OMI SO$_2$ and AAI measurements of the Eyjafjallajökull ash cloud

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Figure: Colin Seftor, NASA/GSFC
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• ESA/DUE projects TEMIS and SACS
  http://www.temis.nl  http://sacs.aeronomie.be

• KNMI/NASA for OMI data

• EUMETSAT/O3MSAF for GOME-2 data

• ESA for SCIAMACHY data
Overview

• Algorithms for AAI and SO2 from OMI
• Strong and weak points of UV sensors
• Results
• Ground-based results
• Conclusions
• Outlook for future monitoring of ash clouds
UV satellite measurements

OMI:
• Dutch/Finnish instrument launched in July 2004 on NASA’s EOS/Aura
• Spectrometer 270 – 500 nm, resolution 0.45 nm at $\lambda > 310$ nm
• Pixel size 13x24 km$^2$ (subsatellite)
• 2600 km swath width
• Overpass over Western-Europe around 14 UTC

GOME-2:
• Launched in Nov 2006 on EUMETSAT’s Metop-A
• Spectrometer 240-800 nm, resolution 0.2 nm in UV
• Pixel size 40x80 km$^2$ (over entire swath)
• 1920 km swath width
• Overpass over Western Europe around 10 UTC
SCIAMACHY:

- German-Dutch-Belgian spectrometer launched in March 2002 on ESA’s Envisat
- 240-2380 nm, resolution 0.2 nm in UV
- Pixel size 30x60 km²
- 960 km swath width, only 50% of time nadir view
- Overpass over Western-Europe around 11 UTC
Absorbing Aerosol Index (AAI)

Definition:

\[
\text{residue} \quad r = -100 \cdot \left\{ 10 \log \left( \frac{R_{340}^{\text{meas}}}{R_{380}^{\text{meas}}} \right) - 10 \log \left( \frac{R_{340}^{\text{Rayleigh}}}{R_{380}^{\text{Rayleigh}}} \right) \right\}
\]

where the surface albedo \( A \) for the Rayleigh atmosphere simulations is such that:

\[
R_{380}^{\text{meas}} = R_{380}^{\text{Rayleigh}}(A)
\]

\( A \) is assumed to be wavelength independent:

\[
A_{340} = A_{380}
\]

The residue represents the observed 340/380 nm colour as compared to the pure Rayleigh colour. (OMI wavelength pair: 354-388 nm)
Generally:

- no clouds, no aerosols \( r = 0 \)
- clouds, no absorbing aerosols \( r < 0 \)
- absorbing aerosols \( r > 0 \)

**AAI:** \( r > 0 \)

+ AAI can detect UV absorbing aerosols:
  - volcanic ash, desert dust and smoke.
+ AAI works in cloudy scenes.
+ AAI works over ocean and land.

- AAI is an index: it is sensitive to AOT, SSA and altitude.
- AAI is very sensitive to absolute calibration.
MODIS with OMI AAI overlaid

(figures: Colin Seftor, NASA)
OMI AAI 14 – 16 April
GOME-2 AAI 15 – 16 April

About 11 UTC

O3MSAF processing
OMI AAI 17 - 19 April
OMI AAI 12 - 14 May
OMI AAI 15 - 16 May
GOME-2 AAI 13 - 15 May
GOME-2 AAI 16 - 18 May
OMI SO2 algorithm

- Linear Fit algorithm by Yang, Carn, Krotkov et al. (JGR, 2007).
- Wavelength range: 318 – 333 nm.
- SO2 and AAI runs in the OMI SIPS data processor.
- SO2 and AAI data processing is NRT (< 3 hrs)
- FMI is working on VFD = very fast delivery (< 20 min.) using direct broadcast data.
- New iterative algorithm (ISF, Yang et al., GRL, 2009a) has been developed to correct for non-linear effects in case of high SO2 loadings (> 100 DU).
OMI SO2 14 – 16 April
OMI SO2 4 – 6 May
OMI SO2 7 – 9 May
OMI SO2 10 – 12 May
AOT from OMI on 17-18 April 2010

17 April

OMAERO product

AOT at 483.5 nm

18 April
SCIAMACHY spectrum of ash cloud

Absorption due to ash

16 April 2010
Groundbased volcanic ash data in NL

Lidars in Cabauw (UV lidar and Raman lidar):
• Ash concentration profiles

Sunphotometers (Aeronet and PFR):
• Optical thickness and Angstrom parameter

Ceilometer network (10 instruments with backscatter profiles)
• Extent and altitude of ash cloud
Cabauw UV lidar results on 16 & 18 April
- depolarization -

Thick ash cloud, 16 April

Thin ash cloud, 18 April
Ozone sonde launches on 16-17 April in De Bilt
Conclusions

• AAI from UV satellite sensors is a powerful tool to detect ash, especially thick and medium ash clouds.
• Using GOME-2 and OMI there are two global observations per day at 10-14 UTC.
• AAI can e.g. be used to verify SEVIRI thermal IR ash detection.
Outlook

More AAI observations in the future:
• GOME-2 PMD can provide 10x40 km2 pixels
• GOME-2 on Metop-B
• Tropomi on Sentinel-5/Precursor
• Sentinel-4 on MTG: hourly data for Europe
• Ash plume height from O2 A-band?

SO2 improvements:
• OMI SO2 plume height from extended ISF algorithm (Yang et al., GRL, 2009), using spectral range 300 – 330 nm.
Websites

• OMI, SCIAMACHY and GOME-2 AAI:  
  http://www.temis.nl

• SO2 and AAI from OMI, SCIAMACHY and GOME-2:  
  http://sacs.aeronomie.be
Back up slides
AAI wavelength pairs

- OMI AAI: 354 – 388 nm
- GOME-2 AAI: 340 – 380 nm
- SCIAMACHY AAI: 340 – 380 nm
OMI SO2 17 – 18 April
OMI AAI 9 - 11 May
Friday 16 April 2010

Calipso overpass over Netherlands

Cabauw Raman lidar