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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Size-resolved mixing state of black carbon in the Canadian high Arctic and implications for simulated direct radiative effect" *by* John K. Kodros et al.

Anonymous Referee #1

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In this paper, the authors present measurements and modeling of BC mixing state in the springtime Canadian high Arctic. Measurements were collected using Single Particle Soot Photometer (SP2) and Ultra-High Sensitivity Aerosol Spectrometer (UHSAS). The authors reported that measurements of aerosol mixing state provide important constraints for model estimates of direct radiative effect. The dataset and the associated analysis and modeling results are valuable to atmospheric and environmental researchers and the topic is fitting well within the scope of ACP. I suggest some revisions to improve the clarity and scientific merit of the current manuscript, after which I recommend publication.

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Specific comments: 1. Particles measured by SP2 and UHSAS were combined to determine the number fraction of rBC particle. These two instruments have different size-cut and different measurement sensitivity. It would be worthwhile to include some details on the influence of the instrumental size-cut on the overall results, instrumental inter-calibration and any size adjustment for combining data from two different instruments. For example, if we have a 100 nm particle (mobility or some sort of equivalent size), do the SP2 and UHSAS both measure it as the same size. If not, how do the authors combine the measurements from two instruments to construct the distribution of the number fraction of rBC particles as a function of size? For the size distribution shown in Fig. 4A, how much are we missing below the measurement window (100 nm)? Is it possible to get a closure in Fig4A (i.e., total particles = bare-BC+ coated-BC+ non-BC)? They have some limited discussions on these, but it's hard to follow and get the whole picture. Details would be helpful for general readers. Details can go to the SI.

2. The discussion in Sec. 3.1 is limited. The authors should consider expanding the discussion in this section. There is no mention of Fig. 4B. What's the implication of fitted line in Fig4B? Can the authors propose any parameterization based on this fitting in Fig.4B, which can be used for constraining/evaluating model results in a similar environment where there are no measurements? The campaign-average mixing state is mostly focused in this section. Were there any changes in mixing states depending on air mass trajectory (relatively-fresh vs. aged) in that very clean environment?

3. Details measurements of aerosol properties are essential to improve model predictions and provide better constraints on the model results. However, based on the discussions in Sec. 3.3., it is not clear how much constraints are getting added by the detailed size-resolved BC mixing state measurements. It is clear that fully-externally or fully-internally mixed assumptions are not very realistic ones. However, external*1.5 bounding case vs. two constrained cases (fBC-constrained and rshell-constrained) showed a similar level of uncertainty on the estimated DRE. For example, In page 12,

L-26-28: “the fBC-constrained DRE is 0.3-0.4 W m-2 more positive than the external*1.5 mixing-state assumption, while the rshell constrained mixing state is 0.3-0.4 W m-2 more negative”. Here, the two constraints cases provide two different results. If we don’t know which measured case is a better representative one, then the details measurements are not adding that much of additional values compared to some bounding case. It would be worthwhile to include some discussions on this and current limitations and future directions that should be focused more.

4. The denominator of Eq. 1 [(r_core3)/(r_shell3+r_core3)] is confusing. If I understand correctly, to get the total volume of a coated-BC particle, we need to add core volume (r_core3) and shell volume (r_total3 - r_core3), where r_total= r_core+2*r_shell. In that case, [r_shell3+r_core3] would not provide the total volume of a coted-BC particle.

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