

Anonymous Referee #2

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.

First of all, we would like to thank Referee#2 for their willingness to review our manuscript. We are grateful for the referee's positive assessment of our study and the helpful comments and suggestions that we are happy to address to improve our manuscript.

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.

We are grateful for this hint. As suggested by the referee, we will revise the manuscript in order to give the mechanism underlying the flux differences more visibility.

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).

We thank the referee for mentioning these important studies related to the topic of our study that we were missing. We will be glad to reference and discuss these papers in our manuscript.

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.

This is very valuable advice. We are eager to expand our manuscript, regarding the link between observations and our results and their meaning for modeling 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.

We will add a table to give an overview of the different perturbation experiments and their characteristics, as suggested by the referee.

- 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”.

We are glad to change the wording here according to the referee's suggestion.

- 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

This is indeed a good idea and we will follow the referee's suggestion.

- 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?

This is an interesting point raised by the referee. We will add a discussion of the influence of the shear-margin width.

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 Margins. *Journal of Geophysical Research: Earth Surface*, 124(11), 2521–2541, ISSN 2169-9003 (doi: 10.1029/2019JF005399)