the compelling near-term SeaWiFS responsibilities. Many Group members felt "caught in the middle".

V. Salomonson clarified that the SeaWiFS follow-on (COLOR) would apparently be handled differently, with support embedded in the MODIS contract. Salomonson agreed that the current SeaWiFS / MODIS contracts must be kept separate and discrete, in order for SeaWiFS research and algorithm development to be ready on time.

O. Brown agreed completely, but was concerned about how to orchestrate the division of duties and responsibilities between SeaWiFS and MODIS. This is obviously an area that requires additional administrative attention.

## 21. CLOSING REMARKS

V. Salomonson closed with remarks on the plan for the next "plenary - type" science team meeting. He intends for it to be held in conjunction with the Preliminary Design Review (PDR), scheduled for the week of October 19, in

Santa Barbara, California. O. Brown suggested that the science team meeting be held the following week of October 26. P. Menzel recommended that both meetings be held the same week.

There was a reprise of the discussions of modifications to filter requirements, with C. Justice emphasizing the need that radiance software be made available for addressing the filter issue. V. Salomonson requested that W. Barnes coordinate the effort. P. Slater noted that B. Guenther has a high resolution spectrum. J. Barker and A. Fleig agreed to pull together the reflected radiance data, and to see that it is distributed to team members. Salomonson concurred. Y. Kaufman re-emphasized the need for precision in these spectral tools to help with decisions on acceptance/rejection of the suggested filter changes, and Salomonson averred that the data would be assembled as best possible in light of the tight schedule.

Salomonson thanked all team members for their conscientious efforts, their willingness to step forward enthusiastically in facing the issues, and their effectiveness in solving problems.

## PLENARY SESSION ACTION ITEMS

**L. Stuart:** Gather any comments on the MODIS logo, and modify the logo accordingly.

**Team Members:** Comment on the change of the name of MODIS, from MODIS-N to MODIS -- Moderate Resolution Imaging Spectroradiometer.

**MCST:** Review and track the status of the MODIS Calibration Working Group and Science Team meeting calibration action items.

**MCST:** Study the accuracy of the 3.75 µm band, in light of AVHRR capabilities.

**Discipline Groups:** Furnish A. Fleig with initial versions of planned algorithms as soon as possible.

**EOS Project:** Respond to C. Justice's request for improved pointing accuracy.

**EOSDIS:** Respond to C. Justice's request for a statement on EOS topographic requirements.

**TLCF:** Continue discussions w/C. Justice on the use of the Facility for Land algorithm development and data simulation.

**Land Discipline Group (Vanderbilt & Muller):** Address the issue of Peer Review at the next Group meeting.

**MAST:** 1). Consider the requirement to extend personal invitations to instrument team and IDS leaders to attend the MODIS Science Team meetings; 2). Work out a plan for approval of algorithm changes before final submission to SPSO.

**W. Barnes:** Coordinate the provision of solar spectral reflectance data to discipline groups/team members and the team response to Project.

**All Discipline Groups:** In light of to-be-provided spectral reflectance data, evaluate the SBRC-proposed filter changes and recommend action.

**Oceans Discipline Group:** In the absence of input from any other source, draft Algorithm Delivery and Data Management Plans at the Discipline Group's May meeting. Report the plans to A. Fleig.

**Science Data Support Team (SDST):** Determine validity of June delivery date for the Algorithm Delivery and Data Management Plans.

**Unassigned (NASA Hq):** Clarify the financial and algorithm development relationships between SeaWiFS and MODIS.

# MODIS SCIENCE TEAM MEETING
# April 15 - 16, 1992

# ATMOSPHERE DISCIPLINE GROUP
# MINUTES

Meeting Participants:
Michael King - Group Leader
Yoram Kaufman
Paul Menzel
David Rosten - Executive Secretary

George (Tom) Arnold
Kenneth Brown
John Cooper
Philip Dabney
Liam Gumley
Janine Harrison
Brent Holben
Lorraine Remer
Vincent Salomonson
Eric Vermote
Richard Weber
Jim Young

## 1. RESOLUTION OF SBRC FILTER ISSUES

King presented the group's agenda (Attachment 2.1), the first item being the resolution of suggested SBRC MODIS-N filter specification changes. Although Weber conveyed some urgency for the discipline groups to address this issue, King felt there remains some confusion over what version of requested spec changes is the most recent one. Menzel's initial reaction to the broad-based suggestions (limit wavelength tolerance to 0.25%, percent bandwidth to 1.5%, and bandwidth tolerance to 20% in select bands) that SBRC presented during their Instrument Status report at this Science Team Meeting was positive—the requested changes seemed reasonable. King felt that since the spectral band specs were initially chosen for very specific reasons, the group should go through the changes band-by-band, study them more carefully, and approve/disapprove the requests in detail, which they proceeded to do. Their biggest impediment was not knowing what the

relative cost decrease (increase) would be under approval (disapproval) of each kind and magnitude of the requested spec changes. In particular, what is the cost/performance tradeoff between bandwidth tolerance and edge range?

## 2. MODIS-N ALGORITHMS

King stated that, as a group, they must update the atmosphere product list and, as individuals, each scientist must describe the status of algorithm development for the MODIS-N products. Originally, the plan was to have the product lists updated before the Science Team meeting and to have the lists returned to SDST at the meeting, but the algorithm list was only first delivered with the meeting packet. Menzel mentioned that, although he hadn't had the current product list, he compiled information regarding his own science products: approach, algorithm, software, delivery to SDST. He included this summary in his Quarterly Report. The SDST database lists the expected data products linked to each investigator, the planned algorithms, and an abstract of the scientific product background and usage—including technical literature references. King asked the group members to spend time, off-line, reviewing and updating their science product list by logging into the database. Menzel and others acknowledged that they need to take some time to learn how to properly access this database, and wished to know by what date SDST requests the investigators to complete their changes. (See Action Item) All group members expressed some aversion to spending so much time *planning* scientific work, rather than *doing* the scientific work, particularly since the funding estimates usually encompass only the actual work and not so much the time spent on forecasting and/or an administrative explanation of the work. But King reminded them of the intended use of the SDST database: a means by which scientists (both inside and outside of MODIS) could identify future sources of important data products, based on current MODIS expectations.

There was some question regarding notation on the SPDB list of the total MODIS products, grouped by discipline. (This is a different database from that just discussed.) The meaning of notational differences on the listing—such as "MODIS" vs. "MODIS*"—was unclear. It may have signified the former MODIS-N and -T distinction or the new EOS-AM and -PM platforms. This was later cleared up: the asterisk signifies that the data product requires the use of MODIS-T.

Menzel presented his version of the algorithm development plans and schedule for development in his Quarterly Report, subject to review by the group. It listed anticipated algorithm delivery dates to SDST. A discussion ensued regarding the superficially long product list. Many items on the list are essentially delivering the same science, just at different resolutions, etc. Also, the group members agreed to exchange Quarterly Reports among

themselves in the future. King reported that he was given the option to receive all Monthly Reports, but declined. Tuesday's meeting closed with a look-through of the remaining handouts in the MODIS packet and a review of Wednesday's agenda.

Wednesday's meeting began with a discussion of the results of team members' work to update the database the night before. Each expressed some concern that the MODIS data science products need to be limited in such a way that the system is not overloaded with Mbytes of data. Kaufman commented that in his opinion nothing should be entered into the database without approval from the investigators. Others seem to be inferring secondary science products from the primary listing, when in many cases this is in error. King informed Kaufman that he should rewrite his product list and submit it to Fleig. Menzel said he would determine whether the list could be downloaded to a floppy for editing, rather than rewriting it all. More confusion arose over the SPDB data product listing as to what italicized product names signified. A summary of the Atmosphere algorithm development status is given in Attachment 2.2.

## 3. SUNDRY TOPICS

King expressed some concern that a number of algorithms were listed as originating from Didier Tanre, and that he did not know with what confidence he could assure that those products would be delivered. Kaufman mentioned that Tanre's superiors may feel that French activities have higher priority than MODIS, and therefore his efforts are consistent with (and constricted by) this viewpoint. When he is asked for collaboration, Kaufman added, Tanre quickly provides assistance, but because of the situation, best collaboration with him can be while he is on a sabbatical (2 years) at GSFC. King acknowledged that Tanre's work never appears on a budget line.

King commented on the MODIS Science Team Meetings always residing at GSFC. Scientists such as Tanre might be better able to contribute if a meeting were held in Europe. Looking to ERBE as an example, the ninth of thirty-one meetings was held in Paris, so MODIS still had time to follow suit (since this was its seventh). All expressed concern over the cost of such travel, however. In a discussion regarding the Brazilian field experiment, King mentioned that a small party will need to arrive early to make arrangements for connections and logistics. Menzel asked if Alberto Setser was still the main Brazilian contact, but Kaufman reported that the current contact is Volker Kirchoff.

## 4. MODIS PEER REVIEW

Opening thoughts by Kaufman: atmospheric correction is a complex, interdisciplinary procedure that should not be done "behind closed doors." Feedback is necessary to evaluate the assumptions made and to correct any

errors if found. Mainly, the connection between surface properties requires input from the Land Discipline and the connection between sensor capabilities requires input from the Calibration Discipline. Kaufman felt that the Peer Review and other kinds of "checks" made on cross-discipline algorithm development should be done often and taken seriously as an opportunity to critique the efforts of all investigators. Menzel agreed, but he felt that the shortcoming in Peer Review is the title. Peer Review usually signifies that a person's proposal for funding is reviewed by four individuals who give a "yes" or "no" answer. But this is not what the MODIS team is looking to accomplish. It should be an interactive discussion that checks the strength of the investigator's work and suggests changes if it falls short. Kaufman suggested the title Peer Advisory. He agreed that the term "review" seems to suggest that, like a journal review, if the paper does not meet approval, it is rejected—end of story. If we wish to conduct a discussion or an exchange of information, a less "hostile" word must be in the title. Kaufman further suggested the advisory / review take place at least twice: once in '92 and again just before the release of a product algorithm beta version. Menzel asked what form the advisory / review would take: a written distribution or an oral presentation? All agreed the presentation is a much better means to acquire interactive discussion.

King made his Peer Review presentation (Attachment 2.3). Menzel felt it might be relatively easy for the Atmosphere Group to have a semi-formal review prior to algorithm development, since, unlike Land, the former is a more manageable size—both in terms of persons and algorithms. Perhaps this meeting could be coordinated with CERES, he suggested. Menzel reiterated that everyone needs to be aware that this meeting (advisory / review) is not to establish an adversarial relationship. It's simply a means for others to not only advise and constructively criticize, but to be informed by learning what kind of algorithm activity is underway. All consented again that this kind of algorithm evaluation / review is extremely important. If others in the science community are given the opportunity to preview the assumptions entering into the algorithm as it is being developed, it decreases the probability that, once MODIS is underway, a particular algorithm will be useless due to erroneous assumptions. Colleagues who were suggested as appropriate advisors for the Peer Review include: Joel Susskind, Tom Ackerman, Bill Smith, Larry Stowe, and Ben Herman. It is likely that the path MODIS chooses for the Peer Review will be adopted for all of EOS.

Kaufman again suggested the advisory / review should be done twice—once now before algorithm development and once later when the algorithm has likely transformed a great deal based on new understandings of the science. He also suggested that the first review joint with CERES should include some MISR people, since they are doing cloud work as well. Gumley mentioned that Fleig feels it's important to have an early advisory / review for two

reasons: 1) if you say you will deliver a product now, and later recall it because it becomes unfeasible, others who were dependent on that product suffer, and 2) if you do not announce a product until late in the program, someone may not have been able to develop an additional product by using yours. King felt that October was already too crowded with the Science Team meeting to add a Peer Review.

Kaufman asked King if he intended to use MISR cloud data in his algorithms. King expressed reservation about depending upon other instrument's data and that he'd rather see MODIS products be self-contained. Kaufman clarified that he would not suggest using coincident data from MISR, but rather statistical calculations (monthly, for example) which would be more precise in King's model than certain assumptions. King wanted to know how Kaufman would use such data. Kaufman explained that in its high resolution mode, MISR definitely generates optical thickness better than MODIS, although coverage is limited. The group finished this item by discussing who might serve well on the Atmosphere Panel Peer Review.

## 5. MODIS AIRBORNE SIMULATOR STATUS

King was the first to present status information on MAS (Attachment 2.4). The version of MAS which flew in November was of a slightly different configuration than initially anticipated. Four channels are recorded as 10 bits each, while the other seven are 8 bits each, with one of these channels in the visible spectrum. An image taken over the Gulf of Mexico in a 5 December 91 flight was shown. On the first overhead, which showed images from the VIS and NIR channels, he pointed out some regions of interest, including an optically thin section ("hole") and a blurred area. The blurred area was determined to be high level cold cirrus clouds, based on corresponding information from the 8.8 and 11 μm bands. The hole was not that visible in these images; rather it showed that lower boundary layer stratus clouds were a different temperature than the warmer surface. Kaufman asked if King noticed any difference between the latter two channels. No, was the reply, and Menzel will elaborate in his talk (See below). King said he would like to produce some brightness temperature images to see if anything in ice water phase shows up. He didn't notice anything obvious in the unaltered images; also the images shown were stretched to the full dynamic range.

Menzel made his presentation (Attachment 2.5). Ken Brown and he worked together to analyze some of the preliminary MAS data. Working with the same IR images that King presented, Menzel explained that they assumed water temperature (in the Gulf of Mexico) did not fluctuate significantly over a several kilometer area, and they calculated scene rms temperatures (~285 K). The image was rather noisy, and in some cases, noise as small as 0.7°C was defeating to the cloud science, so spatial averaging was done. They conducted

a “sanity check” by using a black-painted Styrofoam cooler holding ice water—a steady 0°C—and measuring differences between the calibration and the ice bucket look while on the ground.

The results were very good (see attachment), as accurate as 0.1°C in the IR. Menzel added that Brown is working on the problem of instrument temperature fluctuations while in the aircraft, which caused gain fluctuations. The gain was eventually fixed, based on the two on-board blackbodies. Menzel showed a 12 µm band image, which he pointed out as having significant line striping. This was due to line-by-line calibration differences, arising from ~0.7°C rms noise in the single sample blackbody measurement. They averaged the blackbody over nine lines and there was a marked improvement. Averaging up to 15 lines was done, but deemed more than necessary. Without this averaging, Menzel said, his cloud science could not separate between ice and water enough. Menzel recommended that this technique be employed when using IR radiances.

Gumley asked whether the noise was due to insufficient sampling of the blackbody or the 400 Hz coherent noise. Menzel replied that it was mostly due to insufficient sampling. Gumley further asked what is actually produced in the data stream, one blackbody look or an average of twelve? An average of twelve looks, was Menzel’s reply. Gumley reiterated that he believes a good deal of that noise will be eliminated when the 400 Hz problem is gone.

Menzel showed a second image at 11 µm, pointing out a river seen through clouds, at 50 m resolution. After performing spatial averaging to reduce the resolution to 250 m, the river is lost. This demonstrates the need for at least some higher resolution data. Menzel summarized by stating that once it is calibrated, the FIRE data are quite useful. Menzel switched his discussion to HIRS, as it relates to global cloud climatology. Don Wiley has been processing these data for a number of years, and Menzel gave a summary of a recent presentation in Atlanta. Menzel felt he could produce science by comparing the $CO_2$-slicing method applied to the shortwave (4 µm) with one applied to the longwave (15 µm). He doesn’t have access to a longwave channel in the MAS data, so he attempted something similar with two shortwave FIRE channels, but was hampered by solar reflectance contamination. Menzel justified this investigation because if longwave channels are not available, the two shortwave approach may be a substitute. If longwave *is* available, he can combine the two approaches to produce a better algorithm. Although the longwave has greater sensitivity, the shortwave has greater SNR.

Menzel’s upcoming plans include the use of his purchased fifteen flight hours in November or December to get more very thin ice and water clouds over the Gulf. He will be comparing cloud cover over land versus water. Kaufman expressed an interest in conducting some ground measurements during Menzel’s flyby.

Ken Brown made his presentation (Attachment 2.6). He began by explaining that GSFC had not previously worked with the contractor (Daedelus) who built the ER-2 MAS imager. GSFC realized that it could provide valuable images, but had significant problems. He believes the majority of these performance problems arose because the contractor never was truly aware of the hostility of the aircraft environment. (The original platform was a small aircraft, not the ER-2, and the instrument design was not properly adjusted as the platform changed.) The contractor was very concerned when they were informed of the kinds of problems that existed, and are working to trace their origins. Before proceeding further, Brown explained the current data system for this instrument is ill-suited. He, therefore, introduced Philip Dabney who discussed an alternative data system, currently being prepared for ASAS (Advanced Solid-State Array Spectroradiometer). The storage capacity of this latter system for a five-hour flight is ~9 Gbytes, if 2 bytes per pixel are used. This nears the limit of Exabyte recorders. (See Attachment 2.7.) The performance parameters listed on the attachment are using uncompressed data. With data compression, the data rate can be increased to those required by MAS. With a VLDS system, you have a 10.6 Gbyte storage in a T-120 set, and these can be ganged to avail 21 Gbyte storage capability. These recorders are ~$45K. The system that Dabney discussed is also software configurable, allowing useless bands, for example, to be eliminated during a particular flight. King asked for a ballpark figure on cost. Dabney said easily under $10K, since the development costs for the data system have already been paid and all that would remain for application to MAS is a minor board redesign, assembly, and integration. Group members appeared quite interested in this alternative data system, particularly because of its large storage capacity on a single tape, including all science, aircraft, and ancillary data.

Returning to Brown's original discussion, during the first three months of the contract, revisions to the instrument were made to educate the contractor on the hostility of the aircraft environment. Before the mission, we attempted to change the spectrometer. The scan head can be removed from the spectrometer. In contrast, Ames uses one scan head and changes the spectrometer, but this involves re-calibrating each time. For the FIRE mission, we changed an array to a single detector in order to locate a visible scene, altered the second and third detectors (ports), and shifted the fourth port to get into the 8.5 µm range. We did not have respectable SNRs (<12 bits). We also saw a significant performance change with aircraft altitude (see attachment). Brown did not elaborate much further beyond the material outlined in the attachment, but summarized the two major problems that still exist: 1) temperature causing gain changes, and 2) humidity in the aircraft causing condensation on the optics and electronics. Brown reported that the contractor looked into how the instrument could be hardened. The temperature fluctuations were simulated and the gain change problem can be fixed by attaching thermal stabilizers to the instrument. This is the solution intended for the full instrument. There is also a problem with 400 Hz

coherent noise. We believe it arises from the pod heaters surrounding the data system. Menzel interjected a suggestion from Fred Best who used an inexpensive C-clamp device that completely eliminated 400 Hz noise in their project. Brown agreed to follow up the suggestion, but also noted that the wiring scheme in the aircraft is not properly laid to prevent noise pickup either. Brown mentioned he has asked the contractor to study the stability of the electronics as well. They do not know polarization effects on the instrument. Brown further noted that some serious work needs to be done to quantify the calibration of the NIR channels over their entire dynamic range. Near 300° K, it is believed that the gain is nonlinear. We also question why an oversized calibration source was not used. Menzel questioned how much stray light is involved, because it would easily show up as an anomaly in the cold blackbody sample. Overall, group members expressed a positive reaction to MAS, despite its problems, simply because it still gives useful data, particularly impressive considering the age of the technology it employs.

Liam Gumley talked briefly about his SDST report (Attachment 2.8). He presented routines based on input from Menzel *et al* which run on IRIS and VAX computers to process MAS data to calibrated, geolocated radiances in the Net CDF format for all channels. The data are self-contained and portable. The document tells what the data are and how to access them. To date, the most popular way to download the data is using FTP (File Transfer Protocol). We plan to switch to Exabyte 8 mm tapes soon. King asked Gumley to discuss the time code offset. Gumley went on to explain that during FIRE, MAS has its own internal clock separate from the inertial navigational clock. There is an offset of 45-65 sec between these two clocks, and this shows up in the dataset. Gumley warned against accidentally using the wrong navigation information, and explained that they are working to synchronize the clocks before the next flight.

John Cooper presented (Attachments 2.9 and 2.10) an update on shortwave calibration support for MAS. The illustrated test setup incorporates a 45° mirror, since MAS can only look at nadir and their 48" integrating hemisphere can only look sideways. They use an Optronics Spectroradiometer to calibrate the hemisphere. Calibration of the mirror is accomplished through a rotation stand: the center of the mirror and the axis of rotation of the stand are aligned; and while the monochromator views the lamp via the mirror, the stand is rotated. A measure of transmittance of the mirror is achieved. Results of these steps are shown in the attachment. The members were concerned about the need for the intermediate mirror, since aluminum has some undesirable dips in its reflectance curve. Gumley suggested calibrating the scan mirror in a similar manner, but Cooper was not sure if that would be possible, since the mirror is recessed. Cooper stated that there is some concern about FIRE calibration under low lamp levels.

The Atmosphere Discipline Group broke to meet with the Land Discipline Group. King discussed Airborne Field Campaigns and MODIS Algorithm Status (Attachment 2.11). Kaufman discussed the biomass burning field experiment in Brazil, Fall '93, the objective of which is to study the radiative and physical effects of biomass burning on the atmosphere. Lorraine Remer discussed her work at NASA/Wallops on characterizing atmospheric effects. Her study flew four channel cameras (blue, green, red, NIR) on the Skyvan, with images taken at four different altitudes of known scenes. Her work will continue in May in Israel.

## ACTION ITEMS

*All Group Members* - By June 1, update MODIS product list, including status of algorithm development, and return to SDST, who will implement the changes into the database. Also, deliver modifications to SPDB product listing to Stuart A.S.A.P.

# MODIS SCIENCE TEAM MEETING
# April 13 - 16, 1992

# CALIBRATION DISCIPLINE GROUP
# MINUTES

This meeting was held Monday, April 13, 1992, at NASA/GSFC in Building 22, Room 365. This session was chaired by Phil Slater of the U. of Arizona. Present were Peter Abel, John Barker, Bill Barnes, Stuart Biggar, Ken Brown, Bruce Guenther, Joann Harnden, Brian Markham, Jan-Peter Muller, Tom Pagano, June Tveekrem, and Jim Young. Jim Butler was executive secretary. **(Note: The complete list of attendees at this meeting was not made available; however, all of the aforementioned persons gave presentations or spoke at the meeting.)**

## 1. EOS CALIBRATION/DATA PRODUCT VALIDATION

Phil Slater (University of Arizona) suggested that participants go around the room identifying themselves and their affiliation. Slater reviewed the MODIS Science Team Meeting agenda for the week, noting that the morning of Tuesday, April 14, was reserved for a Plenary Session. Slater presented a quick review of three major points examined in the EOS Calibration/Data Product Validation Meeting held the week of April 6 in Boulder, Colorado. The first major point concerned the idea of and the benefits gained from the AM platform acquiring sets of filters for:

(1) use in stable radiometers to be used for the preflight cross comparison of calibration sources;
(2) use in Hugh Kiefer's camera used to calibrate the moon;
(3) use in the cross comparison of the monochromator systems that will be used to measure the transmission of the filters;
(4) use in monitoring filter stability over long periods of time.

Slater pointed out that the AM platform should be able to take advantage of the cost savings incurred in manufacturing filters in bulk. The second major point concerned the issue of the calibration PDR becoming part of the system and instrument PDR. Slater indicated that the visible/near infrared working group at the EOS Calibration/Data Product Validation Meeting recommended that the calibration and the system/instrument PDR take place together. The third major point concerned the fact that the present GE integration plan calls for the calibration stage to take place before the environmental (i.e.

pyrotechnic, vibration, acoustic, etc.) tests. Slater warned that instruments might need to be prepared to clean their optics if tests are conducted in this sequence.

## 2. MODIS/MCST AND CALIBRATION WORKING GROUP REPORT

The next speaker was John Barker (NASA/GSFC). Barker spoke on the MODIS/MCST and Calibration Working Group Report (see Attachment 3.1). The calibration strategy for MODIS was reported to be an evolving strategy. Concerning the level 1 MODIS calibration data products, Barker reported that level 1A data are raw data and level 1B data are calibrated data. Barker is also planning to provide data users with a scheme for automated quality assurance of MODIS data along the lines of the system used for Landsat. It was reported that the provision of at-launch level 1 data to GE before launch cannot be guaranteed at this time. On the subject of the Level 2 MODIS calibration data products, Barker reported that the calibration and the science products of CERES and MODIS will be available through the DADS. However, Phil Slater remarked that there is still a measure of uncertainty in the level of our ability to compare MODIS and CERES data. Concerning the level 3 MODIS calibration products, Slater remarked that the retrieval of solar spectral irradiance implies an SBRC preflight calibration employing a NIST source.

Barker then presented an overview of the MODIS/MCST Calibration Plan and Handbook and requested input and feedback on version 1 of these living documents. In regard to the SBRC Instrument Delivery Schedule, Barker stated that the MODIS PDR is scheduled for October, 1992, the CDR is for October 1993, and that the protoflight model is scheduled to fly on the AM platform. Barker stated that SBRC has been delivering the instrument radiometric math model on a regular basis.

On the subject of the SBRC mirror scanning sequence, Barker reported that the exact frequency of inflight calibration will be examined at a later date. Bruce Guenther added that the MODIS Calibration Working Group is responsible for the calibration plan and all calibration scenarios must be resolved between this group and SBRC. Concerning the calibration site selection procedure, Barker reported that the usefulness of heavily cloud-contaminated scenes is currently being examined by Jon Burelbach.

Barker next spoke briefly on the Appendix to the MODIS/MCST and Calibration Working Group Report. Concerning the illustrative flow diagram of the MODIS level 1B radiometric processing on page 60 of the appendix, Barker stated that an overview for MODIS data processing flow is presented. The MODIS algorithm will be updated through SDST. MCST updates the radiometric model through the data team, who then sends the

information to ECS. Slater pointed out that there are at least two sets of algorithms in the scheme on this view graph.

## 3. EOS CALIBRATION

## AND DATA PRODUCT VALIDATION PANEL MEETING

The next speaker was B. Guenther (NASA/GSFC) who presented a summary of issues discussed at the EOS Calibration/Data Product Validation Panel Meeting in Boulder, Colorado on April 7-10. Guenther was pleased to report that significant progress has been made in the area of spacecraft contamination. Polarization problems due to thin film deposition still need to be examined. Guenther stated that he will send out a memo to this working group and to SBRC concerning the calibration PDR. Guenther expressed the desire to capture more of the flavor of the level 2 and higher products in the calibration PDR by finding some people at that level to sit on this working group. Concerning the nature of the algorithm review process, Guenther remarked that the project demands that the algorithms must be reviewed; and the MST is expected to come back to the project calibration panel with ideas on how to do this. The project calibration panel will then review that procedure.

Guenther announced that the EOS Calibration/Data Product Validation meeting will be held this year at Utah State University, Sept. 14-18. The meeting will be held in conjunction with the thermal infrared radiometer workshop. Guenther also announced that progress was made at the Boulder meeting in data product validation. There was a strong overall preference from the Boulder meeting to do data products well. Guenther will draft a policy to arrive at a consensus on this matter. Guenther stated that the representation of land, oceans, and atmosphere working group personnel at this Calibration Working Group meeting was insufficient. This statement was supported by Slater's remark that there was a problem of insufficient Interdisciplinary Science (IDS) representation at the data product validation sessions in Boulder.

## 4. MODIS CALIBRATION

The next presentation was by Jim Young (SBRC) on calibration of the MODIS instrument (see Attachment 3.2). Young stated that for the most part the calibration requirements and performance predictions for MODIS remain unchanged. On the subject of MODIS calibration methodologies, Young and SBRC anticipate the use of not only SBRC methodologies, but also vicarious methodologies. Young spoke about the MODIS Calibration Plan and its outline of multiple measurement methodologies. SBRC anticipates visits from the U. of Arizona and the National Institute of Standards & Technology

(NIST) to test their sources. Young reported that no components of the MODIS calibration model are proprietary at this time, but there are some detector division models which are proprietary. However, those models are so far into the component level that they would have no bearing on the system model.

Young reviewed each aspect of the MODIS in-flight calibration capability and several questions were raised. Young reported that there will be an injected voltage source acting as an electronics stability check. In addition, the method by which the voltage step is implemented has been well characterized by SBRC and should present no problem. On the question of what portion of a pixel will be able to be registered with the SRCA, Young reported that in the cross track direction they will be able to register to 0.1 pixels. The along track number needs more work but they anticipate that they will be able to do at least 0.1 pixels. Young believes that cross track information should be able to be input to a designed ability to adjust the focal plane array while the instrument is in flight. Young also reported that it will be possible to use and monitor the diffuser more often than once per week but not more often than once per orbit.

Young indicated that the requirement documents listed in his presentation (Attachment 3.2) under the title "Requirement Flow Down" are available from SBRC. He then discussed the major modifications to the SRCA and the SDSM design approaches. Young anticipated major modifications if they were required to push the characterization of reflectance and emissivity to the mid infrared from the SWIR and from the thermal IR, despite the fact that the detectors are sensitive to both areas and can be calibrated with both. He agreed that it would be interesting to know the response of these detectors to mid IR emissions.

Concerning the integrating sphere approach to the SDSM, Young stated that SBRC will look at imaging the source onto the diffuser. Concerning the v-groove blackbody, he reported that it is assumed that the blackbody will be machined. On the subject of the full aperture solar diffuser, he remarked that diffuser measurements will be made over one-minute time frames. Solar diffuser measurements will be made at a time when the nadir is in shadow in order to minimize earth shine. Young pointed out that the predicted inflight radiometric accuracy has acceptable margins in 35 of the 36 bands with band 24 not meeting the 1% accuracy. He indicated that the SRCA design has changed. Young stated that the integrating source is a 5-cm sphere employing different lamps and an IR source operating at 390°K, and noted that SBRC would like a S/N of greater than 200 for all vis/NIR/SWIR, but there are three bands that do not have as much margin as they would like. Thermal analysis of the SRCA design has been scheduled. The power budget for the SRCA in operating mode is being met with some margin. Young reported that the lamps have 3,000- to 4,000-hour lifetimes, and a 5° average change is

expected during an orbit. This is a steady-state temperature. The detector temperature will be controlled and will be stable. On the subject of MODIS being able to be tested preflight for orbital transient effects, all system test procedures will be given to NASA for their review and approval. The issue of orbital transients will be examined by SBRC.

On the effect of scan mirror contamination on the vis/NIR/SWIR reflectance of the scan mirror, Young reported that the silver mirrors are an evaporated silver with a dielectric coating to protect the silver. He presented data showing the effect of 50 Å contamination on the scan mirror reflectance in the vis/NIR/SWIR. A thin film program is used to produce these data. He also reported that the reflectance for a bare mirror looks flat for all wavelengths, and that contamination modeling has been done for 0, 25, and 50 Å thicknesses of carbon.

Concerning the performance verification matrix, Young reported that radiance calibrations of MODIS will be done in ambient temperatures and in a vacuum. In addition, some calibrations will be done prior to the environmental tests, with the thermal vacuum calibration being done after the environmental tests.

On the subject of the MODIS preflight calibration hardware and test experience based on TM, the linking of pre-launch and in-orbit calibrations will be discussed later. Young stated that MODIS will be calibrated over a temperature range of 120-360˚K. The space view simulator is anticipated to be a liquid nitrogen blackbody at least at 90˚K. Fixturing inside the chamber will be built the latter part of this year; SBRC is beginning to think about it now. Concerning the water absorption that will be seen with the calibrator outside the chamber, SBRC will do their best to purge this system. The vacuum calibration of MODIS will be considered the primary calibration, and SBRC will use their ambient calibration as much as possible. SBRC has ordered one large integrating sphere from Labsphere and will use more than one method to calibrate the sphere. The U. of Arizona will have their set of portable radiometers for transfer calibration purposes.

The nature of the equipment and techniques that will be used in the calibration at GE still remains an open question. B. Guenther remarked that each instrument will be able to provide a set of equipment for the BAT. This will be followed by a different set of equipment from the project for the cross comparison. Young anticipates that current-based control on the integrating sphere will be employed to ensure stability. Concerning the radiance levels of spherical integrating source versus the requirements, SBRC's plan is to test for transient responses on a 20-pixel period rather than a 1,000-pixel period, which are 10 to 15 IFOVs. This testing will be done at the system level at the focal plane of the calibrator. The fact that GSFC is talking about 1,000-pixel transients and not 20-pixel transients needs to be discussed. The design for

the MODIS calibrator is essentially a new one with concepts borrowed from TM.

## 5. MODIS RADIOMETRIC MATH MODEL

Following a break for lunch, Tom Pagano (SBRC) spoke on the MODIS Radiometric Math Model (Attachment 3.3). Pagano emphasized that the model is evolutionary and is a useful tool in characterizing the inflight behavior of the instrument. The scene data that SBRC uses in the model is what is provided by NASA. Ground plane noise is not in the model and limits are defined to integrate the 1/f spectrum. Pagano reported that specular, incident solar light can be a problem. During the solar calibration, SBRC wants to detect only that light that is off the diffuser through direct illumination from the sun. Young pointed out that the diffuser is located inside the MODIS instrument and that it is protected to an extent from glint. SBRC is providing provisions for baffling. A real concern was expressed about earth shine introducing thermal non-uniformities and scattering in the instrument. Pagano reported that 0.12 or 0.13% of the light results from scatter from the diffuser to the instrument and back to the diffuser. Pagano stated that the model's approach for determining the magnitude of the effect of detector nonuniformities is to integrate the response profile with respect to its position on the detector. The radiometric accuracy for the situation of 100% polarized light being introduced into the instrument followed by rotation of the plane of polarization 180° was reported to be 2%.

During Pagano's presentation, it was pointed out that with respect to the MODIS emissive in-flight radiometric accuracy in most bands, the MODIS cannot meet the 0.5% radiometric accuracy by averaging over several pixels. This point is of special interest to the sea surface people. In response to this problem, it was proposed that if averaging is done in the along track direction, a measure of the radiometric accuracy may be gained.

In summary, Pagano indicated that SBRC needs additional data to be input to their model. The model will be worked on and run through instrument calibration.

## 6. MODIS CALIBRATION/CHARACTERIZATION PLAN

John Barker presented a review of the MODIS Calibration/Characterization Plan (Attachment 3.1) and asked the group for feedback on this document. Barker requested that the group consider the following items: pre launch calibration, cross calibration, and image-based calibration. During the presentation by Barker, Pagano expressed a desire to see the link between registration error and radiometric error. He remarked that both items are difficult to analyze but are related. Barker reported that image-based calibration techniques will be used to correct for destriping. It was remarked

that MODIS calls for reflectance-based and solar-based calibration methods, but reflectance-based calibration is not explicitly discussed in the calibration / characterization plan. Barker remarked that it will be addressed and placed after "External Solar" in the table of contents. Slater remarked that a study to look at the effects of misregistration and geometric effects in terms of the instrument MTF and radiometry should be done. Slater indicated that this is not a simple problem.

## 7. EOS CROSS-CALIBRATION RADIOMETERS

Stuart Biggar (U. of Arizona) presented his work on EOS cross-calibration radiometers (Attachment 3.4). He outlined the U. of Arizona's plans to build a system of traveling radiometers. Biggar noted that he needs information in three areas at this time in order to direct his work on the radiometers. These areas include: (1) operating the radiometers in vacuum; (2) radiance levels from the instruments; and (3) ideas on scheduling. Several comments were made during Biggar's presentation. C. Johnson (NIST) noted that NIST is currently looking into building a sphere for use in vacuum. It was also noted by M. Maxwell (Swales) that the filters appear to be the weakest link in this radiometer scheme; and in order to operate these in vacuum, a way of changing the filters in vacuum must be designed.

Slater noted that Guenther has asked NIST to build another set of traveling radiometers. He also stated that Guenther is trying to coordinate a site visit of instrument people to GE to tour and discuss the GE facilities. Slater believes that this activity is moving in the right direction, but it is moving very slowly. Lastly, Barker emphasized that the MODIS Science Team must determine its feelings on these matters and try to push these questions.

## 8. SIMULATED MODIS IMAGERY

Brian Markham (NASA / GSFC) presented his work on simulated MODIS imagery from TM (see Attachment 3.5). Markham reported that they are looking at Chernobyl and snow scenes, and are using them for the development of the utility algorithm. The recommendation was made by J.-P. Muller (University College, London) that they look at FIFE data.

## 9. MATH MODELING

Jan-Peter Muller presented his work in developing a math model for the MODIS instrument sensors (see Attachment 3.6). With regard to his modeling of the MODIS sensors (i.e.. MODCAL 1991), Muller expressed a need for information on the MODIS camera geometry (i.e. the pointing vector through the focal point as a function of time in WGS84 coordinates). Muller reviewed the camera models of ASAS and MAS. J. Barker noted that MODIS

will examine the Land Group requirements this week and the need for global ground control points in order to do pixel level calculations with MODIS data. Muller remarked that MISR is currently working toward global ground control points, and that a joint MODIS/MISR working group could help in this. Muller proceeded to review the orthophoto generation from images of the linear array sensor and to present the MODCAL 1992 work plan.

## 10. MAS' ROLE IN FIRE

Ken Brown (NASA/GSFC) presented a summary of his work on the MODIS Aircraft Simulator (MAS) and its role in the recent FIRE campaign (see Attachment 2.6). The MAS is a 4 channel instrument with each channel dispersed by grating onto array detectors. A total of 50 bands are possible. The IFOV of MAS is 2.5 mrad. During the FIRE campaign, MAS collected data in 11 channels which were selected by scientists. MAS was flown eleven times over three to four weeks in an ER-2. Ames personnel spent significant amounts of time and effort in minimizing the heater noise from the pod. MAS personnel saw gain changes due to thermal changes in the mounting of the dewars used to cool the detector elements. The instrument builder will fix this problem in the future. MAS personnel made several additional recommendations to improve the instrument. Brown reported that they have not looked at using an integrating sphere with the MAS instrument yet. Barker remarked that the MODIS and MAS people should coordinate on setting MAS bands and registration requirements in order for the MAS data to help MODIS data processing. Also, Barker recommended that the MODIS requirements must be made clear to Michael King (NASA/GSFC) so that he can price the improvements to MAS.

## 11. NASIC

Peter Abel (NASA/GSFC) presented his plans to improve the NASA Aircraft Satellite Instrument Calibration (NASIC) instrument (see Attachment 3.7). Abel reported that the NASIC instrument operates from 400 NM to 1050 NM, and the FOV of the instrument is 3 by 5 satellite pixels. The instrument is being improved with the addition of Invar spacers to improve thermal control and the addition of two more IFOVs. Abel reported that the spatial registration of the satellite and aircraft IFOVs poses a problem. The current instrument error budget (RSS) with respect to accuracy is 4.3%, which will be improved to 1%. The current instrument precision is 3.8%, which will be improved to 0.8%. Slater remarked that a carefully bore-sighted camera would help this instrument in registration problems.

## 12. SeaWiFS

Bill Barnes (NASA/GSFC) presented an overview of the SeaWiFS instrument (see Attachment 3.8). He reported that the instrument delivery is scheduled for next May with a projected launch in August, 1993.

## Action Items

Item 1: Bruce Guenther will contact Carol Bruegge for the cost of filters for the MISR preflight calibration.

Item 2: Phil Slater will contact A. Ono to see if ASTER will provide sets of filters to U.S. scientists.

Item 3: Phil Slater will ask Jim Young to cost 6 to 12 sets of MODIS filters.

Item 4: AM platform instrument representatives will report to Bruce Guenther and ask for funding for the filter procurement.

Item 5: SBRC will examine the possibility or plans to test MODIS for preflight transient effects.

Item 6: Phil Slater will provide SBRC with a solar irradiance data set.

Item 7: Stuart Biggar will provide SBRC with data on Spectralon scattering as a function of polarization and with computed atmospheric polarization data. Also, Biggar will provide SBRC with information on diffuser degradation changes to the BRDF.

Item 8: SBRC will provide a list of data to Bill Barnes or John Barker, which they need for their filter models and calculations.

Item 9: Barbara Grant will add polarization to the calibration plan table of contents.

Item 10: John Barker and Brian Markham will examine FIFE data as an extension to their simulated MODIS imagery study.

Item 11: John Barker will provide Jan-Peter Muller with information on the MODIS camera geometry (i.e. pointing vector through the focal point as a function of time in WGS84 coordinates).

**The Crosstrack Calibration Meeting was held Tuesday Afternoon, April 14, in the Building 8 Auditorium at NASA/GSFC. The goal of the meeting was to review the crosstrack calibration strategies and come to a recommendation as to which strategy is best.**

Attendance:

| Name | Affiliation | Phone |
|---|---|---|
| Jim Butler | NASA / GSFC 925 | (301)286-4606 |
| Barbara Grant | RDC | (301)286-2382 |
| Peter Abel | NASA / GSFC 925 | (301)286-6829 |
| Phil Slater | U. of Arizona | (602)621-4242 |
| Stuart Biggar | U. of Arizona | (602)621-8168 |
| Akira Ono | NRLM / MITI | 81-298-54-4031 |
| Jim Young | SBRC | (805)562-7180 |
| Eric Young | NASA / GSFC 725 | (301)286-1366 |
| Steve Neeck | NASA / GSFC 725 | (301)286-3017 |
| Dick Weber | NASA / GSFC 421 | (301)286-5992 |
| John Bauernschub | NASA / GSFC 421 | (301)286-6395 |
| Eugene Waluschka | NASA / GSFC 717.4 | (301)286-2616 |
| Rod Durham | SBRC | (805)562-7342 |
| Tom Pagano | SBRC | (805)562-7343 |
| Russ Abbink | Sandia Nat'l Labs | (505)845-8351 |
| Ken Anderson | NASA / GSFC 422 | (301)286-6845 |
| Anand Swaroop | Hughes / STX | (301)513-1607 |
| Marvin Maxwell | Swales | (301)595-5500 |

## 12. MODIS CONTAMINATION MODEL

The first speaker was June Tveekrem (NASA / GSFC) who presented information on the MODIS contamination model (see Attachment 3.9). Tveekrem indicated that the MODIS-N contamination study was prompted from the previous contamination work done on MODIS-T. In the contamination model, a 3-dimensional flux distribution of contaminants is assumed. The analyses performed to date assumed a forward-looking aperture for MODIS-T, but not for MODIS-N. Propellant effects were reported to have been taken into account. Tveekrem reported that the model assumes rays of contaminants with a steady-state view factor approach.

In the course of Tveekrem's presentation, P. Slater inquired whether it would be possible to clean the scan mirror at GE. J. Young replied that cleaning the scan mirror could pose the risk of damaging the overcoated silver mirror. With TM, they did some spot cleaning; but with MODIS this requirement should be minimized.

Tveekrem reported that during integration and testing at GE so many people are involved and the overall cleanliness will be affected. Tom Pagano, therefore, recommended that the covers be kept closed on the instrument. Tveekrem also added that the instrument should be kept bagged. Tveekrem indicated that SBRC will need to deal with the issue of vacuum baking instrument components during the assembly phase. T. Pagano indicated the SBRC is currently looking at the selection of bearing lubricants for their sealed bearings.

Tveekrem stated that carbon epoxy is figured into the contamination model, and that they are finding that this is becoming an increasingly less critical problem. As long as the surface T is greater than 145°K, water will not condense; and water is the main outgassing contaminant in carbon epoxy. Mirror rotation has also been accounted for in the model. The boundaries used in the MODIS contamination flux calculations were EOS A1 values for the lower limit and UARS values for the upper limit. Tveekrem reported that the absence of sunlight striking the scan mirror helps the contamination situation in that it prevents solarization. It also enables the use of optical constants for regular oil and not ones for dark brown oil in the model; and it reduces the sticking coefficients. Therefore, the 19 A upper limit is believed to be pessimistic. The subject of the instrument flying through clouds of contaminants was examined. Pagano stated that the MODIS instrument can indeed close its door to avoid such contaminants and the fail safe mode for the door is open. Concerning the larger sources of contamination, Tveekrem reported that since the spacecraft is larger and not as clean, it is a bigger source of contamination. NASA is currently working with GE on contamination minimization. Tveekrem also remarked that unless GE hears the instrument requirements along this line, they will not act. It was noted during the presentation that Nimbus 6 and 7 showed a contamination followed by a cleanup due to solar max. Tveekrem responded that the altitude of EOS and the geometry of MODIS lessens this effect.

## 13. SPACECRAFT YAW

Dick Weber reported that he asked the platform people about yawing the spacecraft 90° in order to view the same ground area. The platform people rejected the request. They also indicated that they would need to respond to a letter on this subject from the science team. In concluding the session on contamination, Slater added that the anechoic chamber at GE is dirty and is a concern.

## 14. CROSSTRACK CALIBRATOR

J. Young presented information on the SBRC-proposed crosstrack calibrator (see Attachment 3.10). The source of the large polarization problem at 0.7 microns in Young's plot of polarization versus angle of incidence was

reported possibly to be due to an interference phenomenon. Young indicated that the beam out of the SRCA is fixed. Only a relatively small region of the scan mirror can by measured by the SRCA method.

D. Weber pointed out that one problem with the approach of using a series of lamps at different wavelengths in the SRCA is that these lamps will degrade at different rates.

Young also reported that the size of the retroreflectors is three inches.

## 15. MIRROR CONTAMINATION

Peter Abel presented information on the proposed role of his NASA Aircraft Satellite Instrument Calibration (NASIC) project in monitoring mirror contamination (see Attachment 3.7). Abel reported that he will gain a better idea of how improvements are going on a flight later this year. The following items were discussed during the presentation. Abel identified his errors and precisions as 1 sigma numbers. Abel indicated that perhaps by October of this year the 1% accuracy could be achieved. He would like to put an on-board calibration system onto the instrument, ensure the proper alignment of nadir and azimuth angles, and put a GPS on the aircraft.

D. Weber pointed out two other calibration techniques which have been mentioned. One technique is to turn EOS 90° in yaw such that the crosstrack is now along track. The platform has rejected the idea. A second technique is to take data for three months and collect the data in bins 5° apart. This is followed by a series analysis of MODIS imagery over the same target. On the latter point, M. Maxwell indicated that if a band matches a Geostationary Operational Environmental Satellite (GOES) band, there will be a scan line that will be passing through the same atmosphere. This would be a simultaneous observation and assumes that GOES is stable.

## 16. CROSSTRACK CALIBRATION TECHNIQUES

Joann Harnden presented the results of her analysis of the proposed crosstrack calibration techniques (see Attachment 3.11). Harnden looked at the technique of time series analysis of MODIS imagery over the same target and yawing the spacecraft to acquire along track data.

The above presentations were followed by a discussion of the various crosstrack calibration techniques. D. Weber noted that none of the on-board hardware solutions provide a solution to this problem. Weber remarked that we are left with P. Abel's approach and other vicarious and analytical approaches. Assuming aircraft underflights would be used for crosstrack calibration, J. Young asked whether there is any need to know the effects of polarization on the aircraft measurements. Abel reported that the aircraft

instrument is sensitive to polarization due to the presence of the window. They also fly a polarization compensator before the instrument and after the mirror.

The main conclusions of the meeting were that the best approaches to all the polarization and contamination problems are the vicarious methods. These vicarious methods look as promising as the hardware solutions. Therefore, the ER-2 experiment must be made as stable as possible and a bore-sighted camera must be flown with the experiment in order to solve the registration problem.

## Action Items

Item 1: June Tveekrem will find out what GE is planning to do in the way of contamination control for MODIS.

**A meeting of the MODIS Science Team Calibration Working Group was convened on Wednesday morning, April 15.**

Attendance:

| Name | Affiliation | Phone |
|---|---|---|
| Jim Butler | NASA / GSFC 925 | (301) 286-4606 |
| Barbara Grant | RDC | (301) 286-2382 |
| John Barker | NASA / GSFC 925 | (301) 286-9498 |
| Phil Slater | U of Arizona | (602) 621-4242 |
| Stuart Biggar | U of Arizona | (602) 621-8168 |
| Akira Ono | NRLM / MITI | 81-298-54-4031 |
| Eugene Waluschka | NASA / GSFC 717.4 | (301) 286-2616 |
| Kate Forrest | NASA / GSFC 726 | (301) 286-7138 |
| Dick Weber | NASA / GSFC 421 | (301) 286-5992 |
| Eric Young | NASA / GSFC 725 | |
| Jim Young | SBRC | (805) 562-7180 |
| Bill Barnes | NASA / GSFC | (301) 286-8670 |
| Bruce Guenther | NASA / GSFC | (301) 286-5205 |
| R. Durham | SBRC | (805) 562-7342 |
| W. Farthing | Swales | (301) 595 5500 |
| G. W. Bothwell | JPL | (818) 354-3237 |
| Lalit Wanchoo | NASA / GSFC | (301) 513-1682 |
| Janine Harrison | NASA / GSFC | (301) 286-5324 |

## 17. RADIOMETRIC MATH MODEL

The first speaker was Tom Pagano of SBRC who presented details on the radiometric math model of MODIS (see Attachment 3.12). Pagano pointed out that the radiometric math model computes sensitivity and accuracy and includes many contributors.

Concerning the refined accuracy analysis model of Pagano, the recommendation was made that SBRC talk to Phil Slater about problems encountered when the spacecraft radiances are referenced to a tungsten lamp. In addition, the recommendation was made that SBRC meet with P. Slater and S. Biggar to discuss the BRDF issue surrounding the diffuser.

J. Young stated—in reference to the emissive band in-flight radiometric accuracy assumptions—that relative to the specified radiometric calibration accuracies, SBRC has assumed uniform scenes. Young suspects some inaccuracies imbedded in the data when the sensor scans a non-uniform scene. D. Weber pointed out that this is covered in the MTF specification as being able to follow the change in MTF across some gradient.

On the subject of the emissive inflight radiometric accuracy assumptions, R. Durham (SBRC) inquired on the ability to differentiate what we must look at to demonstrate proper instrument operation both preflight and inflight. B. Guenther reported that the technical team has nixed the idea of on-board measurement of MTF; now the deconvolution of the MTF from high contrast scenes is being considered.

Young stated that two levels of problems exist. For all 1-km spectral bands there will be a change in MTF from band to band. Young does not understand how to overlap the 250- and 500-m bands, in which there are massive changes in the MTF, with the 1-km bands. J. Barker stated that historically we have not had a lot of algorithms to put bands together. However, it is likely that these will be developed in the future.

Concerning the emissive inflight radiometric calibration accuracy and the use of uniform, extended sources, Pagano remarked that radiometric accuracy cannot be separated from all the spatial/spectral requirements. He recommended that the team get together a unified model to set this problem straight.

Ian Barton remarked that the MODIS accuracies for certain bands are no better than AVHRR, which is a function of the accuracy of the blackbody. The emissivity of 0.992 is not quite state-of-the-art and should be improved. Guenther remarked that he has made CERES information available to the MODIS team in order to improve this. Barnes remarked that 0.1°K is as good as they can do with a blackbody in a system. Guenther added that the calibration/validation panel meeting will present information on blackbodies, and this problem could potentially be worked out there.

Phil Slater reviewed a draft summary of the meeting (see Attachment 3.13). Concerning action item 8, Slater made the suggestion that Weber contact Schoengerdt at the U. of Arizona for insight into that process. Also, with respect to action item 3, the recommendation was made to Barker that the calibration of MODIS not be restricted to a static calibration only. Also, an action item was added that Biggar provide data on Spectralon to SBRC. Slater also presented the algorithm status report.

## 18. MCST SCHEDULES

John Barker spoke on the MCST schedules (see Attachment 3.14). According to Guenther and in accordance with the schedules, a PDR must be in place by October. A serious review of the calibration plan was recommended at the next MST meeting. The SBRC calibration plan might not be ready until the PDR. Also, it was recommended that appropriate science types be lined up now for the algorithm review activity. Finally, Barker reported that the filter procurement activity is on track.

D. Weber pointed out that if the MST is held before the PDR, SBRC will not be there. SBRC will only participate in MST if it is after the PDR. Phil Slater expressed concern that this might mean that they will not be able to review the calibration issues for MODIS before the PDR. Weber is going to check on the 30- or 60-day in-advance requirement concerning documentation.

## Action Items

Item 1: SBRC needs to talk to Phil Slater about referencing their values of $L_{SC}$ to a tungsten lamp.

Item 2: SBRC needs to talk to Phil Slater and Stuart Biggar about their assumptions concerning the diffuser BRDF at 62°.

Item 3: John Barker will supply SBRC with information on thermal transients analyses.

Item 4: John Barker will lead a serious review of the calibration plan at the next MST meeting.

Item 5: John Barker and Phil Slater will identify and contact people in the MODIS program who are knowledgeable in the scientific algorithms in preparation for the algorithm peer reviews.

Item 6: Dick Weber will check on the validity of the 30 or 60 day in advance requirement for delivery of MODIS documentation for purposes of reviewing the documentation before the PDR.

**A meeting of the MST Calibration Discipline Group was convened on Thursday morning, April 16.**

Attendance:

| Name | Affiliation | Phone |
|---|---|---|
| Jim Butler | NASA / GSFC 925 | (301) 286-4606 |
| Peter Abel | NASA / GSFC 925 | (301) 286-6829 |
| Stuart Biggar | U of Arizona | (602) 621-8168 |
| Phil Slater | U of Arizona | (602) 621-4242 |
| Barbara Grant | RDC | (301) 286-2382 |
| Jim Young | SBRC | (805) 562-7180 |
| Carol Johnson | NIST | (301) 975-2322 |
| Akira Ono | NRLM / MITI | 81-298-54-4031 |
| Dick Weber | NASA / GSFC421 | (301) 286-5992 |
| Bill Barnes | NASA / GSFC | (301) 286-8670 |
| John Barker | NASA / GSFC 925 | (301) 286-9498 |
| Doug Hoyt | RDC | (301) 286-9415 |

Jim Young led a discussion of several MODIS issues. The first issue was the solar diffuser monitor. SBRC planned to use the solar diffuser monitor as a relative measurement device. They anticipated that they would not get an absolute value for radiance—that would be accomplished by measuring the BRDF as a function of wavelength and angle. Then with a knowledge of the angle of incidence of the sun on the diffuser and as a function of orbital lifetime, they would make measurements of the solar diffuser using the monitor. If the solar diffuser monitor detected a change, the radiance / reflectance values would be adjusted accordingly. P. Slater stated that the SDSM can work in two modes, and the choice of which mode depends on the amount of stray light onto the diffuser. The only calibration of the ratioing radiometer is an accurate measurement of the solid angle of acceptance of the instrument.

The second issue under discussion was the filter procurement. Jim Young expressed a need to get the order for the filters out now. Phil Slater submitted to the group a copy of his memo to B. Guenther on the plan for the filter sets. (Attachment 3.15) In addition, Phil Slater remarked that he did not understand why the engineering model of the instrument needs specification-quality filters. A full preflight calibration of the engineering model will be performed and the engineering model must perform as the flight model will. Jim Young indicated that filters will be ordered for the engineering model and all flight models. Jim Young inquired on plans to order filter sets for other users. His experience was that filter vendors claim that the filters have such critical tolerances that they will not be able to use witness pieces to track the behavior of the actual filters. In response to J. Young's question on the degree to which these filters must match the flight

filters, S. Biggar remarked that there is significantly less chance for error if these filters are close to the flight filters. P. Slater added that these filters are sensitive to solar Fraunhofer lines and where this is of particular concern is in Hugh Kiefer's calibration of the moon in which these lines are present.

Jim Young pointed out that if Hugh Kiefer's radiometer is not identical to MODIS (i.e. same F number) the filters will not behave the same. Peter Able inquired on the ability to match Hugh Kiefer's radiometer to MODIS.

On the subject of filter sets, Jim Young added that suppliers have indicated that they will have from two to seven witness pieces outside the central filter piece. The sizes of these additional pieces is about 0.5 inches. One vendor has explicitly stated and others have implied that these pieces will not have the same properties as the central unit. Phil Slater remarked that we may have to accept these shortcomings. Jim Young stated that it may take several runs to produce a uniform filter and witness batch.

Dick Weber stated that no source of additional funding has been identified for these filter sets. At this time the procurement of filter sets seems difficult to impossible but has not officially been put to rest. B. Guenther and D. Weber could carry the filter request forward again, but the first order answer was no. The recommendation was made that information be sent to Jim Young on how these filters will be used. Jim Young would then contact the filter vendors for cost information. Dick Weber would then go to the project again with a request for additional funding of the filters.

A. Ono (NRLM / MITI) inquired, since the SWIR and TIR filters will be cooled in orbit, whether the witness filters will be kept in low temperature storage on the ground. J. Young answered that the filters might not need to be stored at low temperature but may only need to be stored at ambient temperature under dry nitrogen. However, when measurements are made on the filters, the filters will be cooled to their operating temperature.

The third issue discussed was the imbedded data in the housekeeping TM. Bill Barnes indicated that after the instrument is buttoned up, there will be no access to the data stream but there will be access to the engineering stream. This might be a good way to tell if the detectors are alive after the instrument is buttoned up. This plan was reported to have been scrapped.

The fourth issue concerned stray light on the diffuser plate. P. Slater inquired on the amount of stray light incident on the diffuser. J. Young pointed out that this has been modeled by Tom Pagano. There are two sources of stray light: (1) sunlight through the solar diffuser door, illuminating the cavity and reflected onto the diffuser, and (2) earth shine illuminating the diffuser. In order to characterize the earth shine component, calibration data must be taken when the instrument is behind the terminator.

The fifth issue discussed concerned the ability to monitor in-flight changes to the diffuser using the lunar calibration. Bill Barnes said Jack Schumacher did a study that indicated that MODIS will be able to see the moon an average of 3.8 times per year. This number could be increased by rocking the platform 20°. However, in the non-rocking scenario, there may be periods of six months at which the moon will not be viewed. John Barker remarked that we need to put forward a MODIS position that states that 4 lunar looks per year is adequate for lunar calibration. Stuart Biggar added that the proof of concept for lunar calibration will be the SeaWiFS instrument. Carol Johnson has spoken to defense people who look at the moon at high altitudes. These people have indicated that they plan to contact Hugh Kiefer in the future. John Barker inquired on the ability to monitor non-uniformities on the scan mirror using the moon. This was recognized as being a potential end of life experiment because it will require drastic movements of the platform.

The next MODIS instrument quarterly review was announced for June 22 at GSFC.

## Action Items

Item 1: Jim Young will send Phil Slater a copy of the memo on the SDSM.

Item 2: Phil Slater will send Jim Young copies of the reprints from the SPIE meeting held in April 1991.

Item 3: Phil Slater will provide Jim Young and Dick Weber information on how the preflight calibration filters will be used.

Item 4: Jim Young will provide Phil Slater with information on the temperature effect on the wavelength of the filters.

# MODIS SCIENCE TEAM MEETING
# April 14 - 16, 1992

# LAND DISCIPLINE GROUP

# MINUTES

Meeting Participants:
Chris Justice - Group Leader
Alfredo Huete
Jan-Peter Muller
Vincent Salomonson
Alan Strahler
Vern Vanderbilt
Zhengming Wan
David Toll - Executive Secretary

David Carneggie - EROS Data Center
David Diner - Jet Propulsion Laboratory
Al Fleig - NASA/GSFC
Dorothy Hall - NASA/GSFC
Ray Hunt U. Montana
Yoram Kaufman - NASA/GSFC
Tom Mace - Environmental Protection Agency
Peter Mouginis-Mark - University of Hawaii
Phil Teillet - CCRS/Canada
June Thermosgaard - EROS Data Center
John Townshend - U. of Maryland
Michel Verstraete - CEC Joint Research Center
Yasushi Yamaguchi - ASTER

## 1. GENERAL ISSUES

Chris Justice reported that the Land Group needs calibration and sensor-related information on: (1) the 3.75 µm band calibration; (2) the difference in modulation transfer function (MTF) between bands 1 & 2; and (3) the impact of the proposed changes to the filter specifications on land sensing and atmospheric corrections.

Justice recognized a need for improved feedback to the Land Group from the MODIS project on broad issues such as topographic requirements and

geometric registration of MODIS data. Justice and Alan Strahler reported there are differences between their last copy of "MODIS Data Products" and the version given to them in the handout.

Vince Salomonson reported that the listing and documentation of the data products by each individual investigator is important in the planned revision of contracts. Salomonson wanted information on the land response to possible changes for the filter specifications. C. Justice wants additional information and wants to consult with Y. Kaufman and D. Tanre on atmospheric effects when deriving land surface values.

## 2. JUSTICE RESEARCH SUMMARY

C. Justice reported on his work related to four MODIS "At-Launch" data products.

1. Atmospheric Corrected Radiance with D. Tanre and Y. Kaufman.
2. Vegetation Index with Alfredo Huete
3. Land Cover with Alan Strahler
4. Fire product with Yoram Kaufman

He then briefly discussed his work with three "Post-Launch" products.

1. Vegetation growing season length.
2. Regional trace gas emission from biomass burning.
3. Land cover change

Justice indicated that the Landsat Pathfinder Streams 1 & 3 and the EPA Land Characterization data sets include scenes of the tropical forest in the Amazon Basin and parts of the United States and Caribbean in work associated with GSFC and EPA. The EPA pathfinder data set is mostly MSS with an attempt to make Thematic Mapper (TM) data available with geo-corrections. Chris Elvidge is in charge of the EPA pathfinder activity.

## 3. HUETE RESEARCH ACTIVITY

A. Huete reported on his Vegetation Index-related work, which includes the effects of atmosphere, background (understory), and directional reflectance. Additionally, he is working on temporal compositing techniques. His work also includes topographic effects, biophysical parameters (absorbed photosynthetic active radiation, or APAR), leaf-area-index (LAI), net primary productivity (NPP), and length of growing season. C. Justice questioned the relationship between the various proposed vegetation index products. Huete will confer with Strahler on the bi-directional reflectance distribution function (BRDF) effects on the vegetation index.

Additional work is planned with Strahler on temporal spectral mixtures and with Running on vegetation stress. Thermal inertia (day-night temperature difference) will be worked on with Z. Wan.

## 4. RUNNING RESEARCH ACTIVITY

Ray Hunt substituted for Steve Running. Hunt summarized their work on NPP and using MODIS input products of vegetation index, land cover, APAR, and incident photosynthetic active radiation (IPAR). They also need information on woody biomass, soils, and climate. They are working on growing season length and vegetation stress. Information on woody biomass may be obtained from Jon Ranson and Roger Lang through their SAR team activities. Justice said Running's group should define ancillary product needs soon.

## 5. GEOMETRIC CONSIDERATIONS

John Barker gave a presentation on MODIS geometric considerations. A copy of the presentation is in Attachment 4.1. A back-up set of additional view graphs is given in Attachment 4.2. Barker recommended a minimum goal of registration at 250 m and not 480 m for MODIS bands 1 & 2.

The MODIS instrument geometry requirement is 90 arc seconds (310 m at nadir). SBRC reported that most of the misregistration is systematic with only a small amount that is random (primarily from bearings). W. Barnes estimated 70% error is biased from spacecraft-related variation. B. Guenther reported that misregistration error may come from scan mirror momentum, bearings, momentum from other sensors (e.g., Advanced Spaceborne Thermal Emission and Reflection Radiometer, or ASTER), thermal stress, antennae movements, and recorder movement. Guenther said for pointing instruments (e.g., Multi-Angle Imaging Spectrometer, or MISR) the noise effects are worse.

J. Barker said from a land perspective they are interested in the final registration and that the Project should decide if the Land Group's geometric specifications are met from ground facility use of Ground Control Points or using a spacecraft configured system (stellar with optical navigation or a Global Positioning System, or GPS).

Bruce Guenther will take an action item from the Land Group to provide additional information on registration-related uncertainties. Justice said he will speak to Piers Sellers and David Schimel of the IWG about possible misregistration effects on their Interdisciplinary Science (IDS) products. W. Barnes said he will look into costs and problems associated with sensor and spacecraft biases.

Chris Justice recommended that ASTER, MISR, and MODIS investigators coordinate their geometric requirements. Al Fleig gave a hand-out on "Questions Regarding MODIS Geolocation / Registration Requirements" to the Land Group (Attachment 4.3). Fleig said there are numerous specific questions in planning the Team Leader Computing Facility (TLCF). The attachment outlines most of them. The list mentions the level (Level 1b or Level 2) where resampling occurs, corrections to specific (or all) scenes, etc. John Townshend will coordinate responses to the TLCF from a land perspective. Townshend said we need better coordination between the science group and MISR and ASTER members. In addition, he would like assistance from John Barker. Townshend is concerned that the EOS project will burden the ground processing group with too many requirements at the end and won't take measures now to provide accurate geo-corrected data.

## 6. UTILITY ALGORITHMS

John Barker gave an overview of the MODIS Calibration Science Team (MCST) Utility Data Products. The two data products included a texture product and a classification / mask overlay (Described in Attachment 4.1). Barker said MCST is trying to determine whether the MODIS products should be available on the MODIS AM and / or PM spacecrafts. Barker said that their two utility algorithms should be peer reviewed under the Land Review. The classification overlay includes clouds, water, snow-line, and vegetation. Muller said glint and hot spot pixels also should be included. Muller also said potential tie points for image-to-image registration should be included as a Utility Product. From a MODLAND perspective, work on the Utility Products should be the third priority for the MCST, behind instrument characterization and calibration, and algorithms and work related to monitoring MODIS in orbit.

Dave Diner said MISR is having a cloud mask meeting for Level 1 data in Canada around Aug. 17, 1992.

## 7. J.-P. MULLER RESEARCH

J.-P. Muller gave a presentation on misregistration effects from variations in topography. He recommended that a grid spacing of 0.5 km is sufficient for most applications. The grid spacing may be approximately a few hundred meters. He is studying effects of slope, aspect, and grid size on shading. In addition, he is studying topographic requirements for low resolution (zero order for geoid), moderate resolution (atmospheric path length and terrain), and high spatial resolution (scattering from adjacent pixels, slope / aspect effects, and shadowing).
Muller is working on a peer review paper on the misregistration effects on MODIS data caused by not incorporating topographic effects. C. Justice said Muller may want to confer with EDC for a joint MODIS paper. Muller should

do a summary paper for EOS with a requirement statement by next fall. Justice said the topographic corrected data will help the MODIS user community and that a joint effort between sensor groups (e.g., ASTER and MISR teams) is recommended. Muller said having support from IDS investigators P. Sellers and D. Schimel would help. D. Diner echoed the need for topographic correction and said that the need for MISR data with the pointing radiometers at the extreme angles has a higher topographic-related requirement than MODIS. Al Fleig said that a firm recommendation to the IWG for NASA to address topography is appropriate. Muller said MISR data may be used to develop a DEM, but will that take two years after launch and should be thought of as a validation source.

## 8. EDC DAAC

June Thermosgaard from EROS Data Center (EDC) gave a presentation on Distributed Active Archive Center (DAAC) activities. She said their work on misregistration effects from a terrain displacement is up to 2 AVHRR pixels, and up to 3 pixels for large scan angles (25°-40°). EDC is examining the accuracy of DEMs from SPOT and JERS-1 stereo data. She reported that they have 57 AVHRR validation sites across the United States and 10 sites in Alaska (Attachment 4.4). They are 20 square kilometers over homogeneous areas and are near radiosonde data. They have completed 1990 and 1991 data and are near finishing validation using the 1989 and 1992 daily AVHRR data. They will test temporal data compositing procedures with A. Huete.

David Carneggie, from EDC, completed the DAAC summary and highlighted Version 0 Activities (Attachment 4.5). He said the EDC DAAC recently had a peer review of their program. They are working on system level activities, including work on catalog, user interface, data formats and a science processing library. EDC is also working on an 18-month AVHRR global land database starting with mid-year 1992 data. This work is in conjunction with IGBP-DIS. They are working towards providing global coverage of HRPT (High Resolution Picture Transmission) network data. In addition, they are investigating a long-term archive of airborne data (TIMS, NS001, and AVIRIS, or Advance Visible and Infrared Imaging Spectrometer). Justice recommended that the TLCF receive the global EDC data for subsequent dissemination to the Land Group. Fleig said that as of today the TLCF is not designed to disseminate data to the Land Group, but they will consider the request. EDC will archive AVHRR, ASTER, and MODIS data. EDC should consider permanent archiving of Advanced Solid State Array Spectrometer (ASAS) and MODIS Airborne Simulator (MAS) data also.

EDC is in the process of procuring Multispectral Scanner (MSS) and AVHRR data for MODIS (Attachment 4.6) for $25,000. EDC also sells AVHRR data at the cost of reproduction. They will work with MODIS investigators on an electronic transfer of image data. EDC is supporting the EPA (Environmental

Protection Agency) Landsat Pathfinder data for their test sites. Justice would like to see an electronic transfer of the minutes of the EDC DAAC Science Advisory Meetings. A copy should be sent to each MODIS member.

## 9. GLOBAL LAND DATA SET REQUIREMENTS

John Townshend gave a report (Attachment 4.7) on requirements for a global 1 km AVHRR data set. In addition, he gave a draft report on a proposal for a high resolution data set from the Land Cover Working Group of the International Geosphere Biosphere Program (IGBP)-Display and Information System (DIS) (Attachment 4.8). Additional MODIS requirements are needed to define science requirements for working with raw and processed ancillary data (e.g., AVHRR). Muller said 1 km AVHRR raw data are needed for evaluation of surface albedo products.

## 10. LAND SURFACE TEMPERATURE

Z. Wan gave a summary of his work on land surface temperature. He is examining accuracy of selected radiative transfer models. Wan said an error of 0.5% of land emissivity will provide an estimate of surface temperature to 0.3-0.4 °C. Wan needs an accurate estimate of emissivity by land cover class. He will examine pre-launch ground, aircraft and satellite data (1992-1997) to study problems when estimating surface temperature. Justice recommended that Wan coordinate surface temperature derivations with ASTER investigators (and any other thermal sensor investigators) and that he should attend ASTER meetings. In addition, Wan should talk with I. Barton about his emissivity correction plans. Justice also said Wan should identify his ancillary data requirements. Wan should also continue his liaison with the IGBP-DIS surface temperature working group.

## 11. BRDF, ALBEDO, STRUCTURE AND LAND COVER

A. Strahler summarized their work to date on BRDF, albedo, spatial structure and land cover. His work included MODIS-T and MISR evaluation with Muller, and BRDF work with Barnsley. Strahler said the BRDF information may be used to extract physical parameters (e.g., LAI, leaf geometry, and size of leaves) as a post-launch product. He said MISR (over MODIS) is probably best designed to directly estimate surface albedo. A. Strahler's group is examining spatial structure at the spatial resolutions of MODIS (250 m, 500 m and 1000 m) using 30 m Thematic Mapper (TM) data. He said the land cover information would come from other MODIS products (e.g., surface temperature, spatial structure, snow cover, and NPP) and MODIS spectral data. He is currently evaluating classification procedures and satellite data temporal compositing problems.

## 12. TOPOGRAPHIC CORRECTION, GLOBAL BRDF, SURFACE ROUGHNESS, LAND COVER FOR CLIMATE, SPECTRAL ALBEDO, SCENE SIMULATION AND CAMERA MODEL

Jan-Peter Muller reported on his work to date on topographic correction, BRDF, surface roughness, land cover, spectral albedo, scene simulation, and camera model. The camera model comprises an automatic registration of multiple views. He is looking at NS001 type data. Muller said scene navigation information may be used to register multi-temporal data. In addition, he said that automatic tie pointing between images will give approximately 0.7 RMS pixel misregistration (i.e., AVHRR type pixels). Muller said MODIS should place more importance on cloud screening and identification. M. Barnsley is evaluating MISR/BRDF work. They are studying how many pixels of a location are needed to estimate surface albedo. He also said they are planning to develop a DEM database. Justice said that because of the uncertainty in both Muller's and Tanre's (i.e., non-U.S.) funding level, their MODIS data products may be at risk. The group needs to assess the importance of a MODIS albedo product to the EOS community.

## 13. POLARIZATION VEGETATION INDEX

Vern Vanderbilt reported on his work to modify the vegetation index for polarization effects. He said the specular component of reflectance is high in the red region and may have a significant affect on a vegetation index if not considered. He is examining the use of polarization data from ADEOS, to be launched in 1996, to modify MODIS data.

## 14. MODIS AIRBORNE SIMULATOR

Michael King summarized the MODIS Airborne Simulator (MAS) activities. They used only one visible band for their November FIRE flight. They are planning a Brazilian flight in September, 1993. Paul Menzel reported on his MAS research. He said that the 3.75 μm band has a 1.7°C rms accuracy and the 8.8 μm band has a 0.3°C rms accuracy. He said the biases are typical for the 0.4-1.3 μm bands. He said there are in-flight gain changes to 20%, with temperature changes of 10°C. Justice said that the Land Group should consider and plan its requirements for the MAS in field studies and coordinate future aircraft campaigns.

## 15. SMOKE, CLOUD, AND RADIATION (SCAR) EXPERIMENT

Y. Kaufman reported on the Smoke, Cloud, and Radiation (SCAR) Experiment planned for Brazil. The primary objective of the experiment is to

study radiative and physical effects of biomass burning on the atmosphere, and to prepare a comprehensive data set for the evaluation of remote sensing procedures from ground and air measurements of the optical and physical properties of aerosol particles, cloud drops, firs and the surface reflectance. The experiment is a joint effort between several U.S. (NASA, US Forest Service, and University) and Brazilian (IBAMA and INPE) teams. See Attachment 4.9 for a summary of objectives, participants, and methodology. They are looking for interest and participation from MODLAND.

## 16. LAND SURFACE REFLECTANCE

Lorraine Remer, of SSAI, who is working with Kaufman, gave a brief presentation on their work to characterize the land surface reflectance using a Hasselblad camera and digitization techniques. Their goal is to summarize the land surface reflectance for many parts of the world.

## 17. NDVI CORRECTION

M. Verstraete gave a presentation on the development of a spectral vegetation index algorithm that corrects for atmospheric effects (Attachment 4.10). The dynamic range of the vegetation information is maintained and in some cases increased. Verstraete was invited to attend the vegetation index subgroup meeting June 22 at GSFC.

## 18. SNOW & ICE

D. Hall summarized her MODIS work on snow, sea ice, and glaciers. She has plans to use MODIS and MISR to measure albedo. In addition, she plans to provide global mapping of snow and related watershed areas with MODIS. She is investigating adverse effects from fog and vegetative cover on the mapping. She plans future work in Ontario; BOREAS sites; and Glacier National Park.

Analysis of MAS data indicated that the red band is saturated over snow. P. Mouginas-Mark said the MAS should be adjusted in gain for snow areas to readily correct the problem. Dorothy Hall and others have MAS data over the Sierra Nevada and ASAS data over Glacier National Park in Montana.

## 19. BOREAS PROPOSAL

Ray Hunt reported on the Boreal Forest (BOREAS) Proposal from the MODLAND Group. The BOREAS work will permit the MODLAND team to

develop and test algorithms. Hunt wanted figures on proposed algorithms and input/output products from the MODIS team. C. Justice said the proposal is O.K. if we are not asking for funding, but should it be reworked if we are requesting a significant budget. Justice recommended submitting a no-cost proposal. A. Strahler thought some costs should be included. D. Hall recommended using MODIS funds.

## 20. TEST SITES

C. Justice reported on the MODIS team global test sites. The primary plan was to select land cover test sites by biome throughout the global land surface. As a first step, a selection of MSS scenes was identified for FY91 through EDC. (Landsat scene inputs are due by the end of May. There are 50 global sites with three Landsat scenes per year and these sites will include historical data.) AVHRR could be added on a daily basis. D. Carneggie said Landsat TM could soon be added to the database. EDC is preserving historical Landsat data throughout the globe with a goal of three scenes a year. Muller said Sun Photometer data should be added for test sites. Running will participate in a Long Term Ecological Regions (LTER) site selection. Justice should try and coordinate the test site selection with the IGBP but the MODIS sites will have more of an emphasis on globally selected sites. Tom Mace said linkages should be made with the EMAP sites. Diner said they are looking for 300 square km test sites that MODIS might also select for the MISR "local mode" selections.

## 21. MODIS MSS TEST SITES

A. Huete summarized the MODIS request for EDC to purchase 50 MSS scenes. D. Hall would like to add additional snow scenes to the order. D. Carneggie said EDC is paying to register 200 Landsat MSS scenes in the southwestern United States and Mexico and will consider registering MODIS scenes. The primary purpose of the MSS data purchase will be algorithm development and validation. A. Strahler would like to see the data from EDC formatted well in a condensed medium. D. Carneggie said we should contain our plans on data formatting reasonably well and consider how EDC can package the Landsat data with ancillary data. Tom Mace said MODIS should reinforce EPA and consider freshwater and wetlands in their test site selection. Ray Hunt said LTER managers want to work more with global implications in their work and may consider remote sensing data.

## 22. ASTER

Z. Wan summarized information on the ASTER Science Meeting. Attachment 4.11 summarizes the ASTER spectral and spatial bands and other

characteristics in comparison to Landsat TM. Wan said that for the thermal bands (8-12 mm), the signal to noise is low at cold temperatures. ASTER calibration sites include Lake Casitas and Death Valley for study of geology and emissivity. Z. Wan cannot attend the ASTER meeting in Japan during June, 1992. P. Muller said the ASTER sensor may provide terrain data for the 30% of the Earth's surface requiring topographic correction data.

## 23. MISR

A. Strahler reported on activities at the MISR Science Team Meeting. He said MISR is considering tradeoffs between spatial resolution, bands, and camera angles when determining their local and global model test sites. Diner said a case should be made by MODIS if they want a 1-km global data set and not a 2 km data set. MODIS and MISR may want to consider a joint proposal on land global and local mode configurations. In addition, they can select data at 960 m over 9-angles and 4-bands and 240 m over 3-angles and 4-bands. MISR is working on 3 different cloud screening approaches. Justice said MISR should consider using MODIS data to screen clouds and that an EOS cloud screening strategy should be coordinated through the project and program at NASA Headquarters (G. Asrar). Diner said for Level 2 processing the data should be combined, but for Level 1 data significant risks may occur when requiring data from another sensor. MISR data will be managed through the Langley DAAC. MISR and MODIS should coordinate improved pointing and location capabilities. This should be pursued and coordinated through the EOS project office.

Al Fleig said it was his understanding that radiance and reflectance data would not be registered (only non-calibrated image data). The MODLAND group disagreed. Justice said we need a broad community consensus on image registration and resampling procedures. This is especially important for geometry, cloud masking, and topographic correction.

## 24. RADIOMETRIC CALIBRATION

Alfredo Huete represented the MODIS Land Group at the MODIS Calibration Meetings on Monday. He said there is no action item as of today for the Land Group. He said it was odd that there was no discussion of the changes to the filter specifications. He recommended the MCST not look for uniform radiance areas using the Normalized Difference Vegetation Index (NDVI). He said the report by Ken Brown on MAS represented a pessimistic portrayal of the instrument. He reported that Brown said that the MAS was never tested for environmental temperature changes. However, most of the MAS problems are correctable. Huete said Markham is working on MODIS simulation work. Huete said the MCST will need to consider special calibration requirements and sensitivities to satisfy the Land Group. In

addition, any specific topographic requirements should be summarized. Muller said the MCST may be attempting to take on too many problems and recommends that they emphasize cloud masking and geolocation problems. He said perhaps the MODIS Associate Members could fund specific tasks (e.g., cloud masking and geolocation).

Jon Burelbach from the MCST said the snow group (D. Hall) is examining MODIS simulated data. The simulation includes scanner and detector effects. Justice said that once the basic algorithm is developed, the MCST should place a reduced emphasis on MODIS simulation work. Wan and Huete are needed at calibration meetings. Wan should further work out the thermal calibration requirements through W. Barnes. Vanderbilt and Muller are assigned to the Calibration Advisory Group.

## 25. MODLAND PUBLICATION

Justice said V. Salomonson is waiting for a land publication that is equivalent to the MODIS atmospheric paper by M. King and others. Justice said the paper could include a summary of concerns on topics such as topographic effects on geolocation. He said the paper could include effects on science if certain requirements are not met. Hunt said that Running's paper for the group is on hold because of the BOREAS proposal. He said Running needs figures from the group and paragraphs on their products. In addition, a list of input and ancillary data is needed. Justice said the current MODLAND paper needs to be reworked and should not have the final objective being NPP and LAI (Leaf Area Index). All MODLANDERS are invited to assist Running in moving the paper forward.

## 26. INTERDISCIPLINARY SCIENCE

Justice said it is important to determine how MODLAND can provide information through data products to the IDS investigators and to determine what the IDS investigators expect from MODIS.

P. Mouginas-Mark gave a presentation on volcanic eruption effects to the atmosphere. His team's major concern is getting access quickly to the data to examine atmospheric effects soon after an eruption. He said he wants continuous collection of the SWIR and LWIR channels. They also need an absolute calibration of the thermal bands. One of the signals they hope to extract is lava versus land fire. He said AVHRR is approximately 70% effective in studying volcanic activity. He thinks MODIS will provide a significant improvement. They also plan to use TOMS data to measure ozone and sulfur dioxide. In addition, MODIS will be merged with MISR (topography of plumes), ASTER (high resolution thermal analysis of lava flows), GLRS-A (nadir topographic profile and height of plume), and AIRS (vertical atmospheric profiles and calibration). P. Muller said the sulfur

dioxide from volcanoes may effect the gaseous absorption to MODIS optical bands and could have an impact on the MODIS calibration.

## 27. VEGETATION INDEX AND LAND COVER MEETINGS

Justice said the Vegetation Index group should have a one day meeting on June 22 (Mon.) before the International Land Surface Climatology Project (ISLSCP) meeting in Columbia, MD. The BRDF group should meet June 26 (Fri.) and June 27 (Sat.). Muller said he could add S. Gerstl and D. Diner to the BRDF team. A Land Cover meeting will be held in the late summer in Montana.

The remainder of the meeting was spent discussing preparations for the Plenary Session and is summarized in the Plenary Section .

### ACTION ITEMS

1. Bruce Guenther will further investigate and report on registration-related uncertainties.

2. Chris Justice said he will speak to Piers Sellers and David Schimel (IWG) about possible misregistration effects on their Interdisciplinary Science (IDS) products.

3. W. Barnes said he will look into costs and problems associated with sensor and spacecraft biases.

4. Townshend will coordinate the MODLAND response to the TLCF from the "Questions Regarding MODIS Geolocation/Registration Requirements".

5. Muller should do a summary paper with a requirement statement on misregistration effects to MODIS data when not incorporating topographic requirements.

6. Carneggie should provide to the MODLAND group an electronic transfer of the minutes of the EDC DAAC Science Advisory Meetings.

7. Wan should coordinate surface temperature derivations with ASTER investigators (and any other thermal sensor investigators) and should attend ASTER meetings.

8. Wan should collaborate with I. Barton about his emissivity correction plans.

9. Wan should identify his ancillary data requirements.

10. Wan should continue his liaison with the IGBP-DIS surface temperature working group.

11. MODLAND Group - Justice said the land group should consider and plan its requirements for the MAS in field studies and coordinate their future aircraft campaigns.

12 Verstraete was invited to attend the vegetation index subgroup meeting June 22 at GSFC.

# MODIS SCIENCE TEAM MEETING
# April 15 - 16, 1992

# OCEAN DISCIPLINE GROUP

# MINUTES

Present were Wayne Esaias, Ian Barton, Otis Brown, Frank Hoge, Mark Abbott, Robert Evans, Ken Carder, Howard Gordon, and Greg Mitchell. A number of other guests, including technical team members, were occasionally in attendance. Locke Stuart acted as executive secretary. An agenda proposed by Esaias is Attachment 5.1

## 1. FILTERS

Much of the group's deliberations were concerned with possible relaxation of spectral filter requirements. In summary, it was decided that there was insufficient time and information at the meeting to make fully rational decisions on modifications to the previously carefully crafted specifications. There was some stress on the propriety of the filter review request: previously a set of proposed modifications had been sent to team members by Santa Barbara Research Center, then a wholly new (and in some cases conflicting) set was presented on the first day of the Science Team meeting. A week's deadline for response was allowed by Project. Although the deadline is inappropriate for a fully-defined filter review, it is possible on a selected basis with a concentrated effort by certain members of the Oceans Group, led by Howard Gordon. Gordon will work particularly closely with O. Brown and P. Slater to complete the recommendations on schedule. Following are some initial thoughts and concerns relating to filter specifications.

**THOUGHTS:**

1) **Edge Response:** The 50% slope is important. 70% or more is unacceptable.
2) **Spectral Background:** While the team had the solar spectrum over which to lay the filter specifications (Attachment 5.2), it was concluded that "at-satellite radiances" would be required before modifications could be studied. The tropical atmosphere was considered important. It was hoped that P. Slater would overlay the filter characteristics on the reflected Fraunhofer spectrum.
3) **Methodology:** Extremes in tolerances need to be laid out on the at-satellite spectrum, and absorption lines and filter drift considered.

**CONCERNS:**

1) **Modeling:** The filter specifications need to be intensively modeled, before relief to the current specifications can be offered.
2) **Change of Request:** The Oceans Group was unsure of how to respond to the changed set of requested modifications, and determined that the only rational response could be to the original relaxation request, which was sent to the team members in sufficient time to allow a response**.**
3) **Zero Sum:** B. Guenther noted that the costliness of the filters could affect other parts of the instrument or science program, since there is only a limited amount of money budgeted to the instrument build.
4) **Shift:** Concern about within-orbit (0.2 nm) and long-term (1 - 2 nm over 5 years) spectral drift was expressed by Brown and Carder.

**ACTIONS/ISSUES/CONCERNS**

1) **Howard Gordon:** Review the requested filter modifications, and advise Bill Barnes of decisions.
2) **Santa Barbara Research Center:** Provide software for the determination of filter parameters.
3) **MODIS Technical Team/P. Slater:** Provide a fully-developed background spectrum on which to overlay filter parameters.

## 2. PEER REVIEW

In general, the concept of algorithm peer review was well received by the Oceans Group. While there was some concern that it was a bit early to institute reviews (before algorithms are sketched or drafted), it was felt that current peer review could prove valuable in considering the scientific concept. Internal reviews (within the Group) are initially preferred, followed by MODIS Science Team review, and then regular publication / presentation of algorithms and concepts in an appropriate forum. Attachment 5.3 summarizes the peer review conceptualization.

**THOUGHTS:**

1) **"Usable" Algorithms:** Because of SeaWiFS, a usable set of algorithms should be in place by March, 1993.
2) **Review Longevity:** In structuring the principles of the peer review, the entire lifetime of MODIS should be considered. The review should stretch from initial principles through validation, and include approach, non-MODIS data requirements, and testing.
3) **Leadership Role:** In response to a question regarding what Project's expectations were, it was decided that MODIS is in a position to recommend to Project the appropriate format for peer review.
4) **Peer Review Attendance:** It appears appropriate to invite outside guests to the internal reviews—they may offer fresh viewpoints which catalyze productive efforts.

5) **Meeting Hierarchy:** Initial internal group reviews should be held in private to expedite task accomplishment. The next stage—the team review—should admit invited guests, with concentration on the inclusion of IDS investigators. The final review should be wholly external. The American Geophysical Union was mentioned as an appropriate outside source of review. Internal group reviews should rotate among member facilities, and may constitute two of the proposed four meetings a year.

**CONCERNS:**

1) **EOSDIS Framework:** The structure of EOSDIS will not be known for two years. It will be difficult to design algorithms to a nonexistent structure.
2) **Data Management Plan:** A data management plan is required. This needs to be a "living" document, available to other programs and efforts, which is a prerequisite for peer review. It will outline scientific principles, equations, algorithm structures, products, validation plans, and science results. This plan will be the prime vehicle to the outside community, and will be developed from original proposals, tempered by the internal reviews.

**ACTION ITEMS:**

1) **Locke Stuart:** Invite Oceans IDS investigators to the next (October) team meeting.
2) **Ocean Group:** Meet in Miami May 20-22 to begin development of data management plan and peer review process..

## 3. DATA PRODUCTS

A substantive review of data products was made, in view of the demise of MODIS-T. Generally, Oceans data products were not eliminated by the disappearance of MODIS-T; in fact, the product list may be complicated by the advent of both an A.M. and P.M. MODIS. The importance of interim data products was discussed and the relationship of IDS and other instrument requirements was recognized.

1) **Potential Deletions:** The loss of MODIS-T results in the deletion of certain (classes of) products:
   A). Phycoerithryn will not be measurable;
   B). Any tilt strategies are nullified;
   C). No change in IR or fluorescence can be observed;
   D). A much reduced data set of water-leaving radiances;
   E). A loss in contiguity of bands covering the visible spectrum;
   F). Accessory pigments and Chlorophyll absorption need to be measured *in situ*;
   G). Wind velocity from glint field.

2) **Additions:**
   A). Morning and afternoon IR measurements have to be assimilated.
3) **General Response:** The names of a number of products, as hierarchically derived by the Science Processing Support Office (SPSO), were considered misleading or inadequate. Hierarchical changes were recommended. Some specification levels and limits were adjusted, and units of measurement were reviewed. Each team member turned in a mark-up of the data product requirements, which will be reviewed by the Team Leader before execution by SPSO.
4) **Absolute Accuracies:** O. Brown suggested the immediate need for review of the product absolute accuracies, in light of the fact that there currently is no Configuration Control Board. Now would be a good time to review and change.
5) **Algorithm Delivery Schedule:** K. Carder referenced A. Fleig's need for "testing" algorithms early on. Carder suggested that a set of "strawman" algorithms be ready in May.

## 4. OTHER DISCUSSIONS

Other MODIS issues were addressed, and a forum for the initiation of tutorials on team member's research was informally established. The MODIS issues addressed covered instrument specifications, science team plans and schedules, and SeaWiFS and its Follow-on (called COLOR). I. Barton gave a status report on the Along Track Scanning Radiometer (ATSR). Research tutorials were presented by I. Barton (Structure of the Top Meter of the Ocean), K. Carder (Solar Stimulated Fluorescence), and F. Hoge (Phycoerithryn Modeling).

Instrument discussions stressed the need for MODIS' thermal accuracy to be comparable to that of ATSR. Science Team schedules stressed the need for more than two discipline group meetings per year — probably four meetings are required under the presently required level of effort. Most of the SeaWiFS and COLOR concerns addressed data availability and distribution, the relationship between SeaWiFS and MODIS algorithms, and the coordination of calibration and data validation.

Highlights of ATSR instrument performance were its thermal measurement precision and accuracy.

Barton's presentation on the ocean structure stressed an *in situ* measuring device, which is towed and gives vertically stratified measurements. Carder's fluorescence tutorial stressed the output region from the ultraviolet to the far red. Hoge stressed the need for absorption meter measurements to add precision to his modeling efforts.

## 5. INSTRUMENT SPECIFICATIONS

In discussing filters, some consideration was given to other sensitive instrument areas:

1) **Thermal Accuracy:** The Along-Track Scanning Radiometer (ATSR) accuracy of 0.1°K was compared to MODIS, and consideration was given to improving the MODIS thermal specification. Additional cost is an important consideration.
2) **Descope Options:** In response to a mention in plenary session that a descope plan should be in place and appropriately prioritized, the previous "official" descope plan was distributed. The only comment (from O. Brown) addressed the possibility of deleting the Solar Calibration Monitor. Attachment 5.4 presents the previous MODIS descope plan.

## 6. SCIENCE TEAM PLANS & SCHEDULES

**PLANS:** A number of plans are required by the Project. These plans will be incorporated into the Team Leader's documentation. Plans to be considered by the Oceans Discipline Group are:

1) **Software:** It is hoped that a strawman plan will be available.
2) **Science Computing Facility**
3) **Data Management & Algorithm Development**

**SCHEDULES:**

**1) Milestones:** The milestone schedule for algorithm development and delivery should be added to the MODIS Technical Team Minutes. This will serve as a constant reminder of due dates, and as a forum for announcing any changes.

**2) Reports:** In like manner, Team Member report due dates should be announced. A reminder of the required content of the report would be helpful.

**3) SeaWiFS Meeting:** The SeaWiFS Calibration/Validation Meeting (Critical Design Review) is scheduled for 14 - 15 May. C. McClain should be invited to attend. Clark expressed concern that the MODIS/SeaWiFS ties be tightened.

**ACTIONS/ISSUES/CONCERNS**

1. **Locke Stuart:** Include milestone schedules and report due dates in MODIS Technical Team Minutes.

## 7. SeaWiFS & OCEAN COLOR FOLLOW-ON

Mark Abbott led the discussion of the follow-on to SeaWiFS and presented comments on the SeaWiFS Data System Critical Design Review (Attachment 5.5) Questions addressed the management of the follow-on (COLOR) mission. L. Stuart averred that COLOR would be attached to MODIS, and administered scientifically by MODIS. Concern was expressed about the handling of SeaWiFS data, and data purchase policies. It was proposed that the issue of purchasing data be reviewed through MODIS. O. Brown commented that the handling of deliverables under SeaWiFS is poorly understood, and that purchasing data depends on MODIS funding.

The issue of the relationship of MODIS and SeaWiFS algorithms and products was raised by D. Clark, who asked if the development and implementation for the two instruments were mutually exclusive. Stuart responded affirmatively with respect to the current SeaWiFS, but noted a change in plans with the advent of the COLOR mission, wherein a common preparation and processing chain would be emplaced.

How will SeaWiFS data be merged into the EOS data system? It was decided that the focus must initially be on SeaWiFS, then on those algorithms adapted to MODIS. Funding may be inadequate to tie SeaWiFS to MODIS.

R. Evans was concerned about a coordination of SeaWiFS and MODIS calibration and validation. If SeaWiFS comes in with their own requirements, separate and apart from MODIS, then additional funds are required. Evans' SeaWiFS funding is for data processing only, and includes no money for calibration / validation. An example of MODIS' funding of SeaWiFS cal / val is the quality analysis of optical buoy data.

O. Brown, G. Mitchell, and R. Evans expressed concern about cuts in MODIS funding, when SeaWiFS efforts obviously depend on an active MODIS oceans effort.

G. Mitchell emphasized that MODIS Ocean Group members are *de facto* SeaWiFS panel members. A NASA Research Announcement (NRA) will be publicly distributed in a couple of weeks. Additional proposals will be selected, and the current panel will be instrumental in the proposal review. If any current SeaWiFS panel members have a compelling research concept, they should propose through the NRA.

G. Mitchell expressed the opinion that COLOR, scheduled for launch in 1998, would be a copy of SeaWiFS, if that mission were successful. If it is not successful, a new design would likely be sought. O. Brown opined that science representation on COLOR is important early on, and asked W. Esaias his availability as a representative.
SeaWiFS data distribution policies were discussed, and the Group felt that the current policy is unduly restrictive. Data cannot be easily shared for research

purposes. Brown went further to suggest that it is very important to evolve an international data handling and distribution policy. Currently other countries are looking for parity, and consequently are espousing comparably restrictive policies.

## 8. ATSR STATUS

Ian Barton reported on the Along Track Scanning Radiometer (ATSR):
- Active cooling at 80°K;
- 10 cm optics;
- Two black bodies with absolute measurement accuracy of 0.02 - 0.05°K;
- Same channels as AVHRR;
- Dwell time per pixel of 80 µsecs;
- Repeat cycle of 3 days (will be varied to thirty-five days during life);
- Spatial resolution of 1 km;
- Ascending node at 2300 local time (sun synchronous);
- NE$\Delta$T of .02 to .04°K (compared to 0.12 for AVHRR);
- Temperature accuracy of 0.3°K

In light of the precise instrument capabilities, one major effort will likely be identification of near-surface humidity.

Barton also gave a seminar on the structure of the top meter of the ocean, wherein he identified the method of measurement as instruments on a towed vessel. The instruments arrayed from two meters above the surface to one meter below. Ocean "skin" measurements are made at a millimeter or less.

## 9. SOLAR STIMULATED FLUORESCENCE

K. Carder advised the group of his efforts in the area of solar-stimulated fluorescence. He showed graphs of the input stimulation across the spectrum from 300 to 500 nm, and outputs at an efficiency of ≤1.5% for the spectral range from 400 to 700 nm. Data were collected in broad, shallow seas. About 5 - 10% of the emission is Raman scattering. Carder is also looking at very short wavelengths for fluorescence — <200 nm. F. Hoge mentioned that probing with an ultraviolet laser definitively identifies organics.

## 10. PHYCOERITHRYN MODELING

F. Hoge addressed his modeling efforts in sorting out phytoplankton, chlorophyll, and gelbstoff. He uses a laser at 355 nm to activate dissolved organic matter (DOM) fluorescence. Laser-induced fluorescence allows quantification of the absorption coefficient. Hoge stressed that the

development of an absorption meter is key to the success of a number of *in situ* experiments.

Hoge noted that the Gulf Stream has very little gelbstoff, but he intends to make his measurements in this area, because of its convenience.

H. Gordon commented that DOM should be measured in small packets with irradiance, and that weak absorption may be derived from the residue. Raman scattering has to be removed.