1 Response to Anonymous Referee #1

The authors present a framework to produce probabilistic sea-level projections which allows to incorporate and update contributions from different models of the individual drivers in a flexible, yet consistent, way. It builds on the ISSM-SESAW sea level solver by Adhikari et al. (2016), which was also presented in this journal and which is based on an unstructured mesh, allowing high accuracy at very limited computational costs. The manuscript is clear, it reads well and it presents enough graphics to show the working and capabilities of the software package. Below, I am suggesting a number of minor improvements, listed in the order as they appear in the manuscript.

We thank the referee for the time spent reviewing the manuscript, and for the positive assessment of the manuscript and the methodology implemented in the ISSM-SLPS projection capability. We have tried to address all the concerns raised, as well as present the changes that will be implemented in the amended manuscript to be submitted once the editor requests.

- Line 60: The argument about the time invariancy of fingerprints does not seem very strong, since it is always possible to increase the number of fingerprints for a given source, with the option of using independent scaling factors for each sub-source. Besides, the authors do not seem to demonstrate the effect of time-variable fingerprints on sea level projections. The improvement could be from a computational point of view (due to, e.g., the modularity of the approach), but then it could be explained more clearly.

  We agree with the referee that it is always possible to increase the number of fingerprints for a given source, and of using several across time too. However, doing so converges towards a solution that we effectively generalized in our framework, where we can handle any type of thickness change pattern at whichever resolution is required, and at whatever time resolution is optimal. We agree with the reviewer that we have not in the manuscript shown the effect of time variable fingerprints explicitely, though we did compute temporally variable fingerprints to generate Fig. 8. Fig. 1 of the present document shows the impact of temporarlly variable fingerprints using an ISMIP6 model projection of ice thickness changes in Greenland. The figure clearly demonstates the significant impact between normalized RSL fingerprints at 2016 vs 2045 and 2075 , with significantly different spatial patterns down to Marocco or Cuba, and over the entire arctic. We will add this figure to the manuscript, as it quantifies clearly the need for temporally variable fingerprints, and we will add the following text in the manuscript:
  An example of the inadequacy of temporally constant fingerprints is shown in Fig. 1 for a projection of Greenland's contribution to RSL at 2016 vs 2045 and 2075. Normalized RSL patterns are clearly different between 2016 and 2045, and the differences are not just local to Greenland, but spill over into North Europe, Alaska, the Canadian arctic, etc...

- Line 65: Not sure what "profound geometry" means, it is possibly a typo.
  We will replace "profound geometry" with "pronounced spatial pattern", which was the original intended meaning.

- Line 124: Could you add a reference about the "alternative approach" described here?
  Thank you for the suggestion. We will add Thompson et al. (2016) (Fig.3) as an example of this approach.

- Line 148: I guess the term STR refers to a global mean value, not a local one as stated, since RSL_{STR} only depends on time.
  We thank the reviewer for catching this, indeed STR refers to the global mean value. We will correct the manuscript accordingly.

- Line 168: I am surprised by the fact that RSL_{GRD} includes viscoelastic deformation of the solid earth, rather than just elastic as in most studies of this kind. If this is the case, it should be highlighted in the introduction.
  We thank the reviewer for spotting this. Indeed it should be explicitely noted that visco-elastic deformation is currently allowed in the projection system. Here, we define visco-elastic deformation any deformation that is not related to GIA, but to smaller time-scale loading processes (50 to 100 years) as observed in West Antarctica Barletta et al. (2018). In practice, this type of deformation is not yet handled in ISSM, but will in the future. We will make the following explicit comment in the manuscript at line 151: *This implies that viscoelastic deformation is split between long-term time scales and short-term fast rebound of the bedrock uplift, such as observed in West Antarctica (Barletta et al., 2018), acting essentially oveer time scales of 50-100 years.*

- Line 215: I suggest adding that the number of elements is significantly smaller than in the case of an equi-angular 1x1-deg grid, which would already be rather coarse.
  We thank the reviewer for the suggestion, indeed the equi-angular grid at 1x1 deg would require 64,800 vertices, with our mesh standing at only 19,486. We will add this to the manuscript.

- Lines 225-241: I am not sure whether showing a few lines of code is normal in GMD, but, if possible, it would be nice to replace this by a flow chart.
  We understand the reviewer's point of view. We have debated this extensively, having in the past presented pieces of code in GMD. However, this is the main algorithm core, and we believe it should be explicitely and exactly described. The goal here is to avoid any confusion that could arise from a flowchart. We respectfully ask to keep the code as is, but will defer to the editor's decision.

- Line 299: It seems a few words are missing, since Fig.8b shows GMSL values, while values for 9 cities around the world are shown in Fig.9. In addition, the caption of Fig.9 does not mention the timeframe for which the projections are generated.
  We thank the reviewer for pointing this redirection to the wrong figure. We

will correct the manuscript accordingly, and add a quick description of Fig 8b in the text as showing the evolution of GMSL's PDF through time. We will also add the time frame in Fig. 9.

- Line 304: I suggest also mentioning that the width of the two PDFs shown in Fig.10 is different, rather than only the mean, because it makes an even stronger point about the benefit of this approach.
  We thank the reviewer for the suggestion. After checking though, the PDFs standard deviations are only different by .4% on a relative basis. The PDFs do indeed appear different at their basis, but we believe this is a visual effect from the color choice. We will put a comment to this effect in the caption of Fig. 10 to dispel any confusion.

- Line 316: "impact" (spelling).
  Thank you for pointing out the typo, we will correct the manuscript accordingly.

- Line 338: The importance of "geodetically compliant patterns", in spite of being part of the manuscript title, is nowhere really discussed nor explained. From this line, my understanding is that it refers to the possibility of defining the mesh in such a way that it matches the location of specific geodetic observations, hence avoiding unnecessary interpolations. In any case, the issue warrants a more extensive discussion, possibly in the introduction.
  We thank the reviewer for the comment. Geodetically compliant referred to the fact that ISSM-SLPS computes spatio-temporal GRD patterns throughout the projection sampling, which is not always done consistently for other similar frameworks. We will add comments in the introduction referencing this explanation explicitely. In particular, we will add the following at line 117: *"The latter feature builds the basis for a geodetically compliant projection system where GRD patterns and their computations is done systematically and does not introduce biases in the RSL projections."*

References

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Goelzer, H., Nowicki, S., Payne, A., Larour, E., Seroussi, H., Lipscomb, W. H., Gregory, J., Abe-Ouchi, A., Shepherd, A., Simon, E., Agosta, C., Alexander, P., Aschwanden, A., Barthel, A., Calov, R., Chambers, C., Choi, Y., Cuzzone, J., Dumas, C., Edwards, T., Felikson, D., Fettweis, X., Golledge, N. R., Greve, R., Humbert, A., Huybrechts, P., Le clec'h, S., Lee, V., Leguy, G., Little, C., Lowry, D. P., Morlighem, M., Nias, I., Quiquet, A., Rückamp, M., Schlegel, N.-J., Slater, D., Smith, R., Straneo, F., Tarasov, L., van de Wal, R., and van den Broeke, M.: The future sea-level contribution of the Greenland ice sheet: a multi-model ensemble study of ISMIP6, The Cryosphere, https://doi.org/10.5194/tc-2019-319, URL `https://www.the-cryosphere-discuss.net/tc-2019-319/`, 2020, accepted.

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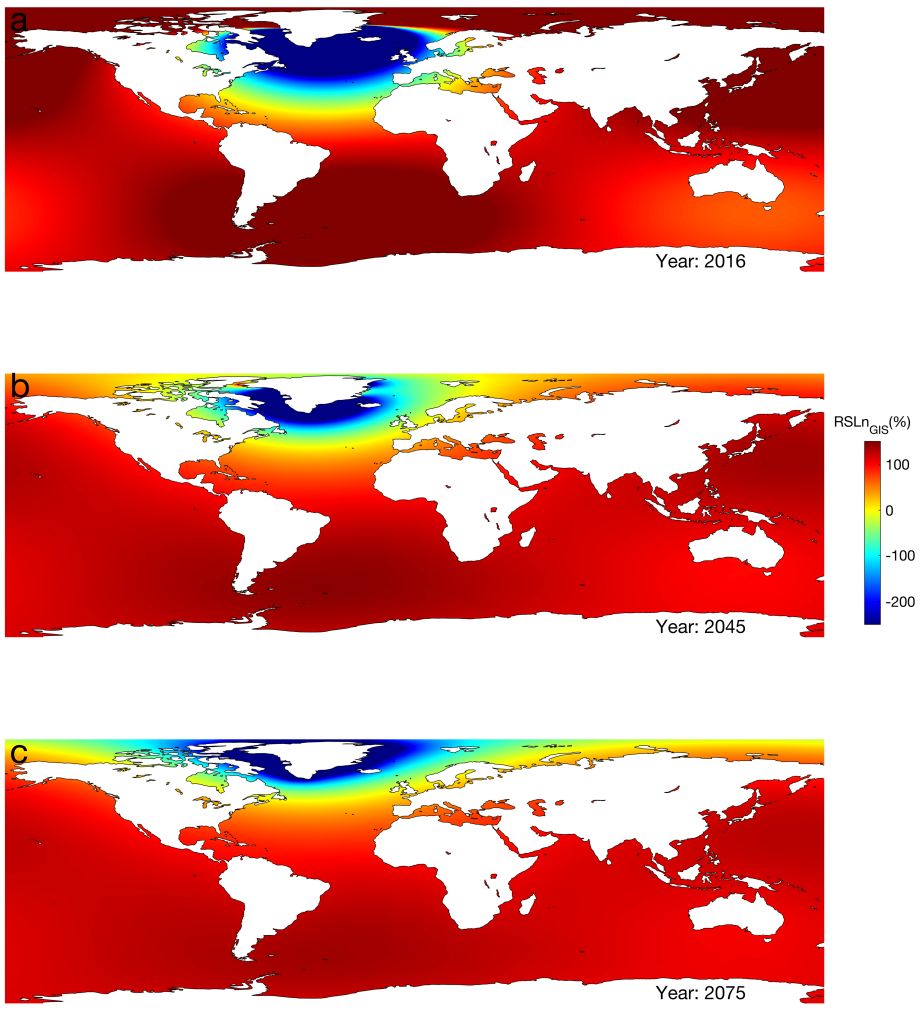

Figure 1: Normalized fingerprints for Greenland at 2016, 2045 and 2075, based on the JPL ISSM experiment 5 simulation contributed to ISMIP6 (Goelzer et al., 2020, accepted). Variations in ice-thickness change patterns are significantly different between the East and West coast of Greenland, and along a South-West gradient too, resulting in significantly different contributions to local RSL at different time snapshots