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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.

N. Tangdamrongsub et al.

natthachet.tangdamrongsub@newcastle.edu.au

We firstly would like to acknowledge the insightful comments and suggestions provided by reviewer 2. Followings are the responses (R) based on the comments:

Different GRACE gravity field models are available, CSR (this study, p6, l227ff), GFZ, JPL, CNES/GRGS (Sakumura et al 2014). Why was CSR selected and how are the differences between the different GRACE processing models for the study region. I understand that the focus of the article is on the added valued of the DA, however it would be interesting to see whether GRACE is actually providing added value based on the variability in GRACE processing models.

R1: Comparing to GFZ, JPL, and CNES/GRGS, the CSR product is the only product that provides the error variance covariance matrix of the spherical harmonic coefficients. Therefore, it is selected in this study. Note here that the variance covariance matrix is the only information that reflects the true GRACE error. As this information is not available from GFZ, JPL, and CNES/GRGS, they are not considered in this study. We agree with reviewer that it would be interesting to see whether GRACE is consistently improving the water storage estimates based on different products used. The comparison can be conducted as soon as the error information from other data centre is released.

Groundwater head data can be quite complex depending on the well depth and the aquifer being pumped. So far the authors only use head data without information about the aquifer systems. Different aquifer systems also result in individual specific yields. This needs to be addressed. based on a quick literature search hydrogeologic studies (e.g. Ma et al. 2005) are available for the region. Please, do provide information on whether the wells access the same aquifer. Further, groundwater heads were converted to units of storage using a scale factor (p.8, l301ff) as specific yield data were not available. Ma et al. 2005 (and probably more papers as well) provide aquifer properties for the Shiyang basin. Given that the wells are in the same aquifer system, please, show how your units of storage compare to literature values for the region.

R2: We thank reviewer 2 for this valuable information. Unfortunately, the data we used does not come with the aquifer information, so we cannot guarantee whether the well accesses the same aquifer as in Ma et al. (2005). As such, the specific yield is computed based on the best hydrological knowledge (model) and observation. The estimated values are between 0.04 and 0.3, which is in line with the specific yield values Yang et al. (2001) determined from the pumping tests, 0.01 – 0.3. Therefore, our estimate value can be considered sufficiently accurate for the head conversion. For clarity, we add the additional statement to the revised manuscript: "Yang et al. (2001) showed that the specific yield values obtained from the field measurements over the

Shiyang River Basin was between 0.01 and 0.3. Although, the measurement was not conducted at the well stations used in this study, the values obtained can be used as a guidance of the specific yield of the Shiyang River Basin. In this study, the head measurements were converted to storage unit with the approach described in Sect. 4.3.1. The bias term in Eq. (3) was found to be very close to zero, as the variation (mean removed) was used in the regression analysis. The estimated scale factor was 0.23, 0.04, 0.24, 0.25, and 0.32 at W1 – W5, respectively, which was in line with the values obtained from the field measurement."

Regarding the precipitation errors the RMS of TRMM was used (p12, l440). As the authors also compared TRMM to station data, was that error included as well?

R3: As the error of other precipitation products are not available, no error is included in the analysis of Sect. 4.2 to avoid the inconsistency of the comparison.

Minor comments: The abstract is a bit too extensive, please, shorten.

R4: The abstract will be shortened in the revised manuscript.

p2, l57-59. Provide reference

R5: References (Gong et al., 2004; Zhu et al., 2015; Cui and Shao, 2005) will be given in the revised manuscript.

Fig. 1. Include all symbols in the figure caption (crosses). Since color is used, the river networks could also be added (1b).

R6: The symbol will be added to Fig. 1 caption of the revised manuscript as " . . .the locations of considered groundwater wells (x) and river stream gauges (+)." The river network will also be added to Fig. 1b.

p6, l208/209. Please, explain 'the sum of different states'. What are e.g. '4 interception' states?

R7: TWS variation is computed from the sum of 27 different water storage components

(layers), which are 8 soil moisture layers, 2 groundwater layers, 4 interception layers, 8 snow layers, 4 inundated top water layers, and 1 surface water layer. For clarity, we revise the statement to:

". . . the total water storage (TWS) is computed as the sum of 27 different water storage components: 8 soil moisture layers, 2 groundwater layers, 4 interception layers, 8 snow layers, 4 inundated top water layers, and 1 surface water layer.".

p9, l331ff. What exactly was done with the NDVI values? Was the growing season length determined as the period above and below 0.2? If it was only used for visualization in Fig. 14, the section can be shortened to a couple of lines.

R8: NDVI and GWS variation were analysed together to determine if the growing season was being extended beyond the limited rainy period through groundwater extraction for irrigation. The reviewer is correct in that the growing season length is determined as the period above ~0.2. In the revised manuscript, we remove a few statements in Sect. 4.4.3 to make the section more concise.

Fig. 14a. Is the GW head relative to amsl? What is the depth to the surface?

R9: Yes, the measurement is relative to the mean sea level. For clarity, we will add an additional statement to the revise manuscript:

". . . form of piezometric heads (relative to the mean sea level), . . ."

The depth from to the surface is not available from the data provider, and therefore we cannot provide the value here.

References

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