The Cryosphere Discussions

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Comment on tc-2021-327

Anonymous Referee #2

Referee comment on "Shear-margin melting causes stronger transient ice discharge than ice-stream melting in idealized simulations" by Johannes Feldmann et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-327-RC2, 2021

This study evaluates the sensitivity of ice flux from ice streams to the location of sub-ice shelf meltwater. In particular, the authors compare localized sub-ice shelf melting that occurs in the trunk of the ice shelf to melting that occurs in the shear margin, where ice velocity decreases rapidly. In model runs of PISM, they find that localized melting in the shear margins affects ice flux more than melting in the trunk of the ice stream and they suggest that this is due to the slower velocities in the shear margin. The study seems comprehensive and is laid out in an intuitive manner. The paper itself is well-written. I believe there is much to think about when it comes to the effects of shear margin dynamics on ice shelf buttressing, and I am heartened to see studies tackling this question. There are some comments below that may improve the readability and clarity of the paper.

Dynamics: In general, while I follow the logic of the underlying dynamics that cause shear margin melting to affect ice flux more than melting in the trunk, I felt that this argument could have been presented more clearly in the paper. While the discussion section does introduce a number of interesting points, I found it to be missing a clear explanation for the reasons behind the disparity in flux response. There is some explanation in the results section in lines 17-25 of page 5, but I found this explanation to be a bit buried in the results section and quite short given that this appears to be the primary physical explanation for the results of the paper.

I also wondered if the study needed more of a formal connection to other shear margin

studies that consider the effect of shear margin dynamics on ice shelf/ice stream stability. For example, Alley and others 2019 proposes a physical mechanism for the localization of melt underneath ice shelf shear margins, and invoking these studies would strengthen the motivations of this work quite a bit. Further, there's been quite a bit of work done on heating in shear margins which suggest that shear margins are likely to be quite warm (and even temperate), and I would be interested to know whether this may further increase basal melting in these regions given that the ice is already quite warm (see: Suckale and others 2014, Perol and Rice 2015, Haseloff and others 2019).

Connection with observations and modeling: In the last paragraph of the study the authors discuss implications for Antarctic ice stream dynamics. In particular, they mention observations of enhanced melting in ice stream margins, which provides significant motivation for the work presented in this study. I believe it may be useful as a takeaway for the reader to either expand on these observations and provide a clearer link between the work in this study and those observations or to suggest what these observations and the physical mechanism proposed in this study may mean for how we represent and model ice sheet dynamics.

Minor Comments:

- In the discussion of the results, I found myself losing track of the different perturbation experiments and some of the acronyms. It may be useful to have a table of the different experiments and the corresponding the melt rates.
- Line 22 on page 4: I wondered whether "efficiency of the melting" was a clear descriptor of Equation 1, rather than something like "sensitivity of the flux to melt rate".
- Lines 7-12 on page 8: the comparison of melt rates in this study to melt rates estimated in ice shelves may be more useful in the "Setup and experimental design" section as a motivation for the choice of melt rates, as I found myself wondering how you chose the melt rates and whether they were physical
- Does the width of the shear margin matter? If the shear margin is quite wide and thus velocities are going to zero slowly (i.e. if the flow law exponent is lower), would this dampen the effect of melting in the shear margin?

Citations

Alley, K.E., Scambos, T.A., Alley, R.B., Holschuh, N. (2019) Troughs developed in ice-stream shear margins precondition ice shelves for ocean-driven breakup. *Science Advances*, 5(10), doi: 10.1126/sciadv.aax2215

Suckale J, Platt JD, Perol T and Rice JR (2014) Deformation-induced melting in the margins of the West Antarctic ice streams. *Journal of Geophysical Research: Earth Surface*, **119**(5), 1004–1025 (doi: 10.1002/2013JF003008)

Perol T and Rice JR (2015) Shear heating and weakening of the margins of West Antarctic ice streams. *Geophysical Research Letters*, **42**(9), 3406–3413, ISSN 00948276 (doi: 10.1002/2015GL063638)

Haseloff M, Hewitt IJ and Katz RF (2019) Englacial Pore Water Localizes Shear in Temperate Ice Stream Mar- gins. *Journal of Geophysical Research: Earth Surface*, **124**(11), 2521–2541, ISSN 2169-9003 (doi: 10.1029/ 2019JF005399)