Response to comments from reviewer 1

We appreciate valuable comments on our manuscript by the reviewer. Our responses are listed below.

Review of the manuscript titled 'Measurement report: Shipborne observations of black carbon aerosols in the western Arctic Ocean during summer and autumn 2016–2020: impact of boreal fires.'

The manuscript significantly improved after the first revision. I have a few minor comments as indicated below.

Minor comments:

Line 7: Several studies were conducted to understand the chemical composition of aerosols over the Arctic. The authors can use the literature here. I would recommend modifying this sentence.

Reply> The original expression "Arctic aerosol chemical composition may include black carbon (BC), sulfate (SO_4), nitrate (NO_3), organics, sea-salt, and mineral dust." has been modified to "Arctic aerosol chemical composition may include black carbon (BC), sulfate (SO_4), nitrate (NO_3), organics, sea-salt, and mineral dust (Sakerin et al., 2015; AMAP, 2021b; Schmale et al., 2022).". (P2, L7-9)

Page 5, Line 5: What authors would like to convey here by discussing SP2 as a reference instrument in the previous studies? Did the authors use any of these datasets in this study?

Reply> By discussing SP2 as a reference instrument, we intend to rationalize the comparisons between COSMOS and SP2 (P5, L2-5) and between Aethalometer and SP2 (P5, L19-22). We didn't use any SP2 data in this study.

The original expression "The SP2 is used as a reference instrument in previous studies (e.g., Ohata et al., 2019; Sinha et al., 2017)." has been modified to "The SP2 was often used as a reference instrument in previous studies (e.g., Ohata et al., 2019; Sinha et al., 2017).". (P5, L5-6)

Page 5, Line 12: How did the authors estimate the lower detection and error limits? I would suggest adding the details here. Also, explain the noise level of the Aethalometer measurements in this study and how the authors treated them while processing the data. I would also like to mention here the multiple scattering effects in the Aethalometer datasets.

The authors did not mention it in the manuscript and the applied correction procedures if they had done it.

Reply> To confirm the performance of the Aethalometer, the manufacturer conducted a 24-hour particle-free zero air testing. The results demonstrated that the instrument met the 24-hour zero air mean detection limit of 20 ng/m³ and a 5-minute zero air standard deviation limit of ±30 ng/m³, as stated in the instrument manual (https://www.psi.ch/sites/default/files/import/catcos/ProjectDetailCatcosOperationsEN/Aethalometer_book_2005.07.02.pdf). To minimize noise levels, we averaged the 5-minute data to 1-hour intervals for further analysis. The multiple scattering effects in the Aethalometer datasets were not corrected, which could be one of the main reasons for the large uncertainty compared to COSMOS and SP2, as discussed in the second half of the paragraph.

The previous expression "The data integration time was set to 5 min, which was then averaged to 1 h for further analysis. The default manufacturer-provided MAC value of 16.6 m^2 g^{-1} was applied. The lower detection limit of the Aethalometer at 1 h time resolution is 20 ng m^{-3} with the error limit of ±30 ng m^{-3}." has been modified to "The data integration time was set to 5 min. For further analysis, hourly averages were used to minimize noise levels under clean atmospheric conditions. The default manufacturer-provided MAC value of 16.6 m^2 g^{-1} was applied for all analyses since the study area covers a wide range of latitudes. The manufacturer's particle-free zero air testing meets a 24-h mean detection limit of 20 ng m^{-3} and a 5-min standard deviation limit of ±30 ng m^{-3}.". (P5, L12-16)

Page 6, Line 5: Is there any specific reason for screening the data specifically for 3 ms-1.

Reply> We determined the data screening criteria by experimenting with various criteria as well as referring to previous studies, such as Taketani et al. (2016). Other criteria we tested include requiring the 1-min wind direction and speed relative to the ship's course to be within ±70° of the bow and >2 m s^{-1}, respectively. Ultimately, we selected wind direction within ±60° of the bow and a wind speed >3 m s^{-1}. This choice effectively screened out data associated with simultaneous significant decreases in O_3 and increases in BC observed in the open North Pacific Ocean (approximately north of 42° N) and the Arctic Ocean.

Page 6, Line 20: The authors used the Global Fire Emissions Database with small fires (GFED v4.1s) with 0.25° × 0.25° of spatial resolution in this study. This data is available only

up to 2016. But, this study focused on 2016- 2020. How does it affect the results of this study?

Reply> GFED v4.1s data is available from 1997 through the present. For details, the reviewer may refer to these websites: https://www.globalfiredata.org/data.html and https://www.geo.vu.nl/~gwerf/GFED/GFED4/Readme.pdf

Page 7, Line 5: Explain the reason behind estimating the airmass trajectories above 10 m above ground level in this study. I would expect the inlet position of the ship to be higher than this height. Also, I would recommend the authors use the satellite fire count data sets and the trajectories as separate figures in the supplementary details for each cruise period.

Reply> We agree that the inlet position of the ship could be higher than 10 m above the model ground level. In this study, we only used the trajectories started at 500 m above the model ground level for BC source interpretation. And we used trajectories starting at 10, 500, and 1000 m above the model ground level for background period identification. This information has been added to the revised manuscript as shown below: "Note that for the source interpretation of the observed BC, only back trajectories starting at 500 m above model ground level were employed. Trajectories starting at 10, 500, and 1000 m above the model ground level were used for background period identification.". (P7, L11-13)

We have presented biomass burning BC emission maps and back trajectories for the three feature episodes as Figs. S9, S11, and S14. We have decided not to include satellite fire count data and back trajectories for all cruise periods in the supplemental file, as we believe it would not significantly contribute to the discussion points in the manuscript.

Other minor changes:

(P6, L19-20) The original expression "Within the hourly BC mass concentration data, 5–13 % of COSMOS data and 63–71 % of Aethalometer data fall below their respective detection limits." has been modified to "Within the hourly BC mass concentration data, 5–13 % of COSMOS data fall below its detection limit.".

(P11, L3) "mean(± 1 standard deviation)" has been modified to "mean(±standard deviation)".

(P15, L4-5) "The m_{BC} presented here is at 1 h time resolution and the data influenced by ship exhaust has been removed." has been added to the caption of Fig. 3.

(P26, L2) "CO (b), CO_2 (c), and CH_4 (d) mixing ratios" has been modified to "CH_4 (b), CO_2 (c), and CO (d) mixing ratios".

Text S1, Table S1, and Fig. S18 are changed due to changes in the background O_3 mixing ratios. Please refer to the track-change version for details.