

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 #2

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In their study the authors use three different precipitation and temperature products to reconstruct past variability of terrestrial water storage (TWS) from 2017 back to 1901. The reconstruction is performed by estimating the parameters of a statistical model which is calibrated by relating precipitation and temperature to observed TWS from the GRACE satellite mission. To account for temporally and spatially correlated errors in the reconstructed TWS the authors apply a spatial autoregressive model to generate a large number of ensemble members representing the uncertainty of the estimated TWS anomalies. Afterwards, the derived reconstructions are evaluated against different independent datasets, showing the value of the dataset for different hydrological and climate applications.

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The presented data and method are new and sufficiently described in the text. Long and consistent time series of TWS as presented here will be very useful in future for many different user groups, thus it is a valuable contribution to ESSD.

Generally, the manuscript is well structured and well written. Data access is easy and well documented. Downloaded data are ready to use without problems. The data is of high quality as shown by the authors in several appropriate evaluations.

General comments:

Chapter 2.2: Instead of ERA-Interim as used in the study, it would be better to use the new ERA5 reanalysis (at least for the next update of the reconstruction, as ERA-Interim production will eventually end). Probably this would even improve the quality of the reconstruction.

Chapter 2.3: Some aspects of the modelling approach are unclear to me:

Where does Eq. 5 come from? A sentence on this for explanation would be helpful for the reader.

Does time t in Eq. 6 refer to months and $TWS(t)$ to a monthly average (in contrast to before, where t was time in days)? If so, the notation should be adjusted accordingly, e.g. using t' and $mean(TWS)$ to distinguish monthly from daily resolution. ε also depends on (monthly) t , this should be indicated in Eq. 6 (and accordingly in Eq. 8), e.g. with $\varepsilon_{t'}$.

Chapter 2.4.2:

I do not understand Eq. 13: To my understanding σ_{η} is the “variance of the autoregressive process” (line 8) which should be “larger than that of the driving white noise process” (line 9), which is σ_{ε} . However, for large autocorrelation φ the expression $\sqrt{(1-\varphi^2)}$ approaches zero, thus σ_{η} is smaller than σ_{ε} for any autocorrelation different from zero. Please comment on this.

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Specific comments:

P. 5, line 9: (typo) adjustment must be adjustment

P. 9, line 20: (Eq. 8) dependence on time for GRACEREC and ε should be visible in equation.

P. 12, line 9: does “ensemble hindcast” refer to a mean of all 6 reconstructions (each with 100 ensemble members)? Please point this out more clearly. Otherwise, please indicate which reconstruction is evaluated.

P. 13, line 19: so no SAR model was used for daily products? Maybe mention this and the reason for it explicitly.

P. 15, line 13ff: Did you evaluate the difference between the two GRACE solutions in advance? Usually, GRACE solutions of different processing centers do not differ largely, thus it is not surprising that they lead to similar reconstructions.

P. 16, line 19ff: This is a repetition of P. 14, line 10-13. It should be summarized and discussed at one location.

P. 17, line 5: The GRACE solution from Graz is officially called ITSG-Grace2018 (not just ITSG2018). Mayer-Gürr et al., 2016 is an outdated reference; if you used the 2018 solution, please cite: Mayer-Gürr, Torsten; Behzadpur, Saniya; Ellmer, Matthias; Kvas, Andreas; Klinger, Beate; Strasser, Sebastian; Zehentner, Norbert (2018): ITSG-Grace2018 - Monthly, Daily and Static Gravity Field Solutions from GRACE. GFZ Data Services. <http://doi.org/10.5880/ICGEM.2018.003>

P. 19, line 8f: Please comment on how this is possible since GRACE cannot resolve features as small as 1° .

P. 19, line 19: “size smaller than ...” Do you mean “size larger than...”? Otherwise I do not understand why you only use the very small basins.

P. 19, line 20: “leaving 12'496 stations”, please indicate number of stations for each

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time period, as in Figure 13c only 9306 stations are evaluated.

Figure 1b: y-axis label should be changed from cm H2O to TWS [cm]

Figure 3 caption, line 2: delete “also”

Figure 4: a, b and e are too small. In c, only one x-axis label is printed, please add more.

Figure 7: Please mention to what the bars and lines refer to. Standard deviation, min and max? Is the global mean computed with or without Greenland and Antarctica?

Figure 8: In 8a for some time series (red, purple, light blue) the numbers at the scale are missing. b and c are too small to distinguish different reconstructions.

Figure 13d: Repetition of legend from 13b would be nice, to see at a glance what is displayed here.

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