Remapping of aerosol emissions in a modal models as a source of error

T. Korhola[1], H. Kokkola[2], H. Korhonen[2], A.-I. Partanen[2], A. Laaksonen[1,3], S. Romakkaniemi[1]

[1] Department of Applied Physics, University of Eastern Finland, Finland
[2] Finnish Meteorological Institute Kuopio Unit, Kuopio, Finland
[3] Finnish Meteorological Institute, Climate change, Helsinki, Finland
Keywords: modelling, modal representation, emission inventories, activation
Presenting author email: tapani.korhola@uef.fi

Prescribed datasets for natural and anthropogenic aerosol emissions are widely used in global climate modelling. These inventories include i.a. recommendations for size distributions for emitted aerosol particles often given as parameters for log-normal modes. Most aerosol models use log-normal modes to describe the aerosol distributions. In these global models, the maximum mode diameter is often restricted due to technical reasons. These restrictions cause artificial minima in the model's aerosol size distribution at certain fixed sizes.

We have noticed that if the recommended mode diameters (Dentener *et al* 2006) in emission inventories are close to these artificial minimums, the model then remaps the emitted particles between two adjacent modes and never uses the actual emission distribution that is described in the inventories. In this work, we study how this affects the cloud droplet number concentration (CDNC) and aerosol-cloud interaction (ACI) parameter.

The simulations were done by using a box model, which allows the use of both free and restricted modes and a better control over physical, technical and statistical phenomena compared to a global model. The CDNC was calculated by using the Fountoukis and Nenes (2005) parametrization. The ACI was defined by

$$\mathrm{ACI} = \frac{d\log(\mathrm{CDNC})}{d\log \mathrm{N}}, \qquad (1)$$

where N is the total number concentration of the emitted (inventory based) aerosol. The ACI parameter fundamentally describes the sensitivity of droplet formation to aerosol distribution.

To study the effects of the mode size restrictions and the following remapping on the CDNC and ACI, we calculated both parameters with the unaltered emission size distribution recommended by the inventories and with the emissions that were forced under the global model restrictions. We did the same simulations with and without background aerosol.

The CDNC and ACI were evaluated as a function of N and vertical velocity of the cloud forming air parcel. Finally, we calculated the relative difference of these parameters between the unaltered and remapped emission.

The mode remapping effectively reallocates the mass and number concentration that exceeds the set upper diameter limit of a given mode (Binkowski and Roselle 2003). This reallocation decreases the mode average diameter and creates a new larger mode, or increases the number concentrations of pre-existing larger mode (Figure 1).

Our results show clearly that the mode remapping causes underestimation of both the CDNC (Figure 2) and ACI. The underestimation of the CDNC is most evident in the case with no background aerosol, where the relative difference is more more than 50 %. With the background aerosol, it is still more than 30 %. The underestimation due to remapping is because the critical diameter is smaller than the average diameter of the emission mode, but bigger than the smallest particles in the mode resulting from mode remapping. When the mode is remapped, significant number of the particles that would activate, are moved to a mode that is mostly below the critical diameter. For the same reason, as mentioned above, the ACI parameter shows stronger correlation between the unaltered emission and CDNC compared to the remapped emission. The underestimation of ACI by remapped emissions is up to 40 % with background and up to 20 % without background aerosol.

Depending on the emission inventories and aerosol models used, the widespread method of aerosol reallocation and mode remapping can cause a clear underestimation of cloud droplet number concentration and aerosol-cloud interaction parameter.

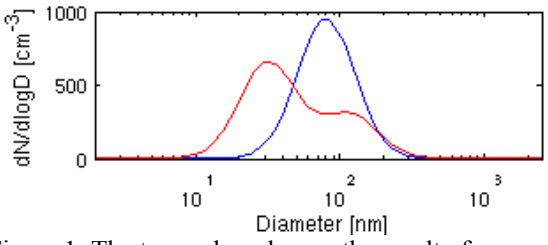

Figure 1: The two red modes are the result of remapped blue mode.

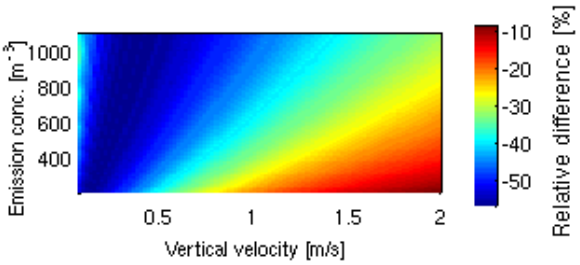

Figure 2: The relative difference between unaltered and remapped emission modes without background aerosol.

This study has been supported by the strategic funding of the university of Eastern Finland.

Dentener F. et al. (2006) *Atmos. Chem. Phys.*, **6**, 4321–4344.

Binkowski, F., Roselle S., (2003) *J. Geophys. Res.*, **108**, 4183, 18 PP.

Fountoukis, C., Nenes, A., (2005) *J. Geophys. Res.*, **110** D11212.