Editor comments on "Resolving GIA in response to modern and future ice loss at marine grounding lines in West Antarctica" by Wan et al

I would like to thank the authors for providing a clear response to the reviewers, and for submitting a revised version of their article following completion of the additional model run. I am satisfied that the edits address all the points raised by the reviewers and there is no need to request further review by the original reviewers. However, in reading through the manuscript I have identified a number of issues that require clarification and a couple of areas where terminology is a little inconsistent. These are listed below (line numbers refer to version 3 of the manuscript).

This is an important study that is very thorough in its investigation of the impact of grid resolution and earth model choice when modelling GIA in Antarctica. There is a significant amount of work presented in the article and the conclusions are robustly supported by the results.

My decision is to publish this article subject to minor revisions (review by the editor). Although there are quite a few points listed below, the majority can be resolved very easily. Where I have requested additional detail on the modelling, you are welcome to address this by editing the supplementary material, if suitable.

Thank you for submitting your article to The Cryosphere.

Pippa Whitehouse (editor)

Main points

Definition of GIA: The opening paragraph of the Introduction is very useful for introducing the range of processes associated with GIA but there is some discrepancy in how you use this term throughout the rest of text. For example, I think the sensitivity experiments (section 3) just consider solid Earth deformation but in section 4 you present results for sea-level change, which reflect deformation of both the solid Earth and the geoid. In both cases, the results are generally described as representing 'GIA', with no clarification of which components are included. You also use the term GIA to refer to the elastic response to surface load change and the rapid viscous response that is triggered in low mantle viscosity regions such as the Amundsen Sea Embayment – these are not standard definitions, and many people still consider the 'GIA signal' to be the decaying response to long-complete ice mass change immediately following the Last Glacial Maximum. Make sure you are explicit about what processes are captured by your use of the term GIA and, if necessary, clarify which components are included in the different sections of the paper.

Grid resolution vs load size: the abstract relates grid resolution to load radius, but care is needed when discussing this result because an *increase* in resolution equates to a *decrease* in grid size. It is stated in the abstract that a ratio of 1:3 is required to accurately capture the elastic response of the Earth – it would be useful if you could clarify whether this is an upper or lower bound (noting the care needed when talking about 'resolution'). Also, in some cases you quote a 1:3 ratio and in others a 3:1 ratio (with wording appropriately altered) – please be consistent in how this result is reported.

Quantification of error: in all cases, you report errors relative to the results obtained using the finest-resolution grid (rather than relative to, e.g., an analytical solution). This is clear in most places, but please check for instances where it is ambiguous, e.g. line 24 of the abstract.

Representation of loading: (i) Figures 2a-c show total ice thickness change, but this does not reflect net surface mass change in locations where there is a transition from marine-grounded ice to ocean because much of the ice load will be replaced by water load. Have you plotted the net surface mass change, and would it be useful to include such plots to aid interpretation of the results? (ii) Errors peak along the location of the final grounding line in experiments ICE-GOL and ICE-RD (fig. 4). This is described as the 'load edge' at various points in the text but if I have correctly interpreted how net surface mass change is computed the grounding line will not necessarily align with the 'edge' of the load. Did you consider whether the misfit along the final grounding line position may be fundamentally related to representation of this transition within the GIA model? (iii) To understand how you calculate the 'Mass Factor' (fig. 3) a little more information is needed on how the model applies the load. Using the sensitivity experiments as an example; is the same load (i.e. 100m ice) applied to all elements that lie within, or partially within, the footprint of the load, or is the load scaled according to how much of each element is covered by the footprint of the cylinder?

Minor clarifications

Place names: rather than 'the West Antarctica' we tend to refer to 'West Antarctica' or 'the West Antarctic Ice Sheet' (similarly for East Antarctica), however, we do refer to 'the Antarctic Peninsula'. 'Central Antarctica' (line 218) is not standard terminology.

Section 2.2: I think the 15 km grid is used to produce results for section 4 but not section 3; it would be useful to clarify this somewhere in this section.

Line 162: 'incrementally smaller regions' – please clarify whether you use a series of nested regions, i.e. the 3.75km grid is always located within a slightly larger 7.5km grid, which is located within the 15km grid, or whether each higher-resolution grid is inserted directly into the 15km grid.

Line 164: 'a few layers down to 10 km' – line 158 states that the shallowest layer in the grid is at 12km; do you add extra layers when creating the higher-resolution grids?

Line 170: is the elastic/density structure used in the purely elastic model the same as that used in the 3D models (described on line 174)? What is the lithosphere thickness used in the elastic model?

Line 203: 'close to the preferred value in Kaufmann et al.' – I couldn't work out what this refers to since there is no mention of a scaling factor in the cited article. In general, it is not clear how the scaling factor is applied, making it difficult to derive useful insight from the values quoted here.

Lines 209-210: suggest '…viscosity estimates derived from GPS bedrock uplift rates in three regions' (note that the Antarctic Peninsula is often defined to be a separate region to the WAIS)

Line 227: is initial bedrock topography (as well as ice thickness) derived from Bedmap2?

Section 3.1/figs 3, 4, 7: when calculating the RMSE/percentage error in fig. 3, and the misfits shown in figs 4 and 7, how do you quantify the difference between results determined using different grids, i.e. in situations where output is produced at different resolutions?

Line 320: I think the ICE-SH model covers 25 years, between 1992-2017 (also check caption to fig. 2).

Line 373: should include references to fig. 2, not fig. 3?

Line 400-401: 'Along the final grounding line…' – based on fig. 7c, I don't think this statement holds.

Line 403: you mention five earth models, but only four are described in this paragraph. I suspect the fifth model is the 1D/WAIS model described in the next section, but this is not clear.

Line 407: I think the EM1_L and EM1_M models are derived using different 1D viscosity profiles as well as different viscosity scaling factors – this may be worth mentioning.

Lines 437-444: statements about time in this paragraph (e.g. 'after 50 years', 'within decades') are ambiguous because it is not clear whether they are referenced to the start of the model run (in 1950) or the start of the 21st century (as suggested by the opening sentence).

Line 452: is the 'maximum' value defined by the 75th percentile *plus* 1.5 times the interquartile range (I think 'minus' is correct for the 'minimum' value)? Comment also applies to various figure captions.

Line 469: 'the difference in predictions associated with earth model configuration lies between ~2-10% ...' – this statement is based on a comparison between results derived using the EM1_L and EM1_M models, which are derived from the same underlying seismic model, i.e., this is not the most extreme comparison that could be made. This statement may require a caveat.

Line 482: 'the elastic signal' -> 'the total signal'?

Line 539: a value of 7 +/- 3 is quoted elsewhere (e.g. line 300, caption to figure 3) – which is correct?

Figures: please add latitude and longitude labels to relevant figures.

Figures 1c,d and S1: I think the black line marks the edge of the ice shelf and the grey line marks the grounding line – not the 0 m contour, which is typically much further inland.

Figure 3: (i) 'calculated within 2 km of the loaded region' – does this statement apply to multiple plots in the figure? (ii) The ratio between cylinder radius and grid resolution is quoted as 3:1, not 1:3, in the main text (lines 298-299). (iii) Do the colours saturate in plots b-e?

Figure 5: (i) the reference to plot (a) is not needed. (ii) The reference to 'left to right' when describing what is represented by the edges of the boxes does not make sense – plot rotated?

Figure 8: (i) in the lower panel of fig. 8b, why does ice thickness not reach zero by 2100? My understanding is that the grounding line retreats upstream of this point during the model run. (ii) I suggest splitting the sentence that describes what is shown in plot (b) – it is very long! (iii) Please refer to Powell (2021) rather than the article in review.

Figure 9: please clarify which earth models were used to produce each set (row) of results.

Figure S1: please include a label indicating the depth associated with each plot in panels (a) and (b).

There are occasional small words missing or grammatical errors – please carry out a final check for such issues before resubmitting the article. Please also check that all values quoted in the text agree with values listed in the figures (e.g. line 344).