Hydrology and
Earth System
Sciences
Discussions

Interactive comment on "Technical Note: A measure of watershed nonlinearity II: re-introducing an IFP inverse fractional power transform for streamflow recession analysis" by J. Y. Ding

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Response to Anonymous Referee #1

Part 1 - IFP transform method

I appreciate the positive feedback and critical review from Referee 1. This first response will address questions about the properties of the IFP transform, leaving those about Brutsaert-Nieber (BN) model as commonly implemented to a second response.

1. Is the IFP transform model time-scale invariant? (Paragraph C7376, Paragraph 2; Page C7377, second to last paragraph)

Referee 1, in his/her second sentence, captures the essence of BN model by the IFP transform: it produces a linear transformed recession time series.

The time scale invariance is a consequence of the resultant linearity. Only two points are needed to define a straight line representing a transformed recession hydrograph. (A third point in between is needed to falsify the given b value.) This holds, no matter how close or how far apart the two points are, thus the conclusion that BN model by IFP transform is time scale invariant.

2. Can the shape parameter b value be greater than the upper limit of 2? (Page C7377, Paragraphs 2 and 3)

Referee 1 isn't convinced that the shape parameter b value should be less than 2. He/she is correct in that BN(1977) derived a theoretical value of 3 for early-time recession (Page 15663, Lines 21-24).

But the upper limit of 2 is a logical consequence of the IFP transform model (Eq. 2a) being an exact solution of BN model (Eq. 1) and constrained by a monotonically increasing nonlinear storage-discharge relation (Eq. 3).

To move from a parameter b value of 2- to 2+ represents a phase change in the concept of the catchment storage: from a water storage or storage "surplus" to a storage "deficit." The latter requires an additional set of equations of some complexity to account for the soil moisture deficit (e.g. Chen and Wang, 2013).

For drought flow analysis which covers a longer time span than hours or days, the use of a b value of less than 2 regardless the timing, early or late, of flow recession is thus justified. The IFP transform helps stabilize BN exponent b as a system nonlinearity index varying between 1 and 2 that can be used as a "hydrologic signature" for watershed classification.

3. Is the correlation coefficient sufficient for parameter calibration? (Page C7376, last paragraph; Page C7377, Paragraph 3)

For an event and a given b value, the correlation coefficient, along with the slope and intercept, is one of the result from fitting a linear regression line to the transformed recession hydrograph. As Referee 1 also observes in Table 3, the correlation coefficients in absolute value for all 3-way combinations of event, parameters b and a are all close to or at one. This means the correlation coefficient alone is not sufficient to discriminate performances among different pairs of parameters b and a. This, I should add, is a case of the equifinality phenomenon even for models having only two parameters (Beven, 2006).

The upper limit of 2 for parameter b narrows the types of IFP transform to between the log and Recip(rocal) transforms.

Finally, for a given b value, variance of parameter a by visual inspection further lowers the type from Recip to RoSR transform.

Additional references

Beven, K. J. (2006) A Manifesto for the Equifinality Thesis. Journal of Hydrology, 320 (1-2). pp. 18-36.

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