MODIS DATA STUDY
TEAM PRESENTATION

June 1, 1989

AGENDA

1. Updated Summary of MODIS Data Products
2. Accuracy Considerations for MODIS Level-1 Data Navigation

UPDATED SUMMARY OF MODIS DATA PRODUCTS

The following few pages provide a listing of the present data products for which we have factsheets as of June 1, 1989. The factsheets are organized according to the disciplines of atmosphere, ocean, land, and calibration. Within each major category, several minor categories are listed. Duplicate names indicate that more than one team member has proposed or desires the development of a particular parameter. Factsheets also exist for field experiments and are listed here.

As more data products are identified, additional factsheets will be developed and added to the database.

The suffix ** at the end of a product ID code indicates a newly proposed or identified data product.

MODIS DATA PRODUCT IDENTIFICATION CODE

Product Category:

C Calibration
O Ocean
L Land
A Atmosphere

Product Level:

L1 Level-1A/B
L2 Level-2
L3 Level-3
L4 Level-4
LC Calibration
LA Algorithm (no proposed product)
LS Simulated Data

Originating Team Member:

MA Mark R. Abbott
IB Ian Barton
OB Otis B. Brown
KC Kendall L. Carder
DC Dennis K. Clark
WE Wayne Esaias
RE Robert H. Evans
HG Howard R. Gordon
FH Frank E. Hoge
AH Alfredo R. Huete
CJ Christopher O. Justice
YK Yoram J. Kaufman
MK Michael D. King
WM W. Paul Menzel
JM Jan-Peter Muller
JP John Parslow
SR Steven W. Running
PS Philip N. Slater
AS Alan H. Strahler
JS Joel Susskind
VS Vincent V. Salomonson
DT Didier Tanre
VV Vern Vanderbilt
ZW Zhengming Wan

Sequential Identification Number:

0001-9999

Examples:

AL2MK0029 is a Level-2 MODIS data product for the atmosphere originated by Mike King.

LL3VS0036 is a Level-3 MODIS data product for land originated by Vince Salomonson.

SUMMARY OF MODIS ATMOSPHERIC DATA PRODUCTS

AEROSOL PROPERTIES (OPTICAL DEPTH):

AL2MK0031) Level-2 Aerosol Optical Depth over the Oceans
AL3MK0032) Aerosol Optical Depth over the Oceans Maps
AL3DT0033) Aerosol Optical Depth over the Oceans Maps
AL3DT0034) Aerosol Optical Depth over Deserts Maps
AL3DT0036) Aerosol Optical Depth over Polar Regions Maps
AL4DT0037) Global Aerosol Climatological Maps
AL3YK0019) Global Aerosol Loading Maps

AEROSOL PROPERTIES (SIZE DISTRIBUTION):

AL2MK0022) Level-2 Aerosol Size Distribution over the Oceans
AL3MK0023) Aerosol Size Distribution over the Oceans Maps
AL3KC00**) Aerosol Size Distribution over the Oceans Maps
AL3YK0020) Global Aerosol Size Distribution Maps
AL3DT0024) Aerosol Size Distribution over the Oceans Maps
AL3DT0025) Aerosol Size Distribution over Deserts Maps

AEROSOL PROPERTIES (POLARIZATION AND ABSORPTION):

AL2MK0017) Level-2 Degree of Polarization over the Oceans
AL3MK0018) Degree of Polarization over the Oceans Maps
AL3DT0035) Aerosol Absorption over Deserts Maps

AEROSOL PROPERTIES (SUPPORTING PRODUCTS FOR OCEANS):

AL2RE0010) Level-2 Single Scattering Aerosol Radiance over Oceans
AL2KC00**) Level-2 Single Scattering Aerosol Radiance over Oceans
AL2RE0012) Level-2 Single Scattering Aerosol Radiance over Oceans
AL2KC0008) Level-2 Backscattering Coefficient at 565nm over Oceans
AL2KC00**) Level-2 Rayleigh Scattering Radiance over Oceans
AL3RE0011) Single Scattering Aerosol Radiance over Oceans Maps
AL3HG0013) Single Scattering Aerosol Radiance over Oceans Maps
AL3KC0009) Backscattering Coefficient at 565 nm Maps over Oceans

AEROSOL PROPERTIES (ADVANCED STUDIES):

AL4DT0038) Global Aerosol Transport Processes (including sources and sinks of desert aerosols)
AL4YK0027) Aerosol Effect on Cloud Albedo Studies

ATMOSPHERIC CHEMISTRY PRODUCTS:

AL3YK00**) Total Precipitable Water (cm.) in Clear Skies
AL3YK00**) Total Precipitable Water (cm.) within Clouds
AL3JS00**) Temperature-humidity-ozone Profiles
AL3JS00**) Total Column Ozone (cm.)

CLOUD PROPERTIES (FRACTIONAL COVER):

AL3JS0043) Effective Cloud Fraction Maps (%/unit area)
AL3KC00**) Cloud Cover Maps (%/unit area)
AL3YK00**) Cloud Size
AL3YK00**) Cloud Perimeter Size
AL3SR00**) MODIS-N North American Cloud Cover
AL3WM0047) Three Day Mean Cloud Extent by Type Maps (%/unit area)
AL3WM0044) Three Day Mean Cloud Extent Maps (%/unit area)
AL3WM0045) Global Monthly Cloud Extent Maps (%/unit area)
AL3WM0048) Global Monthly Cloud Extent by Type Maps (%/unit area)
AL4WM0049) Global Four Year Cloud Type Climatological Maps
AL4WM0046) Global Four Year Cloud Extent Climatological Maps

CLOUD PROPERTIES (TEMPERATURE AND PRESSURE):

AL3YK00**) Cloud Top Pressure (mb)
AL3JS0039) Cloud Top Pressure Maps (mb)
AL3WM0040) Three Day Mean Cloud Top Pressure Maps (mb)
AL3WM0041) Global Monthly Cloud Top Pressure Maps (mb)
AL4WM0042) Global Four Year Cloud Top Pressure Climatological Maps
AL3YK00**) Cloud Top Temperature

CLOUD PROPERTIES (OPTICAL THICKNESS):

AL2MK0029) Level-2 Daytime Cloud Optical Thickness
AL3MK0030) Daytime Cloud Optical Thickness Maps
AL3YK00**) Cloud Brightness or Cloud Optical Thickness

CLOUD PROPERTIES (OTHER):

AL3MK0021) Daytime Cloud Effective Particle Radius Maps (um)
AL3YK00**) Cloud Particle or Droplet Size
AL3MK0028) Daytime Cloud Thermodynamic Phase Maps (flag=ice,water)
AL3WM0052) Three Day Mean Cloud Emissivity Maps
AL3WM0053) Global Monthly Cloud Emissivity Maps
AL4WM0054) Global Four Year Cloud Emissivity Climatological Maps
AL3JS0051) Longwave Cloud Forcing Maps
AL4JS00**) Precipitation (mm/day)

RADIATION BUDGET COMPONENTS:

AL4AS0014) Bidirectional Reflectance Distribution Function (BRDF)
AL4JM0015) Bidirectional Reflectance Distribution Function (BRDF)
AL2AS00**) Production Mode Spectral Surface Radiance ($W/m^2/sr$)
AL3JS0050) Outgoing Longwave Radiation Maps (OLR) (W/m^2)
AL4JS00**) Cloud Free Albedo (%)
AL4VS0006) Daily Outgoing Solar Exitance at Top of the Atmosphere
AL4VS0007) Daily Outgoing Thermal Exitance at Top of Atmosphere

SUPPORTING ALGORITHMS:

AL4YK0026) Atmospherically Corrected Imagery
ALAAS0001) Atmospheric Correction Algorithms
ALADT0002) Atmospheric Correction Algorithm

AL4JM0003) MODIS Atmospheric Correction Tables
ALAAS0004) Registration Algorithms for Tilt-pass Products (Level 2)
ALAAS0016) Rectification Algorithms for BRDF Products (Level 3)
ALAAS0005) Inversion Algorithms for Estimation of BRDF from Rectified Tilting Passes

OTHER DATA PRODUCTS:

ALSDT0055) Simulated MODIS-N Imagery Data

SUMMARY OF MODIS LAND DATA PRODUCTS

RADIATION BUDGET COMPONENTS:

LL3VS0032) Daily Global Bi-Directional Radiance Maps (Land Leaving Radiances; $W/m^2/sr$)
LL3VS0033) Weekly Global Bi-Directional Radiance Maps ($W/m^2/sr$)
LL4VS0004) Daily Surface Reflected Solar Radiation Maps (W/m^2)
LL4VS0003) Daily Surface Downward Solar Radiation Maps (W/m^2)
LL4VS0002) Daily Surface Upwelling Thermal Radiation Maps (W/m^2)
LL4VS0001) Daily Surface Downwelling Thermal Radiation Maps (W/m^2)
LL4VS0005) Daily Surface Albedo Maps (percent)
LL2SR0013) Level-2 Absorbed Photosynthetically Active Radiation
LL3SR0014) Daily Absorbed Photosynthetically Active Radiation Maps
LL3VV0042) Polarized Part of Ground Radiance ($W/m^2/sr$)
LL3YK00**) Surface Spectral Reflectance (6 bands)

LAND SURFACE TEMPERATURE (LST):

LL2ZW0030) Level-2 MODIS-N Land Surface Temperature (deg. C)
LL2SR0028) Level-2 MODIS-N Land Surface Temperature (deg. C)
LL3ZW0031) MODIS-N Land Surface Temperature Maps (deg. C)
LL3SR0029) MODIS-N Land Surface Temperature Maps (deg. C)
LL3SR00**) MODIS-N Weekly Maximum NDVI Land Surface Temperature Maps (deg. C)
LL3SR00**) MODIS-N Weekly Average Nighttime Land Surface Temperature Maps (deg. C) for Cloud Free Conditions
LL3YK00**) Land Surface Temperature (C) for identification of fires (see Biomass Burning)
AL3JS00**) Land and Sea Surface Temperatures (LST and SST)

SURFACE SNOW AND ICE COVER:

LL2SR0037) Level-2 Daily North American Snowcover
LL2VS0034) Level-2 Daily Global Snowcover
LL3SR0038) Daily North American Snowcover Maps
LL3VS0035) Daily Global Snowcover Maps
LL3SR0039) Weekly North American Snowcover Maps
LL3VS0036) Weekly Global Snowcover Maps
LL3**00**) Sea Ice Cover

NORMALIZED DIFFERENCE VEGETATION INDICES AND POLARIZED VI'S:

LL3CJ0008) Daily MODIS-N NDVI Maps
LL3SR0006) Daily MODIS-T/N NDVI Maps
LL3SR0007) Weekly MODIS-T/N NDVI Maps
LL3**0009) Greenest MODIS-T/N NDVI Maps
LL3AH00**) Weekly Soil Adjusted Vegetation Index (SAVI)
LL3CJ0017) Global Phenology (10 day composites of NDVI)
LL3VV0043) Polarized Vegetation Indices
LL4CJ0019) Global Growing Season Length and its Interannual Variability
LL4CJ0018) Multi-Resolution Global Phenology

LAND COVER MAPS:

LL3AH0026) Generalized Vegetation-Soil Distribution Maps (units = biome types and soil types)
LL4SR0021) Biome Types (units=biome names)
LL4JM0054) Low Resolution Land Cover Types Map (unit=biome names)
LL4JM0049) Geolocated Surface Types by Spectral Behavior
LL4JM0050) Geolocated Surface Types by Spectral BRDF's
LL4JM0051) Geolocated Surface Types by Agro-physical Parameters
LL4JM0052) Geolocated Surface Types by Unvegetated Mineral Composition
LL4JM0053) Geolocated Surface Types by Unvegetated Rock Type
LL4JM0048) Geolocated Spectral Signatures

OTHER BIOLOGICAL DATA PRODUCTS:

LL4SR0012) Daily Net Photosynthesis Maps (t C/ha/day)
LL4SR0024) Daily Evapotranspiration Maps (mm H_2O/ha/day)
LL3SR0025) Weekly Evapotranspiration Map (mm H_2O/ha/week)
LL4SR0040) Weekly North American Water Stress Maps (units TBD)
LL3SR0015) Weekly Net Photosynthesis Map (t C/ha/week)
LL4SR0016) Annual Net Primary Production Map (t C/ha/yr)
LL4JM0020) Canopy Leaf Area Index (LAI; dimensionless)

ADVANCED STUDIES:

LL4DT0044) Vegetation Development Study
LL4CJ0023) Land-Degradation in Sub-Saharan Africa
LL4YK0045) Biomass Burning Studies (percent/unit area/unit time)
LL3AH0027) Organic Carbon Pools in Living Biota and Soil
LL4CJ0022) Grassland Biome Annual Production Estimates (units TBD)
LL4JM0055) MODIS Digital Elevation Models (DEM)
LL4JM0056) MODIS Surface Roughness Maps

SUPPORTING ALGORITHMS:

LLAAS0010) Inversion Algorithms for Canopy Structure
LLAAS0011) Algorithms for Estimation of Green Biomass, Woody Biomass, IPAR, etc.
LLAVV0041) Atmospheric Polarization Correction Algorithms
LLAVV00**) Photosynthetic Capacity Algorithm
LLAJM0046) Automated Image Understanding System (ATIUS)
LLAJM0047) Monte Carlo Ray Tracing (MCRT) Algorithm
LLAAH00**) Vegetation-detritus-soil Spectral Decomposition Algorithm ($Wm^{-2}sr^{-1}$) (VSD)

SUMMARY OF MODIS OCEAN DATA PRODUCTS

SEA SURFACE TEMPERATURE:

OL2IB0005) Level-2 Fast Delivery Sea Surface Temperatures (deg. C)
OL3IB0006) Fast Delivery Sea Surface Temperature Maps (deg. C)
OL2IB0007) Level-2 Daily Global Sea Surface Temperatures (deg. C)
OL3IB0008) Daily Global Sea Surface Temperature Maps (deg. C)
OL2OB0009) Level-2 MODIS-N Sea Surface Temperatures (deg. C)/Quality Flag
OL3OB0010) Daily MODIS-N Sea Surface Temperatures (deg. C)/Quality Flag Maps
OL3OB00**) Weekly MODIS-N Sea Surface Temperatures (deg. C)/Quality Flag Maps
OL3IB0011) Weekly Global Sea Surface Temperatures (deg. C)
AL3JS00**) Land and Sea Surface Temperatures (deg. C)

WATER LEAVING RADIANCES AND RELATED PRODUCTS:

OL2RE0002) Global Water Leaving Radiances Maps ($W/m^2/sr$)
OL2HG0001) Global Water Leaving Radiances Maps ($W/m^2/sr$)
OL2KC00**) Global Water Leaving Radiances Maps ($W/m^2/sr$)
OL3WE0030) Incident Spectral Irradiance over the Oceans (W/m^2)
OL3DT0004) Global Ocean Color Map

CHLOROPHYLL PIGMENT:

OL2JP0014) Level-2 Chlorophyll Pigment Concentration in Australian Waters (ug/L)
OL3JP0015) Chlorophyll Pigment Concentration in Australian Waters Maps (ug/L)
OL2FH0018) Level-2 Chlorophyll Pigment (ug/L)
OL3FH0019) Chlorophyll Pigment Maps (ug/L)
OL3KC0020) Case II Chlorophyll Maps (mg/m^3)
OL4MA0012) Daily Chlorophyll Fluorescence Yield Maps
OL4MA0013) Monthly Chlorophyll Fluorescence Yield in the Oceans

OTHER PIGMENTS (COLOR DERIVED PRODUCTS):

OL2FH0022) Level-2 Phycoerythrin Pigment (ug/L)
OL2FH0024) Level-2 Phycocyanin Pigment (ug/L)
OL2JP0016) Level-2 Other TBD Pigment Concentrations in Australian Waters (ug/L)
OL3FH0023) Phycoerythrin Pigment Maps (ug/L)
OL3FH0025) Phycocyanin Pigment Maps (ug/L)
OL3JP0017) Other TBD Pigment Concentrations in Australian Waters Maps (ug/L)
OL3KC0021) Case II Degradation Products Maps (mg/L)
OL3KC0039) Selected Case II Suspended Sediment (mg/m^3) (or suspended matter concentration)
OL3KC00**) Case II Water Type Flag Maps (Marine Humus Flag)
OL3KC00**) Case II Water Type Flag Maps (Suspended Detritus Flag)
OL4HG0040) Detached Cocolith Concentration Maps (m^{-3})
OL4RE0041) Detached Cocolith Concentration Maps (m^{-3})
OL4FH0026) Species Diversity Maps

PRIMARY PRODUCTION AND BIOMASS:

OL4FH0028) Regional Primary Productivity Maps (t C/ha/day)
OL4KC00**) Regional Primary Productivity Maps (t C/ha/day) (case II waters)
OL4MA0029) Daily Primary Production in the Oceans Maps (ug/L)
OL3WE0035) Five Day Mean Low Resolution Primary Productivity
OL3WE0037) Monthly Mean Low Resolution Primary Productivity
OL4MA0036) Monthly Primary Production in the Oceans (ug/L)
OL3WE0038) Annual Mean Low Resolution Primary Productivity
OL4FH0027) Regional Oceanic Biomass Maps

OTHER DATA PRODUCTS:

OL3DC0003) Ground-truth Ocean Parameters
OL3WE0031) Mixed Layer Depth (m)
OL3WE0032) Diffuse Light Attenuation Coefficient at 490 nm
OL3WE00**) Diffuse Light Attenuation Coefficient for PAR
OL3WE0033) Population Structure of the Oceans
OL4WE0034) Physical History of the Oceans

FIELD EXPERIMENT SUMMARY (ID NUMBER)

01) Reflectance-based Calibration Experiment I (C01V)
02) Reflectance-based Calibration Experiment II (C02V)
03) Aerosol Properties Experiment I (A03A)
04) Aerosol Properties Experiment II (A04V)
05) Conventional Atmospheric Data Collection Experiment I (A05D)
06) Conventional Atmospheric Data Collection Experiment II (O06D)
07) Cloud Parameter Algorithm Development Experiment (A07A)
08) Cloud Parameter Validation Experiment I (A08V)
09) Cloud Parameter Validation Experiment II (A09V)
10) Vegetation Canopy Geometry and Atmospheric Transmission Experiment (A10V)
11) Vegetation Canopy Geometry and Soil Surface Roughness Experiment (L11A)
12) NSF Long-Term Ecological Research Sites Experiment (L12V)
13) Vegetation Soil Distribution Validation Experiment (L24V)
14) Stokes Polarimeter Experiment (L13A)
15) Land Surface Radiance and Temperature Experiment (L14A)
16) Surface Insolation Measurements for Snowcover Derivation Experiments (L15V)
17) Ground-truth SST Experiments (O16V)
18) ARGOS Drifting Buoy SST Observations (O17V)
19) Ship of Opportunity SST Observations (O18V)
20) Optical Buoy Experiment (O19V)
21) Australian Waters Ground-truth Data (O20V)
22) NASA Airborne Oceanographic Lidar (AOL) Experiment (O21V)
23) U.S Global Ocean Flux Study (GOFS) and JGOFS Survey (O22V)
24) California Current System Experiment (O23V)

ACCURACY CONSIDERATIONS FOR MODIS LEVEL-1 DATA NAVIGATION

1. Objectives:

To diagnose the impact of specified platform position accuracies and platform attitude knowledge accuracies (absolute and within the platform structure).

To evaluate the impact of line-of-sight pointing errors originating from within the MODIS-N and MODIS-T instruments.

To analyze the sensitivity of the Earth location accuracy to atmospheric refraction, terrain elevation, and various anchor point location/interpolation strategies.

Obtain an optimal Level-1 data navigation strategy for MODIS as part of the MODIS Level-1 Data Processing Plan.

2. Method:

Develop a prototype Earth location algorithm based on earlier (e.g., Nimbus-7 ERB and CZCS) versions.

Acquire atmospheric thermodynamic structure and digital terrain elevation data sets.

Develop a "truth" data set of Earth locations based on an absolute knowledge of position, attitude, scan, atmosphere, and topography for a range of scan angles, latitudes, and seasons for each instrument.

Vary the platform position and attitude, MODIS line-of-sight, (angle and scan-rate) atmospheric structure, and Earth topography to obtain simulated (perturbed) Earth locations. Obtain perturbations for a variety of pixel location interpolation strategies.

Obtain the sensitivity of the MODIS data navigation to each of the error sources; assume these error sources are uncorrelated.

Use the sensitivities to build up realistic models of the MODIS location accuracies under various assumptions and scenarios, for both RMS and "three sigma" cases.

3. Data Sources:

Phase-A Study Report for the MODIS Level-1 Processing

The Coastal Zone Color Scanner (CZCS) Geolocation Algorithms

Global Digital Elevation Data Tape

Nimbus-7 ERB Earth Location Algorithms

Nimbus-7 CZCS Earth Location Algorithms

Refraction Algorithm for computing deflection of line-of-sight by scan angle, atmospheric temperature and pressure, and reference atmospheric profiles.

4. Mathematical Development

Define:

POS = Platform position
ATT = Platform attitude
LOS = Sensor line of sight
TOP = Earth topography/elevation
ATM = Atmospheric thermodynamic structure
ANC = Anchor-point interpolation
X = Geocentric position vector of target point
= xi + yj

$$dX = \partial X/\partial POS\ dPOS + \partial X/\partial ATT\ dATT + \partial X/\partial LOS\ dLOS + \partial X/\partial TOP\ dTOP + \partial X/\partial ATM\ dATM + \partial X/\partial ANC\ dANC$$

$$dx^2 = (\partial X/\partial POS)^2\ dPOS^2 + (\partial X/\partial ATT)^2\ dATT^2 + (\partial X/\partial LOS)^2\ dLOS^2 + (\partial X/\partial TOP)^2\ dTOP^2 + (\partial X/\partial ATM)^2\ dATM^2 + (\partial X/\partial ANC)^2\ dANC^2 + \text{cross terms (covariances)}$$

Assume the error sources are uncorrelated.

One and three-standard deviation estimates for the system errors can be substituted into the differentials, e.g.,

$\sigma_{POS}^2 = dPOS^2$ and $(3\ \sigma_{POS})^2 = dPOS^2$

to yield the RMS and "three-sigma" Earth location accuracies.

5. Milestones

Obtain SCF 3081 finding authorization and accounting code.

Analyze Nimbus-7 ERB Earth Location Algorithms

Obtain and analyze CZCS Earth Location Algorithms

Read and utilize Global Digital Elevation Data Tape

Read and utilize atmospheric Refraction Data

Select and code prototype Earth Location Algorithm

Develope "Truth" Earth Location Data Set

Conduct perturbation analysis by varying all input parameters to Earth Location problem.

Determine sensitivity of Earth location to inaccuracies in input parameters.