Responses to the reviewer's comments

Thanks to the authors for updating the manuscript. After re-reading the manuscript, I suggest two important and a few minor changes before publication.

→ We thank the reviewer for this careful examination of our revised manuscript. The reviewer's comments are hereafter in black and our responses are in blue.

(1) Comparison of parameterisations with observations and modeling

Adding the comparison with Seroussi et al., 2017, is very valuable to assess the parameterisations. However – in line with the comment on page 18, line 26 by Reviewer 2 – I strongly encourage that the comparison with observations in Figure 8 as well as with model results in the newly added Figure 11 is made using both, γ and δT, as tuned for the use of the respective parameterisation in ISMIP6 in the Amundsen Sea.

Because of the quadratic dependency of melt rates on thermal forcing in the parameterisations, γ and δT theoretically both influence the melt sensitivity to ocean warming (γ the slope and intercept, δT the intercept). And the Figure below shows that for the ranges of δT used in the paper, its effect is not negligible: switching between temperature corrections for the 'AntMean' and 'PIGL' tuning approaches in the Amundsen Sea yields more than 20 m a^{-1} °C^{-1} higher melt rate sensitivities for 'PIGL' and about 5 m a^{-1} °C^{-1} lower sensitivities for 'AntMean'.

How large are the differences in the δT tunings for Figures 8 and 11 to the ISMIP6 tuning and how does this affect the melt sensitivity? Depending on that the assessment of the parameterisations in Section 5.2 should be updated with the values for γ and δT from your ISMIP tuning.

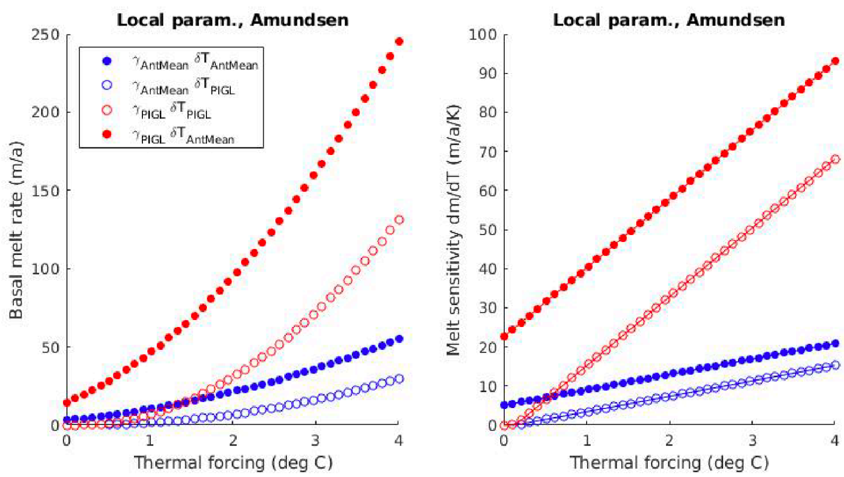

Figure 1: (Left panel) melt rates and (right panel) melt rate sensitivity to ocean warming as a function of local ocean temperatures. Both are shown for the local parameterisation, using the median γ_0 values estimated for AntMean and PIGL. The solid dots show values for δT as estimated for the 'AntMean' tuning method in the Amundsen Sea region ($\delta T_{AntMean}$ = 1.28°C) and the circles show values for δT estimated with 'PIGL' in the Amundsen Sea region (δT_{PIGL} = -0.14°C, see Figure 5 of the manuscript).

→ Figure 8 is not an ideal comparison, but there are no oceanic observations to calculate the sector-averaged thermal forcing at interannual time scales. So we have to deal with either Pine Island or Dotson, i.e. with the melting parameterizations applied to an individual ice shelf rather than the entire Amundsen sector as in ISMIP6. This makes a difference: in the newly developed climatological T,S dataset, the average thermal forcing is different when applied to Dotson (1.09°C), Pine Island

(1.40°C), or the Amundsen sector (1.07°C), so the δT values should also be tuned differently to get the correct present-day melt rate in individual cavities or for the entire sector.

Furthermore, δT has been introduced partly to correct biases in the ocean dataset (in addition to other imperfections of the parameterization itself). The time-average and cavity-average thermal forcing derived from observational CTD profiles is 2.27°C and 1.62°C for Pine Island and Dotson, respectively. This is much higher than in the newly developed dataset (1.40°C and 1.09°C for Pine Island and Dotson, respectively). This indicates that applying the same δT correction to the climatological dataset and to interannual CTD profiles would lead to very large errors. Actually, temperature biases have an influence on the melt sensitivity to ocean warming, and as such, we argue that they should be corrected. We are therefore convinced that δT values must be adapted to each dataset in order to obtain the correct melting sensitivity to ocean warming.

To make this clearer, we have added a few sentences, see track-change pdf file.

→ Figure 11 is quite different from Figure 8, as we apply a +0.5°C anomaly to the climatological dataset over the entire Amundsen sector (which is very similar to the design of the regional numerical simulation conducted by Seroussi et al. 2017). So here, the exact same γ_0 and δT values as in ISMIP6 are used. We have made this clearer in the manuscript. The comparison in Figure 11 is methodologically more meaningful than in Figure 8, but it is a comparison to a model, not to observations.

Further specific comments:

- p.12 l.6-9: Note that, due to the quadratic formulation, not only γ_0 influences the melt sensitivity, but also the temperature correction δT.
  → We agree, and this is why we wrote that "γ_0 explains most of the melt sensitivity". We nonetheless have made this clearer in the revised manuscript (see aforementioned changes).

- Figure 8: 'Keeping the δT previously determined for the Amundsen sector would not make sense as sector-averaged thermal forcing must be replaced by ice-shelf-averaged thermal forcing for this comparison.' See main comment above. In addition, do you have an idea how switching the thermal forcing calculation from the entire region to one ice-shelf influences the results?
  → We agree on the influence of δT on the sensitivity to ocean warming, but temperatures themselves also affect the sensitivity because of the quadratic dependency, and as such, need to be corrected. We nonetheless have made this clearer in the revised manuscript (see aforementioned changes).

- Figure 11: What underlying values for δT were used for this comparison? See major issue above.
  → These are the same values as in ISMIP6. This has been clarified in the manuscript.

- Interpretation of Figure 11. Probably the change in melt rates is more relevant for ISMIP6 than the initial basal melt rates since the ISMIP6 results are presented with respect to control simulations.
  → This is a good point, we have added this comment.

(2) Tuning of the melt parameterization

Still more details on the tuning procedure are required, especially as this is central to the paper.

- p.15 l.1: Be more precise about the PIGL tuning for the non-local parameterization. In particular, I suppose that you use the Amundsen-Sea-wide, average thermal forcing with the randomly sampled temperature correction applied everywhere? Explain your method in the text.

→ Yes, exactly. We have specified "normally-distributed uniform error over the entire Amundsen basin".

- p.15 l.11: Explain more how you determine δT, especially what do you mean with 'we estimate by randomly sampling...thermal forcing in normal distributions'? This is not part of Figures 3 and 4. Also in your script (calculate K0 DeltaT quadratic.f90) I cannot find where the randomly sampled thermal forcing ('rr' in line 641) is called again in the calculation of δT. Also, it seems that an additional step is taken in the 'readjust deltaT _' routines? Describe your methodology with more detail.

  → The error on the thermal forcing is indeed only used to calculate the γ_0 distribution. We thought that it would not make sense to again introduce random thermal forcing errors in the δT calculation, because the calculated δT corrections would then just compensate for the random error, and ISMIP6 melt rates are calculated from the T,S climatology without errors. So the reviewer is right to raise the inconsistency in p. 15, l. 11: we have removed "and thermal forcing". The two schematics were correct.

(3) Further comments

- comment P12L06 by Reviewer 3 (Hartmut Hellmer). I think that this is a misunderstanding of the comment. The comment is not about individual ice shelves having deeper and lower parts, but about different ice shelves having potentally different depth, i.e., a overall shallow ice shelf in the Amundsen region might have higher melting due to the high thermal forcing of PIG and TWG.

  → Yes, our response was indeed not very good. There are reasons why a shallow ice shelf in the Amundsen Sea could be influenced by deep melting at PIG and TWG: the very strong overturning in PIG and TWG cavities bring warm water towards the ocean surface outside of these cavities (which can melt sea ice, see Jourdain et al. 2017). But this clearly depends on the location of the shallow ice shelf with respect to PIG and TWG, and the sector average rather than ice-shelf average is more a practical choice for ISMIP6.

- p.13 l.16: '..samples give percentiles of the γ_0 distribution that converge...'

  → Thank you, this has been corrected.

- Figure 11: The black bars for Seroussi et al. (2017) do not represent values for the 95th and 5th percentiles of γ_0.

  → Thank you, this has been corrected.