Review: "Groundwater dynamics beneath a marine ice sheet"

by Cairns et al.

Submitted to *The Cryosphere*

1 General

In this paper, the authors analyze the flow of water in the porous till below ice sheets. This is a valuable paper with insightful calculations. At the same time, the paper is a tome, aiming to accomplish many goals with several ideas. From what I can tell, the paper has gone through a round of revisions already before it has come to my desk, so my comments are brief and focused on how to improve the paper.

2 Specific comments

1. Abstract: the last sentence is ambiguous and could be clarified. Also, it could be beneficial to zoom out and briefly state the significance of results.

2. Smith et al. (2020) is not a great reference for motivating contributions to future sea-level rise. What about a paper like Seroussi et al. (2020)? Or both?

3. line 20: could add 'potential' between 'important' and 'contributor', to reduce the certainty of the statement to a level comparable with the evidence.

4. line 100: could define effective pressure. It is implicit, but could be clarified.

5. line 140: it could be valuable to explain a bit more about which grounding line position and aquifer thickness are good scales. Is it the initial value? Could be more clearly stated.

6. The nondimensionalization is a little hurried. I think specifying clearly the valuables that are scaled and by what would be valuable. This is clearly needed since the first equations after the nondimensionalization have h and H in them. This is confusing if you just scaled the height H by H.

7. Section 2.3: with zero effective pressure and a focus on ice streams, it is hard to imagine that the shallow-ice approximation is the right limit of the Stokes equations. There will likely be more than 'negligible bed slip'. At this stage in the review process, the best I can hope for is a clearer description of why this model was chosen, the drawbacks, and later in the paper, how it affects your results.

8. figure 2: does the solution become singular at $x = 0$?

9. paragraph at line 270: I think the relationship between q_E and K could be clarified with a figure.

10. paragraph at line 360: it could be valuable, given the venue at *The Cryosphere*, to describe some of the implications of the hysteresis.

11. section 5: I think this part of the paper could be its own paper. That would allow for more discussion of the results in all sections. Currently, the text continues to be hurried.

12. How does this model compare to the SLW salinity measurement? It seems like text would be devoted to this point – did I miss it?

13. I like the conclusions section, it is a nice wrap up of the paper, much like an expanded discussion section. The paper would benefit from more discussion generally.

References

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B. Smith, H. A. Fricker, A. S. Gardner, B. Medley, J. Nilsson, F. S. Paolo, N. Holschuh, S. Adusumilli, K. Brunt, B. Csatho, K. Harbeck, T. Markus, T. Neumann, M. R. Siegfried, and H. J. Zwally. Pervasive ice sheet mass loss reflects competing ocean and atmosphere processes. *Science*, 368(6496):1239–1242, 2020. doi: 10.1126/science.aaz5845.