We thank the Editor and the three Reviewers for critical comments and suggestions, which helped to revise this manuscript constructively. We provide our answers to each question below.

Reviewer query: black

Answer: Blue

Added/revised text to the main manuscript: Blue, *italics*

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Reviewer 2#

General comments

This manuscript produces a new analysis of global-mean sea level change over the common era using process-based modeling with an examination of thermosteric and barystatic (Antarctic, Greenland, and glaciers) contributions through time. The authors compare their modeled GMSL with proxy reconstructions of global sea level and find general agreement, although the model-based estimate underestimates twentieth-century GMSL. They find that glaciers acted as the dominant source of GMSL changes during the common era; however, the uncertainties were large especially in the last millennium. The paper is generally clear and well written and while there are some large uncertainties in the results, it is valuable to have new process model-based estimates of GMSL to compare with proxy reconstructions and to further understand the relative contributions of processes driving GMSL changes over longer timescales through the common era.

I would recommend the manuscript to be published in Earth System Dynamics if the following several points could be addressed to improve the discussion of the results and comparison with proxy reconstructions. My comments focus on these aspects of the paper, as I cannot expertly comment on the intricacies of the process modeling methods themselves.

We thank the reviewer for this comment.

Specific comments

The last paragraph of the introduction mainly refers to analysis during the PCE (except for Ln 71 which says "changes over the CE") which is inconsistent. However, the results and discussion do cover the entire CE, not just the PCE, so I would suggest altering the text accordingly.

Thanks. We made a change and refer to CE in the text.

Because the authors clearly state questions in the introduction that the paper will attempt to answer (Ln 71-73), I would expect clearer answers to each of these questions in the discussion or at the conclusion of the paper. Especially concerning the major sources of uncertainty – while the large uncertainties are referenced throughout the paper, it would be helpful to clearly state the sources of these uncertainties at the conclusion of the paper and suggestions for how to minimize them in future work.

Thanks for this suggestion. We have added a final section (conclusion) in the paper to summarize the main conclusions of the paper and provide a general discussion of the uncertainties as pointed by the Reviewer.

Section 2.4 could be strengthened to explain the proxy-based reconstructions of global sea level – such as the proxy data that was used, the basic methods with spatiotemporal modeling. Specific details like Ln 361-365 describing the different curves could be moved to section 2.4 instead. It would also be helpful to more completely explain the Kopp/Kemp/Walker global reconstruction – that it is an estimate of global sea level via the signal common to all of the sea-level records in the Common Era proxy database. It is therefore the "globally uniform" term among sites from the spatiotemporal model, and not exactly an estimate of GMSL. The Kopp/Kemp/Walker method could give a true estimate of "GMSL" in the presence of spatially complete data.

Thanks! Also considering comments from Reviewer 1 on the same, we have expanded the description of proxy sea-level reconstructions in section 2.4 as shown below:

GMSL derived from proxy-based sea-level reconstruction for the common era from Kopp et al. (2016), Kemp et al. (2018) and Walker et al. (2022) are considered for comparison with our model GMSL. Those GMSL reconstructions are iterations of a spatio-temporal statistical model applied to a growing database of Common Era proxy reconstructions. In this spatio-temporal model framework, GMSL is an estimate of global sea level obtained from the signal "common" to all of the sea-level records in the Common Era proxy database. Since the GMSL is the "globally uniform" term among sites from the spatio-temporal model, the method could give a true estimate of "GMSL" in the presence of spatially *complete data. Consequently, the quality of the estimate depends on the geographic distribution of proxy records which is very uneven (however, some sensitivity tests to explore the effect of geographic distribution of proxy records has been done in Kopp et al. 2016). As the Walker et al. (2022) reconstruction is based on the latest update of the proxy sea-level database, and the Kemp et al. (2018) and Kopp et al. (2016) curves do not differ much over the CE, we show GMSL from Walker et al. (2022) and Kemp et al. (2018) in our model comparison. Also note that in Kemp et al. (2018), the GMSL during -100 – 100 CE is made equal to GMSL over 1600 – 1800 CE to avoid a spurious regional sea-level trend component. However, such a constraint is not employed in Walker et al. (2022) reconstruction. As a result, there is an apparent difference between the GMSL curves in these two reconstructions before ~ 600 CE.*

The descriptions of the proxy-based reconstructions of global sea level need to be corrected. In Ln 361-365 describing the methodological constraint, it is correct that Kemp et al. (2018) used this constraint. However, Walker et al. (2021) also utilized this constraint so this needs to be corrected in Ln 365. The constraint was used for all of the analysis in Walker et al. (2021) and the global curve shown in that paper uses the constraint. A supplemental figure in Walker et al. (2021) shows the global curve without using the constraint – which is the curve that is shown in this paper in comparison to the process model estimate. This needs to be made clear throughout this manuscript and in Figure 4. Alternatively, Walker et al. (2022) could be referenced, which did remove the constraint for the analysis and so the global sea-level results do not include the constraint – this would be the equivalent global curve to what is actually shown in this paper.
Walker, J.S., Kopp, R.E., Little, C.M. et al. Timing of emergence of modern rates of sea- level rise by 1863. Nat Commun 13, 966 (2022). https://doi.org/10.1038/s41467-022-28564-6

We thank the reviewer for pointing this out. To avoid any confusion and to reduce text, we refer to Walker et al. (2022) while discussing figure 4.

In Ln 339-342, could the authors speculate as to what would cause the differing response of the Greenland and Antarctic ice sheets to surface temperature changes? Or provide any references that also support these findings?

Greenland surface temperature and its sea-level contribution shows an in-phase variability. Higher temperatures induce more melting of the Greenland ice sheet and thus a sea level rise (Lines 334 – 340)). The relationship of Antarctic sea level contribution and surface temperature, on the other hand, was described as 'inverse' as the temperature increase over Antarctica leads to increased mass accumulation and a decrease in sea level (line 330 – 333). "*The surface temperature over Antarctica in the past two millennia (Stenni et al., 2017) exhibits an inverse relationship to sea level over multi-centennial periods*

(Fig. 2b). Our experimental design can explain this relationship as a warmer climate generally enhances precipitation over Antarctica and decreases the GMSL (Frieler et al., 2015; Medley and Thomas, 2019)". The dominance of different processes explains the differing response of the two ice sheets and we have shifted Lines 330 – 333 to after Line 342 to make this difference between the two ice sheets easier to follow.

In Ln 360 (and throughout the paper) I think it would be more clear and helpful to refer to "reconstructions" as "proxy-based reconstructions" instead.

We have modified the paper as suggested by the Reviewer.

In Ln 405-409, first a positive contribution is related to GMSL rise in Ln 405, meaning a negative contribution is related to GMSL fall in Ln 406. So how is in Ln 408-409 "All the GMSL components except Antarctic ice sheet have a positive contribution to net GMSL fall during 1200-1800 CE" supposed to be interpreted?

What is shown in panels 5 b-e is the ratio of the rate of individual contribution to total GMSL rate (in terms of percentage). Hence, a positive contribution simply means that the rate sign of both the component and GMSL are same (i.e. both rates are either positive or negative). And, a negative contribution means that ratio is negative (GMSL and component rate have different signs). Hence, "*All the GMSL components except Antarctic ice sheet have a positive contribution to net GMSL fall during 1200-1800 CE*" means that the net GMSL and sea level from individual components (except Antarctic) is falling (ratio is positive) during the 1200-1800 CE.

I understand the uncertainties and limitations using the process-based model, but I find it difficult to put too much weight on the results for the PCE, when the 20th century global sea-level estimates are inconsistent with reconstructions and observations and are underestimated to a degree that there is not even overlap within the uncertainties. If the model was altered/improved to match the observations/reconstructions in the twentieth-century, how would this change GMSL and the relative contributions of driving processes (especially glaciers) over the rest of the PCE? Can a more formal list of improvements be recommended to address this discrepancy? How much of this is due to the initial conditions in the model and is there a way that these could be adjusted? I think these questions need to be addressed more completely in the discussion.

The underestimation of twentieth-century model GMSL comes from the barystatic components (see for instance the agreement between model and reconstructed twentieth-century thermosteric sea level in fig. 1). We have uncertainties on model initialization, reference climate state used, and forcing fields in the common era. Alternative strategies are possible as the reviewer suggests. The models state in 1800 results from the simulation since 1CE and thus may integrates biases over this all period, in particular due to model drift and uncertainties in the forcing. We could 'correct' the state in 1800 to have better results over the last 2 centuries but, for example, the glacier distribution around ~1800 to initialize the model is not well-known and of the new model drift it will induce at the start of the simulation is hard to estimate. Such experiments would be interesting but our goal is to provide a consistent set up over the full millennium, with uncertainties clearly highlighted, not to have the most realistic set up for the twentieth-century (which is the aim of other existing studies (e.g. Marzeion et al. 2015; Frederikse et al. 2020) as we have noted in section 4.1: "*Uncertainties on ice sheet simulations are even larger and what we present here is a qualitative description of ice sheet changes in the common era based on Physics but it's quantitative assessments (for example the twentieth-century change) require further improvements (better constraining the climate forcing, developing paleo data etc.)*". We have added a few more sentences to highlight these aspects in the discussion part.

Technical corrections

Ln 49, 50, 361, 365: these should reference Walker et al. 2021, not 2020

It is corrected.

Ln 424: 'focused' spelled incorrectly

Thanks. It is corrected.

Figure 1: the caption says the Zanna et al., (2019) reconstruction is blue, but it is green on the figure

Thanks. It is corrected.

Figure 4b: would be helpful to show the uncertainties in the rates for the Kemp/Walker/Neukom curves

The confidence level of the model GMSL rate is estimated using the large ensemble members (section 2.5.2 L262). On the other hand, single confidence level (another single curve) is available for the reconstructions. Moving rate of this additional curve would not be an uncertainty estimate of the original rate curve. Also, showing the range of all the curves would make the figure hard to read. Given these, we restrain ourselves showing the range of rate curves for the reconstructions.