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Hydrology and Earth System Sciences Discussions

# *Interactive comment on* "Applying a simple water-energy balance framework to predict the climate sensitivity of streamflow over the continental United States" *by* M. Renner and C. Bernhofer

**Anonymous Referee #2**

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The main aim of this paper is to apply the conceptual eco-hydrologic framework developed in the companion paper Renner et al. [2011] on 431 US watersheds in order to answer the following research questions:

1. Can we predict and attribute the streamflow changes to the respective changes in precipitation and evaporative demand?

2. How strong is the effect of estimated basin characteristic changes on (i) the change



in streamflow and (ii) the sensitivity methods, which only regard climatic changes? Another main contribution of the paper was to compare the new framework with a couple of Budyko type frameworks.

The conceptual framework builds off the concept of precipitation (W) and evaporation (U) excess in Tomer and Schilling [2009]. The novelty of the approach applied in this paper lies in the fact that the authors combine the two excesses (additively) to define 'catchment efficiency'. These three hypotheses follow clearly from the definition:

a. CCUW Hypothesis: the climate change impact hypothesis resulting from constant catchment efficiency (catchment efficiency describes the ecosystem function and will remain constant unless basin changes take place)

b. BCUW Hypothesis: Basin characteristic change impact hypothesis: increasing or decreasing CE as a function of basin changes

c. Combination of both, where the relative contribution of both can be computed from observed change signals of U and W

The CCUW hypothesis is then used to derive the elasticity of the streamflow in study watersheds to precipitation. These results are compared with the values of elasticity derived from two Budyko type formulations. Next, the full data record is broken into two periods: 1959-1970 and 1971-2003. The change in streamflow for the 2nd period is then predicted using the CCUW and the Budyko hypotheses and results are compared.

Main comments:

1. Although the definition of excess water (W) and excess energy (U) is simple, the definition of catchment efficiency itself is arbitrary. Is there previous literature on catchment efficiency that the authors could cite in the current paper? If this is the first proposed definition of this eco-hydrologic variable, the discussion section should include that fact, along with another that it is a chosen functional form and in reality the CE can be a non linear combination of U and W. Besides basin land use changes, can climate change

also impact CE (for example, by changing vegetation patterns over long periods)? It is yet another point that can be included in discussion.

2. The main purpose of this paper was to validate the theoretical framework developed in Renner et al. [2011] and compare it against the Budyko-type frameworks that are prevalent in literature. However, the analysis mixes up significant and insignificant changes in precipitation and neglects the uncertainty in the input data. Overall, although the theoretical method itself follows straight from the assumptions, its validation is weak. The following points are noted in this regard.

3. In the previous paper of Renner et al. [2011] three functional forms to the Budyko-type relationship were used for this comparison: Ol'Dekop, Mezentsev, and Schreiber. In the current paper only the first two were chosen for further analysis. This is baffling considering the fact that in Table 2 of Renner et al. (2011), it is clearly seen that only Schreiber out of the 3 Budyko type methods performs well for the Murray-Darling River Basin. To maintain consistencies between the two companion papers, Schreiber method should also be included for comparison in the current paper.

4. Page 10840, Lines 1-17: Overall, the CCUW hypothesis does not perform better than the two Budyko hypotheses (again, Schreiber can easily be mentioned here for comparison). The case is made for the CCUW hypothesis in lines 11-17, based on the smaller prediction errors it produces. Given the uncertainty in the source data, use of Hargreaves for PET calculation (which is known to systematically under/over prediction of PET eg. [3], [4]), can this claim be considered valid at all? If yes, an estimate of uncertainty (or precision) in the input data should be given and considered in the performance evaluation.

5. Page 10840, Lines 23-27 & Page 10841 Lines 1-2: If most of the precipitation changes have not been significant for the given data periods, and as claimed in section 4.2, the climate sensitivity is mainly correlated with (P/Q), should the basins with insignificant changes be included in the analysis? Again given the uncertainty in input



data, and insignificance of precipitation change, maybe only the basin with a significant change should be included in this analysis?

6. Page 10842, Lines 12-16: Most of these basins do not have a significant change in the UW space. It would help to re-write the results only for basins with significant changes. The other option is to present results in both contexts.

7. Page 10843, Line 11: Latitude should be changed to longitude.

References:

[1] Renner, M., Seppelt, R., and Bernhofer, C.: A simple water-energy balance framework to predict the sensitivity of streamflow to climate change, Hydrol. Earth Syst. Sci. Discuss., 8, 8793-8830, doi:10.5194/hessd-8-8793-2011, 2011.

[2] Tomer, M. and Schilling, K.: A simple approach to distinguish land-use and climate-change effects on watershed hydrology, J. Hydrol., 376, 24–33, 2009.

[3] Amatya D.M., Skaggs R.W., and Gregory J.D. (1995). Comparison of Methods for Estimating REF-ET. Journal of Irrigation and Drainage Engineering. Vol 212, No. 6, November/December 1995, pp. 427-435. doi http://dx.doi.org/10.1061/(ASCE)0733-9437(1995)121:6(427)

[4] Lu, Jianbiao; Sun, Ge; McNulty, Steven G.; Amatya, Devendra 2005. A comparison of six potential evapotranspiration methods for regional use in the Southeastern United States. Journal of American Water Resources Association. 41(3): 621-633.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 8, 10825, 2011.