

Response 1 on “Influence of water extraction on subglacial hydrology and glacier velocity”

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We are grateful to the referee for highlighting potentially confusing aspects of the paper and suggesting areas for improvement. The reviewer’s comments are in black text and our responses are colored in blue text.

1 General comments

The title of this paper is too general to represent the contents of the article accurately. The scenarios examined are very specific (e.g. wintertime only) and this should be acknowledged in the title. The influence of water extraction goes far beyond this work. We have changed the title to “A model of water extraction from subglacial hydrology under idealized conditions”

The level of mathematical detail here was appreciated, but I found it frequently to be at the cost of the ease of understanding of the paper overall. For a journal such as The Cryosphere it should be possible for a reader without a detailed mathematical background to still understand the overall study, but the details of the simulations run and their purpose are often lost in the weeds of the mathematical solutions.

We have streamlined the mathematical detail, reordering the sections according to the reviewer suggestions for clearer flow, and moved section 3.2.1 to the appendix

The authors frequently do a good job of stating the assumptions made and the limitations of this work in the main body of the text. They do, however, then jump to much more general conclusions that go beyond what their results show in the discussion section. The results do not suggest that water extraction can slow glaciers, except under very specific circumstances. More work is needed to determine if glaciers can be slowed under realistic scenarios (i.e. with summer melt). The paper is a little inconsistent in sometimes doing a good job of being realistic about the results (i.e. that more modelling work is needed) and sometimes making broader statements that could be taken out of context.

We have added qualifiers to soften our statements about the effects of pumping. In addition, we have responded to the specific comments below to address the reviewer’s concern.

While the authors state that the practical, moral, ethical implications of field testing are not considered, the fact that possible future field deployment is mentioned and the location studied has a local population should not be ignored. Can the authors please acknowledge the Indigenous population of Greenland and their rights to decide about possible future field testing that happens in their home.

We have removed any statements about field deployment. We have now included an acknowledgment of the indigenous population of Greenland.

The authors have acknowledged that two of them have connections to the Arête Glacier Initiative, yet describe this as ‘focussed on sea level rise’ whereas Arete’s home page states ‘Arête is leading sea-level rise forecasting and glacier stabilization efforts’. While it is appreciated that the authors are declaring this interest, the fact that this is an initiative with a specific goal to research glacier stabilization should be made clear. For a topic that has attracted a lot of controversy to the cryospheric community 100% openness is essential.

Agreed, we have updated our conflict of interest to reflect these comments.

2 Specific line by line comments:

Line 71 - Could the authors please expand on why the Theis method would be expected to be applicable to a subglacial environment e.g. as presumably this evolves much more quickly than a groundwater system

We agree that the paragraph required some clarification. In the updated text, we have described the subglacial analogy in more detail and reduced the technical details about the Theis method. We have reworked this section to describe the similarities (and differences) with the Theis solution.

Line 105 (eqn 1) - How much does the choice of sliding law matter here? Given it’s directly proportional to N it seems quite important.

The sliding law is indeed important. We did not test other sliding laws in these initial simulations. We are currently running simulations that utilize a generalized Coulomb sliding law.

Table 1 - This would be much easier to follow if the parameters were also named as for anyone not familiar with SHAKTI there is a lot of back of forth to try and understand the equations.

Good idea. We have added words next to the variable definitions in the table.

Line 134 - Does the continuous pumping assume no movement of the glacier (i.e. connection to the bed at the same place)? How might that impact future work that looks at feasibility of keeping drill holes open?

Yes, here we assume that the pump site is fixed relative to the motion of the glacier. We agree, in reality, it would be a Lagrangian tracer following the flow and quantifying its speed would be important.

Line 146 - I got a little confused between q , \mathbf{q} and if these equations are looking at total water flux from the whole circle in figure 2 or just water movement across the boundary at the circumference. Possibly the above suggestion of making parameter names clearer might help with this.

The axisymmetric flux in SHAKTI only points radially inward here, so we were not careful enough with the distinction between q and \mathbf{q} . We also streamlined the section describing the equations, combining parts of 3.2.2 back into the original description. One result of this reshuffling is that we hope that the definition of the flux should now be clearer.

Line 187 (Fig 4) - More details about the simulations carried out here would be helpful, is this revisiting simulations from another paper? There aren't any other simulations plotted previously.

We are referring to the simulations in figure 1 that we use as a guide for our analysis. We have updated the language in this sentence to clarify. We have also added addition details about the simulations when they are introduced and when we discuss the simulation results.

Line 369 - This is a very minor impact, but is described as a 'modest' impact in the abstract which is overstating 0.5-1%.

We have rephrased the language describing our results in the abstract and throughout the paper.

Figure 10 - Can the authors please explain what is happening around day 90, and what the small fluctuations in the effective pressure are showing?

There is an initial overshoot then equilibration.

Line 377 - Can you see the reconfiguration of the drainage network with SHAKTI?

Our results suggest that some reorganization occurs: in figure 12d we see a channel forming in the main trunk of Helheim.

Line 379 - typo

Thanks!

Line 417 - The results don't show this, they show it can slow them under winter conditions only.

Fair point, we have adjusted the language accordingly.