

The Cryosphere Discuss., referee comment RC2
<https://doi.org/10.5194/tc-2021-248-RC2>, 2021
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Review of Wang, "Thermal structure of the Amery Ice Shelf from borehole observations and simulations"

Anonymous Referee #2

Referee comment on "Thermal structure of the Amery Ice Shelf from borehole observations and simulations" by Yu Wang et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-248-RC2>, 2021

In this manuscript, the authors present observational and modelling results for the temperature distribution of the Amery Ice Shelf. Observations are from borehole measurements along three different flow lines and encompass sites with and without basal layers of marine ice. Two types of simulations are discussed, namely (i) 3-D simulations with the Elmer/Ice model, and (ii) 1-D simulations of ice columns advected along flow lines. The authors compare the findings from the observations and simulations, revealing a generally reasonable agreement. Systematic deviations occur in the marine ice layers, for which the observations show essentially isothermal conditions due to the presence of liquid saltwater. Reproducing this by the simulations would require a particular treatment of the thermodynamics of marine ice, which is identified as a crucial component for future work.

The study is somewhat preliminary in nature, and I do not think it has the potential to be a game-changer in the field. However, science is largely an evolutionary process, and not every paper can be. It is still a decent piece of work and presents results that are of interest to the community. Therefore, I think it should be considered for publication. However, I would like to raise some issues that should be dealt with before that.

Since the paper draws strongly on Gladstone et al. (2021), I think it should not be published before the latter one is available at least as a preprint with a persistent identifier (e.g., DOI). The separation of the two studies does not always become clear. This refers in particular to Section 2.2: I don't fully understand what was already done by Gladstone et al. (2021), and what is new. This should be made crystal clear in all details. Further, as Section 2.2 is a subsection of "Data and methods", any results (such as Fig. 2 and accompanying text - even if already discussed by Gladstone et al. (2021)) should be moved to Section 3.

The story with the temperature field of the 3-D simulations confuses me. In line 165, the authors say that the temperature field is computed by Elmer/Ice, whereas in lines 188-190, they explain that they use englacial temperatures computed by SICOPOLIS for ISMIP6-Antarctica. The latter statement is essentially repeated in lines 198/199 ("The original ice temperature field from the SICOPOLIS modelling is retained throughout"). How does this go together?

I noticed quite a few issues with the English writing. Some of them are pointed out below, but the manuscript can certainly do with a very thorough round of proofreading.

Detailed comments:

Line 33/34:

Inconsistent capitalization. I'd suggest capitalizing the whole term as "Lambert-Amery Glacial System (LAGS)". This entails several further changes to "LAGS" throughout the manuscript.

Line 50: "of the marine ice layer"

Line 56: "in - situ"

Line 64: "water - filled"

Line 84: "in - situ"

Line 91: of the basal melt rate

Line 94: "lower surfaces , and the transition temperature"

Line 120: "through the AM03 borehole"

Line 121: "close by the AM02 borehole"

Line 124: "ice shelf temperature_{1,2} and the other"

Line 163:

"The 3-D steady-state temperature simulations"

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"3-D steady-state temperature simulations"

Line 166: "ice flow dynamics_{1,2} the current study"

Equation (1): Add a comma after the equation.

Line 171: "varies the viscosity, η " -> "varies the viscosity η "

Equation (2): Add a comma after the equation.

Equation (3): Add a full stop after the equation.

Equation (4):

Why is the enhancement factor squared? Usually (e.g., Greve and Blatter, 2009, "Dynamics of Ice Sheets and Glaciers", Springer, Sect. 4.3.4), it appears as a linear term in the ice viscosity.

Equation (4): Add a full stop after the equation.

Line 188: "In this study_{1,2} we utilize"

Line 190:

"generated with the SICOPOLIS model (Greve et al., 2020; Seroussi et al., 2020)"

Line 210, "Tikhonov regularisation parameters":

Give a reference for this.

Equation (5): Add a comma after the equation.

Lines 259/260:

"We use a surface resistance coefficient..., and a reference speed..."

Line 290: "is assumed to be given by"

Equation (6): Add a comma after the equation.

Lines 293/294, "scale it linearly with depth to zero at the lower surface to approximate the vertical advection":

While this should be a reasonable approximation for grounded ice, I don't think it is good for floating ice because of the generally significant basal mass balance (melting/freezing). This requires a comment.

Line 313: "column simulations"

Line 335: "at the pressure melting point "

Line 344: "Borehole thermal regimes"

Fig. 5b:

What is the meaning of the dotted parts of the red curve?

Line 357:

"(a) at AM01, AM04 and AM05, and (b) at AM02, AM03 and AM06"

->

"(a) at AM01, AM04 and AM05 (with marine ice), and (b) at AM02, AM03 and AM06 (without marine ice)"

Line 359: "mark impermeable (solid line) and permeable (dotted line)"

Line 360: of the upper and lower surfaces

Line 370: "500m" -> "500 m"

Lines 452/453:

"from grounded ice to floating ice shelf" -> "from grounded to floating ice"

Line 510: "at _the_ AM02, AM03 and AM06 sites"

Line 536: "at high-elevation" -> "at high elevation"

Line 545: "with _the_ ocean below"

Lines 581/582, "Considering that it takes ~1100 years for ice to reach the ice front from the southern grounding zone":

This statement requires a reference.

Line 583: "20th _c_ entury"

Line 584: "steady state_,_ then"

Line 586: "spatially variations" -> "spatial variations"

Line 608: "measurements)__,_ which means"

Line 632: "in_-_situ"

Lines 694-697:

These two sentences are a bit convoluted. Rather something like

"The AM01, AM04 and AM05 boreholes have a permeable basal layer of porous marine ice approximately 100 m thick, which appears to conform to the pressure-dependent seawater freezing temperature. The AM02, AM03 and AM05 boreholes experience active melting, and large temperature gradients up to $-0.36 \text{ degC m}^{-1}$ are found at the base."

Line 721, "This study presents the first quantitative analysis of the 3-D temperature field of the Amery Ice Shelf":
Is this really true in view of the companion paper by Gladstone et al. (2021, in prep.)?

Line 730: "of _the_ depth-averaged"

Line 733: Put the divisor "(RT_h)" in brackets.

Lines 824/825:

This reference is wrong. It should rather be
"Greve, R., Calov, R., Obase, T., Saito, F., Tsutaki, S. and Abe-Ouchi, A.: ISMIP6 future projections for the Antarctic ice sheet with the model SICOPOLIS, ..."