Atmospheric Chemistry and Physics Discussions

Atmos. Chem. Phys. Discuss., referee comment RC2
https://doi.org/10.5194/acp-2022-131-RC2, 2022

Comment on acp-2022-131

Anonymous Referee #2

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-RC2, 2022

This study uses the PartMC-MOSAIC model to evaluate the influence of the treatment of the BC mixing state on aerosol optical properties. The authors show that averaging the mixing state ("composition averaging") overestimates absorption coefficient and underestimates scattering coefficient. In addition, the authors evaluated the dependence of these optical properties on relative humidity.

This study fits well within the scope of the ACP, and their results will be important for more accurate estimation of aerosol optical properties by climate models. The manuscript is generally written well and is suitable for the publication of this journal after considering some minor comments described below.

Minor comments:

1) Lines 14-19

The authors show some examples of studies estimating direct radiative forcing of BC and aerosols. However, the values in these studies (0.9 W m^{-2} for BC and -1.9 W m^{-2} for aerosols) are much larger than the values reported in the IPCC AR6. I suggest the authors revise this part considering the latest findings and assessment reports.

2) Lines 52-64

In this paragraph, the authors describe that it is difficult to represent both particle size and mixing state in 3-D models. However, recent studies have developed regional 3-D models and global climate models that explicitly represent both particle size and mixing state (Matsui et al., 2013; Matsui, 2017). They have also evaluated the importance of resolving particle size and mixing state in the estimation of optical properties and radiative forcing (e.g., Matsui and Mahowald, 2017; Matsui et al., 2018). I suggest the authors describe these studies in Introduction or Discussion section.

3) Line 107, Table 1

Please show the ranges for model outputs also. It would be good to show how the ranges of mass concentration, number concentration, and mixing state of individual aerosol species in model outputs are consistent with available aerosol observations.

4) The caption of Figure 1

black carbon black -> black carbon

5) Lines 160-162

In the composition averaging, the particle sizes of aerosols are also averaged because the resolution is lowered for both mixing state and particle size. How much does the lower resolution of the particle size (particle resolved -> 8 bins) change the results? Can the averaging of the mixing state and the effect of the lower resolution on the particle size be separated?

6) Line 180

It is difficult to follow the equations in section 2.5. Can the authors add a figure showing what χ means by using the schematic image of particle size and mixing state like Figure 1, for example?

7) Line 213, equation 9

Please clarify the difference between v' and v.

8) Line 222, equation 10

Does n_i in this equation mean total number concentrations (the sum of particles with and without BC)?

9) Lines 224-228

I think the description that averaging increases BC core particle size is incorrect. As shown on the right side of Figure 5 (at 50%), averaging increases the number of BC containing particles and decreases the BC core diameter of individual BC particles. If I understand correctly, ΔD_core in Equation 10 is positive not because BC becomes larger, but because the number of BC containing particles increases (the product of ni and Di_core is zero for many particles before averaging but is non-zero for all particles after averaging). It would be better to describe that the surface area of particle populations increases, or that the number of BC containing particles increases.

10) Line 275, equation 11

Do V and m include BC? If so, does this affect the increase in Δm_real because the real part of the refractive index of BC has a larger value than that of other species.

11) Line 282, coating refractive index

Related to comment 10, Is Δm_real calculated for coating species only?

12) Lines 282-283, The increase of BC core size after composition-averaging

As described in comment 9, this description seems to be incorrect. Please revise.

13) Line 310

refratcive -> refractive index

14) Line 335

As described in comment 5, the averaging does not conserve particle size. Total number and volume (or mass) concentrations are conserved, but surface area and particle size are not necessarily conserved by averaging. I suggest the authors revise this part.

References:

Matsui et al., 2013, doi:10.1029/2012JD018446

Matsui, 2017, doi:10.1002/2017MS000936

Matsui and Mahowald, 2017, doi:10.1002/2017MS000937

Matsui et al., 2018, doi:10.1038/s41467-018-05635-1