

Reply to reviewers of the manuscript: “Increase in precipitation scavenging contributes to long-term reductions of black carbon in the Arctic”

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We thank both the reviewers for their positive and constructive comments. We have modified our manuscript based on their suggestions. The last few changes have been made to the manuscript.

1 Reviewer 1

1.1 SUMMARY

- 5 Thank you for your detailed responses and implementing the feedback you received. I believe you have contributed an excellent study to the scientific literature. There remains just one important, and a few smaller comments, which I urge you to implement before publication

1.2 MINOR COMMENTS

- 10 Specific comments (Numbers refer to Line numbers in the revised manuscript PDFs) Regarding the use of the GFED fire emission inventory, you really need to specify the exact version you used, i.e. GFEDv4.1s, since “The fourth version of the GFED” is technically GFEDv4 and does not necessarily include small fires (see: https://daac.ornl.gov/VEGETATION/guides/fire_emissions_v4_R1.html).

Added the following: “The fourth version with small fires i.e. GFED4s is used in partnership with the HYSPLIT back trajectory...”

15 1.3 Technical corrections

Line 24: forces -> forcercs

Changed as required

Line 443: follow instructions of red text, then delete red text

Changed as required

20 **1.4 Supplement**

1.5 General Comments

None

1.6 Specific comments

None

25 **1.7 Technical corrections**

Figure S16: follow instructions of red text, then delete red text

Changed as required. Updated plot.

1.8 SPECIFIC COMMENTS

2 Reviewer 2

30 2.1 General Comments

I appreciate the authors for incorporating the comments from all reviewers. Overall, I believe that the manuscript's readability significantly improved after the revision, and the quality of the analysis, along with the relevance of the science, is now well highlighted.

While I don't have any major requests for revision, I do have a fundamental question. The absorption coefficient exhibited a
35 decrease from 2002 to 2010, followed by a stable period (2010-2016) and an increase thereafter (2016-2022). The magnitude of these trends, and potentially even the direction, varies depending on the period of interest. Therefore, is it reasonable to quantify a linear and unique trend? Does a decreasing or increasing coefficient capture the fate of absorbing aerosol in such a complex region, especially when climatic anomalies exert an increasing control over aerosol concentrations? Perhaps the author could engage in such a reflective consideration.

40 In response to the comment we have added the following sentences to the 2.2.4 Trend analysis section. The paragraph is as follows: "It should be noted that a single linear trend cannot fully capture the fate of light-absorbing aerosol in such a complex region. However, the use of linear trends to simplify long-term changes has been used previously (e.g., Stone et al., 2014; Hirdman et al., 2010; Schmale et al., 2022; Collaud Coen et al., 2020a). Here, it is used to allow for greater exploration and interpretation"

45 2.2 Main Manuscript

2.3 Specific comments (Numbers refer to Line numbers in the original manuscript PDFs)

2.4 Specific comments:

As it follows, minor technical adjustments.

-Verify the use of brackets for references especially when using e.g.

50 Changed to using "cite[e.g.,][]" for references as required

-In F2 and F3 there is an evident disproportion in font size between the axis label (large and visible) and legend (extremely small).

For clarity I have added the information in the legend to the caption to so that the reader is able to read it. It is not obvious where the legend would go given the structure of the plot.

55 -F2: This is more a personal taste. But, the graph would be nicer and easier to read if every panel will be correlated with the corresponding period: a) Arctic Haze, b)

Changed as required. Also to the subplot in the supplement which has a similar layout.

-the title of section 2.2 and 2.2.1 ends with a ":". Not sure why it is needed

Changed as required.

60 -F5 caption. Not sure to understand the meaning of the sentence starting with "In a) each bar representing"

Changed to "The annual trends in a) the occurrences of each respective cluster, 1-5, and b)" and "In b) the height of each bar represents the annual mean σ_{ap} and is subdivided based on the occurrence of each respective cluster."

-F6. I am not sure what the top panel is supposed to show. I would remove it or specify the content the meaning of the colors, etc...

65 Changed to the top panel to just black, hence removed the colours which represented seasons.

-F7: what do the crosses represent in the graph?

Added "Outliers are marked by the + symbol and represent trends outside of the extent of the whiskers."

-T1. Make sure to add units and include the rest of 2022 and 2023.

70 A mistake was made in the processing of the data, the fact that the GFED data had a 3 hour resolution was not taken into account. Previously, it was assumed to be 1 hour. The table was expanded to 4 columns so that the 22 years are divided into 2 groups of 5 years and 2 groups of 6 years.

3 Additional changes

Added more information to the caption of Table which was not previously there, and is believed to be required.