Comparison of single- and multi-channel AOD revisited

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Objective and Strategy

**Motivation:**
- Two aerosol products are reported in the CERES SSF data:
  a) derived from the NASA/GSFC multi-channel MODIS AOD and
  b) estimated from MODIS reflectances with the NOAA/NESDIS single-channel algorithm.

**Objective:**
- Compare single-channel and multi-channel retrievals of AOD when **only** the algorithms differ.

**Strategy:**
- Retrieve single-channel AOD$_S$ at 25 oceanic locations from reflectances in the NASA/GFSC MODIS Atmosphere Parameters Subset Statistics (MAPSS) dataset.
- Compare AOD$_S$ with multi-channel (level 2 MOD04, MYD04) AOD$_M$ from MAPSS.
The MAPSS data

MODIS Atmosphere Parameters Subset Statistics (MAPSS) dataset has spatial statistics for 5 by 5 boxes:

- the reflectance at the middle point in a 5 by 5 box,
- AOD at the middle point in a 5 by 5 box,
- average of 10-km reflectances in a 5 by 5 box used in AOD retrieval,
- average of 10-km AOD in a 5 by 5 box.
25 sites representing different dominant aerosol types are selected for this study.

Only three sites (in red) have SP.
Revisiting the Problem

• Results presented at the 2\textsuperscript{nd} CERES-II meeting:
  – good agreement in 1632-nm channel AODs,
  – positive single-channel AOD bias in 644-nm channel,
  – scattering-angle dependent bias.

• So why again?
  – MODIS retrieval was revised (Collection 5).
  – MAPSS reflectances are from L2 not L1 as previously assumed. They are already “corrected” for gas absorption!

• Previous study accounted for gas absorption twice, thus over estimated AOD.
MAPSS Reflectance Checks

- Reflectances in the original L2 HDF files were compared to those in MAPSS.
  - Identical reflectances.
- The locally implemented MODIS code, for which the L2 HDF files are direct inputs, was used to retrieve the AOD.
  - Identical AODs.
- Conclusion: MAPSS reflectances are indeed corrected for gas absorption.
Single-Channel AOD Retrievals

- **Calculated new LUT**
  - Same procedure as for CERES, but no gas absorption.

- **AOD retrieval from 10-km reflectance:**
  - for **anti-solar** side of orbit, and solar zenith < 70°, sensor zenith < 60°:
    - **Collection 5 Terra/MODIS:**
      - 02/2000 – 06/2007 (31 months)
    - **Collection 5 Aqua/MODIS:** 07/2002 – 06/2007 (34 months)

AOD is retrieved from the **644-nm** and **1632/2119-nm** channels.
Mean difference MD for Terra is small; it is larger for Aqua.

<table>
<thead>
<tr>
<th>AOD$_S$-AOD$_M$</th>
<th>10-km</th>
<th>50-km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terra</td>
<td></td>
<td></td>
</tr>
<tr>
<td>644 nm</td>
<td>0.004</td>
<td>0.002</td>
</tr>
<tr>
<td>1632 nm</td>
<td>0.000</td>
<td>-0.005</td>
</tr>
<tr>
<td>Aqua</td>
<td></td>
<td></td>
</tr>
<tr>
<td>644 nm</td>
<td>0.015</td>
<td>0.014</td>
</tr>
<tr>
<td>2119 nm</td>
<td>-0.020</td>
<td>-0.029</td>
</tr>
</tbody>
</table>

50-km statistics of MD are similar to those for the 10 km central MAPSS pixel.
Scatter plot of single-channel AOD vs. multi-channel AOD at 644 nm and 1632 (2119) nm for the single-channel geometry.

Relative to the multi-channel AOD, single-channel AOD is larger/smaller at small/large AOD.
AOD_S > AOD_M at small AOD
- Compared MODIS and single-channel LUTs with AOD=0
  - \( R_S < R_M \)
  - converted \( R_S - R_M \) to AOD with SS approx.
  - not large enough to explain offset.

AOD_S < AOD_M at large AOD
- More obvious as wavelength increases
- Large AOD is usually associated with large particles according to MODIS
  - Partially explains single- and multi-channel AOD difference (next slide)

### Table

<table>
<thead>
<tr>
<th>Wavelength (nm)</th>
<th>( R_S - R_M )</th>
<th>AOD_S - AOD_M</th>
<th>Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td>644</td>
<td>-1.058E-3</td>
<td>0.013</td>
<td>0.019</td>
</tr>
<tr>
<td>1632</td>
<td>-2.809E-4</td>
<td>0.005</td>
<td>0.024</td>
</tr>
<tr>
<td>2119</td>
<td>-1.839E-4</td>
<td>0.004</td>
<td>0.017</td>
</tr>
</tbody>
</table>

### Graph

- Number of MODIS retrievals
- AOD at 644nm
- AOD at 1632nm
- Multi-channel AOD
- Multi-channel Fine Mode Weight
• AOD$_S$ < AOD$_M$ at lower end of scattering angle range; reverse is true at upper end at 644 nm.
• AOD at these scattering angles is associated with larger particles.
• Single- and multi-channel phase function differences may explain the AOD difference.
Summary

• Compared single- and multi-channel AOD derived from the same “aerosol” reflectance at oceanic sites.

• Good agreement between S and M products in spite of substantial algorithm differences.

• Agreement is better for Terra than Aqua (not clear why).

• Scattering angle dependence of the AOD difference can be partially explained by the different aerosol models applied in the retrievals.

• On average:
  – $\text{AOD}_S > \text{AOD}_M$ at 644 nm
  – $\text{AOD}_S \geq \text{AOD}_M$ at 1632 nm
  – $\text{AOD}_S \leq \text{AOD}_M$ at 2119 nm