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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Improving estimates of water resources in a semi-arid region by assimilating GRACE data into the PCR-GLOBWB hydrological model" *by* N. Tangdamrongsub et al.

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This MS describes a study about the assimilation of water storage estimates derived from the GRACE satellite mission data into the hydrological model PCR-GLOBWB using an Ensemble Kalman Filter approach for the Hexi Corridor in Northern China. The authors found that area-averaged values of TWS, soil moisture, and groundwater storages over the region decreased with an average rate of approximately 0.2, 0.1, and 0.1 cm/yr in terms of equivalent water heights, respectively. They concluded that this decrease was likely due to the groundwater consumption required to maintain the growing period.

The MS is very well written and presents an interesting GRACE DA model application

for the analysis of the effects of groundwater consumption on water storage in an arid region. Thus, it fits well to the scope of this journal. However, there are some issues regarding the structure, the methods and interpretations of the results (see comments below).

General comments concerning the hydrological modelling:

The interactive modules for simulating water abstraction etc. with the PCR-GLOBWB model are described in greater detail, but these did not be used in this study. Thus the model description should focus on the considered process.

The model parameterisation with respect to the soil hydraulic properties needs to be better described.

I suggest adding some plots showing the special distribution of simulated TWS for the different DA scenarios.

In the DA scheme only TWS is considered. It is no clear, how "added" or "subtracted" water was distributed by DA to the different model storages (e.g. SM, GW, snow).

Compared to the model results the variations in GRACE determined TWS are much more pronounced. Possible reasons should be discussed in greater (e.g. influence of the pattern restauration procedure).

It is unclear if at all or how groundwater abstraction was considered in the modelling. If this was considered, why was the groundwater abstraction not considered in the DA (e.g. by updating the groundwater abstraction parameter)?

Specific comments

Title: The term "semi-arid" is not correct (see below)

At times TWS variations are simply termed "TWS". This is somewhat confusing. The terms "TWS variations" or short "TWSV" should be always used.

L45: The groundwater well data should integrate of smaller areas than the catchment area of the streamflow data. Therefore, I am not convinced that this is a problem of spatial resolution.

L57-59: According to the Köppen climate classification this region belongs to “cold desert climate” (BWk).

L67-68: This depends largely on the measured variable. For instance, streamwater discharge data provides integrated information for large catchment areas.

L81: In addition, hydrological models typically suffer from inadequate process representations (model structure errors).

L98: “jump” of what?

L115: What is the size of the area?

L115-118: How do you know (e.g. the watershed area of the Rhine river is much smaller than the Hexi Corridor area)? Can you provide the SNR values for these different areas?

L122: What is the difference between “surface water” and “inundated water”?

L128-129: In which way are the results validated against remote sensing?

L147: The term “basin” is not appropriate.

L181: “distributed hydrological model”

L184-185: Also indicate the temporal resolution of the model.

L185-193: It is unclear, how or if at all these interactive modules for simulating water abstraction etc. have been used in this study. Clearly it was not the focus of this study. Thus I suggest removing this section incl. Appendix A.

L197: Delete “an”

L208: Change “states” into “water storages”

L219: This is rather a conceptual model.

L230: Explain “complete to the degree and order 60”

L259: Does this increment correspond to the monthly change in TWS?

L261: Is this the general uncertainty of GRACE?

L263-264: By looking at Fig. 4 this procedure seems to have mainly intensified the already existing pattern. To which extent are the temporal variations in TWS estimates influenced by this procedure?

L287-289: It is well-know that global precipitation products show considerable uncertainties, which is also indicated by the low NS values. Since in-situ data is available, I suggest to correct the TRMM data product using the approach suggested by Condom et al. (2011).

L298: Actual or potential ET?

L327-329: Actually, more appropriate data is available from other gauging stations in the Hexi Corridor for this study (see e.g. Zhang et al., 2015, 2016).

L307-322: Because of this conversion method any comparison of groundwater storage changes from in-situ and GRACE observations will not be independent. This needs to be discussed in some detail. In addition, in the procedure described in Tangdamrongsub et al. (2015) two parameter were used instead of one. Please comment on this difference.

L317-318: Please provide a figure with the data and the regression.

L320: Why are you using an averaged f value to calculate the groundwater storage for each well? I would have thought that the variations in parameter f should represent local variations in storage parameters of the aquifers. Please explain the reasoning

behind this procedure.

L451: Please explain how you selected these parameters (e.g. did you use a sensitivity test?).

L526-527: Change into Figure 10. . .

L545: “on” instead of “of”

L549-550: Please provide information on the origin of these parameter values.

L543: How do you know that the groundwater store of the Desert Region is small.

L553-554: Please explain in greater detail, why higher values of K_sat and lower values of J have led to a smaller amount of water addition.

L599-600: I wonder whether the better agreement with the GRACE DA results is due to (or a least partly du to) the scaling procedure of the piezometer data. Please add a discussion on this.

L642: Clearly, predictions for G2 were improved to a lesser degree.

L647-648: These are very low amounts of precipitation, indicating very local precipitation events. It would be interesting to see the spatial distribution of these rainfall events and the resulting modelled soil moisture distribution.

L676-678: Why should the SM storage of the Desert Region decrease although precipitation shows an increasing trend? Please discuss.

L712-714: Until now, there was no indication that groundwater abstraction was considered in the modelling. Please add a description. Why was the groundwater abstraction not considered in the DA?

L734-735: See comment above. Would it be possible to update the groundwater abstraction parameter?

L744: Please provide quantitative information on groundwater abstraction.

Literature

Condom T, Rau P, Espinoza JC (2011) Correction of TRMM 3B43 monthly precipitation data over the mountainous areas of Peru during the period 1998–2007. Hydrol Process 25:1924–1933. doi:10.1002/hyp.7949

Zhang L, Nan Z, Xu Y, Li S (2016) Hydrological Impacts of Land Use Change and Climate Variability in the Headwater Region of the Heihe River Basin, Northwest China. PLoS ONE 11(6): e0158394. doi:10.1371/journal.pone.0158394.

Zhang A, Zheng C, Wang S, Yao Y. (2015): Analysis of streamflow variations in the Heihe River Basin, northwest China: trends, abrupt changes, driving factors and ecological influences. Journal of Hydrology: Regional Studies. 3:106–24. doi: 10.1016/j.ejrh.2014.10.005.

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