Latest aerosol algorithm developments for OMI and TROPOMI

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Abstract: Improvements and development of current OMI aerosol algorithms along with future TROPOMI mission algorithms are ongoing. These developments are being carried out in parallel with work conducted as a part of the ***ESA Climate Change Initiative (CCI) Essential Climate Variable (ECV) project for aerosols***. Aims of the Aerosol-ECV project mesh with OMI and TROPOMI algorithm development include

1) **Trend analysis of absorbing aerosol index (AAI) data and simulation of the AAI;**
2) **Development of common modules for treatment of surface albedo, cloud-clearing and aerosol models**.

The latter goal is an attempt to harmonize current and future European community AOT retrieval efforts. This work presents the **latest developments of OMI OMAERO AAI and AOT products and how they overlap with the Aerosol-ECV project goals**. Discussion will also highlight how developments from both OMI OMAERO aerosol algorithms and Aerosol-ECV project common modules will shape the future TROPOMI algorithms.

1. Aerosol ECV Project

Aerosol index (AI): ECV goals

1) evaluate impacts of different wavelength pairs;
2) make a long-term AAI record based on European sensors using GOME, SCIAMACHY, GOME-2 and OMI;
3) Create a simulated aerosol index which links AI fields to model fields and which contains kernel-like information about the height dependency of the aerosol layer

AOT retrievals: Common Aerosol Models

ECV goal to facilitate better comparison of AOT retrievals by creating common modules for cloud clearing, surface treatment and aerosol models **(Table 1).**

Table 1. Optical, geophysical properties are shown for the common aerosol models.

Aerosol Component	Real part Refr. Index (550 nm)	Im. Part Refr. Index (550 nm)	Reff (µm)	sig ma	Geometric mean radius (µm)	Comments	Aerosol layer height
Dust§	1.56 (varies with wavelength)§	0.0018 (varies with wavelength)§	1.8	1.7	0.79	Non-spherical	Fixed height at 2-4km
Sea salt	1.4	0.0	1.82	1.7	0.9	AOD threshold constraint	0-1km
Fine mode very weak-abs	1.4	0.003	0.142	1.7	0.07	(ssa at 500 nm: 0.98)	0-2 km
Fine mode strong-abs	1.5	0.025	0.142	1.7	0.07	(ssa at 500 nm: 0.80)	0-2 km

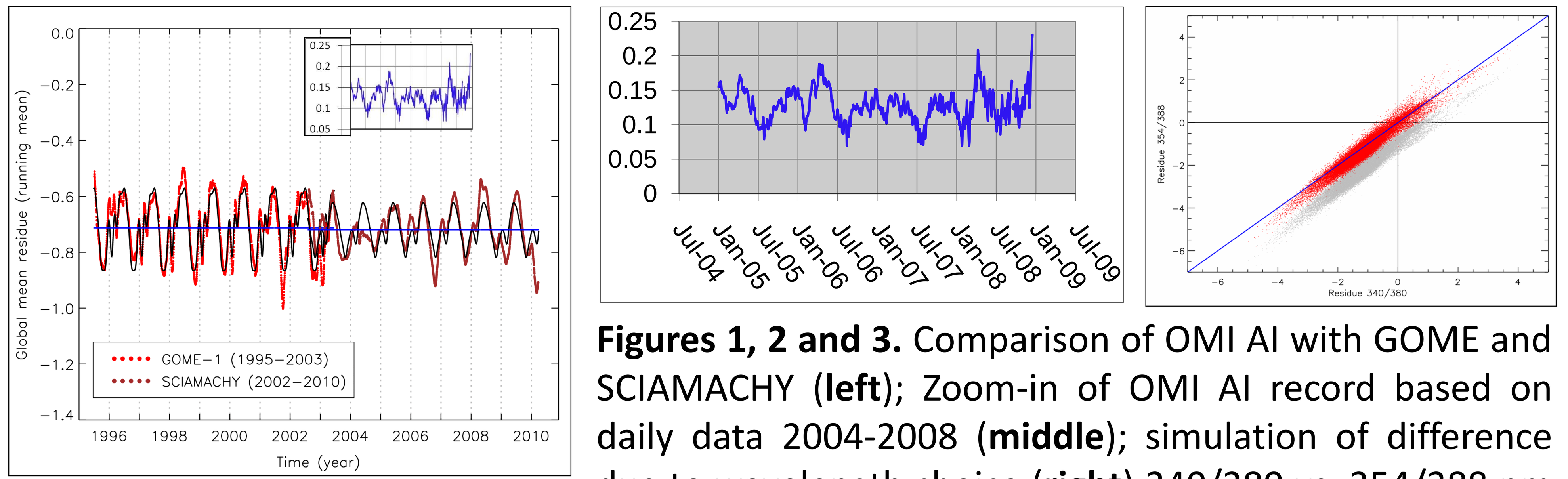
2. Aerosol Index (AI)

Long-term records are key for trend monitoring, estimating the global impact of anomalous episodes. **Table 2** shows the instruments measuring AI which will be used during the ECV project to construct a long-term record

Table 2. AI sensors used to make an ECV long-term record

Instrument	Wavelength pair (nm)	Pixel size at nadir (km)	Days needed for global coverage	Platform / Operation Dates
GOME	340 / 380	320 x 40	3	ERS-2 (1995 – 2003*)
SCIAMACHY	340 / 380	60 x 40	6	Envisat (2002 - present)
OMI	354 / 388	13 x 24	1	Aura (2004 - present)
GOME-2	340 / 380	80 x 40	1.5	Metop-A (2006 - present)

OMI OMAERO approach: 1) Compare AAI from GOME, SCIAMACHY to OMI 2) Define offsets due sensor issues like calibration and degradation (OMI row anomaly etc); 3) Evaluate wavelength pair choices 4) Extend AI record with TOMS data. **Figures 1-3** illustrate initial work conducted for creating a long-term aerosol index record.



Figures 1, 2 and 3. Comparison of OMI AI with GOME and SCIAMACHY (**left**); Zoom-in of OMI AI record based on daily data 2004-2008 (**middle**); simulation of difference due to wavelength choice (**right**) 340/380 vs. 354/388 nm based on SCIAMACHY data (*from: Gijs Tilstra, KNMI*).

Simulated Aerosol Index: Link to global models

Aerosol index is very useful for evaluating spatial distribution of absorbing aerosols. It can however, be difficult to interpret because it depends on AOT, layer height and SSA. Aerosol models embedded in global models produce fields including AOT and SSA, with full global coverage. **The near-global coverage of OMI AI is well suited for model field comparisons but requires the development of a tool to calculate a simulated AI.** One ECV goal is to compare measured and model-simulated AI to **evaluate the vertical sensitivity of the AI.**

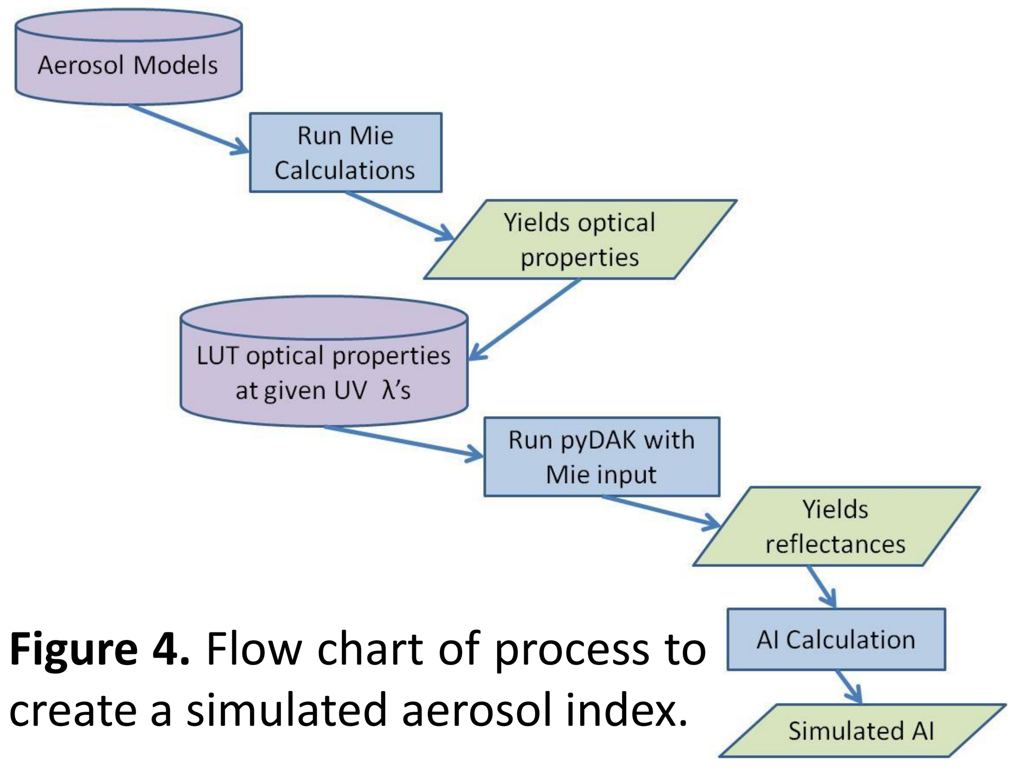


Figure 4. Flow chart of process to create a simulated aerosol index.

3. Aerosol Optical Thickness (AOT)

The biggest issue for the OMI OMAERO AOT retrieval is cloud clearing due to the relatively large pixels (13 x 24km). As can be seen in **Figure 5**, the comparison between AI and AOT points out several areas where clouds are identified as aerosol *(left),* and where aerosol is removed due to cloud clearing.

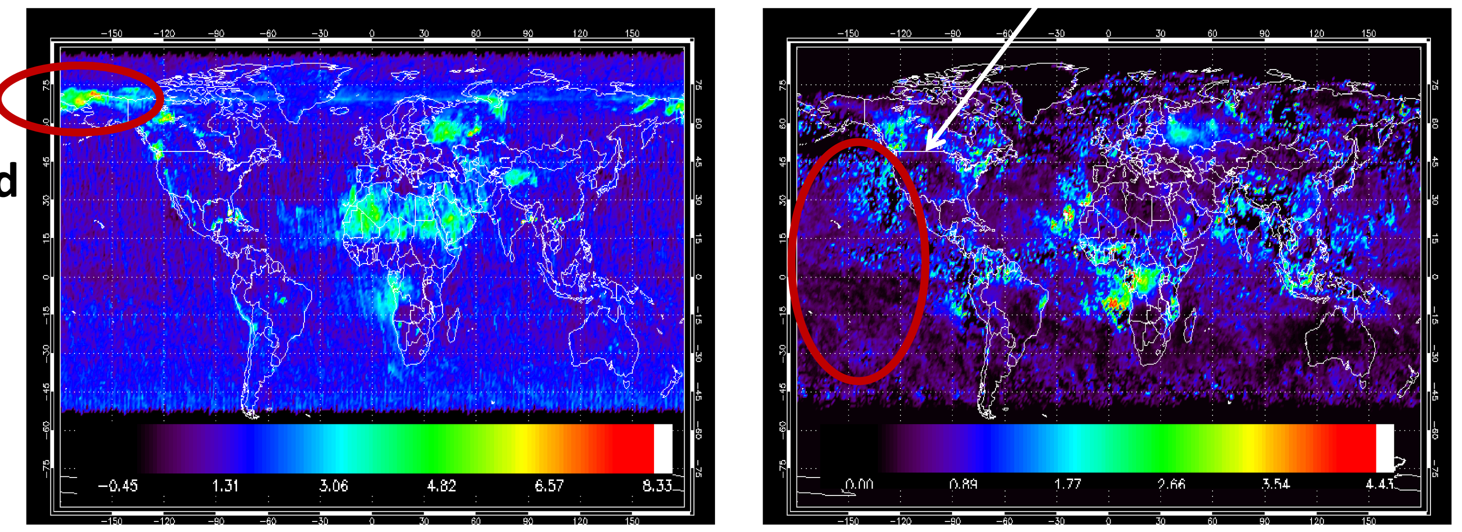


Figure 5. Composite for 01-09 Aug 2010 (Moscow fires); AI (left) and AOT (right)

4. TROPOMI Mission

Smaller pixel size: 7 x 7 km

It is the hope that with TROPOMI some of the problems shown in Figure 5 will be minimized with the smaller pixels (Figure 6). ECV identified cloud clearing methods may be used as well.

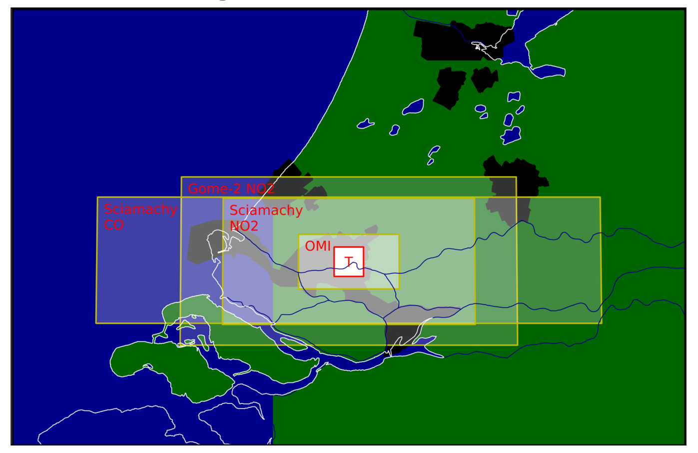


Figure 6. TROPOMI pixel size in comparison to other sensors.

Table 3. Anticipated TROPOMI aerosol products

Data product	Uncertainty of observations	Ground pixel size at nadir (km × km)	Remarks
AAI (absorbing aerosol index)	≤ 0.25	≤ 5×5 (G); ≤ 10×10 (T)	Derived from Earth radiance and solar irradiance
AOT	≤ 0.08; ≤10%	≤ 5×5 (G); ≤ 10×10 (T)	At 400 nm; cloud-free scenes
SSA (single scattering albedo)	≤ 0.05	≤ 5×5 (G); ≤ 10×10 (T)	Cloud-free scenes
ALH (aerosol layer height)	≤ 0.5 km (G); ≤ 1 km (T)	≤ 5×5 (G); ≤ 10×10 (T)	Cloud-free scenes

Something new: O_2 A-Band Aerosol Layer Height

As shown in **Table 3**, Aerosol layer height (ALH) is an anticipated product that will be created for TROPOMI. It is likely that this 'independent' retrieval of layer height will be used to both improve the AOT retrieval and interpret the AI data.