

Review

The manuscript entitled “Multi-year black carbon observations and modeling close to the largest gas flaring and wildfire regions (Western Siberian Arctic)” by Popovichka et al. presents a detailed study on Black Carbon (BC) measurements in a new Arctic station in Kara Sea. The study investigates the seasonal differences in measured optical properties and assess the inter-annual variability of BC sources using an atmospheric dispersion model. The manuscript is well structured for the readers to understand the analytical steps and the results obtained.

I recommend the publication of the manuscript following minor revisions.

First I would like to mention a few general comments which apply to the whole manuscript:

- (1) Please define the abbreviations the first you are using them and not each time in a new sentence, section or Table.
- (2) Be careful with the units. For BC/eBC you either use ng m^{-3} or $\mu\text{g m}^{-3}$, and then you present your statistics in ng m^{-3} . Please choose one and do not show your results in both. It's confusing. Also be consistent and use ng m^{-3} and not ng/m^3 . Correct everywhere.
- (3) The numbers in the units must to be in superscript. Correct everywhere.

Minor comments (The number of the lines below correspond to the submitted manuscript):

Lines 15-31: I am missing one-two sentences on FLEXPART and which are the main emissions sources the authors found to be contributing to BC at the station.

Line 24: Define eBC

Lines 44-45: Please consider rephrasing this sentence – it's too vague. Which are the complicated processes? Define Arctic haze.

Lines 52-53: What about the latest AMAP report? Does the latest report provide updated results on forcing? If yes, please updated accordingly.

Lines 62-63: “The most complicated issue ..” Such as? Rephrase or be more specific.

Lines 70-72: If you link these sentences with your text earlier please rephrase - otherwise say why, it is not clear.

Line 82 and wherever mentioned again: “Barrow”. Please consider using the local name Utqiagvik or as Barrow/Utqiagvik to be more respectful to the local community.

Line 88: What about the results presented Matsui et al. 2022?

Line 89: replace “in” with “is”

Lines 105-106: Too vague. Please say a bit more here.

Lines 119-120: add a reference for your statement: “as the station is located along the main pathway of large-scale emission plumes from industrial regions and Siberian wildfires entering the Arctic.”

Line 128: AAE – in line 73 – no need to define again

Line 132: Add a sentence on what the following sections show.

Line 143: “.. snow coverage, wind speed, and relative humidity ...”

Lines 145-146: On what criteria you base the split in two periods? If possible, mention.

Lines 144-149: Instead of providing an annual value please provide a value for the two periods (cold/warm) – would be easier for the reader to get an overall idea – as you do in lines 150-154

Lines 155-161: Move this part in the beginning of the following sub-section (2.2) – it fits better there.

Line 179 – equation 2: Define b_{abs} in equation 1

Line 213: “Both methods have important uncertainties ..”: Please give percentages/numbers. Also discuss/mention AE33 uncertainties here.

Line 235: Consider rephrasing the title to “Atmosphere dispersion modelling and emissions” or something similar

Line 235: From the text you provide here it is not clear for which periods/years you run the model. Please mention.

Line 241: Are 30 days sufficient period to account for Arctic Haze? Did you test longer periods? Where do you base the 30 days? Please justify your choice if possible.

Line 243: What is tracking?

Lines 269-272: Mention that the satellite image is shown in Figure 1e. Also is there any particular reason you are mentioning this here? You could simply mention it once directly when you discuss Figure 1e.

Line 272 and afterwards: Please consider discussing the main patterns for temperature, wind speed and direction in Section 3. It would be more interesting to see there the wind patterns.

Lines 280-284: Do you know why? If yes, please discuss.

Lines 329-331: Why? Please clarify

Lines 345-358: You compare your results with other studies at Zeppelin. What about at other Arctic sites where there published papers even if the period is a bit shorter, e.g. Barrow/ Utqiagvik?

Line 372: Why are you showing eBC in Fig. 2? You start discussing about eBC/BC from Fig. 4. Consider showing eBC time series later.

Line 376: add “, respectively” after Table S2.

Line 377: You mention p-value here for eBC. Could you calculate the p-value for all the measurements you provide? Also mention how did you calculate the p-value.

Line 413: It seems it's missing something before the parenthesis "(370 and 520 nm)"

Line 444: Do you mean 0.82 instead of 0.7? Based on the Figure 7.

Line 445: What about biases? Can you calculate them as well and provide the numbers?

Line 452: Do you think if you have used CAMS emissions, with a resolution 10 km², you would have got better results?

Lines 461: How many vertical levels did you use in the model? Did you allocate the emissions in the surface or did you distribute them at different levels? Please mention in the relevant section.

Line 574 – Conclusions: This section is way too long. It also reads as a grocery list and not as a scientific discussion. Please consider re-writing this section by interpreting your main findings and the main take away message the reader should take.

Line 665: The link for the supplement material is missing. Please provide.

Lines 1059-1074: Please consider correcting Barrow to Barrow/Utqiagvik. In the manuscript you mention Tiksi, Pallas and Villum. Please show their location in the Figure.

Lines 1082-1088: Figure 3. Please consider correcting Barrow to Barrow/Utqiagvik.

Lines 1075-1081: Figure 4. Add a legend in Fig.3a showing cold and warm period. In the b_{abs} time series there is a peak after 04.20 showing in blue. For eBC the same peak is shown in red. Why? The same goes for 04.21. Also please consider changing the format of the date axis in this figure and whenever else (in the rest of the figures) is applicable. It took me some time to realise these are dates. The format you are using is confusing.

Lines 1102-1108: Figure 6 - In figure 6a you mention "-0.96" while in the text you discuss 0.96. Why? Is 2019-2020 included in the warm/cold period? If no, why?

Lines 1109-1115: Figure 7 - What do the slopes show? Please mention

Lines 1116-1121: Figure 8 – In the title you refer to the station as "Bely station". Please be consistent and refer to the station as "Island Bely" station