

This is the second review of ‘A Climate Data Record (CDR) for the global terrestrial water budget: 1984-2010’. I thank the authors for their response to reviewer questions and comments and for their revisions to the manuscript. A few minor points still remain to be clarified, however. These are detailed below.

C1. Section 2.2.1, page 8-9: I thank the authors for their explanation in their response to the question about the use of “optimal” to describe the merging technique. Based on this, it seems that it is perhaps more accurate to qualify this “optimality” as constrained by or conditional on limited data availability rather than being the optimal approach. A few minor edits, consistent with the authors’ response to R1-Comment 2, in the abstract and section 2.2.1 would clarify this point.

R1: Thanks for the reviewer’s suggestion, we’ve edited it accordingly in the abstract at Page 1, line 18 -23, and section 2.2.1 at Page 8, line 30-33 and Page 9, line 1-3.

“Conditioned on the current limited data availability, a systematic method is developed to optimally combine multiple available data sources for precipitation (P), evapotranspiration (ET), runoff (R) and the total water storage change ($TWSC$) at 0.5° spatial resolution globally and to obtain water budget closure (i.e. to enforce $P - ET - R - TWSC = 0$) through a Constrained Kalman Filter (CKF) data assimilation technique under the assumption that the deviation from the ensemble mean of all data sources for the same budget variable is used as a proxy of the uncertainty in individual water budget variables.”

“There is no best estimate or observation of each individual water budget component at the grid scale over the globe due to the limited spatial coverage of in-situ measurements. This is especially true for evapotranspiration observations from the flux tower networks. Thus, the limited availability of gridded ground observations makes it impossible to quantify the error in each water budget component. Therefore, in this study, the deviation from the ensemble mean of all data sources for the same budget variable is used as a proxy of the uncertainty/error in individual products. The merging procedure for each budget component is a weighted, averaging where the optimal merging weight w_i is given by the following equation...”

C2. Page 9, Lines 31-32: It would be helpful here to state that the assumed 10% error in VIC runoff is based on the authors’ experience and judgment “given there is no global grid level (0.5 degree in this study) runoff observations to quantify the error.”

R2: Thanks, and this is further clarified at Page 10 line 2-3.

“And this is highly empirical based on the authors’ knowledge and confidence about the VIC model calibration given there is no global grid level (0.5 degree in this study) runoff observations to quantify the error.”

C3. Page 11, lines 25-30: I recognize the difficulty in accounting for groundwater extraction and management globally. As the authors note, there are regions (California Central Valley, US High Plains, Iran, etc) where historic regional storage declines challenge the assumption of zero long

term TWSC. For completeness, an explanation of the consequences of this assumption on the CDR results for these areas, either in section 3.2 or in the discussion in section 5, seems warranted.

R3: Thanks and we have added explanations of the potential consequences by neglecting the groundwater extractions at page 12 line 3-4.

“The “zero TWSC” assumption would potentially introduce local/regional bias into the water budget estimates in the regions with groundwater depletions.”

C4. Page 13, line 22: In response to R1-comment 12, the authors state that the filtering out of basins with non-significant correlations “was done in order to remove those basins such as Indus and Senegal which might have incorrect observational data.” This was not immediately apparent from the explanation on page 13 of the revised manuscript – please edit to include this point for clarity.

R4: Thanks for the reviewer’s comment. We’ve edited this point at page 13 line 29-32.

“A test of significance test was conducted to remove those medium and small basins with non-significant correlations between GRDC runoff observations and CDR runoff records. This was done in order to remove those basins such as Indus and Senegal which might have incorrect observational data.”

C5. Page 16, lines 8-12 and Figure S7: I thank the authors for the additional text and plots addressing the question of inter-annual variability in the CDR. However, this section is a little unclear. Please define SPI and provide more detail in the Figure S7 caption to indicate what is shown in the plots (i.e which parts are from the CDR?)

R5: Thanks. We have edited the caption of Figure S6 in order to make this clear.

“Figure S1 1998-1999 US drought captured by CDR in terms of 6-month SPI and drought extends calculated from CDR precipitation”

And the SPI is also defined in the text at Page 16 line 17 -18.

“Figure S7 further provides an example of how the CDR captured the 1998-1999 US drought in terms of Standardized Precipitation Index (SPI) and drought extends calculated from CDR precipitation.”

C6. Figures – general: The number of figures in the main manuscript makes the main point of this manuscript less clear. Some of the figures could be moved to the supplemental information to better emphasize the results of the study. For example, the data product comparisons (Figures 2-10) could be limited to just continental (or river basin) plots and the remainder moved to the SI.

R6: Thanks for the reviewer’s suggestion. We understand the reviewer’s concern and we have also struggled with the display of the figures. After careful consideration, we think it would be better to keep the figures as they are as we have a large portion of text describing and discussing the

seasonal cycles at both continental and basin levels. Therefore, figures 2-10 would be better to be all kept in the main manuscript instead of the supplement.

C7. Figure 2: The caption references TMPART but this seems inconsistent. Should it instead reference the CSU dataset?

R7: Thanks and we have changed TMPART into CSU in the caption of Figure 2.

C8. Figure 11: Please provide a more descriptive caption to accompany this flowchart.

R8: Thanks and we have changed the caption of Figure 11 into “Flowchart describes the progress of data pre-processing, error analysis, water balance constraint and multi-scale water budget analysis”