

## Authors' Response to Reviewer 3

### General Comment.

Global sea level budgets are examined using two machine learning techniques. Through identifying regions of similar sea level variability, the authors examined sea level budget in different basins of the world oceans. It is found that for most of the ocean regions, sea level variation can be explained using steric height changes and mass transport between ocean and land. But for some highly dynamic regions, the sea level budget closure may be affected by the mass redistribution associated with strong western boundary currents. All these make sense to this Reviewer. This is an excellent example of SOM application in oceanography and climate research community. I would like to recommend the manuscript be accepted after some minor revision. Specific comments are listed as follows.

### Response:

Dear Reviewer,

Thank you for your feedback and positive review. We have addressed all the issues item by item as follows.

Kind regards,

Carolina Camargo, on behalf of the authors

## Comment 1

Pioneer work on SOM analysis of sea level variability should be properly mentioned. These include the first time SOM analysis of the satellite altimetry data (Liu et al., 2008), and the dual-SOM applications including the regionalizing of sea level variability in the Gulf of Mexico (Liu et al., 2016). It would be good to add the following information to the paragraph explaining the SOM (L138 - L156) or the Introduction part (L44-45):

“SOM has been used to extract patterns of sea level variability from satellite altimetry data (Liu et al., 2008; Nickerson et al., 2022; Weisberg & Liu, 2017). Dual-SOM application has been proposed to analyse sea level data, one focused on the characteristic spatial patterns, and the other focused on the characteristic time series, using sea level in the Gulf of Mexico as an example (Liu et al., 2016). The latter resulted in regionalizing the sea level variability, and is pursued here in this study to analyse global sea level data.”

**Response:** We have added the information about pioneer work on SOM on the paragraph explaining the SOM

The ability of SOM to extract patterns of sea level variability from satellite altimetry data has been shown in previous works (e.g., Hardman-Mountford et al., 2003; Iskandar, 2009; Liu et al., 2016; Liu et al., 2008; Nickerson et al., 2022; Weisberg & Liu, 2017). To analyse sea level data, SOM can be applied either on the spatial domain, focusing on the characteristic spatial patterns, or on the time domain, focusing on the characteristic time series (Liu et al., 2016). The latter results in regionalizing the sea-level variability, and is pursued here in this study to analyse global sea level data.

### Comment 2

L361-L362 indicate the challenges of sea level budget in coastal regions. This is true, as coastal ocean dynamics of sea level (e.g., Liu & Weisberg, 2007) are more complicated than that of deep ocean, and key dynamics may not be properly represented in the global data. It would be good to add a sentence to L364 about the sea level budget issues for coastal regions: “Note that sea level budget for coastal regions is more challenging (Liu & Weisberg, 2007) with some of the dominant coastal ocean dynamics are not properly represented in the global data sets.”

**Response:** Thank you for the comment. Indeed, the sea-level budget in coastal regions is more challenging. We added a sentence about this, as suggested by the reviewer:

Note that the sea-level budget in coastal regions is more challenging (Dangendorf et al., 2021), since some of the dominant coastal ocean dynamics are not properly represented in the global data sets (Liu & Weisberg, 2007).

### Comment 3

Throughout the manuscript, “sea-level” should be changed to “sea level” — no hyphen.

**Response:** We appreciate the suggestion. There is no clear consensus if sea level should be hyphenated or not. We hyphenate sea level when it is used as a compound modifier and not when used a *noun* phrase. For example: "Global sea level rose over the past century."; "What causes sea-level rise?"

#### Comment 4

The abbreviations of “sea level change” and “sea level budget” are not necessary at all. They do not save much space in text, rather they may cause inconveniences to readers, as readers may need to go back to search what they stand for, particularly for the case of many other acronyms are used later.

**Response:** We understand that acronyms can cause confusion. We have removed the abbreviations of SLC and SLB for "sea-level change" and "sea-level budget", respectively.

#### Comment 5

L23, it would be good to provide an example, Chambers et al. (2017), for this sentence.

**Response:** We added the reference example to the sentence:

The attribution of sea-level change to its different drivers is typically done using a sea-level budget approach (Cazenave et al., 2018; Chambers et al., 2017).

#### Comment 6

L90, GRD is not defined.

**Response:** Thank you for calling our attention. It should have been defined in the previous paragraph. We added GRD definition:

$\eta_{GRD}$ , the Gravitational, Rotational and viscoelastic Deformation (GRD) response of the Earth to ...

### Comment 7

Line 139, it would be good to insert a sentence to mention the powerfulness of the SOM technique: “It was demonstrated to be more powerful than conventional feature extraction methods (e.g., Liu & Weisberg, 2005).

**Response:** Thank you for the suggestion. We added the mention of the advantage of SOM over the other techniques:

SOM (Kohonen, 1982) is a feature extraction and classification method based on an unsupervised neural network (Liu et al., 2006), which was demonstrated to be more powerful than conventional feature extraction methods (e.g., Liu & Weisberg, 2005).

## References

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