The Cryosphere Discussions

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Review of tc-2022-53

Anonymous Referee #2

Referee comment on "Subglacial hydrology modulates basal sliding response of the Antarctic ice sheet to climate forcing" by Elise Kazmierczak et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2022-53-RC2, 2022

Review of Kazmierczak et al. 'Subglacial hydrology modulates basal sliding response of the Antarctic ice sheet to climate forcing'

In the manuscript, the authors study the sensitivity of the Antarctic Ice Sheet model to the choice of subglacial hydrological model and to the values of power exponent in the Weertman/Budd sliding law. The authors conduct two series of numerical experiments, considering extreme and realistic environmental forcings in the ABUMIP and ISEMIP6 setups, respectively. One of the novel findings presented in the study is the increased sensitivity in case when the subglacial model depends on the subglacial water pressure.

The paper in question is definitely of scientific interest, is well-written, and I would recommend it for publication after minor revisions. I have two general comments, detailed below, followed by specific comments/questions.

General comments:

- The subject of the study is the sensitivity of the sliding laws and various subglacial hydrological approaches. However, the sensitivity is not formally defined in the text. This makes it difficult to follow the discussion and to reason about the results of the paper. I therefore suggest the authors to define the sensitivity quantitatively and to use that definition throughout the text in a consistent way. An additional figure presenting the summary of the sensitivity study for the ice sheet scale would also simplify the interpretation of the results.
- One of the factors that determine the dynamics of the ice sheet is the basal sliding coefficient $\boldsymbol{A_b}$ first used in the Eq. 1. In the paper, the spatial distributions of $\boldsymbol{A_b}$ are obtained through the optimisation procedure for every combination of the power exponent $\boldsymbol{m}$ and the model for sublacial hydrology. Are these values of the basal sliding coefficient constrained in any way, e.g., in order to be within physically plausible ranges? How these values depend on the choice of $\boldsymbol{m}$? I would recommend providing the figure(s) presenting the spatial distributions of $\boldsymbol{A_b}$ at least for some representative

problem setups and discussing how the values and spatial variation of A_b influence the response of the ice sheet both on large scale and basin scale.

Minor comments/questions:

- p. 1, l. 7 - please define "RCP" before first use;
- p. 6, l. 118 - how Q_l is calculated?;
- p. 6, l. 125 - "and the subglacial water flux, i.e.," - change to "and the subglacial water flux φ, i.e.,";
- p. 6, Eq. 10 - please define A_o, e.g., "and Ao the initial value of A_b, obtained through a nudging method described in Section 3";
- p. 6, l. 131 - "the effective pressure N is considered constant for SWF" - what is the value of the effective pressure N? Does this value influence the results?;
- p. 7, l. 137 - please define the "yield stress" of what is discussed;
- p. 7, l. 145 - W instead of W_{til};
- p. 7, l. 153 - "δp_o is the lower bound on N, taken as a fraction of the ice overburden pressure." - I suggest changing it to "δp_o is the lower bound on N, taken as a fraction δ of the ice overburden pressure p_o" for better readability;
- p. 15, l. 258 - "between difference" should read "between different";
- p. 16, Fig. 9. - the TIL model seems to be dramatically different from other models for $m > 1$, especially for the Enderby Land basin (Fig. 9c). It would be useful to see an explanation for this.