

Author Response to Reviewer 1

The authors appreciate the constructive comments from Reviewer 1. We have revised the manuscript based on the suggestions from Reviewer 1. Our responses are below to the specific comments and minor corrections.

Specific comments:

Ln 108-122: Is it possible to add the volume of samples in this section, somewhere?

Author Response: The following sentence has been amended to, "...were collected in 150 mL pre-cleaned and combusted amber glass bottles."

Data availability: would the rBC data be made available with the manuscript?

Author Response: Yes, the rBC concentrations are listed in Table 1. A Data Availability statement has been added for clarity, "The rBC and NAAPS modeled deposition data are included in Table 1."

Minor corrections:

Line 63: "... and was determined..." - shouldn't it be "were"?

Author Response: This sentence has been updated for clarity, "The mean concentration of the samples collected was 2.6 ng/g and the mean peak was 15 ng/g. Based on these results, it was determined that EC/OC do not influence the snow albedo in the NW sector of the GrIS dry zone (Polashenski et al., 2015a)."

Figure 1: The source of the images is mentioned in duplicity (both in the bottom of the image and in the caption). In my opinion this is unnecessary, and the authors could remove one of them.

Author Response: The authors agree and the redundant information has been removed from the Figure caption.

Lines 317-318: "... especially during episodically..." - seems odd to me, please check and if wrong, rephrase.

Author Response: Thanks, 'during' has been deleted from the sentence.

Author Response to Reviewer 2

The authors appreciate the constructive comments from Reviewer 2. We have revised the manuscript based on the suggestions from Reviewer 2. Our responses are below to the specific comments and minor corrections.

Specific Comments:

The manuscript mentions that the study site is near the S6 automatic weather station. I think providing data from the weather station over the course of the sampling period would help to provide context for the measurements. In particular, the paper discusses that flushing or melt might have caused the reduction in rBC values before the August 11 measurements. Would it be possible to determine if major rain events occurred or if particularly high temperatures or large deviations in surface energy balance might have resulted in this flushing/melting between August 2 and August 11? I do not know what data are available from this AWS, so perhaps this is not possible.

Author Response: This is a great idea but unfortunately it doesn't look like precipitation is measured here:

https://www.projects.science.uu.nl/iceclimate/aws/files_oper/oper_01309

Work by Lewis et al. (2021) in Geophysical Research Letters also presents black carbon concentration measurements from the percolation zone of the Greenland Ice Sheet made using an SP2. I believe all of their measurements were further from the margin of the ice sheet and resulted in BC concentrations less than 1.5 ng/g, but it still seems worth including in the review of BC measurements in Greenland.

Author Response: The following sentence has been added to the introduction, "Similarly, rBC concentrations from the percolation zone of the GrIS have been shown to be relatively low, less than 1.5 ng/g (Lewis et al., 2021)."

It may be worth discussing what the magnitude of the impact of these levels of rBC concentration would be on the overall broadband albedo. I understand that assumptions would need to be made about grain size, other LAIs, solar conditions, etc., but using the SNICAR model (as I note is done in the Khan et al. 2017 JGR: Atmospheres paper) could provide a range of the potential effect given these BC concentrations. Because it is clear that there are a number of other LAIs (particularly in the surface hoar samples), this could be more difficult if there are too many assumptions that must be made, so I would leave it to the authors' discretion if they think this is worthwhile.

Author Response: We appreciate the suggestion and actually had a similar thought during the manuscript preparation. Prior to submission, we chatted with the developer

of the SNICAR model, Mark Flanner. We decided that there would be too many assumptions needed to be made to explore albedo modeling and radiative forcing with this dataset, however, we absolutely agree that this is of utmost interest as a next step in this work.

Line 184: It is assumed that the rBC ratio to total mass biomass burning smoke is 7%. Please add in a couple of sentences indicating what factors affect this percentage and given that this is a median value, perhaps how large of a range might be expected.

Author Response: The following sentences have been amended/added to this section: “Estimating atmospheric properties related to biomass burning is highly complex and is influenced by wide variety of factors such as the type of fuel, combustion temperature, and atmospheric conditions. Also, the chemical, optical and physical properties of biomass burning aerosols can change during atmospheric transport and dispersion. The mass ratio of rBC to total mass in biomass burning smoke particles is estimated to be 5–10% black carbon in the NAAPS-RA model based on field studies (see a summary in Reid et al., 2005) and here we chose 7% as a median value.”

Line 217: It may be useful to show each size distribution for the individual samples, perhaps in a supplement if not in the main paper, in order to demonstrate that there is no pattern.

Author Response: A third panel has been added to Figure 2, “...and C) the size distribution of each surface hoar sample categorized as light, medium and dark.”

Figures 3 and 5: Consider marking the sample days with a vertical line so it is easy for the reader to see how these model results line up with the sampling.

Author Response: The five sampling dates are marked in orange on Figure 3.

Figure 5: Consider separating out the total precipitation into a separate figure stacked below because it can be difficult to parse the overlapping lines.

Author Response: Total precipitation has been removed and added as a second panel in Figure 5.

Line 260: Where it states the modeled smoke deposition is 300 $\mu\text{g}/\text{L}$, what time period is that over?

Author Response: This sentence has been amended to, “The modeled smoke deposition flux is 3000 $\mu\text{g}/\text{m}^2/\text{day}$ or 300 $\mu\text{g}/\text{L}$ over 24 hours.”

Lines 262-264: If the measurement is already in units of $\mu\text{g-rBC/L-H}_2\text{O}$, doesn't that already account for the amount of snow water equivalent? Perhaps I am misunderstanding, but I'm not sure how multiplying by 10% would make sense, so please clarify. I do think that the assumption that 7% of smoke is BC would be a source of uncertainty worth discussing more (see comment above about line 184).

Author Response: Thanks for catching this. The authors agree and the following sentence has been deleted, "If we assume the snow water equivalent is 10%, then the rBC-snow concentration (i.e., the concentration of rBC in the fresh wet snow being deposited) would be $2.1 \mu\text{g-rBC/L-H}_2\text{O}$."

Technical Corrections:

Line 37: "Thus, role" – "Thus, the role"

Author Response: This update has been made.

Line 60: "higher concentrations" – "higher concentration"

Author Response: This update has been made.

Line 169: "Moderate Imaging" – "Moderate Resolution Imaging"

Author Response: This update has been made.

Line 210: "sizes" – "size"

Author Response: This update has been made.

Line 244: "based NAAPS-RA" – "based on NAAPS-RA"

Author Response: This update has been made.

Line 245: should it be AOT instead of AOD?

Author Response: This update has been made.

Line 260: should that be 10 L/m^2 ?

Author Response: This update has been made.

Line 266: "NAAPs" – "NAAPS"

Author Response: This update has been made.

Line 283: add in DOY so that it is easier for reader to reference the figure

Author Response: This update has been made.

Figure 5: I think the right y-axis should be red instead of blue, if I understand correctly.

Author Response: Total precipitation has been removed and added as a second panel in Figure 5, per the suggestion above.

Line 318: remove word “during” or otherwise rephrase

Author Response: This sentence has been amended to, “However, NAAPS model results also indicate the increase is likely related to accumulation of episodically deposited wildfire-derived smoke. For example, the smoke event in early August, which brought smoke from the western Northern Hemisphere.”

Lines 379 + 382: references missing article titles

Author Response: This update has been made.

References:

Lewis, G., Osterberg, E., Hawley, R., Marshall, H. P., Meehan, T., Graeter, K., et al. (2021). Atmospheric blocking drives recent albedo change across the western Greenland ice sheet percolation zone. *Geophysical Research Letters*, 48, e2021GL092814. <https://doi.org/10.1029/2021GL092814>

Author Response: The reference has been added to the manuscript.