Response to Reviewer #1:

We thank the reviewer for their comments. Our responses are shown in blue, and the updated lines are in green. In addition, we have made minor grammatical corrections and fixed some typographical errors.

I have reviewed the paper by Paola Papapetrous et al called "The Sensitivity of Grounding Zone Melting to Subglacial Discharge Configuration and Sediment Dynamics Across Contrasting Ice Shelf Cavity Regimes". I have thoroughly enjoyed reading this paper. I really appreciated the structure of each of the sections and the clarity of the results presented. I absolutely recommend this paper for publication after minor revisions.

Minor comments in order of appearance in the paper:

Line 34: Do you really want to use HSSW, or do you want to use DSW, as it is more general for the seas around Antarctica?

We agree that DSW is a more appropriate and general term in this context, particularly given its broader use when discussing cold ice shelf regimes around Antarctica. We have therefore replaced HSSW with DSW.

Section 2.1: Are there any limitations in the way sediments are coded in ROMS, that are important for your results?

Our model configuration does not explicitly resolve flocculation, whereby fine particles aggregate and disaggregate, potentially changing their settling properties (Sherwood et al., 2018). Additionally, our use of a single sediment bed layer limits the representation of vertical sediment stratification. We have acknowledged these limitations in the Discussion, as follows (Section 4):

"Our sediment formulation does not explicitly represent flocculation, which may affect the settling of fine particles (Sherwood et al., 2018), and uses a single bed layer (NBed=1), precluding the representation of vertical sediment stratification. These simplifications may influence the settling and deposition of fine-grained sediment, although their effects on the circulation and melt rate responses examined here remain uncertain."

Section 2.1: Do you have comments on how the basal melt was parameterised? I.e. Gwyther 2020?

Basal melt is parameterised using the three-equation formulation (Holland and Jenkins, 1999) implemented in ROMS following Galton-Fenzi et al. (2012). We acknowledge that, as discussed by Gwyther et al. (2020), simulated basal melt rates can be sensitive to the vertical resolution and to the representation of the ice-ocean boundary layer, including how meltwater fluxes and thermal driving are resolved.

In our simulations, ROMS uses a terrain-following vertical coordinate with enhanced resolution near the ice–ocean and ocean–seabed boundaries, with 21 vertical layers and a minimum layer thickness of approximately 0.4 m. While these modelling choices may introduce uncertainty in

the absolute magnitude of the simulated basal melt rates, our analysis focuses primarily on the relative and qualitative response of the system to different discharge configurations and cavity regimes. To ensure completeness and clarity, we have revised the text as follows (previous lines 85-86):

"It has also been extended to account for the pressure exerted by the overlying ice shelf (Dinniman et al., 2007), and to incorporate ice-ocean thermodynamic processes that parametrize basal melting using the three-equation formulation of Holland and Jenkins (1999), as implemented in ROMSIceShelf by Galton-Fenzi et al. (2012). Following Gwyther et al. (2020), we note that simulated basal melt rates may be sensitive to the vertical resolution of the ice-ocean boundary layer."

Line 115: What would happen if you distributed the flux not across all vertical layers, but only into the top layers?

Vaňkova et al. (2025) tested different vertical distributions of subglacial discharge (top layer, bottom layer, and uniformly distributed throughout the water column), and found that, although the resulting melt can differ by 20%, the scaling relationship between melt and discharge remains unchanged. While it would be interesting to examine the differences resulting from the vertical discharge profile, much like in Vaňkova et al. (2025), it is beyond the scope of this study.

We retain the full-column distribution consistently across all experiments presented here (following Gwyther et al. (2023) and Papapetros et al. (2025)), and have revised the text as follows (Section 4):

"*The vertical distribution of subglacial discharge in the model may influence the magnitude of basal melt: Vaňková et al. (2025) tested discharge confined to the uppermost or bottommost layer, as well as discharge distributed throughout the water column. Although the resulting melt rates differed by up to 20% depending on the discharge configuration, the scaling relationship between melt and discharge remained unchanged.*"

Line 145 and Figure 1: Is there a uniform definition of the grounding zone between the figure caption and the description? Where are you counting 8 km from?

We have corrected Figure 1 so that the red rectangle now consistently represents the 8-km grounding zone described in the text.

Line 152. Why are you referencing Yung 2026 here?

We originally included Yung et al. (2026) as a point of comparison, as they report similar barotropic streamfunction patterns for the cold and warm regimes using the same ISOMIP+ cavity configuration. However, we agree that this comparison is not necessary here, as the circulation patterns described are directly shown in Figure 2a. We have therefore removed the citation from this sentence.

Figure 2. I love this figure. Do you feel like adding velocity at the top grid cells under the ice shelf would benefit your discussion?

We thank the reviewer for the positive feedback. Although we feel that the barotropic streamfunction is better suited to illustrate the circulation structure relevant to the discussion, we have added a figure (Figure A4, Appendix A), with current speed in the uppermost ocean grid cell for all experiments. This additional figure provides further evidence for the jet-like structures described in the main text, and complements the streamfunction fields presented in Section 3.2.

Figures 3 and 4. Can these figures be larger? For example, make it horizontal.

We considered rotating Figures 3 and 4 to increase their size. However, due to the length of the captions, it did not result in a larger overall figure size. Instead, we have increased the width of both figures by approximately 1 cm, which is the maximum increase that still allows the figures to fit within the page.

Section 3.2. You're slipping into qualitative description here, which you don't suffer from in other sections. Statements like "align more," "more strongly constrained," and "march larger fraction" could be quantified better.

Although Section 3.2 primarily aims to describe and interpret the spatial patterns of the subglacial freshwater and sediment responses across the different experiments, we agree that some of the original wording was overly qualitative. Given the number of configurations presented in Figures 3 and 4, reporting individual values for every experiment would add considerable detail without necessarily improving the overall interpretation of the spatial patterns. We have therefore revised the text to make the spatial comparisons more precise and less subjective, and added representative quantitative values and ranges where appropriate to support the main comparisons. Two examples are mentioned bellow:

"Consequently, these discharge locations produce thermohaline structures that extend farther across the cavity, with the strongest signals extending from 10 km (experiments Sgw+Sed28_warm and Sgw+Sed28_cold) to 36 km (experiments Sgw+Sed54_warm and Sgw+Sed54_cold)."

"Localized cooling in the upper-layer, with temperatures reaching approximately - 2°C, persists east of several discharge sites driven by the recirculation of colder cavity water within the anticlockwise circulation cell (Figure 3a,c,d)."

Line 240: How realistic do you think these episodic erosion events are? Do they happen often? Is it realistic that they are happening over the course of hours? Is there any comparison with estuaries you can make here?

There are currently no direct observations of short-term sediment dynamics near Antarctic grounding lines that would allow us to constrain the frequency or magnitude of erosion events.

Sediment entrainment, transport, and deposition respond continuously to changes in hydrodynamic forcing, but the intensity of these processes can vary rapidly. Consequently, while the overall evolution of the seabed occurs over longer timescales, individual phases of enhanced

erosion and sediment remobilisation occurring over hours are physically plausible. The frequency and magnitude of such events, however, cannot currently be constrained for Antarctic ice shelf cavities.

Estuarine and coastal environments provide useful conceptual context in this regard, because tides, currents, freshwater discharge, sediment supply, and evolving bed conditions can interact to produce rapid changes in sediment transport and episodic sediment remobilisation. We therefore have added the following text (Section 4):

"Our interpretation of sediment remobilisation draws on process-based insights from estuarine and coastal environments, where interactions between currents, tides, freshwater discharge, sediment supply, and bed morphology can produce episodic sediment erosion and deposition (Dalrymple et al., 1992; Perillo et al., 1995; Wang et al., 2012). These systems provide a conceptual analogue for the processes involved, although differences in geometry, circulation, and boundary conditions preclude direct comparisons of event frequency or magnitude."

Line 261: "localised the buoyant jets" - Would a velocity map, again, help you with this discussion?

A current speed map has been added to Appendix A (Figure A4).

Section 3.4. This is a really strongly written section, and I really enjoyed it. Good job.

We thank the reviewer for the positive feedback.

Paragraph starting at line 370. Would you care to expand on this topic? How would you create different classifications of ice shelf grounding lines

We have expanded the paragraph to clarify that we envision grounding zone regimes are not defined solely by the thermal state of the cavity. This framework is intended as a conceptual basis rather than a formal classification with fixed thresholds, and highlights that similar thermal conditions can produce different melt responses depending on the dominant forcing and its spatial distribution. We have clarified this point in the revised manuscript as follows (Section 4):

"Such regimes could be characterized not only by the thermal state of the cavity, but also by the magnitude and spatial distribution of subglacial discharge, by the relative role of tidal mixing on stratification, and by the spatial structure of the resulting melt response. For example, grounding zones with similar thermal conditions may exhibit substantially different melt behaviour depending on whether discharge is weak, distributed, or strongly concentrated."

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