Assessment of OMI decadal record on aerosol absorption

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September 29-October 2, 2014
Sheraton, Steamboat Springs, CO
Ozone Monitoring Instrument (OMI)

An international project: Holland, USA, Finland

Nadir solar backscatter spectrometer
-270-500 nm

-13X24 km footprint

-2600 km swath width

-Launched on 07-15-04

One of four sensors on the EOS-Aura platform (OMI,MLS,TES, HRDLS)

Retrieval Products:
Radicals: Column $O_3$, NO$_2$, BrO, OCIO
$O_3$ profile
Tracers: Column SO$_2$
Cloud top pressure
Aerosols

OMI flies on the A-train
As of Nov 17-2011, 29 rows (1 thru 24 and 56-60) out of 60 remain unaffected. Currently OMI achieves global coverage in 2 days.
OMI Near-UV Aerosol Algorithm (OMAERUV)

**Purpose:** Retrieval of Aerosol Single Scattering Albedo and Absorption Optical Depth

**Measurements:** Radiances at 354 and 388 nm (13 x 24 km²)

**Physical Basis:** Radiative interaction between particle absorption and molecular scattering in the UV.

In spite the sensor’s coarse resolution for aerosol retrieval, valuable information on particle absorption can be derived from OMI near UV observations.

**Retrieval Products:**
- AOD and SSA (388 nm)
- Absorbing Aerosol Index

**Inversion Scheme:**
For a given aerosol type and ALH, satellite measured radiances at 354 and 388 nm are associated with a set of AOD and SSA values.

Level2 calibrated radiances at 354 and 388 nm

Three aerosol types:
- Desert Dust
- Carbonaceous aerosols
- Weakly absorbing

Seven aerosol models per type (varying $\omega_0$)

Assumed aerosol parameters:
- Particle size distribution
- Real comp. refractive index
- Relative spectral dep. of imag. refractive index.

OMAERUV Retrieval Procedure

Radiative Transfer Calculations

Absorbing Aerosol Index

Cloud Screening

Aerosol Type

Aerosol Layer Height (CALIOP Climatology)

Inversion Scheme

Surface Albedo (TOMS Climatology)

-AIRS CO data
-Surface Type

Extinction optical depth
Single Scattering Albedo

Retrievals over the ocean only account for the presence of desert dust and carbonaceous aerosols.
**Aerosol Type Identification in OMAERUV**

The presence of weakly (or non) absorbing aerosols is assumed if $\text{AAI} < 0.8$ (land only).

If $\text{AAI} > 0.8$ the aerosol load is assumed to be either carbonaceous or desert dust aerosols.

At the two near UV channels (354 and 388 nm) there is no information to differentiate smoke from dust.

External CO information from Aqua-AIRS is used to select either smoke or dust.

- If $\text{CO} \geq \text{CO}_0$ smoke type is selected.
- If $\text{CO} < \text{CO}_0$ dust type is selected.

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The combined use of Al and CO allows the identification of smoke layers over arid areas.

CALIOP-based Aerosol Height Climatology

Torres, O., C. Ahn, and Z. Chen, Improvements to the OMI Near UV aerosol algorithm using A-train CALIOP and AIRS observations, AMT, 6, 3257-3270, 2013
Sample Retrieval (March 9, 2007)
AOD Validation

OMAERUV-AERONET AOD Comparison at representative sites:

1. **Desert Dust**
   - MD_Science_Center: $Q = 83.33$, $N = 234$, $\rho = 0.79$, $\text{RMS} = 0.08$
   - Tamanrasset: $Q = 73.07$, $N = 401$, $\rho = 0.88$, $\text{RMS} = 0.08$
   - IER_Cinzana: $Q = 61.90$, $N = 462$, $\rho = 0.83$, $\text{RMS} = 0.18$
   - Blida: $Q = 60.74$, $N = 326$, $\rho = 0.79$, $\text{RMS} = 0.11$

2. **Carbonaceous Aerosols**
   - Barcelona: $Q = 73.57$, $N = 367$, $\rho = 0.62$, $\text{RMS} = 0.10$
   - Dakar: $Q = 68.77$, $N = 381$, $\rho = 0.80$, $\text{RMS} = 0.15$
   - Mukdahan: $Q = 49.62$, $N = 133$, $\rho = 0.78$, $\text{RMS} = 0.16$
   - Agoufou: $Q = 62.34$, $N = 470$, $\rho = 0.87$, $\text{RMS} = 0.18$

3. **Urban Industrial Aerosols**
   - Skukuza: $Q = 80.18$, $N = 338$, $\rho = 0.82$, $\text{RMS} = 0.11$
   - Hamim: $Q = 50.98$, $N = 255$, $\rho = 0.63$, $\text{RMS} = 0.17$
   - Alta_Floresta: $Q = 61.32$, $N = 106$, $\rho = 0.91$, $\text{RMS} = 0.17$
   - Kanpur: $Q = 53.37$, $N = 193$, $\rho = 0.75$, $\text{RMS} = 0.25$
OMAERUV AOD Validation: The Global Picture

Number of pairs per 0.02 AOD bin. Maximum pair density (50 to 110) shown in pink.

65% of evaluated data agree within expected uncertainty (larger of 0.1 or 30%).

$y$-intercept = 0.10
Slope = 0.79
$Q = 64.93$

$N = 10134$
$\rho = 0.81$
RMS = 0.16
SSA Evaluation

OMAERUV SSA assessment: Comparison at selected AERONET sites

51% (75%) of matched pairs agree within 0.03 (0.05)
OMI versus AERONET

Global Picture

- OMI’s retrieved SSA is generally larger than AERONET’s.
- Retrievals agree with each other within AERONET’s stated uncertainty (±0.03) for AOD>0.4
- Closer agreement for larger aerosol loading.
The level of agreement improves with increasing AAI.
Retrievals agree with each other within AERONET’s stated uncertainty (±0.03) for AAI > 1.0.
Best agreement (±0.01) for AAI > 2.0.
SKYNET is a Japanese sky radiometer network (Chiba University) that uses sky-radiance measurements to derive aerosol particle size and optical properties (similar to AERONET).

Aerosol absorption properties are derived at 340, 380, 400, 500, 670, 1020 nm.

Observing sites in Japan, China, Thailand, Mongolia, South Korea, India, Europe.
OMAERUV – SKYNET SSA COMPARISON (2006-2008)

Preliminary comparison results
2007 AAOD Global Seasonal Average Maps

WINTER

SPRING

SUMMER

AUTUMN
Assessed long-term record of OMAERUV Aerosol Optical Depth and Single Scattering Albedo

OMI-AERONET comparison of monthly mean values of AOD and SSA over nine years

DAKAR, SENEGAL (14.4N, 17W)
OMI-AERONET comparison of monthly mean values of SSA over nine years (2)
Nine-year Global record of OMI Aerosol Absorption Optical Depth
Summary

Significant progress on the quantification of aerosol absorption has been achieved during the first decade of OMI operation.

- A ten year data set of 388 nm AOD and SSA has been derived from OMI observations.

- The decadal OMI AOD and SSA records have been evaluated by direct comparison to independent ground-based AERONET observations.

The OMI SSA and AAOD data sets are the first ever quantitative multi-year records on aerosol absorption from satellite-based observations.

Continuation of the OMI record on aerosol absorption is required for conclusive analyses of global/regional trends.