Response to Reviewer 2

We thank the reviewer for providing constructive and positive critique of our manuscript. The points raised are relevant and interesting. We also thank the reviewer for pointing out numerous typos. Below, we propose a response to the reviewer's comments.

General comments

From my point of view, the manuscript is well written and the study is well prepared and with many of the limitations of the model considered. However, there are two general aspects that I would like to comment on.
(i) Regarding the content, I have missed several details about the physical settings of Peterman and Ryder glaciers (see specific comments below), as well as the entire description of 79N Glacier system. In order to understand the transition range to which each system is subject, it would also be convenient to report approximately how deep the SPW, the front of the ice tongue, the sill and the AW reach in each system. In the limitations of the model, I believe that the implications of not including subglacial discharge in the melting flow should be further developed. It would also be convenient to take into account that melt buoyant plumes can reach neutral buoyancy at different depths. If either of these depths is close to h_L, it could encourage a transition to the hydraulically-controlled regime. Even, if the plume NBD is reached deeper than the sill, the plume flux would be totally trapped in the ice cavity; there would be no exchange flux to the oceanward side of the sill (entrainment ratio of 1) and the waters from the ice cavity would turn colder and fresher without input of the AW.
Suggested response: We will give more information on the three glacial system at appropriate sections in the paper. We agree with the reviewer that the validity and consequences of neglecting subglacial discharge in the conservation relations (section 2.1) deserves a discussion. Reviewer 1 raises a similar point, and in response we propose to add a new appendix that discusses how subglacial discharge that is higher than basal melt affects the model results qualitatively; see below and also the response to Reviewer 1.

The reviewer's point that that melt buoyant plumes can reach neutral buoyancy at different depths is relevant, but we deem that our model needs to be further developed to examine this interesting issue. Thus, we leave this point for future studies.

(ii) Regarding the organization of the content, I would consider it appropriate to make some adjustments to facilitate the understanding of the study, although I also understand that each person must have their own style and I propose my comment as a suggestion. I think the most appropriate structure would be:

1. Introduction: The state of the art, motivation and objectives as they are (I would not include here the subsection about the Physical settings of the glacier-fjord systems).

2. A two-layer model. As it is, although I am not sure about whether subsection 2.2.1 should be at the same level than Sections 2.2 and 2.3.

3. The dynamics in the hydraulic regime.

4. Application of the hydraulic regime to glacial sill fjords (as a 'Case of study'). Independent from the previous section, and including here the glacier-fjords' description of Peterman, Ryder and 79N.

5. Conclusions

We think that the structure suggested by the reviewer is good and logical. However, to follow this suggestion would entail a major revision of the paper. Therefore, we propose to keep the structure of the paper.

Specific comments and typos

L.18 - Basal melt relates to the melting occurring at the base of an ice body (either grounded or floating). However, basal melt here only refers to the floating part of the ice (ice shelves and ice tongues), but it doesn't to tidewater glaciers with vertical ice front, which are also marine-terminating glaciers.
Good point: we will use subsurface melt, rather than basal melt.
L.19 – The definition of grounding line given here is only valid for ice shelves and ice tongues. The grounding line feature is also present in tidewater glaciers with a nearly-vertical ice front, where no permanent floating ice exists.
We propose to add a footnote explaining what applies for tidewater glaciers.
L.20 – The effects of water column stratification on submarine melting was also reported on De Andrs et al. (2020).
This is relevant reference that we will cite here, and on L290.
L.46 'effects due Earth's rotation' – 'effects due to Earth's rotation'.
We will correct this.
Section 1.1 - As stated in L.52-53: 'the model results are discussed in relation to observations from... and 79N glacier'. However, no information of the physical settings of 79N glacier is provided within the whole manuscript. Is there any reason for this lack of information?
We decided to focus the comparative discussion on Petermann and Ryder because they are relatively close geographically, and hence have similar Atlantic Water conditions outside the fjords. However, we agree with the reviewer that it is relevant to provide some information on 79N as well.

We propose to start section 1.1 by giving some general facts concerning these three ice tongues in North Greenland, and point to papers that describe 79N (e.g. Wilson et al., 2017; Lindeman et al., 2020; Schaffer et al., 2020), before we begin the comparison between Ryder and Petermann.
- In order to contextualize the rate of frontal advancing/retreating and get a frame of reference for the sill influence on hydraulic control, could the author specify what the lengths and widths of these two glaciers and fjords are? and the depth range of the grounding lines and ice-tongue fronts? I can only found GL and front details for Ryder glacier in Fig.2 caption.

We will provide the information the reviewer asks for in the caption of Fig. 2, and maybe also in Table 2.

L.57 - It would be better to quantify 'a relatively deep and wide sill'.

We propose the write: 'a ∼400 m deep and ∼12 km wide sill '.

Fig.2 - In panel a), it would be nice to have the coordinates frame and the North arrow.

- In panels b) and c), a scale bar (and a more precise bathymetric colorbar) would help with the fjord and sill dimensions. It seems that the coordinate 630'W appearing on the left y-axis of pannel b) is a mistake. It would also be helpful to have in these pannels (b and c) the location of the CTD casts used in Fig. 3.

We will revise the Fig. 2 as suggested.

L.80 and 86 - Based on CTD observations, it would be helpful to give a thickness range of the two layers considered in the model, as well as the thickness of the surface-polar-waters layer (it could also be highlighted on Fig.3).

We will work on a revised version of Fig. 3 that indicates the model layer thicknesses; if needed we will make a separate figure showing this.

What are the limitations on the study (if any) of avoiding mixing between glacially modified and surface polar waters?

The important model constraint is that glacially modified does reach and mix with near surface waters that receive a strong input of surface runoff, as this freshwater source is not included in the model. Some mixing between glacially-modified plume water and the layer of surface polar water is expected to occur. This will cool and freshen the outflowing waters to some extent, but this process is neglected for simplicity.

L.82-83 - What are the limitations of neglecting subglacial discharge as a mechanism enhancing basal ice-tongue melting?

The main effect of subglacial discharge that is comparable to or larger than the basal melt is that Eq. (10) in the paper – the relation between the difference in salinity (ΔS) and the temperature (ΔT) between the two layers – becomes modified and depends on the subglacial discharge. Essentially, ΔS will for a given ΔT be larger than predicted by Eq. (10). This strengthen the layer density difference and causes the transition into the hydraulically-controlled regime to occur for somewhat greater sills heights than in the limit where subglacial discharge is neglected in the freshwater budget. We propose to include a new appendix that briefly describes some qualitative effects of finite subglacial discharge; see also the response to Reviewer 1 on this point.

L.82-83 Table 1 - Last row, in Gade temperature relation, change the 'equal symbol' by the 'almost-equal symbol' (as it appears in L.111 and L.116). Also, I am a bit confused, since it seems to be inconsistencies with the magnitude and units of this Gade temperature. A value of 80 K is given in Table 1 (which is consistent applying the proposed relation therein), but a value of 80 C is given in L.111. From other studies (e.g. Jenkins, 1999; Mankoff et al., 2016), this Gade temperature values are about -90 C. Could you, please, unravel this question?

The reviewer points to some unclarity in our definition of the Gade temperature T_G, which would be the drop in temperature of a unit volume of water from which sensible heat is extracted to melt ice corresponding to a unit volume of liquid water. The equivalent ice temperature used by Jenkins (1999) is essentially $-T_G \cdot \frac{\rho_w}{\rho_i}$; where the factor ρ_w/ρ_i emerges because we use unit volumes of liquid water in the definition of T_G. We will state this in the text. To avoid possible confusion related to the use of both the Kelvin and Celsius temperature scales, we will change to use only Celsius. Also, we will use the following slightly more accurate numerical values $L/c \approx 75$ °C and $T_G = L/c + c_i/c(T_f - T_i) \approx 80$ °C (where the ice temperature $T_i = -15$ °C).

L.111 - Modify L/c value/units according to my previous comment.

We will do this using °C.

L.198 - 'This show the' → 'This shows that the'

We will change this.

L.204-205 - Could also a significant subglacial discharge flux motivate this subcritical-to-critical transition? Answered in L.272-273.

OK.

L.206-207 - See also Hager et al. (2022), where a simple model is used to estimate the proportion of refluxed freshwater in a silled fjord and the potential impacts on submarine melting are discussed.

This is a relevant paper, and we will cite it in the beginning of section 3.2.1.

Foot note 1 - The word 'than' is repeated twice in the second line.

We will correct.

L.245 - Shouldn't it be $R < 1$ in the hydraulic regime, since $R = 1$ is reserved for the melt-controlled regime?

Correct! We will change this.

Fig.4 - What are the h and deltaT used to make axes non-dimensional?

We will explain the non-dimensionalisation in the caption.

L.289-290 - Increased stratification generated by strong surface melting has also been observed to dampen submarine melting in tidewater glacier-fjord systems (De Andrs et al., 2020).

We will cite this relevant paper.

L.292 - 'The reasoning above and suggest that' → 'The reasoning above suggests that'.

We will correct this.

Fig.8 - in L.3, 'is smaller (greater) than one the hydraulic' → 'is smaller (greater) than one in the hydraulic'.

We will correct this.

L.446 - I understand the near-bottom temperatures for the ice cavity, to get better estimates of those temperatures near the grounding line, but, shouldn't outside-forced temperatures be those at the near-sill depth, where the flow exchanges are taken place?.

Figure shows that the near bottom temperatures outside the sills, which characterise AW temperatures, are essentially equal to temperature at the sill depth. We will rewrite to make this clear.

L.460 - Please, quantify 'with large error bars'. We removed 'with large error bars' as there is difficulty to provide such from measurements taken at one particular time. Instead we will write: ' to be on the order of $50 \cdot 10^3$ m^3 s^{-1}.'

Fig.11 - in L.2, 'and 79' → 'and 79N'.

We will correct.

Fig. 12 - To get a more comprehensive understanding, it would be nice to have the squares for the three glaciers, not only for the Ryder glacier.

Regrettably, this is not possible as the basal melt shown in Fig. 12 is based on the Ryder model parameters. Separate figures are needed to show the other glaciers, and we decided to present only the Ryder case.

L.490 - 'Our results suggests' → 'Our results suggest'.

We will correct.

L.521 - 'longer that today' → 'longer than today'.

We will correct.

References

Lindeman, M. R., F. Straneo, N. J. Wilson, J. M. Toole, R. A. Krishfield, N. L. Beaird, T. Kanzow and J. Schaffer, 2020: Ocean circulation and variability beneath Nioghalvfjerdsbræ (79 north glacier) ice tongue. *Journal of Geophysical Research: Oceans*, **125**(8), e2020JC016091.

Schaffer, J., W. J. v. T. Kanzow, J. E. A. L. von Albedyll and D. H. Roberts, 2020: Bathymetry constrains ocean heat supply to Greenland's largest glacier tongue. *Nature Geoscience*, **13**, 227–231.

Wilson, N., F. Straneo and P. Heimbach, 2017: Satellite-derived submarine melt rates and mass balance (2011–2015) for Greenland's largest remaining ice tongues. *The Cryosphere*, **11**(6), 2773–2782.