

Response letter to reviewer #2

We appreciate the reviewers for giving valuable comments and are pleased to resubmit this manuscript. The comments are in blue text and our responses in black and italic text.

Major comments

The authors model the RSL change during the Holocene in Dronning Maud Land and the surrounding applying two published glaciation histories and two earth structures. The histories are the original ICE6G_C model and a modified history based on surface exposure data, Nice6gSi6g_09-05_PART, in the following I call it Nice6g. The applied viscosity structures are the vm5a attached to ICE6g_C and one that was suggested by Whitehouse et al. (2012b) representing the Antarctic lithosphere and mantle. These the authors discuss as weak and strong, respectively.

The modelling was performed with a state-of-the-art GIA code, solving in addition to the viscoelastic deformations the sea level equation, considering moving coast lines and rotational deformations.

The authors present new sea-level data, for the Lützw-Holm Bay covering the Holocene (9 ka BP to present day). They combine these data with further published compilations and compare them with the GIA model results at the respective sites.

The conclusions based on this small set of GIA models are in general a better fit with Nice6g, but the results demand further improvements with respect to the glaciation history, where they argue for an asynchroneous change of the ice sheet in this region. For me it is not clear if such an asynchronicity is already considered in Nice6g. The authors also do not discuss witch of the two earth structures better fit.

Throughout the text, the authors focus on surface exposure data, although this is not the main topic of the paper. The authors apply the refined Nice6g model, which is based on this type of data. Although one of the authors of this paper is also author of Nice6g, you should reduce the discussion of this aspect and refer to the respective study.

Thank you for your suggestion. We have reduced the description of surface exposure data and focused more on the GIA model. The section of sea-level data has added before the Methods section. The data from 42 GPS sites, 62 SEDs, 12 Holocene sea-level records, and 9 continental shelf sedimentary facies are used in ICE-6G (Argus et al., 2014), cited from Whitehouse et al. (2012). However, these datasets do not include SED data from Rayner Glacier (White and Fink, 2014), Gjelsvikfjella (Suganuma et al., 2022), and Soya Coast (Kawamata et al., 2020).

Language

The authors used an AI tool to improve language. This explains to a large extent the style, which does not follow the conventions and nomenclature in the current scientific literature of the respective research fields. This makes the text sometimes tricky to understand.

The text should really be improved by a native speaker which has experience in scientific writing. I recommend a more concise style of writing, as the authors tend to repeat statements at some places, which hinders the flow of the the text. To show this I placed here some examples I took from the Introduction.

Thank you for your comments. We have revised the manuscripts based on the comments from the English editing service, Editage.

Examples

1. L33: 'The East Antarctic Ice Sheet (EAIS) has an ice volume equivalent to the sea level of approximately 53 m'

I read as 'The East Antarctic Ice Sheet (EAIS) has an ice volume equivalent to a mean global baristatic sea level rise of approximately 53 m.'

We have revised the sentence.

2. L35: 'Recent studies indicate that a part of the EAIS was lost compared with the present situation during the Last Interglacial under a climate about +1°C warmer than the present'

I read as 'Recent studies indicate that during the Last Interglacial parts of the EAIS were lost compared to its current state, under a climate about +1°C warmer than today'.

We have revised the sentence.

3. L37: 'However, despite the growing importance, investigating the spatiotemporal distribution of reconstructions is insufficient for quantifying ice mass changes and elucidating the mechanism of these changes (Jones et al., 2022).'
- I read as 'Jones et al. (2022), emphasised the need for a better understanding of the ice sheet dynamics in this region during the Holocene, which should be based on improved reconstructions of the spatiotemporal distribution of the EAIS.' The following sentence is redundant.

We have revised the sentence and removed the following sentence.

4. L41: 'The glacial isostatic adjustment (GIA) modelling study plays an important role' I read as 'Modelling of glacial isostatic adjustment (GIA) is an important method to reconstruct'

We have revised the sentence.

Scientific content

I strongly recommend to extend the modelling in the direction the authors have stated in the outlook. My concerns regarding the language go hand in hand with the presentation of the results.

We have changed the structure of the manuscript

By adding the sea-level data section before the Methods, the structure of the manuscript has been adjusted to focus more on the modelling aspect.

Details Specific phrases

1. I would not call sea level data or index points being RSL reconstructions. From my understanding a reconstruction is based on an interpretation of a set of data points. So, reconstruction includes some modelling. In current literature these data are called sea level data points which are split into sea-level index points and limiting points.

We have replaced reconstructions with data.

2. **Nice6gSi6g_09–05_PART** I would abbreviate, as it reads a bit lengthy throughout the text.

We have renamed the model as mod-I6G_DML.

3. RSL should not be used in plural form as it represents a measure. Also other terms like 'modelling' are not used in plural. These are again only some examples.

We have revised the words.

Text

1. L25: Not clear, on which glaciation history the found consistency is based.
We have revised the sentence.
2. L 32: The authors state that the AIS significantly influenced global climate. Is there evidence for this and can you give a reference? A potential of 53 m sea level rise I would not rate a sufficient to explain its potential impact on the climate.
We have moved the reference.
3. L41: The authors should also state that on the first place, GIA models the viscoelastic deformations in response to surface loading.
We have revised the sentence.
4. L 43: 'The GIA modelling utilizes the fact that the sea level approximates [...]'. This is strictly speaking not correct. In GIA modelling the sea level height is considered to follow the geoid. This is of course a good approximation, but the impact of ocean dynamics on the sea level, are neglected.
We have revised the sentence.
5. L50: LHB and PB are not indicated in Fig. 1.
We have revised the figure.
6. L64: This sentence is not clear to me.
We have removed this part.
7. L 89: I would expect that the lithosphere thickness has a substantial impact, why do you keep it constant.
Thank you for your comment. Comparison with data has reported that lithosphere thickness does not influence sensitivity to RSL (Whitehouse et al., 2012). Additionally, we conducted a sensitivity test for lithosphere thickness, suggesting that the results showed little variation. Therefore, this study adopted a lithosphere thickness of 100 km.

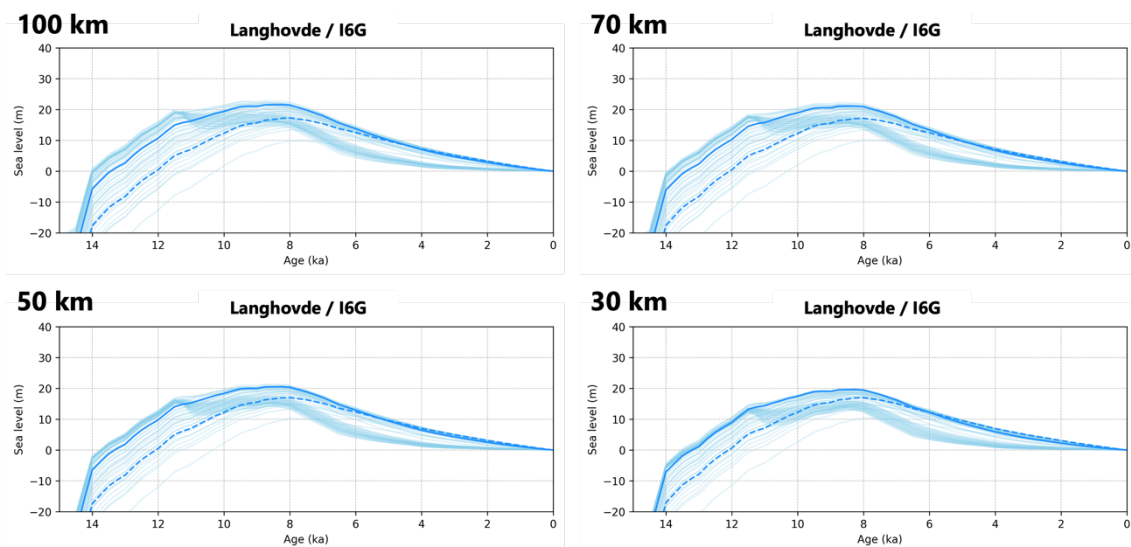


Figure R2-1: The results of sensitivity tests of lithosphere thickness. Solid lines are upper mantle viscosity of 5×10^{20} Pa

s, and lower mantle viscosity of 3×10^{21} Pa s. Dashed lines are upper mantle viscosity of 1×10^{21} Pa s, and lower mantle viscosity of 3×10^{21} Pa s.

8. L92: Applying a software does not explain how the resampling is done. The authors should state, which method they applied.
We have revised the sentence.
9. L 93–95: The authors have described the method already above.
We have removed this sentence.
10. L105: I guess they mean 'the drainage basins 5-7 according to the Antarctic Drainage System of Zwally et al. (2012).'
11. L106: I do not understand this description, are the 15 ka and 0 ka at the end of the sentence related to ICE6G_C?
Yes, they are related to ICE6G_C. We have revised the sentence.
12. L107: change to 'Figure 2', convention is to not to abbreviate 'Figure', when appearing at the beginning of a sentence.
We have revised the word.
13. L134: What are trench samples?
We have added the explanation to L144.
14. L151: Add 'respectively' at the end of the sentence.
We have added the word.
15. L164: The sea level itself cannot be constrained.
We have revised the word.
16. L196-198: I read that in previous reconstructions only TL data are used, and that further ML data applied in this study confirm these findings.
We have removed this sentence since it leads to misunderstanding.
17. L210–218: Why not list these data in a table. It is tricky to keep all these numbers in mind while reading and to have a clue on how the numbers differ between the respective regions.
We have made the table 2, summarising the Holocene sea-level peaks in study sites.
18. L244–266: The authors discuss here in length the applied surface exposure dating, but this is not the scope of this study as the data is already applied in constructing Nice6g, and I assume they are also discussed in the respective referenced studies. I suggest to condense these three paragraphs and only summarise the findings regarding the adopted changes in the glaciation history.

We have moved these sentences to an introduction.

19. L296ff: The authors state here that Nice5g needs further modifications, why not apply them? In the current study the changes to be made read rather unspecific with many 'may be 's'.

We have revised the sentences.

20. In addition to the adjustment of the glaciation history. What is the effect to f the different earth structures? Which structure is the preferred one, if any?

We have discussed about the rheology in L231–L237. It is difficult to determine which is preferred because there is the trade-off between ice loading and rheology.

21. L312–318: The authors present here additional data. This paragraph together with Table 2 should be placed in Section 3. Also, they only present here GNSS data for LHB. Are there no further data from the other regions discussed with respect to RSL?

We have moved Table 2 to Results section and have added to the GNSS estimation for PB.

22. L325ff: The authors should be more specific in which way the asynchronicity manifests.

We have revised the sentence.

23. L332ff: After reading the conclusions, the results seem to be rather preliminary. The first sentence is not a conclusion of this study as the glaciation history is already documented in the publication of Nice6g. In this section, I won't use past tense, as the results should stand.

Thank you for suggestion. We have revised the sentence.

24. L338: In this sentence, I am really not sure what the authors want to say.

We have removed the sentence.

Figures

In general the figure captions should be shortened.

We have rewritten the captions.

Figure 1: The LHB is not indicated on the map. Is the Zwally Antarctic Drainage System a common phrase? In the text the authors only use Antarctic Drainage System. Also Zwally et al. 2012 should be cited then. The regions 5, 6 and 7, I would call 'drainage basins 5–7 following the Antarctic Drainage System of Zwally et al. (2012)',

Thank you for the suggestion. We have mistaken the citation of used drainage. We have used the drainage system from Rignot et al. (2011).

The applied tool I would acknowledge in the acknowledgements. Furthermore, the figures were not developed but generated using GMT.

Thank you for the suggestion. We have revised the sentence.

Figure 2: In d), the differences are really marginal. Also, Fig. 2 does not assist the discription, L105–107, especially how the different regions evolve over time. I would change the sign of the unit, so that sea level equivalent represents a renormalised ice mass. Furthermore, why the authors do not plot the ice volume only for the regions of interest. Then, it would become more clear what happens. with the ice volume.

Thank you for the suggestion. We have revised the figure to focus only on the region. The unit was set to sea level equivalent to support discussions about the relationship with the global sea-level.

Table 1: 'vertical error was set to m' in the table as in the text also larger values appear. You should state the data only represent recent LHB data. You should add an appendix with the data presented in the HOLSEA format if you use new data.

Thank you for your suggestion. We have revised the vertical uncertainty in the table. We have uploaded the sea level data used in this study to ADS (<https://ads.nipr.ac.jp/dataset/A20240131-001>), which meets the criteria of HOLSEA.

Figure 3: I would not repeat here the parameterisations of the viscosity structures. The description of the different symbols used in the figure is really lengthy.

We have revised the captions.

Figure 4: For details one can refer to Figure 3. This guaranties the reader, that the set up of the two figures is the same.

We have merged Figure 3 and 4 to Figure 2.

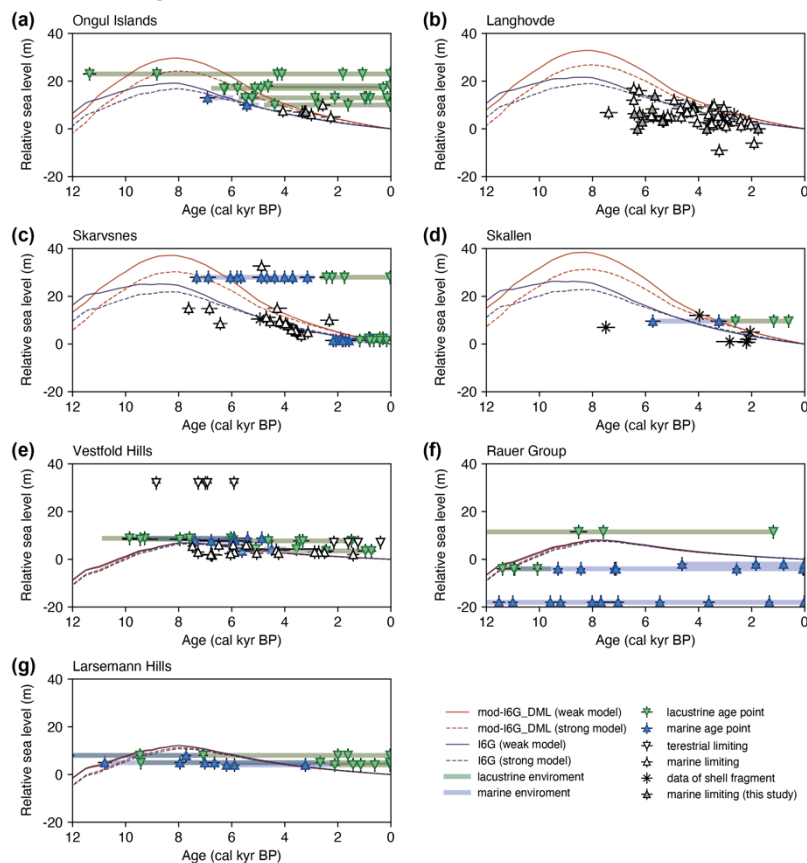


Figure 2: RSL data and GIA-predicted RSL over the past 12,000 years for (a) Ongul Islands, (b) Langhovde, (c) Skarvsnes, (d) Skallen, (e) Vestfold Hills, (f) Rauer Group, and (g) Larsemann Hills. Blue and red lines are the GIA-predicted RSL using the I6G and mod-I6G_DML, respectively. Solid and dashed lines denote the weak and strong models of rheology, respectively. Black upward- pointed triangles denote marine limiting of RSL data in this study. White upward- and downward-pointed triangles denote previously reported marine and terrestrial limiting. Crosses denote the data from shell fragments. Blue upward- and green downward-pointed triangles indicate age points of marine and lacustrine environments

obtained from isolation basin sediments, and blue and green thick lines represent durations of marine and lacustrine environments, established by Bchron (Haslett and Parnell, 2008). Age uncertainty is two sigma.

Figure 5: (g) should be (e).

Why not regroup, where the left column represents the results using the weak structure (a), (b), (e)=(a)-(b) and the right column the strong structure with (b), (d) and (f)=(b)-(d). The meaning of the circles I would explain at the end of the caption and also refer to Fig 1.

We have revised the figure as follows.

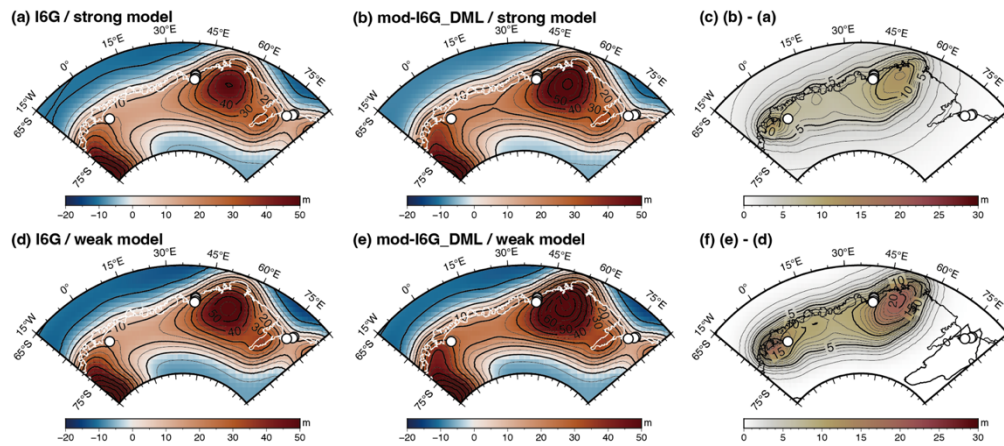


Figure 4: Spatial distribution of relative sea-level (RSL) at 8 ka, based on the different ice-loading histories and rheology models used in this study. Circles indicate the discussed RSL sites for (a) I6G and (b) mod-I6G for the strong model. (d) I6G and (e) mod-I6G_DML outputs for weak model. (c) portrays the offset between (a) and (b). (f) presents the offset between (d) and (e).

Conclusion

My recommendation is between resubmission and major revision.

We appreciate for your comments and look forward to your reply.

Sincerely,

Takeshige Ishiwa, Ph.D.