Interactive comment on "The size distribution and mixing state of black carbon aerosol over Europe" by Reddington et al.

In this manuscript, the performance of a global aerosol model in simulating BC concentration was evaluated against SP2 measurements. The comparison shows an overestimated concentrations and mode diameters of BC. This study has been well designed and the results were carefully discussed. Inclusion of aircraft measurement data is important since most other comparisons were based on ground-based measurements. Though the agreement in size-resolved data is not as good as in bulk data, in my opinion, it provides more valuable insight into the mechanisms of aerosol models. I appreciate the authors' scientific work and I find their results interesting and promising. Overall, I find the manuscript meets the scope of the journal and I would recommend publication after minor revision. Please find my comments/suggestions as follows.

(Original texts in *italics*, comments in plain font)

General comments

1. Coating thickness distribution

To fully describe the soot mixing state, two kinds of information are needed, the soot-core distribution and the coating thickness distribution for soot-core of certain sizes. I would encourage the authors to present the modeled coating thickness of BC (e.g., either as Fig. 10 in Cheng et al., 2012, or plot coating thickness for BC-cores of certain size), which contains as much information as the BC-core distributions, even when no measurement data are available.

2. Complimentary information

The comparison between measurements and modeling results is nice and is the focus of this study. The modeled data represent the coarse grid averaged results. So even the model works perfectly, discrepancies could still be expected compared to flight measurements. But I think it is still worthwhile performing such comparison.

It would be great if the authors could think about and provide complimentary information about the spatial and temporal distribution of BC particles that have been

simulated in this paper.

3. Improving model performance

The authors have suggested several explanations for the disagreement. It would be nice if a few of them could also be roughly tested in this paper. For example, to test the impact of emissions, will the modeled results (of BC and total particles) be better when increasing BC-core mode diameter to ~100 nm and reducing its emission rates by 10 times?

Specific comments

P26505, l20-22*:*

'The degree of mixing, or "mixing state", of atmospheric BC particles with these hydrophilic aerosol components not only influences their CCN activity, but also affects their radiative properties and is therefore important for assessing the direct radiative forcing of carbonaceous aerosol (Jacobson, 2001; Bond et al., 2006).'

Comments: Besides the review paper, I suggest adding a few direct references, e.g., Rose et al, 2011(CCN activity), and Cheng et at 2006 (radiative properties).

P26505, l27 to P26506, l9*:*

'Pierce et al. (2007) showed that carbonaceous aerosol increases global CCN concentrations at 0.2% supersaturation (CCN(0.2 %)) by … depending on the assumed emission size of carbonaceous particles.'

Comments: All these effects are referring to carbonaceous aerosols. How much contribution is from BC? My impression is that POM is the main contributor and BC plays a minor role. If so, please clarify this.

P26522, l5-7*:*

'Modelled flight-mean number concentrations range from 31 to 87cm−3 in experiment BCOC_sm and from 56 to 150 cm−3 in experiment BCOC_lg, overpredicting the observations by a factor 1.7–10.8.'

Comments: I am wondering why in Fig. 5 and 6, BCOC_lg shows lower campaign-mean values.

P26548, Table. 2*:*
In addition to *D*, I suggest including σ,

P26556, Fig. 4*:*
'Mean concentrations are shown by the solid lines, the observed median concentrations are shown by the dashed lines, the standard deviation is represented by the error bars.'

Comments: Is there any specific reason to compare mean values with median values?

Ref:

Cheng, Y. F., Eichler, H., Wiedensohler, A., Heintzenberg, J., Zhang, Y. H., Hu, M., Herrmann, H., Zeng, L. M., Liu, S., Gnauk, T., Br üggemann, E., and He, L. Y.: Mixing state of elemental carbon and non-light-absorbing aerosol components derived from in situ particle optical properties at Xinken in Pearl River Delta of China, J. Geophys. Res., 111, D20204, doi:10.1029/2005JD006929, 2006.

Rose, D., Gunthe, S. S., Su, H., Garland, R. M., Yang, H., Berghof, M., Cheng, Y. F., Wehner, B., Achtert, P., Nowak, A., Wiedensohler, A., Takegawa, N., Kondo, Y., Hu, M., Zhang, Y., Andreae, M. O., and P öschl, U.: Cloud condensation nuclei in polluted air and biomass burning smoke near the mega-city Guangzhou, China – Part 2: Size-resolved aerosol chemical composition, diurnal cycles, and externally mixed weakly CCN-active soot particles, Atmos. Chem. Phys., 11, 2817-2836, 10.5194/acp-11-2817-2011, 2011.