MODIS Science Team Meeting Minutes

May 3-5 1995

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Glossary of Acronyms

ADEOS
    Advanced Earth Observing Satellite
AFGL
    Air Force Geophysical Lab
AGU
    American Geophysical Union
AHWGP
    Ad Hoc Working Group Panel
AIRS
    Atmospheric Infrared Sounder
AO
    Announcement of Opportunity
APAR
    Absorbed Photosynthetic Active Radiation
API
    Application Programmable Interface
ARVI
    Atmospherically Resistant Vegetation Index
ASAS
    Advanced Solid State Array Spectrometer
ASTER
    Advanced Spaceborne Thermal Emission and Reflection Radiometer
ATBD
    Algorithm Theoretical Basis Document
ATMOS
    Atmospheric Trace Molecule Spectrometer
ATSR
    Along Track Scanning Radiometer
AVHRR
    Advanced Very High Resolution Radiometer
AVIRIS
    Advanced Visible and Infrared Imaging Spectrometer
BAT
    Bench Acceptance Test
BATERISTA
    Biosphere-Atmosphere Transfers/Ecological Research/In situ Studies in Amazonia
BATS
    Basic Atlantic Time Series

BCS
Blackbody Calibration Source
BOREAS
Boreal Ecosystem Atmospheric Study
BRDF
Bidirectional Reflection Distribution Function
CAR
Cloud Absorption Radiometer
cc
cubic convolution
CCB
Configuration Control Board
CCN
Cloud Condensation Nucleii
CCRS
Canadian Center for Remote Sensing
CDHF
Central Data Handling Facility
CDR
Critical Design Review
CEES
Committee on Earth and Environmental Sciences
CEOS
Committee on Earth Observation Satellites
CERES
Clouds and Earth s Radiant Energy System
CIESIN
Consortium for International Earth Science Information)
CNES
Centre National d Etudes Spatiales (French Space Agency)
CPU
Central Processing Unit
CZCS
Coastal Zone Color Scanner
DAAC
Distributed Active Archive Center
DADS
Data Access and Distribution System
DCW
Digital Chart of the World
DEM
Digital Elevation Model
DIS
Data Information System or Display and Information System
DMA
Defense Mapping Agency
DMCF
Dedicated MODIS Calibration Facility

DoD
    Department of Defense
DOE
    Department of Energy
DPFT
    Data Processing Focus Team
DPWG
    Data Processing Working Group
DTED
    Digital Terrain and Elevation Data
PDR
    Delta Preliminary Design Review
ECS
    EOS Core System (part of EOSDIS)
Ecom
    EOS Communications
EDC
    EROS Data Center
EDOS
    EOS Data and Operations System
EFS
    Electronic Filing System
EM
    Engineering Model
EOS
    Earth Observing System
EOSDIS
    EOS Data and Information System
EPA
    Environmental Protection Agency
ER-2
    Earth Resources-2 (Aircraft)
ERS-2
    ESA Remote Sensing Satellite
ESA
    European Space Agency
ESTAR
    Electronically Steered Thinned Array Radiometer
FIFE
    First ISLSCP Field Experiment
FOV
    Field of View
FTP
    File Transfer Protocol
FY
    Fiscal Year
GAC
    Global Area Coverage

GCM
Global Climate Model; also General Circulation Model
GCOS
Global Change Observing System
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
GOOS
Global Ocean Observing System
GSC
General Sciences Corperation
GSFC
Goddard Space Flight Center
GSOP
Ground System Operations
GTOS
Global Terrestrial Observing System
HAPEX
Hydrological-Atmospheric Pilot Experiment
HDF
Hierarchical Data Format
HIRS
High Resolution Infrared Radiation Sounder
HOTS
Hawaii Ocean Time Series
HQ
Headquarters
HRIR
High Resolution Imaging Radiometer
HRPT
High Resolution Picture Transmission
HRV
High Resolution. Visible
HTML
Hypertext Markup Language
I & T
Integration and Test
ICD
Interface Control Document

IDS
    Interdisciplinary Science
IFOV
    Instantaneous field-of-view
IGBP
    International Geosphere-Biosphere Program
IPAR
    Incident Photosynthetic Active Radiation
ISCCP
    International Satellite Cloud Climatology Project
ISLSCP
    International Satellite Land Surface Climatology Project
IV&V
    Independent Validation and Verification
IWG
    Instrument Working Group
JERS
    Japanese Earth Resources Satellite
JGR
    Journal of Geophysical Review
JPL
    Jet Propulsion Laboratory
JRC
    Joint Research Center
JUWOC
    Japan-U.S. Working Group on Ocean Color
K
    Kelvin (a unit of temperature measurement)
LAC
    Local Area Coverage
LAI
    Leaf Area Index
LAMBADA
    Large-scale Atmospheric Moisture Budget of Amazonia/Data Assimilation
LARS
    Laboratory for Applications of Remote Sensing
LBA
    LAMBADA/BATERISTA/AMBIACE
LCD
    Liquid Crystal Display
LTER
    Long-Term Ecological Research
MAB
    Man and Biosphere
MAS
    MODIS Airborne Simulator
MAT
    MODIS Algorithm Team

McIDAS
Man-computer Interactive Data Access System
MCST
MODIS Calibration Support Team
MERIS
Medium Resolution Imaging Spectrometer
MFLOP
Mega FLOP, or a million floating point operations
MGBC
MODIS Ground Based Calibrator
MISR
Multiangle Imaging Spectro-Radiometer
MOBY
marine optical buoy
MODARCH
MODIS Document Archive
MODIS
Moderate-Resolution Imaging Spectroradiometer
MODLAND
MODIS Land Discipline Group
MOPITT
Measurements of Pollution in the Troposphere
MOU
Memorandum of Understanding
MPCA
MODIS Polarization Compensation Assembly
MSS
Multispectral Scanner (LANDSAT)
MST
MODIS Science Team
MTF
Modulation Transfer Function
MTPE
Mission to Planet Earth
NASA
National Aeronautics and Space Administration
NASDA
National Space Development Agency of Japan‘
NASIC
NASA Aircraft Satellite Instrument Calibration
NDVI
Normalized Difference Vegetative Index
NE L
Net Effective Radiance Difference
NE T
Net Effective Temperature Difference
NESDIS
National Environmental Satellite, Data, and Information Service

NIR
: near-infrared

NIST
: National Institute of Standards and Technology

NMC
: National Meteorological Center

nn
: nearest neighbor

NOAA
: National Oceanic and Atmospheric Administration

NPP
: Net Primary Productivity

NPS
: National Park Service

NSF
: National Science Foundation

OBC
: On-Board Calibration

OCR
: optical character recognition

OCTS
: Ocean Color and Temperature Scanner

ONR
: Office of Naval Research

OSC
: Orbital Sciences Corporation

OSTP
: Office of Science and Technology Planning

PAR
: Photosynthetically Active Radiation

PDQ
: Panel on Data Quality

PDR
: Preliminary Design Review

PFM
: Protoflight Model

PGS
: Product Generation System

PI
: Principal Investigator

POLDER
: Polarization and Directionality of Reflectances

QA
: quality assurance

QC
: quality control

QCAL
: calibrated and quantized scaled radiance

RAI
Ressler Associates, Inc.
RDC
Research and Data Systems Corporation
RFP
Request for Proposals
RMS
Room Mean Squared
RSS
Root Sum Squared
SAR
Synthetic Aperture Radar
SBRC
Santa Barbara Research Center
SCAR
Smoke, Cloud, and Radiation Experiment
SCF
Scientific Computing Facility
SDP
Science Data Processing
SDSM
Solar Diffuser Stability Monitor
SDST
Science Data Support Team
SeaWiFS
Sea-viewing Wide Field of View Sensor
SIS
Spherical Integrator Source
SNR
Signal-to-Noise Ratio
SOW
Statement of Work
SPDB
Science Processing Database
SPSO
Science Product Support Office
SRC
Systems and Research Center
SRCA
Spectroradiometric Calibration Assembly
SSAI
Science Systems and Applications, Inc.
SSMA
Spectral/Scatter Measurement Assembly
SST
Sea Surface Temperature
STIKSCAT
Stick Scatterometer

SWAMP
Science Working Group AM Platform
SWIR
shortwave-infrared
TAC
Test and Analysis Computer
TBD
to be determined
TDI
time delay and integration
TDRSS
Tracking and Data Relay Satellite System
TIMS
Thermal Imaging Spectrometer
TIR
thermal-infrared
TLCF
Team Leader Computing Facility
TM
Thematic Mapper (LANDSAT)
TOA
top of the atmosphere
TOMS
Total Ozone Mapping Spectrometer
TONS
TDRSS On-board Navigation System
TRMM
Tropical Rainfall Measuring Mission
UARS
Upper Atmosphere Research Satellite
UPN
Unique Project Number
URL
Uniform Resource Locator
USGS
United States Geological Survey
VAS
VISSR Atmospheric Sounder
VC
vicarious calibration
VIRSR
Visible/Infrared Scanning Radiometer
VIS
visible
WAIS
Wide-Area Information Servers
WVS
World Vector Shoreline

WWW
    Worldwide Web

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3.0 FINAL PLENARY SESSION

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Day 1 Plenary Session Minutes

1.0 DAY 1 PLENARY SESSION

1.0 DAY 1 PLENARY SESSION

1.1 Welcome and Meeting Overview

The MODIS Science Team Meeting was chaired and called to order by Vince Salomonson, team leader. Salomonson presented the meeting agenda (Attachment 1) and then introduced David Herring to present an overview of the meeting objectives (see Attachment 2). Herring stated that the emphasis for this meeting is to provide a working session for the Science Team. Rather than split into Discipline Groups, discussion will be interdisciplinary among selected panelists and a moderator.

Herring told attendees that everyone is encouraged to submit electronic copies of handouts or presentations to MAST, which will in turn distribute all handouts electronically in either Macintosh or PC formats. Additionally, Herring demonstrated MAST's new LCD overhead projection panel, and stated that in the future presenters will be encourage to use it or other electronic media to deliver their presentations. MAST hopes these changes will save trees, time, and cost; as well as facilitate distribution.

The next MODIS Science Team Meeting is tentatively scheduled for Oct. 16 - 20.

1.2 EOS Senior Project Scientist's Report

Salomonson introduced Michael King to deliver the EOS Project Science Office report. King reported that there is a new initiative at NASA HQ to review the implementation plans of the EOS program through the year 2000 in light of increasing political pressure to reduce the budgets of both NASA and NOAA. Science programs and data systems in particular are being reviewed. King stated that the review will be discussed at the Joint Science Executive Committee Meeting next week in Paris, and any conclusions will be presented at the next IWG. This summer, King expects Congressman Robert Walker to review the U.S. Global Change Research Program, particularly EOS and EOSDIS. The IWG and the Joint meeting in Paris will help the EOS Project Office prepare for Walker's review.

Salomonson observed that MODIS may serve as the keystone instrument aboard EOS AM-1 and PM-1 for conducting global Earth science. Additionally, it could serve as a Pathfinder for future "light" sensors and new technologies.

1.3 Headquarters' Perspective

Robert Frouin, MODIS co-program scientist, began his presentation with an update on the SeaStar launch schedule (see Attachment 3). Frouin stated that spacecraft integration is complete and that SeaStar is currently being kept in Germantown, where environmental testing is being performed. He noted that there are still problems with the Pegasus XL Fin motors, and there are problems with the onboard computers. Additionally, the flight and ground software for SeaWiFS is not yet ready. Currently, SeaStar is tentatively scheduled to launch in October 1995. The present HQ position is to launch SeaStar at the earliest opportunity, once Orbital Sciences Corp. demonstrates readiness.

Frouin told attendees that in October 1994 Charles Kennel decided not to pursue placing COLOR on Landsat 7. Rather, Kennel elected to pursue other flights of opportunity. If the SeaWiFS mission succeeds, then Kennel is in favor of funding an enhanced calibration/validation (cal/val) effort. If SeaWiFS fails, then an alternate flight approach will be explored, in addition to enhanced cal/val efforts. Kennel requested the GSFC ocean color community to develop a plan for an enhanced international cal/val effort.

Frouin said that in response to Kennel's request, a three-day workshop was convened in Miami to discuss the combined use of ocean color data from SeaWiFS, MODIS, OCTS, POLDER, MERIS, GLI, etc. Representatives from each of those instrument teams, as well as other international agencies' representatives, attended the workshop. Frouin said the plan will need to be approved by the IGBP and endorsed by CEOS. An interagency advisory board will coordinate activities within the United States and make financial decisions. This advisory board will also be responsible for transferal of funds to a U.S. Ocean Color Project Office, which will then execute the tasks of the project. The interagency board will consist of representatives from NASA, DOE, NOAA, NSF, ONR, and the USGS. The board's overall objectives will be to exchange information on ocean color, coordinate activities on a global scale, and encourage collaboration to enhance the complementarity of ocean color programs.

1.3.1 EOS Announcement of Opportunity

Frouin reported that a new EOS Announcement of Opportunity (AO) is forthcoming in July 1995. The emphasis of the AO is on interdisciplinary investigations of specific oceanic regions, regimes, or systems, such as the Indian Ocean, equatorial Pacific, eastern boundary currents, and major river systems.

Frouin recommended that any new members added to the MODIS Ocean Discipline Group have specialties in either retrieving water composition in coastal zones, or estimating primary production on monthly or seasonal timescales using models of photosynthetic activity.

1.3.2 Calibration/Validation Issues

Frouin said there needs to be prelaunch evaluation of calibration algorithms. Specifically, he said there needs to be dedicated experiments with AVIRIS, MAS, etc. Frouin stated that the validation/calibration system is needed to establish a global network of standard, automated instrumentation for above- and underwater measurements.

1.3.3 Questions Raised by Congress Regarding MTPE

Diane Wickland, MODIS co-program scientist, read the following questions forwarded by Rep. Walker to Dan Goldin, NASA administrator, concerning Mission to Planet Earth: ¥Is the science being conducted fully justified on a strictly scientific basis? ¥In the planning process, are active measures being taken to fully evaluate options to ensure that new technology and new breakthroughs are being utilized? ¥Is your program adequately scoped so that data are properly archived and useful and available to the science community? Wickland reported that the NASA Advisory Council to Goldin commented that MTPE as a whole has rather lofty goals, but that it lacks an implementation plan as to how to get there. Wickland concluded that if any principal investigator is planning a field campaign, he/she should brief the MODIS Program Office so that the program scientists can work with the PIs to help construct milestones and timelines. Wickland said that a response will be made to the Advisory Council by May 17.

1.4 EOSDIS Status Report

John Dalton, ESDIS Project Scientist, presented a status report on EOSDIS (see Attachment 4). Dalton reported that the first quarterly review of science software for AM-1 instruments was held recently. Also, EOSDIS hosted a Science Software Integration & Test Workshop , attended by instrument team software developers and representatives from the DAACs, to discuss and delineate the science software integration procedures and deliverables. At the workshop, the MODIS science software integration and testing procedural steps were reviewed and modified. Also, at that meeting it was determined that the GSFC DAAC will be available to the MODIS Team for pre-acceptance testing. The first draft of the MODIS/GSFC DAAC Science Software Integration and Testing Agreement is due June 1, 1995, and the final draft is due Oct. 1, 1995.

Dalton reported that his team has completed its analysis of options for consolidating Ecom and the EOSDIS Science Network. Although this network won't affect the science teams directly, Dalton said the effort is to identify better ways of archiving and distributing data, while reducing cost. ESDIS supports two networks: 1) Ecom, to get data from White Sands to the EDOS System in West Virginia, and 2) the DAAC-to-DAAC network, which supports the flow of data products.

1.4.1 EOSDIS Science Processing Issues Being Tracked

Dalton reported that Toolkit 5 is scheduled to be delivered on July 31. Future toolkit deliveries are being scheduled to provide complete HDF and Symmetric Multi-Processing functionality. Bob Evans' product generation scheduling requirements are also being examined.

Dalton stated that MODIS Level 1 and 2 processing has been modeled; Level 3 processing models are being developed. EOSDIS is considering increasing the Level 2 granularization from 2.5 minutes to 25 minutes to reduce resource strain on the system. Also, reducing the number of Product Generation Executables from about twenty to three reduces pressure on the scheduler but not on the archive requirements.

A number of MODIS ancillary data questions are currently being addressed by EOSDIS. Here is a brief summary: ¥ECS will convert most NOAA data to HDF. ¥HDF tools can then be used by instrument teams to subset the data by parameter and time. ¥Instrument team ancillary data preprocessing software can be run as part of the ancillary data ingest process at the DAAC.

1.4.2 ESDIS Organization Update

Dalton presented a current ESDIS organization chart and discussed recent changes in its structure and staffing. There are four major entities within the ESDIS Project: 1) the Science Office, headed by H.K. Ramapriyan, 2) the Development Office, headed by Mel Banks, 3) the System Management Office, headed by Ellen Herring, and 4) the Resources Office, headed by George Barth. Steve Wharton is now the ESDIS Project Scientist.

1.4.3 ESDIS Issues and Challenges

Dalton reported that ESDIS is now beyond its PDR and is preparing for its CDR. He emphasized the need to meet the science software delivery milestones for integration and testing so that EOSDIS as a system may be thoroughly tested prior to launch. Dalton listed the main challenges currently facing ESDIS.

Salomonson said he is concerned about the size of MODIS' processing allocation. He asked if EOSDIS is allocating enough to handle MODIS' processing needs. Dalton responded affirmatively.

1.5 EOS AM Platform Status Report

Chris Scolese, EOS AM Project Manager, told attendees that assembly of the hardware has begun for the spacecraft and sensors. He showed a picture of the ASTER thermal infrared detectors, and reported that the ASTER engineering model (EM) will soon go into a thermal vacuum chamber for testing. CERES instrument development is the farthest along of all EOS instruments. A CERES instrument will launch in September of this year, and again in August of 1997 aboard the TRMM spacecraft. Scolese said there are a few small problems in its development, but nothing major. The MISR EM is assembled (Scolese showed a picture) and testing has begun. Likewise, the MODIS EM is assembled and is being tested in SBRC's Calibration Chamber. He said the instrument is working fine and appears to be more robust than was originally expected. There are, however, some minor problems. Cost control is a concern, so EOS Project is pushing SBRC to correct any problems quickly, so that MODIS can remain on schedule for flight unit tests. The MOPITT EM is currently being assembled. The instrument's flight cooler is being tested now at Lockheed.

Scolese reported that the EOS AM-1 bulkhead structure assembly is underway and will be completed late this summer. Testing of the structure will begin by December 1995. In January 1996, Martin Marrietta/Lockheed will begin integrating spacecraft flight hardware onto the platform.

Scolese stated that discussions regarding a lunar view maneuver for calibration are still ongoing. He observed that a lunar view maneuver cannot be completed within half an orbit. He explained that EOS Project would like to be able to rotate the spacecraft to look at the moon and deep space, and then back at the Earth again before the spacecraft comes around to the dark side of our planet. There are also concerns about the solar impingement on the instruments. Scolese concluded that further analysis is needed and a report will be forthcoming in June 1995.

1.6 Data Assimilation

Ricky Rood, of the EOS Data Assimilation Office, delivered a presentation on data assimilation (see

Attachment 5). Rood explained that the data currently obtained from all sensors--ground-based, airborne, and satellite-based--is very irregular in spatial and temporal scales. Data assimilation provides added value to these data in the following ways: ¥Organizes data--the model provides a "physically" and "chemically" consistent interpolator; ¥Complements data and fills in unobserved regions--the model propagates information from data rich to data poor regions; ¥Supplements data and provides unobserved quantities--the model, especially the physical parameterizations, provides estimates of unobserved quantities; Quality control of observations--the model provides an estimate or "first guess" of what the field is expected to look like; ¥Instrument calibration--this is potentially a powerful application that requires forward modeling of the first guess field.

In short, Rood said that data assimilation provides the best estimate of the state of the system, in that it allows extraction of maximum information content from data and it allows more quantitative interpretation of satellite data.

1.7 SDST Status Report

Ed Masuoka, SDST Team Leader, presented a status report on SDST's activities (Attachment 6). Masuoka introduced Barbara Putney, a new SDST team member, as taking the lead on data integration for the Land and Atmosphere Groups. Previously, Putney was the ESDIS science software systems manager. Masuoka announced that SDST also has a new support contractor--SAIC/GSC.

Masuoka told the Science Team that SDST needs their inputs for the Data Product Reference Handbook by May 1995 so that it can be incorporated in the document prior to its June 1995 distribution at the IWG. This input consists of a one-page description of each product. Additionally, SDST needs the Science Team's input into the Science Product Quality Assurance Plan by June 1995. Producing this document is a requirement according to the Team Leader Agreement. Also, SDST needs input from the Science Team for both the Data Product Catalog and the Interface Control Documents (ICDs) by June 1995. This input should consist of descriptions of each product at the bit level, which will facilitate software integration and help keep the user community informed. Inputs for the ICDs should describe the format and content of each data product, provide characteristics of the data, describe quality control flags, as well as validation methodologies. Finally, SDST is also producing a Validation Plan, for which input will be solicited at the Panel Discussion later in this meeting. The first draft of the Validation Plan will be produced by December 1995.

1.7.1 Beta Software Delivery

Masuoka presented the schedule for the delivery of beta software from the Science Team to SDST. The Level 2 Beta 3 integrated (swath) science software is due in July 1995; the Level 3 Beta 3 integrated (grid) science software is due in August 1995. Masuoka explained that Beta 3 will use MODIS radiances, read ancillary data, perform limit checks, perform error handling, and read the output of the products above it in that product's processing thread. The Beta 3 delivery should also include a Science Data Processing (SDP) Toolkit, a MODIS Level 2 API that is both swath- and HDF-based, and a MODIS Level 3 API that uses the ISSCP grid and allows for incremental processing.

Masuoka showed a chart listing the status of all delivered code. He stated that by January 1996, end-to-end system tests will be complete and the beta releases will be baselined and delivered to the DAAC. By April 1996, the integration and debugging of all MODIS software at the DAAC will be complete.

1.7.2 Test Data

Al Fleig, of SDST, announced that two primary products are now complete: 1) complete test data sets and 2) tools for making test data on order. The first useful data set will be made available later this month, with several planned upgrades. Fleig solicited input from the Science Team as to what will be useful to them. Fleig acknowledged the efforts of Ki Yang, Shiyue Qiu, Steve Ungar, Joann Harnden, John Barker, and Jack Schols in producing the simulated data set.

The data in the first dataset include correct viewing geometry according to the characteristics of an EOS platform orbit. The data include a characteristic MODIS scan pattern with all 36 channels and the bowtie effect, and are processed into MODIS Level 1B format (250m and 500m data are replicates). Sun-Earth geometry are included as a function of time, date, and location.

Future builds will include BRDF classes from Alan Strahler and Wolfgang Wanner, higher resolution surface classification (artificial) varying surface temperature, global coverage, more days, better ocean data from the SeaWiFS model, flat opaque clouds, and more camera model effects (e.g., ghosting, triangular weighting function, noise, band-to-band misregistration, and geolocation errors).

1.7.3 Simulated Data

Steve Ungar, of SDST, presented his work in producing simulated MODIS data scenes of the United States. He showed sample TOA (top of the atmosphere) radiances that are not based on any observations--they are totally simulated. Ungar stated that he is putting together a simulated MODIS data set to include all 36 MODIS bands at a resolution of 1,534 by 1,534 pixels (1.7 km is the average size). Ungar refined the simulated scene over the U.S. to include the MODIS instrument response functions supplied by Ed Knight. The next level of refinement will include an improved representation of the MODIS scan geometry and variable atmospheric path length. The ground truth elements consist of primary surface type (11 categories), secondary surface type (16 categories), mixture ratio, and elevation. The surface type assignment is based on the classification of eight 1-km AVHRR NDVI images from March to November 1991.

Ungar stated that his simulated data may be accessed via anonymous file transfer protocol (FTP) at highwire.gsfc.nasa.gov in the "/pub/modsim" directory.

1.8 EOS Test and Simulated Data

Skip Reber, EOS investigator, reported that EOSDIS needs test data from the Science Team that it can use to test its hardware, and so that they may begin integrating software. Also, test data will help EOSDIS accurately estimate the resources needed for full up processing of all instrument teams' data products. (Refer to Attachment 7 for more details.)

Reber asked if it is reasonable to process data from Level 1 to Level 2 to Level 3, or should each level be produced separately? In principal, he said, it is preferable to process from Level 0 to Level 1 or 2 with the same data, but that is not always practical.

Reber reported that tools are being developed by ECS that investigators can use to provide data. Reber said the instrument teams should provide feedback to ECS if there is anything else it can do to help coordinate joint modeling activities between instrument teams on the EOS AM and PM platforms.

1.9 MODIS Project Status Report

Richard Weber, MODIS Project Manager at GSFC, presented an overview of MODIS hardware development (see Attachment 8). He reported that ambient tests of the Engineering Model (EM) are complete at SBRC, and thermal vacuum testing is now in progress. He reminded the team that although SBRC will be moving to El Segundo, the Protoflight Model (PFM) and all MODIS FM1 subsystems will be completed at SBRC prior to the move. However, FM1 final integration and testing will take place at the Hughes El Segundo facility. Weber noted that, to help offset losses in SBRC MODIS personnel, Hughes is offering substantial completion bonuses, as well as relocation allowances for any personnel moving to El Segundo after PFM completion.

Weber reported that all materials are either on order or have been received for the PFM and flight model 1. He stated that cost remains a major concern, as is the development schedule in that any slips will negatively impact cost. Weber listed his top five technical concerns currently facing MODIS development: 1) transient response, 2) scan motor lifetime, 3) bandpass filters, 4) radiative cooler, and 5) electronics.

1.10 SBRC Status Report

Lee Tessmer, of Hughes, reported that the MODIS EM is now in the home stretch of thermal vacuum testing. (Please see Attachment 9.) Overall, he said, the MODIS program at SBRC is in good health, although there are significant areas of concern. Tessmer stated that the MODIS EM optical bench is assembled and the onboard blackbody has been integrated. He listed the milestones SBRC has reached and the major events that have occurred since the last Science Team Meeting. He also listed the top five concerns currently facing SBRC.

Regarding the MODIS PFM, Tessmer reported that the engineering documents from the EM are readily transferable to flight status, noting that there are only minor changes to 10 of the 52 drawings. The procurements of hardware for the PFM have already begun.

Paul Menzel inquired as to the nature of the problem with the LWIR filters. Tessmer responded that the specifications were beyond the design capabilities of SBRC. Regarding the focal plane assembly, Tessmer added that all four have been delivered and are in various stages of integration and testing.

Tessmer reported that all parts for the Solar Diffuser Stability Monitor are on order. He noted that SBRC is now operating OASIS/12 software on STE-1, but that they are having system crash problems. He concluded that Sun computers and OASIS software are presently incompatible.

1.10.1 EM Test Results

Tessmer reported the results of SBRC's EM tests; overall, the polarization meets most requirements. All bands are within specs except Band 3. He stated that the thermal vacuum testing includes comprehensive spatial, spectral, and radiative tests, the results of which show excellent co-registration, low scan-to-scan jitter, as well as optimized gains and offsets.

Tessmer stated that the near-field response tests verify SBRC's test methodology. They found that there is an unacceptable problem with the first dichroic, and they have all the instrumentation in house they need to make a new, modified first dichroic and plan to begin immediately. He said that SBRC's ambient test demonstrates good spatial performance--ambient spectral data was acquired for all MODIS bands.

In summary, the EM is fully functional and robust. It performed as expected, demonstrating good linearity, high SNRs, low polarization, good registration, and early saturation. The instrument meets specs in terms of size, mass, power, and data rate. There will be a comprehensive review of the EM test results June 13 and 14 at SBRC.

1.11 MCST Status Report

Bruce Guenther, MCST leader, delivered a status report on MCST's activities (Attachment 10). He began by listing the publications and major software delivery deadlines upcoming. He announced that MCST recently completed its transition to its new support contractor--GSC. Guenther said his team established a MODIS Test and Analysis Computer (TAC) at GSFC for processing MODIS test data sets. Also, a Risk Management Board was established to identify, track, and control risks. Overall, he stated, MCST is comfortable with the polarization performance of the EM.

Guenther reported that the MCST ATBD was recently revised and will be again revised in early 1996. He noted that MCST hasn't carried its ATBD concept into its version 2.1 and 2.2 software deliveries.

MCST will host a vicarious calibration workshop in August at Wallops Flight Facility to focus on its Level 1B data products. Their objective is to identify vicarious calibration data sets, to review the instruments that produce them, and to consider ways to use the data sets in developing Level 1B data products. Guenther said that he is concerned that most vicarious calibration data sets are produced with a range of concepts for error bars. He hopes to establish a common scale for quantifying error and uncertainty . He invited anyone working with EOS vicarious calibration instrumentation to attend the workshop.

Guenther reported that MCST is conducting analyses of MODIS' key characteristics, such as scan angle effects. He explained that in the infrared there are instrument saturation problems so it is difficult to get scan angle effects in ambient. Vacuum chamber testing doesn't provide an opportunity to rotate the scan mirror so you cannot have SNR tests or a broad range of scan angles. Consequently, there is concern as to how to track scan angle once MODIS is in orbit. MCST is considering the following strategies: 1) placing a second onboard blackbody in the scan cavity near the diffuser, 2) using deep space to observe emissive infrared wavelengths, and 3) using the moon to observe reflected solar wavelengths.

Another key sensor characteristic MCST is analyzing is its near-field scatter problem. Guenther stated that at present the MODIS ghosting problem seems to be well understood and well-corrected. Additionally, SBRC has made detector crosstalk measurements, and will release the data to MCST in the near future.

Guenther stated that according to test measurements, the filters for Bands 20 - 25 are out of spec. John Barker, of MCST, is conducting some sensitivity analyses to understand the impact of these filters. Guenther encouraged concerned Science Team members to consult Barker as soon as possible to ensure that they understand this situation.

1.12 SWAMP Update

Piers Sellers, EOS AM project scientist, presented an update on the activities of the Science Working Group AM Platform (SWAMP) activities (Attachment 11). Regarding lunar view calibration maneuvers, Sellers announced that Hugh Kieffer, EOS interdisciplinary investigator, is preparing a white paper on the subject. Sellers stated that a lunar maneuver may cause contamination problems for the MISR D cameras, so that instrument team may need to implement baffles.

Concerning gridding, Sellers reported that Bruce Barkstrom is producing a white paper on the subject. Sellers feels that timely resolution of the gridding issue is important, especially for non-instrument researchers who plan to use the data.

Sellers reported that the Quarterly Science Software Reviews conducted recently were helpful in that they provided insight into the process of delivering software. However, the review did not provide insight into algorithm quality, although it was not intended to.

Sellers announced that the next SWAMP meeting will be an EOS-IWG lunchtime meeting on June 27, 1995.

1.13 ATSR Overview Presentation

Ian Barton, MODIS Ocean Discipline Group Member, presented an overview of the Along Track Scanning Radiometer (ATSR). He told attendees that ATSR was built specifically to take accurate measurements of sea surface temperatures (SST) for environmental and climate applications. The instrument has been operating for almost 4 years. A replacement instrument (ATSR-2), including three visible and near infrared channels to enhance the use of data collected over land, was recently launched aboard the ERS-2 satellite. A third ATSR is under construction. (Refer to Attachment 12 for details.)

1.14 CEOS Meeting Summary

Barton summarized the recent meeting held by the Committee on Earth Observation Satellites (CEOS). CEOS was created as a result of the 1982 Group of Seven Economic Summit to serve as a focal point for international coordination of space-related Earth observation activities, including those related to global change (see Attachment 13 for more details). Barton said CEOS will convene plenary sessions at least once annually, but splinter groups meet throughout each year.

CEOS has three primary objectives: 1) to optimize the benefits of spaceborne Earth observations through the cooperation of its members, 2) to aid both members and international user community by serving as a focal point for communication, and 3) to exchange policy and data.

At their last meeting two days prior to the MODIS Science Team Meeting, CEOS discussed calibration issues surrounding ocean color physics, the status of SeaWiFS and its calibration/validation plans, the status of OCTS and it calibration/validation plans, and activities within the European community.

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MODIS Science Team Meeting Minutes

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Roundtable Discussion Sessions

2.0 ROUNDTABLE DISCUSSION SESSIONS

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2.0 ROUNDTABLE DISCUSSION SESSIONS

2.1 Remote Sensing of Aerosols and Atmospheric Corrections

This session was moderated by Yoram Kaufman. Panelists were Dave Diner, Dorothy Hall, Robert Fraser, Howard Gordon, Teruyuki Nakajima, Didier Tanre, Eric Vermote, and Zhengming Wan. Kaufman presented the agenda for this session (Attachment 14).

2.1.1 International Workshop

Kaufman with Tanre, Nakajima and Gordon are organizing a workshop in Washington, D.C. during April 15-19, 1996. The goal of the workshop is to present and discuss issues related to the remote sensing of aerosols and the correction of satellite radiance data for atmospheric effects. There will be a special JGR peer reviewed set of manuscripts edited by the organizers follows procedures of JGR. Manuscripts will be requested three months prior to the workshop. Workshop plans call for ten subjects with two concurrent sessions at any one time. The workshop will be for invitees only, comprising approximately 15 presenters and 20 additional panelists.

2.1.2 Information Content of At-Satellite and Ground Solar Spectral Radiation

Tanre presented results showing the extraction of the aerosol particle size distribution using spectrally derived data (470 nm to 2130 nm) over an ocean surface using Mie theory (Attachment 1.2). Inputs were from a broad range of model simulations. Results indicated primarily two principal components of information. Information extraction on the chemical composition and aerosol absorption properties were largely inconclusive.

Gordon presented results of an analysis examining the use of shortwave mid-IR radiation (1-2 microns) to extract information of the refractive index and absorption (Attachment 1.3). He concluded for larger aerosols the SW mid-IR radiation provided good separation.

Nakajima presented results on the extraction of aerosol optical depth, particle size distribution function, single scattering albedo and aerosol absorption characteristics (Attachment 1.4). Nakajima thought the Tanre and Kaufman method was a good selection for deriving information on the aerosol particle sizes. Nakajima and others are deriving information charts to be used for estimating the aerosol optical depth. He indicated chemical information on the aerosols will be difficult to derive.

2.1.3 Atmospheric Model Development

Kaufman and others are attempting to update and provide more specific information to the AFGL (Air Force Geophysical Lab) atmospheric models in a set of dynamic models accessed over AERONET network. The goal is to use the more complex modeling to improve the modeling of the phase function and particle size distribution as a function of the aerosol optical depth. He said long term research should be directed towards combing satellite and in situ reference measurements to more fully study aerosol characteristics. Currently, they are extracting aerosol information from a set of ground Sun photometers and Sun/sky spectroradiometers. Lorraine Remer presented results largely from SCAR-A on the particle size and density distributions, chemical composition and phase function (Attachment 1.5).

2.1.4 High Latitude Atmospheric Correction

Hall wanted attention brought to the atmospheric correction of data for high latitudes. Diner said MISR related techniques should provide good atmospheric corrections for targets with contrast such as snow/forest, snow and ice, and open water, etc. However, atmospheric techniques currently using MISR will not work for large homogeneous targets such as snow covered areas. SAGE may provide additional information over polar regions. Vermote indicated the BRDF for polar regions may be important. Kaufman indicated the low Sun zenith angles (high atmospheric path lengths) in Arctic environments will result in significant atmospheric effects. He noted the day to day variation in aerosol effects is likely lower in comparison to lower latitudes.

2.1.5 Defining Atmospheric Products

Fraser said MODIS should carefully reconsider the Atmosphere data products in terms of the communities needs. Kaufman agreed to further investigate the atmosphere products.

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2.2 Gridding and Averaging

Alan Strahler served as moderator, and presented the discussion outline (Attachment 15) Panel members were Bob Evans, Alfredo Huete, Robert Wolfe, Chris Justice, Paul Menzel, Joann Harnden, Jan-Peter Muller, Ed Masuoka, Steve Ungar, and Earl Hansen (MISR). Another significant participant was Piers Sellers.

2.2.1 ISSCP Grid

An ISSCP grid processing scenario as adopted by SWAMP was presented by Robert Wolfe (Attachment 16). Wolfe presented the proposed Level 3 grid, whose preferred name is the ÒSinusoidal Binned and Nested GridÓ. The grid is nested from 140 km down to 0.27 km. A distinct advantage of the proposed grid is resampling in only one dimension to go into an equal- area grid. This is a binned grid. There are no empty cells, as in the case of a regular grid. Binning is accomplished by taking the distance along a line of latitude at the midpoint of the row, then rounding to the nearest integer number of cells along the row. The remaining fraction is distributed among all the cells. This is not an equal-area grid; there is a distortion in the area of the cells. The area is set to 1 at the equator; at the pole there can be up to a 40 percent error. At mid-latitudes, there is a 1 or 2 percent error, primarily due to quantization of the fraction of cells. Ungar suggested aggregating up from 1.1 km, to reduce error.

2.2.2 Research Needs

Justice asked if it is a MODIS Team responsibility to generate these grids. Masuoka reported that he would pass on responsibility to EOSDIS. Sellers mentioned that the primary users will be global modelers. MODIS needs to collect in a common grid, to suit the modelers. Evans noted that the option exists to produce a discipline-specific grid. Sellers requested a minimum nested set of common data products, and Evans wanted to know if there will be a requirement to produce one or some or all the nested products. Sellers stated that modelers need one degree, or half a degree. Ungar stated that the ISSCP grid, as an archival data product, has shortcomings in meeting all the research needs.

2.2.3 Aggregation vs. Nesting

Ungar was concerned that MODIS, and other EOS instruments, pick a utilitarian set of grids. It may make sense to have a mixture of multiple grids, or to define a grid cell and aggregate software that can be adapted directly. This will be transparent to the user. Sellers was emphatic about getting everyone on the same gridding standard. Harnden announced that MODIS will implement any new standard starting with Version 1.

In summary, a ÒcollapsedÓ grid, aggregating from finer to coarser values, was deemed more useful than a nested grid. The large cell area differences in nested grids was considered a problem. It was deemed better to start with a fine grid (e.g., 270 meters) and collapse to larger cell. The collapsed grid will suffer from empty cells in HDF (hierarchical data format), and will need some basic tools to move to other user-required grids.

2.3 Resampling and Remapping

Alan Strahler served as moderator. Panelists were Steve Ungar, John Barker, Dorothy Hall, Al Fleig, Ian Barton, Frank Hoge, and Earl Hansen (MISR). Other significant contributors were Wayne Esaias, Chris Justice, and Joann Harnden. Strahler presented the panelÕs agenda (Attachment 17).

2.3.1 Bowtie Effect

Ungar presented a transparency illustrating the bowtie effect (Attachment 18). Due to scanning ten lines at a time, there is complete overlap at a 55¡ scan angle, and thus there are edge artifacts. This overlap allows inter-detector calibration. Ungar has devised an algorithm to take advantage of the effect in the calibration process.

2.3.2 Resampling and Forward Binning

Strahler listed the resampling problems facing MODIS. EDC DAAC software handles nearest neighbor (nn), bilinear, cubic convolution (cc), and linear convolving algorithms. For control points, EDC uses cc. It appears that most users want nn, but nn damages the geometry: any pixel can be off by a whole half a pixel. Obviously, this is a problem with the bowtie effect--it will require fairly complex algorithms. Esaias wanted to know how SPOT handles the problem. Strahler clarified that SPOT uses a pushbroom scanner and offers a different, single-detector problem. MISR is also pushbroom.

Ungar brought up the cloud masking problem. Strahler admitted that resampling is going to be difficult in that there will be holes and multiple values. Forward binning (Attachment 19) will result in unfilled cells as well as double- or triple-filled cells. It will be possible to stack grids from different dates, from ancillary data, without resampling; but there must be a willingness to accept a sparse grid. Some algorithms may require resampling, while others may not. Barton suggested filling holes by duplicating a pixel and putting it into a hole; or averaging the pixels around it. Esaias wanted to know how clouds would be handled. Strahler suggested using the same algorithm for sampling, which solves the problem of resampling, but spatial consistency is missing.

Level 2 for surface radiances requires a lot of processing; and requires some Level 3 information. Strahler recommended applying such a sampling procedure at Level 2, to make sure that combined products can be used to produce a Level 3 product. Esaias averred that some algorithms are so non-linear that they would never adapt to this process. Strahler retorted that users would want gridded data, which requires binning. There followed discussion which surfaced some disagreement on what the users want. Ungar emphasized that this ÒbinningÓ preserves the data; every piece of information, and should be considered a candidate for an archivable product. Resampling destroys the opportunity of recovery.

2.3.3 Multitemporal Data

Fleig wanted to get an indication of the PanelÕs thoughts on the optimum temporal span of the MODIS products. Spans from 1 day to 32 days were mentioned. Strahler believes that the span is dependent on the product. For example, bidirectional reflection distribution function is geared to 16 days. A monthly product would then be 32 days (2-16 day cycles). There seems to be a need for a weekly snow and ice product. On behalf of the Oceans Discipline Group, Esaias expressed a need for daily, 8 days, then monthly products. The Atmosphere Group wants daily and monthly products. Esaias felt that monthly products would be a composite of daily products, and further postulated that modelers will probably insist on calendar months. Strahler mentioned that bowtie problems could be minimized by using nn resampling to produce a pretty picture, but radiances would not necessarily be correct. Huete was concerned about the shift in geolocation, and Strahler explained that if the pixel center falls anywhere within the bin, you put that pixel in that bin. Your data are preserved. Harnden further explained that sufficient information is supplied to relocate the pixel exactly (this would be done at Level 2, and would be identified as a Level 2G--binned to grid--product). Justice voiced the need to identify an interdisciplinary subgroup to work through this data preservation issue. He admitted that, while not a major issue for Atmosphere, Menzel should probably be requested, and that Gordon would be suitable to represent Oceans.

Conclusions and action items are identified in Attachment 20. The salubrious effect of the bowtie in detector intercalibration was emphasized. Since there is only about a 1-degree view angle difference, topographic effects are not important. The Panel advocated a Level 2G data structure where every pixel is geolocated and allocated (with its tag) to a grid cell. There should be no radiance change; a pixel is simply binned depending on where its center falls. There may be several pixels in one cell, due to the bowtie. This is a bridge around resampling, and should effectively serve a number of algorithms. Harnden, however, felt that this is probably not an archivable product. The identification of a day on a grid was discussed--there may be multiple observations, or no observations. What do you do when the swath goes down the dateline? At the urging of Salomonson, Harnden was identified as the lead on characterizing a Level 2G product.

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2.4 Algorithm Integration

This session was moderated by Ed Masuoka. The panelists were Barbara Putney, Bob Evans, Chris Justice, Robert Wolfe, and Michael King. Masuoka opened the session outlining his agenda for the panel. This included a schedule for software integration and testing, integration approaches by the three discipline groups, grids and tool sets, and integration at the 3 DAACs, with the focus being on the Goddard DAAC. He followed with a discussion of issues relevant to each discipline group.

2.4.1 Atmosphere

On Atmospheres, Masuoka noted that McIDAS meets ESDIS standards with the exception of using INTEGER*2 rather than INTEGER*4, and is asking not to be required to change that.

Currently, beta software delivery is targeted for July for Level 2 and August for Level 3.

King noted that for clouds, there are two products, which need some integration. There is a need to figure out ground rules on this, which will be worked by King and Menzel.

2.4.2 Land

Wolfe began with a slide showing the Land Group Software Integration plan. Masuoka noted that it appeared that they were using a land-specific format for their ICDs, and suggested that they might want to integrate their system with the existing ICD format. Wolfe noted that the Land format was specific to the Land group's needs, and agreed that it could be more general.

Wolfe reported that he has been working with Fleig on simulated data sets, focusing on the need to test most paths through the data. He stated that ancillary data was important to this testing, and talked briefly about the way ancillary data is being handled in the simulated data set. In response to a query from Barker, he noted that the ancillary data does include topographic data. Fleig noted that the simulated data discussed to date has been developed for testing data flow through the DAAC. He sees a need for sets with more scientific data for algorithm testing.

Wolfe discussed the six Land Algorithm Integration groups for Level 2. Rather than six processing threads for Land data, he sees these more as six working groups, reflecting shared data dependencies.

Masuoka then moved on to gridding. Justice stated that Level 2G binning was being worked, and will be used for the beta algorithms. Sellers indicated that he would like closure on the Level 3 grid for the beta software delivery, and will work with SDST on that. Options were discussed on the Level 3 grid, Masuoka wondering if cells would be nested down, and Justice remarking that he thought from an earlier session that there was a sentiment for aggregating up. Evans noted that there was a need to work on a framework for making a decision on this, talking with the CERES and other instrument groups, possibly at the SWAMP meeting. King said that atmospheres really had no preference on the matter; Land and oceans preferred aggregating up. The consensus was that, if the issue were still open after a couple of weeks, the teams would opt to aggregate up rather than nest down. Wolfe noted that work should start on Level 2G algorithms regardless of the Level 3 decision, as the Level 2G gridding is not dependent on the Level 3 grid.

Justice noted that there was not going to be just 1 delivery, and the teams need to work together to make sure that deliveries are what are required. He would like to have a meeting between MODLAND and SDST 3-4 weeks before the deliveries are due.

Masuoka raised the issue that ECS provided for an interim release 1 on a 64-bit operating system (Silicon Graphics). They need to make sure that their 32-bit code is 64-bit clean. Beta and post-beta deliveries may help show this. It would be a good idea to work on software transfer between the SCFs and TLCFs.

Evans suggested that for Level 3, they might want to consider an intermediate Level 3 form, since there is interest in following the means of means and standard deviations over time, and the intermediate Level 3 stores sums and sums of squares.

Turning to actual production of beta software down the road, team members are seriously considering changing their codes over to FORTRAN 90. One problem is that there is no compiler for SGI systems. Other problems with use of FORTRAN-90 need to be identified.

2.4.3 Ocean

Masuoka and Evans discussed the use of FORTRAN-90 for the Oceans deliveries. Evans noted that he expected selected portions of the delivery to be FORTRAN-90 by August.

The discussion moved to details concerning the Miami/ECS I/O interface. It was noted that currently, they can do simple PGE to PGE, but daily Level 3 products are too complex for use of a simple process control file. An RFP for a scheduler has been issued.

To date algorithms produced by various team members have for SeaWiFS have been delivered. These are very similar (if not identical) in form and function is very similar to the MODIS products. Given that the products are at the code freeze point for SeaWiFS, the team is now working on MODIS-specific parts. The only change should be more products being produced, but no change in flow.

In terms of simulated data, Evans noted that he expects to take and retain SeaWiFS I/O for input and use MODIS I/O for output. They should be able to show pixel for pixel conformity. SeaWiFS has HDF I/O routines in place to read (National Meteorological Center (NMC) data. They can continue to use that mechanism, or can substitute MODIS- specific data sets. For production of Level 2 products, the current 4 fields are sufficient. The requirements for Level 3 products still need input from Esaias.

In response to a question from King regarding the fact that MODIS extends sea surface temperature and chlorophyll fluorescence, which will need integrating into the algorithms, it was noted that they can use simulated channels on SeaWiFS data, and will have to come up with something up for fluorescence. For sea surface temperature, using AVHRR data is a possibility. SST algorithms to date need no outside data; the team is looking post-launch for different approaches which may need outside data. It was agreed that discussions of ancillary data would be left to a later roundtable.

2.4.4 Schedule

Masuoka began discussing the delivery schedule for algorithms. He noted that simulated data will come in May 21, with monthly updates following. Level 2 and 3 products are scheduled for July and August. It was suggested that the groups could try running their software at each otherÕs facility

(Miami/Goddard) for portability tests. A problem exists in that there is no hardware at the EDC DAAC for interim release 1. They are trying to reset the dates on later releases to match hardware availability.

Masuoka noted that they were trying to get a lot into beta because of the short time between subsequent releases. They want to do as much as possible with each release while still meeting the timelines. The end goal is to have 90 days to fix big mistakes and 2 years for correcting the science post- launch

Wolfe inquired about use of metadata in the beta release. Masuoka felt that this was not an issue in beta, and noted that the API documentation has coarse metadata capability. While it would be nice to exercise it, it is not critical for beta.

Justice noted a need for some consistency on metadata within land and among other groups, and said that he would like to see what metadata will look like from individual products so they don't get out of hand. Wolfe and Fleig felt that metadata would be more of a Level 1 issue, and shouldn't be a focus in the beta deliveries.

Fleig noted that the simulated data sets will include simulated geolocation files as well as simulated MODIS radiation data, as separate files.

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2.5 Remote Sensing in the Infrared

Bill Barnes moderated this session. The panelists were Ian Barton, Zhengming Wan, Phil Slater, James A. Smith, Didier Tanre, Yoram Kaufman, Paul Menzel, Anne Kale, and Eric Vermote. Significant input was also provided by Gerry Godden. Barnes presented an agenda for the Panel (Attachment 21).

2.5.1 Angular Mirror Response

Godden presented a number of visuals on the angular dependence of scan mirror emissivity. Bands 10, 17, 29, and 30 show a substantial roll-off in emissivity as the scan angle limits are approached (Attachment 22). This roll-off is presently not well characterized and will be difficult to characterize prior to launch. All tests are conducted at ambient; thermal vacuum testing cannot be done because of lack of space. Emissivity should be known within about 0.1 percent. Presently there may be as much as a 7 percent radiometric error from a 1 percent uncertainty in scan angle reflectance. It will be necessary to characterize the condition in space, by maneuvering the spacecraft, wherein cold space can be observed across the entire scan mirror, which requires holding the maneuver for 10 minutes. At 300K (ambient) there is a problem. On a cold cloud (240K), it is assumed that the condition would be a lot worse. Band 24 would be severely affected. Knowledge of the scan mirror temperature is critical; a 1-degree difference in temperature makes a 0.3 percent difference in radiometric error.

Godden feels that 10 minutes of deep space viewing could improve the knowledge by an order of magnitude. Barnes commented that the instrument is supposed to run at 275K and asked Godden why he picked 299K. Godden averred that it was an achievable ambient number, and sufficient to show the relative problem. AVHRR is not similarly affected. Barnes feels that the angular dependence of emissivity in IR must be characterized by a spacecraft maneuver. A fallback would be to put a second ÒblackbodyÓ at a 64-degree angle of incidence, to see if the mirror is changing. This could give us a few points to sample, in place of cold space.

Menzel wanted to know why the mirror coating could not be changed. Weber cited prohibitive costs. Barnes reported that the mirror which was tested is pretty rough, and that some other mirrors may prove less of a problem. Godden explained that the coating was chosen to provide appropriate signal-to-noise ratios at certain wavelengths. Montgomery questioned coating the next mirror with a different coating. Slater was concerned that other coatings would have to be examined for their affect on the visible. A change in coatings might result in an emissivity error of over 2 percent at 420 and 465 µm. Godden also cautioned about changing coatings: water vapor absorption might be affected.

2.5.2 Scan Cavity Temperature Measurement

Considerable discussion followed regarding the thermal environment of the instrument under various conditions and maneuvers. Barnes reported that he expected the scan cavity to change only by a few degrees and that there are 180 thermistors on board to keep track of temperatures.

There may be a polarization problem in the infrared bands, as well. The Calibration Group was given an action to take the MODIS simulator and look at some infrared data at the top of the atmosphere. Godden noted that there is SiO_2 on the mirror, and the desert is SiO_2. Cirrus could also provide polarization. Finally, there is an infrared polarimeter that may be of some use.

2.5.3 Scattered Light in the IR

A scattering problem exists, but needs further characterization through system level measurements. Barnes thinks that on-orbit measurements may be important here, too, because of dust on the mirror. The moon would be a sharp edge for quantifying the scattering. Also suggested was Venus, where point spread functions and MTF could be sampled. Godden cited the GOES experience where he found that lunar temperature falls off rapidly but is not a sharp edge. In the longer term, micrometeoroid debris will have a decided effect, as proven by the AVHRR experience. The MODIS scan mirror is back in the cavity pretty far, but about 6 inches of the mirror is exposed. Barton pointed out that degradation in the scan mirror will be picked up by solar calibration and black body measurements. The space view is where the mirror is exposed to micrometeoroid impacts.

2.5.4 Level 1B Calibration Algorithms

Larry Goldberg, Tom Pagano and Dan Knowles, as well as Dan Knowles, are now involved in this algorithm development. As cited in the calibration ATBD, it will be necessary to correct for contamination on the scan mirror, to correct for black body emissivity, and for the thermal regime of the space view. The action is to supply the Science Team with the calibration algorithm. Jim Smith asked if dynamic range could be adjusted. Montgomery reported that it is adjustable within the 12-bit system. The offset is always controlled, and clamped back to a standard value. Montgomery feels that MCST needs to send a draft of the thermal calibration ATBD to the team for review. Barnes explained that, simplistically, the temperature of the sensor is entered, then the offset is adjusted. Adjustments can be made on orbit. Nothing is currently being done on the ground that is irreversible. Maxwell wanted to know how often the space offset is updated, and commented that the noise will move around substantially, necessitating a running average over the long term.

2.5.5 Filters

Out-of-spec filter conditions were shown for bands 1-26. The scientific impact of the out-of-spec condition needs to be known. Testing of the long-wave filters (27-36) is about a month away. Bands 1-19 were seen earlier. Bands 20-26 are all about 40 nanometers above the specified center wavelength. There is a concern that SBRC does not advise of the inaccuracies until the filters are glued in place. The Team has no option in rejecting them; the cost is too great, consequently a waiver is unilaterally granted.

2.5.6 Engineering Model Data

As anticipated, some Òclean-upÓ is necessary. In the long wavelength focal plane, there is a ÒblipÓ for 6-8 channels, which amounts to about 10 percent of the nominal signal. There are also ÒblipsÓ between each of the channels. This effect appears to be caused by the area between the filters. SBRC intends to correct the condition.

2.5.7 Fire Band Calibration

The fire band dynamic range is 500K. The calibration requirement is not rigorous, and there is a 1000K blackbody to achieve calibration. The requirement is 10 percent, which is not a problem. Ground measurement is with small-aperture blackbodies (which are not very accurate--but great accuracy is not needed). Menzel feels that non-linearity is the crucial element. There is a need to measure on the night and day sides of the Earth to characterize the non-linearity.

2.5.8 Second Blackbody

The question is raised whether the fore-optics scan cavity usable for a quality radiometric check. It is felt that it may not provide the required accuracy. Over 5 years it may not be stable. The emissivity of the black body is 0.92. Use of this cavity is a ÒdisasterÓ fallback position, if an above-the-horizon scan is precluded. Guenther insists that SBRC needs to know if this source is to be considered as a second blackbody. The electronics will need to be modified. Weber thinks that software can satisfy the requirement, and that inserting electronics to create another black body source is non-trivial.

2.5 9 Algorithms for Thermal Band Products

Menzel is interested in the ice versus water content of clouds. He is worried about the 8.6-µm channel reflectance roll-off from the scan mirror. The roll-off is less severe at 10 µm, but increases again at 12.5 µm. Such a variability could play havoc with algorithms. Guenther emphasized that corrections will be important and that a validation program should provide empirical corrections.

2.5.10 Modulation Transfer Function (MTF) Problem

The residue tail-off goes way out across the pixels. Specifications call for 1 percent residue after 10 pixels. This is tantamount to a 1 percent error, which hurts sea surface temperature accuracy. But, there is still substantial value even with MTF problems.

2.5.11 Field Experiments

Menzel wondered if team members should have budgeted for validation field experiments, or should this be in MCST’s budget? Guenther questioned where the resources should be most efficiently concentrated. Menzel urged that a few times the first year major field experiments will be needed. Guenther stated that money will need to be set aside to do this, that no resources have currently been so designated. Since EOS research resources represent a zero-sum game, priority decisions will have to be made. Anne Kahle and Simon Hook support such validation efforts, and are willing to share costs with the MODIS Team, and are in favor of arranging campaigns which are cooperative among several team members. Kaufman called for optimizing plans to accomplish the validation, for enlisting other instruments to share. Barnes identified the calibration and validation scientists to pull together such an effort. Guenther claims that MCST cannot wait for validation results--that will take months and data processing must be done quickly. A method of integrating validation results into the product at a later time will have to be crafted.

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2.6 Simulated Data and Software Verification

This session was moderated by Wayne Esaias. The panelists were Frank Hoge, Barbara Putney, Alfredo Huete, Alan Strahler, Al Fleig, Steve Ungar, Joann Harnden, John Barker, Bob Evans, Michael King, Steve Ackerman, and Jan-Peter Muller. Esaias opened the session with a set of slides outlining his priorities and goals for the session. He began with a suggestion that it is important to define the difference between test data and simulated data. As a first cut, he suggested that test data is intended to exercise and test the data paths through the data processing system, while simulated data is directed more at testing and validating the science algorithms.

This definition was generally well received. It was noted that the Oceans Group had planned on using SeaWiFS data for simulated data, but SeaWiFS hasnÕt launched yet, which is worrisome as deadlines approach (see Attachment 23). A question was raised on possible sources of simulated data. Esaias suggested that the principal investigator is primarily responsible for his simulated data, as he is the most familiar with his algorithms and the data they will need to handle.

Other issues to be covered included a discussion of agreements in place, including ICDs, SOWs, and Team Leader agreements, as well as the level of launch readiness required in the algorithms. The session was then opened up to discussion by the panel members, proceeding around the table.

2.6.1 General Discussion

Strahler suggested that there was a gray area between simulated and test data. He suggested that principal investigators might choose odd data of interest only to their product, which would not be generally useful. He felt that there should be some information value in the test data--more than just 1’s and 0’s or moir patterns.

Fleig felt that the definition of test data was a good one. He agreed that test data needed to be more than just 1’s and 0’s, although test patterns make a good check--if you put a checkerboard in but canÕt get a checkerboard out, you have problems. But ECS will use the test data to determine if they have the system scaled properly; they need the right number of iterations. They also need output usable by next step. So, the test data needs to include a reasonable set of radiances, but doesn’t necessarily need the Òright definition of a cloudÓ. It was noted that, to date, all test and simulated data was cloud free, and at some point there would be a need to exercise the cloud algorithms.

Remer suggested that you need to know when you’re done developing the test data you need the test data to come in with the software, so that should be an issue in figuring the elaborateness of test data. Esaias noted that for the beta version, algorithms would be tested individually. He noted that at some point, you would need a more realistic data set to produce realistic output so the next step can use it.

Putney stated that algorithms would be tested both individually and integrated together, which makes the ICDs important. It was noted that Level 1B data would provide calibrated radiances that could be used for Level 2 products, although not all Level 2 products require Level 1B data--a number use calculated reflectances. She also noted that SDST would bring in error handling routines from the PGS toolkit.

Fleig brought up the requirements for software verification prior to launch. This sparked a discussion between Barker, Fleig, and Esaias about modeling instrument behavior and anomalies. Barker suggested that his use of Level 1b data is different--some will be point data, used to determine whether waivers asked for by SBRC are appropriate. He has concerns on the waivers for bands 20 - 25, and is working on simulations to understand whether that will be a problem. He also thinks that scattering is significant, but it is hard to simulate. It comes down to a modeling problem. Ghosting is something that is well-understood and can be modeled, and the problem can be inverted to provide an image with ghosting. Stray light is not well-understood. For any anomaly, you need to understand how the anomaly is produced and must be able to model it before you can simulate it. MCST will update Level 0 data to reflect anomalies as they are found and understood. Calibration data will be made available in a standard format, as resources permit.

Esaias noted that the science Team doesn't want to impact MCST's work on characterizing the sensor, which is critical, but that the Team does need data to characterize anomalies. A question was raised about how good the data could be. Barker thought that some data might be very good. Ghosting will be very good. MCST will start to get data--possibly engineering, but probably protoflight--which is better than test data can be, and better than can be modeled. MCST will get data that is better than on orbit because of controls that can be done on the ground, such as spectral tests. These will be very good data, which will allow very good simulations before launch. How soon? It's a continuum. Bits and pieces will come in. Radiometric and geometric data will wait for protoflight because some fixes are not present in the engineering model. Spectral data are available now.

Ungar doesn't think the team has a simulation plan because they don't value simulation. He feels that simulation fell by wayside as funds got cut. He suggests that a good simulation is a present product which is extremely well characterized and which can recoup variations in an original scene. With this you can have synthetic scenes, simulated scenes, characterize algorithm sensitivity, adjacency, etc. His second point is that emphasis should be on whatever the team needs to have ready now. He suggests that the best time to have simulations ready is post-launch. He said that in the case of getting a scene back with striping, it would be nice to have a simulation to verify the behavior, and to propose a fix or work around.

King suggested that developing simulated data would be valuable, but could become a big sinkhole. Esaias looked to the group for guidance about how much was enough in terms of simulated data. Ungar suggested that the least effort items should be highest priority, such as synthetic scenes and diagnostic patterns. He noted that people used to adjust their TVs with a test pattern.

Putney noted that Fleig's group was putting together a simulated data package, and was going to evolve it. Fleig stated that he would be willing to talk with people on producing subsets of test data, subject to resource availability. It was noted that the test data would have geolocation and DEM (elevation) data included.

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2.7 MODIS Data Product Browse Capability

Al Fleig served as moderator. The panelists were John Barker, Alan Strahler, Kathy Strabala, Marghi Hopkins, Didier Tanre, and Jan-Peter Muller. Tom Mace, of EPA, provided substantial input. The Team Leader, Vince Salomonson, was also present. Fleig led off the panel discussion by identifying the purpose, nature, and extent of the products (see Attachment 24). Substantial free-form discussion followed.

- Definition: A browse product is defined as imagery, and an image is a rasterized product. Furthermore, the browse product is an image that is needed concurrently with product production.
- Purpose: The identification of clouds, error fields, and visibility of the region of interest are of prime concern.
- Nature: The rate and method of subsampling needs to be defined. For example, would one want the warmest pixel in a 10-by-10 box? In identifying a subsampled element as Ò cloudyÓ, the number of cloudy pixels in the subset needs to be defined.
- Extent of the Products: Browse products for Levels 1B and 3 are probably not needed--Level 1B requires more computation than Level 1A, and Level 3 is already compact enough.

Muller asked who wants the browse products. He feels MODIS team members will need a full set of Level 1 or Level 2 data to validate the products. On the other hand, external users may want only Level 3 products. Mace agreed that others will want to produce their own products, and will need Levels 1 and 2 products. Mace saw the need for an across-instrument browse. Fleig suspects that the MODIS team has no requirement for a browse product. Barker disagreed. Fleig reminded Barker that team members can order a Level 2 product dataset. Barker felt that challenging material should be furnished to the public--theyÕll develop sophisticated uses. Yun-Chi Lu insisted that there is a need to confirm what other users want. Hopkins is not sure thereÕs a particular need for a browse product, but there is a need to access the metadata.

2.7.1 Dynamic Browse

Mace brought up the concept of a ÒdynamicÓ browse, based on the original product, to make a ÒgrossÓ selection of data serving a particular interest. Barker felt that a dynamic browse is necessary, and perceived the first level to be gross, the second level detailed, with the second level being the point at which the user decides if the data are useful. Barker suggested furnishing the raw data, or Level 3 data with a dynamic browse tool. The user would look for a major gross phenomena, then determine if the data are useful for a quantitative analysis. Fleig felt that the ability to subset images is practical, and asked if a browse product is needed for every scene of every pass. Barker felt that the need is high, and that users will select what they need. A browse is needed every time a product is created. Mace was concerned about data quantities, and commented that through 1997 none of the DAACs plan a dynamic browse. Mace considers dynamic browse as a target which EOSDIS will pursue. EOSDIS should work with the DAACs to make the dynamic browse a reality. Strahler cited two viewpoints: 1) the need to look at something before deciding to buy, and 2) how to interact with the data without having to interact with all of it at once. The kind of a flexible tool that selects temporal, spatial, or spectral components is needed. Strahler felt that the tool must come from MODIS or EOSDIS.

Barker then suggested the World Wide Web (WWW) as a mechanism for ÒgrossÓ distribution, with a tool for access to more detailed data. Fleig asserted that the tool would have to be developed by someone else, for financial reasons. Already there are tools available for hierarchical data format (HDF).

Conversely, Hypertext Mark-up Language (HTML) doesnÕt have a tool to provide the choice of a polygon, to go inside it. EDC has a WWW site in place, and is currently indexing data. Fleig suggested a temporal Level 3 WWW product at a resolution that is compatible with WWW bandwidths. This could be a weekly product.

Mace also advocates a WWW product, which could be used as an advertisement only. Next thereÕs a subset of the global dataset, resident at the DAAC. Finally thereÕs the ability (by prearrangement) to go into the database itself. Barker stated that the first could be on the WWW as a dynamically updated product, but would be a limited product or series of products, timed for availability at different times of day. Product 1 is fixed format. The second, also available through Internet, would be an on-line, active storage. The third requires special access. Products 1 & 2 are prepackaged. Product 3 requires special call-up.

2.7.2 Frequency

Muller wants a daily reflectance product, but this was considered impractical for all 36 bands. Fred Gunther opined that the agriculture and fishing communities will not want weekly averaged data but rather near real-time data. Barker would like to think of Òtraveling averagesÓ: a moving window, so that a replacement is made every time there is a new cloud-free pixel. Muller suggested a browse product showing change. Barker challenged that change detection on a subsetted image is necessary, and Mace supported the concept. Fleig felt that there is a lot of science required in determining the reason for change. Alan feels that change is a sophisticated product, which has its role, but is product- specific. It requires substantial intelligence.

2.7.3 Summary

Fleig summarized that a browse via the WWW was a viable concept. A browse can be developed and used at several different levels: first for ordering data; second for characterizing the product; third to explore the value of a daily reduced resolution product; and finally to intensively examine large volumes of data, temporally, spectrally, spatially. The latter would be a prearranged browse, where data are mounted by advanced arrangement. This allows a selection to concentrate in a given area. In its design, a browse needs to be responsive to the entire science community, and the IDS investigators. There is an action to see what the EOS Core System (ECS) plans. Fleig agrees to interact, on behalf of SDST, with the ECS.

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2.8 Ancillary Data and Assimilation

This session was moderated by Kendall Carder. The panelists were Steve Running, Ed Masuoka, Bob Evans, Eric Vermote, Zhengming Wan, Ricky Rood, Paul Menzel, and Matt Schwaller. Carder opened the session with a set of topics he hoped to cover: the output data products and input requirements document; what to use as a substitute before a required data product is ready; and where does MODIS Project go to get products for simulation? (Refer to Attachment 25 for details.) The session was then opened for discussion by each discipline group on their ancillary data needs and concerns.

2.8.1 Ocean Group

Carder noted that there was some ambiguity or confusion in the list of products required for validation, in that some product numbers listed (in the range 0 - 999) were not currently defined. Also, he suggested that if GOES clouds are going to be used by some for climatology, it would be clearer to indicate that in words instead of product numbers.

Evans listed the ancillary data items that ocean required as humidity, wind speed, atmospheric pressure, and ozone for visible bands. For IR, they need something to track radiatively important aerosol and an atmospheric temperature profile. This will allow generation of Level 2 products.

Esaias will need some additional data items to handle level 3, including nutrients and sea surface temperature. It may be possible to calculate some things, such as using heat plus circulation to calculate mixing. Almost everything Oceans needs can be derived from the atmospheric models or the EOS instrument suite, and then run through models for near real- time use. For PAR over several days, they may need inputs from geostationary data, such as GOES clouds

One thing that might bear on timeliness is the use of standard outputs or radiative transfer for mixing layers. There will be a need to figure delivery times on those products--from CERES, for example, which may require staged product delivery. If so, the team will need surrogates as placeholders early on. A representative from the data assimilation office at GSFC noted that they will have the capability to tailor data to give temporal resolution down to minutes. They will be running at about 24 hours assimilation. Products will be produced on the standard EOS grid.

The system calculates in 6 hour bins and applies corrections to every bit of data, rather than providing global corrections for the entire 6-hour block. Data are added in 6-hour blocks as they become available. First run data (24 hours) will be without any AM platform data, while 30 to 90 days later there will be a final run with AM data incorporated. The system allows users to do a fly-through on any of a set of fields, and includes an estimate of error at each grid point.

Evans noted that there is also a resource issue. He expects to have the horsepower to put out products at approximately 2-degree resolution. If the hardware allows, they will put it out at closer to 1 degree. There is also an issue in vertical resolution. Another issue is how well the boundary layer is represented by the model. Plans are to use the TCM model and physical-based data rather than a statistical model for doing interpolation. There will also be an effort to use this approach on SeaWiFS data to compare them with NMC data.

2.8.2 Land Group

Land’s needs include a precipitation index, which is currently available. Soil moisture is also important, but Running noted that he doesn’t think that anyone is going to be able to provide it. They plan to use precipitation and then model surface moisture. Microwave data only provides data for the top millimeters if there is no vegetation. He noted that land biologists are interested in moisture data down to meter (rooting) depth.

Precipitation data is required faster than it is available from surface weather stations. The possibility of using point sources was suggested. Can airport precipitation be provided, even if they don’t use it in GSFC assimilation?

Skip Reber asked whether what NMC produces really meets the teams needs. He noted that most of the discussion talked about data needs in generic terms. In order to provide anything useful, he needs accuracy specs and details of what people want. For temperature data, the Land Group wants ambient near-surface temperature, not skin temperature.

The discussion turned to spatial interpolation. Esaias wondered whether common interpolation tables for Level 2 products could be used? Evans noted that in many cases, interpolation is a better approach than trying to collect tons of data. The generally agreed that a general use, number-crunching approach to interpolation could be done by EOSDIS, but if thereÕs science knowledge involved, the principal investigators should do it themselves.

2.8.3 Atmosphere Group

For the Atmosphere Group, Menzel said that required ancillary items include surface pressure, temperature and moisture profiles, and sea-surface temperature A surface emissivity map would be very useful over land for shortwave IR/longwave IR windows.

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2.9 SCAR-B (Smoke, Clouds, and Radiation - Brazil) Update

The SCAR-B session was moderated by Yoram Kaufman. Key participants were Elaine Prins, Brent Holben, Teruyuki Nakajima, Alfredo Huete, Steve Ungar, Howard Gordon, and Michael King. Other attendees included David Herring, Lorraine Remer, Tom Arnold, Yosio Shimabukuro, Tim Suttles, Dave Starr, Bo-Cai Gao, Vince Salomonson, Shana Mattoo, and Si-Chee Tsay.

Kaufman began the session with a discussion on the SCAR-A and SCAR-C campaigns. He said SCAR-A went well, but that there were some problems during SCAR-C. However, both campaigns yielded good data. Now, the plan is to observe the fires in Brazil, which are more significant in terms of global change. Kaufman noted that the Brazilian president has not yet signed the Memorandum of Understanding (MOU). The scheduled dates of operation are mid-August through September 1995. (All viewgraphs shown during this session are included, collectively, as Attachment 26.)

Holben showed a map of the proposed sun photometer network, consisting of eleven sites. Holben reported that the instruments are being calibrated and he expects them to be sent to Brazil next week. Holben will return to Brazil in June to install the sun photometers, which will be in operation through October. There will be three Cimel photometers, three hand-held units, and one microtops for ozone detection. The other four units are Brazilian. Additionally, there will be instruments for measuring irradiance and radiance.

Kaufman said communications is a concern for the Brazilian campaign. He is considering using a satellite link so that communications can occur among any of the campaign participants, available on a continuous basis. Some consideration is also being given to communicating such things as daily weather maps via the World Wide Web. Kaufman said principal investigators should experiment with communications in June.

Huete reported that the Land Discipline Group plans to focus their efforts on two sites in Brazil: Alta Floresta and another (yet to be determined) where they can measure fluorescence. The Land Group is primarily interested in green vegetation, not yellow. Huete said his group hopes to obtain data over a fire while it is burning, and then data over the same site the week after the burn. They plan to participate for 4 weeks. Huete said he is interested in getting aircraft data on clear days as well as smoky. He said he would like the aircraft to fly low so that smoke can be measured as a function of height.

Regarding flight plans, Kaufman stated that Brazil will be divided into five regions. The SCAR investigators must declare to the Brazilian government which region they plan to conduct flights in at least 24 hours in advance; and 3 hours before a flight, they must file their specific flight plans.

For specific plans, Kaufman said each investigator should develop of list of campaign objectives and priorities before arriving in Brazilia. Regarding calibration, King reported that Arnold is exploring the availability of a monochromator, a power supply, and an integrating sphere that may be transported to Brazilia. Ungar pointed out that BOREAS has a 30-inch sphere which will not be in use this summer.

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2.10 Cloud Masking and Cloud Products

Vince Salomonson moderated this session. Panelists were Steve Ackerman, Dorothy Hall, Zhengming Wan, Eric Vermote, John Barker, Alfredo Huete, Otis Brown, Howard Gordon, Yoram Kaufman, Crystal Schaaf, and Bryan Baum. Salomonson opened the session by going over the general content and the objectives of the roundtable (see Attachment 27).

Steve Ackerman discussed cloud mask work ongoing at the University of Wisconsin. They are using AVHRR LAC plus HIRS data because they provide coverage in the infrared. However, they are lacking in spatial resolution relative to MODIS. MAS data are also being used, but they are limited in coverage. Kaufman suggested that the MAS data help in validation, due to their high resolution. Barker suggested that Landsat data should be used because they offer high resolution views over many parts of the world. Barker will take the ÒleadÓ in exploring and applying the virtues of Landsat for cloud masking work.

Eric Vermote likes AVHRR for his studies because of the frequent temporal coverage and the similarity to MODIS in terms of spatial resolution. Ackerman noted that cloud masks and their character depend upon the application. Using reflectance, which implies that a ÒcorrectionÓ to the radiances has been applied, is a helpful perspective.

To produce the cloud mask, calibrated, navigated radiance data in fifteen channels is needed, along with ancillary data, including:

- a1 km land/water map (will come now from EDC). There is an issue about whether a 250m land/water map is needed.
- 1 km topography and ecosystems maps. Reportedly, Muller will deliver the topography map soon. An AVHRR-based ecosystem map from EDC may be available--T. Loveland at EDC is the contact person on this.
- snow/ice maps
- for cirrus clouds, carbon dioxide channels. It was noted that there are difficulties in polar regions associated with inversions.
- cloud radiance composite maps

There is also the possibility that 1.38 micrometer channel data would be useful.

The cloud mask will be implemented as a 32-bit word. Ackerman described the information that will be in each of the 32 bits. The mask is a 1-km mask, with 250-m data used as a consistency check in the 1 km IFOV. Sun glitter areas use a nighttime approach. There was quite a bit of discussion about developing cloud masks at the 250 m and 500 m resolutions, and how to do this. There was also a good bit of discussion of Òenhancements" to the work being done by Ackerman, et al.

Ron Welch, of CERES, is reportedly working on a method to determine cloud shadow at 250-m resolution. The whole issue surrounding cloud shadows is a research area. The approaches to get cloud height were discussed. Much of this involved using geometry to determine where the clouds were/are located. This is a ÒthreadÓ problem in that it involves the cloud properties efforts and feedback loops. An issue arising from this discussion is that the cloud shadow parameter may ultimately require more than one bit in the cloud mask. The consensus reached was that cloud shadow efforts should be done spectrally initially and then add spatial/geometric algorithms.

The overall conclusion was that the 32-bit approach looks good and should be continued. Enhancements can be added as resources and time permit, but particularly post-launch when the full power and properties of MODIS become available. Interactions with oceans and, particularly, sea surface temperature are encouraged/sought.

The data sets that are being used now by Ackerman, et al., are:

- HIRS/AVHRR cloud mask, which is available on ftp or through SDST. The first data set is only over land
- AVHRR (LAC) data, which has 1 km resolution. This algorithm doesnÕt work over snow.
- MAS Gulf experiment in January 1995. The data from this are now coming on-line.

The issues identified include:

- (a) A land/sea flag. The mask will use the EDC product; an ecosystem map will also come from EDC
- (b) Confidence flag(s) in the cloud mask
- (c) How complex users want the cloud mask to be

Kaufman suggests using SAGE data to help in distinguishing between stratospheric aerosols from cirrus at 1.38 µm. Distinguishing thin cirrus from aerosol is a research issue.

Schaaf discussed MODLAND cloud mask concerns. These include the knowledgeable use of cloud tests and confidence flags, identifying cloud shadows, and the land/water mask. It was noted that a 1-km land/water mask is available based on the Digital Chart of the World (DCW); this is a circa 1991 data set, which is static and does not show recent changes, such as the change in extent of the Aral Sea. A DCW-based mask can and will be enhanced with the World Vector Shoreline (WVS), which should available by launch It was noted that the digital topographical data from J-P Muller must match the DCW and WVS data.

For the post-launch timeframe, there is a need for reflecting seasonal and manmade variations in the ecosystem maps. This probably can optimally be done or refinements provided through the MODIS land-cover product. All this assumes a 1- km product. The use of 250-m data is an issue that needs to be explored.

Vermote discussed his work taking the 32-bit Wisconsin product and work to add refinements that address MODIS land group efforts. These include applying atmospheric correction to pixels that are clear, mixed, or shadowed. These corrections are not applied to cloud covered pixels. Cirrus effects is a separate issue that will involve the 1.38-µm band.

Baum discussed Langley’s work for CERES. He noted that this effort is presently driven by the need to have algorithms working in time for the TRMM launch in 1997. At present, they are using AVHRR (VIRS simulator) data. The VIRS/AVHRR cloud mask is never saved. The saved product will be the MODIS responsibility in the EOS AM timeframe. Currently, sun glint remains a problem.

Using AVHRR data, the CERES group are going global using AVHRR on NOAA-9. Cloud properties now being mapped globally and tested using AVHRR data include:

- cloud fraction
- cloud height
- optical depth
- effective droplet radius (water clouds)

The AVHRR/VIRS data will be mapped within the CERES footprint to at least provide high and low clouds relative to the CERES point-spread function.

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2.11 Resources for Product Generation (Standard & Research)

Wayne Esaias moderated this session. The panelists were Bob Evans, Ed Masuoka, Jan-Peter Muller, H.K. Ramapriyan (Rama), Steve Running, and Alan Strahler. Esaias presented the agenda for this session (Attachment 28). Masuoka provided a set of viewgraphs on the MODIS products, networking, and computing facility (Attachment 29).

2.11.1 Computing Resources

Esaias reported an ongoing issue is if there will be enough computing power to handle the MODIS data products. The modeling and interconnections may result in a very high need for computer resources. Masuoka said the computing resources provided by PGS and TLCF will be significant. Ramapriyan said the PGS will provide four times the CPU resources required at-launch, in order to support processing, re- processing and modest growth in processing requirements. Masuoka said the MODIS science team should update their official computer resource requirements last completed approximately two years ago, though unofficial updates are being provided through the AHWGP modeling activities.

Masuoka said algorithm development and validation should be completed on the TLCF. The PGS will handle more production related work with fairly strict schedule requirements. Masuoka said the SDST will work towards having MODIS science work that cannot be handled easily at SCFs interactively completed using TLCF resources.

2.11.2 Networking and Data Transfer

Muller is concerned that transatlantic Internet data transfer will be too slow for many MODIS research tasks. Strahler also indicated the Internet may not be able to handle the large volume data transfers required after the launch of MODIS. Ramapriyan said there is a network and data availability budget that cannot be exceeded, requiring many tradeoffs and a careful definition of priorities. He said operator assistance with storage medium transfer may be required in some cases. Ramapriyan said Quality and Assurance testing will be given a high priority. Disk storage at the DAACs will reduce the amount of data to be actively kept on-line without off-line storage to a medium. At the DAACs data may be transferred to a medium within a day and possibly within an hour. This may be an issue if the data need to remain on-line longer to allow transfer to SCFs over the network. Masuoka said that the TLCF might be able to act as a buffer storing some of the data on-line for transfer to SCFs over Internet. Strahler said the MODLAND will likely require spatial and temporal subsets of MODIS data for validation.

2.11.3 Direct Broadcast Receiving Stations

Barton would like to see additional planning and support for users of Direct Broadcast Data. He has a question about the software support for processing the Level 0 direct broadcast data to Level 1B, calibrated radiances. In addition, he said the Direct Broadcast Receiving Stations may act as a back-up to the on-board recorder and as a means of distributing data to SCFs which have low bandwidth Internet connection like J.P. MullerÕs connection across the Atlantic. Ramapriyan reported Direct Broadcast Data is a requirement but EOSDIS has no budget to process Direct Broadcast Data.

2.11.4 Standard versus Research Data Products

There are questions about which products will be research products versus standard products. Hoge and Running said the ATBD review may have not properly permitted the MODIS investigator to refute unsubstantiated claims. It was reported the ATBD review process is a tool for King and Asrar to evaluate product designations. They may use or not use the ATBD recommendations as they deem necessary. The panel recommends a better definition of the decision process for determining standard versus research products.

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2.12 DAAC-TLCF-SCF Interactions for Standard and Research Product Generation

Ed Masuoka moderated this session. The panelists were Wayne Esaias, Paul Chan, Jeff Eidenshink, Al Fleig, Chris Justice, Steve Running, and Steve Ungar. This was an abbreviated session with more time transferred to the preceding and related session on Product Generation (see Attachment 30). Attachment 29 shows the IR-1 COTS Architecture of the GSFC DAAC. Additional DAAC-TLCF-SCF interaction-related attachments are also included in Attachment 29.

2.12.1 Goddard and EDC DAACs

Chan reported that approximately 80 percent of the Goddard DAAC work is now towards SeaWiFS data activities. Only 1 of 60 Goddard DAAC people are working towards MODIS. There will be in May 1995 a Version 1 MOU between the Goddard DAAC and the MODIS defining data transfer and related issues. There are plans now being outlined for software integration between MODIS and the DAACs. Plans call for Òtest softwareÓ from the TLCF to be delivered two months prior to a formal deadline to permit the DAAC time for data integration. There will be a lessons learned review of the integration process to determine if any changes in the process need to be made for the Version 1 software integration process.

Eidenshink reported he is the primary person on the EDC DAAC to address MODIS issues. He is examining their computing resource plans to accommodate MODIS data issues. Current EDC hardware has specific commitments. He reported EDC does have an accessible tape archive system for use from Version 0. However, the SGI Challenge attached to the tape archive will need to be upgraded with additional processors to support MODIS software integration activities. EDC would like to begin software testing early to debug any operational issues before the 1997 delivery date. EDC will also need to increase on-line storage to meet MODIS data related requirements. EDC DAAC is willing to provide time on the SGI system connected to their tape archive if its processing power can be upgraded at IR-1 or Release A. There is a planned draft EDC MODIS MOU due in June 1995.

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2.13 MODIS Data Quality Assurance Plan

Bob Evans moderated this session. The panelists were Robert Frouin, Frank Hoge, Alan Strahler, Jan-Peter Muller, Dave Starr, Didier Tanre, and Al Fleig. Skip Reber also contributed substantially.

A working definition of ÒQuality AssuranceÓ was established (see Attachment 31). Quality assurance (QA) was carefully contrasted to validation. QA was identified as what can be done in an algorithm context; e.g., spectral checks, spatial checks, temporal checks, time period. It was further defined as a procedure to identify/flag pixels to granules which Òobviously do not conform to expected accuracyÓ. Fleig was concerned about the delineation among QA, quality control (QC), and validation. Fleig opined that QA is more complex, and particularly needs the clarification of a more precise relationship with validation. QC is needed day-by-day, so validation never replaces QC. Reber referenced the definition fashioned by the Instrument Working Group, and clarified the difference between quality assessment and quality assurance. Justice identified the need for clear definitions before production of a draft plan.

A QA plan should be completed and in place around the time of Beta Version 1 in January 1997, with a formal presentation at Version 2 in mid-97. A generic plan should be available in January 1996, with a draft plan circulated in June, 1996. An early version of that draft plan is contained in Attachment 31A. H.K. Ramapriyan (ÒRamaÓ) wanted to know if QA activities have been included in the EOS processing and storage estimates. Evans affirmed that they had.

While Evans and Fred Gunther discussed the application of QA to Level 2 (and above) products, Reber was particularly concerned about application to Level 1. Evans was unsure if there will be sufficient information at Level 1 to make QA possible. Evans felt that it may be necessary to assess QA at Level 2, and then apply to Level 1. Justice was concerned about the human interaction in assessing QA, given the large volumes of data expected from MODIS. Evans envisioned QA as a simple test, signifying the presence of the product, and identifying the error budget on the fly. Any assessment of the geophysical content would be moved into validation. Starr felt that the Science Team has the obligation to identify the uncertainty. Fleig suggested that the DAAC needs to be integrally involved. Reber agreed that the DAAC is more concerned with quality assurance; but that the Science TeamÕs concern is more ASSESSING the quality, rather than assuring it.

In summary, Evans identified the definition of QA as a major issue, which needs review, modification, and approval of the research community. It is only after the definition is firmly in place, that the QA plan can be cogently crafted.

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2.14 Data Validation

Chris Justice moderated this session. The panelists were Michael King, Robert Frouin, Phil Slater, Frank Hoge, Steve Running, Alfredo Huete, Zhengming Wan, Didier Tanre, Teruyuki Nakajima, Dave Starr, and Brent Holben. There was also considerable input from Alan Strahler.

Justice began the session by stating that the Team needs to define "clarifying terminology" (see Attachment 32). The point was made that validation refers to the accuracy of the data products. Justice briefly discussed the ongoing validation efforts of each discipline group. He encouraged the Science Team to develop a community approach where all groups synergistically benefit from validation efforts. It was generally agreed that in today’s climate of declining budgets, collective validation efforts are desirable. Validation is recognized as a process for long-term assessment based on an analysis of the geophysical content of the data. In the process, inaccuracies are identified, correction methods are applied, and the product is reprocessed.

Each discipline group was polled on its validation plans. Largely, major field campaigns or surface measurement networks were mentioned. The Ocean Group has plans for the Hawaii Ocean Time Series (HOTS) and the Basic Atlantic Time Series (BATS). Tom Mace also mentioned that GOOS, GCOS, and GTOS (mentioned below) are coordinated by one group. The Land Group is involved in the Long-Term Ecological Research sites (LTERs), LAMBADA/BATERISTA (LBA), the sun photometer network, as well as airborne campaigns featuring the MODIS Airborne Simulator (MAS) and the Advanced Visible Infrared Imaging Spectrometer (AVIRIS). Running stressed the importance of interface and cooperation with GCOS and GTOS -- a global network of terrestrial sites that could play a key role in measuring Land parameters. John Townshend is the Chair of GCOS, but MODIS has no affiliate in GTOS. The Atmosphere Group also stressed the sun photometer network, and the need for additional support for this important and rapidly growing network (see Attachment 33). The Smoke, Clouds, and Radiation experiment (SCAR) is critical to the GroupÕs validation plans.

2.14.1 Trans-Instrument Mandate

Strahler initiated the discussion of synergy among instruments. MISR, MODIS, and CERES are all concerned with the same things: there would be a real benefit in integrating instrument validation plans, which are due at the end of the year. Running agrees that further exploration and exploitation of field campaigns and research sites, within each discipline research community, is needed to maximize the data validation effort. Uniformity of measurements across networks and sites/campaigns is important, as is a global pattern of sampling.

The costs of validation are substantial, and in the likely situation where budgets are restricted, it is important to prioritize activities and cooperate among instrument teams. Even so, considerable difficulty arises in planning validation exercises when the future funding level is unknown.

2.14.2 Responsibilities

Starr kicked off the discussion with a position that individual team members/principal investigators should not be responsible for custom-tailored validation experiments, serving their own products only. Validation must be a group effort, with external guidance from the discipline community. Kaufman mentioned that the experiments are growing more complex and expensive, and HeadquartersÕ involvement is crucial. Experienced campaign managers are desperately needed. Reber emphasized the importance of getting Interdisciplinary Science (IDS) investigators involved. Frouin called for a validation/calibration team within EOS, to focus on EOS as a whole system. Butler is working on establishing such a focus group.

In summary, Justice cited the upcoming EOS augmentation as a possible way to improve the validation posture: MODIS is calling for a validation effort under the proposed Announcement of Opportunity. Clearly validation requires a substantial management effort, and needs to be coordinated across instruments, and across disciplines where possible. The potential user community must be involved, with emphasis on the IDS investigators.

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2.15 Plans for Flying Aircraft over Ocean Test Sites

This session was moderated by Frank Hoge. The panelists were Michael King, Paul Menzel, Otis Brown, Dave Starr, and Steve Ungar.

Hoge opened by discussing the merits of the MODIS Atlantic Test site (see Attachment 34). He noted that there are five water masses in close proximity--Coastal/near-coastal waters, continental shelf, continental slope, the Gulf Stream, and the Sargasso Sea. He noted that the area could easily be extended to Bermuda. He stated that the temperate water mass in the test site is very typical of other water masses around the world. He also noted that there are a number of other research organizations in the region available for collaboration, including Woods Hole, Brookhaven National Lab, SUNY, and the University of Delaware. He suggested that there is a need to identify possibilities for interdisciplinary campaigns, as the cost of ship time is a concern, and working with other organizations can cut costs.

Hoge then showed a set of slides presenting the results of a recent campaign involving overflights of a research vessel from the University of Delaware. The methodology was to obtain data during the fly-over, then compare them to data from the ship when they became available, and use these data to validate the algorithms used to produce data products. He noted that the correspondence was very good between shipborne and airborne sensor products. Given that an aircraft can cover roughly 25 times the area a ship can in a given period of time, it is useful to have validated algorithms for the airborne sensors.

The result of this campaign was to validate two of the major MODIS data products, plus one research product. They are able to obtain sea surface temperature data as well. From this, they have data signatures showing the effects of the Gulf Stream on the data collected. These can be used to validate MODIS data, as similar signatures should be present.

Hoge then went on to discuss other benefits of using Wallops Flight Facility, noting that by coordinating test flights with sounding rocket and balloon launches, as well as SeaWiFS and AVHRR overflights, you can validate atmospheric calibration.

The discussion then turned to attempting to identify field campaigns where overflights would be useful. Those identified as candidates include:

- Dennis ClarkÕs MOBY site off Lanai,
- An Arabian Sea campaign in 1996-97,
- One potential site in the North Atlantic, starting up in 1998 or 99,
- European campaigns starting up in about 1997 in the North Atlantic, and
- A site in the Southern Ocean off New Zealand at about 65 or 70 degrees south.

There was a brief discussion of the differences between Gulf Stream waters and the waters off of Lanai, including dissolved organic matter and temperature. Brown noted that it was necessary to do a lot better at collaborations, setting up multi-disciplinary, multi- purpose flights, and doing sufficient planning to insure participation in these campaigns.

Some possible near-term missions discussed include ER-2 flights over volcanoes and clear-sky ocean sites, placing "sniffers" on research flights to collect aerosol data, and possibly placing a MOBY-like buoy off of Bermuda, where there is a lot of data already in hand; and which is easily reachable from Wallops for overflights. The importance of overflights in the algorithm development process was stressed, in that data collection at various altitudes from the surface through low- and high-flying aircraft up to orbital sensors allows for validation of atmospheric correction algorithms.

Hoge noted that as well as identifying some of the field experiments, sites, instruments, and platforms, it is necessary to talk about funding. By piggybacking experiments on planned flights and collaborating with other research organizations on field campaigns, it is possible to reduce the cost to NASA. He concluded by stating that it was necessary to identify pre- and post- launch opportunities for multi-disciplinary, multi- platform campaigns. He feels that aircraft overflights could play an important role in these campaigns.

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2.16 Vicarious Calibration

This session was moderated by Phil Slater. The panelists were Bruce Guenther, Jim Butler, Wayne Esaias, Eric Vermote, Yoram Kaufman, Al Fleig, and John Barker. Substantial input was also received from Skip Reber. To set the stage for calibration discussions, Slater called on Barton, Kaufman, Butler, and Guenther to present related topics from the Infrared, Atmospheric Correction, and Data Validation Round Tables, respectively (see Attachment 35). Kaufman stressed the need for enlisting calibration resources in atmospheric correction efforts.

2.16.1 Calibration Methods and Uses

Slater led off the discussion with information on some 34 sources of vicarious calibration (Attachment 36). Vermote was concerned that not all viable calibration sources were included, and he was encouraged to define additional sources which he felt worthy. Reber asked if MODIS intended to distinguish between kinds of calibration, and their uses. Guenther responded that the initial MCST design for the use of vicarious calibrations in the Level 1B algorithm is still begin developed. He added that MCST is most interested in vicarious calibrations which provide top-of-the-atmosphere radiances. Most of the remaining discussion focused on the role of the Calibration Scientist and his philosophy on calibration processes.

2.16.2 MODIS Calibration

Butler and Starr opened the discussion on calibration processes by defining acronyms: the Panel on Data Quality (PDQ), and vicarious calibration (VC). Butler feels committed to work jointly with Starr to include VC in any overall calibration plan. Important are the sources of such calibration. The weighting factor for vicarious calibration, in comparison to instrument sources, must be internally determined within each instrument team and may vary over time, depending on environmental and mechanical circumstances. Butler praised MODIS for its planned August meeting at Wallops, wherein the status of vicarious calibration within the total calibration plan will be considered. Comparison among methods (i.e., aircraft, ground) will be discussed.

Intrinsic to any understanding of overall systems calibration is the calibration of individual instruments. Each instrument must be understood thoroughly prior to any effort to cross-calibrate among instruments. Slater stressed the need for an across-instrument workshop. Butler agreed, but felt that such a workshop would be most beneficial after the formalization of VC through initial individual instrument workshops. Reber expressed the need to make sure that other instruments are calibrated as good as or better than MODIS. Guenther pointed out that it is obvious that different instruments have different error bars, and that these must be reconciled through cross-calibration efforts. Eventually, a direct face-to-face set of comparisons will be needed, and this will cost money.

2.16.3 Frequency of Vicarious Calibration

Two measurements a year is insufficient; Slater recommends a 2-week intensive campaign after launch to perfect procedures and get error comparisons. Barker acknowledged that this would also be a good time for studying differences in methodologies, and that intensive campaigns will be needed several times early on.

Definition of terms is still a problem, as it was in the Quality Assurance and Validation roundtable sessions. The dividing line between calibration and validation needs to be carefully drawn. Problems of validating the accuracy of VC measurements, and weighting of field campaigns in relation to continuous sites were mentioned. Budgetary considerations require that calibration use extrapolative techniques, such as extrapolating measurements of a few MODIS channels to all channels: this is a challenge that needs to be studied.

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3.0 FINAL PLENARY SESSION

3.1 Calibration Working Group Summary Report

Slater delivered a summary report on the May 2 Calibration Working Group (the agenda for that meeting is included as Attachment 37). He said discussions mainly focused on stray light and ghosting. Additionally, Paul Menzel presented his work on developing vicarious calibration methods.

Slater showed a list of Action Items still open from the October 12 - 14, 1994, MODIS Science Team Meeting (Attachment 38). He said there are still concerns regarding the design of the screen attenuating diffuser. Also, there is a need to compare the preflight calibration of the SRCA with the calibration of the solar diffuser. He asked MCST to review these calibration issues and report any findings or conclusions at the next Science Team Meeting.

Slater then showed a list of new Action Items. Regarding radiative transfer, Slater said that if we only achieve 5 percent uncertainty in the calibration of MODIS and the SRCA preflight, then we can't transfer that uncertainty to the solar diffuser in orbit. He noted that the Team is reluctant to take the instrument outside due to contamination concerns. Slater reported that the ghosting model is complete but that there are still issues to be resolved relating to transient response.

MCST will continue to explore options for using the moon and planets for stray light measurement. Slater said there is some question as to how good MODIS' pointing stability will be. Additionally, there is some concern that different detectors in the same band on the EM show up to 2 percent difference in response as a function of scan angle. MCST will review this problem and report at the next meeting.

Slater said consideration is being given to the possibility of adding a second onboard calibration blackbody to the scan cavity of the PFM. This would help MCST characterize the effect of variation of angle of incidence on the reflectance of the scan mirror. MCST will decide whether a second blackbody is desired and make their recommendation prior to the next meeting.

3.1.1 Calibration Roundtable Session Summary

Slater stated that for the first time ever we will have a great deal of calibration information available to us from the moment the EOS sensors are in orbit. If we are to make the most of this information, we must get organized and determine the relative accuracies of the various methods of vicarious calibration being used. Slater suggested that the EOS Calibration Scientist could coordinate this organization activity. Specifically, this person could: a) coordinate vicarious calibration activities between difference vicarious calibration groups nationally and internationally, b) centralize the evaluation of different techniques used by different groups, c) arrange the cross-comparison of measurements between various groups to help in evaluating vicarious calibration methods, and d) depending upon a through c above, recommend the role(s) MCST may play in the calibration/characterization of MODIS. Slater noted that error budgets between different vicarious calibration teams are not always the same.

3.2 Remote Sensing of Aerosol and Atmospheric Correction Summary

Yoram Kaufman summarized Roundtable Session #1 (refer to Attachment 14). He proposed holding an international workshop in April of 1996 to broaden the scope of the MODIS Science Team Members and to enhance or facilitate further involvement with other investigators around the world. He reported that some discussion focused on wavelength measurements from both ground-based and satellite instruments in determining the affect of single scattering albedo. Kaufman stated that there is a need for strong, continuous interaction among algorithms and parameters, particularly in modeling aerosols.

Regarding interactions between AFGL (Air Force Geophysical Lab) models and dynamic models, Kaufman said most groups using AFGL models suffer from the fact that they are models of averages, not actual conditions. Kaufman concluded that there is a need to integrate satellite and ground-based campaigns.

Jan-Peter Muller asked what is being done to insure consistency of surface reflectance data between MODIS and MISR. He is very concerned that different models used to derive aerosols by two different teams will yield two different reflectance functions. Kaufman responded that the MODIS Atmosphere Group is discussing these issues with the MISR Team. However, he pointed out that the two teams are taking different approaches and it is difficult to say now which is better.

Muller stated that the MISR surface reflectance at nadir should be identical to the corresponding MODIS pixels, and that we must ensure that the surface reflectance is the same even though different algorithms are used. Kaufman suggested that Muller’s point would make a good topic of discussion at the next MODIS Science Team Meeting.

3.3 Gridding and Averaging Summary

Alan Strahler summarized Roundtable Session #2 (see Attachment 39). Regarding gridding, he said that his group only discussed a few, albeit important, issues. He stated that gridding deals with the Level 3 products. His panel concluded that it is probably better to work with a fine resolution grid (250 m) and collapse to coarser grids than to use a nested grid. An Action Item was assigned to Bob Evans, Robert Wolfe, Dave Diner, and Bruce Barkstrom to pursue this issue with the SWAMP.

Strahler recounted that the proposed grid is more or less an equal area grid, but not exactly. The proposal is for a modified, nested ISCCP grid that is defined on the basis of 1.25 degree squares. Steve Ungar persuaded the Panel to move to a fine grid of 270 m so that it will be easy to collapse down to 1.25 degrees. Strahler told the team that the edges of each grid cell will appear ragged like a postage stamp. There is a need for cartographic tools and resamplers so that modelers can go from basic to angled grids to derive map projections.

3.4 Resampling and Remapping Procedures Summary

Strahler also summarized Session #3--examining the MODIS bowtie affect to determine how it affects Level 2 processing (Attachment 40). The panel concluded that the bowtie provides interdetector calibration, which is good, but makes resampling with interpolations difficult, which is bad. Strahler stated that there is a need for a MODIS-specific tool for producing interpolated projections with observed physical features or phenomena in the proper place. For MODLAND, developing this tool is trivial, but for cloud observation it becomes much more difficult.

Moreover, Strahler explained that trying to fit a MODIS image onto a map projection is going to be difficult, and will require some means for resampling. If we don't resample, then we can take those data and place them into a grid. This logic led to Eric Vermote's idea of a Level 2G data structure for forward binning the data, which would work well for computing surface reflectance and BRDF. Strahler pointed out that the Oceans Group is doing something similar, but with a coarser grid.

The panel concluded that Level 1G and 2G products would be very helpful in some cases, but further work and thought is needed there by Joann Harnden, Howard Gordon, Paul Menzel, Robert Wolfe, Steve Ungar, and Strahler. The panel recognized that there is a need to define a "day". The grid may represent a unit of time, Strahler rhetorically asked, but what do you do if the dateline falls in the middle of a swath?

3.5 Algorithm Integration Summary

Masuoka summarized Roundtable Session #4, regarding algorithm integration (Attachment 41). He said the main point he got out of the discussion is that the Science Team needs to deliver its Level 2 code at the end of July and Level 3 code at the end of August. He noted that the Atmosphere Group may need some help from SDST in integrating product # MOD06.

Masuoka stated that for MODLAND, integration and testing of algorithms for scientific accuracy will require more scientifically accurate synthetic data. Ancillary data will be necessary for beta and should be consistent with the simulated data. He announced that a second MODLAND/SDST meeting is scheduled for late July 1995, at which metadata for version 1 delivery will be discussed.

Masuoka noted that the Ocean Group will use RATFOR programming language for its beta delivery, and FORTRAN 90 for delivery of version 1. He stated that the Ocean Group will provide their own simulated input data that SDST can put into a scan cube.

3.6 Remote Sensing in the Infrared Summary

Barnes summarized session #5, regarding remote sensing in the IR. Barnes reported that the panel concluded that a full swath scan of deep space is vital to calibration so the MODIS Team should continue requesting this capability. Barnes said he is developing a white paper on the subject and is working with SWAMP.

The panel would like the Team to consider the possibility of applying a new coating on the scan mirror in order to reduce polarization in the visible region of the spectrum. Barnes said he will review this possibility and report his findings to the Technical Team. The panel also urged the Team to continue studying the possible use of a second blackbody in the scan cavity as a "pseudo" blackbody to obtain calibration data a large angle of incidence to the scan mirror. He pointed out, however, that a second blackbody is no substitute for a deep space view, that will still be required.

Barnes noted that MCST was given an Action Item to evaluate TOA (top of atmosphere) data taken by the MODIS Airborne Simulator (MAS) (See Attachment 42 for more Action Items from this session). Jim Smith was asked to locate carbon dioxide polarization data to complement MCST's efforts. Considerable discussion was devoted to the thermal environment of the scan mirror under various conditions and maneuvers. Barnes reported that he expects the scan cavity to change only by a few degrees. The panel asked SBRC to complete and analyze the new scan mirror temperature measurement design and report at the next Science Team Meeting.

Barnes reported that the latest version of the Level 1B infrared calibration algorithm will soon be forwarded to the Science Team for review. MCST must examine approaches for post-launch validation of infrared radiances.

3.7 Simulated Data and Software Verification Summary

In lieu of moderator Wayne Esaias, Al Fleig summarized session # 6. Fleig quoted a point made by Steve Ungar: it is important post launch to have a way to simulate and study any artifacts found by the Team. Fleig reminded the Team that there is a MODIS simulated data set and it is evolving.

In its discussion, this panel decided that software verification is similar to quality assurance and validation, so the panel decided to leave further discussion up to those session panels.

3.8 MODIS Data Product Browse Capability Summary

Fleig also summarized session # 7. He said the purpose of the browse panel was to determine what browse products should be available for MODIS, keeping cost and utility in mind (see Attachment 43). The purpose of the browse product is to help data users sort through large volumes of data to decide what data to order, what each data product looks like, and whether the requested data instance is a good one. The panel recognized that the nature of browse products can vary for each MODIS product.

Fleig stated that we need to be responsive to the Science Team's, as well as the IDS community's, browse needs. SDST will follow up with ECS to determine their plans. Consideration will be given to provide browse capability via the WWW.

3.9 Ancillary Data and Assimilation Summary

Kendall Carder reported that there are three primary concerns for ancillary data and assimilation: 1) timeliness issues, 2) spatial issues, and 3) pooling ancillary data requests. The panel determined that MODLAND needs precipitation, soil moisture, photosynthetically active radiation (daily), maximum and minimum temperature, and surface pressure data. The Ocean Group's needs have not yet been determined. The Atmosphere Group needs surface emissivity maps over land for its shortwave and longwave IR products. Atmosphere also needs aerosol ancillary data.

The panel concluded that the timeliness of MODIS' model outputs will be tuned to match MODIS coverage. The first iteration of Ricky Rood's model will be available within 24 hours using NMC-like input fields, and the second iteration will be available within 1 month using EOS data fields. Spatially, 1.25 degrees by 1.25 degrees is an adequate grid size to allow modeling--each discipline group will interpolate in space as needed.

Regarding quality assurance of ancillary data sets, Carder stated that each algorithm should be tested independently. Ancillary data sets should be sent to the team member computing facilities along with MODIS data sets for quality assurance. (See Attachment 46 for more details.)

3.10 SCAR-B Update

Kaufman summarized the SCAR-B meeting. He told the team that SCAR-B is the third and last of a series of field campaigns focused on the interactions of Smoke, Clouds, and Radiation. SCAR-B will be conducted in Brazil. Kaufman reported that a Memorandum of Understanding (MOU) has yet to signed by the Brazilian president.

Otherwise, significant progress is being made in preparation. Ground sites for AERONET instruments have been chosen, calibration preparations are being made, a communications infrastructure is being developed, and dates of operation have been determined (August 15 through September 15, 1995). MODLAND plans to participate in the campaign.

3.11 Cloud Masking and Cloud Products Summary

Salomonson reported that during session #10, Steve Ackerman, principal author of the cloud masking ATBD, discussed what is needed to develop a cloud mask algorithm. In short, what is needed is calibrated, navigated radiance data in fifteen channels, as well as certain ancillary data, such as 1 km land/water maps from EDC and 1 km topography data. Also, snow/ice maps and cloud radiance composite maps are also needed.

According to Ackerman, the cloud mask will be implemented as a 32-bit word. He said there is some question as to whether cloud shadow can be determined at 250 m resolution, an issue that still needs further research. Ackerman concluded that the cloud shadow efforts should be done spectrally initially, and then spatial/geometric algorithms should be added afterward.

Salomonson stated that the 32-bit approach looks good and development should continue. Enhancements will be added as resources and time permit. The data sets currently being used for development are the HIRS/AVHRR cloud mask, AVHRR LAC data, and MAS Gulf Experiment data. Salomonson told the team that the main issues remaining are 1) development of a land/sea cloud flag, 2) confidence flags, and 3) input from the Team as users stating how complex they want the cloud mask to be. Salomonson concluded that although there was some nervousness last summer during the review of the cloud mask ATBD, he is now comfortable with the progress being made. (Notes from this session are included in Attachment 27.)

3.12 Resources for Product Generation Summary

Masuoka summarized the panel discussion, although it was moderated by Wayne Esaias (See Attachment 44). Masuoka reported that 100 percent of the bandwidth required by MODIS products will be available at launch. In terms of CPU capacity, 4 times more will be available than MODIS' stated needs, however this capacity will be phased in. At launch, MODIS storage space allocation will be 400 Gbytes. Capacity models are being developed for the processing of MODIS Level 1 and 2 data products.

Masuoka stated that the question of where time-slicing will occur still remains. Also, the decision process for determining standard versus research products needs to be determined.

3.13 DAAC-TLCF-SCF Interactions Summary

Masuoka reported that discussion focused on EDC beginning software testing early to iron out operational issues before the 1997 delivery deadline. The EDC DAAC is willing to provide time on an SGI system connected to their tape archive but ESDIS will need to increase the capacity of that machine to support MODIS testing. Both the GSFC and EDC DAACs stressed the importance of recruiting highly skilled science and operations staff throughout early software and system integration and later operational processing. This staff would provide better feedback on lessons learned, as well as quicker response time in resolving operational problems. Currently, each DAAC has one full-time person supporting MODIS science software, and both would like to add several more personnel. (Please see Attachment 30 for more details.)

3.14 MODIS Data Quality Assurance Plan Summary

Evans reported that the MODIS Data Quality Assurance Plan is currently being developed and is in draft form now. He told the team that the EOS Data Quality Control Panel is chaired by Mike Freilich (Discussed in Attachment 31).

Evans stated that quality assurance (QA) in an algorithm context refers to spectral checks, spatial checks, and temporal checks within one day of obtaining the data. Validation refers to all other tests. The QA process will identify or "flag" pixels to granules which obviously do not conform to expected accuracy. Evans added that QA will also allow the Team to monitor the health of products.

Evans said that the beta version of the QA Plan will be submitted by January 1997, and the final version will be completed by mid-1997.

3.15 Validation Summary

Justice stated that there are some good models in place as to how the MODIS validation effort can proceed; including the sun photometer network, the SCAR campaigns, Land test sites, and the Ocean Color Working Group initiative. He said the Team needs "community" guidelines on the level of required validation. He pointed out that validation planning is a problem in light of the constantly changing budget. For example, he rhetorically asked, who pays for aircraft for field campaigns?

Justice observed that there are international coordination mechanism for validation already in place through such organizations as GOOS, GCOS, GTOS, CEOS, and IGBP. He feels that the Land community needs a distributed network of sites to supplement intensive NASA campaigns, such as FIFE, BOREAS, and LBA. Dave Starr encouraged the Team to continue developing its "bottom up" validation initiatives. Justice concluded that to achieve product validation, the Team will need help from the EOS Project with coordination-- particularly with interagency and international coordination and funding. (Justice’s notes are included as Attachment 45.)

Salomonson asked how the Team will pay for ocean cruises. Esaias responded that NASA is beginning to consider paying for ship time.

3.16 Plans for Flying Aircraft Over Ocean Test Sites

Hoge stated that plans are needed for Case 1 and Case 2 Atlantic Ocean field experiments involving the MODIS Atlantic Test Site (MATS) and the Bermuda Biological Station Measurement Series (BATS). He added that plans are progressing for a joint MOBY-MAS campaign in Hawaii in the spring of 1996. He feels there is a need for the Team to identify post-launch airborne field experiments.

Hoge concluded that airborne platforms, sites, and institutions do exist to conduct robust experiments--he recommended focused planning sessions. (See Attachment 34 for Hoge's notes.)

3.17 Conclusion

Salomonson concluded the meeting with brief discussion on this meeting's format. In brief, he liked the roundtable panel discussion format and plans to reuse it. The next meeting, scheduled for Oct. 16 - 20, 1995, will feature a shorter plenary session, roundtable discussions, discipline group splinter sessions, and a final plenary summary session.

Salomonson thanked the Japanese contingent of scientists for coming.

Other Sections of these Science Team Minutes:

- Plenary 1.0 Session
- Roundtable Sessions

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Related World Wide Web Sites:

- The MODIS Home Page