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Hydrology and Earth System Sciences
Discussions

Interactive comment on "HESS Opinions: Beyond the Long-term Water Balance: Evolving Budyko's Legacy for the Anthropocene towards a Global Synthesis of Land-surface Fluxes under Natural and Human-altered Watersheds" *by* A. Sankarasubramanian et al.

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Here are some thoughts/queries that I had while reading the paper (that by sharing hopefully strengthen the revised version of this paper). This is not a complete review (since I am not assigned being a reviewer). I enjoyed reading the paper.

- It is stated that Budyko has been verified "over thousands of natural watersheds around the globe". However, the studies that you cite are not necessarily at the wa-

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tershed scale (e.g. Williams is a FLUXNET based study, using plot scales), nor do I expect that all the thousands of watersheds in the other studies can be classified as "natural". In addition, what does "verified" really mean here? (Note hereby that e.g. many of Williams points fall outside the energy and water limits; Sivapalan does not present any Budyko curve in its study (only related concepts)).

- It is stated that there ". . .is a critical need to enable a complete understanding of global hydroclimate during the Anthropocene. The Budyko framework provides an ideal approach for such inquiry. . ." Prior to this statement, many aspects of change are listed, including flood changes. Listing this example, and stating you want a "complete" understanding of hydroclimatic change suggests to me that it should include changes in floods as well. What is your logical basis for using Budyko for understanding flood changes since its original use and assumptions have very little to do with hydrology at the short time-scales over which many floods are produced?

- It is stated that "Studies have also focused on the impact of land cover and climate on long-term water yield using global data (Zhou et al., 2015)". However, this study is mathematically flawed; see https://www.nature.com/articles/ncomms14795. This makes me question if this study is a good example to cite. . .

- In the section "Long term water balance" (line 106 and onwards) the ability of the original Budyko curve is tested in explaining global water balance variability. However, the ET data to which it is compared is model output. Would it make sense to use something more directly observation-based, to avoid that it remains unclear to what extent scatter around the curve is based on real-world behaviors, and to what extent it arises from inaccuracies of GLDAS? The fact that (almost?) not a single data point with aridity $<\sim 1$ plot above the Budyko curve is hereby interesting since this is not typically observed in other datasets (as far as I am aware).

- It is stated that "[. . .] limited/no effort has been undertaken on how this data cloud of long-term water balance cloud is expected to change under potential climate change

and how this interplay between moisture and energy is expected to affect the long-term water balance under different type of watersheds (Creed et al., 2014).” However, at the same time, your paper states that Budyko can be straightforwardly used to decompose the effects of climate change vs human influences (e.g. line 90-94), which also implies that you can straightforward use it to predict... This seems to be somewhat contradicting?

- The discussed “Extension of Budyko’s “supply and demand” concept for infiltration” (and other suggested extensions) sounds interesting. However, we need to be aware that plotting variables using demand & supply axes that BOTH have the same term in their denominator partly show strong correlations/patterns because they have spurious self-correlations due to a common denominator [Bensen, 1965; Brett, 2004]. This does not mean we should not use it, I just think the community sometimes forgets about this fact (for example, it’s rarely acknowledged that Budyko itself is partly a spurious self-correlations due to a common denominator).

References Benson, M. A. (1965). Spurious correlation in hydraulics and hydrology. Journal of the Hydraulics Division, 91(4), 35-42. Brett, M. T. (2004). When is a correlation between nonâĂŘindependent variables “spurious”?. Oikos, 105(3), 647-656. Gudmundsson, L., Greve, P., & Seneviratne, S. I. (2017). Correspondence: Flawed assumptions compromise water yield assessment. Nature communications, 8, 14795.

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