

The Cryosphere Discuss., referee comment RC3
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Comment on tc-2021-274

Helen Ockenden (Referee)

Referee comment on "Derivation of bedrock topography measurement requirements for the reduction of uncertainty in ice-sheet model projections of Thwaites Glacier" by Blake A. Castleman et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-274-RC3>, 2021

General comments

This paper steps through a series of experiments exploring the impact of uncertainty in bed topography beneath Thwaites Glacier on future sea level rise. Each experiment is clearly explained and there is a logical progression between them, with sensitivity tests included. The authors conclude that there is still significant variation in the future trajectory of Thwaites Glacier given current bedrock uncertainty, and that in order to constrain sea level rise to $\pm 2\text{cm}$ at least a 2 km spatial and 8m vertical resolution is required.

Given that the paper is well written and structured, I would recommend it for publication, although there are a couple of points that I think need addressing in the discussion, and a few minor changes to consider.

Specific comments

In Experiment 1: Minimum and Maximum bedrock resulting spreads, you make the assumption that the minimum bedrock topography represents the maximum possible retreat and the maximum bedrock topography represents the minimum possible retreat. This is supported by your figures for max bedrock (4.8cm SLR), control (21.1 cm SLR) and min bedrock (26.7 cm SLR). However, beds which contain a mixture of plastic and viscous areas can exhibit behaviour which is outside the range bounded by purely viscous and purely plastic beds. (Koellner et al., 2019, <https://doi.org/10.1016/j.epsl.2019.03.026>). Do you think that there is a possibility that more retreat could be seen by a scenario between the max bedrock and min bedrock endmembers? The smoothest and roughest beds available within the 3σ bounds from Bedmachine might provide a different set of extremes? Nias et al (2016, <https://doi.org/10.1017/jog.2016.40>) might be a useful

reference here.

Melt rate obviously has an impact on sea level rise, as you discuss in experiment 5. However, it's not really addressed in this paper whether there is any interplay between the topography sensitivity and the melt rate. If the ocean warmed faster than expected, would a higher melt (ie 2x instead of the max 1.8x you use) mean that a higher topographic resolution is required?

You also don't mention at any point the effect of variations in basal slipperiness, or basal sliding law, on the future sea level rise. It would be good to see this addressed in the discussion/future work section.

Technical comments

"Ice sheet model", "Ice sheet instability" and "sea level rise" should technically be written with a hyphen as ice-sheet model, ice-sheet instability and sea-level rise. There are a few instances of this throughout the paper.

L17 Upper case G, Glacier

L50 For basal melting rates, because stochastic evolution is prevalent in ocean circulation, especially beneath ice shelves, melting rates are difficult to accurately observe, model, and predict. >> Basal melting rates are difficult to accurately observe and model, because stochastic evolution is prevalent in ocean circulation, especially under ice shelves.

L71 Data are technically plural, so 'The data are interpolated'

L75 It's confusing to say that bedrock topography is directly measurable using remote sensing, because this is not true. We can measure surface elevation using remote sensing, and then use this to interpolate between radar lines to get the bed topography. Instead you could say something along the lines of 'bed topography is directly measurable using ice-penetrating radar (see Holt et al., 2006, Holschuh et al., 2020 etc)(<https://doi.org/10.1029/2005GL025561>, <https://doi.org/10.1130/G46772.1>).

L77 Although there are a variety of different digital elevation models, the modelling community has primarily only used Bedmap (v1 and 2) and Bedmachine Antarctica. So this sentence is maybe misleading, and could be removed without altering the paragraph significantly.

L107 Shelfy-Stream (hyphen and capital missing)

L112 Can you add a sentence clarifying what the modification from Yu et al. (2018) does?

L114 Is the model of Schlegel et al. (2018) from Schegel et al. (2013)? It seems like you don't need the Schlegel et al (2013) reference here.

L140 Schlegel et al. (2018)

L158 Is there a missing 'a' here? "...using a sub-element on a partially floating..."

L166 I don't think provided is necessary here

L194 I would change yield to is "The resulting SLR difference between A and B is 21.9cm"

L196 Figure 2 only shows the grounding line position after 200 years, and not the evolution of the grounding line. Can you confirm here somehow that there is a stabilisation of the grounding line, and that it wouldn't retreat further if the model was allowed to run for longer?

L226 "extreme" not "extremes"

L227 Thwaites Glacier (insert glacier after Thwaites)

L298 'produces' not 'produce' (Noise amplification ... produces geological landforms)

L325 I think it's clearer to say 'See Appendix (Sect 9.2) for further details on...'

L330 'Many' rather than 'much' (Many of the perturbations are...)

L425 You're missing a 'the' here (We use the LHS sampling algorithm)

L596 The wording here is confusing because Thwaites Glacier is not an active landmass, it's a glacier which sits on top of an active landmass. You could just rephrase this as 'Thwaites glacier is affected by vertical land motion'.

L601/602 Change 'its' to 'their' (We hope to explore their contribution), because couplings are plural.

L606 Change 'promotes' to 'promote'

L610 '...would therefore not be correctly configure for the sensitive experiments we perform' >> sensitivity experiments?

L655 it is highly critical to better constrain uncertainty in simulated SLR contribution that is sourced in bedrock topography >> it is critical to constrain the uncertainty from bed topography in simulated SLR contribution OR it is critical to constrain how much of the uncertainty in simulated SLR contribution is sourced from bedrock topography? Something about this sentence is a little unclear, it maybe needs rewording.

L668 upper case G, Glacier

Your reference list is also not consistently formatted, and it's probably faster for you to tidy this up in your files before the typesetting stage