Review for “Modelling the effect of submarine iceberg melting on glacier-adjacent water properties”
by Davison et al.
under consideration in The Cryosphere

Summary:
The authors describe a series of numerical modeling experiments that explore the influence of iceberg melting on ocean water properties at the glacier-ocean boundary. Modeling is performed using the MITgcm, which is widely used to simulate fjord circulation and ice-ocean interactions. The authors test a wide variety of iceberg conditions (including variations in keel depth, aerial coverage of icebergs, power-law distributions for iceberg sizes) as well as a number of different ocean temperature profiles, for idealized fjord geometries without and with a sill. The experiments are well thought-out, including covariance of the iceberg conditions, and likely span a variety of real-world conditions. The experiments indicate that iceberg melting causes ocean properties to become more uniform with depth. The homogenization of the water properties with depth should reduce glacier melting near the surface but increase glacier melting in the relatively cold near-surface Polar Water layer. These modifications to the glacier submarine melt profile may influence the stress balance at the glacier terminus, influencing terminus stability.

The manuscript is well written, interesting, novel, and easy to follow. A few questions regarding the applicability of the results given the limited fjord geometry and seasonality of the experiments, as well as some more minor comments are included below.

Major Points:

1. For the iceberg melt parameterization, why were equations commonly used for glacier melting applied rather than the more traditional iceberg melt parameterizations from Bigg et al. (1997) and a number of more recent studies (Moon et al., 2018; Fitzmaurice et al., 2016; 2017)? Even if this choice is justified in Davison et al. (2020), it should be briefly explained here as well since it may strongly influence the melt rate estimates. It is not apparent why a plume-based model should be used when a face-normal (meaning horizontal for the vertical iceberg sides) relative velocity is used to estimate the melt rate.
2. Although I imagine that the simulations may have taken a considerable amount of time to execute, I wonder why the authors did not perform a subset of the same experiments using different fjord geometries. The implications of the study have the potential to be much more broad if a few other simple geometries are incorporated into the analysis. For example, would the results be markedly different if the fjord was shallower (~200 m-deep), such that the subglacial plume was ejected into the Polar Water layer? Additionally, would the relaxation time change considerably depending on fjord width? If I had to prioritize, I’d be much more interested in the influence of fjord depth on the analysis than fjord length.

3. Similar to my comment above, the authors only consider summer ocean conditions despite incorporating simulations without runoff. Winter hydrographic data are limited, as stated by the authors in the discussion, but some data are available in Sermilik Fjord as an example. The runoff vs no runoff portion of the manuscript is not really discussed beyond the results but this may be very important: it looks as though iceberg melt in the upper-most 50 m is entirely suppressed when runoff is present because the temperature near the surface is at the freezing point. This result suggests that melting at depth in the winter may buffer small icebergs from melting, promoting the growth of sea ice and mélange. Of course your model cannot yield insights into the influence of near-surface melt suppression on mélange properties, but it is certainly worth discussing.

Minor Comments:

- Table 1 comes before you explain the different scenarios, resulting in some confusion when the different iceberg configurations are described at the bottom of page 6. Consider moving this table or making it clear earlier-on that you modify a number of iceberg parameters separately and also in combination (if I am correctly interpreting the present description). Alternatively, you can omit the fact that you modified the parameters separately since you never discuss those independent modifications.
- Figure 2: How did you distribute the iceberg sizes across the fjord domain? They clearly are not uniformly-distributed across the fjord but there is no description of the distribution in the text.
- Make sure you are consistent with terminology. In the results, you describe simulations with and without subglacial discharge but the term runoff is used in the Figure 3 caption.
- line 333: Change “Iceberg-melt-induced” to “Iceberg melt-induced”
- Figure 8: I recommend averaging or down-sampling the observed profiles to the same depth resolution of the model simulations. It may also help to show the most similar profiles from the simulations in each plot.