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Interactive Comment

Interactive comment on "Black carbon concentrations and mixing state in the Finnish Arctic" *by* T. Raatikainen et al.

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We would like to thank Referee #2 for the constructive comments. Below are the issues raised by the referee (quotes shown in italics) and our replies (plain text).

This study provides valuable data in the Arctic ground site, however needs to address the followings:

Major: The introduction part I would suggest to shorten the part which explains the BC instrumentation, but more focusing the BC measurements in the Arctic ground sites.

We have now given more details about the surface BC in the Arctic with the focus in study area. We have also slightly shortened the part explaining BC instrumentation.

About SP2- 1. Has the Aquadag calibration been applied to the ambient, i.e. different instrument response to Aquadag and ambient BC. 2. I would suggest to use an inverted Mie table to calculate the Dp/Dc using core refractive index 2.26+1.26i and coating 1.5+0i [Taylor et al., 2015; Liu et al., 2014]. 3. It is better to show a Dp and Dc size distribution for BC, and Dp size distribution for scattering particle to explicitly explain how you calculate the rBC number fraction.

1. No, because we do not have tools to determine the difference in instrument response between Aquadag and ambient Arctic rBC. To our knowledge, there are no previous studies from the Arctic where the difference has been reported. This potential bias is mentioned when SP2 and MAAP results are being compared.

2. We have previously used this method, but considering the uncertainties related to particle morphology, LEO method, detections limits and optical constants, it is difficult to say if this improved the results or not. At this point we are assuming that all particles scatter light as pure ammonium sulfate. This is also consistent with our updated terminology where core-shell model is not presumed (see the comment by Referee #1 and our response). Since this is still an open question in the SP2 community, we aim to take a neutral position.

3. We have now simplified this section especially regarding the LEO method. Adding more technical details (the suggested figure) would make this section less clear. The calculations are actually very simple: we just calculate number concentrations by integrating the relevant size distributions over the same particle (LEO) size range.

About the result analysis 1. To me, the Dp/Dc ranges 1.7-2.2, GMD 150nm-240nm; BC number fraction 0-0.5. All of these variations are significant. There must be very interesting stories there however have not been fully analysed and explained. 2. A general look of Fig. 3 is the BC mass is significantly lower in cloud than no cloud, does that mean a fraction of BC has been scavenged? Have you removed the data when snow precipitation? 3. About section 3.2.1, again when you have fully explained your *own story, the comparison will be more interesting however at the moment the base is not solid. 4. There is no much point for section 3.2.2, as there will be no apparent diurnal trend for this remote site. 5. Could we show the clustered air mass types in Fig.3. 6. For section 3.4, I would suggest to calculate the MAC (absorption/mass) for different air masses, is rBC size or coating thickness affecting MAC?*

1. Yes, these variations are significant, but not as large as those of the rBC mass concentration. It seems that the lack of correlation between these variations (except that of rBC mass concentration) and those of the other parameters is the most interesting story. The lack of correlation (or the correlation for total rBC mass) is now explained in the results section.

2. As mentioned in the text, significant correlation was not found between BC mass and clouds. This is good for us, because clouds could have caused a bias to our results, but the lack of correlation shows that other factors than clouds (mainly activation and removal by the PM10 inlet) dominate (in-cloud scavenging, precipitation, etc. may have altered the size distributions any time before the observation at Pallas, but we do not have tools to examine that). Snow fall events were not removed from the data. These could not be examined in detail, because, the weather station had low data coverage. On the other hand, the observed snow fall events occurred during in-cloud events (no precipitation during most of the in-cloud events), which are examined.

3. In this section we have compared our numerical mean values with those from other campaigns. More qualitative comparison of "stories" with that from a similar study would be interesting, but currently this is the first appearance of long-term SP2 ground study from Arctic.

4. The absence of diurnal variations of the mixing state parameters is a result itself. We have also observed a diurnal cycle for rBC concentration when polar night and early spring are considered separately. Therefore, keeping this short section is justified.

5. We have added trajectory directions (and CO concentration) to Fig. 3 so that the

marker color is based on the trajectory direction.

6. We did some additional calculations where we tried to correlate rBC to eBC ratios (can be related to MAC) with trajectory directions and rBC mixing state parameters (mean size, rBC number fraction and particle to core diameter ratio), but significant correlations were not found. Therefore, these are not shown in the paper.

Specific: Abstract "On the average, the number fraction of particles containing rBC was 0.24 and the average rBC core size in these particles was half of the total size (coated to core diameter ratio was 2.0). These numbers mean that the core was larger and had a significantly thicker coating than in typical particles closer to their source regions."

State the number fraction of rBC is for what size range of particles –PM1? These numbers means core 'larger'? It is not surprising the BC in this remote site is thickly coated, so does not mean too much if compared to 'sources'. 'Comparison of the measured rBC mass concentration with that of the optically detected equivalent black carbon (eBC) showed a factor of five difference, which could not be fully explained without assuming that a part of the absorbing material is non-refractory.' – part of the absorbing material is non-refractory, what does that mean.

Size ranges for the calculations are now given. We have now clarified that rBC core size is typical for aged air masses, but particle to rBC core volume equivalent diameter ratio is higher than in most other studies. We have also clarified that only a part of the light absorbing material is refractory and absorbs light at the wavelength used by the SP2.

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