Black text: Referee comments by Anonymous Referee #2

Blue text: Our replies

Red text: Modified parts of the manuscript

* Line number is the number in the tracked manuscript.

Kinase et al., 2023 "Long-term observations of black carbon and carbon monoxide in the Poker Flat Research Range, central Alaska, with a focus on forest wildfire emissions" presents long-term observations of BC mass concentrations and CO mixing ratios in the Poker Flat Research Range, which is located in Central Alaska. The authors use the FLEXPART-WRF model to estimate contributions from black carbon source regions and sectors and the HYSPLIT model to trace airmasses that originate from forest wildfires. This study shows a good correlation between the BC/ΔCO ratio and the fire radiative power (FRP) and concludes that the FRP should be used to improve emission inventories. This work provides very useful datasets and novel ideas. The methods and analysis support well the conclusion of this study. The text is well-written although in some parts the structure needs to be carefully revised. I have some minor comments for the authors to consider, presented below:

→Thank you for your kind review and important comments. All the comments were helpful for us in improving our manuscript. Please see our answers to the specific comments below.

Abstract: Although the measurements of this study were taken in Alaska, the high BC mass concentrations were originated from wildfires in both Alaska and Western Canada (section 3.5). Therefore, I would suggest discussing in the abstract about wildfires at high latitudes rather than just in interior Alaska. I would also suggest to mention already in the abstract the whole period of sampling at the PFRR.

→Thank you for your important comment. We extended the source regions from only Alaska to boreal forests in Alaska and Canada. We also added a whole period of observations as below.

“line 17: from April 2016 to December 2020.”

“line 22: a contribution of boreal forest wildfires in Alaska and western Canada” “lines 395–396: The estimated BC source sectors and regions were biomass burning from Russia, Alaska, and sometimes Canada…”

Section 2.2: Some additional information about COSMOS is needed here. At least it should be added that this is a filter-based absorption technique.

→Modified.

“lines 91–93: The measurement technique of BCM3130 is based on filter-based optical absorption, thus other light-absorbing particles and scattering particles can be a source of interferences on BC measurement (Bond et al., 1999; Kondo et al., 2009).”

Lines 163-164: Unclear sentence; please, rephrase.

→Thank you for your important comment. We discussed for the differences in BC concentration at PFRR and Utqiagvik again and modified to be more specific. Please check.

“lines 174–183: The median hourly BC mass concentration and 10th and 90th percentile values throughout the observation period were 13, 3, and 56 ng m^{-3}, respectively. No clear increase in annual median BC mass concentration was observed (Table 1). Observed median BC mass concentrations were the same level as previous reports at Utqiagvik (Barrow) (12 ng m^{-3}), which showed BC mass concentration over the long term using the same instrument (BCM3130) employed in this study (Sinha et al., 2017; Mori et al., 2020). Abrupt peaks (up to 5540 ng m^{-3}) were occasionally observed during summer at PFRR, but these peaks were not observed at Utqiagvik. On the other hand, increases in BC mass concentrations were reported in Utqiagvik between January and March, while not in PFRR. These different variations may be attributed to the topological separation by the Brooks mountain range and to the polar dome structure (Quinn et al., 2007; Sharma et al., 2013).”

Lines 201-202: Why are the black carbon emissions better captured in central Alaska? Is Alaska the only source region of the measured black carbon? A discussion on the topography of the sites and meteorological conditions is needed to support this statement.

→As shown in Figure 1, most boreal forest wildfires occurred in the interior of Alaska and western Canada, and PFRR is located in the centre of these forest wildfire-occurring areas, i.e., PFRR is surrounded by strong BC emission sources, while other observation sites compared in this study are located on the edge or outside of forest wildfire occurring regions.

As reviewer #2 mentioned and we showed in Section 3.3, other boreal forests, i.e., Russia and Canada, can also affect the BC concentration at PFRR. However, as shown in Figure 5, most large peaks (exceeding 1 μg m^{-3}) were associated with Alaskan forest wildfires. Also, BC from the Russian forest wildfires can affect BC concentration at PFRR, however, BC concentration did not exceed 0.1 μg m^{-3} in these cases, likely due to the deposition and diffusion during their long-range transport. BC from Canadian forest wildfires also affected PFRR BC concentration, however, it was a minor case. We added the sentence below.

"lines 220–222: because PFRR is the only BC-measuring site located in the central interior of Alaska and is surrounded by forest wildfire occurring regions while other BC observation sites are located on the edge or outside of interior Alaska."

"lines 285–287: BC from forest wildfires that occurred in western Canada also affected the BC concentration at PFRR (Figure S6), but to a lesser frequency. Russia was also estimated as an effective BC source region (Figure 3), but BC concentration did not exceed 0.1 μg m^{-3} in most cases (Figure 5)."

Lines 219-223: Figure 2 shows also that emissions in Canada contribute to BC concentrations at the PFRR during the warm season. How important is this contribution? I would suggest discussing this in this section since you will link later the high BC concentrations with the forest wildfires in Canada.

→Fractions of BC from Canada in warm seasons were 1.0–21% in the 10–90 percentile, relatively lower than that of Alaska and Russia. However, as pointed out by this comment, sometimes BC plumes from western Canada were captured at PFRR during BC high concentration periods. Therefore, we added this information to the manuscript as shown below.

"line 241: and sometimes Canada (1.0–21% in the 10–90 percentile)" "lines 285–286: BC from forest wildfires that occurred in western Canada also affected the BC concentration at PFRR (Figure S6) but to a lesser frequency.

"

Lines 251-256: I would suggest moving this text somewhere in the next section because it is not relevant to section 3.4.

→Modified. These sentences were moved to Lines 312–318.

"lines 312–318: In the previous section, we showed that most high BC mass concentration cases were related to forest wildfires in Alaska. Increases in biomass-burning-derived BC/ΔCO ratios with combustion efficiency were suggested from an observational study on boreal forest wildfires (Kondo et al., 2011b) and from laboratory-scale burning experiments of crop residues (Pan et al., 2017); however, in-depth studies examining variabilities in BC/ΔCO ratios based on long-term, near-forest observations have not been conducted. To consider the possibility that combustion conditions (flaming and smouldering) primarily control the BC/ΔCO ratio, we are going to investigate the relationship between the BC/ΔCO ratio and forest wildfire intensity in this section. We selected …"

Line 259: Can you support the statement here with the back trajectory analysis?

→We added example cases of footprints when Alaskan and Canadian forest wildfires affected the BC concentration at PFRR in Figures S5 and S6 in our supporting information.

"

Examples of PES footprints and contributions of BC from biomass burning emissions at 12:00 on 27 June 2019.

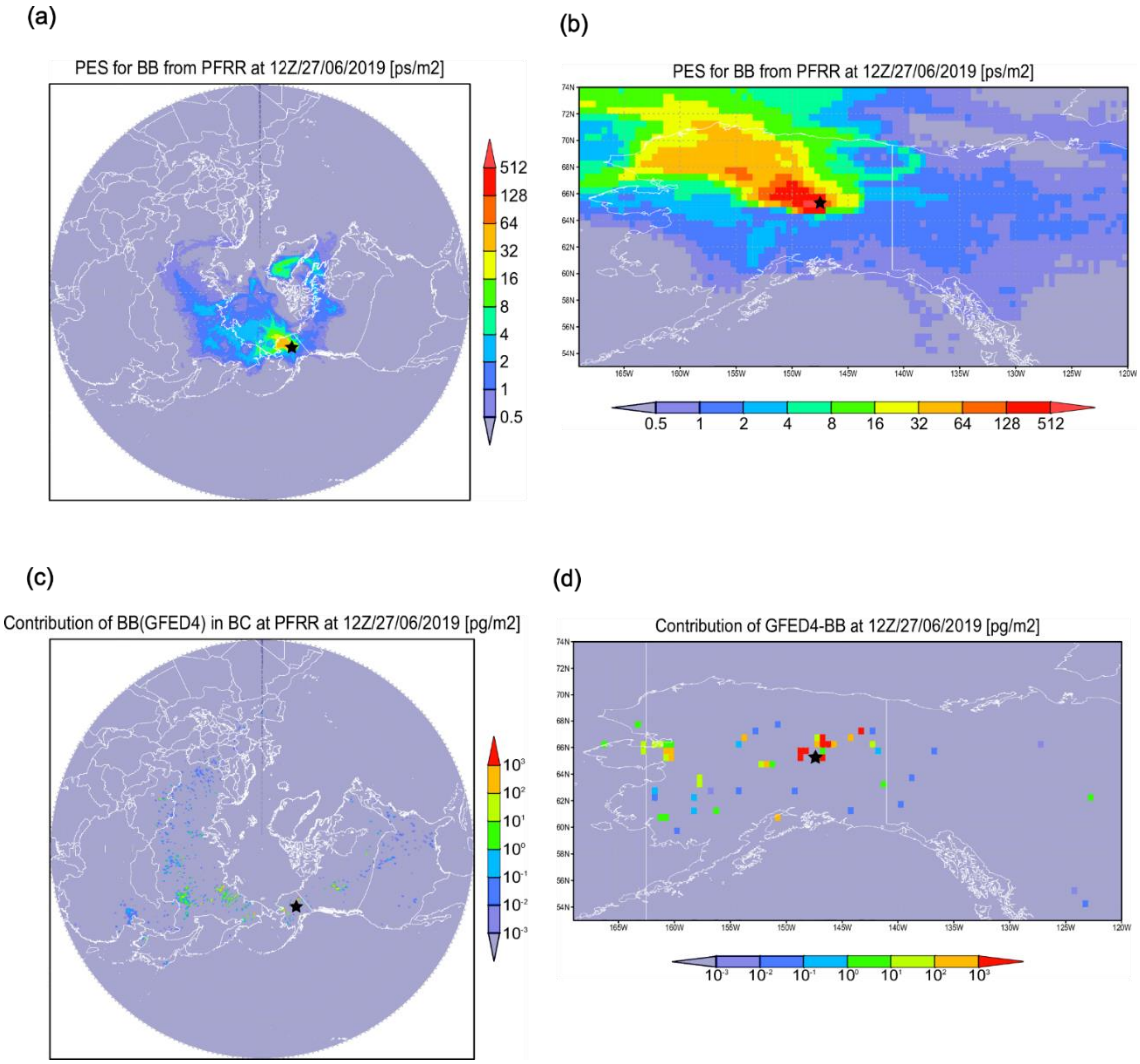


Figure S5. Examples of (a) a PES footprint on a global scale, (b) that focused on Alaska and Western Canada, (c) a BC emission contribution from biomass burning on a global scale, and (d) that focused on Alaska and Western Canada at 12:00 on 27 June 2019. In this case, high BC concentration (1611 ng m^{-3} on hourly average) was observed at PFRR and most BC came from forest wildfires around PFRR. Star marks indicate the PFRR location.

Examples of PES footprints and contributions of BC from biomass burning emissions at 00:00 on 12 July 2017.

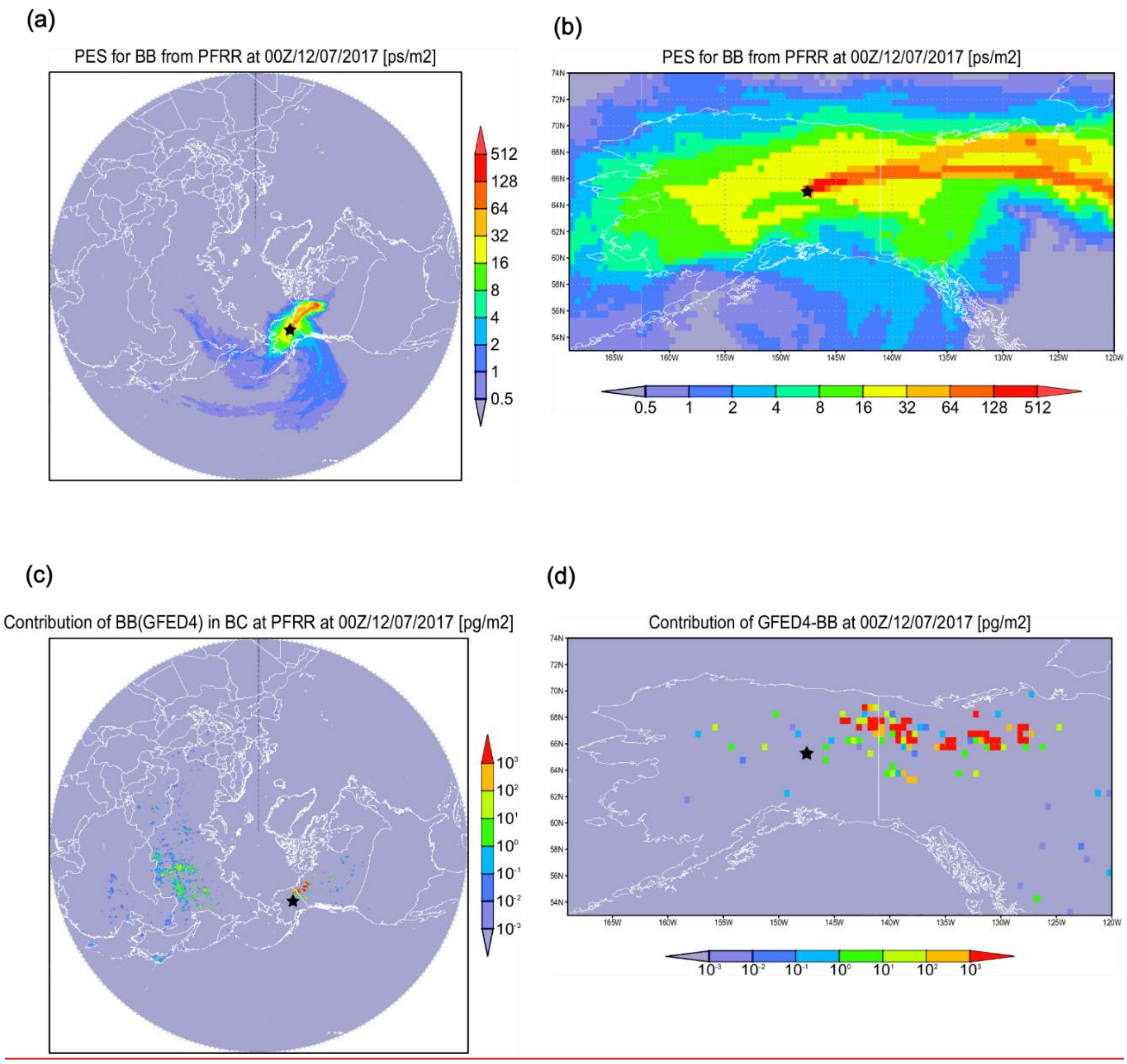


Figure S6. Same as Figure S5 but at 00:00 on 12 July 2017. In this case, high BC concentration (204 ng m^{-3} on hourly average) was observed at PFRR and most BC came from forest wildfires in western Canada and partly Alaska. Star marks indicate the PFRR location.

lines 278–280: The medians of the contributions of biomass burning and the mean age of BC estimated by the FLEXPART-WRF simulation in these high BC mass concentration cases were higher and shorter (95.5% and 2.6 days) than those in other periods (7.6% and 6.9 days) (Figure 4(b) and (c)), indicating a strong contribution of BC from neighbouring forest wildfires (Figures S5).”

Line 261: East Asia is a separate category in Fig. 5. The text should be corrected.

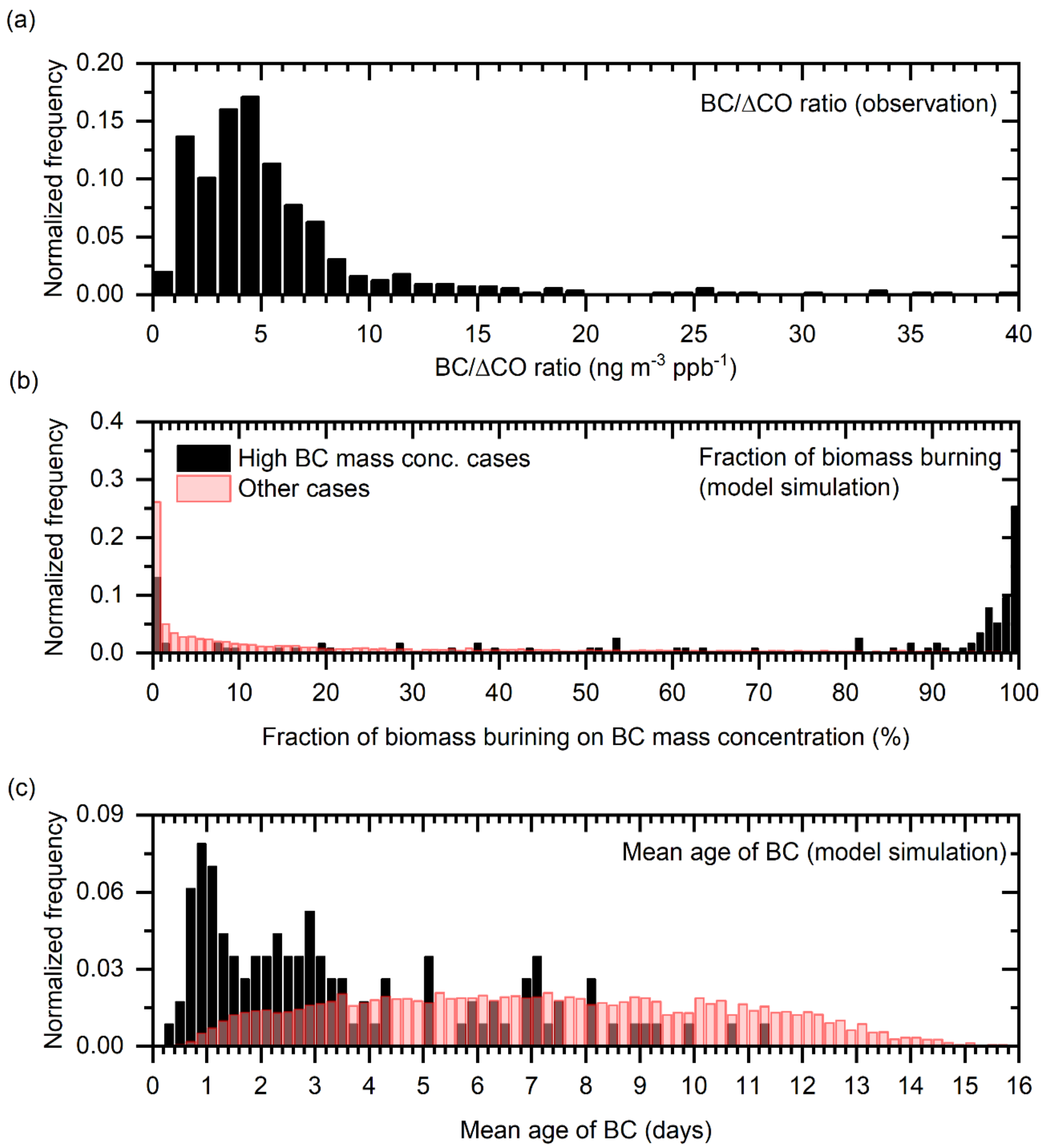
→Our explanation in the sentence was wrong, the text in Figure 5 is correct. We modified our explanation in the manuscript.

“line 281–282: 6 categories based on Figure 3(b), Central Asia and Europe are included in Others”

Figure 4b. Typo in the label (x-axis).

→Modified.

“

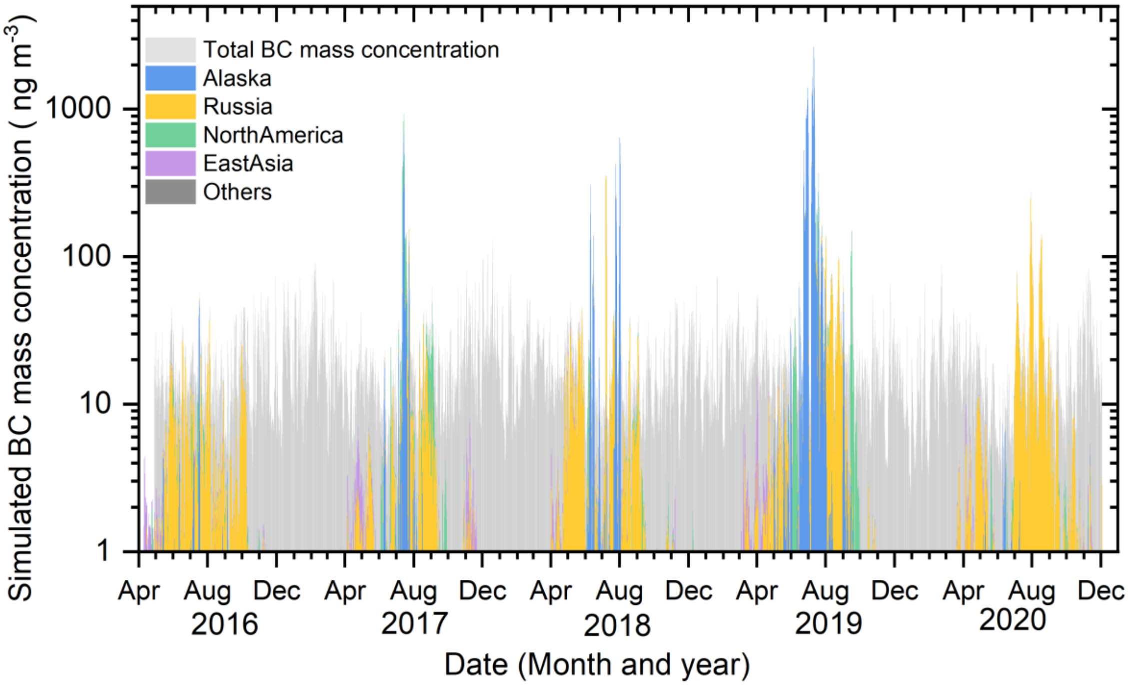


”

Figure 5: I would suggest the x-axis to be the same as in Figure 2 for easier comparison.

→Modified. In addition to this comment, the colour profile has been changed to the same as in Figure 2.

“



”

Lines 291-292: Unclear sentence; please, rephrase.

→There was too much information in that sentence and it probably made it confusing and unclear. Therefore, we deleted redundant parts as below.

“lines 322–323: We found a positive correlation (*r* = 0.44, $p < 0.0001$, $n = 184$) between the BC/ΔCO ratio and ∑FRP/point values (Figure 6).”

Line 311: There is a typo.

→Modified.

“line 357: BC/ΔCO”