Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2018-471-SC1, 2018

Hydrology and Earth System Sciences
Discussions

Interactive comment on "Monitoring Groundwater Storage Depletion Using Gravity Recovery and Climate Experiment (GRACE) Data in the Semi-Arid Catchments" *by* Nizar Abou Zaki et al.

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Received and published: 11 December 2018

In this study, data from the GRACE satellite program was used to monitor groundwater depletion problems in a semi-arid environment. The study attempted to establish a correlation between GRACE data and in situ measurements to create a method to assess and monitor other catchments suffering from extreme groundwater depletion. The main points of this paper include; judging the efficiency of GRACE data in catchments smaller than the recommended limit of 200 000 km2, as well as comparing the GRACE-derived data and in situ measurements groundwater depletion estimates. The study focused on a catchment with an area less than 16% of the proposed GRACE

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area limit (200 000 km2) with an aquifer area of less than 5%, despite recently published work showing that data for catchments below 63,000 km2 becomes too noisy for interpretation (Vishwakarma, Devaraju, & Sneeuw, 2018). To address this limitation, two indices were calculated, comparing GRACE water mass and in situ groundwater volume variation to calculated net precipitation. Results of the indices showed that GRACE data could not be related to precipitation while in situ measurements were directly proportional to precipitation and evapotranspiration rates. Due to the relative commonality of papers using GRACE data to examine groundwater depletion, and its focus on a catchment smaller than the effective limitation of GRACE data this paper does not stand out nor make a significant impact.

Major Comments:

1) The section “Estimating Groundwater Storage Changes” is unclear as to whether ΔS is calculated from observation wells or GRACE data. The opening paragraph mentions both methods, thus confusing the reader.

2) The main point of this paper was to assess the catchment using GRACE-derived water mass data (WMI) against in situ monthly measurements. To analyze this, the methods section describes isolating the groundwater component (GWMI) given in Equation 5. Yet minimal explanation of this is made in the results section and little is discussed other than the fact that GWMI and ΔÂňSI results show a proportional fit. What is the average monthly variation of GWMI?

3) Calculated groundwater depletion estimated from ΔÂňSI was determined to be 905 mm; GRACE data showed a 76 mm decline. However, results showed a groundwater level average depletion of 10 m in the catchment aquifers. Where does this value come from? This seems to disagree with the suggestion that the GRACE-derived data and groundwater level fluctuations showed good agreement, as presented in the conclusion section.

4) It is confusing throughout the paper to what the KB indices represent. It is presented

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as representing GRACE data in some cases, and representing in situ measurements in others, despite being defined as KB = ΔSI / WBI in Equation 7. Examples:

- P7, L19: “GRACE data alone are not sufficient for analyzing catchment water mass fluctuations (Tourian et al., 2015), the data were compared against calculated net precipitation (WBI) and groundwater volume variation (ΔSI)”

- P8, L2: “KB shows the corresponding relationship between the GRACE data and groundwater volume variation.”

- Figure 5: “water mass (KA) and groundwater level (KB) fluctuation with respect to monthly net precipitation change in the Bakhtegan catchment”

- P14, L2: “KB shows the relationship between net monthly precipitation and groundwater level variation”

Specific comments:

5) P1, L17: Remove comma in 200,000 km2 to remain consistent with formatting in the remainder of the paper

6) P4, L2: The paper mentions that GWMI and ΔÂňSI results show a proportional fit. However, there is no graph of these results available in the report.

7) P6, L22: add the word values after C20 to improve the clarity of the statement.

8) P7, L6: Remove “so-called” from the sentence, or substitute with “proposed”

9) P7, L15: was taken, instead of “were also taken”

10) P7, L18: Grammar. As GRACE data alone are is not sufficient for analyzing catchment water mass fluctuations (Tourian et al., 2015), the data were is compared against calculated net precipitation (WBI) and groundwater volume variation (ΔSI).

11) P8, L2: KB is stated as the relationship between GRACE data and groundwater volume variation. However, it is defined as ΔÂňSI/WBI (Accumulated groundwater

volume variation/Net precipitation in month n) which are both in situ measurements. Which is correct?

12) P8, L11: Consider adding “the” before “monthly sum of”

13) P10, L1: Snowmelt is one word

14) P10, L4: Consider replacing “increasing” with “increasingly”

15) P13, L11: include “a” in between on and monthly to improve sentence flow

16) P14, L2: water mass changes on “the” catchment scale. . .

17) P14, L8: results showed that “the” groundwater level decrease

18) P16, L1: With “an” increasing area of irrigated

19) P:17, L23: Remove “basically” from the sentence

20) Figure 1: Increase the quality of the inserts, specifically insert A.

21) Figure 5C: Vertical axis variables do not match those listed in the figure description. GRACE data (GWBI) should be GRACE data (GWMI)

22) Figure 6: What do the black lines surrounding the aquifers represent?

Overall, this paper is weak, and it is not clear how the work goes beyond the status quo in the GRACE literature. The generally confusing formatting and explanations of findings throughout make publication in HESS at this time likely not possible.

Before this paper is ready for publication, an effort should be made to clarify the methods and results to improve readers comprehension, as well as emphasizing the need for another paper investigating groundwater depletion using GRACE data and justifying the viability of interpreting GRACE data on a catchment smaller than the recommended area.

Reference

Vishwakarma BD, Devaraju B, Sneeuw N. What Is the Spatial Resolution of grace Satellite Products for Hydrology? Remote Sensing. 2018; 10(6):852.

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