Evaluation of size-resolved elemental carbon emission in Europe and its influence on long-range transportation

Y. Chen[1,2], Y. F. Cheng[2], S. Nordmann[2,3], W. Birmili[1,3], H.A.C. Denier van der Gon[4], N. Ma[1,2], R. Wolke[1], B. Wehner[1], J. Sun[1], G. Spindler[1], Q. Mu[2], U. Pöschl[2], H. Su[2] and A. Wiedensohler[1]

[1]Leibniz-Institute for Tropospheric Research, Leipzig, 04318, Germany
[2]Multiphase Chemistry Department, Max Planck Institute for Chemistry, Mainz, 55128, Germany
[3]German Environment Agency, Dessau-Roßlau, 06844, Germany
[4]TNO, Dept. of Climate, Air and Sustainability, Princetonlaan 6, 3584 CB Utrecht, The Netherlands

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Presenting author email: chen@tropos.de

Elemental carbon (EC) particles are characterized by their strongly radiation absorbing effect and adverse health effects. The emission inventory is one of the key elements for the evaluation of the EC climate effect with models. Unfortunately, high uncertainties still exist in EC emission inventories, with at least 50% on global scales, and a factor of 2-5 on regional scale (Ramanathan et al., 2008). The fully online-coupled WRF-Chem was applied and focused on central Europe to evaluate European EC inventory, developed within the frame work of European Integrated project on Aerosol, Cloud, Climate, and Air Quality Interactions (EUCAARI), adopted with a $1/8^{o} \times 1/16^{o}$ high resolution and three size segregations (PM1, PM1-2.5 and PM2.5-10 (Visschedijk et. al., 2008). The simulation results were evaluated by the meteorological and EC in-situ measurements from GUAN and HOPE-Melpitz Campaign.

The WRF-Chem simulations were performed for the HOPE Campaign (10-20th September 2013) and for a special case in April 2009 (Nordmann et al., 2014). The model was initialized and forced by Final Analysis (FNL) Operational Global Analysis data. EUCAARI and EMEP (http://www.ceip.at) inventories were applied as the anthropogenic emissions. Detailed model setup can be found in Chen et al. (2015).

The meteorological parameters were in good agreement between simulation and ground observation at the Central European Observatory Melpitz, with a correlation coefficient (R^2) of 0.88, 0.72, 0.74, and 0.74 for temperature, relatively humidity, wind speed and wind direction respectively. The vertical thermal stratification was well captured, validated by the radio-sounding observations over Europe. However, the EC mass concentrations were overestimated by a factor of 2.8 at Melpitz, and by a factor up to 6-10 for peak periods with a remarkable high fraction in the coarse mode. We found that this was due to an overestimation of the point sources EC emissions by a factor of around 2-10 in Germany, especially in the coarse mode (Chen et al., 2015). The plume, emitted from a nearby point source, approached Melpitz and lead to the overestimation. A similar phenomenon was also found for the measurement station Bösel in Northern Germany.

For the area emissions of EC, the fraction of coarse mode EC (ECc) was overestimated in the inventory by about 10-30% for Russia and 5-10% for Eastern Europe (e.g., Poland and Belarus), respectively (Chen et al., 2015). This over proportion of EC in the coarse mode results in a shorter atmospheric lifetime of EC particles and inhibits their long range transportation. We re-simulated the case in Nordmann et al. (2014), where the model underestimated the EC concentration in the east of Germany by at least a factor of 2 in April 2009. In this simulation, the ECc fraction in the emission inventory was adjusted to only 5% (the average value for Western Europe, longitude<15^{o}E). Our results show that the over proportion of ECc in the emission over Eastern Europe can be one of the reasons for the underestimation of EC in Germany. It contributed to 20-40% of the model underestimation of EC concentration in Melpitz when air masses came from the eastern direction (Chen et al., 2015). This result is consistent with a deposition-transport concept model (Fig. 1, Chen et al., 2015).

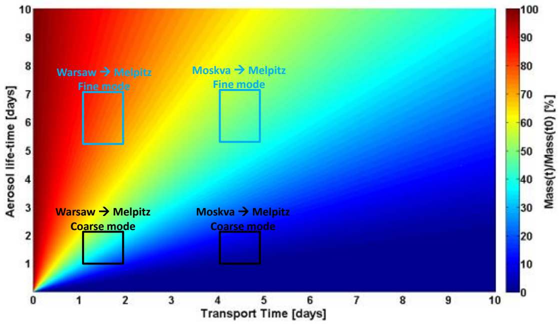

Figure 1. Aerosol mass residential rate with relationship of transport time and lifetime. The color indicates the percentage of mass that can be transported to Melpitz.

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