EGUsphere, author comment AC1
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Reply on RC1

Menaka Revel et al.

Author comment on "Assimilation of transformed water surface elevation to improve river discharge estimation in a continental-scale river" by Menaka Revel et al., EGUsphere, https://doi.org/10.5194/egusphere-2022-412-AC1, 2022

Referee #1

General comment:

In this research, the authors performed data assimilation (DA) experiments to explore the capacity to improve daily river discharge within current limitations of global hydrodynamic modeling. For this purpose, the water surface elevation (WSE) from satellite altimetry was assimilated in a configuration of three experiments, the direct (absolute values), the anomalies and the normalized anomalies. The authors also evaluated the capability of these DA experiments in some scenarios, for instance when some parameters/forcing (river bathymetry and runoff) of the hydrodynamic model are biased, as well as conditions when river bathymetry is calibrated. The results showed that, in general, the normalized DA performance was the best, improving the daily discharge estimates in up to almost 60% of the stations evaluated, compared to the simulation without DA. These results considering the current limited conditions of the global hydrodynamic models (e.g. without calibration).

The major contribution of this research is the evaluation of these experiments and scenarios, providing adequate knowledge and insights in terms of how DA techniques could be used to improve discharge estimates, which fits with the perspectives of SWOT missions for example. In general, this work is worth publishing in the Hydrology and Earth System Sciences journal, however, it needs “moderate revisions”. Some suggestions for revisions are as follows.

Reply:

We would like to thank the referee for his kind remarks. We will address all the comments in the revised manuscript, and comprehensive explanations are provided below.

Moderate comments:

1. The article is well written and follows a logical order. Although it is a bit long, an average reader can follow the reading, however at a certain point there are more experiments than initially described. For example, the evaluation of DA under biased runoff and river bathymetry conditions; DA under calibrated river bathymetry conditions; DA using the runoff forcing of a bias-corrected model. That is why I recommend the

authors to describe more explicitly these experiments in section 2.6.

Reply:

Thank you very much for the recommendation. We will include brief descriptions of the additional experiments in section 2.6 considering the length of the manuscript.

2. Regarding the selection of virtual stations (VSs) for assimilation or validation, the justification is a bit vague, even though this may be important for the performance of the experiments, so I recommend improving this point.

Reply:

We would like to express our gratitude to referee #1. We simply separated VSs to assimilation and validation 80%, and 20%, respectively. We will revise the description to reflect the selection of the VS for assimilation and validation

3. In sections 3.1.1, 3.1.2 and 3.1.3 take care with the description of the time series in figures 4, 5 and 6, respectively. There is a confusion between the description of the gauges results. For example, line 315 describes the Santos Dumont station on the Purus river, however the series in Figure 4d are from a gauge on the Juruá river. This confusion occurs for the stations Gaviao (Juruá) and Manacapurú (Amazon) in Figure 5, and in all the gauges in Figure 6. This was probably an involuntary error in the preparation of the figures, please correct.

Reply:

We thank referee #1 for recognizing the mistake. It was indeed an involuntary error in preparing the figures. We will correct the cross-reference with the corresponding figure and the text. Furthermore, we will correct the manuscript according to the referee's comment. Basically, we will replace Figures 4, 5, and 6 to match the descriptions in Sect. 3.1.1, 3.1.2, and 3.1.3, respectively.

4. Experiments that assimilate absolute (direct) values, anomalies and normalized anomalies are referred to by the acronyms Exp. 1, Exp. 2 and Exp. 3 respectively, however throughout the manuscript both nomenclatures are used. I suggest that only one be adopted to improve the readability of the text. Even so that the information can be quickly abstracted by the reader these experiments could be called DIR_DA, ANOM_DA and NORM_DA for example.

Reply:

We appreciate the suggestion from referee #1. We will adopt a better naming convention for the experiments in the revised manuscript such as DIR, ANO, and NOM.

5. Since the authors have used a localization method in the DA scheme, I suggest reinforcing the discussion on how this might affect discharge estimates due to assimilation of WSE within or outside the influence coverage of the VSs.

Reply:

We would like to thank the great suggestion by the referee. The localization method we used in this study is an adaptive localization method (Revel et al., 2019) which is far different from conventional localization methods which use fixed square-shaped local

patches. The comparison between those methods can be found in Revel et al., (2019). The adaptive localization method recognizes the highly correlated areas and removes less correlated areas (e.g., small downstream tributaries). We will highlight the effect of adaptive localization in the revised manuscript.

6. Could you discuss a bit about to what do you attribute the lower efficiency of flow estimates in the upper Solimoes River ? efficiency of the CaMa-Flood model ? selection of VSs ? localization ? large uncertainties in the VSs data in that region ?

Reply:

We would like to thank referee #1 for raising the question. The WSE simulations using CaMa-Food of these two locations show a reasonable agreement with the satellite altimetry observations, therefore direct DA method performed better. On the other hand, anomaly and normalized value DA have a limitation that the assimilated WSE is dependent on the statistics (i.e., mean and standard deviation) of open loop simulation. If statistics may not represent the actual values of mean WSE and the standard deviation of WSE, the assimilated WSE can be also different from the actual values in the anomaly and normalized assimilation method. When the relationship between the WSE and discharge (i.e., rating curve) is well represented in the model, the anomaly and normalized DA may not correctly estimate the river discharge if the statistics are biased. We will add some explanation to the manuscript regarding this.

Specific comments (Line-by-line comments):

Introduction:

1. 35: It is more accurate to say, "River discharge records can be used...".

Reply: We will revise the sentence as per referee #1’s comment.

2. 42: I would say that also these simulations (of GHMs) have been used to complement observed records.

Reply: We agree with referee #1 that the simulations of GHSs have been used to complement observations rather than compensate. Hence, we will revise the text to reflect the referee's comment.

3. 48: If we go deeper we could say that these forcing factors can also be rainfall and climatic variables.

Reply: We concur with referee #1 that the forcing factors are primarily rainfall and climatic variables. Therefore, we will modify the text to include rainfall and climatic variables.

4. 50: I would say: “Given the current limitations of GHMs and in-situ measurements, …”.

Reply: We admit referee #1’s suggestion that both GHMS and in-situ measurements have their own limitations. It will be updated in the revised manuscript.

5. 57: This sentence mentioning the SWOT mission seems a bit loose, you should rework it to integrate it with what you want to mention above.

Reply: The sentence will be revised to reflect the referee #1’s comment.

6. 62: Typo: "combining" instead of "combing".

Reply: We will correct it.

7. 83: This statement describes information repeated in the previous one, perhaps you could combine them.

Reply: By thanking referee #1, the paragraph will be modified.

Methodology:

1. 124: In this sentence you can already start reporting on the period of DA experiments (2009-2014).

Reply: We would like to thank Referee #1 for the nice suggestion. But we try to dedicate this section (2.1) solely to describing the assimilation framework. So, we will introduce the period of the experiments in section 2.6.

2. 215: Why wasn't the SURFEX-TRIP model outputs used since it also belongs to WRR2?

Reply: We would like to thank referee #1 for the question. We did not consider outputs from the SURFEX-TRIP model because those are not compatible with the CaMa-Flood model. The SURFEX-TRIP model consists of the capillary rise in the runoff variable where CaMa-Flood is not capable of dealing with such runoff data. Therefore, we will add some descriptions to the text.

3. 236: To reference these annual average rainfall values you can cite Builes-Jaramillo & Poveda, 2018; Espinoza et al., 2009. (https://doi.org/10.1029/2017WR021338 and https://doi.org/10.1002/joc.1791)

Reply: We would like to express our gratitude to referee #1. We will use the above studies when describing the annual average rainfall in the Amazon basin and the text will be modified considering the above studies.

4. 237: Please specify what you mean by large number of observations, perhaps this is valid for remote sensing observations because it is a large basin with strong hydrological signals, hence the citation of Fassoni-Andrade et al. 2021.

Reply: We thank referee #1 for raising this issue. Yes, indeed we refer to remote sensing data in the Amazon basin. So, we will revise the text of the manuscript.

5. 249: You could elaborate a little more on this sentence. Why these virtual stations could affect the estimates using assimilation? this exclusion of 3% was by a visual analysis of the series only? these stations are located in some particular place in the Amazon, maybe rivers with a small width?

Reply: We would like to express our gratitude to referee #1 for the important question. We did some extensive analysis of these largely biased VS which cannot be compared with the MERIT DEM (Yamazaki et al., 2017). This exclusion was done by comparing the mean WSE of satellite altimetry observation with the MERIT DEM, not on visual analysis. Our analysis revealed that most of the “biased VS” were in narrow rivers at relatively high elevations. We will include some descriptions of these biased VS in the revised manuscript.

6. Sections 2.7.1 and 2.7.2 could be merged, as it could confuse the reader. The main objective of this research is to evaluate the performance in simulating daily discharge but here also the performance of WSE will be evaluated. This merged section could be called "observational data" since the altimetry data has also been used for validation.

Reply: We appreciate the comment on merging Sections 2.7.1 and 2.7.2. We will revise it in the revised manuscript.

Results:

1. 294-296: This sentence seems to be repetitive with the previous one, you could merge them.

Reply: We would like to thank referee #1 for the suggestion and we will revise the text.

2. 302: It would be appropriate to refer to Figure 4b in this sentence.

Reply: Thank you very much for pointing out this. We will refer to figure 4d in the sentence.

3. 309: The time series for the Santos Dumont station is not shown in Figure 4d. Instead, a station on the Juruá River is shown. See my major comments above.

Reply: Thank you very much for the comment. We will revise Figure 4d to be compatible with the description in the text.

4. 325: The information in parentheses should go in the methodology section.

Reply: Thank you for the kind suggestion. We will include that in the methodology section.

5. 330: "WSE performance decreased…" instead of "WSE decreased…".

Reply: Thank you very much. We will revise it in the revised manuscript.

6. 332: The Gavião and Manacapuru gauges do not correspond to Figures 5c and d.

Reply: Thank you. We will revise figures 5c and d to match the description in Section 3.1.2.

7. 351-352: None of these described gauges correspond to figures 6c, d and e.

Reply: Thank you for raising this error. We will replace the correct figures for figures 6c, d, and e and the description will be modified to correspond to figures 6c, d, and e in Section 3.1.3.

8. 412: I think there is a typo, please delete "3.2.1.".

Reply: Thank you for pointing out it. We will delete "3.2.1.".

9. 8: It is not possible to distinguish gauges inside or outside the coverage area of the altimetric satellites. Could you differentiate them somehow?

Reply: Thank you for the great suggestion. We will modify figure 8 to distinguish the gauges inside and outside satellite altimetry coverage.

10. Table 3. I have noticed that some values in this table do not correspond exactly to those described. For instance, in the first column (All and r) in the table, the values are 0.74, 0.85 and 0.84 for experiments 1, 2 and 3 respectively. While in the description the values are 0.73, 0.84 and 0.83 (L. 431, L. 415 and L. 439 respectively).

Reply: Thank you for cross-checking the description with the data provided in the tables. The values in the table are correct values so we will revise the text according to Table 3. We will revise the L. 431, L. 435, and L. 439 with the values of 0.74, 0.85, and 0.84.

11. 452: As shown in Figure 9, the BIAS values are only positive, so I recommend describing somewhere (probably methodology) that the index is an absolute value of BIAS.

Reply: Thank you for pointing out this. We will add “absolute bias” to the methodology section when introducing “BIAS” term as follows:

12. Figure 9: It is a bit difficult to differentiate the VSs that were used for assimilation and validation. Perhaps it could be improved by changing the symbology from "o" to "*", increasing the size of the maps by reducing the space between them and decreasing a little the size of the station symbols so that they do not overlap too much. This is just a suggestion.

Reply: Thank you very much for your precious suggestion. We will revise figure 9 and other similar figures to better represent symbols.

13. Section 3.3: Please detail how in this experiment you have generated the realizations of the set for assimilation.Was it with the same perturbation as for the WRR2 models?

Reply: Thank you for asking for clarification. This section used the same assimilation outputs from the direct, anomaly, and normalized DA experiments. The perturbations are similar to WRR2 model outputs.

14. 476-478: The end of this sentence sounds strange, I suggest to redo it or delete this last part from "...,direct DA (Exp 1)...."

Reply: Thank you. We will revise the sentence in the revised manuscript.

Conclusions:

1. 624: Typo, it's HTESSEL not HTEESSEL (same for L.541, 542 and 544).

Reply: Thank you, We will correct them to HTESSEL.

Reference:

1. Revel, Ikeshima, Yamazaki and Kanae: A Physically Based Empirical Localization Method for Assimilating Synthetic SWOT Observations of a Continental-Scale River: A Case Study in the Congo Basin, Water, 11(4), 829, doi:10.3390/w11040829, 2019.
2. Yamazaki, D., Ikeshima, D., Tawatari, R., Yamaguchi, T., O’Loughlin, F., Neal, J. C., Sampson, C. C., Kanae, S. and Bates, P. D.: A high-accuracy map of global terrain elevations, Geophys. Res. Lett., 44(11), 5844–5853, doi:10.1002/2017GL072874, 2017.