Dear Anonymous Referee #3,

Thank you for your feedback on our paper “Using altimetry observations combined with GRACE to select parameter sets of a hydrological model in data scarce regions”. We hereby would like to respond to your comments:

Comment 1: Using GRACE observation to constrain parameter space is definitely worthy to be evaluated. However, the uncertainty of GRACE observations in the model calibration process need to be considered. The parameter sets reproduce GRACE observation well may not be reasonably reflect hydrological process of the basin. It is in doubt whether it is reasonable to discard 75% of the parameter set only based on their poor ability to reproduce GRACE observations. It is recommended to calibrate the model based on radar altimetry firstly and then based on GRACE observation. The differences between the two cases may give some new insights about amount of information contained in the two types of satellite observations for hydrological model calibration.

Response: We agree there are quite some uncertainties related to the GRACE observations, especially when using it for a small river basin. This will also be included in the discussion as it is still missing. As Referee #3 suggested, we compared the following two calibration approaches: 1) calibrate based on GRACE first, then altimetry (done in the manuscript), 2) calibrate to altimetry first, then GRACE (new). This change of the order mostly affected the selection of the “best” parameter set, especially for Altimetry 1 and Water level 2 (Figure 1), but affected the selection of feasible parameter sets less when using altimetry data as can be seen by the similar ranges in the boxplots. This order had a larger effect when using water level time series at the gauge station.

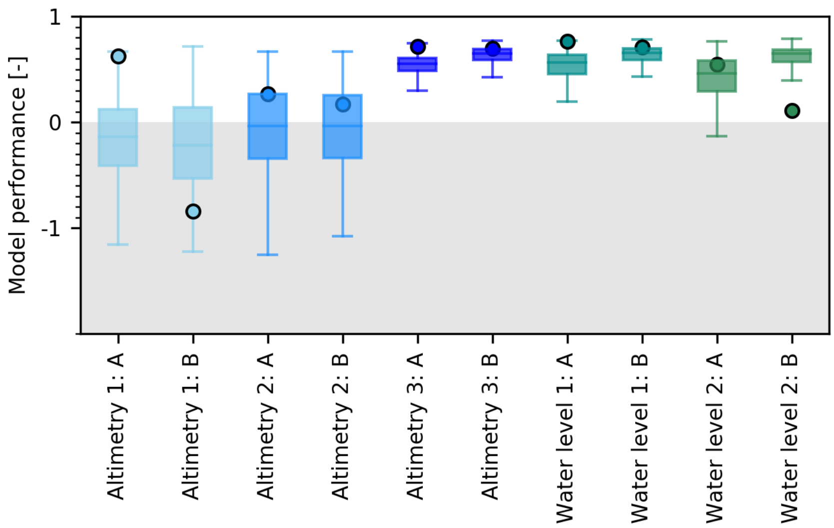

Figure 1: Model performance with respect to discharge for each calibration strategy. Parameter sets were selected based on A) first GRACE, then (satellite based) river water level, or B) first (satellite based) river water level, then GRACE.

Comment 2: Table 4 shows that the parameter set has the highest model efficiency in calibration based on satellite observation is not necessarily to perform best in simulating streamflow. To judge which strategy is more effective in model calibration, it is suggested to show the correlations between model efficiency in simulating the satellite observations and streamflow corresponding to each parameter set.

Response: Thank you for this interesting comment. As recommended by Referee #3, Figure 2 visualizes the correlation between the model efficiency with respect to (satellite based) river water levels and with respect to discharge. This figure shows that a high model performance with respect to the stream levels did not necessarily mean the model performance with respect to discharge was high.

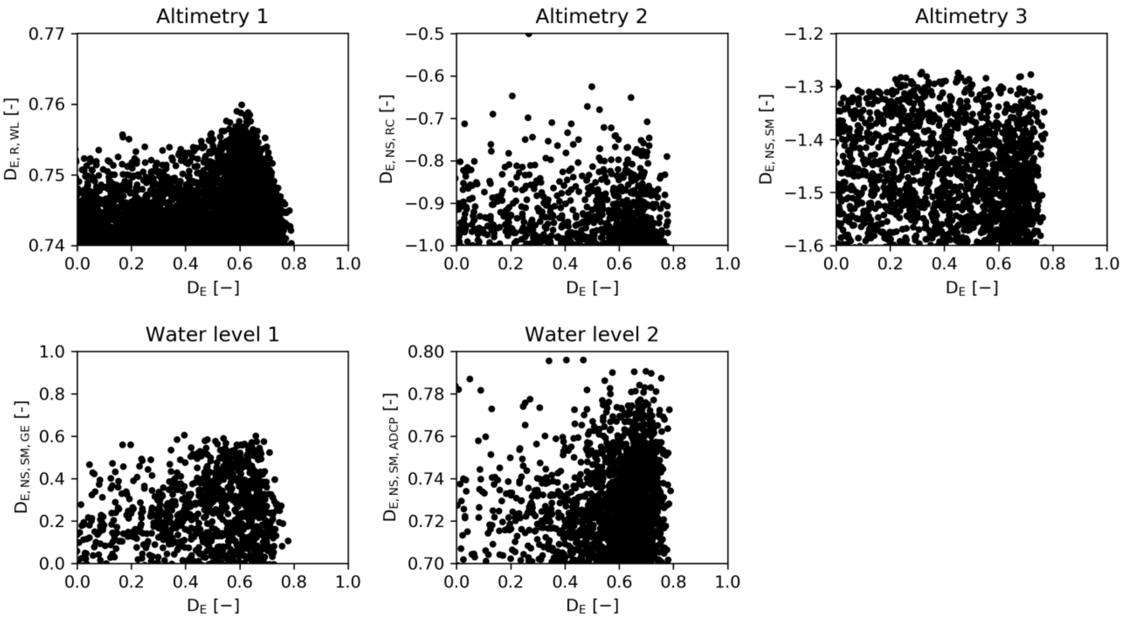

Figure 2: Model performance with respect to discharge (horizontal axes) vs. model performance with respect to (satellite based) river water level (vertical axes) for each calibration strategy

Comment 3: The discussions about the influences of number of virtual stations on model simulation should be extended to exam its influences on streamflow estimation.

Response: It is indeed a very interesting idea to extend the analysis such that the influence of the number of virtual stations on the streamflow simulation is included. As illustrated in Figure 3, the model performance with respect to discharge increased when using more virtual stations. However, at some point an optimum is reached where the model performance remained constant even when adding more virtual stations. The number of virtual stations where this optimum was reached varied per strategy. We will add this point to the discussion of the results.

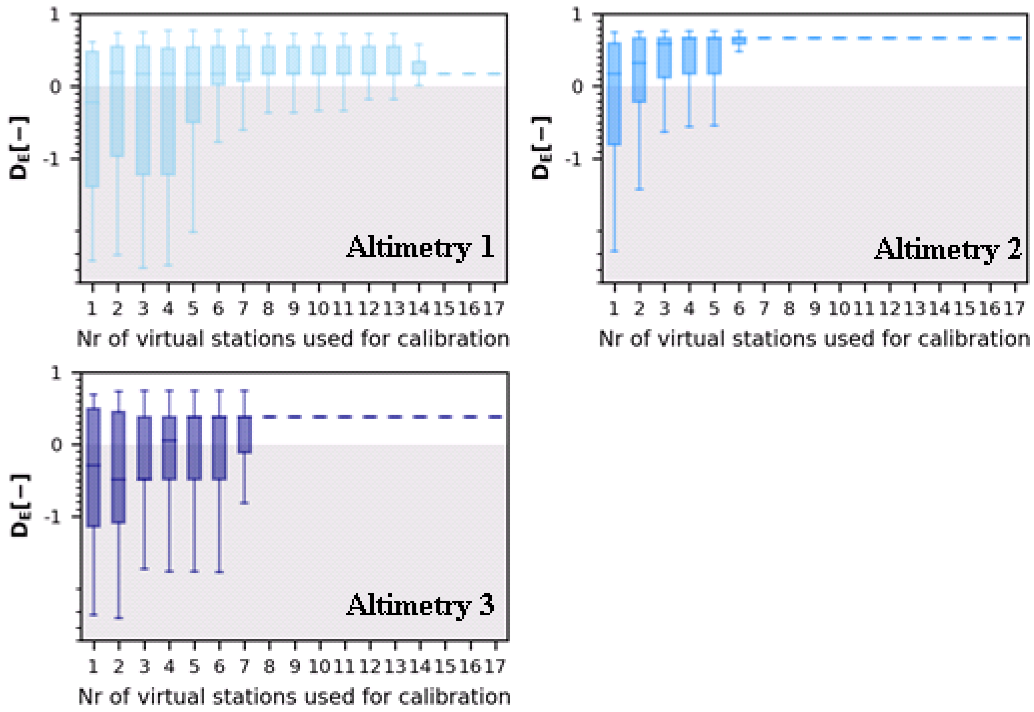

Figure 3: Model performance with respect to discharge (all signatures combined) using an increasing number of virtual stations for calibration

Comment 4: The spatial resolution of GRACE observations and hydrological simulation are different. How did you treat this difference in model calibration?

Response: We agree, in the manuscript it is not explained how we dealt with the differences in the spatial resolution. The gridded information was rescaled to the model resolution of 0.1°. If the resolution of the satellite product was higher than 0.1°, then the area weighted average was taken of all cells located within each model cell. Otherwise, each cell of the satellite product was divided into multiple cells such that the model resolution is obtained, retaining the original value. This will be included in Section 2.1.2.

Comment 5: In the results and discussion section, it is expected to get more understanding about the implications for the future studies in this research field from the findings of the current study, rather than limitation and comparison with previous studies, for which the relevance to the simulation results is not very high and therefore the content need to be reduced. Also the length of abstract need to be reduced.

Response: Thank you for this comment. There are indeed many interesting opportunities for future studies that could be included in the manuscript; this will be done by including a new section in the discussion. For example, it would be very interesting to combine altimetry observations with CryoSat based altimetry observations which provide water level information at lower temporal resolution (every 369 days), but higher spatial resolution (equatorial inter-track distance of 7.5 km) providing valuable information to estimate the river slope. Also, it would be very useful to improve cross-section estimates with respect to the submerged part as already explored in previous studies (Domeneghetti, 2016). We will make the abstract and the section suggested by the reviewer more concise.

Literature

Domeneghetti, A.: On the use of SRTM and altimetry data for flood modeling in data-sparse regions, Water Resources Research, 52, 2901-2918, 10.1002/2015WR017967, 2016.