# Taking the step from bulk to size-segregated aerosol description: Modelling of size distributions with the EMEP/MSC-W model

M. Karl[1] and S. Tsyro[2]

[1] Norwegian Institute for Air Research, NILU, Kjeller, NO-2027, Norway.
[2] Norwegian Meteorological Institute, met.no, Oslo, NO-0313, Norway
Keywords: Atmospheric chemistry transport model, Particle number climatology, Aerosol dynamics
Presenting author email: svetlana.tsyro@met.no

Knowledge of the size distribution of atmospheric aerosols in the submicron size range is essential for estimation of aerosol climate effects and also health implications. Concerning effects on Earth's radiative balance, aerosol extinction of short and long wave radiation and interaction with clouds depends on their size. On the other hand, growing evidences suggest increased health effect from transport-related particles, in particular ultrafine ones (e.g. Oberdörster, 2001; Krzyzanowski et al., 2005). Ultrafine particles contribute negligibly in currently regulated $PM_{10}$ and $PM_{2.5}$ mass and should be described in terms of number density.

The EMEP/MSC-W model (Simpson et al., 2012) is an atmospheric chemistry transport model, calculating photo-chemistry and PM on regional to global scale. It is flexible with respect to the choice of projection and horizontal resolution (tested for between 4x4 km and 1x1° grid), and has 20 vertical layers up to 100 hPa. The standard model deals with bulk aerosol mass, distinguishing fine and coarse particles.

Table 1. Median particle number concentrations in the size range 30 - 50 nm and 50 - 500 nm. Observed values adopted from Asmi et al. (2011).

| Site | $N_{30-50}$ obs. (#/cm$^3$) | $N_{30-50}$ model (#/cm$^3$) | $N_{50-500}$ obs. (#/cm$^3$) | $N_{50-500}$ model (#/cm$^3$) |
|---|---|---|---|---|
| Birkenes | 156 | 296 | 511 | 121 |
| Aspvreten | 284 | 241 | 1081 | 132 |
| SMEAR | 223 | 239 | 878 | 115 |
| Pallas | 89 | 97 | 205 | 37 |
| K-Puszta | 697 | 592 | 3120 | 375 |
| Melpitz | 860 | 434 | 2327 | 275 |
| Kosetice | 700 | 460 | 3194 | 265 |
| Waldhof | 878 | 413 | 2434 | 263 |
| Cabauw | 1914 | 889 | 3387 | 554 |
| Finokalia | 220 | 660 | 1345 | 625 |
| Ispra | 1341 | 1032 | 4448 | 598 |
| Mace Head | 105 | 364 | 241 | 199 |

Recently, aerosol dynamics of the sectional aerosol model MAFOR (Karl et al., 2011; http://mafor.nilu.no) have been implemented in the EMEP model to simulate size-resolved particle number and mass concentrations. In this work, 16 size sections were used to represent the aerosol size distribution from 1 nm to 10 μm. The new approach consistently solves the time evolution of the particle number and mass concentration distribution using the fixed sectional method in a robust manner on a 3-D atmospheric grid.

We present European maps of size-resolved aerosol and evaluate the model ability to reproduce observed particle size distributions. First comparison of modelled number concentration in the sizes of 30 - 50 nm ($N_{30-50}$) and 50 - 500 nm ($N_{50-500}$) to observational data (2008-2009) published by Asmi et al. (2011), summarized in Table 1, revealed reasonable agreement for most remote sites and esp. for the ultrafine fraction, whereas $N_{50-500}$ was underestimated by the model. The discrepancies are partly associated with uncertainties in the particle emission data, but are also due to currently deficient treatment of processes: better descriptions of particle deposition and of particle growth due to condensation of inorganic and organic vapours, are expected to improve the model's predictive capabilities.

Modelled size distribution at Birkenes, Ispra and K-Puszta for winter and summer are shown in Figure 1. The shape of the size distributions has little variability among the sites, probably due to the use of a uniform particle emission spectrum for entire Europe. Increased nucleation of sulphuric acid led to higher numbers of nucleation mode particles in summer.

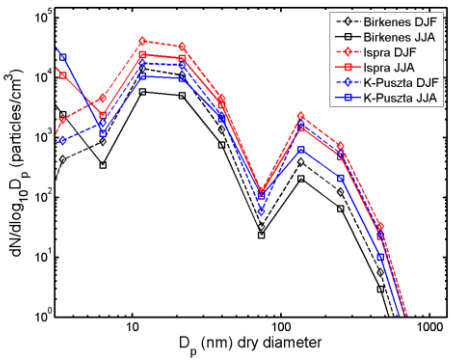


Figure 1. Modelled number size distribution in winter (DJF) and summer (JJA) at various sites in Europe.

This work was partly supported within the EC seventh framework project (no. 243406) TRANSPHORM.

Asmi, A., Wiedensohler, A., Laj, P., Fjaeraa, A.-M., Sellegri, K., Birmili, W., and co-authors (2011), *Atmos. Chem. Phys.*, **11**, 5505-5538.

Karl, M., A. Gross, C. Leck, and Pirjola, L. (2011), *Tellus*, **63B**, 1001-1025.

Oberdörster, G. (2001), *Int. Archives of Occupational and Environmental Health*, **74** (1), 1-8.

Krzyzanowski et al., 2005. WHO, ISBN 92-890-1373-7.

Simpson, D., Benedictow, A., Berge, H., Bergström, R., Emberson, L. D., Fagerli, H., and co-authors (2012), *Atmos. Chem. Phys.*, **12**, 7825-7865.