

The study addresses a limitation of EOF-based GMSL reconstructions in capturing interannual variability. The proposed approach of examining and modelling the Signal Differences between tide gauges and nearby altimetry is well motivated, and the reported improvement in the reconstructed GMSL variability is promising. The manuscript is generally clearly structured, and the topic is meaningful to the sea-level reconstruction community.

Two methodological details require clarification before publishing. In particular, the treatment of GIA corrections and reference frames, and the possible contribution of non-linear and periodical vertical land motion signal to the estimated Signal Differences.

1. Please clarify the treatment of GIA corrections and reference frames. The manuscript states that the tide-gauge records are corrected for GIA, while the altimetry data are also corrected using the **drad250** GIA correction. Since tide gauges measure relative sea level whereas satellite altimetry measures absolute sea level, it is unclear whether these two GIA corrections place the two datasets into the same reference frame. The manuscript seems to apply two different GIA-related corrections: a relative sea-level GIA correction to tide gauges and a **drad250** radial-deformation correction to altimetry. Please explain how their application ensures that the corrected tide-gauge and corrected altimetry records are comparable in a common reference frame before calculating the Signal Differences.

Reply : We thank the reviewer for raising this very important point. We did find that GIA Altimetry correction was applied incorrectly in the original manuscript. We confirm that the Altimetry GIA was applied correctly in this revised manuscript and the subsequent analysis redone. To clarify the GIA corrections, in this study, tide gauge data were corrected using the relative sea level prediction (drsl250.PSMSL.ICE5Gv1.3_VM2_L90_2012b), which includes both the geoid change and vertical land motion contributions (https://psmsl.org/train_and_info/geo_signals/gia/peltier/index.php). For the altimetry data, we applied the geoid-only GIA correction, obtained as the sum of the relative sea level and vertical land motion components (dsea250.lgrid.ICE5Gv1.3_VM2_L90_2012 + drad250.lgrid.ICE5Gv1.3_VM2_L90_2012). We have revised the manuscript text to make this distinction clear. (Please see lines 191 to 194)

2. Recent studies have shown that vertical land motion (VLM) at tide-gauge sites cannot always be represented as a purely linear process, and that nonlinear VLM can affect tide-gauge relative sea-level records and their interpretation (Oelsmann et al., 2024). In addition, GNSS studies have identified quasi-periodic surface displacement signals near a 6-year period, including vertical components (e.g., Ding and Chao, 2018). Similar signals have also been reported in satellite-altimetry-minus-tide-gauge

residuals and have been considered when aligning tide-gauge and altimetry records for sea-level reconstruction (Wang et al., 2025). Because the Signal Differences in this study are defined as the difference between tide gauge and altimetry, it would be useful for the authors to clarify whether such vertical land-motion-related signals could contribute to the estimated differences. If these land-motion-related signals can be incorporated into the framework, they may further improve the resulting GMSL reconstruction. It will be better if the authors test this possibility. If such an analysis is beyond the scope of the present study, the authors should acknowledge this issue as a potential limitation and discuss how it may affect the interpretation of the regression-based correction.

Reply : We have added a paragraph in the discussion that addresses the VLM. Thank you (see lines 655 to 665).

Other comments

Line 117:

“though linear regression” should be “through linear regression.”

Reply : Corrected, thank you (line 121).

Line 158:

The sentence “A total of seven yearly observations were removed from the entire data set during this procedure” is somewhat unclear. Please specify whether these seven removed observations correspond to seven station-years across different tide gauges, seven years from a single tide gauge, or another configuration. It would also be helpful to list the affected tide-gauge stations and years, or provide this information in a table or supplement.

Reply : We have added text in the manuscript that references a table (Table1) showing the tide gauges that have been affected. Thank you (see lines 161 to 171)

Line 160:

The manuscript states that the quality-controlled tide-gauge stations were spatially averaged into $1^\circ \times 1^\circ$ tide-gauge bins. Please clarify the exact binning procedure. For example, were all stations falling within the same $1^\circ \times 1^\circ$ grid cell averaged directly, or was an additional distance criterion used? Please also specify how stations with overlapping or different temporal coverage were combined within each bin.

Reply : We have added text to the manuscript to make it clearer, thank you (lines 174 to 177)

Lines 221-223: The notation may be visually confusing because the summation operator $\sum$ and the covariance matrix Σ appear very similar. I suggest better to distinguish it clearly from the summation symbol.

Reply : We changed the summation operator $\sum$ to a bold font and placed the upper limit ($i=N$) and the lower limit ($i = 1$) above and below $\sum$ making it more obvious this the symbol represents the summation operator compared with the covariance matrix Σ that is not bold and does not have upper and lower limits. Thank you (lines 240 to 243)

Line 296:

There is an extra period after “reconstruction.” Please change “reconstruction.” to “reconstruction.”

Reply : Corrected, thank you.

Line 315:

“using 229 tide gauge” should be “using 229 tide gauges”

Corrected, thank you. (line 340)

Line 425:

Reply : “less of factor” should be “less of a factor.”

Corrected, Thank you (line 450)

Line 582:

Reply : “large scale” should be hyphenated as “large-scale” when used adjectivally.

Corrected, thank you. (line 609)

References:

Oelsmann, J., Marcos, M., Passaro, M., Sanchez, L., Dettmering, D., Dangendorf, S., & Seitz, F. (2024). Regional variations in relative sea-level changes influenced by nonlinear vertical land motion. *Nature Geoscience*, 17(2), 137–144. <https://doi.org/10.1038/s41561-023-01357-2>

Ding, H., & Chao, B. F. (2018). A 6-year westward rotary motion in the Earth: Detection and possible MICG coupling mechanism. *Earth and Planetary Science Letters*, 495, 50–55. <https://doi.org/10.1016/j.epsl.2018.05.009>

Wang, S., Shum, C. K., Bevis, M., He, X., Zhang, Y., Ding, Y., Zhang, C., & Montillet, J.-P. (2025). Sea level reconstruction reveals improved separation of regional climate and trend patterns over the last seven decades. *Earth System Science Data*, 17(12), 7055–7077. <https://doi.org/10.5194/essd-17-7055-2025>

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