Hydrol. Earth Syst. Sci. Discuss., 9, C4378–C4381, 2012
www.hydrol-earth-syst-sci-discuss.net/9/C4378/2012/

Hydrology and Earth System Sciences Discussions

HESSD

9, C4378–C4381, 2012

Interactive Comment

Interactive comment on "Are streamflow recession characteristics really characteristic?" *by* M. Stoelzle et al.

J. Ding

johnding_toronto@yahoo.com

Received and published: 25 September 2012

1. Introduction

The Discussion paper by Stoelzie, Stahl and Weiler (2012) represents a continuing fascination with analytical techniques of streamflow recession, the low end of flow regime. The purpose of this brief note is to bring to the attention of the hydrology community a forgotten technique buried in engineering archives.

2. Power-transform method

For recession flow analysis, Brutsaert and Nieber (1977) pairs the first-order time difference and addition of the flow data, Q(t-1)-/+Q(t). Prior to their work, the analysis was done using directly the raw data, Q(t), usually plotted in log-scale on a semi-log paper (e.g. Roche, 1963).

Regarding the second part of Equation 4 of the Discussion paper:

(4.2): Q(t) = {Q0ˆ(1-b)-[1-b]at}ˆ[1/(1-b)], if b<>1,

By taking the power of (1-b) on both sides, this becomes:

(4.2a): Qˆ[-(b-1)](t) = Q0ˆ[-(b-1)]+(b-1)at,

Note there exists a linear relation between the transformed flow value, Qˆ[-(b-1)](t), and the elapsed time t (e.g. Ding, 1966).

(Note: Between Pages 10572 and 10573 of the Discussion paper, some lines appear missing.)

3. Flow recession parameters

Regarding the interpretation of recession parameter b, this can be related back to the degree of nonlinearity N in a nonlinear storage-outflow relation, Q = (cS)ˆN, in which c is a scale parameter. Ding (1974) presents a similar, linearized recession equation as follows:

(4.2b): Qˆ[-(1-1/N)](t) = Qˆ[-(1-1/N)](0)+(N-1)ct,

Equating the powers of Q(t) in Eqs. 4.2a and 4.2b: -(b-1) = -(1-1/N), one obtains:

b = 2-1/N.

Parameter b is thus a re-scaled nonlinearity of the watershed nonlinearity N.

Similarly, equating the two corresponding time-dependent terms yields a = Nc.

Since parameter N is now known to vary, for practical application, from 1 to 3 (e.g. Ding, 2011), b is thus expected to vary between 1 and 1.67.

In Figure 1, the three middle, vertical sub-plots using linear regression for model fitting show respectively the best-fitted b values of 1.48 (by Vogel), 1.69 (Brutsaert), and 1.46 (Kirchner). Brutsaert's b-value of 1.69 lies slightly above the upper (practical as opposed to theoretical) limit of 1.67. Both Vogel's and Kirchner's lie close to but below b = 1.5, which corresponds to an N value of 2.

Ding (1966) shows that an N of 2 characterizes in part the outflow hydrograph from a cross section of an unconfined aquifer. As the outflow from groundwater storage becomes the lateral inflow to the river, the type of water storage in a watershed and its contribution to the base flow of a stream shift, in a downstream direction, from that in aquifers to that in river reaches. Since the channel storage is characterized by an N value of 1.67 by Manning friction or 1.5 by Chezy, (e.g. Ding, 2011), this gives a corresponding b value of 1.4 or 1.33.

4. Are streamflow recession characteristics really characteristic?

To respond to the provocative question, raised by the authors, which headlines the Discussion paper, the answer is to be a YES, as far as the recession (shape) parameter b is concerned. Results from the authors' numerical analysis, as shown in Figures 1 and 3, pairing the linear regression procedure, and the Vogel and Kroll, and the Kirchner data extraction procedures, as well as those from the writer's previous theoretical analysis, both indicate a narrow range of the re-scaled nonlinearity b from 1.4 to 1.5.

5. An alternative

In contrast to the Brutsaert and Nieber, and two other similar RAMs (recession analysis methods) evaluated in the paper, the use of the power-transformed flow values in linear regression analysis offers an explicit (in the outflow) but indirect (in the computation) alternative for fitting recession parameters to the extracted recession data. The conventional log-transform method is a special case of the power-transform one in which the watershed nonlinearity (re-scaled or not) is unity, i.e. it being a linear storage system.

Acknowledgement. The base flow recession for unconfined aquifers was shown in Roche (1963) text as Equation (16-VII) reproduced here: q = q0[1+u[SQRT(q0)](t-t0)]ˆ(-2), where the Greek u (mu) is a constant. One day around the summer of 1964, a linearized form, 1/SQRT(q) = 1/SQRT(q0)+u(t-t0), leapt off the page, when a fellow graduate student, Paul K. K. Yin, at the Ontario Agricultural College at Guelph, Canada, suggested flipping the nonlinear recession equation.

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 9, 10563, 2012.