Science Impact of MODIS Calibration Degradation and C6+ Improvements


Special thanks to MODAPS for CEOS desert sites subsets

MODIS Science Team Meeting
April 29, 2014
C5 Trends: Aerosol and Clouds

DT Aerosol: AOD and AE (R. Levy)

Cloud Opt. Properties: COT (S. Platnick)

Levy et al. (2010), Global evaluation of the Collection 5 MODIS dark-target aerosol products over land, ACP.

Koukouli et al. (2010), Signs of a negative trend in the MODIS aerosol optical depth over the Southern Balkans, Atm. Environ.
C5 Trends: Land

- Reported NPP decrease of 0.55 PgC/decade;
- Tropics: 91% of global NPP var. (Amazon: 61%);

ΔNDVI=0.01 ~ 1 PgC GPP

Wang, Morton et al. (2012), Impact of sensor degradation on the MODIS NDVI time series, RSE.

Amazon Browning and Greening Anomalies from MOD09 C5 (dashed) and MAIAC C6 L1B data (solid).

Correlation Analysis with MEI – Hilker & Lyapustin
Polarization Sensitivity of MODIS Terra

- Part of nadir aperture door was overheated during TVC;
- May 2003 anomaly: SD diffuser door permanently open, SD screen closed.

Illustration of MODIS Terra MS difference & polarization sensitivity with MAIAC (10km striping).
Polarization Correction: Terra-Aqua Xcal
(algorithm developed by the ocean color team)

\[ \frac{L_m}{M_{11}} = L_t + m_{12}Q + m_{13}U \]

- \( L_m \): measured TOA radiance (Terra)
- \( L_t \): expected TOA radiance (from L3 Aqua)
- \( Q, U \): linear Stokes vector components, modeled from Rayleigh and glint
- \( M_{11}, m_{12}, m_{13} \): fitted instrument characterization parameters (depend on band, MS, detector, scan angle)
Cross-calibration of MODIST to MODISA: correction coefficients for 443nm

Scan angles (frame): lunar (22), nadir (675), Solar diffuser (989), end-of-scan (1250)
Polarization Correction: MAIAC Analysis

Right side of scan: improved AOT and SR (2012, DOY 349)

Uncorrected

- TOA
- CM
- BRF
- AOT

10km striping

Corrected

- TOA
- CM
- BRF
- AOT
Polarization Correction: Detailed MAIAC Analysis (clear-sky pixels, monthly averages)

Partitioning between RVS and PC
Bias Partitioning Between AOT and BRF in MAIAC (cloud-free pixels)

April 12, 2003 (Georgia, 500km Tile)

TOA

AOT

Atlanta

BRF

CM

Average B3 BRF: trend ~0.002/decade

Average B1 BRF: trend ~0.003/decade

AOT Monthly Average

Uncorrected

Corrected

Dec-01 May-03 Sep-04 Feb-06 Jun-07 Nov-08 Mar-10 Jul-11 Dec-12
CEOS Desert Site Analysis: Monthly BRF$_n$

1. PC introduces artifacts in Red (B1) and Green (B4) bands. Decided to use PC for the “Blue” spectral region only (B3, B8-B10).
2. Small residual trend and T-A bias
MODIS de-trending and X-calibration

- Repeated trend analysis based on normalized daily TOA reflectances ($R_n$). Use of *daily* (vs *monthly*) values helps avoid sampling bias;
- The $R_n$ ($\lambda$) were computed for fixed geometry ($\text{VZA}=0^\circ$, $\text{SZA}=45^\circ$) using MAIAC BRDF, WV, AOT. Normalization of geometry allows X-calibration between Terra and Aqua based on TOA radiance.
- Selected 4 sites (*Libya1, Libya2, Libya4, Egypt1 – thanks MODAPS!* with similar trends. Three sites were excluded: *Niger* shows strong seasonality, and *Sudan1, Mali1* gave much larger and opposing trends.
MODIS de-trending and X-calibration

• Obtained trends per unit of reflectance were averaged over 4 selected sites;
• The average de-trending was applied to Terra and Aqua giving new L1B.
• Normalized TOA reflectance were generated again for 4 sites. The final X-cal gain adjustment (for Terra) was obtained as an average over 4 sites.

### Average trend/decade/unit_refl.

<table>
<thead>
<tr>
<th>Bands</th>
<th>$\Delta_T$</th>
<th>$\sigma$</th>
<th>$\Delta_A$</th>
<th>$\sigma$</th>
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<tbody>
<tr>
<td>B1</td>
<td>0.0048</td>
<td>0.0020</td>
<td>-0.0046</td>
<td>0.0022</td>
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<tr>
<td>B2</td>
<td>0.0035</td>
<td>0.0019</td>
<td>-0.0062</td>
<td>0.0027</td>
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<tr>
<td>B3</td>
<td>-0.0082</td>
<td>0.0015</td>
<td>-0.0048</td>
<td>0.0016</td>
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<tr>
<td>B4</td>
<td>0.0049</td>
<td>0.0022</td>
<td>-0.0021</td>
<td>0.0023</td>
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<tr>
<td>B8</td>
<td>0.0094</td>
<td>0.0015</td>
<td>-0.0015</td>
<td>0.0013</td>
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</tbody>
</table>

### Average X-gain for Terra

<table>
<thead>
<tr>
<th>Bands</th>
<th>Egypt1</th>
<th>Libya1</th>
<th>Libya2</th>
<th>Libya4</th>
<th>Xcal gain</th>
<th>$\sigma$</th>
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<tbody>
<tr>
<td>B1</td>
<td>1.017</td>
<td>1.023</td>
<td>1.021</td>
<td>1.019</td>
<td>1.020</td>
<td>0.0024</td>
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<td>B2</td>
<td>1.004</td>
<td>1.008</td>
<td>1.007</td>
<td>1.006</td>
<td>1.006</td>
<td>0.0016</td>
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<tr>
<td>B3</td>
<td>0.989</td>
<td>0.992</td>
<td>0.992</td>
<td>0.990</td>
<td>0.991</td>
<td>0.0013</td>
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<tr>
<td>B4</td>
<td>1.006</td>
<td>1.013</td>
<td>1.010</td>
<td>1.009</td>
<td>1.009</td>
<td>0.0031</td>
</tr>
<tr>
<td>B8</td>
<td>0.997</td>
<td>0.996</td>
<td>0.998</td>
<td>0.994</td>
<td>0.996</td>
<td>0.0015</td>
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Final Analysis for Georgia: BRFn, NDVI, EVI

<table>
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<tr>
<th>Version</th>
<th>ΔNDVI</th>
<th>ΔEVI</th>
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<tr>
<td>Terra_C5</td>
<td>-0.021</td>
<td>-0.032</td>
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<td>Terra_Final</td>
<td>-0.012</td>
<td>-0.010</td>
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<td>Aqua_Final</td>
<td>-0.008</td>
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</table>

ΔNDVI=0.01 ~ 1 PgC
Summary

• Adapted OBPG PC for atmospheric/land processing;
• Developed de-trending and X-calibration technique based on desert sites analysis. This technique will be transferred to the calibration group;
• The L1B post-processing code (PC, de-trending, X-calibration gain factor) is provided to MODAPS group for global testing. The current consensus is the discipline-based implementation for C6 re-processing;

Final Considerations

• The remaining uncertainties from de-trending analysis are large (limited stats; non-uniform behavior over different “presumably stable” sites), yet proposed corrections cause changes in the right direction;
• Proposal: Prototype de-trending approach for Greenland ice sheet (e.g. Summit, 3.5km) where change is minimal and RGB signal much larger (expect at least a factor of 2 reduction in uncertainty);
• Changes are needed in L1B calibration (B3, B8): polarization correction should become a part of RVS-trending rather than a post-processing (J. Xiong).