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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The Absorption Ångström Exponent of black carbon: from numerical aspects" *by* Chao Liu et al.

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Overall: First of all, we would like to thank the two anonymous reviewers and Dr. Corbin for their thoughtful review and valuable comments to the manuscript. In the revision, we have accommodated all the suggested changes into consideration and revised the manuscript accordingly. All changes are highlighted in the revised manuscript in RED in the revision.

Inspecting aerosol AAE is important for multitude of applications, and the originally derived values are problematic, as the authors correctly point out.

The authors want to be able to break AAE (a derived particle-scale quantity) into, essentially, microphysical factors contributing to AAE, and this is indeed how I also see

the field moving forward. While derived quantities are useful in same situations, BC can be argued to be too varied, either due to coating or differences in aggregation, for a single number to reliably represent all cases.

I think the work done here is important and of high quality, and is definitely worth being published. I have a few main questions I'd like to see addressed as well as a few minor comments.

Response: Thanks for the comments on the manuscript. We definitely agree with the reviewer that there are significant uncertainties on BC AAE, and numerical models should make their contributions to improve our understanding. The following presents our answers as well as the revision for the manuscript.

Major notes:

Is the coating always observed to be a sphere encompassing the aggregate? For a less compact aggregate would the coating be a very large sphere or rather would the shape follow that of the aggregate? Is that something that could be studied with the model used here?

Response: Geometry is one of the most significant uncertainties on coated BC. In real atmosphere, the electronic microscopic images do show BC particles with quite different shapes. For less compact aggregates, some numerical models are developed to build coating with the shape following that of the aggregate, whereas none of those studies consider the AAE. We discuss some of those studies about different coated BC models in the revision. It is possible to consider almost any geometries numerically, and we tried out best to find the most representative one for general study. Meanwhile, we also stress that our work considers only a special case to account for the effects of BC aging. In the revision, we further emphasis the limitation of the Coated BC case, and further investigations should be carried out to consider the effects of other particle geometries. (Line 8 of Page 6)

Individual BC particles are not perfect spheres nor perfectly smooth in reality. Is it possible to investigate the effects while taking these non-idealized factors into account? Do the authors think these factors would have significant effects or can they safely be ignored?

Response: Yes, the non-idealized factors, such as overlapping or necking among monomers, nonsphericity, and poly-disperse monomer, do exist in reality, and even the fractal aggregate model may show differences from the realistic BC cluster. Those effects can be considered by numerical models other than the MSTD, and there are some studies that investigated such effects, such as Skorupski and Mroczka (2014), Yon et al. (2015), Wu et al. (2016a, 2016b), and Liu et al. (2016). These studies generally indicate that the minor factors do influence the optical properties to some degree, whereas those influences on the absorption are minor compared to the particle overall geometry or size. Overall, the size and overall geometries show the most significant influences on BC optical properties, and, thus, this study captures those main factors. We include similar discussions in Section 2.1 of the revision. There will be definitely following-up studies to show the influences of those factors on BC AAE, considering that the effects of those factors on BC AAE have not been considered yet. (Line 20 Page 5)

Is there a way to parametrize the results by using e.g. equivalent-sized (coated) Mie spheres with some kind of an effective medium approximation? This would greatly help facilitate the use of these types of particles in many applications (moreso than just a better estimate of AAE).

Response: This is a great suggestion for the approximation. As we have seen from other studies, neither the equivalent-sized Mie sphere nor equivalent medium approximation can give accurate approximation on optical properties of BC aggregates (Li et al., 2009; Liu et al., 2013). We included those previous studies in the revision. Furthermore, in Figure 6 of the revision, we include results given by Mie for the equivalent volume sphere approximation, and discusses the errors that may be introduced. As we

can see from the figure, the Mie results are significantly different from others. Considering the poor performance given by the Mie results, we will not include the results for core-shell Mie or for equivalent medium approximation, because the inhomogeneous structure will bring another factor for the numerical errors. The changes are made at Figure 6 and the corresponding discussions. (Figure 6 and Line 19 of Page 11)

Minor notes:

Page 9, line 16: "straightforward", not "straight forward"

Response: Corrected. (Line 24 of Page 10)

Page 10, line 13: Reference is italicized, unlike most other references. Should be consistent

Response: Thanks, and we have modified the format. (Reference Section)

Fig. 2: X-axis says "Evquivalent", should be "equivalent"

Response: Corrected. (Figure 2)

Fig. 9: Legend says "Comapct" instead of "Compact" Response: Corrected. (Figure 9)

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