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# *Interactive comment on* "GRACE-REC: a reconstruction of climate-driven water storage changes over the last century" *by* Vincent Humphrey and Lukas Gudmundsson

**Anonymous Referee #1**

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General Comments: This manuscript describes a new data product that represents reconstructed terrestrial water storage changes from 1901 – present. The data product is created by developing a model that is trained to ∼15 years of GRACE observations. The model takes as input precipitation and temperature information from various models. The authors present a total of six different reconstructions (using two different GRACE data products and three different precipitation data products), with 100 ensemble members for each, to capture the uncertainty associated with each reconstruction. The authors perform various comparisons with other data (sea level budget, streamflow data, BSWB data, and GRACE data itself, as an effort to do validation on their dataset(s), as well as hydrological models. The authors find that by large, their



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reconstruction(s) agree better or on par with the hydrology models for the various comparisons (validations) made in the paper.

In general, the paper is thoughtful, well-written, and a welcome addition to the literature. The dataset(s) presented are well-validated by the authors (to the extent possible), and could be very useful for other Earth System studies. I congratulate the authors for this nice contribution.

My primary criticism of the paper is the choice to use the JPL RL05 data rather than the RL06 data (released in October 2018), primarily due to timeliness. Understandably, much of the analysis was likely done prior to the release of the RL06 data, and it would require substantial efforts to redo the analysis. The authors did show that the reconstructions were much more sensitive to the choice of precipitation dataset than the GRACE data, so it is entirely plausible that calibrating the model to RL06 data would make little difference in the results. The hesitation comes with an anticipated use-case of the dataset, as mentioned by the authors (abstract and introduction), which is to fill the gap in between GRACE and GRACE-FO and to "reconcile" the two datasets. The first GRACE-FO data will be in so-called "RL06" data standards. It would behoove the authors to address this discrepancy, and provide some analysis/insights on whether any conclusions change when using RL06 data to calibrate the model. The authors discuss the potential for errors in low degree spherical harmonics (Section 4.3), and in fact, many of the changes from RL05 to RL06 occur in the low degree harmonic coefficients for the JPL data product, including the "mean pole correction" of the C21/S21 coefficient as recommended by Wahr et al., 2015.

Specific Comments:

Section 2.3.2: The model is calibrated independently for each mascon. It is unclear to me – does this mean for the JPL data product it is done on each 3-degree mascon, while on the GSFC data product it is done on each 1-degree mascon? There are many more mascons in the GSFC data product than degrees of freedom in the

GRACE dataset – but perhaps this does not matter for the model calibration since spatial correlations are taken into account. Can you comment?

Figure 4c and 4d: It is unclear to me what each data point represents. Is each dot for a single mascon?

Section 3.4: The title “Global Average” is perhaps misleading since it does not include ocean areas. Suggested revision.

Figure 7: Are these simply the global average (area weighted) of Figure 5 and 6?

Section 4.3: This analysis is done excluding Greenland and Antarctica. Are Greenland and Antarctica excluded from the actual GRACE data (JPL and GSFC) when computing correlations/RMS with altimetry/steric information in Figure 11b/c? I wonder what the impact of including/excluding it is? Presumably small, but some discussion on this would make for a better comparison.

Section 4.3: It is hypothesized that low degree errors could be responsible for the GRACE data having a worse correlation than the modeled data. I agree. I could also envision errors in high degrees also being a culprit. The mascon solutions used in theory do not necessitate any post-processing, but it is very likely that residual longitudinal stripes remain. The GRACE-REC model should not calibrate to these residual stripes, but rather the signal since the stripes are more stochastic in nature from month to month. However, it is plausible that residual stripes could contaminate correlation/RMSE comparison with a detrended/deseasoned timeseries of presumed ocean mass from sea level budget analysis (altimetry/steric).

Section 4.4: Could you include some discussion of the length of the timeseries of the BSWB data? Figure 12 is confusing because in Figure 12a, the BSWB data does not overlap with the GRACE data record. However, Figure 12b/c compare the BSWB data with the actual GRACE data – inherently implying some overlap.

Section 4.4 and 4.5: In both sections it is pointed out there is slightly better performance





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in GSFC than JPL, and this is potentially owed to the better spatial resolution of the GSFC data. Did you apply the scale factors to the JPL data? These are designed to reduce such leakage error on the basin scale. If not, I suggest doing so for this analysis. Second, when making these comparisons, is the length of the data record always consistent? The JPL data both begins before, and extends after, the GSFC data. The tails of the GRACE dataset are of worse quality, and I am curious if the inclusion of these extra months on the JPL data is perhaps responsible for the inferior performance.

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