

Atmos. Chem. Phys. Discuss., referee comment RC1
<https://doi.org/10.5194/acp-2022-131-RC1>, 2022
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Comment on acp-2022-131

Anonymous Referee #1

Referee comment on "Quantifying the effects of mixing state on aerosol optical properties"
by Yu Yao et al., Atmos. Chem. Phys. Discuss.,
<https://doi.org/10.5194/acp-2022-131-RC1>, 2022

Yao et al presents a particle-resolved model study to characterise the relationship between aerosol mixing state and optical properties. A useful mixing state algorithm (mixing state index) is applied to quantify the complicated role of aerosol mixing state in the calculations of aerosol optical properties. Overall, this study is well written, and the results of this study are important for the estimation of atmospheric aerosol climate effects. I have two major comments and several minor comments before the manuscript can be accepted for publication.

Major comments:

- The aerosol optical properties and mixing state simulated by the particle-resolved model has been discussed well. However, it would be better to present the mass absorption coefficient (MAC) results as well for a broader interest. Given PartMC-MOSAIC can also present mass-resolved results and following the methods described in Fierce et al. (2020), I think both the volume-based and mass-based parameters can be derived through the PartMC-MOSAIC simulations.
- Following the major comment above, it would be helpful to provide the absorption enhancement information (Eabs) as well. I encourage the authors to add the Eabs results as a function of BC mass fraction and include the discussions in the relevant sections.

Minor comments

- The authors claimed that the absorption of brown carbon (BrC) is not considered in this study and the maximum diversity value is 2. Therefore, I think the term "chi" mainly works for the BC and non-BC material. I suggest the authors change the term "optical mixing state metrics" to "black carbon mixing state metrics" or just define it as "mixing state metrics".
- Figure 1: Suggest adding a legend to the figure as colour blue also stands for nitrate in the following graph. The sentence "black stands for black carbon black" also needs rephrasing.
- Line 196: "in urban environments, BC ages quickly, forming internal mixtures with secondary species". May need a reference for this.
- Page 13, Line 270: Should be the "core mass ratio" to avoid misleading. As the core volume ratio maintained the same in each bin indicated by the caption of Fig. 7. It might be helpful to add the core mass ratio in each bin to Fig. 7 for better illustration.
- Line 353-357: The authors may benefit from including the results from Hu et al (2021) for the discussions of BC morphology.

References

Fierce, L., Onasch, T. B., Cappa, C. D., Mazzoleni, C., China, S., Bhandari, J., Davidovits, P., Fischer, D. A., Helgestad, T., Lambe, A. T., Sedlacek, A. J., Smith, G. D., and Wolff, L.: Radiative absorption enhancements by black carbon controlled by particle-to-particle heterogeneity in composition, *Proceedings of the National Academy of Sciences*, 117, 5196, 10.1073/pnas.1919723117, 2020.

Hu, K., Liu, D., Tian, P., Wu, Y., Deng, Z., Wu, Y., Zhao, D., Li, R., Sheng, J., Huang, M., Ding, D., Li, W., Wang, Y., and Wu, Y.: Measurements of the Diversity of Shape and Mixing State for Ambient Black Carbon Particles, *Geophysical Research Letters*, 48, e2021GL094522, <https://doi.org/10.1029/2021GL094522>, 2021.