Review of 'A protocol for calculating basal melt rates in the ISMIP6 Antarctic ice sheet projections' by Nicolas Jourdain et al.

In the manuscript parameterisations and their calibration to generate basal melt rate forcing for the ISMIP6 experiments are presented. In a first step, a present-day climatology of the ocean is generated from different datasets and extrapolated by horizontal filling underneath ice-shelf and into currently ice-covered regions. The derived, local temperature and salinity then inform the parameterisations. The authors present two different parameterisations, both have a quadratic dependency on thermal forcing, one based on the local thermal forcing and one on a mixture of local and basin-wide averaged thermal forcing. Furthermore, a procedure to tune the parameters including an assessment of their uncertainties is presented. Tuning parameters are a pre-factor γ, which is constant for the entire continent, and basin-wide temperature corrections δT_b for 16 different basins b. The first tuning approach uses the Antarctic-wide basal mass flux for tuning of the parameters and the second approach observed melt rates close to Pine Island Glacier's grounding line. While present-day melt rates are, by construction, similar for both sets of parameters, melt rate sensitivities are very different and hence the projected melt rates differ by an order of magnitude.
In general, this manuscript is well written and presents a novel and comprehensive approach to systematic tuning of parameterisations including uncertainty ranges for parameters. It clearly indicates problems related to the tuning and potential future developments.

Major comments

(1) The aim of this work it to provide a suitable basal-melt rate parameterisation and oceanic input for ISMIP6 projections. Since the two calibration methods you present yield largely different results, it would be useful to identify upper and lower limits for basal melt rate sensitivities and discuss how your parameterisations fit into that range. In particular, do the projected changes in basal melt rates for the (95th percentile of the) PIGL parameterisation represents an upper limit and the (5th percentile of the) AntMean parameterisation a lower limit given current observations and modelling studies? How does the slope-dependent parameterisation fit in there?

(2) More details on the PIGL tuning are required, see specific comments below.

Specific comments

- page 3, line 32: I do not understand this sentence, since you only focus on basal melt rate forcing here?
- page 5, line 19: Can such a switch be simulated in CMIP models without representing ice-shelf cavities and the continental shelf?
- page 6, line 28: Please explain for readers not familiar with WOA the terms 'statistical mean' and 'objectively analyzed mean'.
- page 6, line 30: I'm not sure I understand this, you 'bin' the WOA18p data onto the same grid?
- page 8, line 1: Why do you use different procedures for the datasets? In particular, why do you chose to vertically interpolate the WOA18p data and not the other datasets since this might introduce vertical variations if the other data has vertical gaps?
- page 8, line 22: How are salinities affected?
- section 3.2: Do I understand correctly that the only way the compiled observational dataset is vertically extrapolated is by filling the deeper levels with copies of the lowest available data point?
- page 9, line 10: 'ocean model data and the climatology'

- page 9, line 12: Is it correct that the open ocean is not separated by the basin boundaries as shown in Fig. 2 for the interpolation (otherwise ocean regions, e.g., in the Weddell Sea, would be very small and might not contain data)? And for the ice-covered regions that the values at the boundaries are used?
- Figure 2, 'shading' should be 'colors'. Please add more explanation to the legend, especially make clear what regions are actually used in this study.
- page 9: Please add figures showing your final datasets for an exemplary depth and along the current ice-shelf draft including basins boundaries and basin averaged values.
- page 10, line 5: Please give an example here.
- page 13, line 8, page 15, line 5: Do I understand correctly that you fit melt rates in units of average m/a for each region, not in Gt/a? How different are results depending on the choice of average or aggregated melt rates?
- page 13, line 30: More detail is required here. In particular, do I understand correctly that you use the highest 10 melt rates from the spatial pattern? Do you fit γ such that melt rates in the respective location are similar, or that melt rates in the area close to the grounding line have a similar melt rate?
- page 15, line 2: Wouldn't it help to better constrain the melt sensitivity in PIGL by using the temporal variation from Figure 8 for calibration?
- Figure 3 and 4: Please add explanation to the legend.
- page 15, line 6: δT should represent changes of water masses being transported into the cavities as well as uncertainties in observations. Since the first would only act to decrease temperatures at depth, shouldn't a decrease in temperatures be favored over an increase (i.e., not a normal distribution be assumed)?
- page 18, line 7: If you add $\delta T = 1.07K$, how large are temperatures in the Amundsen Sea then for present day? And how do they compare to observations in that region?
- page 18, line 26: Do I understand correctly, that you retune parameters here for the Amundsen region? Since changing γ or δT affects the basal melt rate sensitivity, the comparison to observations is not very meaningful for the other parameter choices. Also, do you apply the observed T, S profiles as anomalies to your climatology? Such a procedure might be better to assess the parameterisations, since the melt sensitivity of your parameterisations depends also on temperature.
- Figure 6: Please add also uncertainty ranges based on different values of γ, similar figures for the local parameterisations as well as for the slope-dependent ones.
- page 23,24: One explanation for the discrepancy could also be that with your parameterisations all ice shelves have the same melt rate sensitivity (modulated by their respective temperature), however, FRIS might have a lower sensitivity than PIG, not only due to the initial temperature, but also due to its geometric properties (see Holland et al. (2008) testing this for an idealized geometry).
- page 24, line 26: It might be key to include the basal slope in parameterisation. How does this affect future changes in BMR as shown in Figure 10?

References

Holland, P. R., Jenkins, A., and Holland, D. M. (2008). The response of ice shelf basal melting to variations in ocean temperature. *Journal of Climate*, 21(11):2558–2572.