Author response to Reviewer 2 - Basal melt rates and ocean circulation under the Ryder Glacier ice tongue and their response to climate warming: a high resolution modelling study

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MS No.: egusphere-2022-1296
MS type: Research article

Please find below our response to the comments of reviewer one to our manuscript. The reviewers comments are written in cursive, our response in regular font. Within our suggested texts, changes are marked as crossed out for deletions and in bold for additions.

1 General comments

This is a nice set of experiments on the sensitivity of an idealized Greenland ice tongue cavity to variation in ocean thermal forcing and subglacial discharge of ice sheet runoff. The results are presented in the context of other modeling studies of ice-ocean interactions in Greenland fjords and Antarctic ice shelves.

I have some comments and suggestions for revisions to the paper which fall in two main categories:

a. I think some of the results could be analyzed or explained more fully — particularly regarding the plume buoyancy (both its along-fjord evolution and its relationship to varying thermal forcing) — see starred comments.

b. References to observed/projected changes and connections to the real-world RG-SOF/GrIS systems could be expanded. This will help lend significance to the results and distinguish this paper from a more generic idealized modeling study.

- Thank you for your review of our manuscript and your comments—they were very helpful in clarifying several aspects of the results and improving the manuscript in general. We address the comments and detail the alterations (in boldface) with respect to the manuscript in line with your suggestions below.

One additional request: Because a large portion of the study focuses on the evolution of the plume itself, a direct comparison to a simple 1-D buoyant melt plume model simulation with the same initial T-S profiles and SGD fluxes could be quite valuable to the community in evaluating the relative benefits of running a high-resolution simulation of this nature. I hope that these comments are useful in revising the paper and look forward to seeing this work published.

- Thank you for this suggestion. A comparison between an ocean circulation model results and those from the 1-D idealized plume model from [Jenkins, 2011] is not straightforward. An ocean circulation model, like MITgcm we are using, includes for example non-linear and viscous terms and resolves the plume with several grid points in the vertical, whereas the 1-D model simulates a uniform (in the normal direction to the ice) plume. Nevertheless, we compare the resulting melt rates of both models here.

In Figure 1 we compare melt rates from our control_sum (10% SGD) simulation with these from 1-D Jenkins plume model. The plume model is set up with the same ice geometry and the steady state temperature and salinity profile from the MITgcm simulation. We apply the same SGD flux and channel height (20 m, see section 2 in the manuscript). Entrainment and drag coefficients are taken from [Jenkins, 2011]). The MITgcm shows around three times lower melt rates than the plume model. This can be explained by higher velocities in the plume model and can be tuned by changing for example the drag coefficient or the entrainment coefficient (see e.g. [Dansereau et al., 2013, Cai et al., 2017, Slater et al., 2022]). Since the area averaged melt rates in our simulations are comparable to those from satellite observations ([Wilson et al., 2017], see discussion in the manuscript) we do not attempt the tuning.Importantly, both

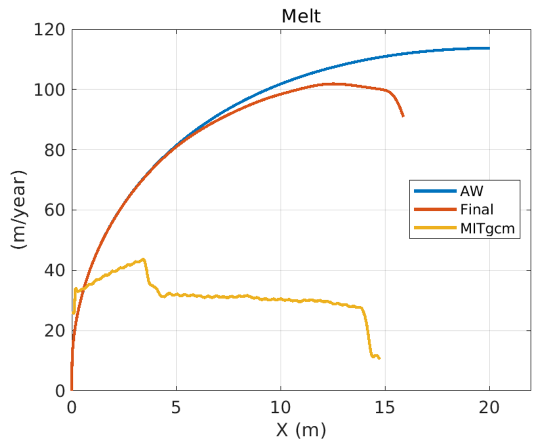

Fig. 1: Simulated melt rate as a function of distance along the ice from MITgcm, the Jenkins plume model using a single layer with no stratification ("AW") and the finale profile at x=21 km from MITgcm ("Final"). Plume Model simulations are done with profiles and SGD from the control_sum experiment from the manuscript.

models show the sensitivity to the stratification (compare "AW" and "Final" in figure 1, namely the two-regime structure in melt rates, that is described and discussed in the submitted manuscript (Section 3.1 and Discussion line 340).

2 New Plume Criterion

Please note, that based on the comments by the first reviewer, we adjusted our definition of the plume by adding a buoyancy criterion. This influences the values of plume thickness, velocity and average buoyancy. For a detailed discussion please see our response to reviewer one, comment 20. Updated versions of figures 3 and 5 from the manuscript are given below (Figure 4).

3 Specific comments

1. Line 82, etc. *It would be great to have a map showing the RG-SOF system with the locations of the grounding line, ice tongue front, sills, and the hydrographic profiles used to initialize the model (as referenced in line 134-135), as well as maybe a smaller inset map showing the location of RG within Greenland.*

   - A map of the region is shown in [Jakobsson et al., 2020]. Because in our manuscript we focus on idealized modelling and the bathymetric results are already published in the paper above, we suggest that it is enough to add a direct reference to their figure to our manuscript: "The third largest remaining ice tongue in North Greenland belongs to the Ryder Glacier (RG) in North Greenland (54° W, 82° N **, see [Jakobsson et al., 2020], Figure 1**)."

2. Line 100. *I initially thought this was saying that the sills were within the ice tongue cavity. Adding a map as suggested above would help to clarify this statement. However, I think it would make sense to move this information to the description of the model domain in Section 2.*

   - Thank you for your comment. We can clarify, that the sill are outside of the modelled domain. Therefore we also think it fits in better in the description of the area here than in the description of the model domain (as they are not in the model domain). See also the response to reviewer 1, comment 6:

   "This study presents **results from a series of** high-resolution ocean-circulation model simulations of basal melt and ocean **circulation in a cavity below an ice tongue** ~~flow in a fjord with an ice tongue~~. The model geometry is idealised, but its qualitative features are selected to be representative for RG and SOF. ~~Note that SOF has two sills, which are not represented here. This is because the present focus is on flow and melt beneath the ice tongue, which are only indirectly affected by the sills: they primarily control the features of the AW reaching the ice tongue.~~ **Note that SOF has two sills outside the ice cavity, so they are not considered in the model simulations presented here. The impact of the sills that control properties of AW reaching the ice cavity is a subject of a follow-up study.**"

3. Lines 172/210 & Figure 1a-b. *In you use negative melt rates in a few places but otherwise you use positive values, which I think is more common and intuitive. This should be consistent and I would encourage you to stick to positive values = melting since you don't talk about refreezing at all. You can still keep the way you've plotted the melt rates in Fig 1a-b by using a reversed y-axis.*

   - Thank you for the comment. The negative melt formulation (Equations 2-4) is taken from [Losch, 2008] as is done in [Cai et al., 2017] (see also response to Reviewer 1, comment 13). For consistency across publications (and with the model formulation) we suggest to keep the sign in the equations and add a sentence around line 172 (see response to reviewer 1 comment 13). We will adopt your suggestion of plotting positive values on a flipped y-axis (See Figure 2)

4. Line 177. *You could add a very brief intro paragraph (2-3 sentences) to Section 2.2 referencing Table 2 and A1-A2.*

   - Thank you for your comment. We can add a short introduction about the scope of the experiments here (line 178).

   "**We set up two sets of experiments, one without subglacial discharge (SGD) and one including SGD. The goal of the first set of experiments is to elucidate on the dependency of basal melt on the oceanic thermal forcing. The second set is supposed to shed more light on how different SGD volumes influences the basal melt. Chosen experiments are listed in table 2. For a complete list of experiments the interested reader is referred to the appendix tables A1 and A2.**"

5. Lines 179-184.

   1. The title of this subsection is "Oceanic thermal forcing" but then you use the term "temperature forcing" throughout the rest of the paper. I think thermal forcing is more widely used but either way, would be good to stick to one term.

   - Thank you for you comment. We use "oceanic thermal forcing" when introducing or discussing the general concept of heat transport from the ocean toward the glacier (as there can also be atmospheric thermal forcing). We choose to stick to "temperature forcing" whenever we refer to our model experiments. We will carefully go through the manuscript again and make sure this is done consistently.

   2. This had me wondering (a) what typical values are for T_b in this system and (b) how T_{AW} is related to T_{GL} (i.e. is there significant mixing that occurs along the inflow pathway). From Table 2, my impression is that T_b is roughly constant at -2.68° and that the water reaching the grounding line is effectively unmodified AW. This is something you could state explicitly, i.e. TF can be estimated as $T_{AW} + 2.68°$ (as you later use in Fig 4).

   - We introduced T_{GL} mostly to exclude the possibility, that modification of the AW (due to mixing with glacially modified water or SGD water) would change the dependency of the melt on TF. As you say, the AW at the grounding line is approximately the same for all experiments (with only negligible variations or $O(10^{-3})$. We can note this explicitly as suggested.

   "**To quantify the response of the system in terms of melt rate and circulation changes to changing oceanic thermal forcing (by varying T_{AW}), w**e define a**n average** temperature forcing (TF= $T_{GL}(x_{GL},z_{GL})$ - $\mathbf{T}_f(x_{GL}, z_{GL})$) **for each experiment, based on the time averaged fields when the model is in a statistical steady state (model days 61-100).** ~~where~~ T_{GL} is the **time averaged** water temperature at the grounding line (x_{GL}, z_{GL}) and $\mathbf{T}_f$ is the freezing point temperature evaluated at the same point using the local water salinity $S(x_{GL}, z_{GL})$~~and quantify the response of the system in terms of the melt rate and circulation changes to changing~~

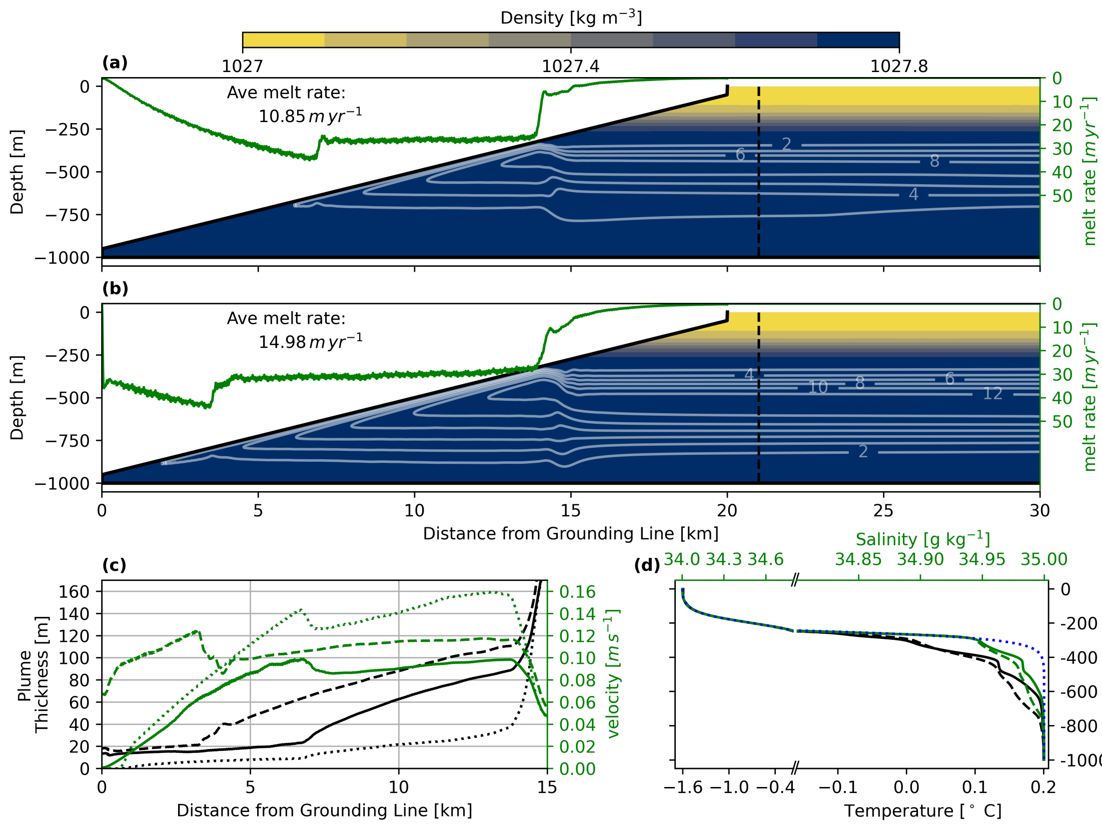

Fig. 2: a) The stream function (white contours in m^2 s^{-1}) of the steady circulation superimposed on the density (colors) and the melt rate (green line, right axis**, flipped**) along the ice ocean interface (black line) for control_win. The black dashed line indicates the location of profiles shown in figure 2 and 6; b) same as in a) but for control_sum; c) The plume thickness (black) calculated for summer (dashed) and winter (solid) control simulation; and the vertically averaged plume velocity (green) for summer (dashed) and winter (solid) control simulations. **Dotted lines show plume thickness (black) and averaged velocity (green) for an alternative plume definition based on the stratification below the ice in the control_win simulation (see text).** d) Initial and open ocean boundary condition profiles of salinity and temperature (showing as one blue dotted line for the chosen axes limits) and the steady state temperature (black) and salinity (green) profiles of the summer (dashed) and winter (solid) control simulations at x = 21 km. **Note the split in the x-axes marking two different scales.**

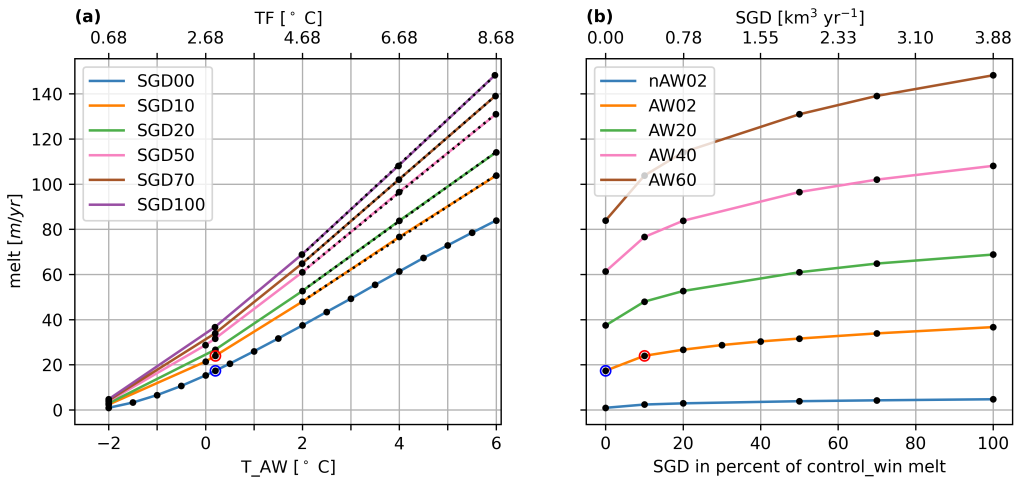

Fig. 3: As figure 7 in the manuscript. The dotted lines in panel a show the linear fits for TF>3.18°C. SGD values in the upper x-axis are calculated for at 10km wide ice tongue.

~~TF~~. **Note that the water at the grounding line is a slightly modified AW so T_{GL} is close to T_{AW}. Furthermore, T_f at the grounding line is essentially constant throughout all experiments at T_f = -2.68°C, hence we can approximate TF=T_{GL}+2.68°C (See tables 2, A1 and A2).** We apply a wide range of AW temperatures to quantify the response of the melt rate and the resulting circulation to varying TF with more confidence."

6. Lines 185-190.

1. Could you expand a little on the values of SGD volume flux used here? I understand the general reasoning for referencing percentages of winter basal melt flux for comparison, but it would be helpful to compare the resulting values to any existing estimates of SGD volume flux (e.g. see Supporting Info S03 for Slater et al. 2022 in GRL `https://doi.org/10.1029/2021GL097081` — bearing in mind that those fluxes are integrated across the grounding line while you are considering a 10 m slice, and the horizontal distribution of SGD is also likely relevant to its overall impact on basal melt, as you note elsewhere)

- Thank you for your comment and for the reference. We will be glad to compare our subglacial discharge volumes to those of former studies e.g. aforementioned [Slater et al., 2022] and observations from [Schaffer et al., 2020]. Furthermore, in table 2 and A2 in the manuscript we now give SGD as an actual volume flux in km^3/yr. For consistency we also changed the integrated Melt Flux in all tables to have the same units. See table 1 & 2. In accordance we added a second x-axis to figure 7b with SGD values in km^3/yr (see figure 3).

Reformulation suggestion: "A second set of sensitivity experiments is conducted to investigate the influence of subglacial discharge (SGD). Due to a lack of accurate estimates, the SGD volume fluxes are set ~~to fractions of~~ **in relation to** the integrated melt flux of the winter control simulation. **Direct observations at a nearby glacier (79NG) found that about 11% of the total fresh water leaving the cavity was from subglacial discharge ([Schaffer et al., 2020]). Therefore we set our lowest SGD volume ("SGD010") to around 10% of total melt from control_win. Higher SGD is applied in multiples of "SGD010". Using RCMs, [Slater et al., 2022, Mankoff et al., 2020] estimated SGD of 357 m^3 s^{-1}= 11.26 km^3 yr^{-1} for a fjord width of around 11 km. Our highest SGD value, assuming a 10 km wide fjord, is around 40% of their value. For exact values of SGD volume applied in the presented simulations please refer to table 2 and A2.** SGD is implemented [...]"

2. What is the vertical extent of the plume as you initialize it? Is this a typical approach to implementing SGD in this type of model?

- Thank you for your comment. We implement the SGD as in for example [Sciascia et al., 2013]. We chose a channel height of 20 m. This is typically done this way. Please also refer to our response to comment 9 of reviewer 1, proposing to include this information and more detailed explanation in section 2, line 132.

7. Line 221 (& Figure 1d). *It's difficult to see the differences between the simulations in figure 1d. Would it be possible to e.g. add an inset in the lower left zooming in on the lower part of the pycnocline that you reference here?*

   - Thank you for the comment. We agree, that the differences are hard to see. We adjusted the figure by dividing the x-axis into two parts with different scalings (see Figure 2).

8. Lines 237-239. *Figure 1c does not show the plume velocity dropping to zero. This made me wonder about your definition of the plume vs the outflow jet — is the outflow jet part of the plume or is it distinct? (If it's the latter you might need to refine your definition of the plume in line 223.) Does it have to do with the acceleration becoming negative? The buoyancy becoming negative?*

   - Thank you for the comment. You are indeed correct. It should just say "... the plume velocity drops (Figure 1c), which marks the location ...". We will correct it. Furthermore, currently we determine the plume termination point and subsequent shift to outflow by finding the point of maximum plume flux underneath the ice tongue (in figure 3 and 5). However, looking into it after reading your comment we now think the better way of defining the termination point of the plume would be to find the decline in melt rate (minimum gradient of the melt rate in the second regime), which is directly related to the changes in buoyancy and velocity and is a more intuitive criterion than what is used currently. We will change figures 1, 3 and 5 accordingly so they only show values that correspond to the plume.

9. Lines 239-241. *I think by "T-S transition layer" you mean a layer of glacially-modified waters. It would be nice to see this on a T-S plot, but even without one, you could describe this more explicitly (i.e. compared to the idealized initial profiles, the outflow is colder and fresher, consistent with the signature of melt-modified ocean waters).*

   - Thank you for the comment. We agree, that this can be described more explicitly with respect to the T-S characteristic and the influence of the melt. Changes in the T-S plot are hardly visible, as the profile spans a larger range than the changes due to melting.

   "The outflow forms a T-S transition layer between the AW and the PW, that was smoothed out in the idealized initial profiles (Figure 1d and 2b). **This layer is characterized by a cooling and freshening compared to the initial profile, in line with what would be expected from glacially modified water. This glacially modified layer can also be found** ~~This transition is recognizable~~ in the observations of (Jakobsson et al., 2020, **Figure 2**), lending confidence to the model results."

10. Lines 252-253. *It took me a little while to understand what you meant by "sharpening" the pycnocline here because I was looking at the wrong part of the profile in Fig. 2b — maybe you could clarify that you're talking about "the base of the pycnocline"?*

    - Thank you for you comment. We will clarify which part of the pycnocline we are referring to.

    "The increased melt water input freshens and cools the plume and the outflow, sharpening **the density gradient at the base of** the pycnocline in the outflow without changing its thickness (Figure 2b)."

11. *Lines 259-260. *Why is there a sudden increase in buoyancy at the regime transition? It's even more striking in the summer/SGD simulations in Fig 5d but it also happens in 3d, and this is counterintuitive to me. Is it related to the definition of buoyancy in Line 254? Since you're defining your plume using a velocity condition, is rho_p an average over the plume thickness, and rho_a is an average over the same depth range at x=21km? I'm wondering if something funky happens in that calculation as the plume reaches the pycnocline and thickens. Another possibility is that if the isopycnals are sloping significantly (hard to tell in Fig 1a-b) comparing the plume density to such a distant reference may not be ideal.*

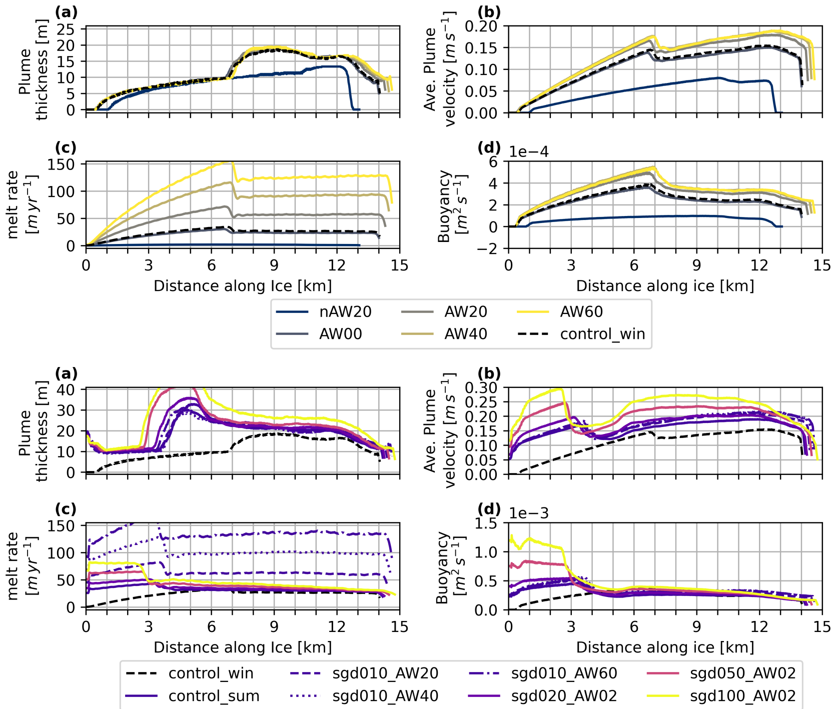

Fig. 4: As in figure 3 and 5 in the manuscript but with the new plume definition (see reviewer one).

- Thank you for the comment. The plume buoyancy is calculated from the density difference between the plume density and the ambient density at the same depth at x=21 km for every point in the plume (see line 254 in the manuscript). Your comment made me realize, that we unfortunately used an old version of the figure where we are showing depth integrated buoyancy. Since at the regime shift, the thickness starts to increase, the integrated density difference also grows, which makes this harder to interpret. We would like to suggest to show the correct averaged buoyancy instead, which is easier to interpret and does in fact show the expected (and explained) decrease in buoyancy at the regime shift (See figure 4).

12. Line 269-270. *Reporting the value of T_c as a range between two experiments seems confusing to me (took me a while to connect this to Table A1 and understand where these values came from). I think you could simply write something like "...for experiments with a temperature forcing of TF_c = 3.18°C or greater (Figure 4a)."*

    - Thank you for the comment. We will adopt the suggested change.

    "In doing so, we find the highest coefficient of determination (R^2) and the lowest root mean squared error of a linear fit for experiments with a temperature forcing **of TF≥3.18°C (*AW05*).** ~~larger then the cut-off value 2.88 <TF_c < 3.18°C (Figure 4)~~."

    In the following sentence, I initially interpreted "across the whole TF range" as including TF<TF_c, which isn't the case/I don't think is what you meant, so could be rephrased to clarify. It's nice to see the reduced residuals; could you also report the R^2 and p values for the fits here? Did you do any fitting of the range of TF<TF_c?

    - Thank you for the comment. We agree, that the sentence is not well formulated and will rephrase it. Further we are happy to provide values for R^2 and RMSE as supplementary material (See figure 3a in response to Reviewer 1). We originally excluded them from the manuscript to keep the already high number off figures down.

    "The adjusted linear fit has smaller residuals ~~across the whole TF range~~ **for all TF≤3.18°C** (Figure 4a) implying a non-linear dependency of melt flux on TF for TF≤ 2.88°C (*control_win*) and a linear dependency for TF≥ 3.18°C (*AW05*).”

13. *Lines 273-281 and 368-377. *This is a nice plot (4b) and interesting to think about. I think the interpretation requires a little more careful consideration here.*

    You've established that melt rate increases linearly with TF above 3º. This should correspond to roughly linear decreases in plume temperature and salinity (relative to ambient). But the change in buo-T and buo-S will also depend on the changes to the ambient stratification that you have imposed. I think this is why buo-S begins to level off (while buo-T changes linearly as the melt concentration increases).

    Consider that varying T_{AW} while holding S_{AW} and PW properties constant will change the ambient stratification and dT/dS slope. This in turn will affect the relationship between plume properties and ambient properties at a given density. I am finding this difficult to explain clearly so I'm putting a little cartoon at the end of this document in case you want to think about it more.

    Do you have another explanation in mind for why the relationship between buoyancy and TF changes? Whether or not I am correct about the mechanism I think it merits a bit more thorough discussion to make clear under what conditions this result may be expected to hold.

    \- Thank you for the comment. We agree with your explanation and will elaborate about the T-S properties in the simulations. Please see comment 26 in the response to reviewer 1 for further explanation, where we include a T-S diagram that shows the same as your sketch and a reformulation suggestion to be added to the Discussion of the manuscript. We will add a pointer to the discussion around line 277:

    ”The effect of temperature and salinity start to balance one another and the total buoyancy becomes independent of temperature for experiments with thermal forcing of TF> 6.18° C. **We elaborate on this in Section 4, *Response to oceanic thermal forcing*.** This explains the very weak [...]”

14. Lines 290-292. *Could the simulations with the increased T_{AW} be omitted here, until the paragraph beginning line 304, to keep the structure more straightforward? Also, in the previous subsection, the simulation names from Table 2 aren't used in the text, so it would be nice to keep this consistent.*

    \- Thank you for your comment. For consistency, we agree the warmer experiments should only be mentioned later on. No information will be lost by doing so. We agree, that adding the experiments names in Subsection 3.2 will improve clarity.

    ”For *control_sum*, ~~*sgd010_AW20* and *sgd010_AW_40*~~ the transition point jumps more than 3 km closer to the GL...”

15. *Lines 302-303. *Just re-upping the point that while the variation in buoyancy after x=4 km or so makes sense to me, it is unclear to me why it increases abruptly around the point of the regime transition.*

    \- Thanks for the comment. Please see the answer above to comment 11.

16. Lines 305-308. *I think this could be expanded to at least a full sentence or two for each of these points. For point (i), it would make sense to show the regression(s) for Fig 7a to compare to the results in 4a.*

    \- Thank you for the comment. We can expand on these points. The fits are now plotted in figure 7a (see figure 3). Instead of the paragraph starting in line 304 we suggest:

    ”**The effect of oceanic thermal forcing (increasing TF) on simulations with subglacial discharge is shown in figure 7. It leads to the following observations:**

    (a) The functional response of the melt rate to TF found in the winter simulations (without SGD; Figure 4a) holds for the simulations with SGD (Figure 7a). For the experiments conducted, the linear regression (dotted lines in figure 7a) fit with the simulated melt rates for TF≥3.18°C.

(b) **The linear increase of the melt rate becomes stronger, for higher SGD; 14.02 m yr^{-1} K^{-1} for *SGD010*, 15.47 m yr^{-1} K^{-1} for *SGD20*, 17.68 m yr^{-1} K^{-1} for *SGD50*, 18.80 m yr^{-1} K^{-1} for *SGD70* and 20.17 m yr^{-1} K^{-1} for *SGD100*, compared to an increase of 11.71m yr^{-1} K^{-1} for no SGD. Beware, that for SGD experiments the fit is only calculated for the three available data points with TF$\geq$3.18°C.**

(c) **For experiments with constant TF, the melt rates increase less than linear (in a fractional manner) with SGD (Figure 7b). The exponents c in the relationship between melt rate M and SGD volume V_{SGD} $M=a+bV_{sgd}^{c}$ are 0.41 for SGD experiments with TF$\approx$0.68°C (**_nAW20*, 5 experiments), 0.46 for SGD experiments with TF$\approx$2.87°C (**_AW02*, 5 experiments) and TF$\approx$4.67°C (**_AW20*, 5 experiments) and 0.47 for SGD experiments with TF$\approx$6.65°C (**_AW40*, 5 experiments) and TF=8.67°C (**_AW60*, 5 experiments). Using the additional experiments available for **_AW02* experiments the exponent is 0.45 (7 experiments), showing some sensibility of the fit to the number of data pairs used within a fixed range."**

17. Lines 308 and 397-398. *Could you make a more quantitative comparison to e.g. the $x^{1/3}$ relationship found by Slater et al. (2016)?*

    - Thank you for this comment. We would like to refer to our answer to comment 16 above and comment 34 by reviewer 1.

18. Lines 390-392. *My understanding of the [Slater and Straneo, 2022] paper is that it is more about the changes under realistic forcings, so this statement could be made much stronger by comparing the experiments here to observed and projected changes (see the dataset linked above in comment on lines 185-190).*

    - Thank you for the comment. We will include [Slater et al., 2022]'s data set in the discussion of SGD at this point. We can not find any predictions for a future SGD values in [Slater et al., 2022] but rather a discussion about seasonality.

    "We found that the subglacial discharge (SGD) has a pronounced effect on the basal melt rates. The average melt rate for the summer control simulations (where SGD is set to 10% of the average basal melt flux for the control winter), is increased by 38%, and for the experiment with the the SGD input set to 100% of the average winter melt rate the increase in melt is 111%, consistent with the conclusions of Slater and Straneo (2022) for northern Greenland**, that there is large seasonal variability in melt rate due to atmospheric forcing through SGD. Given that the SGD values presented here are still lower than the average SGD reported by [Slater et al., 2022] for June, July and August, we would expect very high seasonal variability in melt rate at north Greenland's ice shelves.**"

4 Technical corrections

19. Line 128. *Ice tongue terminates in a 950 m deep front, or 50 m above the sea floor (not 50 m deep)*

    - Thank you for the comment. In line 128 we describe the depth of the tip of the ice tongue. The ice tongue in our simulation does in fact terminate 50m below the ocean surface at x=20km so at a depth of 50m. The groundling line depth is 950m and described in line 130.

20. Line 143. *border (not boarder)* - Thank you, we will correct it.
21. Line 254. *Check that units here match y-axis of Fig 3d/5d?* - Thank you, we will correct it.
22. Line 319. *SGD (not SDG) — spotted in Fig 7 caption as well* - Thank you, we will correct it.
23. Line 333. *Reference Table 2.* - Thank you, we will add it.

4.1 Figures

24. Figure 1. *A legend showing dashed line = summer and solid line = winter would be helpful in 1c/d.* - Thank you, we will add it.

    On my screen, the dotted line in 1d looks green (not blue as stated in the caption). - Thank you, we will change the color to a more clear blue shade. What are the small blue and orange horizontal lines in 1d? - Thank you, for the comment. They show the depth of maximum outflow at x=21km. The lines are a remnant and we forgot to take them out. The same diagnostic is shown for all experiments in figure 2b and 6b (colored dots).

25. Figure 2. *In last sentence of caption, could you add "The dotted horizontal lines in (b)..."* - Thank you, we will adjust it.

26. Figures 2a & 6a. *It would be helpful to darken/otherwise distinguish the vertical grid line at u=0 to emphasize the change of depth of velocity reversals.* - Thank you, we will do that.

27. Figure 4a. *Could you highlight (e.g. circle) the point corresponding to the control simulation here?* - Thank you, we will do that, see figure 3 in response to reviewer 1.

4.2 Tables

28. Table 2. *Would be nice if you could further highlight the two control simulations here since the winter control is in the middle of the AW temp range (light grey shading of those rows?), and maybe add a dashed line between sgd100_AW02 and sgd010_AW20 to separate the two sets of summer experiments.*

    - Thank you, we will try to make the tables clearer by adding shadings. See table 1.

Tab. 1: Setup parameters and characteristic diagnostics for subglacial discharge sensitivity experiments. From left to right: Atlantic Water Temperature, subglacial discharge Volume for a 10 km wide Fjord, model time step, temperature forcing, overturning time scale, averaged melt rate, integrated melt (calculated for a 10km wide ice shelf).

ExpName	T_{AW} [°C]	SGD Vol. [km^3 yr^{-1}]	dt [s]	TF [°C]	τ_o [days]	Ave. Melt [m yr^{-1}]	Melt Flux [km^3 yr^{-1}]
nAW20	-2.0	0.00	10	0.68	78	0.92	0.18
AW00	-0.0	0.00	10	2.68	27	15.28	3.06
control_win	0.2	0.00	10	2.87	27	17.36	3.47
AW20	2.0	0.00	10	4.67	23	37.43	7.49
AW40	4.0	0.00	5	6.66	22	61.34	12.27
AW60	6.0	0.00	5	8.65	22	83.91	16.78
control_sum	0.2	0.39	5	2.87	18	23.96	4.79
sgd020_AW02	0.2	0.78	5	2.87	15	26.67	5.34
sgd050_AW02	0.2	1.94	5	2.87	12	31.60	6.32
sgd100_AW02	0.2	3.88	3	2.86	10	36.67	7.34
sgd100_AW20	2.0	0.39	5	4.67	17	47.96	9.60
sgd010_AW40	4.0	0.39	5	6.65	16	76.59	15.33

29. *In caption, I'm not sure it's necessarily correct to imply that melt rate and ice retreat are equivalent (in your model, the ice base position is static, I think? And in reality, "retreat" would also depend on ice flow divergence?)*

    - Thank you, we think you are right. We will correct it in the captions to table 2, A1 and A2 in the manuscript (see caption in Table 1 - 2).

Tab. 2: Setup parameters and characteristic diagnostics for subglacial discharge sensitivity experiments. From left to right: Atlantic Water Temperature, subglacial discharge Volume for a 10 km wide Fjord, model time step, temperature forcing, overturning time scale, averaged melt rate, integrated melt (calculated for a 10km wide ice shelf).

ExpName	T_{AW} [°C]	SGD Vol. [km^3 yr^{-1}]	dt [s]	TF [°C]	τ_o [days]	Ave. Melt [m yr^{-1}]	Melt Flux [km^3 yr^{-1}]
sgd010_nAW20	-2.0	0.39	5	0.68	23	2.37	0.47
sgd020_nAW20	-2.0	0.78	5	0.68	18	2.90	0.58
sgd050_nAW20	-2.0	1.94	5	0.69	14	3.85	0.77
sgd070_nAW20	-2.0	2.72	3	0.69	12	4.24	0.85
sgd100_nAW20	-2.0	3.88	3	0.69	11	4.71	0.94
sgd010_AW00	-0.0	0.39	5	2.67	18	21.41	4.28
sgd050_AW00	-0.0	1.94	5	2.67	12	28.69	5.74
control_sum	0.2	0.39	5	2.87	18	23.96	4.79
sgd020_AW02	0.2	0.78	5	2.87	15	26.67	5.34
sgd030_AW02	0.2	1.16	5	2.87	14	28.73	5.75
sgd040_AW02	0.2	1.55	5	2.87	13	30.33	6.07
sgd050_AW02	0.2	1.94	5	2.87	12	31.60	6.32
sgd070_AW02	0.2	2.72	3	2.86	11	33.89	6.78
sgd100_AW02	0.2	3.88	3	2.86	10	36.67	7.34
sgd010_AW20	2.0	0.39	5	4.67	17	47.96	9.60
sgd020_AW20	2.0	0.78	5	4.66	15	52.67	10.54
sgd050_AW20	2.0	1.94	4	4.65	12	60.98	12.20
sgd070_AW20	2.0	2.72	3	4.64	11	64.82	12.97
sgd100_AW20	2.0	3.88	3	4.63	10	68.82	13.77
sgd010_AW40	4.0	0.39	5	6.65	16	76.59	15.33
sgd020_AW40	4.0	0.78	5	6.65	15	83.78	16.77
sgd050_AW40	4.0	1.94	5	6.63	12	96.52	19.31
sgd070_AW40	4.0	2.72	3	6.62	11	102.01	20.41
sgd100_AW40	4.0	3.88	3	6.60	10	108.11	21.63
sgd010_AW60	6.0	0.39	5	8.65	16	103.81	20.77
sgd020_AW60	6.0	0.78	5	8.63	15	114.13	22.84
sgd050_AW60	6.0	1.94	5	8.61	12	130.97	26.21
sgd070_AW60	6.0	2.72	2	8.59	11	139.10	27.83
sgd100_AW60	6.0	3.88	2	8.57	10	148.24	29.66

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