Overview of MODIS Processing within the Ocean Color Discipline Processing System (OCDPS)

B. Franz, 11 June 2003
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Abstract

This document provides some details on the current status of MODIS processing within OCDPS, with emphasis on the algorithmic differences between the products generated by OCDPS and those previously produced by the MODIS Adaptive Processing System (MODAPS). Plans for further development are also listed. This document will be maintained to reflect future changes in the processing software or calibration.

I. Introduction

The Ocean Color Discipline Processing System (OCDPS) is currently processing and distributing MODIS/Aqua data from Level-0 through Level-3 using a mix of standard MODIS codes and standard SeaWiFS/SIMBIOS codes. The initial goal of this effort was to establish the mechanics for processing and distributing global 1-km data as a prototype for discipline-specific oceans processing of NPP/VIIRS. Another goal was to develop the capability for near real-time image support using MODIS data, and to provide an alternative method for MODIS data browse and distribution. These goals have been realized, and NPP prototyping efforts will continue to develop, but recent changes in the structure of the Ocean Biology and Biogeochemistry Program at NASA have directed that the former SeaWiFS/SIMBIOS Project will now become the primary source for MODIS ocean color data processing and distribution. To that end, the current focus of this Project is to enhance the accuracy and stability of water-leaving radiances retrieved from MODIS/Aqua through improved instrument-level and vicarious calibration and characterization, and updated atmospheric correction and bio-optical algorithms. The specific, near-term goals outlined by Dr. Paula Bontempi, Manager for NASA's Ocean Biology and Biogeochemistry Programs, include:

1. addition of MODIS processing capability into SeaDAS
2. compatible scaling, data formatting, and data projection for SeaWiFS and MODIS
3. interim reduction of the MODIS product suite into a few key parameters, including, but not limited to, water-leaving radiances
4. data distribution via the SeaWiFS and NPP-prototyping interface
5. near real-time data distribution for Aqua MODIS oceans data

The data products produced through this activity are currently available for download through the global browse search and order utility at http://oceancolor.gsfc.nasa.gov/. A rolling archive of the most recent Level-1A, Level-1B, Level-2, and geolocation data is also available via anonymous ftp from ftp://oceans.gsfc.nasa.gov/. In addition, the ftp site provides the full mission global Level-3 mapped images of selected products at 4 and

9–km resolution on daily, weekly, monthly, and seasonal time-scales. All products at Level-2 or higher are in SeaWiFS-like HDF formats:

http://oceancolor.gsfc.nasa.gov/ocformats.html

Users of this data should be aware that this is a rapidly evolving effort and the products will be periodically updated to reflect the current state of calibration, software, and algorithm development. The software and calibration are likely to change in the forward stream, and frequent reprocessings to bring the retrospective data in-line with the forward stream should be expected. However, the community will be kept informed of any changes via the ocean color mailing list:

http://oceancolor.gsfc.nasa.gov/cgi/ocmailsubscribe.cgi

and community input will be actively sought in the development process.

II. Quality of Derived Products

a. See the "validation" link of the ocean color web http://oceancolor.gsfc.nasa.gov/ for *in situ* match-up comparisons and cross-sensor comparisons.
b. Additional analyses will be available soon.
c. Feedback from the user community is welcomed.

III. Major Differences Between ODPS and Previous MODAPS Processing

a. SeaWiFS-like file formats for Level-2 and higher.
b. SeaWiFS-like product suite with addition of 11um SST.
c. Updated Level-1B look-up tables (log-fit m1 LUTs).
d. Corrected polarization sensitivity tables
e. Different vicarious calibration/characterization approach (no radcor).
f. Alternate BRDF correction (flat-ocean Fresnel).
g. Reduced aerosol model suite (12 models).
h. Different NIR water-leaving radiance correction (Arnone rather than Seigel).
i. Additional correction of nLw for out-of-band response.
j. Different glint correction (SeaWiFS algorithm).
k. Different whitecap correction (SeaWiFS algorithm).
l. Different solar irradiance models (Thuillier 2003).
m. No NIR smoothing is currently performed.

Additional details regarding these differences in processing methodology are described in Section VIII of this document.

IV. Data Source, Product Distribution, and Processing Strategy

a. The primary data source is the near real-time feed from EDOS, provided by NOAA as part of NPP prototyping collaboration. Format provided is MODIS Level-0 in 5-minute granules.
b. The secondary data source is MODIS/Aqua Level-1A ocean color subsetted data (MYD01SS) from the Goddard DAAC, which is used to fill any missing granules lost in the near real-time feed.
c. Near real-time data is processed through Level-2 as soon as it is received, and distributed through the global browse search and order system (http://oceancolor.gsfc.nasa.gov/) and the anonymous ftp site (ftp://oceans.gsfc.nasa.gov). **The near real-time products are generally available within 2-4 hours of observation**. Processing for these initial products is performed using climatological meteorological and ozone data and predicted attitude and orbit information.
d. When the definitive attitude and orbit and coincident meteorological and ozone data are received, the MODIS data is reprocessed from Level-1A through Level-3, and redistributed to the browse system and the ftp site. This generally occurs about three days after the observation date. Users requiring the highest quality data for scientific analysis would therefore be advised to wait several days to one week before downloading.

V. Level-1A Processing

a. The Level-0 data is processed to Level-1A using standard PGE01 SDST code (http://ltpwww.gsfc.nasa.gov/MODIS/SDST/).
b. The Level-1A is further reduced, by zeroing or removing all extraneous data (land/atmosphere bands, etc.), to minimize storage requirements and maximize data transfer rates. The resulting format is structurally equivalent to the GDAAC-distributed MYD01 format (http://daac.gsfc.nasa.gov/MODIS/Aqua/rad_geo/MYD01.shtml), except that it lacks the 250-meter and 500-meter science data sets. A standard MODIS Level-1A product is 575MB (about 220MB compressed), while the reduced Level-1A is 215MB (about 50MB compressed). The reduced file format retains the following band information:

Band	Wave
8	412 nm
9	443 nm
10	488 nm
11	531 nm
12	551 nm
13L	667 nm (lo gain)
13H	667 nm (hi gain)
14L	678 nm (lo gain)
14H	678 nm (hi gain)
15	750 nm
16	870 nm

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20    3.7 um
22    3.9 um
23    4.0 um

25    4.5 um
26    1.3 um
27    6.7 um
28    7.3 um
29    8.5 um

31    11 um
32    12 um
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c. The entire mission archive of reduced Level-1A ocean color data is maintained online, and all higher-level products are derived from this archive. The processing software accepts both the full or reduced format.
d. The Level-1A file naming uses a SeaWiFS-like convention which indicates sensor (A for Aqua/MODIS, T for Terra/MODIS), sampling rate (LAC for full 1-km sampling), and time of the first scan in the file (Ayyyydddhhmmss.L1A_LAC).

VI. Geolocation

a. Running standard PGE01 SDST MODIS geolocation (http://ltpwww.gsfc.nasa.gov/MODIS/SDST/).
b. Using predicted ephemeris for near real-time processing.
c. Using definitive attitude and ephemeris for all retrospective processing.
d. Near real-time data is reprocessed as soon as predicted ephemeris and ancillary meterological and ozone data are available (~3-days delay).

VII. Level-1B Processing

a. Running standard PGE02 MCST Level-1B code, version 4.3.1 (http://www.mcst.ssai.biz/mcstweb/).
b. Slightly modified to handle ocean subsetted Level-1A.
c. Using latest available, log-fitted m1 LUTs (4.3.1.5S).

VIII. Level-2 Processing

a. Running the Multi-Sensor Level-1 to Level-2 code (MSL12, http://oceancolor.gsfc.nasa.gov/DOCS/MSl12_Users_Guide.pdf) developed by the SIMBIOS Project, modified to read and process standard MODIS/Terra and MODIS/Aqua Level-1B, full-resolution or extract (diagnostic data set) formats.
b. Applying a single, time-independent vicarious calibration based on match-ups with the MOBY *in situ* sensor (http://oceancolor.gsfc.nasa.gov/ocvalidation.html).
c. Currently applying no additional post-launch instrument corrections (e.g., RSMAS radcor corrections) for Aqua, meaning no RVS or destriping corrections beyond those already applied at Level-1B.

d. Using standard MODIS Rayleigh tables derived by RSMAS (including I,Q,U components).
e. Applying polarization corrections based on a re-analysis of pre-launch laboratory measurements of instrument polarization sensitivities (http://oceancolor.gsfc.nasa.gov/DOCS/polcormemo.pdf).
f. Using SeaWiFS glint correction algorithm (Ref 2).
g. Using SeaWiFS white-cap correction algorithm (Ref 2).
h. Using MODIS-specific aerosol and transmittance tables for 12 models (o99,m50,m70,m90,m99,c50,c70,c90,c99,t50,t90,t99).
i. Using SeaWiFS single-scattering to multi-scattering relationships (Ref 5).
j. Using standard SeaWiFS flagging and masking, with cloud flag based on glint-subtracted surface reflectance at 869 nm (Ref 2). Same cloud flag for SST.
k. Using Arnone et al. NIR water-leaving radiance correction, adjusted for MODIS band passes (Ref 2).
l. Applying correction for out-of-band response to nLw, based on convolution of MODIS band relative spectral response with Morel bio-optical model.
m. Applying simple flat-ocean Fresnel BRDF correction (Ref 2).
n. No NIR smoothing is currently applied.
n. Standard chlorophyll product is MODIS chlor_a2 (OC3M) algorithm, but alternate algorithms are available.
o. SST product using standard MODIS 11um NLSST algorithm with coefficients derived by RSMAS and input SSTguess from Reynolds OISST products.
p. SeaWiFS-like Level-2 output format (http://oceancolor.gsfc.nasa.gov/ocformats.html).

IX. Level-3 Processing

a. Standard SeaWiFS code and SeaWiFS-like bin and SMI map formats (http://oceancolor.gsfc.nasa.gov/ocformats.html).
b. Binning to 4-km equal-area products.
c. No quality levels. If a bin is filled, quality is “good”.
d. Currently distributing mapped products for chlorophyll, nLw(551), Angstrom(531), AOT(869), K(490), and SST(11) on 4 and 9-km equi-rectangular projection at daily, weekly, monthly, and seasonal time-scales.

X. Future Plans

a. Continue collaboration with MCST to develop and assess changes in the instrument level calibration, based on analysis of the pre-launch laboratory measurements and interpretation of the onboard calibrator (OBC) data.
b. Perform independent vicarious characterization based on comparison with SeaWiFS, including assessment of polarization effects and response versus scan angle (RVS), and provide feedback to MCST.
c. Make use of standard MODIS aerosol tables (consolidated HDF format, also change SeaWiFS to use the HDF table format), and allow runtime specification of the aerosol model suite.

d. Add support for night data.
e. Product suite to be modified/expanded based on community interest.

XI. Change History

a. March 2003
   1. MSl12 v3.1
   2. initial development o support MODIS processing

b. June 2003
   1. MSl12 v3.2
   2. replace SeaWiFS aerosol models with 12 equivalent MODIS models
   3. replace SeaWiFS diffuse transmittance tables with MODIS tables
   4. incorporate MODIS out-of-band water-vapor correction
   5. set 748-nm gain adjustment back to 1.0
   6. use correct ozone interpolation for TOMS
   7. **comparisons with standard MODIS software (modcol) show near identical results for nLw, chlorophyll, AOT, and epsilon, when modcol is run with no NIR Lw correction, no replacement of detector 1 with 2, and no optimization of the aerosol model selection process.**

c. 7 July 2003
   1. MSl12 v3.3
   2. begin deviation from standard MODIS processing algorithms.
   3. install MODIS-specific water absorption and backscatter coefficients for Arnone NIR water-leaving radiance correction, and enable correction.
   4. install MODIS-specific out-of-band correction coefficients for nLw, and enable nLw out-of-band correction.
   5. replace Cox & Munk glint probablility distribution with Ebuchi & Kizu.
   6. modify cloud flag algorithm to remove glint reflectance, and reduce cloud flag reflectance threshold from 0.08 to 0.04.

d. 13 August 2003
   1. MSl12 v3.4
   2. add support for 11-12um SST product .

e. 5 November 2003
   1. MSl12 v3.5
   2. change glint correction to be consistent with SeaWiFS, including: correct interpretation of the glint coefficient (mu0/pi error modcol), probability function reverted to Cox & Munk, no modcol scale factors, no modcol elevation of wind speeds, use of direct transmittance terms.
   3. add glint polarization components to polarization correction (as implemented for standard MODIS/Terra collection 4.1).
   4. change whitecap correction to be consistent with SeaWiFS (scale factor increased from 0.25 to 0.4, wind speed limited at 8 m/s).

5. update to generalized earth-sun distance calculation.
6. replace Neckel & Labs solar irradiance model with Thuillier 2003.
7. update band-pass-integrated solar irradiances for MODIS/Aqua using newly developed relative spectral response functions, including measured out-of-band response.

f. 24 November 2003
   1. MSl12 v3.5.1
   2. Bug fix for SST masking
   3. Implement new smoothed L1B LUT from MCST
   4. Enable full BRDF corrections
   5. Disable all vicarious gain adjustments (no radcor)
   6. Reprocess entire Aqua mission.

g. 8 January 2004
   1. MSl12 v3.5.2 (minor fix)
   2. Implement single-point (time-independent) vicarious gain adjustments using avaiable MOBY matchups.
   3. Still using latest L1B LUT from MCST
   4. Reprocess entire Aqua mission.

h. 26 January 2004
   1. Still MSl12 v3.5.2
   2. Still using latest L1B LUT from MCST
   3. Change from full BRDF correction to “Gothic-R” geometry correction only.
   4. Regenerate vicarious calibration to account for BRDF change.
   5. Reprocess entire Aqua mission.

i. 4 May 2004
   1. MSl12 v4.0.1
   2. L1B LUT V4.3.1.5S
   3. New polarization sensitivity tables (modisa_polsen_2004085.hdf).
   4. Change from “Gothic-R” BRDF correction to flat-ocean Fresnel.
   5. Reduced cloud threshold to 2.7% (SeaWiFS threshold).
   6. Glint masking enabled at Level-3.
   7. Updated vicarious calibration.
   8. Reprocess entire Aqua mission.

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