

Review of “Assessing supraglacial lake depth using ICESat-2, Sentinel-2, TanDEM-X, and in situ sonar measurements over Northeast Greenland”

General Comments

Thank you for submitting this research - it is a lovely piece of work which eloquently and almost completely defends the research claims of the authors. I believe the overall quality of the manuscript meets the expectations laid out in the principal criteria of TC. In particular, the in situ sonar data will aid other researchers and constitutes an important addition to the knowledge base. Overall, I only have a few suggestions for the authors which I expect will constitute large enough changes to the manuscript to be of use.

Specific Comments

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”

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.
- 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).
- 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.
- 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.

Introduction

- 6) [line 45] Philpot (1987) is the correct citation for this equation – see in References section of this review.
- 7) [line 46-48] I strongly suggest citing Melling et al. (2024) here (and perhaps elsewhere in the manuscript). The Melling et al. (2024) paper is very relevant to this manuscript and compares the use of the same equation by Philpot (1987), ArcticDEM digital elevation modelling, and ICESat-2 laser altimetry. See References for the full citation.
- 8) [line 57] Please explain what ‘optically deep water’ constitutes – I think it is ‘more than 40 metres deep’ from the Sneed and Hamilton papers cited.
- 9) [line 59] Change “Ice, Cloud and Elevation Satellite” mission to “Ice, Cloud and Elevation Satellite 2 mission”
- 10) [line 60] Change to “Lake Surface-Bed separation algorithm (Fair et al., 2020) and Watta algorithm (Datta and Wouters, 2021)”.
- 11) [line 62-63] Suggest removal of “go one step further” as this is not required.
- 12) [line 69] “dramatic perturbations” feels like odd phrasing, perhaps change to “large perturbations”

- 13) [line 71] Currently, you define the RTM abbreviation on this line but it would be helpful if you define it at the first instance of the term. This occurs on line 43.
- 14) [line 73-75] Suggest changing to “The associated errors and uncertainties of each method are quantified and discussed to understand the pitfalls of each method.” (with the potential change to the active voice as discussed in comment #2).

Data and Methods

- 15) [line 78-79] Suggest changing to “This study consists of four methods based on various data sources.” The end of this sentence does not add to the manuscript and can be removed without issue.
- 16) [line 83] Add a citation for the revisit time.
- 17) [line 92-93] Suggest changing to “Ideally, suitable imagery is acquired from the same date as the ICESat-2, in situ sonar, or TanDEM-X data; ...”
- 18) [line 98] Unless the rest of the depths are written as negative values, this equation should read as “ g ” under the fraction line, not “ $-g$ ”. Suggest changing to “ g ” considering the rest of the manuscript.
- 19) [line 104] Cite Moussavi et al. (2020) here for 30-m ring for A_d (already in your reference list).
- 20) [line 105-106] Suggest changing to “Furthermore, although it is intended that R_∞ be calculated for each image, optically deep water is not present in every scene due to ...”
- 21) [line 106-110] Melling et al. (2024) lists the relative importance of the RTE parameters which should help defend your calculation of R_∞ here.
- 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.
- 23) [line 117] Add Das et al. (2008) citation for rapid SGL drainage (already in your reference list).
- 24) [line 118] Suggest changing “enabled” to “possible” as the current sentence reads strangely.
- 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)
- 26) [Figure 1] I suggest having the ICESat-2 beam IDs in the Appendix only, perhaps link to the ID number with e.g. “NE1”, “NE2”, “SW1” etc. This should make the figure easier to read.
- 27) [line 146] Please add some citations here to back up “Based on best judgement and consistency with previous 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.
- 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.
- 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.
- 31) [line 185] Change to “... captured one day before...” instead of “...captured from the date before...” – this is a clearer way of explaining your data acquisition dates.

- 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.
- 33) [line 211] Change “is a relatively rare event” to “is difficult” or an appropriate synonym of “difficult”.
- 34) [line 218] Remove “Nonetheless”.
- 35) [line 221] Change “In order to” to “To”.

Results

- 36) [line 236] Change “reference” to “represent” for both instances on this line. “Reference” feels misleading.
- 37) [line 242] I think you are referring to Fig. 5(b) here, not 5(c).
- 38) [line 243] Same conclusion was reached by Melling et al. (2024). Adding this should add weight to your claims.
- 39) [line 251, Figure 5 caption] R^2 looks strange here, it is not the same as in other parts of the manuscript.
- 40) [line 252] See comment above.
- 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.
- 42) [line 315] Suggest changing “This large difference can be seen for example” to “An example of this large difference is seen”
- 43) [line 328, Figure 7 caption] Remove “[km^3]” this is not required as it is in your figure.

Discussion

- 44) [line 334] I think you mean 3 metres here, not 4 metres.
- 45) [line 356] Insert “of” between “couple” and “effects”.
- 46) [line 417-419] Suggest moving sentence starting with “Furthermore” and ending in “overestimated” to the end of line 411. This helps it to read better. If you agree, also change:
 - a. [line 412] “second” to “third”
 - b. [line 419] “Contrarily” to “Similarly”
- 47) [line 419] Change “thus” to “also”.
- 48) [line 420] Remove “also”.
- 49) [line 421-422] The sentence starting “Finally” is basically a reproduction of the part starting on line 412. Suggest removing “Finally, the presence of floating ice...” sentence and moving the part starting in “This also can be problematic...” to the sentence ending in “deep part of a lake to a shallower part.” To the end of the sentence which finishes on line 417.

Appendix A

- 50) [Table A1, column 2] Please make the ICESat-2 Beam ID into the full ICESat-2 file path for reproducibility.
- 51) [Table A1] I suggest the addition of another column that lists the location of the lake (by region i.e. NE, SW, CW)
- 52) [Figure B1, caption] Remove reference to “[m]” (2 instances) in caption as these are in your figure.
- 53) [Figure B2, caption] Remove reference to “[m]” (1 instance) in caption as this is in your figure.
- 54) [Figure B3] Include subplot identifiers e.g. a, b, and c or g , A_d , and R_∞
- 55) [Figure B3, caption] Remove reference to “[km^3]” as this is in your figure.

References

Climate Change Initiative (ESA Greenland_Icesheet_CCI, Grounding Lines from SAR Interferometry)
link: http://products.esa-icesheets-cci.org/products/details/greenland_grounding_line_locations_v1_3.zip/

Melling, L., Leeson, A., McMillan, M., Maddalena, J., Bowling, J., Glen, E., Sandberg Sørensen, L., Winstrup, M. and Lørup Arildsen, R., 2024. Evaluation of satellite methods for estimating supraglacial lake depth in southwest Greenland. *The Cryosphere*, 18(2), pp.543-558.

Mobley, C.D., 1995. The optical properties of water. *Handbook of optics*, 1(43), p.43.

Further comments

I wholeheartedly believe that reference to the Melling et al. (2024) paper will substantially reinforce the findings detailed in this manuscript. However, I understand it may come across as citation manipulation so I suggest that the authors only cite this paper if they agree that reference to it will reinforce this manuscript. I can be contacted at l.melling@lancaster.ac.uk and would be willing to expand on any of the above comments if required.