Aerosol layer height climatology derived from synergistic use of UV-VIS sensors

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Why Aerosol Height?

• Radiative effects:
  - Vertical profile of radiation field
  - Aerosol-cloud interactions

• Air quality:
  - Link between total column vs. surface-level aerosol concentrations
  - Different altitudes for different targets, i.e., surface air quality or aviation safety

• Aerosol transport modeling:
  - Indicative of long-range transport
  - Model evaluations for injection height
The objective is to provide the height of UV absorbing aerosols with daily global coverage using passive UV-VIS sensors.
Aerosol Height from Space

IR technique (Lyapustin et al., in press)

O$_2$–O$_2$ band (e.g. Chimot et al., 2018)

Oxygen A/B-band (e.g. Sanders et al., 2015; Xu et al., 2019)

2016-04-17 11:23 UTC
• Synergistic use of MODIS, OMI, and CALIOP
• UVAI ~ f(AOD, SSA, ALH)
• Applied to smoke aerosols only
• Smoke detection based on UVAI and Ångström exponent
• Jeong and Hsu (2008)
• Application extended to mineral dust layers and VIIRS/OMPS
• Lee et al. (2015, 2016)
• Retrieves aerosol layer height and SSA using UVAI and 412 nm TOA reflectance

• AOD and surface reflectance constrained by VIIRS Deep Blue product

• Aerosol optical model:
  - Bimodal lognormal distribution
  - 550 nm fine-mode AOD fraction
  - Absorption AE
  - Nonspherical dust
Evaluation against CALIOP over N. America

**VIIRS-OMPS-CALIOP**

Smoke Altitude (North America)

August 2012-2018
AOD > 1.0

- N = 39
- MB = +0.1 km
- RMSE = 0.6 km
- f = 89%(94%)

**VIIRS-OMPS**

Smoke Altitude (North America)

August 2012-2018
AOD > 1.0

- N = 42
- MB = -0.1 km
- RMSE = 1.1 km
- f = 61%(90%)

**VIIRS-TROPOMI**

Smoke Altitude (North America)

August 2018
AOD > 1.0

- N = 22
- MB = -0.3 km
- RMSE = 1.0 km
- f = 77%(90%)
### Smoke Altitude over Major Source Regions

#### Number of smoke pixels

<table>
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<tr>
<th>Region</th>
<th>2012-2017</th>
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<tbody>
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<td>N. America</td>
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<td>S. America</td>
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#### Percentage above PBL

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<tr>
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<tr>
<td>S. America</td>
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<td>S. Africa</td>
<td>37%</td>
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<tr>
<td>SE Asia</td>
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<td>Siberia</td>
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#### Percentage above SAL

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<td>SE Asia</td>
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<td>Siberia</td>
<td>27%</td>
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AOD-PM2.5 relationship for smoke aerosols

VIIRS DB AOD (550 nm) - 04 SEP 2017

ASHE Aerosol Altitude - 04 SEP 2017

PM$_{2.5}$/AOD - 04 SEP 2017

PM$_{2.5}$–AOD Relationship over CONUS

Smoke PM$_{2.5}$–AOD Relationship over CONUS

Overall

Smoke

H < PBL

H = ~PBL

H > PBL
Synergistic use of UV-VIS sensors or sensors with similar capability (TROPOMI, OCI/PACE, etc.) have potential to provide daily global aerosol height of biomass burning smoke and mineral dust.

Present algorithm can run without CALIOP observations, significantly improving data coverage and facilitating the implementation in the operational processing system.

Comparison against CALIOP over North America suggests retrieval accuracy within ~1-1.5 km when considering the entire transect for wildfire smoke cases.

Since ASHE utilizes Level 2 aerosol products, it can directly benefit from future improvements to the data set. Improvements in AOD from V2 VIIRS DB and C7 MODIS DB are underway.

The ASHE retrievals can inform Deep Blue of appropriate aerosol model and height for better AOD retrievals, which can in turn improve the performance of ASHE.
Saharan Dust Transport

ASHE Aerosol Altitude - MAR 2012-2017

CALIOP Aerosol Altitude - MAR 2012-2017

ASHE Aerosol Altitude - JUN 2012-2017

CALIOP Aerosol Altitude - JUN 2012-2017