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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Black carbon fractal morphology and short-wave radiative impact: a modelling study" *by* M. Kahnert and A. Devasthale

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Response to anonymous referee 1:

This study reports an importance of black carbon morphology regarding its optical and radiative properties. The result indicates that a spherical assumption for black carbon, which is commonly used in climate models, results in large error for the evaluation of the global climate. This study is well organized, includes important findings, and agrees with the scope and scientific significance of this journal. I have several comments that will help to improve this paper.

We thank the reviewer for his encouraging evaluation and for his helpful input. Below we list an itemized response to the reviewer's suggestions and a description of the changes we intend to make in the final version of the paper.

1. *Fresh black carbon vs aged black carbon*
   This study mainly discusses fresh black carbon that has no coating. However, as authors mentioned (e.g., in abstract and conclusion), black carbon particles can have coatings and have different optical properties (e.g., Bond et al., 2006; Adachi et al., 2010). Although authors discuss the point in conclusion 3 as "a thin film of organic material", more discussion will help readers to understand the limitation of this study. Especially, black carbon with "thick" coating, which could be dominant in polluted air, needs to be mentioned.

   We do mention on page 23123 (line 14) the significance of encapsulation of black carbon into soluble material. With "Encapsulation" we mean exactly the same thing as the reviewer means by "thick coating". Our use of the term "encapsulated geometry" follows the terminology suggested by Bond and Bergstrom (2006) and Bond et al. (2006). We will make appropriate changes to the text to clarify our terminology. Also, since we agree with the reviewer that this is an essential point, we will emphasise once more the significance of encapsulation ("thick" coating) in the conclusions or discussion section.

2. *Modeled black carbon particle size*

2-1. *This study uses black carbon aggregate particles with 600 spherules with 25nm radius, which yield 420 nm of volume equivalent diameter. This particle size seems to be large comparing to that observed in ambient air. For example, Kondo et al. (2011) reports mass median diameter of black carbon particles from Tokyo is approximately 150 nm.*

We very much agree with the reviewer that the size range we consider may be a bit of an overkill. But we do think that it is better to consider too large a size range than too small a size range. We will amend the text of the revised version of the paper and make it clear that our size range is perhaps slightly larger than necessary. Also, we thank the reviewer for bringing the paper by Kondo et al. to our attention; we will add a citation of this paper in the revised manuscript.

2-2. *Authors use a wide range of particle size (Rv) in Fig. 2. For smaller particle sizes, the sizes of black carbon spherules become much smaller than the original value (25 nm for radius).*

This is an interesting point. Considering the condensation and coagulation processes by which black carbon aggregates are formed in combustion processes, it seems to make sense that smaller aggregates also consist of smaller monomers. We will add some text to the revised manuscript and point out that we neglected this effect in our calculations. Based on our earlier sensitivity studies (Kahnert, Aerosol Sci. Technol. 2010), taking this effect into account will not affect the absorption cross section, but it may slightly lower the single scattering albedo for the smallest aggregates. It would be interesting to take this effect into account in future studies.

3. *Conclusion*
Although it is a matter of taste, the conclusion of this study is relatively long and includes some discussion and repetition. I recommend having a discussion section or other section in this paper rather than such long conclusion section.

We agree. In the revised manuscript, we will split the last section into a longer discussion section and a shorter conclusion section.

4. *Technical comments*

4-1. *Table 1 & 3 and 2 & 4 can be combined. Otherwise, tables 3 and 4 should have more independent captions.*

If we combine the tables, then they will span two columns in the final ACP version

of the paper. We can try to do this and see how it looks. If it doesn't work well, we will expand the table captions, as suggested by the reviewer.

4-2. *Page 23116 line 9. Typo "by by".*

We thank the reviewer for pointing this out.

We would like to add one additional point. We noticed that we forgot to discuss a very important observation in our results, which refers to the wavelength dependency of the optical properties. Due to the challenges involved in computing the optical properties of black carbon aggregates with electromagnetic theory, some investigators have suggested to simply use the measured value of the mass absorption cross section (MAC) at a wavelength of 550 nm, and to extrapolate this value to other wavelengths by a $1/\lambda$ scaling. However, our analysis clearly shows that this approach will give highly inaccurate results. The main problem with extrapolating the measured value of MAC by a $1/\lambda$ scaling becomes apparent when inspecting the wavelength dependency of the absorption cross section C_{abs} in Fig. 2 (upper left panel). In the red and IR part of the spectrum, C_{abs} scales indeed as $1/\lambda$. However, starting at green wavelengths and continuing throughout the blue and UV part of the spectrum, the $1/\lambda$ scaling completely breaks down. The reason for this is that the refractive index of black carbon (especially its real part) changes quite rapidly in that part of the spectrum. Using a $1/\lambda$ scaling of measured MAC values would therefore introduce substantial errors in broadband radiative forcing simulations. We conclude that we need to properly account for the spectral variation of the dielectric properties of black carbon to obtain accurate estimates of the radiative forcing effect. In the revised paper, we plan to add a short discussion of this important point.

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 23103, 2011.