**The number and mass size distributions of black carbon aerosol over Europe**

C. L. Reddington[1], G. McMeeking[2], G. W. Mann[1], H. Coe[3], M. G. Frontoso[4], D.Liu[3], M. Flynn[3], D. V. Spracklen[1], and K. S. Carslaw[1]

[1]Institute for Climate and Atmospheric Science, School of Earth and Environment, University of Leeds, UK.
[2]Department of Atmospheric Science, Colorado State University, Fort Collins, CO, USA.
[3]School of Earth, Atmospheric and Environmental Sciences, University of Manchester, UK.
[4]C2SM - ETH Zurich, Zurich, Switzerland.

Black carbon (BC) aerosol is the strongest light-absorbing component of atmospheric aerosol and therefore plays an important role in the direct radiative forcing of climate. Carbonaceous combustion aerosol, in which BC is often incorporated, is also a major source of cloud condensation nuclei in polluted environments. The magnitude and sign of the combined direct and indirect radiative forcing due to BC-containing particles is therefore strongly dependent on their physical properties such as mass, number concentration and size distribution. Here we use a global aerosol model to test our understanding of BC microphysical properties against one month of aircraft measurements of BC particle number and size from the Single Particle Soot Photometer (SP2) over Europe during the European Integrated Project on Aerosol Cloud Climate Air Quality Interactions (EUCAARI) campaign in May 2008. The model agrees well with observed BC mass concentrations in the detection range of the SP2 (90 - 400 nm BC diameter), predicting concentrations that lie within the factor 2 uncertainty of the carbonaceous particle emission inventory. However, the model predicts BC particle number concentrations a factor ~3.5 - 5.7 higher than measured and a mode diameter that is ~40 - 65 nm smaller than observed. More than 90% of the model particles in the SP2 size range are predicted to contain BC, while the observations suggest only 21%, with an uncertainty range of 7% to 56%. These model-observation biases in the BC particle number concentrations and sizes are considerably greater than for the overall particle distribution (when all components are included), for which simulated size-resolved number concentrations at various size ranges are within ~50%. The much worse biases in the simulated BC size distribution than the total size distributions suggest the discrepancy is associated with model assumptions about the size and mixing state of the emissions source of carbonaceous particles. We expect the discrepancy in BC size distribution we find here to be common among most global aerosol models, with implications for model estimates of absorption optical depth and direct radiative forcing.