

# Greenland and Canadian Arctic ice temperature profiles database

## Response to Referee Comments on tc-2022-138

Brice Van Liefferinge (Referee #2)

We thank you for the time and energy that you have invested in reviewing our community paper. Below, please find responses to all comments. Your comments are in colored and italic text, and our replies are in black and plain font style.

*Comment from feedback overview:*

*The xlsx file is for me unnecessary as the dataverse and github repository are well defined and clear. I would like to emphasize the quality of the open data sets shared with this Publication.*

The .xlsx file only lists the borehole classification that we adopt for Section 6 of this manuscript (comparison with PISM temperatures). We therefore only link this classification .xlsx to this manuscript, rather than the Dataverse/GitHub, as these classifications may vary with user interpretation.

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*L1: In the xlsx supplement 70 boreholes are identified but i see 79 on github and dataverse*

The supplement file has now been updated to include categorization for all 95 borehole profiles. Note, additional temperature profiles have been included in the database since the referee comment was posted.

*L2: replace “profiles” with “boreholes data”. If you use “profiles”, it refers to the “85 ice temperature profiles” and as a result, the percentage should be 29.5%*

We appreciate the potential for confusion, however, instead of using “boreholes data” we have rephrased the sentence in the following way “Profiles from only 31 boreholes (36%) were previously available in open-access data repositories”. We hope this eliminates the confusion. Note, the number of borehole profiles and the percentage of the database it makes up has changed since the referee comments were posted, since additional profiles have been included in the database.

*L3: same here, it should refer to the boreholes and not the profiles*

Same here - we rephrased the sentence: “The remaining 54 borehole profiles (64%) are being made digitally available here for the first time.”

*L5-6: these two values must be included in the xlsx supplement.*

The .xlsx file only lists the borehole classification that we adopt for this specific manuscript discussion point (Section 6; comparison with PISM temperatures). The database is not available in .xlsx format. It is only available in .csv format for both the Dataverse DOI snapshot and the GitHub living database. The two ice thickness scales are already available in both these database versions.

Page 2

L18: ice

Fixed

L36: e.g.

Fixed - e.g. is added as suggested.

*L39-40: could you please provide more details: locations, depth, how many did you find,...?  
Too vague*

We know from historical accounts that previous profiles exist but locating these data has not been straightforward. We have no constraint on the number of pre-1950 profiles.

*L39: delete "may"*

For the above mentioned reason we decided to keep the "may" in the sentence.

Page 4

*fig1: I don't really understand why use a satellite image as background as it is never referred to in the main document. It might be more useful to have something useful for the discussion e.g. a simpler colored background with grounding line indicated, zones of surface melt, ...*

We now refer to using satellite imagery to classify whether boreholes are located above or below the contemporary snow line as an indicator of whether their surface mass balance regime is accumulation or ablation.

Page 5

*Your KML file is in the EPSG 4326 projection. As you use the EPSG 3413 projection for the figures, it would be good to add a Geojson or .shp file with these projections in the repository. It's a plus not a must have*

Done. See [https://github.com/GEUS-Glaciology-and-Climate/greenland\\_ice\\_borehole\\_temperature\\_profiles/commit/8afaa2014d2c2790fc6a4191276eb7d23a2976fa](https://github.com/GEUS-Glaciology-and-Climate/greenland_ice_borehole_temperature_profiles/commit/8afaa2014d2c2790fc6a4191276eb7d23a2976fa) . Uploaded to GitHub for now. This has also been uploaded to dataverse, but we are waiting to publish the next Dataverse version when multiple changes associated with this review round have been accepted.

*Why did you apply a cubic spline interpolation? Why not simply use a simple piecewise linear interpolation ? The effects of thermodynamical parameters (mainly surface temp, geothermal heat flow, ice velocity, ...) on the ice temperature vary with depth and so a cubic spline is not necessarily the best fit for all depths. Could you explain why you used a cubic spline everywhere ?*

We opted for cubic spline because there are some records with large depth distance between measurements and a curved line appeared to fit the data better. We provide easy access to both the raw data (see `data.csv` file in each folder in [https://github.com/GEUS-Glaciology-and-Climate/greenland\\_ice\\_borehole\\_temperature\\_profiles/tree/main/boreholes](https://github.com/GEUS-Glaciology-and-Climate/greenland_ice_borehole_temperature_profiles/tree/main/boreholes) ) and our code so users can access raw data if they need to reprocess it differently.

L78: cross out "format" behind "KML"

Fixed

L78: insert "format" in front of "KML"

Fixed

L85: insert "t"

Fixed

#### Page 7

*I understand that it is complex to show all the drill site temperature data in one figure but at this scale it is difficult to see which data set is which. In itself, the figure is interesting to show the overall variations in the temperature data but not useful to show specific data sets. Maybe using differing linestyles would help separating out data sets visually. Another solution would be to make a bigger figure as supplementary material.*

We have tried many different visualization approaches pre-submission within our author team including some of the points suggested here, but all seemed to have shortcomings. So we are receptive to specific editorial feedback. To accommodate the comment, the figure has been made larger but is currently still included in the main text.

#### Page 10

*You should mention how deep you find the coldest temperature (surface, near the surface). It could give the false impression that the whole profile is quite cold which is only true in the upper part of the profile and does not reflect the processes occurring near the bed*

I have added the following "halfway down the profile at normalized depth 0.48." So the full sentence now reads: "The inland profiles also exhibit the coldest temperatures, with temperatures reaching a minimum of around -32°C halfway down the profile at normalized depth 0.48"

#### Page 13

*Table 3: Could you please define what "negligible" is. For some, 0.01 °C is also negligible (e.g. modelers). In other words, what is your defined limit ?*

We now state "negligible (<0.01 °C)" in the table caption to constrain the adjective for readers.

*Section 6: This paragraph is interesting and shows the importance of providing good constraints for models. You should add a table listing the key parameters used in the model (even-though it is not a paper on PISM) and explain how well they are constrained.*

Instead of making a table we added the following (at the end of section 6): "In this modeled run key parameters influencing the modeled temperatures are the enthalpy, which requires understanding of the liquid water fraction in the ice column and its evolution in time, the geothermal heat flow which also have the potential to affect the presence of water in a given location, and the surface boundary conditions i.e. accumulation rate, which control vertical temperature advection, and ice surface temperatures. These parameters are all very difficult to constrain, however, this is especially the case for the enthalpy and the geothermal heat flow parameter. "

Page 14

*L250: You should mention that GHF is underestimated in some locations, see the paper of : Rezvanbehbahani, S., Stearns, L. A., Kadivar, A., Walker, J. D., and van der Veen C. J. (2017). Predicting the geothermal heat flux in Greenland: A machine learning approach. Geophysical Research Letters, 44, 12,271–12,279. <https://doi.org/10.1002/2017GL075661>*

We now acknowledge that there is a diversity of opinion regarding the magnitude and spatial distribution of geothermal heat flow beneath the ice sheet, and that modeled ice temperatures are likely influenced by choice geothermal heat flow map. We cite Rezvanbehbahani et al. (2017) and Colgan et al. (2022), which provide end members.

*L259: The constraint at the bed (GHF) has a key influence on the thermal state. Could you please develop in one or two sentences the conditions used in the model at the bed?*

Yes - We have added the following sentence “The geothermal heat flow map by Shapiro and Ritzwoller (2004), variable in space but not time, was used as a basal thermal boundary condition.”

Page 15

*Table 4: the caption is not related to the table. Same as table 3 !!*

The caption has now been updated to match table 4 instead of table 3. New caption: “Overview of the number of profiles in the three regimes before and after excluding profiles not usable for the model comparison analysis.”

Page 17

*L302: The community has decided to use flow and not flux anymore see : <https://tc.copernicus.org/articles/14/3843/2020/> and the associated white paper. Please change flux to flow in the whole manuscript.*

The term “flux” has now been changed to “flow” in the four instances where it occurred in the text.

*L306: Please also mention the paper of Rezvanbehbahani, S., et al, 2017 see above*

We have now cited this paper.

Page 21

*L441: the link is not valid*

Fixed, the link is now valid.