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Discussions

Interactive comment on "Technical note: Transit time distributions are not L-shaped" *by* Earl Bardsley

Anonymous Referee #2

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The note of Earl Bardsley raises the valid point that water parcels and solute particles cannot traverse a catchment with infinite velocity, implying that the probability density function $p(\tau)$ of travel time τ should start at zero. The author likes to call distributions with non-zero probability density at time zero as "L-shaped" and argues with modes of the distributions at $t > 0$. This is not only confusing but can also be wrong. You could think of a pdf $p(\tau)$ that starts of at a finite value, increases, and then drops. This distribution does not look like an L but would be conceptually wrong nonetheless. The physical constraint that the author should enforce is $p(0) = 0$. This can be stated more or less in a single sentence without the thought experiment leading to equations 1 and 2, which was only partially enlighting.

So far, so good. But is this really new? I don't think so. And it misses the point what

we are actually doing when we fit models. Simple parametric distribution are chosen by practioners (and reseacrhers) in hydrology because of parsimony rather than correctness. The exponential distribution is the maxentropic distribution for a non-negative variable with known mean. For any other distribution, you need more information in the data. Often, travel-time and residence-time distributions occur in a wrapped way, e.g., when assuming a transient-storage zone in stream transport or when assuming kinetic sorption (, where it is the time that a solute stays in the immobile zone rather than the passage through the domain), thus, travel-time distributions may be convoluted with other distributions (in the simplest case the input signal) to obtain the measureable quantity (i.e. a breakthrough curve in the outlet of the system). Under such conditions, the data are often not good enough to fit anything better than an exponential distribution. Does this mean that a serious researcher really believes that this the correct distribution? Hopefully not! It simply implies that you were not able estimate more than the mean of the distribution, and you take the simplest model to express that. Any interpetation beyond that is pure hydrofantasy. If you fit the inverse-Gaussian distribution, as suggested by the author, you fit the analytical solution of the advection-dispersion equation with constant coefficients; but you'd better not believe that transport is Fickian *in reality* (most likely the tails are wrong), you actually fit the mean and variance of the distribution. That's often OK, but it already requires two parmeters rather than one and thus more information than the exponential model.

As a way out, the author suggests to use the gamma distribution with a shape parameter slightly bigger than one. That enforces the pdf to start at zero, but the author cannot really say how much bigger than one the shape parameter should be. Hence, the suggestion is not truly very helpful.

Thus, if you have really good data to calibrate a model, you can choose from a large variety of parametric travel-time distributions that start off at zero (we often use a generalized inverse Gaussian function with an offset; it has no real physical meaning but does a good job in tracer tests). If the data are extremely good, you can determine the travel-time distribution by non-parametric deconvolution, enforcing non-negativity and a starting-value of zero (we have done that, too). But if your data are not that great, you stick to the simplest distributions thinkable. This does not imply that you believe the distribution to be exact, but it may have the one feature that you can extract from the data. If there is any plea to be made than that we should not overinterpret fitted model parameters.

On an editorial side: Don't write about "L-shaped" distributions, and don't write about "stores" (which should be "storage zones" to avoid confusion with shops). And of course, it does make sense to integrate from the hill crest to the river if you want to derive an analytical expression (by the way, rain can even fall into the river itself).

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