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Discussions

Interactive comment on "Recession analysis 42 years later – work yet to be done" *by* Elizabeth R. Jachens et al.

Anonymous Referee #2

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——Paper summary——————————

The authors explore sources of variability in the fitted parameters of the power law streamflow recession model: dQ/dt= -aQˆb by generating collections of synthetic recessions. Three cases are examined to investigate the various ways one might obtain conflicting results when comparing individual event vs. point cloud methods.

——General Comments————————

While I agree with the authors that there is "work yet to be done" in the field of streamflow recession analysis, and really appreciate some of the authors' discussion points on the practical implications of using point cloud analysis vs. individual event analysis (Page 8), there are a number of parts in this manuscript that I find difficult to under-

stand, or that I believe impose "baked in" sources of variability that may not reflect the forms of variability imposed by actual physical processes.

1) In some respects, it seems that Case 1 really encapsulates the main point of this paper (which numerous authors have already argued; though I think the point is worthy of reiteration); that individual recession events typically have steeper slopes than the best fit slope of a line through a point cloud generated by a collection of individual events. Case 1 demonstrates how this might happen; if the recession scale parameter (a) scales with the initial flow condition of the recession (Q0), the intercept of the recession curve in log-log space will shift up or down with Q0, and so a collection of steep recession curves will "stack" in a such a way as to create a point cloud that is less steep than the individual curves of which it is composed (see specific comment #5 for additional comment on imposing this form of variability in 'a'). Cases 2 and 3 are primarily used in the Discussion and Conclusion to demonstrate this same point. For this reason, I do not see how these cases are useful. These cases might be advantageous if the authors were able to systematically explore the effects of the magnitude-frequency distribution of recharge events on individual recession curves (for example, convincingly attributing the spread in "b" to the magnitude-frequency statistics of recharge). However, I would argue, there is no clear way to perform such a systematic exploration given our present understanding of the physical origins of power law recession dynamics.

2) The methods need to (a) more thoroughly explain exactly how to generate the various forms of synthetic recession, and (b) how these different forms might reflect the impacts of real, physical processes in a watershed. On the first point:

(a)

i. How do the authors translate a recharge magnitude (presumably with units of [L]?) into a flow increment (with units of [L/T])? In the case of nonlinear recessions, the flow increment is a nonlinear, flow dependent function of the recharge depth.

ii. What are the parameterizations used for the various distributions from which flow increments and inter-arrival times are sampled?

iii. How am I to interpret the .mat file uploaded to Hydroshare? I loaded this file, and I see there are columns "mag", "start_locs", and "value". How do I use this information to reconstruct the recession curves the authors analyzed? It's undocumented, and not described in the text.

iv. For Cases 2 and 3, can the authors more clearly define their superposition procedure? Going off of Figure 2, how is the "underlying second event" (QC) constructed? Is the recharge increment added to the value of flow at the end of the previous recession? Or is this how QA is generated? One possibility for QC (once the authors clarify how it is constructed) is that we have effectively created a second "reservoir" with an initial storage equal to the magnitude of the recharge event. Then, QD would equal the sum of the discharge from the continued first event and the discharge from the second reservoir.

(b)

Referring to comment (iv.) above, it's not clear how this appearance of a second reservoir represents any physical process, or why it's a meaningful way to generate variability. The idea that the previous event recession somehow continues unabated and superposed with the current event effectively splits the watershed into two parallel components that, owing simply to the occurrence of a recharge event, now operate independently of one another. The procedure amounts to taking the sum of two nonlinear reservoirs with identical values of 'b' (page 5, Line 23), and varying value of 'a' imposed by Page 4, Line 17. I don't disagree that this will generate a new recession curve with entirely different power law parameters which depend on previous flow conditions, but the authors do not provide a rationale for imposing this form of memory. A more defensible approach (in my opinion) taken by previous authors is to explicitly acknowledge physical mechanisms that might give rise to parallel reservoirs throughout a landscape

(for example, conceptualizing a watershed as a collection of contributing hillslopes with varying hydraulic response times). In such cases, parallel reservoirs may generate increased nonlinearity, as demonstrated by Harman et al (2009) and Gao et al (2017). While it is true that these previous authors use superposition of linear reservoirs, the actual dynamics that give rise to increased nonlinearity are similar to those operating in the present work. On a related note, I think the authors should be citing these previous manuscripts, which I believe are very closely related to the present work.

3) I do not understand the purpose of the "early" vs. "late" fitting method in the context of this work. The early/late time methodology derives from the analysis of Brutsaert and Nieber [1977], who show that a shift from a recession slope of 3 to 1.5 is a direct consequence of the dynamics of a Boussinesq-style hillslope groundwater table. The physical implications of the authors choices in construction of synthetic hydrographs (e.g. existence of parallel reservoirs in the previous comment) are not necessarily consistent with the dynamics of a single hillslope groundwater table, so why use a form of analysis that is specific to the Boussinesq framework?

———Specific comments————————

1) Page 2, Lines 16 – 18: Do the authors intend to say that sources of variability in a,b between events may derive from these sources? Also, it is not clear what the authors mean by "flow superposition from previous events".

2) Page 2, Line 29: This statement is vague; of course the hydrology of a recession event affects the recession event.

3) Page 3, Line 9: Use of superposition without defining the term.

4) Page 3, Line 22: "theoretical"

5) Page 4, Line 15 – 17: While I agree that this is certainly one way to introduce variability in the recession scale parameter, it is nevertheless arbitrary to impose this particular relationship pinned to a 45 day timescale. Subsequent interpretation should be quali-

fied with “where a = -w/(t0*Q0ˆ(1/w)) holds. . .”. While it is a convenient expression for imposing variability in ‘a’, I am unaware of any process-oriented result that shows the recession scale parameter should be determined in this way. Related to this, on Page 6, Lines 3 – 12, this discussion is difficult to follow. I think the authors are making the point that within their imposed timescale framework, the recession scale parameter ‘a’ must collapse to a single value that no longer depends on the flow initial condition in the limit as b=1. I agree that, mathematically, this is what happens, but the authors don’t provide a compelling case that this is physically what should happen with real recessions; so the conclusion, “yet this result suggests that a condition where b=1. . .” should be qualified with the requirement that this would be true in circumstances where the authors’ imposed form of variability for ‘a’ holds.

6) I assume the authors meant to put “3 Results” not “3 Methods” on page 5.

7) Page 7 Line 23: “We hypothesize. . .” is an almost tautological statement.

——-Figures——————————-

- Figure 2: Why is there a "t0" at the top of the plot? Isn’t t0 the 45 day timescale imposed to generate the recession scale parameter?

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