RC1

This study focuses on the analysis of interannual and decadal (slow changes) terrestrial water storage – TWS from GRACE solutions and two global hydrological models. The main contribution of this study is the analysis of slow changes in areas where interannual and decadal anomalies are dominating, and how are compared with the two global hydrological models.

I found an interesting read, very well written, however, I have some few observations below:

- Line 92-93: Since in the title and in the abstract they mention GRACE and GRACE-FO, I expected the analysis to include the new data returned by GRACE-FO, but I see that it only covers the time period of the first GRACE mission between 2002 and 2016. GRACE-FO was launched in 2018

We were limited in our comparison study by the availability of WGHM data, only provided until December 2016. We only show results on the common data period (April 2002 - december 2016), therefore excluding the GRACE-FO mission. We removed any mention of GRACE-FO in the title and abstract.

- Line 95: Do the two models used in the analysis belong to CMIP6 and ISI-MIP? If so, it should be clarified, since it is not very well understood why to compare GRACE with these two specific models.

ISBA-CTRIP has been used in CMIP-6. WGHM has been used in ISI-MIP. This has been clarified in the text.

- In figure 1, are the maps the average of the entire study period?

In Fig. 1, we show the range of interannual TWS changes over the entire study period. The range at 95% CL (confidence limit) is calculated as the difference between the 97.5 and 2.5 percentiles of the TWS anomalies estimated in each grid cell over the entire study period. This allows removing outliers, and provides a good estimation of the amplitude of interannual variations of TWS anomalies in various regions of the globe. This is explained at the end of section 2.5. It has been added in the legend of Fig. 1, to avoid the reader going back and forth between the figures and the text.

We thank the reviewer for his/her comments, which helped improve the manuscript.

RC2

This is an important study comparing the slow change in terrestrial water storage between GRACE solutions and two global hydrological models.

I am outlining below some major comments:

1. The term slow change is not defined clearly. Does it include the linear trend? I see from the results it includes the sub-annual component, and I don't think the sub-annual changes can be slow changes. I suggest formulating these definitions using equations. Also, it will be helpful to show some raw time series for some areas for the slow change before and after applying the diffusive filter.

The term slow changes includes pluri-annual and decadal changes. The term "slow" has been replaced by "pluri-annual and decadal" at each use (including in the title, abstract and conclusions) for more accuracy.

We only removed seasonal signals, modelled as the sum of annual and semi-annual sinusoids whose phase and amplitude are estimated at each grid cell (section 2.5). Linear trends contribute significantly to the decadal variability in TWS, therefore we do not remove it (Fig. 4).

We determine the time scales of the residual TWS changes using high-pass (cutoff at 1.5 years), band-pass (cutoffs at 1.5 and 10 years) and lowpass (cutoff 10 years) filters, allowing to extract sub-annual, pluri-annual and decadal signals respectively (section 3). We show that TWS residuals are dominated by pluri-annual and decadal signals (Fig. 3).

We also compute and display the power spectral density associated with TWS time-series estimated with GRACE and global hydrological models over numerous regions of the globe (Fig. 5 to 12, Appendix C). The comparison of power spectral densities (PSD) shows that TWS changes are systematically underestimated at pluri-annual and decadal time scales by global hydrological models when compared to GRACE (PSD are not normalised).

2. Authors did a good job in combining multiple GRACE data, but I feel these efforts wasted by just using the ensemble of all data, also I don't think averaging the mascons and solutions together is a good strategy.

All GRACE solutions are remarkably consistent one with another, which is evidenced by the small dispersion between the solutions (Fig 1b). The differences between the average GRACE solution and global hydrological models (Fig. 1e and f) are much larger than the dispersion between the solutions (Fig 1b, section 3.1). As suggested by the reviewer, we compared the mascon and spherical harmonic sub-ensembles to global hydrological models separately and found remarkably consistent results (supplementary material). We also added a couple of sentences in section 3.1 to make that clearer.

The manuscript is already very long, so we do not wish to add to it. Therefore, we only show the average GRACE-based solution in Fig 1. to 4. The same analyses carried out with mascons and spherical harmonic separately are available in supplementary material. We show the difference between mascons (red) and spherical harmonic (magenta) solutions for the regional analyses (Fig. 5 to 12, Appendix C).

3. Are all GRACE solutions have the same performance for the slow changes in TWS?

Yes. See point 2.

4. It will be more informative to have two ensembles; one for the mascons and another for the spherical harmonics, and compare their performance.

Both sub-ensembles (mascons and spherical harmonics) are remarkably similar (see point 2). Extremely similar results are found when comparing global hydrological models with mascons and spherical harmonics separately (supplementary material).

5. Paragraph #30. “located at the Earth’s surface”, not correct phrasing

We replaced “mass anomalies as a layer of water of variable thickness in space and time located at the Earth’s surface” by “changes in surface density (i.e. changes in mass per unit area) as a layer of water of variable thickness in space and time” to be closer to the definition of Wahr et al., (1998) and Ditmar (2018)

6. Paragraph #35. Do you mean seasonal components and the trend? Or by the decadal change, the author meant the linear trend.

In the study cited here (Humphrey et al., 2016), decadal changes are the long term changes including both linear trends and interannual changes. This has been rephrased and clarified in the revised version of the manuscript.

7. Paragraph #46. “ Multidecadal Atlantic oscillations” è Atlantic multidecadal oscillations

Corrected

8. Since the two hydrological models do not simulate the glaciers storage; comparing them with GRACE data is not fair; and so, the results over the glaciers regions. One suggestion for the authors is to remove the linear trend and limit the comparison to the interannual and decadal fluctuations.

We agree that we cannot compare GRACE with hydrological models around glaciers. We indicate the limits of glaciers estimated with the sixth version of the Randolph Glacier Inventory by white contours in the revised version of Fig. 1. We indicate both in the text and figure legend that GRACE should not be compared with global hydrological models around glaciers.

However, linear trends constitute a significant part of decadal TWS variability, contributing to the biases observed between GRACE and global hydrological models. Therefore, this component should remain in the present assessment study.

9. Is the amplitude defined here as the max(TWS) – min (TWS)? if so, please define it clearly in the methods.

The amplitude is defined as the range at 95% CL (confidence limit), calculated as the difference between the 97.5 and 2.5 percentiles of the TWS anomalies estimated in each grid cell. This allows an accurate estimation of the amplitude of non-seasonal TWS anomalies, avoiding extreme values. This is defined at the end of the method section 2.5. For more clarity, we also included this definition in the legend of Fig. 1.

10. One suggestion on the discussion sections; please start with results for these areas, and then discuss their hydrological characteristics.

We divided the discussion on each region in two subsections: i) study area; ii) comparison of global hydrological models with GRACE. This allows a clearer separation between the hydrological context and our results.

We thank the reviewer for his/her comments, which helped improve the manuscript.