

The Cryosphere Discuss., referee comment RC3
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Comment on tc-2021-357

Anonymous Referee #3

Referee comment on "Evaluation of six geothermal heat flux maps for the Antarctic Lambert–Amery glacial system" by Haoran Kang et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-357-RC3>, 2022

This paper describes a method that can be used to evaluate observations of geothermal heat flux, and its application to a large region of Antarctica: the Lambert glacier and its drainage basin. A sophisticated model is used to estimate warm bedded regions given observations of ice geometry and surface velocity and several estimates of the geothermal heat flux field (GHF). The resulting warm bedded regions vary considerably depending on the choice of GHF, allowing the paper to rank them by comparing those regions to known locations of sub-glacial lakes. The Lambert glacier is representative of the majority of Antarctica since it is large and includes cold based ice, warm based ice that sees slow sliding, and warm based ice that sees fast sliding. That suggest that the method could be applied more widely, so both the method and its results should be of interest. The paper is generally well written and clear.

General Comments

The ice flow model (a Stokes flow model) is a complex one. It is certainly a better choice given unlimited resources than any of its common approximations (SIA,SSA,HOM...) and looks to have been applied correctly, but why is it necessary in this case? In which parts of the domain? It seems that in some parts you only use the direction from Elmer/Ice: how much does that differ from the direction of the surface gradient? The discussion says that this work 'builds on the earlier inversion method employed by Wolovick et al'. (which is SIA based) but how important is that extra effort?

Equation 4 appears to be a 'cold ice' model, i.e one that assumes $T < T_m$. The manuscript should justify this choice, with reference to polythermal models e.g Aschwanden 2013.

Use consistent notation for vectors etc throughout.

Specific Comments

L17. Are abbreviations (GHF) permitted in the abstract?

L38. "Suggesting.."? How?

L41 ice penetrating radar *data*

L50, infers -> implies?

L67. comments on melt-water routing seem out of place in this paragraph

L73. 'Ice sheet models are useful tools' is a matter of opinion, and not connected to the rest of the paragraph.

L97 "Hence, we make inferences" -> We state / We determine?

Section 2

L 103 and fig2 – rephrase, and draw the whole shelf /gl so that the reader can easily tell what is meant by 'half' . Related to this, in 3.3.3 explicitly state the boundary condition at this segment of lateral boundary (I assume it is the same as the other boundaries) and give a justification.

L:156 'Inverse method'- no such thing. You are solving an inverse (that is, ill-posed) problem, using (most likely) some sort of gradient based optimization method. You are also not estimating ice flow velocity and stress, but inferring the basal friction such that the model velocity best fits observations.

L158-163 – Some rewording is needed here. You don't describe the procedure that you hint at for some time, so provide a summary here ('we will describe each model component in sections X and Y, then the coupling in Z')

272, In general, this section need to be cleared up, how for example does 'water input supply a large freezing rate'.

L219: no need to say 'taking six GHF datasets...' or at least rephrase to be clear that you only use one at a time.

L329; Eq 15 is not the Weertman law, it is a linear viscous law which works satisfactorily in inverse problems (because you are really finding T_b , not C) but not in general.

L347 Use subscripts consistently

L363 (and elsewhere) the conductive heat flux $F_c = -k \, dT/dz$ is positive (upward) when the bed is warmer than the ice above, so should you not have $+k \, dT/dz$ (i.e. $-F_c$) if the bed "loses heat from upward heat conduction". What about the case where dT/dz is negative (pressure melting point reached above the ice bed). Does that simply never happen?

L400. This procedure seems important but is glossed over. If $B_{new} \neq B_{old}$, then why does the modelled surface velocity not change?

L450 and fig 6. Why is the heat flux negative? Especially since you talk about magnitudes in the text.

L460 and fig 7 – it is difficult to tell the difference between these. Would it help to show differences relative to (a) Martos? That said, you don't seem to depend much on these figures so are they really needed?

L487. It is not quite accurate to say that 'The Li experiment gives the best fit' (how is the fit quantified?). I suggest rephrasing along the lines of the following sentence which sums up the results more accurately, i.e it is only the Li experiment that results in a warm base that covers all observed lakes.

506-507 (and elsewhere): The datasets/fields should be referenced correctly '(Li et al 2021)', rather than just 'Li'. I also would prefer to see you write 'our experiment using the Li et al 2021 GHF' rather than 'the Li experiment', but I don't think there is any real danger of the reader being misled by that.

