Effects of mixing state on optical and radiative properties of black carbon in the European Arctic

We would like to thank the referees for their detailed and constructive comments, which helped us to improve our manuscript. While the referee comments are given in **black bold,** our answers are given below in blue letters. Additionally, we added the changes we made in the revised manuscript in **blue bold** letters.

Answers of the authors to anonymous Reviewer #1

Anonymous Review of Manuscript acp-2018-45 GENERAL REMARKS

Zanatta et al. present measurements and analysis of aerosol optical properties from a ground site on Svalbard Island during the springtime arctic haze period. The measurements and analysis presented focus on the black carbon component of the aerosol, but also include scattering and AOD measurements. Agreement between the SP2 and COSMOS black carbon mass concentration measurements is demonstrated. The MACs observed are higher than expected for bare BC, but the authors show that is can be explained by coating enhancement of BC absorption which is modeled with Mie theory. It is advantageous that the BC is heavily coated which allows the assumption of a spherical core/shell morphology. The measured optical properties are extrapolated to 1 km height and used along with the AOD in a radiative transfer calculation to determine the radiative forcing of the arctic haze. The radiative transfer calculation shows the sensitivity to the MAC and coating enhancement of the absorbing aerosol.

Specific comments of Reviewer#1

Page 4, line 43: Could you state or summarize the uncertainties in coating thickness.

More details and references were implemented. The phrase now reads:

[…] The relative precision of SP2-derived coating thickness is ±17% (unit-to-unit variability determined by Laborde et al., 2013). Accuracy of absolute values depends on consistency between SP2 calibrations with assumed refractive indices. This was checked by comparing the rBC mass equivalent diameter with the optical diameter of the bare BC core just before incandescence as discussed above, which indicates that potential systematic biases are not greater than above precision. […].

Page 5, line 44: replace '90 degrees angle' with 'a 90 degree angle'

Changed.

Page 6, line 29: PMOD/WRC is not defined in the text.

PMOD/WRC stands for "Physikalisch-Meteorologisches Observatorium Davos, World Radiation Center". For brevity, the acronym is now removed and the sentence is changed in:

[…] is calibrated at the World Optical Depth Research and Calibration Center of Davos. […].

Page 7, line 21: Why is the RI used for the BC core not consistent with the RI used in the analysis of the SP2 data?

The reason rises from the different optical domain to which the SP2 data analysis and the radiative forcing estimation belong. The RI used for the SP2 data analysis is specific to the operating wavelength of the SP2 laser and chosen to minimize potential systematic biases in the coating thickness values (see comment above). We modified the text in Section 2.2.1 to specify this point:

[…] Thereby refractive indices of 1.5-0i and 2.26-1.26i, specific for the Nd:YAG laser operating wavelength (1064 nm), were used for the coating and BC core respectively (Moteki et al., 2010). Using this RI for BC in the SP2 data analysis results in consistency between the rBC mass equivalent diameter with the optical diameter of the bare BC core just before incandescence, thereby assuring minimal systematic bias in retrieved coating thickness values. […].

Differently, the optical and radiative calculations performed in the present work lay in the visible spectrum. In our case a refractive index of 1.95 - 0.79i at a wavelength of 550 nm was chosen (Bond and Bergstrom, 2006). The text in Section 2.4.1 was modified in:

[…] The refractive index (RI) of the BC core was assumed to be 1.95 - 0.79i at a wavelength of 550 (Bond and Bergstrom, 2006). For the same wavelength, an RI of 1.55 - $1 \cdot 10^{-6}$i was assumed for the coating material, which corresponds to a mixture of virtually non-light-absorbing organics and inorganics (Bond et al., 2006a). […].

Page 8, line 36: replace 'coherent with' with 'consistent with' or 'similar to'

Changed.

Page 12, line 20: Please give references for the range of BC AAE.

The work of Zotter et al. (2017) in snow included in the text:

[…] which is in the range 0.8-1.1 (Zotter et al., 2017). […].

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