



Monitoring the 4-D aerosol distribution: Synergetic use of MODIS AOD, in-situ PM observations and the chemical transport model LOTOS-EUROS

Present monitoring techniques –when independently used- are not sufficient to capture the high variability of aerosol fields in space and time. Here, we evaluate the added value of combining the assimilation of both in-situ observations and MODIS AOD for the construction of 4-D information of the aerosol distribution in the LOTOS-EUROS chemistry transport model for the year 2006.

Model description and assimilation approach

LOTOS-EUROS (Schaap et al. 2008) is a regional chemistry transport model (CTM) used to simulate the lower tropospheric aerosol concentrations over Europe. The described aerosols include:

- primary aerosols for black carbon (PM10, PM2.5)
- secondary inorganic SO₄, NO₃ and NH₄
- fine and coarse mode sea salt.

The ensemble Kalman filter data-assimilation technique with:

- random noise to the emissions of primary aerosols or aerosol precursors to define the ensemble and therewith the model uncertainty
- assimilation window of 1 day
- Terra and Aqua MODIS AOD data (v5) data
- daily average EMEP PM10 ground observations

Validation of MODAS AOD data with ground observations

A preliminary validation study for MODIS AOD (v5) against AERONET AOD ($\Delta AOD = \pm 0.01$) showed that MODIS AOD is within the pre-specified accuracy; $0.05 \pm 0.15 \cdot AOD$ over land, $0.03 \pm 0.05 \cdot AOD$ over ocean (1- σ level).

Table 1. Bias and correlation between MODIS AOD and AERONET AOD

	Terra MODIS	Aqua MODIS
Bias	0.03	0.05
Average temporal correlation	0.80	0.80
Annual average spatial correlation	0.81	0.74

Total aerosol mass bias correction in model

LOTOS-EUROS model, like most CTMs, currently underestimates the total aerosol load and AOD. One of the reasons for this bias is that not all aerosol types are included in the model yet, either because the sources (re-suspended dust) or the formation (secondary organic aerosol) are not well understood yet. To account for this underestimation an empirical correction factor, determined from comparison between model results and daily AERONET observations for the year 2006, was applied to the model results.

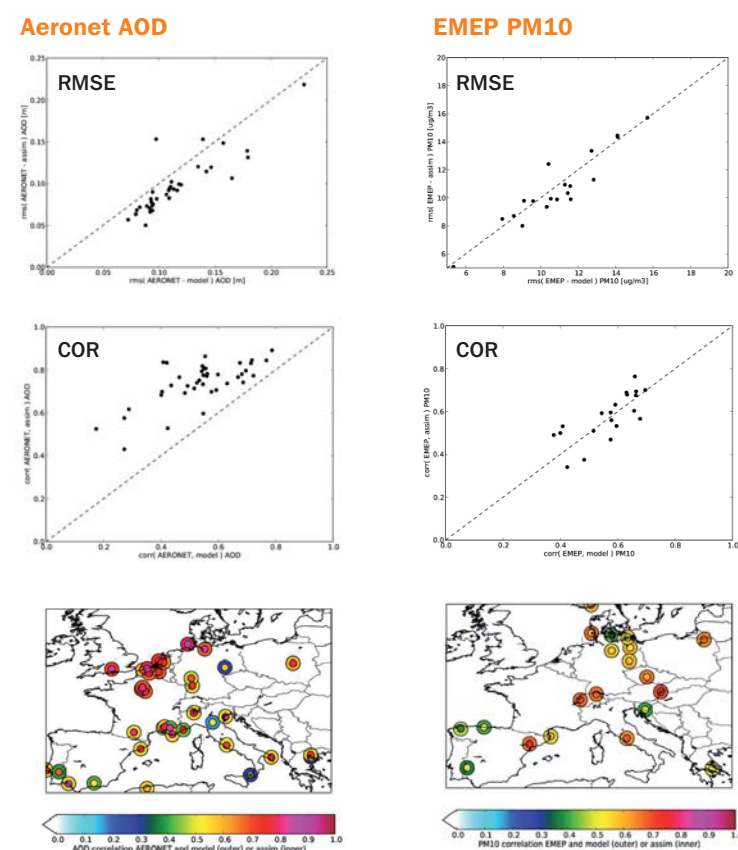
Table 2. Bias correction factors applied to LOTOS-EUROS total aerosol quantities

	Bias correction factor
AOD column	1.6
Total PM10, PM2.5	2.5

Assimilation results and validation

Assimilation of MODIS AOD data hardly changes the annual mean simulated AOD distribution - therewith confirms the proposed and applied bias-correction, but spatial observed features are enhanced. The variability and temporal correlation between simulation and the input observational data, i.e. MODIS AOD or AERONET AOD, increase notably. Further improvement is obtained with the inclusion of EMEP PM10 ground observations.

The validation with an independent but limited set of EMEP PM10 ground data reveals only slight improvement, which is strongly site dependent.



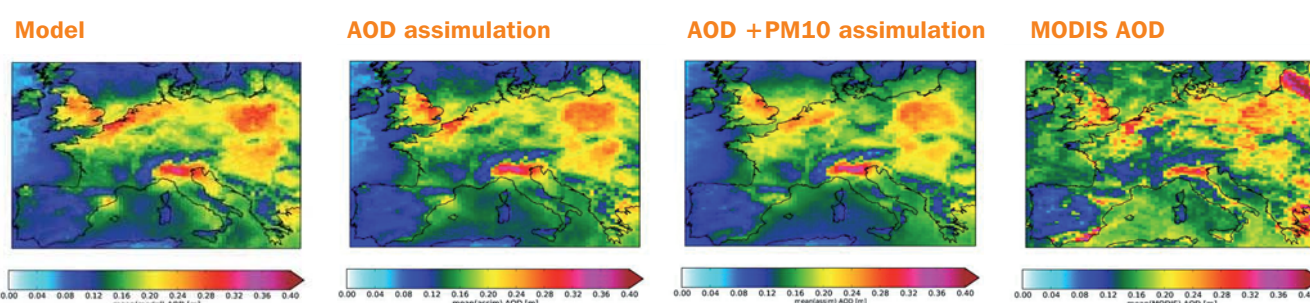
Root-mean-square error (top panels), temporal correlation (middle panels and distribution of temporal correlations (bottom panels between bias-corrected model results - with versus without assimilation of MODIS AOD and EMEP PM10 observations- and observational AERONET AOD (left) and EMEP PM10 (right) data.

Conclusions and outlook

Integrated assimilation of MODIS AOD and EMEP PM10 ground observations in the LOTOS-EUROS model shows overall improvement, especially in the temporal correlation. Validation with an independent set of EMEP PM10 observations shows a scattered and site dependent improvement. Further investigation is required to point out whether the surface emissions are the appropriate choice for the application of the random noise for assimilation or that the validation data set is not suitable.

Reference

Schaap, M., Timmermans, R. M. A., Sauter F.J., Roemer, M., Velders, G. J. M., Boersen, G. A. C., Beck, J. P. & Builtjes P. J. H., The LOTOS-EUROS model: description, validation and latest developments, Int. J. of Environ. and Pollution, 32, No. 2, pp.270–290, 2008.



Annual average simulated AOD for bias-corrected model (left), bias-corrected model with assimilation of MODIS AOD (middle left), bias-corrected model with full assimilation (middle right), and annual average MODIS AOD observations for 2006