Parameterization of dust emissions in the SILAM model

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Goal

Desert dust is an important atmospheric constituent since it affects air quality and climate. The exceedances of air quality limit values for particulate matter (PM) are recurrent in places such as southern Europe where the long-range transport of mineral can achieve a 60% contribution to AOD levels (Tchepel et al, 2013). The goal of this study is to present the dust emission scheme included in the chemical transport model SILAM and show the first results of global model simulations.

Dust source

The dust emission parameterization is based on the saltation/sand blasting processes based on Marticorena & Bergametti (1995) and Zender (2003). The saltation starts when the friction velocity reaches the threshold level allowing the coarse particles (Dp = ~70 μm) to be involve into horizontal movement. Corrections with regard to partitioning of the drag between erodible and non-erodible elements of the surface; leaf area index, and the soil humidity-driven are included affecting the threshold level and the saltation efficiency. The total vertical flux of dust particles released by sandblasting is described by:

$$F = A_s K \alpha Q_s \quad (1)$$

F is the vertical mass flux of dust [kg m^{-2} s^{-1}], A_s is the area fraction of erodible soil in the grid cell, *K* is the coefficient accounting for soil erodibility, α is the sandblasting efficiency and *Qs* is horizontal saltation mass flux. We assumed static aerosol spectre at the source, defined by the soil type and parameterised directly from the data of Weinzierl (2007) via 4 log-normal modes (Dp = 0.01-30 μm). This static-spectrum approach connects the flux for the specific size bin with the wind speed.

Results

The model was run through 2002-2012 globally: 1º spatial resolution and 1hr output time step. The results of the simulations were compared with MODIS AOD, using spatial-temporal-collocation of the datasets (hourly). To facilitate the comparison and estimate the contribution from dust to AOD, primary PM emissions from anthropogenic, sea-salt and wild-land fire sources were included.

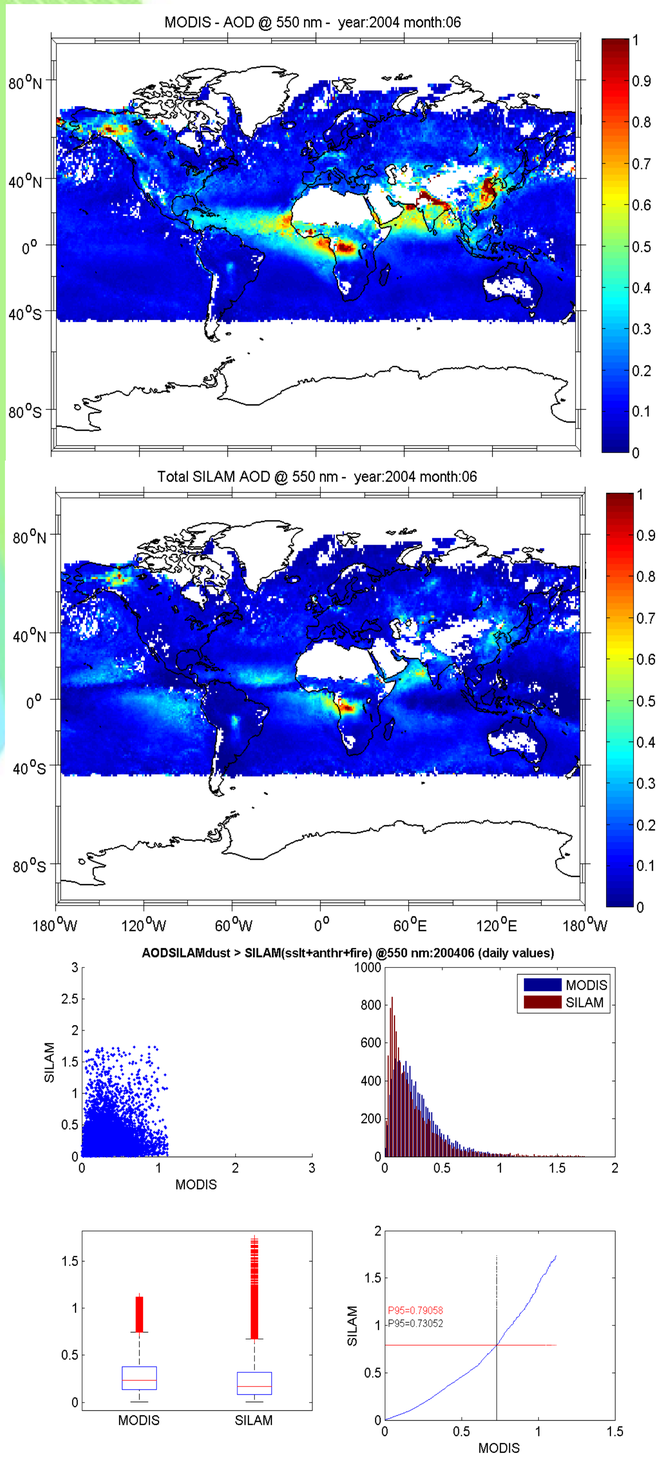

Figure 3: Spatial distribution of the AOD for MODIS(top) and SILAM (middle); and statistics for dust-dominated cells (down) for June, 2004

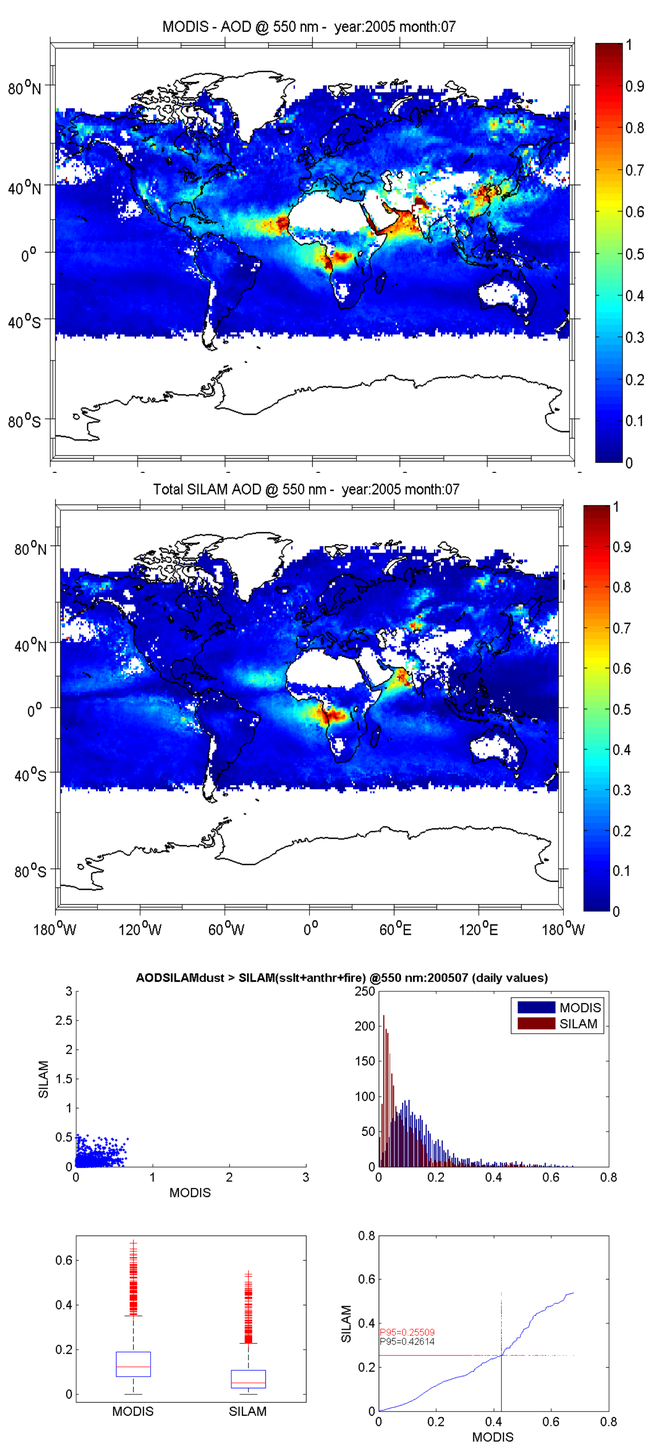

Figure 4: Spatial distribution of the AOD for MODIS(top) and SILAM (middle); and statistics for dust-dominated cells (down) for July, 2005

SILAM system

SILAM system (**silam.fmi.fi**) is a flexible environment made for a wide variety of tasks, including emergency response, air quality, observation analysis, data assimilation and inverse-problem applications. It is a modular system with object-oriented code. Lagrangian and Eulerian dynamic cores utilize the same supplementary routines including meteorological, emission, and I/O servers.

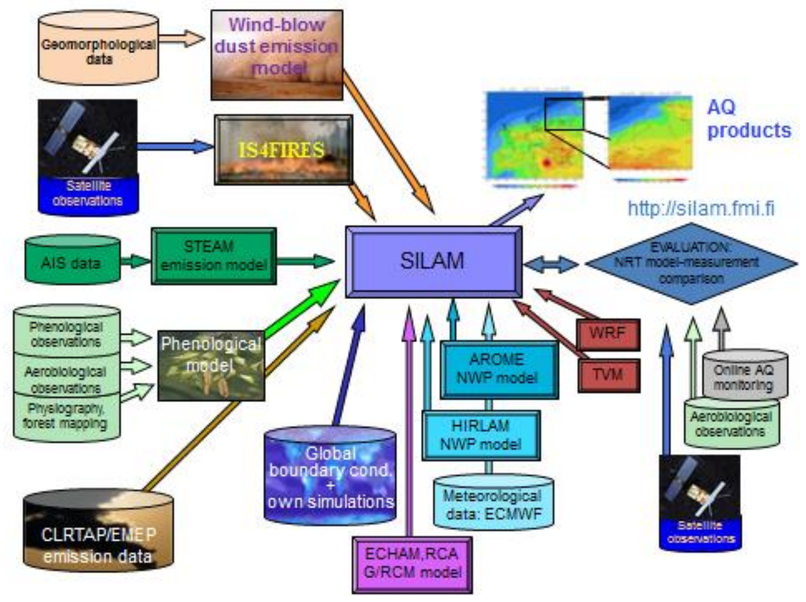

Figure 1. FMI regional AQ assessment and forecasting platform

The total emissions are 35 ± 10 Tg/year within the range provided by other global estimations.

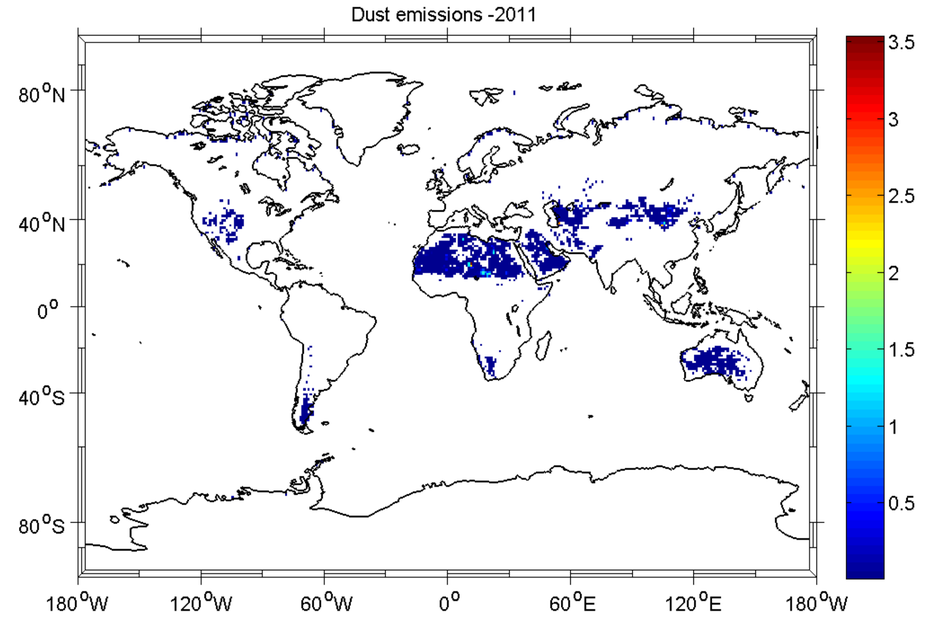

Figure 2: Spatial distribution of the total dust aerosol emissions for 2011 (Tg/year)

Conclusions

The simulations provide encouraging results both for spatial and temporal distributions of dust aerosol in a global scale. In general the system overestimates the dust aerosol load over the North African deserts (a factor of 2) and underestimates over the South American deserts (20-30%). The main transboundary pollution episodic features for dust aerosol are well described by the system. The model-measurement comparison with MODIS AOD improved substantially by adding dust emissions to the model.

References

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Tchepel, O., Ferreira, J., Fernandes, A.P., Basart, S., Baldasano, J.M. & Borrego, C. Analysis of long-range transport of aerosols for Portugal using 3D Chemical Transport Model and satellite measurements. Atmospheric Environment 64, 229-241 (2013).

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