Contributions of different sources and types of aerosols to AOD during spring-2006 wild-land fire episode

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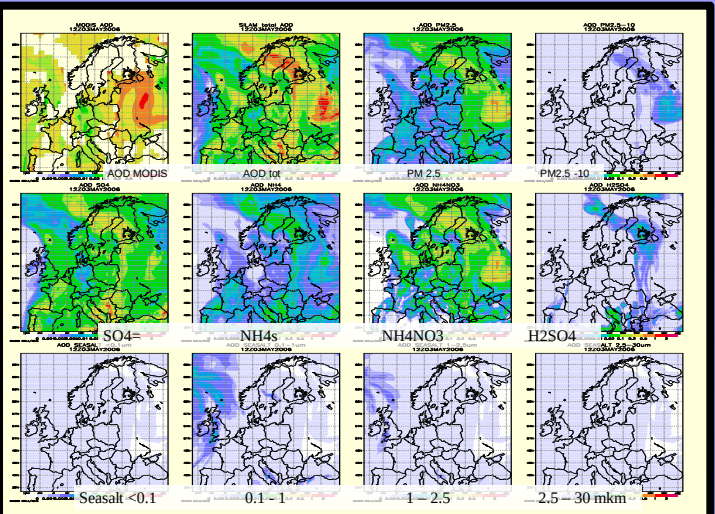
Introduction

Using SILAM model (Sofiev et al, 2006), dispersion of pollution from anthropogenic and wild-fire sources were computed for an episode in April-May 2006, when unusually hot and dry period with low-wind conditions resulted in a build-up of contamination over eastern Europe accompanied by widespread wild-land fires over western Russia.

For SILAM simulations, meteorological forecasts of HIRLAM 6 were used. The model was run with resolution of 0.2 deg and 10 vertical layers up to ~8 km.

Anthropogenic emissions of CO, NH3, NOx, SOx, PM2.5 and PM2.5-10 were taken from TNO and EMEP emission inventories. The wild-land fire emissions were derived from the MODIS temperature anomaly product with FMI Fire Assimilation System FAS-TA for PM2.5, total-PM, CO, HCHO, NOx, NH3 and SO2 using scaling factors from Andreae and Merlet (2001). No diurnal variability for fire emissions was implemented. Separate computations were also done for sea-salt. Total aerosol optical depth at 550 nm was computed using particle refractive indices from OPAC database (Hess et al. 1998).



Contribution of different species to AOD at 550nm and comparison with MODIS

Main contributions to modelled AOD at 550 nm, averaged over the whole period of computations (21 days), came from sulphates (47%), nitrates (30%), and fine-mode primary particles (16%) while the contributions of sea salt and coarse primary particles were found to be negligible. AOD computed by SILAM was compared with AOD measured by MODIS. In most occasions the patterns look similar but SILAM is systematically underestimating the AOD values by ~30%. Exceptions are the fire-dominated pollution plumes, where AOD can be even over-stated. Reasons for underestimating include the missing Atlantic sea-salt and contributions from America; wind blown dust and SOA; also MODIS AOD is missing over cloudy regions where it can be smaller due to wet deposition (thus, MODIS AOD can have a systematic positive bias in comparison with SILAM).

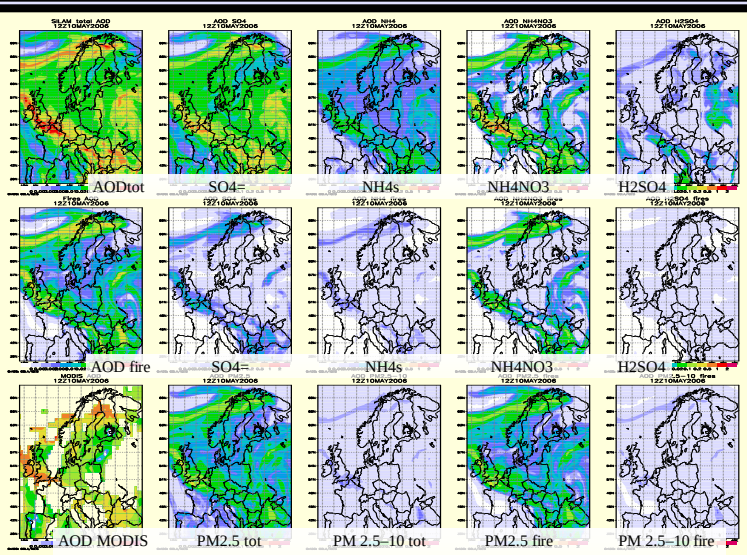
Spatial correlation coefficient ranges from ~0.5 to over 0.7, being highest during days with the highest mean modelled concentrations (26-30 April, 6-7 May) - when wind is blowing from the large emission sources, such as fire sources in Russia. Agreement is worse when wind direction is from areas, such as Atlantic ocean, with low and also partly missing emissions. Sea salt is partly and contributions from America are fully missing due to zero boundary conditions.

The root mean square error stays around 0.25, falling to 0.17 for the first episode (28 April) and raising to 0.35 for the second one (7 May) with the highest fire contributions. Fire emissions include large uncertainties rising from different land use and different meteorological conditions, such as humidity of air and vegetation, for different fires. As the assumptions made in MODIS AOD retrieval algorithm about aerosol composition do not include dominating fire emissions in European area (Kaufman et al, 1997), they might also introduce some bias to the results for fire dominated plumes.

Contributions from fire emissions

The contribution of fire emissions gave about one fourth of the total AOD raising up to 30% for the specific periods, such as 3.-8.5.2008. It mainly consists of similar-level contributions from fine-mode primary particles and nitrates. Particles emitted by fires totally dominate the primary particle concentrations.

Almost all the pattern elements visible at the map of total AOD (anthropogenic + natural + fire-induces pollution) are also visible on the map with fire-only contributions, showing strong synchronization between plumes from totally uncorrelated sources. Fire sources are mainly located in central Russia, anthropogenic sources are mainly in central Europe. Also, fire emissions only make 25-30% of the total AOD (compare AOD tot and AOD fire in figure 11). Still, we are seeing high correlation between maps with total and fire-only AOD. Apart from source locations, the main element forming these patterns is meteorology, which decides the direction and speed of transport of the pollutants and can bring together plumes from different sources as it seems to have happened in the considered case.



Conclusions

Analysis of the case showed that for total modelled AOD at 550 nm over continental Europe, the largest contributons come from sulphates, nitrates and fine mode primary PM, while coarse particles and sea salt contributions are negligible.

Wild-land fires appeared to be one of the major contributors of both PM and reactive gases in Europe during the episode.

Synchronization due to meteorological conditions was found between the plumes from otherwise uncorrelated sources: anthropogenic and biomass burning.

References

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