## Referee #2

## Previous title: Spring and summertime aerosol optical depth variability over Arctic cryosphere from space-borne observations and model simulation

## Revised title: Variability of aerosol over the Arctic cryosphere from space-borne observations and model simulations for the cycle of sea ice growth and decline.

The authors thank the referee for her/his effort, and time taken to review our manuscript. The valuable criticisms and comments have helped us to improve our paper. We hope that we have been able to answer satisfactorily the questions raised and clarify parts of the manuscript which were unclear or ambiguous.

We have changed the title of the manuscript following the recommendation of referee.

In the following the referee comments and criticisms, our responses, as authors, and our resultant changes to the manuscript are colored **black**, **blue** and **red** respectively.

In this study, the authors have used the total aerosol optical depth (AOD) determined by the AEROSNOW algorithm and data from the AATSR satellite instrument over snow- and ice-covered regions of the Arctic. The dataset is used to evaluate the global GEOS-Chem 3D chemical transport model for the period 2003-2011.

The retrievals over bright surfaces are associated with large uncertainties because the main contribution to the signal comes from the surface and not from atmosphere, which is optically thin in Arctic in majority cases. Therefore, I appreciate the work performed by the authors in the evaluation and intercomparison of the retrieved AOT with the global GEOS-Chem 3D chemical transport model for the extended period of time.

I advice that the authors improve the paper. The paper can be reconsidered after major revision. Some comments are given below:

**Q1:** What is the definition of Q_ext in Eq.(2)? Is it /? is the average extinction cross section of particles, is the average projected area of the particles.
**Response:** The $Q_{ext}$ is defined as extinction efficiency ($Q_{ext}$). The extinction efficiency are calculated using refractive index and lognormal size distribution data available from the Global Aerosol Data Set (GADS) (Köpke et. al., 1997; Chin et. al., 2002).
**At line 176, we propose to add the definition of ($Q_{ext}$):**
Where, $Q_{ext}$ is defined as the extinction efficiency. The extinction efficiency is calculated using refractive index and lognormal size distribution data available from the Global Aerosol Data Set (GADS) (Köpke et. al., 1997; Chin et. al., 2002). The column mass loading and the particle mass density are presented as M and ρ respectively (Tegen and Lacis, 1996).

**Q2:** I would advice to change the title of this paper. The title is similar to the title of the paper under review located at https://amt.copernicus.org/preprints/amt-2023-65/amt-2023-65.pdf. I do not think that it is a good idea to have several identical figures in both papers. The identical figures must be removed from this paper.

**Response:** Yes, we agree with the reviewer, we have changed the title from "Spring and summertime aerosol optical depth variability over Arctic cryosphere from space-borne observations and model simulation" to "Variability of aerosol over the Arctic cryosphere from space-borne observations and model simulations for the cycle of sea ice growth and decline".

We would like to cite the two figures we used in this ACP manuscript from our other paper that is under review in AMT: "Swain et al., 2023a. Spring and summertime aerosol optical depth retrieval over the Arctic cryosphere by using satellite observations (doi:10.5194/amt-2023-65).

These two figures are captioned:

i) Figure.1, with title Location of PEARL(80.054°N, 86.417°W), OPAL(79.990°N, 85.939°W), Hornsund (77.001°N, 15.540°E) and Thule(76.516°N, 68.769°W) AERONET measurement stations considered in this study".

ii) Appendix Figure A1. With title "Validation of monthly mean AEROSNOW retrieved AOD colocated with monthly mean AERONET observation AOD obtained over PEARL, OPAL, Hornsund, and Thule stations. The linear regression lines are shown as blue dashed line".

**We propose to modify the title of the manuscript:**
Variability of aerosol over the Arctic cryosphere from space-borne observations and model simulations

**We propose to add a citation to title of Figure 1 and Appendix Figure A1 :**
Figure 1. Location of PEARL(80.054°N, 86.417°W), OPAL(79.990°N, 85.939°W), Hornsund(77.001°N, 15.540°E) and Thule(76.516°N, 68.769°W) AERONET measurement stations considered in this study (Swain et al., 2023).

Figure A1. Validation of monthly mean AEROSNOW retrieved AOD colocated with monthly mean AERONET observation AOD obtained over PEARL, OPAL, Hornsund, and Thule stations. The linear regression lines are shown as blue dashed lines (Swain et al., 2023).

**References:**


- Chin, Mian, Paul Ginoux, Stefan Kinne, Omar Torres, Brent N. Holben, Bryan N. Duncan, Randall V. Martin, Jennifer A. Logan, Akiko Higurashi, and Teruyuki Nakajima. "Tropospheric aerosol optical thickness from the GOCART model and comparisons with satellite and Sun photometer measurements." Journal of the atmospheric sciences 59, no. 3 (2002): 461-483. https://doi.org/10.1175/1520-0469(2002)059.
- Koepke P., M. Hess, I. Schult, and E.P. Shettle, "Global aerosol dataset", Report N 243, Max-Plank-Institut für Meteorologie, Hamburg, 44 pp., September 1997. https://hdl.handle.net/21.11116/0000-0009-EB9B-0