The Cryosphere Discussions

The Cryosphere Discuss., referee comment RC1
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Comment on tc-2021-262

Anonymous Referee #1

Referee comment on "Layered seawater intrusion and melt under grounded ice" by Alexander A. Robel et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-262-RC1, 2021

Robel et al. present a simplified model of a subglacial salt wedge and apply a simple parameterization of associated subglacial melting in ice sheet models to estimate the effects of this process on sea-level projections. They offer a valuable extension of the work recently presented by Wilson et al. (2020) from intrusion in subglacial channels to intrusion in a subglacial water film. Overall, I found the manuscript clearly written, with some additional suggestions for improving clarity provided below. The primary concern I'd like to see the authors address, elaborated below, pertains to the feasibility of the simulated melt rates.

Major comments:

When you discuss the conditions for maintaining stratification between layers, showing that the Reynolds number indicates a laminar regime would be helpful. (Roughly around L240)

A table of some of the cases you discuss in Sections 3.1 and 3.2, i.e., the parameter combinations and distance estimates, would be a useful reference.

It seems that you consider the bed slope but not the ice slope in Equations 3,4. However, I think you also make the assumption that ice base slope is the same as bed slope such that the subglacial film thickness is constant. I think that's fine since you treat the velocity of the upper layer as a free parameter, but I'd like to see Equations 3,4 presented in as general a form as possible.

Can you provide an argument that such intrusion-induced melt rates can exist in a steady state? Given such thin films, I would think it's possible that heat exchange (in this laminar regime) from the open ocean upstream through the subglacial layer might be too slow to maintain these melt rates.

L540: This line reads like a recommendation. However, with such a wide range of intrusion distances and the strong sensitivity to the bed type, this recommendation seems too general to be useful to ice sheet modelers. Can you settle instead on something like, "uncertainty in intrusion-induced melt should be incorporated into uncertainty of sea-level rise projections using ice sheet models" or "sensitivity of sea-level rise projections to intrusion-induced melt should be tested in ice sheet models." Or something even more specific like "given large uncertainties, we recommend applying melt to partially-grounded cells"

Minor comments:

L7. Since you haven't yet discussed what you mean by "hard bed" I recommend instead calling it an impermeable bed.

L11. "10-50% higher or 100% higher" This is a strange way of expressing it without indicating what makes the difference between the two cases.

L12: "whether the conditions are met for extensive seawater intrusion" or "whether extensive seawater intrusion occurs"

L50: "distance" >> "extent"

L89: "the bulk porosity of the sheet" Wouldn't it be better to define \phi_1 and \phi_2 for each layer in Equations 3,4 so that the equations are more general? And similarly for c_d to acknowledge that the ice and bed could have different roughnesses?

L91: This is the final term in Equation 3 but not Equation 4

L106: "vertical interface" To me, this is unclear and would be better stated just as the horizontal extent of the saline layer.

L107: "without considering their compositional differences" Are you referring to the inclusion of the buoyancy (reduced gravity) term? Or the representation as a two-layer system?

L113: "after H_2 is eliminated" This would make more sense if h=H_1/H had already been introduced.

L116: I think it would be helpful to describe what \gamma represents qualitatively (i.e., porosity).

L118: "Fr = Fr_0 h^{-2/3}" should be explained

Figure 1. I think it would be helpful to include a second panel that is the schematic of the soft bed case.

Figure 2. Define h in the caption.

L191: "single hydraulic potential" implies that Equation 12 will contain the hydraulic potential rather than U_in.

L195: Can you direct readers to where in the literature \alpha is defined?

L222: "which" is ambiguous between g' and the density difference.

L246: I think you mean "it is still possible to maintain *two layers* in water sheets 10cm thick"?

L250: Provide a reference for maximum packing density.

L252: "That could be supported in such a thin water sheet" by virtue of what? Do you mean supporting two layers within the film? How did you determine the c_d value of 0.01? If it is just the upper bound in the literature, then it would be clearer to delete the clause I reference here.

L265-272: This paragraph seems to be a distraction. As far as I can tell, the key point is that the layer in the ice sheet interior is on the order of mm and thus too thin for the 2-layer model to apply. That could be stated in the previous paragraph with the Engelhardt and Kamb (1997) reference.

L294: delete "equation"

Figure 3: It is hard to view inset box in panels a,c. It might be worth stating in the caption that the blue region is above the critical slope.

Figure 3 and 4: I wonder if you might find a better colormap for these plots. It's pretty hard to see the difference between values just above and below 10m. Another option would be a contour at 100m since that is the lowest value you implement in the ice sheet model.

L341: Add units to K

L346: "perhaps in under" >> "perhaps under"

Figure 6: Add a legend to panel b for the two points located at x=0

L478: The local bed type isn't easy to accomplish in a model if we still don't have a continent-wide map of hard/soft bed.

L491: "act to prevent strong curvature" This isn't clear offhand. Can you provide a reference?

L531: "rights" >> "right"

L533: "under the right circumstances" repetitive with previous sentence