

# Review of the article entitled “Indication of high basal melting at EastGRIP drill site on the Northeast Greenland Ice Stream”

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## 1 General comments

This study presents measurements of annual ice thickness changes at the EastGRIP site on the NEGIS and their implications regarding basal melt rates and heat fluxes at the base of the ice. The authors first present the measurement that were realised and the processing that was performed to obtain melt rate at the base of the ice. They then elaborate on the potential energy source at the base of the ice to give an overview of the different contribution as well as their relative importance.

I find this study very interesting and insightful on the relative importance of thermal processes at the base of the ice. The paper is well written and sufficiently supported by clear figures and method descriptions. I have a few general questions and comments bellow as well as some more specific points listed line by line.

Regarding the Dansgaard-Johnsen distribution of the vertical strain I feel that the paper is not clear on how this distribution was used. At first it is presented as a comparison point (Line 91) before being quickly discarded on the ground that it does imply a no-slide basal condition. I agree with the fact that this distribution of vertical strain is unlikely to appear in this setting but then it should probably not appear in the discussion and the conclusion should state only “two different scenarios” rather than three (Line 219).

The thickness variations you present for each year have a fairly small errors but the two different years that are presented actually show quite a large spread in the value. Your further analyse on those numbers and the different values that are computed with an alternative method (Line 133) leave me with the impression that the differences that we see here are more related to imprecision in the measurement rather than the natural variability of the thinning. Regarding that point, wouldn't it be more fair to consider the difference between these measure as uncertainty of the method rather than two different thinning rate for different years.

Finally I find the last part of the paper regarding the considerations on energy balance very interesting but I am missing a final summary of this section. It would be nice to

see all the heat sources summarised at the end with the range given by the different approximations. That would also shade more light on the possibility for NEGIS to have high melt rates with a reasonable geothermal heat flux.

## 2 Specific comments

Bellow is a list of more specific comments throughout the manuscript given with line numbers:

- Line 1: associated in place of “associate”.
- Line 3: “is largely unknown”.
- Line 4: Is “role” the proper term here, perhaps “relative importance” would fit better.
- Line 8: I understand that the value given here represent the different years, but wouldn’t it be better to have a value of  $0.19 \pm 0.04 \text{ ma}^{-1}$ .
- Line 14: My opinion here might be biased but I think that the work of Smith-Johnsen et al. (2020a) shows that we can model the NEGIS without relying on inversion.
- Line 15: Shouldn’t it be “inability” here rather than “ability”?
- Line 20: “Increase in mass loss”?
- Line 22: I would say that one should aim at understanding the general dynamics and its different components rather than only lubrication.
- Line 23: “enhances” rather than “enable”?
- Line 24: In my opinion it is not the formation of the subglacial hydrological system that drive the sliding but more the increase in subglacial water pressure.
- Line 25: I would remove “system” here.
- Line 35: It should be stated here that this number is also tied to other parameters of the model. An other interesting point to touch upon might be the sensitivity of the NEGIS system to Geothermal Heat Flux as presented in Smith-Johnsen et al. (2020b).
- Line 73: A reference would be nice here to give a justification for those parameters.
- Line 87: The sentence starting on this line is hard to understand and could be rephrased.

- Line 97: “despite the fact that the no-slip boundary condition at the base is likely unrealistic...”
- Line 103: The notation for the vertical strain is not consistent throughout the manuscript, it is first introduced as  $\Delta H_{\epsilon_{zz}}$  but also appears as  $\Delta H_{\epsilon_{zz}}$  and  $\Delta H_{\epsilon}$
- Line 104: It should be stated clearly here that the Dansgaard Johnsen approximation have been discarded at this point.
- Line 111:  $\Delta H_{\epsilon_{zz}}^{dj}$  here should be  $\Delta H_{\epsilon_{zz}}^{const}$
- Line 112: From the text I am not sure here what the surface refers to. Is it the topographic surface or the base of the ice cave on which the radar is set-up. I expect this is the latter but that should be clarified.
- Line 126: “as large as the one of...”
- Line 131: “Instead of comparing...”
- Line 139: “slightly” here seems like an understatement when the values you show are almost twice as large as the previous estimates.
- Line 141: “side” here should be “site”.
- Line 172: Remove “are”.
- Line 176: I would prefer “thick” here over “vertically extensive”.
- Line 179: I wonder why the thermal conductivity for ice is taken at 273.15 K and not the pressure corrected melting point.
- Line 184: I am puzzled by scenario (ii). Which heat flux is raised? It seems that the raise is lower than the final heat flux or is there an issue with units?
- Line 191: The description of the bounds for the basal velocity here could be clearer.
- Line 193: The value here is expressed in milliwatts when all other values up to this point or in Watts, it might make it easier to read if the units were consistent. This also applies to lines 196 and 202.
- Line 197: Consider rephrasing as follows : “from the roughness of the ice shelf base to a maximum roughness ten time larger...”
- Line 200: Consider rephrasing as follows : “We consider a speed similar to the one of the ocean...”

- Line 203: Remove “by”
- Line 206: “we demonstrate” isn’t the “we” missing?
- Figure A1: It would be nice to state the lines’ colours to their scenarios in the caption of this figure.

## References

- Smith-Johnsen, S., de Fleurian, B., Schlegel, N., Seroussi, H., and Nisancioglu, K. (2020a). Exceptionally high heat flux needed to sustain the northeast greenland ice stream. *The Cryosphere*, 14(3):841–854.
- Smith-Johnsen, S., Schlegel, N.-J., de Fleurian, B., and Nisancioglu, K. H. (2020b). Sensitivity of the northeast greenland ice stream to geothermal heat. *Journal of Geophysical Research: Earth Surface*, 125(1):e2019JF005252.