Anonymous Review for HESSD

Technical Note: A measure of watershed nonlinearity II: re-introducing an IFP inverse fractional power transform for streamflow recession analysis

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Overview

This note describes and illustrates the use of the IFP (Inverse Fractional Power) transformation of flow to estimate the parameters of the Brutsaert-Nieber recession model, $-dQ/dt=aQ^b$. If the value of b can be selected appropriately, then the plot of transformed flow against time is linear, and parameter a can be estimated by linear regression. This IFP method is an alternative to estimating a and b by fitting a straight line to a cloud of points on log(-dQ/dt)-vs-log(Q) axes.

In my opinion, the IFP transformation may be of academic interest, but I do not think the paper has demonstrated any significant advantages over alternatives. The IFP method requires a two-stage estimation process, where b is chosen, and then the best value of a is found. This must be repeated until an optimal combination of a and b is obtained. I did not find that the examples revealing or compelling. In its current form it does not seem suitable for publication in HESS and I recommend Major Revisions.

Main Points

P15661 "However, the approximation of the infinitesimally time-step size dt by a finite difference Δt manifests itself in a scattering of the recession data points, called the cloud" In my opinion, this is not the dominant reason for the scattering which is observed. There are multiple causes, including non-uniqueness of the storage-discharge relationship, and heterogeneity within the catchment, as well as timestep effects.

P15664/5 "Approximation of (dQ/dt) by the backward time-differencing one, $(Q(t)-Q(t-\Delta t))/\Delta t$, is thus the main source of the numerical instability in parameters characterizing the model." And "Linearization of Brutsaert–Nieber model thus removes sources of numerical instability in its parameters." It is unclear what is meant by "numerical instability in parameters". No examples or references are provided. If the author is referring to the possibility of obtaining different a and b values at different timesteps, this needs to be made explicit, and the work of Rupp and Selker (2006) should be referenced here.

P15665 "The physical constraint that $S \geq 0$". I do not agree that this constraint is necessary, and as a result I do not agree with the constraint that $b \leq 2$. See Rupp and Woods (2008) for a demonstration that a negative value of S can be a physically meaningful measure of storage, if it represents a deficit.

P15665 “thus b≤2” If the author allows b=2, then the author has c=0 and N infinite. By the author’s own argument this does not seem reasonable, and yet the author adopts b=2 as physically reasonable. I do not see the author’s reasoning here (but see Rupp and Woods (2008)).

P15665 “its latter expression hints at an intriguing, counter-intuitive transformation of a time series.” I did not find this material helpful. Nor did I find the connection to the Tukey ladder of powers helpful. One could equally find other power transformations from other fields which had the same mathematical form, but this does not mean that there is a useful connection.

P15667 The author never explains of justifies his use of best-fit correlation as his method of selecting a and b. One could hypothesise a number of different measures of the goodness of fit of the model to the data.

P15668 “the highest calibrated a value among four events” It is not meaningful to compare make numerical comparisons of the a values, because they are measured in different units (the units of a depend on the value of b, which takes on many values in these examples)

P15668 “as parameter b value increases, so does parameter a value reflecting the steepness of a transformed recession curve in Fig. 2” Again, it is not meaningful to compare values of a when b is not constant.

P15668 “the Manning (or Chezy) friction law governs the nonlinear storage–discharge relation expressed by Eq. (3).” I do not see why a friction law of this type must govern the storage, because it is not clear that the storage is held in the river; it could equally be in a near-stream aquifer.

Table 2, Table 3 and Figure 2 The author fits the IFP model to individual recessions which do not contain a wide range of flow values. As a result, flow varies almost linearly with time, and many of the power transformations also produce relationships which are close to linear. Correlations are never poorer than 0.97, and it does not seem meaningful to select an optimal b when almost every b value gives a strongly linear relationship.

P15669 “Among three of four events, the linear regression method yields higher b values than the IFP transform one,” The author rejects b values greater than 2 from the IFP method in compiling Table 4, so it is not surprising that the IFP values are smaller than the standard B-N values.

Minor Points

P15667 “Events 2-4” There is no event 4 in Table 3.

References

Rupp, D. E., & Woods, R. A. (2008). Increased flexibility in base flow modelling using a power law transmissivity profile. Hydrological Processes, 22(14), 2667-2671.