Validation of Suomi NPP VIIRS Aerosol Optical Thickness and Particle Size Parameter with AERONET

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• VIIRS aerosol products, AOT and APSP (AE), are derived from 412 - 2,250 nm VIIRS M bands.

• Preliminary evaluation of AOT for May 2, 2012/Jan 23, 2013 - Sep 1, 2013 aerosol data is in Liu et al. (2014):
  – Global biases: 0.01 over ocean and -0.01 over land
  – 64% (land) and 71% (ocean) of retrievals fall within the expected uncertainty range established by MODIS (!) [ocean: ±(0.03 + 0.05AOT); land: ±(0.05 + 0.15AOT)]

• This presentation extends the period to Dec 31, 2014 and establishes expected error range from VIIRS AOT & APSP.

• Outline
  – Aerosol data used
  – Matchup protocol
  – Results
• **VIIRS:**
  
  – *Aerosol Optical Thickness (AOT)* Environmental Data Record (EDR) (6 km): best quality AOT at 550 nm;
  
  – *Aerosol Particle Size Parameter (APSP)* EDR over ocean (6 km) reported as the Ångström Exponent (AE): calculated from AOTs at 865 nm and 1610 nm;
  

• **AERONET:**
  
  – Level 2.0 AERONET Direct Sun Algorithm AOT wavelengths 380-870 nm, and at 1640 nm (Holben et al., 1998; Smirnov et al., 2000)
  
  – AERONET AOTs are interpolated to VIIRS wavelengths using a 2nd order polynomial fit in logarithmic coordinates. (Eck et al., 1999; Remer et al., 2005; Levy et al., 2010, Kahn et al., 2010)
**VIIRS-AERONET AOT Matchup**

**Matchup Protocol:**
Follows Multi-sensor Aerosol Products Sampling System (MAPSS)

**Matchup Criteria:**
- At least 2 AERONET L2.0 measurements are available within time window;
- At least 20% of VIIRS best quality AOT retrievals are available within spatial domain.

**Averages of AOTs are saved in matchup.**

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Figure credit of NASA GSFC MAPSS Group, P. Maksym & C. Ichoku
(http://disc.sci.gsfc.nasa.gov/aerosols/services/mapss/)
• Daily AOTs \((a, c)\), daily and monthly mean AOT differences \((b, d)\) over land and ocean.

• Day-to-day variability \((a, c)\) is similar.

• Large seasonal dependence of bias over land \((b)\); \(>0\) during NH summer, \(<0\) NH winter. (Because of constant surface reflectance ratios ?)

• No significant seasonal variability of bias over ocean, but persistent positive bias is present \((d)\).
Land: Large scatter, but small overall bias (due to cancellation of errors). High AOT is underestimated.

Ocean: Smaller scatter, but overall positive bias (doubled wrt. Liu at al., 2014). Smaller/larger particles from VIIRS when AERONET suggest larger/smaller particles.
# EDR vs. JPSS L1RD Requirements

<table>
<thead>
<tr>
<th>AOT range</th>
<th>Accuracy</th>
<th>Precision</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>specs</em></td>
<td><em>VIIRS</em></td>
</tr>
<tr>
<td>LAND AOT (01/23/2013-12/31/2014)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AOT &lt; 0.1</td>
<td>0.06</td>
<td>0.03</td>
</tr>
<tr>
<td>0.1 ≤ AOT ≤ 0.8</td>
<td>0.05</td>
<td>-0.01</td>
</tr>
<tr>
<td>0.8 &lt; AOT ≤ 2.0</td>
<td>0.20</td>
<td>-0.19</td>
</tr>
<tr>
<td>OCEAN AOT (05/02/2012-12/31/2014, excluding 10/15/2012-11/27/2012)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AOT &lt; 0.3</td>
<td>0.08</td>
<td>0.03</td>
</tr>
<tr>
<td>0.3 ≤ AOT ≤ 2.0</td>
<td>0.15</td>
<td>0.02</td>
</tr>
<tr>
<td>OCEAN AE (05/02/2012-12/31/2014, excluding 10/15/2012-11/27/2012)</td>
<td></td>
<td></td>
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<tr>
<td>865nm/1610nm</td>
<td>0.30</td>
<td>0.10</td>
</tr>
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</table>

Meeting JPSS requirements
Bin VIIRS-AERONET differences according to AERONET (VIIRS) AOT

Calculate mean bias (circle) and (1 \( \sigma \)) standard deviation (box) for each bin.

Linearly fit bin values of mean bias (\( EA \)) and standard deviation (\( EP \)) as function of AERONET (VIIRS) AOT.

Expected Error: \( EE = EA \pm EP \)

- 79% within EE range
- 80% within EE range
Expected Error Estimates

**OCEAN AOT Diff. (VIIRS EDR - AERONET L2), M2M, best QA**

- N = 13976; $\tau$, Bin #: 50
- EA = $-0.017*\tau + 0.028$
- EP = $0.203*\tau + 0.020$
- EE = EA ± EP
- EEPA = 89.7%
- EEPP = 98.4%

76% within EE range

**OCEAN AOT Diff. (VIIRS EDR - AERONET L2), M2M, best QA**

- N = 13976; $\tau$, Bin #: 50
- EA = $0.120*\tau - 0.004$
- EP = $0.214*\tau + 0.012$
- EE = EA ± EP
- EEPA = 98.4%
- EEPP = 89.7%

78% within EE range

**OCEAN AE Diff. (VIIRS EDR - AERONET L2), M2M, best QA**

- N = 5955; AE, Bin #: 50
- EA = $-0.542*AE + 0.595$
- EP = 0.362
- EE = EA ± EP
- EEPA = 46.0%
- EEPP = 74.6%

70% within EE range

**OCEAN AE Diff. (VIIRS EDR - AERONET L2), M2M, best QA**

- N = 5955; AE, Bin #: 50
- EA = $0.022*AE + 0.074$
- EP = 0.537
- EE = EA ± EP

70% within EE range
Motivation: AERONET and VIIRS AOTs are samples of the AOT “population”; should have similar PDFs
• Assume the samples follow a lognormal distribution [O’Neill et al., 2000] and display them on a Probability plot (CDF; Benard median score was used)
  • VIIRS empirical CDF can be compared to AERONET CDF fit.
    • (If true the fit could be used to (objectively) detect outliers.)
• Actually, they do not! But still can be used for comparison.
  • VIIRS and AERONET fit parameters (shape and scale) are similar
Accuracy, Precision and Expected Errors of VIIRS AOT and APSP EDRs are estimated from a 2+ year record of VIIRS retrievals and AERONET L2 data.

Bias over land/ocean is smaller/larger than that in the shorter time period in Liu et al. (2014), but still within JPSS specs.

<table>
<thead>
<tr>
<th></th>
<th>Land AOT</th>
<th>Ocean AOT</th>
<th>Ocean AE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Size</td>
<td>21223</td>
<td>13976</td>
<td>5955</td>
</tr>
<tr>
<td>Accuracy</td>
<td>0.002</td>
<td>0.025</td>
<td>0.097</td>
</tr>
<tr>
<td>Precision</td>
<td>0.120</td>
<td>0.060</td>
<td>0.554</td>
</tr>
<tr>
<td>Uncertainty</td>
<td>0.120</td>
<td>0.065</td>
<td>0.562</td>
</tr>
<tr>
<td>Corr. Coef.</td>
<td>0.815</td>
<td>0.918</td>
<td>0.667</td>
</tr>
<tr>
<td>Slope</td>
<td>0.742</td>
<td>0.953</td>
<td>0.457</td>
</tr>
<tr>
<td>Intercept</td>
<td>0.047</td>
<td>0.031</td>
<td>0.597</td>
</tr>
<tr>
<td>EEPA</td>
<td>60.0%</td>
<td>89.7%</td>
<td>46.0%</td>
</tr>
<tr>
<td>EEPP</td>
<td>94.5%</td>
<td>98.4%</td>
<td>74.6%</td>
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