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Hydrology and Earth System Sciences Discussions

Interactive comment on "Stream recession curves and storage variability in small watersheds" *by* N. Y. Krakauer and M. Temimi

Anonymous Referee #1

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Review of "Streamflow recession curves and storage variability in small watersheds" By N. Y. Krakauer and M. Temimi

This is an interesting paper on a topic of societal importance as demands on fresh-water increase. Reliable methods for quantifying storage at the watershed-scale are needed for informed management of our resources. The lack of correspondence in the amplitude of the variability in storage (as given by the standard deviation) between the recession-derived values and GRACE values is an important observation and should serve as quality-check on GRACE. I am grateful to authors for having submitted a well-written paper such that as a reviewer I could easily focus on content.

The material presented is novel and the topic is within the scope of HESS.

1. The authors should spend more time justifying their assumption of a 1-1 storage-discharge relationship in these watersheds. Even a simple groundwater model with a basis in physics will generate aquifer discharge that is not a 1-1 function of storage (Sloan, 2000; Rupp et al., 2009) and this lack of 1-1 relationship has been observed in basins (e.g., Rupp et. al., 2008). The consequences of lumping together individual recession curves that do not overlap should be discussed. Not only will there be an offset in the dQ/dt vs Q relationship, the slope of this relationship will be affected, and thus the entire tau(Q) function that the authors are generating. The authors should comment on the direction and magnitude of this effect/bias. While the authors discuss the how the inferred storage-discharge relationship based on periods of low precip, snowmelt and evapotranspiration may not hold when these forcings are greater (p. 1848), this does not address that a 1-1 relationships may not be valid even when these forcings are negligible.

2. Figure 4a may be the most important figure in the paper. Unfortunately, I believe that using a locally-weighted least squares linear regression to estimate tau(Q) is not the preferred option here. This LOWESS-type method produces curves that are too locally "jagged" (e.g. Fig 3b) resulting in the spaghetti of curves in Fig. 4a from which it is very difficult to discern patterns among individual curves (though the overall pattern of decreasing tau with increasing Q is apparent). Kirchner (2009) used a quadratic equation, which is nicely smoother, but as the authors point out, may not be as flexible as one would like when analyzing many watersheds. There are alternatives, and a cubic spline might be a good choice. The maximum number of knots in the spline can be set such that curves aren't too wiggly and the general overall pattern is not lost in over-fitting at the local level. For example, packages for fitting generalized additive models (GAMS) that use cubic splines could be applied to fit locally smoother curves to the data.

3. Abstract, lines 4-5: "However, it. . ." The pronoun "it" should be replaced by the thing it is representing, because as it stands, "it" could refer to "the pattern of streamflow

recession" or the "relationship between watershed runoff and watershed storage".

4. Abstract, lines 5-6: The authors claim that "..it has not been. . .related to independent assessments of terrestrial water storage", yet later in the introduction the authors cite Brutsaert (2008) as comparing recession-inferred storage changes to storage changes inferred from well data. The authors should soften their statement in the abstract that independent assessments have not been made prior to their study.

5. p. 1831, lines 13-19: The authors discard the "lower envelope" approach to fitting because, in part, it involves arbitrary thresholds. While this is true that there are practical issues with its application (namely because of noise and error in the data), there is a physical argument to the lower envelope method (Brutsaert and Nieber, 1977). The authors should discuss this argument and explain why they believe they are justified in not using a lower envelope method in terms of their conceptual model of the system. The difference between the lower envelope methods and fitting a curve through the entire data cloud using a least squares error procedure is not simply a matter of technique, but of interpretation of what the data represent.

6. p. 1832, lines 19-22: The authors cite Rupp and Selker (2006a) when referring to bias in estimating the dQ/dt = f(Q) relationship when the recession timescale is of the order of the time interval of the discharge data. While this is a valid citation, a more detailed discussion of this bias and exact analytical expressions for this bias are given in Rupp and Woods (2008).

7. p. 1839, lines 1-4: How was the reference discharge (Q0) chosen to calculate S – S0 from eq. (7)? While it can be arbitrary if only anomalies are of interest, it could be informative to estimate the magnitude of the dynamic storage (S-S0) using the generated tau(Q) functions to check if the estimated dynamic storages are consistent with expectations.

8. p. 1839, lines 13-16: Precipitation, snowfall, evaporation: Were these annual means? Please specify.

9. p. 1839, lines 13-16: Why was stream length divided by basin area (L/A) or (L/A)ˆ2 not tested as predictor variables? This ratio appears in the expression for the recession time constant in many analytical equations for recession discharge (see review Rupp and Selker, 2006b). Furthermore, how about the ratio of evaporation to precipitation, and a dryness index (potential evapotranspiration over precipitation? Plotting these two ratios against each would give the reader a better idea of the range of different watershed climate types in the data set (beyond the map of the US). See for example, Milly and Dunne (2002).

10. p. 1842, lines 11-12: Channel length is listed twice. Remove one of them.

11. p. 1844, line 2: As the authors begin the Discussion section, it would be helpful here to remind the reader what is meant by "inter-stream variability in the recession curve", by stating that it is the variability in tau(Q). E.g., "In our sample, inter-stream variability in the recession curve time constant tau(Q) was . . ."

12. Fig 7. The axis labels say "seasonal storage" and "interannual storage", but the figure captions say the standard deviation of the seasonal cycle and the standard deviation of the interannual variability. Please be more clear as to what is being plotted. If it is standard deviation, then the the axes labels should say standard deviation. It would be clearer if the caption said something such as "standard deviation of (a) monthly storage anomalies and standard deviation of (b) annual storage anomalies", if this is, in effect, what is being plotted.

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