

Response to Reviewer #1 – Laura Melling, submitted 17 June 2024

General response

Thank you for the detailed and constructive feedback on our manuscript. We are pleased that our research was positively received and the importance of our findings highlighted. We find the comments made in your review to be beneficial suggestions to the manuscript and have integrated the majority of them. Here, I will address the comments more specifically.

Specific responses

Title

1) I suggest the addition of “southwest” in the title considering the foray into SW Greenland as shown in Fig. (1) i.e. “Assessing supraglacial lake depth using ICESat-2, Sentinel-2, TanDEM-X, and in situ sonar measurements over northeast and southwest Greenland”

We agree – we only did not add it originally because the analysis using the derived methodologies was conducted exclusively in northeast Greenland; however, we see that it would be more holistic to include “southwest” as well.

General

2) Although this is a personal preference, the use of the active voice as opposed to the passive voice would greatly aid the readability of this manuscript and make it substantially more engaging.

We have revisited the text and integrated the active voice as much as possible for better readability.

3) Please refer to the radiative transfer equation as either ‘equation’, ‘model’ or ‘algorithm’, rather than a mix of those options as it will make it easier to search once the manuscript is published (and it is easier to understand what you are referring to).

We have adjusted the text accordingly.

4) When referring to the components of the radiative transfer equation, please use italics as this is the way they are referred to in the rest of the literature and it is the way TC asks for mathematical notation to be used in-line.

It seems some of the mathematical notation formatting was corrupted during finalization of the manuscript. We have adjusted that accordingly.

5) Did you produce the TanDEM-X DEMs yourself or were they acquired as DEMs? Your manuscript suggests you produced them, but your acknowledgements suggest you got them as complete products.

We indeed processed the TanDEM-X DEMs ourselves. In the acknowledgements, we are simply thanking them for providing the raw TanDEM-X radar data to us.

Introduction

We have integrated the adjustments to the text outlined in comments (6) – (14), and we fully agree with including the citation of Melling et al. (2024), and see how the results align with and support our analysis. This citation was simply overlooked since it was published close to the finalization/internal review of our own manuscript.

Data and Methods

We have integrated the adjustments to the text outlined in comments (15), (17) – (21), (24), (26) – (27), (31), and (33) – (35).

16) [line 83] Add a citation for the revisit time.

The official stated revisit time for the Sentinel-2 constellation is 5 days at the equator. The statement of “a near daily revisit time in northern Greenland” is based on my own observations and observations of other researchers from using the data and understanding generally how the orbital dynamics of satellites work, i.e. for a polar-orbiting satellite, the more northern areas have a higher density of tracks and thus a higher revisit time. Due to this, there is no specific citation I would add for this statement.

22) [line 110] I strongly suggest adding a sentence or two here referring to Melling et al. (2024) and their comparison of the multiplier on the K_d value as g' holds a lot of sway in the outcome of this equation.

We did not add the Melling et al. (2024) citation here, but have gladly added a sentence describing the effect seen from your alteration of K_d and g values into section 4.2 in the discussion.

23) [line 117] Add Das et al. (2008) citation for rapid SGL drainage (already in your reference list).

We find that, especially for such a broad statement, specifically citing one paper seems unnecessary and would be cherry-picking since many papers cover the topic of rapid drainages.

25) [Figure 1] I would be personally interested to know if any of the studied lakes in the southwest are the same as the lakes studied in Melling et al. (2024) (no need for a change here, just scientific curiosity for future studies)

From what I can tell without the exact coordinates, I do not think any of the lakes are the same as in Melling et al. (2024). We do have one ICESat-2 track in common

(ATL03_20200706005932_01630805_003_01_gt2l), but I believe the lakes we used are located a bit more north from yours. It would have definitely been interesting to see the direct comparison of our studies.

28) [line 161-162] n_1 and n_2 values are taken from Mobley (1995) – please reference the original paper as opposed to implying this is Parrish et al. (2019). Equally, the value for n_2 is 1.33469, not 1.334. Please redo the analysis of this lake depth equation with 1.33469 before resubmitting. See reference list for citation.

In this study, we did not use 1.33469 for n_2 since that was calculated as the refractive index for light with a wavelength of 540 nm. Since Sentinel-2's green band has a nominal wavelength of 560 nm, I had recalculated n_2 for that wavelength, which ends up being 1.3343. I indeed did not write the full value in the paper and will correct that, along with adding the Mobley (1995) citation. In the end, the difference in the corrected depths when using 1.3343 or 1.33469 is on the millimeter scale, which is well under the uncertainties from the data and methodology itself.

29) [line 171] From the Climate Change Initiative (see References) none of these lakes are upstream of the 2017 grounding line for Zachariae Isstrom. As such, the area will rise and fall with the tides and cannot be considered grounded. However, this shouldn't pose too much of a problem as you seem to have used depth relative to the surface as opposed to absolute depth. Saying this, assuming these lakes are grounded has given you the wrong narrative for these lakes – their dynamics will be different and this will have affected your interpretation of the results later on in the manuscript. Please take some time to consider the effect of this understanding change and alter the manuscript accordingly. In my expert knowledge on the topics of lake depth and grounding lines, this should not invalidate your in situ data.

Thank you for bringing up this point. You are indeed correct that the 2017 grounding line presented in the Climate Change Initiative is well above the lakes that we measured in situ. This information, however, is contradicted in many other studies. After the large break-up of Zachariae Isstrom's floating tongue between 2002 and 2012, the grounding line has been quite close to the calving front itself. With these grounding lines, our in situ data was all gathered in grounded areas. For examples of

literature showing the lower grounding line, please see Mouginot et al. (2015) and An et al. (2020). It is quite concerning why ESA's CCI product is so off from what others report.

30) [line 175] How did you estimate your error of 0.20 cm? I would like to see a sentence or two added here to explain your calculation.

Thank you for this comment. I realized upon re-reading it, that the units on the error were incorrectly written. I have now corrected it to 0.20 m instead of cm. To address your point concerning the estimation of this error, we assume an error of 20 cm based simply on experience using the sonar tool and visual estimation of the clarity of the bed and surface boundaries. We have now added this clarification into the manuscript.

32) [Figure 4] It would be good to see a discrete colour bar here instead of a continuous one. I suggest colour steps of one metre. It will not drastically reduce the depth resolution of the plot but would make the figure substantially easier to interpret as the reader.

The depths are actually already plotted discretely using one-meter steps. I chose to represent the color bar as a continuous one however to have a more compact view of the scale, since the discrete scale over 14 meters is quite long without a lot of distinction between directly neighboring colors.

Results

We have integrated the adjustments to the text outlined in comments (36) – (37), (39) – (40) and (42) – (43).

38) [line 243] Same conclusion was reached by Melling et al. (2024). Adding this should add weight to your claims.

We did not reference Melling et al. (2024) here in the results, but have added several references to the conclusions made in this manuscript in the discussion.

41) [Figure 6] I suggest using a discrete colour bar here instead of continuous for the same reasoning as the comment on Figure 4. Please also add a north arrow to each of the top row panels.

Same as in comment 32: The depths are actually already plotted discretely using one-meter steps. I chose to represent the color bar as a continuous one however to have a more compact view of the scale, especially with such large depths.

Discussion

We have integrated the adjustments to the text outlined in comments (44) – (49).

Appendix A

We have integrated the adjustments to the text outlined in comments (50) – (55).

References used in this response

An, L., Rignot, E., Wood, M., Willis, J. K., Mouginot, J. and Khan, S. A.: Ocean melting of the Zachariae Isstrøm and Nioghalvfjærdsfjorden glaciers, northeast Greenland, Proceedings of the National Academy of Sciences, 118, doi: 10.1073/pnas.2015483118, 2021.

Mouginot, J., Rignot, E., Scheuchl, B., Fenty, I., Khazendar, A., Morlighem, M., Buzzi, A. and Paden, J.: Fast retreat of Zachariæ Isstrøm, northeast Greenland, Science, 350, 1357–1361, doi: 10.1126/science.aac7111, 2015.