

Response to Reviewer #1:

Title: Aerosols in the central Arctic cryosphere: Satellite and model integrated insights during Arctic spring and summer

The authors would like to thank the reviewer for her/his effort, and time taken to review our manuscript. We hope that we have adequately addressed the raised questions and provided clarification for any unclear or ambiguous sections of the manuscript.

Below, we present the reviewer's comments and criticisms, our responses as authors, and the subsequent changes made to the manuscript. Editor comments are denoted in *black*, our responses in *blue*, and the resulting manuscript modifications in *red*.

Q1: The review of the manuscript of Swain et al., 2024 on the topic “Aerosols in the central Arctic cryosphere: Satellite and model integrated insights during Arctic spring and summer”.

This manuscript presents the integrated view of aerosol load over central Arctic cryospheric region. I would like to appreciate the authors for doing a difficult task of combining satellite and model simulations to study aerosol over central Arctic region, as the retrieval of AOD over highly reflective snow and ice region is very challenging.

This manuscript has been gone through a previous review (<https://doi.org/10.5194/egusphere-2023-730>) and all the critical aspects raised by the previous reviewers were addressed very well in this revised version.

Further, this manuscript is bringing valuable information of spring and summer AOD distributions and the anthropogenic and natural aerosol load behind it and highlighted the need to add summer time aerosol processes in the models for the central Arctic to properly quantify Arctic warming.

In addition, this manuscript is conforming for the first time the unconfirmed prospective highlighted by a recent valuable paper (Schmale et al., 2021), that models might be missing the summer aerosol processes due to sea ice reduction and open ocean emissions by using AEROSNOW space-borne data.

This version of the manuscript has been written very well and falls within the aim and scope of the ACP journal. I would like to recommend it for publication with minor corrections. The minor corrections are listed below:

Abstract: Line 8: Although this study is conducted for the first time over central Arctic cryospheric region, is it necessary to mention in the abstract?

Response: Yes, we agree with the reviewer. The line 8 has been rewritten in the revised version.

We propose to change the line: An integrated study of aerosol optical depth (AOD) across the Arctic cryosphere under sunlight conditions was made feasible through the utilization of the AEROSNOW retrieval method and GC simulations.

Q2: Introduction: The overall introduction has been written very well and the story is very easy to follow.

Results: At Figure 2, please use different colors for clear read. i.e, AEROSNOW (may be red) and AERONET (black).

Response: The color of the AERONET and AEROSNOW data in Figure 2 has been changed in the revised manuscript to red and black respectively.

In Figure 2, we propose to change the color of AERONET and AEROSNOW data as red and black respectively.

Q3: Conclusion: At line 362-365, I would recommend to remove the paragraph “The promising results derived from the AEROSNOW approach hold significant value for both a) constraining the accuracy of AOD simulations in chemical transport models (CTMs) and b) determining the changing AOD in the Arctic sea ice regions currently experiencing AA”. As you are mentioning that the AEROSNOW data is valuable to access models over central Arctic at line 415-420. In summary, I enjoyed reading the manuscript.

Response: The paragraph in the revised manuscript has been removed.

We propose to remove the paragraph at line 362-365.

References:

Schmale, J., Zieger, P., and Ekman, A. M.: Aerosols in current and future Arctic climate, Nature Climate Change, 11, 95–105, <https://doi.org/10.1038/s41558-020-00969-5>, 2021.