High–Arctic aircraft measurements characterising black carbon vertical variability in spring and summer

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#4

Anonymous Review of Manuscript acp-2018-587 GENERAL REMARKS

This paper describes the results from the aircraft measurements of black carbon (BC) aerosols over the high arctic region. The vertical distribution of BC is one of the most important characteristics for assessing its radiative impact. Authors analyzed in detail the vertical distributions, their seasonal variations, and transport pathways of BC using the data sets from the aircraft observations which were performed in the summer of 2014 and the spring of 2015. The analyses of the vertical distribution of BC with potential temperature illustrated the fundamental feature of the transport of BC from the lower latitudinal region (i.e., Sub-Arctic). Single particle soot photometer (SP2) was deployed on the aircraft to reveal one of the microphysical parameters, size distributions, of BC. The changes in the size distributions of BC in the vertical coordinate indicated that the removal process of BC during the transport to the high-arctic region is related to precipitation. The results and discussion presented in this study meet the scope of ACP. The observed features, which are well illustrated in this study, will be really helpful for the research community of Arctic climate changes as well as I actually enjoyed reading this paper. What this paper does not present in detail is the analyses of wet removal process of BC during the transport and its impact on the abundance and microphysical parameters of BC-containing particles. The cloud processing and following precipitation during the transport in East Asia can significantly affect the microphysical parameters of BC-containing particles in the lower free troposphere (Moteki et al., 2012; Kondo et al., 2016) and even in the planetary boundary layer over the outflow area (Miyakawa et al., 2017). There should be a difference in the actual wet removal process between East Asia and Arctic, because the scavenging of BC particles can be affected by cloud phase (e.g., Browse et al., 2012). Furthermore, we are interested in where BC-containing particles were removed and deposited in Arctic region in order to well understand the snow darkening induced by deposited BC. The more data analyses of precipitation during the transport (intensity of precipitation, where air masses were affected by precipitation, etc.) magnify the significance of the data sets used in this study.

The authors would like to point out that the referees raised questions concerning the interpretation of the BC/CO ratio as indicator for wet scavenging and encouraged us to verify the subsequent hypothesis and conclusions. Due to the high number of comments on this specific topic, we prefer to provide here a general and common answer to all reviewers. As a consequence of the above-mentioned reasons, Section 3.4 was substantially modified. The discussion now focusses on the importance of transport patterns on the observed BC concentration. Thus, Figure 7 and Figure 8 were modified. The discussion on potential impact of wet scavenging on BC and BC/CO ratio is now substantially reduced. However, additional analysis of back trajectories, including encounter with clouds, is now presented in the supplementary material.

Specific comments of Reviewer#4

P1, L10. "a factor 10" should be "a factor of 10". P15, L2. "an air parcel" should be "in air parcel".

Corrected

P23, L11-13. The finding in Moteki et al. (2012) is that the average mass of non-BC materials on rBC-containing particles increased with increasing rBC core diameters. They just discussed shell to core (S/C) ratio of rBC-containing particles. When we translate the relative enhancement of shell mass of non-BC materials into the S/C ratio, the similar tendency given in Kodros et al. (2018) will also be found in Moteki et al. Please modify this description and add appropriate discussion on this part.

The same issue was highlighted by anonymous referee#2. The text was modified in order to translate our core to shell diameter ratio into mass ratio. As matter of fact, our results are coherent with the findings of Moteki et al. (2012). The mass of coatings was calculated assuming a fixed density of 1 g cm^{-3} (Moteki et al., 2012) and quantified to be 4.4 fg and 9.7 fg for BC cores having diameters of 140 and 220 nm respectively. However, Section 3.5 was significantly modified and, based on other referees' comments, the statement mentioned by the anonymous reviwer#4 was removed.

REFERENCES

Moteki, N., Kondo, Y., Oshima, N., Takegawa, N., Koike, M., Kita, K., Matsui, H. and Kajino, M.: Size dependence of wet removal of black carbon aerosols during transport from the boundary layer to the free troposphere, Geophys. Res. Lett., 39(13), L13802, doi:10.1029/2012GL052034, 2012.