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Interactive comment on "A Climate Data Record (CDR) for the global terrestrial water budget: 1984–2010" *by* Yu Zhang et al.

Anonymous Referee #1

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In this manuscript the authors describe the development of a global terrestrial water budget time series at 0.5 degree spatial resolution and spanning more than two decades at monthly intervals. This work expands upon previous efforts by some of the co-authors and represents an important next step in bringing together a variety of data sources at the global scale while addressing the problem of water budget closure at the grid scale. The authors describe a rather comprehensive consideration of precipitation, evapotranspiration, runoff, and storage change datasets and how the variations in dataset extent and consistency are addressed to produce merged spatial time-series for each budget component. They then describe the grid-scale water budget constrained data assimilation process and results, notably including a presentation and discussion of attribution of closure errors. Finally, the authors present comparisons of the derived product against independent observations, noting overall ade-

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quate agreement but regions of poorer match and potential reasons for this. Overall the manuscript is well-written and describes the process and results well. Figures are consistent, descriptive, and illustrate important points from the text.

General comments: The authors propose the developed dataset as a publicly-available reference for understanding climate variability and trends. The bulk of this manuscript describes how the derived data product captures mean behavior of the terrestrial hydrology. While this is fundamental and important, less attention is paid to the extent to which the data product captures inter-annual variability. Additional text and perhaps a figure describing the climatologically-relevant variability or cycles in the produced dataset would greatly improve the manuscript and be valuable to users of the product.

This manuscript describes a temporally and spatially disaggregated global terrestrial water budget. It would be helpful to put the results of this work into the broader context of global water budget quantification by including comparisons of the derived average water budget components with previously published global budgets (e.g. Trenberth et al, 2007).

Specific comments:

Page 1 - Abstract: The method used is described as ‘optimal’ or ‘optimizing’. Provide further explanation in the body regarding what is meant by ‘optimal’ in the process used.

Page 2, Line 14: The authors describe the product developed as a climate data record (CDR) that is defined as “a time series of measurements of sufficient length, consistency and continuity to determine climate variability and change”. It is not necessarily clear from the description given, though, the extent to which the produced global hydrologic budget product meets this standard. Additional explanation should be included as to the nature and validity of variability and change captured in the data product.

Page 4, line 9: The authors list accounting for the Earth’s oblateness as one of the

advances in this study. It is not apparent from the rest of the manuscript what precisely this refers to. Is this in reference to the use of a geographic coordinate system rather than a regular square grid? Please include a short description, where relevant, that specifies what is meant by this.

Page 5, lines 19-22: Given the proportion of land mass in Europe, Asia, and North America that exists poleward of 50 degrees N latitude, do you expect that using datasets that do not extend beyond that latitude might also account for part of the variation seen for those continents and river basins?

Page 5, lines 22-25: The spread among seasonal precipitation values for the Danube and Mississippi appears larger than that shown in Pan et al, 2012 as a result of the inclusion of the CSU dataset. Do the same potential explanations apply here, and specifically to the CSU dataset, i.e. a more dense gauge network can lead to more variability in resulting product as a result of variable application of undercatch adjustments and gridding procedures. It would be helpful to include a brief note explaining this along with the discussion of PGF, GPCC, and CHIRPS.

Page 6, lines 15-18: What additional information or value do the cross-combined SRB-CFSR, SRB-PGF and PM/PT datasets bring to the overall analysis and assimilation? In other words, what aspects of ET quantification do these combinations of algorithms provide or cover that are not addressed in the other 6 datasets? A brief justification would help clarify this point.

Page 8, Line 11: Does the resampling in space and time introduce additional error or imposed correlation that warrants treatment in the merging and data assimilation process?

Page 9, Section 2.2.2: How was the error calculated for the runoff component? Were all three sources (VIC, CLM, NOAH) used? Please clarify.

Page 10, Section 3.2 and Figure 12: The description of the example water budget con-

strained assimilation for the Amazon suggests that the precipitation component for the assimilation received the highest non-closure error attribution. If the error covariance for data assimilation is based on the spread of ensemble values for each water budget component (as described in Section 2.2.2), which appears comparatively low (~10-20 mm for precipitation compared to >30 mm for ET, based on plots in Figures 3 & 5, respectively), how does this translate to the attributions reported? Perhaps this is obscured by the fact that the plots in Figures 3 and 5 are seasonal averages whereas the water budget closure assimilation is done monthly? Some additional explanation here (Section 3.2) or in the brief Section 2.2.2 would help clarify these sorts of apparent inconsistencies and guide the reader through the process.

Page 11 - Line 9-11: Given that human activity can impact long term water storage (multi-decadal groundwater storage decline, filling or removal of dams and reservoirs, etc), it seems that a long-term mean TWSC might not be appropriate in some locations. This assumption needs additional justification.

Additionally, how do the authors reconcile the assumption of a long-term zero trend in terrestrial water storage with studies that indicate recent trends in continental water storage (e.g. Reager et al 2016 - 'A decade of sea-level rise slowed by climate-driven hydrology' Science)?

Page 13 - Line 6: What is meant by "non-significant correlations" here? What portion of the total was filtered out for comparison?

Page 12-13, Section 4.1: The authors refer to the developed dataset alternatively as the CDR and the 'MEaSUREs' dataset within this section. Consider revising for consistency and clarity.

The comparison of the developed data product runoff against available gage records (Figures 13 & 14) indicates poorer matches in northern regions and in more arid regions. The authors describe potential reasons for the mismatch in northern basins (lake/wetland influences) and the arid southern Africa data points (poor representation

of sporadic rainfall and quick runoff). I'm curious if the poorer match in arid and semi-arid regions is potentially attributable to unaccounted-for water management activities (which tend to be more pervasive in water-limited regions) or if there is an underlying hydrologic bias specific to those areas.

Page 16, Line 1: It seems the runoff and TWSC components of this process could be improved to better represent lake/wetland dynamics which are noted as potential aspects of budget mismatch in certain regions. Do future plans entail addressing these issues?

Minor edits: Page 4, line 20: Check the tense(s)

Page 6, line 15: 'These four products are referred [to] as. . .' Page 6, lines 15-18: Check sentence for extra words/order

Page 14, line 4-5: Sentence wording a little unclear - consider revising for clarity

Page 20, Table 1: *CLM and NOAH in grey are analyzed but [NOT] merged into . . . ERA-Interim & MERRA lines - 1979-present (misspelling)

Page 22 - Table 4: Typo - NoethernDvina -> Northern Dvina

Page 39 - Figure 15: Misspelling on plot axis: 'infered' -> 'inferred'

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