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Hydrology and Earth System Sciences
Discussions

Interactive comment on "On the shape of forward transit time distributions in low-order catchments" *by* Ingo Heidbüchel et al.

Anonymous Referee #1

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The authors perform a set of numerical experiments to investigate the shape of the transit time distribution for a watershed under different catchment and climate characteristics. They focused mainly the role of soil depth, soil hydraulic conductivity, antecedent soil moisture content and subsequent precipitation amount, but other runs explored also soil porosity, bedrock hydraulic conductivity, depth dependence of the soil hydraulic conductivity and precipitation frequency. The ambitious goal of the article is to relate the shape (i.e., parameters) of common probability density functions (the AD, Gamma, and Beta distributions) to the variability of catchment and climate characteristics.

The paper is well written, with a simple structure that makes it easy to follow. Of course, they authors could not explore the role of all parameters, but the analysis is yet very

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inclusive overall. All the details that necessary to reproduce the work are explained in detail, and the presentation and discussion of the results are comprehensive.

However, I have both some major and minor questions that I would ask the authors.

The major question is mostly conceptual. The authors aim at finding general results about the TTD shape variability across locations with different characteristics. I like their systematic approach as an attempt to quantify this variability, e.g. by linking alpha to F. However, I am not surprised that they could only partly achieve their goal.

The issue is that the authors assume a given distribution (e.g., the gamma) for each run. This is analogous to assume that the discharge depends only on the residence time of the water, and not on the water storage. In other words, the authors do not move away from the assumptions behind the instantaneous unit hydrograph approach. From a mathematical standpoint, other authors introduced this assumption by stating that the storage selection function or the loss function (e.g., Botter, 2011; Calabrese and Porporato, 2015) depend on only the residence time (or age). This, however, is the simplest scenario and the farthest from reality. It is very likely, in fact, that if the authors injected the tracer later in the simulation, the TTDs would again differ.

As an example, a more realistic assumption would be to somewhat include a dependence of the TTDs on the overall water storage, or some proxy for it. I think it would be very instructive to explore the dependence of time dependent TTDs parameters on the time dependent water storage. As I mentioned earlier, I still believe that their analysis is very insightful. It is only that, in my opinion, this work could be even more impactful. I wonder whether the authors have comments on this.

I also have some minor questions/comments.

-It seems that boundary conditions, mainly I am referring to the shape of control volume, may have a big effect on TTDs, perhaps that could partly overwhelm the effect of the parameters studied by the authors. Have the authors tested this (e.g., with a

non-elliptical shape)?

-I don't agree with repeating the one year precipitation time series in loop 32 times. First, it is not realistic, and second it might cause some statistical bias. Why not using a Poisson generator throughout the analysis? It would certainly be more consistent. On a different note, there are numerous references that introduced Poisson rainfall/storm. One of the first was Cox and Isham (1988).

-The authors believe that a truncated Gamma or a lognormal distribution may work better over the all range of ages. Why not trying it?

Hoping that these comments may help improve the manuscript, I suggest major revisions.

Botter, Gianluca, Enrico Bertuzzo, and Andrea Rinaldo. "Catchment residence and travel time distributions: The master equation." Geophysical Research Letters 38.11 (2011).

Calabrese, Salvatore, and Amilcare Porporato. "Linking age, survival, and transit time distributions." Water Resources Research 51.10 (2015): 8316-8330.

Cox, David Roxbee, and Valerie Isham. "A simple spatial-temporal model of rainfall." Proceedings of the Royal Society of London. A. Mathematical and Physical Sciences 415.1849 (1988): 317-328.

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