Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2019-664-RC2, 2020

Hydrology and
Earth System
Sciences
Open Access
Discussions

Interactive comment on “Assessing global water mass transfers from continents to oceans over the period 1948–2016” *by* Denise Cáceres et al.

Anonymous Referee #2

Received and published: 27 March 2020

This manuscript by Cáceres et al. applied an updated version of WaterGAP hydrological model, which integrates the global glacier model GGM, to simulate the contributions of different continental water storage components, excluding ice sheets in Greenland and Antarctica and their peripheral glaciers, to the ocean mass change from 1948 to 2016. Multiple model variants, with different forcing (precipitation) inputs and irrigation scenarios, and with inclusion/exclusion of various human influences, were applied in order to constrain the model uncertainty and separate anthropogenic impacts from climate impacts. The modeled total water storage anomalies (in terms of inter-annual trend, seasonality, and residuals) were validated against an ensemble of GRACE spherical harmonics solutions, and the modeled anomalies of each water component were validated/cross-compared with available observations and/or existing

Printer-friendly version

Discussion paper

literature. They concluded that the modeled total water storage (TWS) seasonality agrees remarkably well with GRACE observations, but the modeled TWS inter-annual decline was overestimated. Since their modeled glacier mass trend agrees well with observations, this overestimation mostly stems from other land water storage components, largely due to the challenge of simulating human water abstraction. Consistent with other studies, their simulation shows that the glacier mass loss is the largest contributor (81%) to ocean mass change, and the human-driven hydrology (including water abstraction and reservoir impoundment) contributes the other 19%. Climate-driven variability in land water storage has a very marginal impact on the long-term ocean mass trend.

Overall, I enjoyed reading this paper. Although very lengthy, it is logically structured and well written. The methods are well elaborated, with lots of technical details that help readers understand and potentially replicate their work. The model validations are overall thorough and in-depth, with extensive cross-comparisons with existing literature. So potentially, I find this paper will be another important contribution towards the improved closure of global water budget.

However, I do have some major concerns/comments, mostly about model validation and result implication. I would like to see the authors' responses before a possible acceptance.

My first concern is the selection of GRACE solutions. Obviously, GRACE solutions are important here as they were used as validation benchmarks. The authors applied the ensemble of four spherical harmonics (SH) solutions. I agree with the authors that the derived water storage trend can be sensitive to different GRACE solutions. Therefore, I wonder why the authors opted to only use SH solutions but not mascon solutions. Mascon solutions have merits in improved resolution and signal isolation. I am wondering what kind of influence the inclusion of mascon solutions will have on the model validation (I know some of the mascon solutions result in a smaller global trend, meaning the modeled LWSA trend even more overestimated). I would like to see more justifications, or at least a little discussion, about the selection of GRACE solutions.

Second, as the authors specified, the Caspian Sea is not included in WaterGAP, so the modeled LWSA excludes the impact of the level decline in the Caspian Sea (which can be substantial). The GRACE solutions, however, include the Caspian Sea in the land mask. I am unclear, at least given what the authors described, whether the GRACE TWSA used for model validation excludes the Caspian Sea or not. If not, the comparison wouldn't be apple-to-apple (GRACE TWSA with the Caspian Sea impact and modeled TWSA without), which leads to an even greater overestimation in the modeled water storage trend.

Third, the modeled impact of reservoir water impoundment may be underestimated, particularly in the recent couple of decades. This is because WaterGAP incorporated the initial version of GRanD (version 1.1), rather than the updated version 1.3 that added another 458 large reservoirs mostly constructed after the year 2000. As a result, the modeled reservoir impact was underestimated after 2000. This underestimation was seen in Figure 6, where LWSA_res flattens and declines during the recent decades. In addition, as the authors mentioned, GRanD only includes the largest reservoirs. Medium-sized and smaller reservoirs, such as partially documented in ICOLD, may add up to a substantial impoundment volume that was not taken into account in the model. These limitations (leading to underestimated LWSA_res) ended up overestimating the declining trend in net human impacts (LWSA_human). The authors may want to discuss more about these limitations about modeling reservoir impacts, and how they affect the conclusions.

A couple of minor comments:

Line 558: "closer to the estimate of Reager et al. (2016)". I found this sentence far-fetching as the estimates of Reager et al. (-0.71 mm per year) and of the authors (-0.41 mm per year) have a difference of a factor of 2.

Lines 660-661: This sentence can be misleading. 0.109 mm per year from 2002 to

2014 as reported in Wada et al. (2017), includes the contribution from both the surface water in the Caspian Sea and its influenced groundwater. 0.114 mm per year from 2002 to 2016 as reported in Wang et al. (2018), is the contribution of the entire Caspian Sea Basin, not the Caspian Sea alone. Based on Wang et al. (2018), the contribution of the Caspian Sea alone, i.e., the trend in its surface water volume, is 0.071 +/- 0.006 mm per year (or 25.52+/-2.12 Gt per year). For improved clarity, I recommend that the authors modify this sentence to be something like: “The contribution of this endorheic lake to SLR was estimated to 0.109 +/- 0.004 mm SLE per year (including variations in both surface water and the influenced groundwater) during the period 2002-2014 (Wada et al., 2017) and 0.071 +/- 0.006 mm SLE per year (including only surface water variation) during the period April 2002 to March 2016 (Wang et al., 2018).”

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2019-664, 2020.

Printer-friendly version

Discussion paper