JPSS Risk Reduction Suspended-mater Algorithm

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JPSS Risk Reduction SM Product

Output for each pixel (about 750m at nadir):

1. SM type flags: (1-presence; 0-Absence)
   - Volcanic ash flag
     passed on from Cloud mask
   - Dust flag
   - Smoke flag
   - Others
     (none/unknown/clear)
   - Cloud flag
   - Snow/ice flag

2. Dust/smoke aerosol index values

3. Quality flags (00/01/11)
   low, medium and high quality for SM type
6S Radiative Transfer Simulations

6S Simulations:
1. MODIS C5 dust aerosol model used
2. Desert, vegetation, ocean BRDF with easterly wind speed of 6 m/s are used to represent surfaces in 6S

DUST reduces the contrast between 412nm and 440 nm as absorption by dust increases with decreasing wavelength.
MODIS Observations: Dust vs. Clear Sky
Smoke:
- Has the similar effect as dust in terms of reduction of the contrast between 412nm to 440nm
- Difference in particle size enables us to pick-out the smoke by introducing short-wave IR channel (2.13 μm)
Dust Aerosol Index (DAI)

$$\text{DAI} = -100 \times [\log_{10}(R_{412\text{nm}}/R_{445\text{nm}}) - \log_{10}(R'_{412\text{nm}}/R'_{445\text{nm}})]$$

$$\text{NDAI} = -10 \times [\log_{10}(R_{412\text{nm}}/R_{2250\text{nm}})]$$

$R'$ -- reflectance from Rayleigh scattering

Detection will not be performed for the following conditions:

- **Clouds**
  - screened by using $R_{412\text{nm}}$ and cloud mask
- **Residual Clouds**
  - over water:
    - screened by using 860nm spatial variability test.
  - Over land:
    - screened by 412nm spatial variability test.
- **Bright surfaces**
  - screened by using bright pixel index (normalized difference of 1.24 $\mu$m and 2.25 $\mu$m).
- **Turbid water**
  - Screened with test based on Shi and Wang (2007) uses 746 nm and 1.24 $\mu$m measurements.
- **Sunglint (for dust only), snow/ice, fire hot spots**
  - screened based on different tests (geometry, spectral etc.)
Dust is detected if DAI and NDAI pass these tests:
- **Water**: DAI ≥ 4 and NDAI ≥ -10
- **Land**: DAI ≥ 11.5 and NDAI ≥ 0
Smoke is detected if DAI and NDAI pass these tests:

- **Water:**
  - thin smoke: $\text{DAI} \geq 4.0$ and $\text{NDAI} \leq -10.0$
  - thick smoke: $\text{DAI} \geq 9.0$ and $\text{NDAI} \leq -4.0$ and $0.2 < R_{410} < 0.4$

- **Land:**
  - thin smoke: $\text{DAI} \geq 5.0$ and $\text{NDAI} \leq -2.0$
  - thick smoke: $\text{DAI} \geq 9.0$ and $\text{NDAI} \leq -2.0$
Dust and Smoke Detection Examples

Smoke plume shown in the VIIRS RGB image on August 3, 2014 Over west coast of U.S.

VIIRS smoke detection algorithm identifies the smoke plumes including the one removed from fire hot spots
Sahara dust outbreaks

September 14, 2013

December 14, 2013
Transatlantic dust transport

Year of 2014
Smoke outbreak over U.S.
06/08 to 07/15/2015
Validation Strategy

- Dust/smoke detection algorithm run on VIIRS data for the entire year of 2013 and 2014.
  - VIIRS smoke/dust detection matchup with AERONET Observations
  - VIIRS smoke and dust detection matchups with CALIPSO VFM
- Derive performance metrics
  - Accuracy
  - Probability of Correct Detection (POCD)
  - Probability of False Detection (POFD)

<table>
<thead>
<tr>
<th>VIIRS</th>
<th>TRUTH DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>No</td>
<td>C</td>
</tr>
</tbody>
</table>

POCD = $A/(A+C)$
POFD = $B/(A+B)$
Accuracy* = $(A+D)/(A+B+C+D)$
## VIIRS vs. CALIPSO

### Year of 2013 and 2014

#### Land

<table>
<thead>
<tr>
<th>Type</th>
<th>True positive</th>
<th>False positive</th>
<th>True negative</th>
<th>False Negative</th>
<th>Accuracy (%)</th>
<th>POCD (%)</th>
<th>FAR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DUST</td>
<td>10669</td>
<td>170</td>
<td>5676</td>
<td>2840</td>
<td>84.4</td>
<td>80.0</td>
<td>1.6</td>
</tr>
<tr>
<td>SMOKE</td>
<td>307</td>
<td>159</td>
<td>19534</td>
<td>14</td>
<td>99.1</td>
<td>96.7</td>
<td>34.1</td>
</tr>
</tbody>
</table>

#### Water

<table>
<thead>
<tr>
<th>Type</th>
<th>True positive</th>
<th>False positive</th>
<th>True negative</th>
<th>False Negative</th>
<th>Accuracy (%)</th>
<th>POCD (%)</th>
<th>FAR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DUST</td>
<td>297</td>
<td>11</td>
<td>139</td>
<td>10</td>
<td>95.4</td>
<td>96.4</td>
<td>3.3</td>
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<tr>
<td>SMOKE</td>
<td>601</td>
<td>507</td>
<td>7605</td>
<td>15</td>
<td>94.0</td>
<td>97.5</td>
<td>45.7</td>
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</tbody>
</table>
## VIIRS vs. AERONET (DUST)

<table>
<thead>
<tr>
<th>Stations</th>
<th>True positive</th>
<th>False positive</th>
<th>True negative</th>
<th>False negative</th>
<th>Accuracy</th>
<th>POCD</th>
<th>POFD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Darkar</td>
<td>2013</td>
<td>63</td>
<td>1</td>
<td>106</td>
<td>10</td>
<td>93.9</td>
<td>86.3</td>
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<tr>
<td></td>
<td>2014</td>
<td>74</td>
<td>3</td>
<td>45</td>
<td>10</td>
<td>90.1</td>
<td>88.1</td>
</tr>
<tr>
<td>Solar_Village</td>
<td>2013</td>
<td>81</td>
<td>26</td>
<td>59</td>
<td>30</td>
<td>71.4</td>
<td>73.0</td>
</tr>
<tr>
<td></td>
<td>2014</td>
<td>11</td>
<td>4</td>
<td>65</td>
<td>5</td>
<td>89.4</td>
<td>68.8</td>
</tr>
<tr>
<td>Capo_Verde</td>
<td>2013</td>
<td>44</td>
<td>0</td>
<td>56</td>
<td>3</td>
<td>97.1</td>
<td>93.6</td>
</tr>
<tr>
<td></td>
<td>2014</td>
<td>53</td>
<td>1</td>
<td>17</td>
<td>1</td>
<td>97.2</td>
<td>98.1</td>
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</tbody>
</table>

### Over 440 AERONET stations

<table>
<thead>
<tr>
<th></th>
<th>Accuracy</th>
<th>POCD</th>
<th>POFD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year of 2013 and 2014</td>
<td>98.5</td>
<td>84.6</td>
<td>14.7</td>
</tr>
</tbody>
</table>
## VIIRS vs. AERONET (Smoke)

<table>
<thead>
<tr>
<th>Stations (Biomass – burning)</th>
<th>True positive</th>
<th>False positive</th>
<th>True negative</th>
<th>False negative</th>
<th>Accuracy</th>
<th>POCD</th>
<th>POFD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alta_Floresta</td>
<td>10</td>
<td>0</td>
<td>178</td>
<td>0</td>
<td>100.0</td>
<td>100.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Bonanza_Creek</td>
<td>1</td>
<td>0</td>
<td>48</td>
<td>0</td>
<td>100.0</td>
<td>100</td>
<td>0.0</td>
</tr>
<tr>
<td>Jabiru</td>
<td>1</td>
<td>0</td>
<td>313</td>
<td>0</td>
<td>100.0</td>
<td>100.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Moscow_MSU_MO</td>
<td>16</td>
<td>2</td>
<td>92</td>
<td>1</td>
<td>97.2</td>
<td>94.1</td>
<td>11.0</td>
</tr>
<tr>
<td>Tomsk_22</td>
<td>17</td>
<td>1</td>
<td>83</td>
<td>0</td>
<td>99.0</td>
<td>100.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Yakutsk</td>
<td>22</td>
<td>1</td>
<td>88</td>
<td>1</td>
<td>98.2</td>
<td>95.6</td>
<td>4.3</td>
</tr>
</tbody>
</table>

### Over 401 AERONET stations

<table>
<thead>
<tr>
<th>Year of 2013 and 2014</th>
<th>Accuracy</th>
<th>POCD</th>
<th>POFD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>97.5</td>
<td>91.6</td>
<td>18.5</td>
</tr>
</tbody>
</table>
VIIRS vs. AERONET (dust)
VIIRS vs. AERONET (smoke)
Near-real time run of JPSS SM algorithm on S-NPP VIIRS DB data

1. JPSS RR SM algorithm has been implemented by using near-real time S-NPP VIIRS DB data over both CONUS and OCONUS

2. It provides daily monitoring of smoke/dust event over CONUS and Alaska
Summary

• JPSS RR Suspended Matter algorithm is simple, fast, and easy to be implemented operationally.

• Validation results indicated that Accuracy and POCD for dust and smoke detection can be as high as 90% and 80 %, respectively.

• Additional investigation of data artifacts (false detections) is required to enhance product accuracy.