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Natural Hazards and Earth System Sciences
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Discussions

Interactive comment on "Variations in water storage in China over recent decade from GRACE Observations and GLDAS" *by* X. Mo et al.

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Dear editors & reviewers, Thanks for your efforts and advices. We have substantially revised our manuscript after reading the comments provided by the two reviewers.

All the revisions are firstly traced based on page and line in NHESS Discussion Documentary. Places with revision are marked on both revised manuscript and NHESSD.

Answers to reviewers: Reviewer #2: 1) Reevaluate precision and number of significant figures throughout. Are these really realistic, and being applied in the same manner throughout? Answer: We checked original GRACE Tellus data, the unit is cm and grid values offer three significant figures after the decimal point. Thus, we chose to keep all the calculated numbers with two significant figures after the decimal point.

2) Please provide some measure of uncertainty (and explain what that uncertainty is) to the values given. Answer: Uncertainty of GRACE TWS (total error) mainly comes from measurement error and leakage error (caused by data noise filting process). These two error fields had already been offered along with the GRACE TELLUS TWS dataset. We further calculated the total error for basin averaged GRACE TWS. For the estimated TWS from GLDAS model assemble mean (uncertainty for specific model is unknown), we simply take the standard deviation relative to multi-model assemble mean as the estimate of models' uncertainty (referred as bias for GLDAS in paper).

3) Bring in more of a context of why this pertains to natural hazards, in the introduction, and then various places throughout the manuscript. Answer: We emphasized TWS's role in disaster monitoring and assessment in introduction. The main influence of nature disaster is reflect in the annual variations of basin scale TWS. Detailed analysis on TWS anomaly (drought or flood) is mainly included in another manuscript under preparation, thus we can't put too much content in this paper.

4) There are MANY acronyms and variables. Please provide either one or two tables with these listed, what they mean, call them Table 1 (or Tables 1 and 2), introducing them early on, and renumbering all the other Tables. Answer: We provided on table for important acronyms and variables, and renumbered all other tables

5) Ensure that what you are doing statistical is clear to the reader. So for example, "Correlation coefficients" in Table 2, it is not stated what kind of correlation coefficients these are in the table caption or in the text, nor if it is r or rËĘ2, nor how one might determine the statistical significance of these. Please go through the entire paper, and ensure that any statistical analyses done are clear 'what' the error/correlation/uncertainty is, how it was determined, so that another reader can reproduce it. In some place statistics are clear–but dense–it is hard to read, as it is almost short hand. In other places, it is not always clear what was done, number of values used, etc., to arrive at the values given. Answer: (1) For correlation coefficients, in this paper we used Pearson correlation. Since the calculation is based on monthly values in 11 year, there

are enough samples, thus significance is not the problem. Besides, we more focused on those high R values which stand for good performance of specific model in specific basin. So we didn't test the significance. NHESSD, Pg. 3258. Line 2-3: Revised as: 'Pearson correlation coefficients R between TWS time series from scaled GRACE and model simulations are listed in Table 2' NHESSD, Pg. 3275. Table 2: For caption of table 2, we revised as: Table 2 Pearson Correlation coefficients R between regionally averaged TWS from the scaled GRACE data and model simulations in China and eight of its basins.

(2) Significance of trends NHESSD, Pg. 3259. Figure 12-15: Revised as: 'To identify major areas with significant TWS increase or depletion in the recent decade, linear trend of scaled GRACE TWS for each grid was calculated based on linear regression, and the long-term trends of seasonal average TWS were also analyzed. Grids with trends passed the F-test (significant of 95% confidence level) are marked with black dots in Figs. 7 and 8.'

NHESSD, Pg. 3285. Figure 7: For caption of Figure 7, we revised as: Spatial distribution of linear trends for TWS in 2003–2013 (unit: cm/yr); (a) and (b) are linear trends from the scaled GRACE data and its detailed diagram for west part of China, (c) is linear trend from the unscaled GRACE data. Grids with trends significant at 95% confidence level are covered by black dots.

NHESSD, Pg. 3286. Figure 8: For caption of Figure 8, we revised as: Spatial distribution of linear trends for the seasonal averaged TWS in 2003–2013 from the scaled GRACE data (unit: cm/yr); (a) spring(March-May); (b) summer(June-August); (c) autumn(September-November). Grids with trends significant at 95% confidence level are covered by black dots.

(3) In fact, quantifying uncertainty is always a tough job in GRACE TWS research. Uncertainty is not only related to the input data, but also depends on those methods dealing with the data, such as noise filtering and scaling technology. It is also difficult to

collect the true uncertainty information of all the variables used. Uncertainty of GRACE TWS (total error) mainly comes from measurement error and leakage error (caused by data noise filtering process). These two error fields had already been offered along with the GRACE TELLUS TWS dataset. We further calculated the total error for basin averaged GRACE TWS. For the estimated TWS from GLDAS model assemble mean (uncertainty for specific model is unknown), we simply take the standard deviation relative to multi-model assemble mean as the estimate of models' uncertainty (referred as bias for GLDAS in paper). The sources of uncertainty and error of GRACE and GLDAS data are introduced in section 2.2.1 and Table 3. More details on the GRACE dataset are introduced in Landerer et al., 2012. We also found that one recent work 'Long, D., L. Longuevergne, and B. R. Scanlon (2015), Global analysis of approaches for deriving total water storage changes from GRACE satellites, Water Resour. Res., 51, 2574–2594, doi:10.1002/2014WR016853.' did a more comprehensive analysis on the uncertainty of GRACE derived TWS.

6) Please ensure that you do not state 'more' in terms of conclusions than what the data are telling you. Answer: NHESSD, Pg. 3261. Line 5-7: In the manuscript, Pg. 9. Line 1-3: 'Generally, basins with large areas are less affected by leakage errors and have slopes close to 1, but geographical location and hydrological cycle characteristics will contribute to this effect, as well.' was revised as 'Generally, basins with large areas are less affected by leakage errors and have slopes close to 1.'

NHESSD, Pg. 3261. Line 18-20: In the manuscript, Pg. 9. Line 14, delete 'This process may be controlled by changes in some large-scale climate processes, which need to be further analyzed in the future.'

NHESSD, Pg. 3262. Line 1-2: In the manuscript, Pg. 9. Line 22, delete 'Reservoir regulations may be one of the factors that alter the TWS signal.'

NHESSD, Pg. 3262. Line. 24: 'Disagreement between ……. TWS variations in this basin.' We revised the statement as: 'The basin averaged TWS, gross water resource and precipitation also showed different processes in the latter half of research period. But Fig.7 revealed that areas with large long term decreasing trends mainly located in midstream of Yellow River basin(Shanxi and Shaanxi Provinces), where is famous for coal mining. To identify the exact causes for decreasing TWS, more local statistical data and groundwater level records should be collected.'

NHESSD, Pg. 3264. Line 4-6: In the manuscript, Pg. 11. Line 18-19, 'According to the analysis in previous section, we inferred that human activities rather than climate parameters are responsible for the significant TWS depletion in North China,' revised as 'According to the analysis in previous section, we inferred that human activities rather than climate parameters could be responsible for the significant TWS depletion in North China,'

NHESSD, Pg. 3266. Line 9-11: In the manuscript, Pg. 13. Line 15, delete 'Thus, more data needs to be added to further quantify and verify the extent of identified TWS change at small scale in the future research.'

NHESSD, Pg. 3267. Line 1-4. We noticed this problem. We decided to just focus on what we really found in analyses. Original text: The TWS variations generally followed the variations in annual precipitation, but depletion in deep aquifers caused by over-exploitation played a significant role in these trends until 2012 in the Hai River basin and Yellow River basin. In the manuscript, Pg. 14. Line 1-2, we revised as 'The TWS variations generally followed the variations in annual precipitation at basin scale, but they showed inverse changes in 2007-2013 in both Hai River basin and Yellow River basin.'

7) Please ensure that for all figures, the TEXT is big enough to read. Some of it is very small. Answer: We have improved figure quality as required.

8) Figure 3. If using colour, please indicate the legend. Answer: This is a mistake. We have fixed it.

9) Where appropriate, add y-axis labels where there are none now (along with units). Answer: We have added y-axis labels in Figures 4-6.

10) Figure 7 and 8. Add units to the legend (text above or to right or below). For the divisions, it is better to do "-1.0 to -0.8" rather than "-1 - -0.8" [note precision, and getting rid of - for 'to'] Answer: We have improved figure quality as required.

11) Spring and other seasons. You never state what months these cover. Answer: NHESSD, Pg. 3286. Caption for Figure 8. Revised as: Figure 8. Spatial distribution of linear trends for the seasonal averaged TWS in 2003–2013 from the scaled GRACE data (unit: cm/yr); (a) spring(March-May); (b) summer(June-August); (c) autumn(September-November).Grids with trends significant at 95% confidence level are covered by black dots.

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