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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Mixing state of black carbon and its impact on optical properties and radiative forcing over East Asia" *by* Xiaoyan Ma et al.

Anonymous Referee #2

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This paper presents a modeling study for the East Asia region where the impact of BC mixing state on direct radiative forcing and heating rates is explored for the month of January 2014. The model system GEOS-Chem-APM is used for this study.

While the general topic is of interest to the community and within the scope of ACP, my major comment on this paper is that it is not clear to me what new insight is gained from this study. The GEOS-Chem-APM model system is a powerful framework for simulating aerosols, but we have known for a long time now that BC DRF is underestimated when BC is treated externally mixed, and core-shell treatment enhances absorption, which is one of the main outcomes of this study. A comparison of three cities is presented,

where differences in coatings and heating rates exist, but no process analysis is provided that would explain these findings. Over the past decade, a lot of work has been done in the area of black carbon radiative forcing and how BC mixing state modulates this, with many papers for the East Asia region and with mixing-state-aware models, for example by Oshima and co-workers and Matsui and co-workers. Those studies are not cited in the paper under review, so it is not clear if the study agrees or disagrees with prior work or what the new findings are. At the end of the conclusions, the authors outline some very interesting questions (how mixing state modulates boundary layer height, haze episodes). Pursuing those with this modeling tool would make a much more interesting paper with new insights for the community.

Specific comments:

1. Section 2.1: Since this paper is about BC mixing state, more detail needs to be provided how the APM model represents this. (What is the bin structure? Is coagulation included? Etc.) Even though this was published in previous work, this information is key for the reader.

2 How exactly was the NoCOAT simulation set up? Was the condensation process "switched off"? This would imply that the total mass concentrations in the NoCOAT and COAT simulations are different. Alternatively, is the aerosol material that would condense in the COAT simulation put into separate particles? Are the size distributions the same in the NoCOAT and COAT simulations?

3. Other missing information in this section are: What is the mixing state of aerosol that is transported into the domain through the boundaries? What is the model timestep? Why was January 2014 chosen for this paper? It seems arbitrary. Was there a spin up simulation time?

4. Section 3: A very much overlooked issue is the question about what is the mixing state that is assumed for carbonaceous aerosol at emission? The modeling approach for predicting mixing state evolution can be very sophisticated, but this won't help if the

emissions are not treated adequately.

5. Is there a temporal profile for the emissions (hourly, daily?)

6. Section 4: The sentence at the start of section 4.1 is not clear (line 128-130). Are you referring to mass concentrations or number concentrations?

7. Line 148: Unless the model includes the change in morphology during the first stage of aging, the fact that BC aging has two stages seems irrelevant here.

8. Line 161: Shell diameter, should read shell thickness.

9. Line 161: The refractive indices: This is an important parameter, I recommend listing these values explicitly. In particular, which species are assumed to be absorbing, just BC or also OC (brown carbon)? Stier et al. (2007) that uncertainties in BC refractive index are a leading cause of differences in predicted DRF, before even starting to think about mixing state.

10 Line 176: Suggest marking the sites in Figure 4. Include error metrics that quantify the agreement of simulated AOD and AERONET data.

11. Figure 2: the font of the wind arrow scale is too small. Mention in the caption that this is a monthly average. “Top column” and “bottom column” should read “top row” and “bottom row”. “mass of BC core” should read “mass concentration of BC core”

12. Figure 4: Is this the absolute difference?

13. The English needs to be improved throughout the manuscript.

14. To improve readability I recommend refraining from using too many abbreviations. For example, the geographic locations (ECC, YRD, PRD, SCB, CC) and species group abbreviations (SS, SP, SNA) can easily spelled out without much effort.

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