

The Cryosphere Discuss., referee comment RC2
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Comment on tc-2021-232

Grace Nield (Referee)

Referee comment on "Resolving glacial isostatic adjustment (GIA) in response to modern and future ice loss at marine grounding lines in West Antarctica" by Jeannette Xiu Wen Wan et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-232-RC2>, 2021

Summary

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

In this study the authors seek to find out what GIA model resolution is required to accurately capture viscoelastic deformation in response to present-day and future ice loss in the Amundsen Sea Embayment of West Antarctica. They conduct several experiments to determine this: 1) the elastic response to an idealised cylindrical load; 2) the elastic response to realistic ice loss; 3) viscoelastic response to realistic ice loss with a 1D earth structure and three 3D earth models. The results are given in terms of percentage error for each grid resolution tested and the authors find that errors converge at a resolution of 3.75 km, or three times the radius for the idealised experiment. Furthermore, the results show that the error from neglecting viscoelastic deformation over short time scales, or from adopting different 3D earth models, is far larger than the error from grid resolution.

This topic is timely given the efforts within the GIA community to improve models. High-resolution models are very computationally expensive, prohibitively so for most, and quantifying the error for different grid resolutions is very valuable. The paper is well written and clearly organised but would benefit from some small amendments to the text as suggested below.

General Comments

1) The main conclusions from this study state that the GIA model grid resolution needed for an isolated cylindrical load is three times its radius, and that for realistic ice loading in

the ASE a grid resolution of 3.75 km is required to achieve an error of 2%. I think the paper could be improved by adding a qualitative discussion of how these findings might apply in other areas. Line 344 states "for most applications, errors of less than 5% can be achieved with a 7.5 km grid, and errors of less than 2% with a 3.75 km grid". It would be beneficial to have a short section in the discussion expanding on this, discussing whether this rule of thumb is limited to ASE, or marine grounding lines, whether it might apply in other areas of Antarctica where present-day ice change is occurring, or how different spatial scale of ice loading change might affect this general rule.

2) In this study the authors find that representation of the ice load on the GIA model grid leads to higher error than the grid resolution itself, however, there is no discussion of how representation of the Earth structure within the model grid might impact the results. Particularly in Section 2.2 and 2.3, what is the resolution of the seismic tomography data that is used? How does this compare with the vertical resolution of the grid with depth, how much is it being down sampled? Perhaps the results from the tests mentioned on line 158/159 could be included in the supplementary information.

Specific Comments

Line 21: The authors repeatedly refer to a "spatially isolated load". The use of this term is particularly important since one of the main conclusions of the paper – a grid resolution needed of 3 times the radius of the load – only holds for cylindrical loads. For clarity, consider changing this term to "spatially isolated disc/cylindrical load".

Line 57: please quantify short spatial scales, e.g. 10s of km, or 100s of km.

Figure 1c: is the white area saturated? Please add to colour bar

Figure 1d: scale bar in the figure is not clear. The choice of colour bar makes it difficult to see the regional variation in viscosity.

Line 151: 70 radial layers – Are these radial layers where properties are assigned, or is this the vertical resolution of the grid? On line 153 it says layer boundaries at 12, 25, and 43km, again are these the boundaries of material properties or grid resolution?

Line 157: 29 million nodes is a lot! It would be interesting to add here what the run time of this model is.

Figure 3a: consider adding solid/dotted/dashed lines to the key for the 2/5/10km ice, or perhaps label.

Figure 3b: x-axis label - Grid Resolution km, not m?

Figure 3b-e: y-axis would look better labelled at 2km intervals rather than 2.5 km intervals.

Line 260: "grid points" do you mean nodes? Is the load applied at the nodes or the centre of the elements?

Line 292: "serve as a guide... appropriate grid resolution for a given problem" I think its important to include here that this guide is restricted to isolated cylindrical loads.

Line 335-344: There is reference to Figure 5(a) and 5(b) in this paragraph but there are no corresponding panels in figure 5. Fig 5 caption also only states (a).

Figure 6: (and 2/4/7) it would be useful to include the acronyms ICE_SH etc referred to in the text in the column headings of these figures.

Line 397: This reference is missing from the list.

Figure 8: panels b and c need y-axis labels; the grey colour showing ice thickness in the lower panels is washed out and hard to see. In the caption for panel a) this is not identical to figure 3c, perhaps figure 2 instead.

Line 402: It is confusing to label these two sites A/B since the panels in the figure are labelled b and c. Perhaps change to 1/2 or X/Y, since I think this is the only time they are referred to anyway.

Line 403: it is not clear what the authors mean by "spin up time".

Figure 9: the hollow diamonds don't show up very well on this figure.

Line 560: add "in the ASE" to the first sentence to clarify the region the conclusions apply to.

Line 564: would be useful to quote the percentage error in conclusion (1)

The following paper is relevant and worth citing:

Blank, B., Barletta, V., Hu, H., Pappa, F., & van der Wal, W. (2021). Effect of lateral and stress-dependent viscosity variations on GIA induced uplift rates in the Amundsen Sea Embayment. *Geochemistry, Geophysics, Geosystems*.
<https://doi.org/10.1029/2021GC009807>

Technical Comments

Line 158: missing word "limited to the surface (and?) a few layers down to 10km"

Line 211: incorrect spelling of adopted

Line 475: reflect rather than reflecting