

# 1 Response to Anonymous Referee #2

The authors developed a new method to account for feedbacks between ice sheets, ocean circulation and solid-Earth deformation through dynamically computed sea-level fingerprints for probabilistic projections of local sea-level change. This is a significant and timely contribution because current probabilistic projections use static fingerprints and cannot readily incorporate advances in forward models. The manuscript is well-structured and provides clear examples of how the SLPS works. However, I think the clarity of the manuscript could be improved with some (minor) modifications of the text and figures, see the comments below.

We thank the referee for the time spent reviewing the manuscript and for the positive assessment of the manuscript, in particular the capability of ISSM-SLPS to readily update projections with new forward modeling advances that are tightly coupled with the framework. We address below all the concerns from the referee, and present future changes to the manuscript that will be implemented if the editor moves forwards with accepting corrections.

- L4: For long-term projections (. . .) that provide such probabilistic projectionstive, can this be rewritten?  
*Indeed this is too heavy, we will reformulate to "For a time horizon of 100 years, frameworks have been developed that provide such projections by relying on ..."*
- L8: solid-Earth ‘uplift’ – displacement or deformation would be more complete?  
*We thank the reviewer for the comment, but believe that solid-Earth uplift is a terminology used throughout the Cryosphere/solid-Earth community that has a very specific meaning. Deformation could convey lateral motion too, as well as displacement. Our focus here is on deformation that impacts RSL through VLM in particular. We respectfully would like to keep the terminology as is.*
- L26: why not give examples of the use of projections globally rather than so many references for just the US?  
*We understand the concern of the reviewer, however, here the intent of the manuscript was to point out to how widely the KOPP14 framework has been adopted. For assessment outside the US, the onus is significantly more on the IPCC assessments, which are arguably, given their 4 year cycle, not as responsive to more recent developments in the science community. Given that our intent was focused on the KOPP14 framework we would like to respectfully request to keep ours references as is.*
- L37 & 118: sterodynamic sea-level change is defined incorrectly here, see Gregory et al. (2019). It is the sum of global (not local) thermosteric expansion and ocean dynamics (which include the local steric effect, both thermo- and halosteric) including the IB effect. Can the authors clarify

this?

Another referee #1 pointed to the same issue, and we thank you for spotting this issue. The definition for STR and DSL for our manuscript indeed follows Gregory et al. (2019). The confusion came from the erroneous use of "local" instead of "global" at line 37. The sentence will now read *"which is the sum of globally averaged thermosteric expansion and local sea-level changes due to ocean dynamics (which include the local steric effect, both thermosteric and halosteric)."*

- L38 & 55: Not just ESMs but also AOGCMs  
Duely noted, and the manuscript will be updated accordingly
- L47: Do you mean Kopp et al. (2017) here instead of (2014)?  
Indeed that is what we meant, thank you for spotting the typo, will be reflected in the amended manuscript.
- L64-66: Can the authors comment on the expected importance of geometry changes to 21st century sea-level projections?  
Referee #1 had a similar comment referring to the fact that we did not demonstrate the importance of time variable fingerprints. We will add an example figure (Fig. 1) of the evolution of  $RSL_{GRD}$  for the Greenland Ice Sheet, using a projection from ISMIP6 (Goelzer et al., 2020, accepted) based on the ISSM JPL run for experiment 5. The nominal fingerprints are shown to be significantly different between 2015 and 2100. We refer the reader to the response to referee #1 for the figure, comments, and corresponding changes to the manuscript that address the present comment also.
- L83: 'results such as (. . .) results' - please rewrite  
We will rewrite this sentence to *"In order to be able to account for strong couplings, or to even be able to ingest recent modeling results, one needs to propagate the local mass changes and the associated uncertainties into regional sea-level projections. This is particularly relevant now given new modeling runs that have been carried out within large Modeling Intercomparison Projects (MIPs) such CMIP5 and CMIP6, as well as ISMIP6 or GlacierMIP2."*
- L91: 'higher-frequency' higher than what? Perhaps use 'high-frequency' instead?  
Thank you for the suggestion. We will replace to "high-frequency", and better define what is meant, with frequencies of interest being daily to monthly.
- L97-103: this paragraph misses a final sentence placing its content in context of the manuscript  
We agree with the reviewer, and will add the following sentence at the end of the paragraph *"All these advances need to be fully integrated into new*

*probabilistic projections of sea-level change, and a new approach therefore needs to be envisioned that will allow for such new processes to be accurately modeled.”*

- L104-107: this sentence doesn't read very well, can you please split this up in smaller sentences?

*We agree with the reviewer. Actually, the whole paragraph will be recast to "Indeed, moving from strategies where continental scale mass changes are sampled and multiplied with the corresponding fingerprint, to actually sampling upstream model inputs is paramount to improving the state of the art. In particular, there is a strong need to fully account for spatial patterns of mass change and their uncertainty (see e.g. Fig. 1b-d), This applies to among others SMB, basal friction, or ice and solid-Earth rheological properties."*

- L114-115: 'and through . . . individual sample' misses a verb, perhaps reverse the order with 'retaining the . . .from Eq. 1'

*We will rephrase the paragraph to "We improve the existing process-based approach by using the Ice-Sheet and Sea-Level System Model (ISSM, Larour et al, 2012c) which allows for inclusion of forward model physics. It also improves the modeling and sampling of covariances between input processes, both temporally and spatially through the computation of high-resolution barostatic-GRD patterns. "*

- Figure 3: the axis labels have fallen off the figure.

*Thank you for spotting this issue, will be fixed in the amended manuscript*

- Figure 5: It is very hard to distinguish colors of cells within the mesh, could this be improved by for example adapting the range of the colorbar?

*We thank the reviewer for the suggestion. By saturating the colorbar, we reach better contrast. We will do so for the manuscript, and provide an improved figure. We will also amend the caption to explain why we saturated the colorbar.*

- L253: has a typo 'approach'

*Thank you for spotting the typo, will be corrected in the manuscript*

- L291-292: "DSL is not sampled, but rather deterministically set to the DSL term of the CMIP5 NorESM-ME runs" – why? please explain

*This is due to the uncertainty in the quality of the CMIP5 runs in terms of global mean thermosteric contribution. We preferred to avoid this uncertainty and concentrate on the geodetically relevant components given the scope of the manuscript.*

- L299: refers to figure 9 instead of 8, and discussion of Figure 9 is missing?

*We refer to referee #1 comments, which also spotted this issue.*

- L316: "inpact"

*Thank you for the typo, will be corrected in the manuscript.*

- L343: 'urther'

Thank you for spotting the typo, will be corrected in the manuscript.:w

## References

- 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.
- Gregory, J., Griffies, S., Hughes, C., et al.: Concepts and Terminology for Sea Level: Mean, Variability and Change, Both Local and Global, *Surv. Geophys.*, 40, 1251–1289, 2019.