Response to Anonymous Referee #2

Major comments:

1) The method section needs to be clearer to me, making me unable to validate the results. First, the AE33 measurement needs to be clarified. How did you retrieve σ_{abs}? Did you correct for multi-scattering? How do you calculate the mass fraction of BC from bulk since you do not know the MAC of bulk? How do you get MAC of eBC? How did you separate iron dust and BC? AE33 measures transmission, which is used to calculate the σ AE33 uses the default MAC to calculate wavelength-depended BC mass concentration. Thus, I do not understand why you need to estimate the MAC of bulk to get σ_{abs}. I also read Zhao et al. 2021, but I do not know how you could use that method since you do not know the BC core size. Moreover, it is also unclear how you calculated $m_{eBC,bulk}$, and estimated the eBC fraction since you do not have an OC-EC analyzer or other measurements to measure organic and BC mass fractions. Moreover, you have different size measurements (APS, SMPS, and AAC), measuring different aerodynamic sizes (APS: optical aerodynamic size, SMPS: electrical mobility diameter, AAC: aerodynamic). How do you combine them together? Furthermore, how do you estimate the particle densities?

<u>Response:</u> Thank you very much for your comments. We add the methodology of retrieving σ_{abs} and corresponding multi-scattering correction in the revised manuscript. Multi-scattering effect was corrected in this study. We add the method of deriving MAC based on size-resolved σ_{abs} in the revised manuscript. Dust is not considered in this study and we add this statement in the revised manuscript. MAC depends on particle size, and we derive size-resolved m_{eBC} in this study. The default particle-size-independent MAC leads to inaccuracy in retriving size-resolved m_{eBC}. Thus, we did not use the default MAC. $m_{eBC,bulk}$ was integrated from size-resolved $m_{eBC,bulk}$. The conversion between different type of sizes was based on the study of DeCarlo et al. (2005). The particle density (1.3 g cm^{-3}) is a fixed value in this study based on the study by Zhao et al. (2019).

2) The trend in mass and σ_abs seem statistically the same, which makes me feel your size-resolved MAC is not different across the different sizes. Please comment on that. I want to see a plot of size-resolved MAC.

<u>Response:</u> Thank you for your comments. Here is an example of size-resolved MAC. The reason why mass and σ_{abs} seem the same is that size-resolved MAC influences the relative distribution of size-resolved mass. Since the averaged size-resolved MAC (8.00 m^2 g^{-1} in this example) is closed to the default MAC of AE33 (7.77 m^2 g^{-1}), the difference in bulk mass calculated from size-resolved MAC and default MAC is not that large.

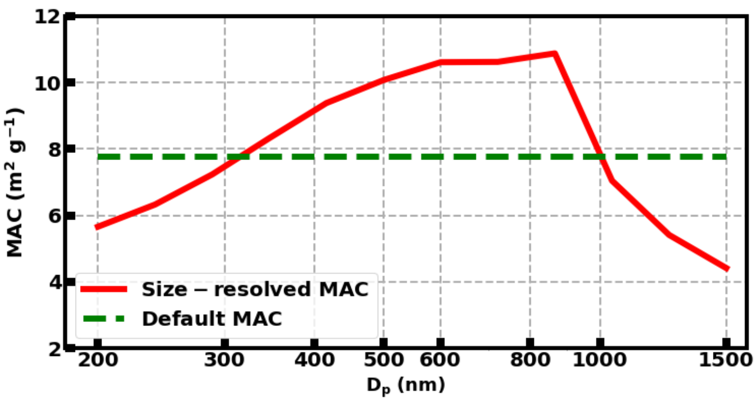

Figure 1: An example of size-resolved MAC (red solid line) and the default MAC of AE33 (7.77 m^2 g^{-1}).

3) Results and Discussion section needs to add uncertainties when you show data. Your value is very low, which might be instrument noise or data uncertainty. I suggest having a summary table.

Response: Thank you for your suggestion. We present the uncertainties of data in the form of "median (lower quantile ~ upper quantile)" in the manuscript. A summary table (Table 1) is added to the revised manuscript.

4) When you discuss MAC and σ_abs, you should always put the wavelength. It is meaningless to discuss light absorption properties without mentioning the wavelength.

Response: Thanks for your comments. We add wavelength (880 nm) to MAC and σ_abs in the revised manuscript.

5) The paper needs to be better organized. The figure number is chaotic. They should be in the same order in the text. Captions of Fig. 3 and Fig. 4 are not acceptable. You should provide all the necessary information in the caption. Also, your subplot label should always be distinct from your plots.

Response: Thanks for your comments. We reorganize the manuscript especially the figure number so that the figure number is in the same order of the text. We provide all the necessary information in the captions of these figures.

6) This paper needed to provide a detailed explanation of the discrepancy between Changzhou and Pekin. Is that due to different eBC sources, seasons, geographical locations, or something else? What can we learn from your results? How can we utilize your results?

Response: Thanks for your comments. We provide detailed explanation of the discrepancy between Changzhou and Beijing in the revised manuscript. What can be learnt from our results is that BC-containing particles larger than 700 nm is of great importance and should be measured extensively. We provide a method of measuring BC-containing particles larger than 700 nm and reference values of direct radiative forcing of

BC-containing particles larger than 700 nm.

7) The manuscript needs to be proofread by professional proofreaders before resubmission. There are lots of grammar issues.

Response: Thanks for your comments. We make corresponding changes in the revised manuscript.

Specific comments:

1) L56-59, "It should be noted … (chow et al., 2001). I suggest discussing "Soot superaggregates from flaming wildfires and their direct radiative forcing." Offline microscopy technology can be used to analyze large soot particles.

Response: Thanks for your suggestions. We add discussion with respect to "Soot superaggregates from flaming wildfires and their direct radiative forcing".

2) Figure 5 a2 and a4: Why PDF mode overlaps with lower quartiles, not the median?

Response: Thanks for your comments. There are quite a few values are larger than the lower quartiles. The distribution of these larger values is sparser and less concentrated, making them less distinguishable than the PDF mode in the plots but still influencing the position of median.

L179-181, "In order to … 1.0 μg m-3." How did you define the thresholds of these three periods? Based on statistical analysis or literature?

Response: Thank you for your comments. The thresholds are defined based on statistical analysis on the data. By this definition, the data in three periods are roughly 1:1:1, making the amount of data relatively unbiased for these three periods.

L218, "It could be … ubiquitous." When you say something is ubiquitous, abundant, etc., you should show the fraction with uncertainties. Please check the manuscript and revise it accordingly.

Response: Thank you for your suggestions. We make corresponding revision.

L242-243, "It could be … boundary layer." What do you mean by Level of eBCMSD? Total mass or particle size? Why do you say that the planetary boundary layer regulates it? There should be more emission of eBC during the daytime, especially at morning and evening traffic peaks.

Response: Thank you for your suggestions. The level of eBCMSD means the value of eBCMSD. We change "level" into "value" in the revised manuscript to avoid ambiguity. We consider the influence of diurnal emission of eBC in the revised manuscript.

L260-261, "The large spread … on absorption." How about different BC mass in different size bins?

Response: Thank you for your comments. It is possible that BC mass influence absorption in different size bins. But we removed the paragraph for better organization of the paper.

L320-323, "The increase in … that in Beijing." Please explain the difference in detail (see my previous major comment).

Response: Thank you for your comments. We add more description on the two measurement sites in the revised manuscript.

Section 3.4 Case study. Why do you have this section here? It should be discussed in your previous sections. Moreover, what's the advantage of using mean diameter compared with geometric mean diameter?

Response: Thanks for your comments. Case study is moved to previous section. The mean diameter is actually geometric mean diameter. We changed "mean diameter" into "geometric mean diameter".

The conclusions section needs to add more discussion about environmental implications.

Response: Thanks for your comments. We add more discussion about environmental implications.

References

DeCarlo, P. F., Slowik, J. G., Worsnop, D. R., Davidovits, P., and Jimenez, J. L.: Particle morphology and density characterization by combined mobility and aerodynamic diameter measurements. Part 1: Theory, Aerosol Science and Technology, 39, 184-184, 10.1080/02786820590928897, 2005.

Zhao, G., Tao, J. C., Kuang, Y., Shen, C. Y., Yu, Y. L., and Zhao, C. S.: Role of black carbon mass size distribution in the direct aerosol radiative forcing, Atmospheric Chemistry and Physics, 19, 13175-13188, 10.5194/acp-19-13175-2019, 2019.