

Review: “Modeling saline fluid flow through subglacial ice-walled channels and the impact of density on fluid flux”

by Jenson et al.

Submitted to *Cryosphere*

1 General

In this paper, the authors analyze flow of brine through subglacial channels. Classic analysis for subglacial channels, e.g. Röthlisberger (1972), neglects the role of solutes in the subglacial flow, which is unlikely to be the case in the natural environment. The authors present the first analysis, as far as I know, of the role of solutes in the subglacial hydrologic system. I found the paper to be interesting to read, yet a bit thin and confusing in places. I was surprised to learn that the major effect is the density of the water, rather than the melting point depression, but that leads me to wonder about the model construction. I will likely support publication but would be interested in one or two rounds of revision to clarify some of my questions.

2 Remarks

1. I am a bit skeptical that the main effect is the density change, given that the salt can so effectively lower the melting point. My rationalization is that the water is already at the local melting point (even in the pure water case) and the salt would just allow channels to exist at lower water temperatures. However, the ice temperature will be warmer, suggesting that the salt can melt the ice and there will be heat transfer. I think this is what is captured by equation (7) but I don't yet fully understand.
2. In the summary of model equations, I am not sure that there are enough equations listed to close the system. It seems like the 7 unknowns are N , S , m , ψ , m , Q , β , and $\hat{\theta}$ and there are 5 equations listed. The other two are the statement of ψ and the melting point $\hat{\theta}$, which are described earlier, but I think it would be clearer if they were stated here as well. Also, I think it would be useful to include a statement of the boundary conditions and initial conditions in this section. As a counting exercise, it would be useful to see all of the conditions required.

3 Specific comments

A few small things that I thought of:

1. A self citation is fair in the section on outburst floods.
2. equation (1): the assumptions here imply that $\psi = \rho_b g \sin(B)$, is that correct? If not, what is ψ ?

3. line 101: “is therefore non-constant” could be “therefore varies”
4. line 184: I think it would be useful to add the units after the list of β values.
5. line 288: I am confused about the effective pressure values coming out of the model: are they all negative and extremely small? I would expect some in the kPa range, rather than something like -100 Pa. Am I missing something?
6. line 306: the authors state that they are using ‘somewhat arbitrary’ parameters. Which ones specifically? And why? Would it be better to add a citation of possible better values?
7. In the appendix, where the dimensionless model is written out, what are the boundary conditions on β ? I don’t think they are stated and would be useful.
8. I think some of the model development that is included in the appendix could be useful to put back into the main text.
9. I am not a fan of the notation $Q(s = 1, t)$ since it looks cluttered (e.g. equation A9) and it is an odd statement. I prefer Q at $s = 1$ or $Q(1, t)$, if absolutely necessary.

References

- H. Röthlisberger. Water pressure in intra- and subglacial channels. *J. Glaciol.*, 11(62): 177–203, 1972. doi: 10.3198/1972JoG11-62-177-203.