

Editor's comments are in black, our reply in blue.

Editor's comments

I would like to thank the authors for submitting a revised version of their manuscript and for responding to all reviewer and editor comments. Several sections of the manuscript have been significantly re-structured, and this has greatly improved the clarity of the paper – thank you for responding to this suggestion from one of the reviewers and for seamlessly implementing the edits.

I am grateful to two of the reviewers who provided feedback on the resubmitted manuscript. One reviewer has requested a couple of minor edits, and both are happy that the article is now suitable for publication.

I have read through the revised version of the article and list below a number of points that require clarification prior to publication – please get in touch if anything is unclear. The points are all minor and therefore I recommend this article can now be ‘published subject to technical corrections’ (i.e. it does not need to undergo any further review by the editor or reviewers).

Thank you for choosing to publish your work in The Cryosphere.

Kind regards,

Pippa Whitehouse (editor)

Minor line-by-line comments

Line 20: “use of six different GHFs” – not clear if this refers to six different GHF models, or simply six different GHF values, please clarify and review use of this phrase throughout the manuscript

Reply: We change it to “use of six different GHF maps”.

Line 32: does “subglacial rifts” refer to a geological feature or a glaciological feature? If the former, it is not clear how this is relevant when discussing the stability of the Lambert-Amery system on a decadal timescale – please clarify what type of feature you are referring to and how it is relevant

Reply: We refer it to a feature of the ice base which are defined by the bedrock, and change it to the term “subglacial canyons”. They are relevant as presumably being similar features to the subglacial lakes that are known to empty and fill on multi-year timescales. We modified this part to “However, there is also evidence of extensive subglacial canyons and lakes (Fretwell et al., 2013; Jamieson et al., 2016; Cui et al., 2020a). Subglacial canyons and lakes are conduits for subglacial water, transporting subglacial meltwater to the coast through complex hydrologic routing, that may change

on relatively fast timescales (Malczyk et al., 2020). Jamieson et al. (2016) report a large subglacial drainage network in Princess Elizabeth Land (PEL), which would transport water from central PEL to the coast passing the Lambert-Amery region. Subglacial water can affect the ice flow (Stearns et al., 2008; Diez et al., 2018), influence the dynamical stability and basal mass balance (Gudlaugsson et al., 2017), and may enhance basal melt of ice shelves (Le Brocq et al., 2013).”

We add some references:

Malczyk, G., Gourmelen, N., Goldberg, D., Wuite, J., & Nagler, T.: Repeat subglacial lake drainage and filling beneath Thwaites Glacier. *Geophys. Res. Lett.*, 47, e2020GL089658. <https://doi.org/10.1029/2020GL089658>, 2020.

Stearns, L. A., Smith, B. E., and Hamilton, G. S.: Increased flow speed on a large East Antarctic outlet glacier caused by subglacial floods, *Nat. Geosci.*, 1, 827, 2008.

Diez, A., Matsuoka, K., Ferraccioli, F., Jordan, T. A., Corr, H. F., Kohler, J., Olesen, A. V., and Forsberg, R.: Basal Settings Control Fast Ice Flow in the Recovery/Slessor/Bailey Region, East Antarctica, *Geophys. Res. Lett.*, 45, 2706–2715, 2018.

Gudlaugsson, E., Humbert, A., Andreassen, K., Clason, C. C., Kleiner, T., and Beyer, S.: Eurasian ice-sheet dynamics and sensitivity to subglacial hydrology, *J. Glaciol.*, 63, 556–564, 2017.

Le Brocq, A. M., Ross, N., Griggs, J. A., Bingham, R. G., Corr, H. F. J., Ferraccioli, F., Jenkins, A., Jordan, T. A., Payne, A. J., Rippin, D. M., Siegert, M. J., 2013, Evidence from ice shelves for channelized meltwater flow beneath the Antarctic Ice Sheet: *Nat. Geosci.*, 6, 945–948, 2013.

Line 79: “...the basal thermal conditions inferred from the new high-resolution topography dataset” – include a reference to clarify which study you are referring to

Reply: Done.

Line 105: suggest “The margins of the inland sub-basins...”

Reply: We change it as you suggested.

Figure 1: it would be useful to depict the coastline/grounding line of Antarctica in plots (a)-(c). Also, I suggest adding text labels to plot (b) to clarify which domain uses data from Cui et al. (2020) and which domain uses data from MEaSUREs – one reviewer comments that this is still unclear

Reply: We improve Fig. 1 as suggested.

Line 165: clarify what you mean by a ‘proper’ initial temperature

Reply: We change “A proper initial ice temperature” to “A proper initial vertical ice temperature profile subject to thermal boundary conditions”.

Line 170: clarify which models you are referring to, e.g. “coupling the forward and inverse models”

Reply: We change it to “coupling the forward and inverse models”.

Line 179: “downhill in the ice surface” – unusual phrasing, perhaps ‘along flowlines’?

Reply: Downhill is what we mean here, which is not always along flowlines. The term was used already in Wolovick et al., 2021. We changed the phrase to “downhill along the ice surface”.

Line 185: ‘step’ -> ‘component’ (using the terminology from line 178)

Reply: The step (1) here refers to line 336-338. We remove “for step (1)” here to avoid confusion.

Equation 1: define ‘m’ and $k(T)$, perhaps also stating whether they take positive or negative values

Reply: Done. We add “ $k(T)$ is the temperature-dependent thermal conductivity of ice, m is the basal melt rate.”

Fig. 3 caption: specify (here and elsewhere) whether this is surface velocity or the full velocity field

Reply: Done. It is surface velocity.

Line 227: in what way is the basal slip ratio ‘added’ to the method? If the method already uses a basal slip ratio perhaps the novel feature here is that you use a spatially variable basal slip ratio?

Reply: Basal slip ratio is not used in the shape function in Wolovick et al. (2021a). So we simply mean we improve the method. We change the phrase to “We also improve the shape function in Wolovick et al. (2021a) by including the basal slip ratio”

Equations 3 and 4: suggest using the del/nabla symbol when representing div, grad etc.

Reply: Done.

Line 287: on line 275 you state that beta is the basal friction coefficient, check use of terminology

Reply: We remove the “C” in line 287.

Line 299: here and elsewhere, you could replace ‘do’, ‘done’, ‘did’ with ‘carry out’ or ‘carried out’ when referring to the methods used, e.g. “An L-curve analysis has been carried out to find...”

Reply: Thanks. We changed it to “An L-curve analysis has been carried out...”.

We also change “Radar surveys have not yet been done...” in line 466 to “Radar surveys have not yet been carried out...”

Line 312: “...from by...” – typo

Reply: corrected.

Line 312: is TM the same as T_m (defined on line 202)?

Reply: Yes. We change T_M to T_m .

Figure 5: state that this figure shows results for the Martos et al. (2017) model

Reply: Done.

Lines 331-332: could relate these statements about heat to the impact of each term on the basal melt rate – this would help to clarify the sign of the final term in the numerator of eq. 10

Reply: We change the sentence to “Geothermal heat and frictional heating from basal slip warm the base, while the upward heat conduction to the interior cools the base.

Note that basal melt rate can be either positive (melting) or negative (freezing) depending on the heat balance.”

Line 335: similar as -> similar to

Reply: done.

Line 336: refer to figure 3 when referring to the ‘mixture’ of information used to determine the input surface velocity (also on line 345 when discussing merging three different pieces of information)

Reply: Done.

Line 347: by -> from

Reply: Done.

Line 438: figure 9?

Reply: Yes. It should be Fig. 9. We corrected it.

Line 442-443: suggest “Regions with positive basal melt rates...”

Reply: Sorry we do not understand the point here. the Line 442-3 reads “where frictional heat is high (Fig. 5b), despite the differences in GHF (Fig. 2). Basal melt rate is above 10 mm yr⁻¹ near the grounding line, reaching 500 mm yr⁻¹ at the” and we do not see how to or why this needs changing as suggested.

Line 454-455: suggest “...the second greatest number of observed subglacial lakes...”

Reply: Done.

Line 477: suggest “the ...accumulation rate field used in our modelling will be...” (similar on line 181)

Reply: Done. We think you mean line 481 rather than 181. We also made similar change on line 481.

Line 478: “because of lower accumulation rates during glacial periods” – reference needed

Reply: We add two references:

Watanabe, O., Shoji, H., Satow, K., Motoyama, H., Fujii, Y., Narita, H., and Aoki, S.: Dating of the Dome Fuji Antarctica deep ice core, Mem. Natl. Inst. Polar Res. Spec. Iss., 57, 25–37, 2003.

Van Ommen, T. D., Morgan, V., Curran, M. A. J., Deglacial and Holocene changes in accumulation at Law Dome, East Antarctic, Annals of Glaciology, 39, 359-365, 2004.

Line 507: suggest “...that does not predict basal melt at the location of the observed lakes...”

Reply: Done.

Line 509: a third possibility is that lakes are present, but we do not have the data to detect them

Reply: Yes, we add this possibility.

Line 515: “direct measurements... are rare” – the important point here is that lakes can exist where basal temperatures are below the pressure melting point, suggest revising the text to reflect this.

Reply: The point that lakes can exist where basal temperatures are below the pressure melting point is mentioned in line 512-513. Therefore, we remove “direct measurements... are rare”. And change line 514 to “and no similar ones are known to exist beneath the Antarctic ice”

Line 517: the paper suggested by the reviewer 1 is by Tulaczyk et al. (2020) not Talalay et al. (2020) –see <https://tc.copernicus.org/articles/14/4495/2020/>

Reply: We changed the reference to Tulaczyk et al. (2020), and slightly modified the sentence to “Furthermore, relatively high electrical conductivity beds such as clay-rich sediments surrounded by bedrock can give rise to false positives in radar detections of subglacial water bodies (Tulaczyk et al., 2020).”

Line 530: Antarctica -> Antarctic

Reply: Done.

Line 533: “...to the our...” – typo

Reply: Done. We removed “the”.

Line 557: include full references for the Martos and Li GHF models (also lines 592-594)

Reply: Done.

line 600: “...has smaller modelled basal friction coefficients...” – is this information quantified anywhere in the manuscript?

Reply: It is not quantified in the manuscript. We remove this half sentence, and change the whole sentence to “The fast-flowing region has fast basal velocities and high frictional heat, but there are large differences in basal melting rates between the 6 GHF

datasets.”.

Please carry out a careful check for grammatical issues, particularly in relation to the use of singular and plural and the definite article (‘the’), which is occasionally missing.