

## ***Interactive comment on “Sea level budget over 2005–2013: missing contributions and data errors” by H. B. Dieng et al.***

**Anonymous Referee #3**

Received and published: 1 July 2015

Title: “Sea level budget over 2005–2013; missing contributions and data errors”

The paper investigates the residuals between observed global mean sea level and the sum of the steric sea level and mass ocean components for the period January 2005 to December 2013. The objective is “to identify the impact of errors in one or several components of the sea level budget on the residual time series”. More specifically, the authors study: 1) the impact of errors in the different components of the sea level budget (GMSL, ocean mass or steric level) on residual trends; and (2) whether and to what extent each component of the sea level budget is responsible for all –or part – of the observed short term (from sub-seasonal to multiannual) residuals.

For the study several residuals time series are considered. Each residual time series corresponds to a certain combination of data products. In particular, the authors com-

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bine in different ways “six altimetry products for the GMSL; four Argo products plus ORAS4 ocean reanalysis for the steric sea level and three GRACE-based ocean mass products”.

The impact of errors in the components of the sea level budget (GMSL, ocean mass or steric level) on residual trends is addressed in section 3. The proposed methodology consists on studying the robustness of residual trends estimation with respect to different data products for a certain component. If residual trends do not vary much using different data products for a certain component (like it is the case for ocean mass and steric sea level) then it is inferred that impact of errors in that component on the residual trend is small. While large variations of residual trends using different data products for a certain component (like it is the case for GMSL) are interpreted as evidence that impact of errors in that component on the residual trend is large. As discussed in section 5, the authors “found that errors in the GMSL products have large impact on the residual trends, with differences, up to 0.55 mm/yr that prevent from accurately constraining missing contributions”.

Whether and to what extent each component of the sea level budget is responsible for all –or part – of the observed short term (from sub-seasonal to multiannual) residuals is addressed in section 4. The proposed methodology in this case consists on evaluating the correlation between each component (detrended) and the (detrended) residuals. The idea is that “What we would expect, if all data sets were error free, is to see no correlation between the detrended variable and its associated (detrended) residuals. The authors found that “at short time scale, residual anomalies are correlated with ocean mass and steric sea level anomalies, indicating that the residual anomalies are related with errors in both GRACE-based ocean mass and Argo-based steric data”.

Also in section 4 the authors provide evidences of the importance of missing Argo data in the Indonesian region for the closure of the sea level budget.

The problem discussed in the paper is important. The study of the impact of errors in

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the components of the budget equation to both trend residuals and short term residuals, and especially the recognition of the relevance of missing Argo data in the Indonesian region for the closure of the budget equation are valuable contribution to the field. There are, however, some issues that need to be addressed. A more detailed discussion follows.

Comment 1. At the beginning of section 3, it is said:

“In this section we present the residual time series. The main objective is to check whether the residual anomalies are correlated- or not – with one or several terms of the sea level budget (GMSL, ocean mass and steric sea level). A significant correlation of the residuals with one component of the budget equation would indicate that this particular component is in error. If not, the residual time series should not contain any signature of that component, because this component signal is supposed to be compensated by the other components in the budget equation”.

According to this sentence one would expect that correlation between residuals and each component of the sea level budget is going to be evaluated in this section, and that high correlation should be interpreted as that component is in error. However when we continue reading in section 3 no correlation between residuals and the components of the sea level budget is evaluated. Rather, in section 3.1, robustness of estimates of residual trends using different products for a certain component is addressed and at the end of section 3, it is said:

“From this section, we conclude that the largest trend differences observed in the residuals time series (Fig.2) come from differences in the altimetry-based GMLS products”.

This result is then interpreted by the authors in section 5 (Conclusions) as that

“ errors in the GMLS products have large impact on the residual trends, with differences, up to 0.55 mm/yr that prevent from accurately constraining missing contributions”.

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As observed before, only correlation between detrended time series are considered in the manuscript, and presented in section 4 of the paper to study the impact of errors in one or several components of the sea level budget on the observed short term (from sub-seasonal to multiannual) residual.

If residual with trends, in section 3 are used to study the impact of errors in one or several components of the sea level budget on the residual trends, this should be clearly stated in the introduction of section 3. Same for the methodology used to achieve this goal. The introduction of section 3 is misleading and should be rewritten.

Comment 2. A rigorous comparison and grouping of the trends shown in table 1 would require to take into account uncertainty on estimated trends (for example evaluating confidence intervals for trends, large overlap of confidence intervals would indicate that there is no evidence that two trends are different). If this is not done the limitation of the information on table 1 for trends comparison and grouping should at least be acknowledged.

Comment 3. As observed before, in order to study whether a given variable (GMSL, ocean mass or steric level) is responsible for all –or part – of the observed short term (from sub-seasonal to multiannual) residual, in section 4 the authors suggest to evaluate the correlation between each variable (detrended) and the (detrended) residuals. The idea is that “What we would expect, if all data sets were error free, is to see no correlation between the detrended variable and its associated (detrended) residuals. Therefore low correlation indicates good result, i.e. little contamination by errors of the associated variables”

The idea of evaluating the correlation between detrended residuals and detrended sea level budget components to evaluate the impact error in one or several components of the sea level budget on the observed short term (from sub-seasonal to multiannual) residual might be intuitive, but ignore interactions between errors in different components of sea level budget and correlation between (detrended) sea level budget compo-

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nents. What would be the performance of the proposed method in complex scenarios, where several components are contaminated with errors and correlated to each other? The uncertainty on the performance of the proposed methodology in complex scenarios should at least be acknowledged in the manuscript.

Comment 4. At the end of section 3, it is said:

“From this section, we conclude that the largest trend differences observed in the residuals time series (Fig.2) come from differences in the altimetry-based GMLS products”.

Then in section 5 (Conclusions) it is said:

“We found that errors in the GMLS products have large impact on the residual trends, with differences, up to 0.55 mm/yr that prevent from accurately constraining missing contributions”.

According to the interpretation of the results of section 3 presented in section 5 (conclusions), the methodology proposed by the authors to assess the impact of errors in the components of sea level budget on the residual trends implicitly assumes the identity:

(robustness of residual trend estimation with respect to different data products for a certain component)= (low impact of the error in that component on the residual trend)

If residual trend do not vary much using different data products for a certain component (like it is the case for ocean mass and steric sea level) then the impact of the error in that component on the residual trend is small. However, the fact that different data products for a certain component lead to similar inferences for residual trends does not necessarily implies that the component is well estimated, inferences could be robust but wrong. In addition, the range of values for residual trend estimates using different GMLS data product provides a measure of uncertainty on residual trends based on existing GMSL data products, but does not directly measure error in the GMSL component.

Minor corrections.

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Line 109: “ less data sets. . Another” should be “less data sets. Another”

Line 115: “(CCI)project” should be “(CCI) project”

Line 224: “Fig.1cshows” should be “Fig.1c shows”

Line 228: “we not differences” should be “we note differences”

Line 317: “associated residuals” should be “associated (detrended) residuals”

Line 326 and 353: “ the correlation computed the detrended residual curve and its associated detrended. . .” should be “the correlation between the detrended residual curve and its associated detrended. . .”

Line 364: “CUGMSL” should be “CU GMSL”

Line 365: “data(linear” should be “data (linear”

Title in Fig.1a: “Global Mean Steric Sea Level from Altimetry” should be “Global Mean Sea Level from Altimetry”

Title in Fig.2: “Global Mean Steric Sea Level from Altimetry” should be “Residuals from Altimetry”

Title in Fig.3: “Global Mean Steric Sea Level from Altimetry” should be “GMSL differences with respect to CCI GMSL”

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