My thanks to reviewer #2 for the comments offered. Comments are copied below in italics and responses follow.

The index proposed by the author does not, in my opinion, provide improved understanding of hydrological processes.

There is no implication that the paper seeks to improve understanding of hydrological processes. All a lower bound can do is to give an indication that the true mean transit time is probably greater than some minimum value. That's not about hydrological processes but it does give some measure of catchment hydrological information and has value to that extent – provided the bound is sufficiently removed from zero of course.

1) What is the usefulness of a (potentially arbitrary) lower bound to mean transit times? The motivations behind this new index are in my opinion not strong enough. The author mentions (page 2, line 15-19) the connection with long history of mean TTD application in hydrological studies, but it is not clear what the connection could actually be. Also note that the transit time literature has notably evolved in the last years (e.g. Kirchner 2016a,b, already cited by the author, but also the time-variant approaches to TTD modeling described by Rinaldo et al., (2015)), with the concept of stationary mean TTD now becoming rather obsolete.

As noted above, the idea of a lower bound to mean transit time can provide some information on a catchment system, to the extent of saying where the mean transit time is probably not. Recognizing at the same time that there is an element of subjectivity about the bound, because specification is required as to what a "good" fit is.
With respect to "connection" the wording should be clarified. It was just meant that the mean transit time still survives here as being referenced by the lower bound – nothing more than that. The contrast was with Kirchner's 2016a index of fraction of young water, which does not mention mean transit time. There is no disagreement that the idea that the stationary transit time distribution concept may be tending toward obsolescence. However, in constructing the paper it was natural to first consider the well-known special case of stationary transit time distributions.

2) As noted by the author (page 3 line 10), the use of nonparametric TTDs typically leads to several different distributions (with different means) that provide equally good results. Hence, there exists a whole distribution of mean transit times that allow fitting tracer data at the user-specified goodness of fit. What is not clear to me is why the author focuses on the minimum value, which is not a robust statistic, instead of focusing on other properties of this distribution which could better highlight the difficult determination of mean transit times.

Not just leads to several different distributions, but leads to an infinity of different distributions, some of which may share common means. This in fact is why there is focus on the lower bound. Any number of transit time distributions with different distribution forms and different means could be compatible with the data to a given level of fit. That is, there is no information that can be extracted about the transit time distribution or mean transit time. However, the more useful approach is to ask the question "how small can the mean transit time be (whatever the transit time distribution might be) before there is unacceptable departure from the data?" This defines the lower bound, which does provide some information provided it is sufficiently removed from zero.
The paper is not concerned with a minimum value in the sense of a sample minimum value and the proposed bound should not be flattered by calling it a "statistic", robust or otherwise. The bound is essentially a subjective indicator of where the mean is probably not, using "probably" in a non-mathematical sense. This is not to say that we should abandon seeking to estimate catchment transit time distributions, it's just that the nonparametric approach is not likely to be helpful for this end. However, it might be possible to use a similar approach to ask "what is the largest and smallest proportion of young tracer that any transit time distribution could tolerate before data mismatch sets in?" This could be a topic for further investigation but is beyond the scope of this brief technical note.

3) The time-varying example is restricted to the very specific case of TTDs with different shapes but equal mean, which is a strong limit. Also, the time-variance of the distributions seems to be just an additional degree of freedom in the minimization process, which it is not related to any physical process that may lead TTDs to change with time. Although this is technically a form of time-variance, it is not the one that is usually pursued in catchment studies.

Yes, there is no question that an example model of a sequence of transit time distributions with common means but varying forms is an overly-constrained representation of time variability. It would be best to substitute with an alternative example where the means vary as well as the distribution forms. However, as noted in the last paragraph of Section 4, there still needs to be some real-world constraints added to provide an upper limit to the extent to which each transit time mean may differ from the previous one. In a given application further constraints might be added by a user to force consistency with some known physical process, to the extent that such information is available. This could lead to a significant LP model with many variables and constraints. However, LP methodology is now well developed and efficient. For the purposes of illustration in a revised paper, the constraints will just be limiting the degree to which the transit time means may differ from each other, while otherwise allowing arbitrary freedom of distribution forms. This gives the maximum flexibility and therefore the lowest possible lower bound subject to limiting the variability of the means.

4) A more convincing proof-of-concept application should be provided. The synthetic dataset used by the author is generated through a TTD which is not realistic for most watershed (the parameter alpha is typically < 1, see Godsey et al., 2010). In my opinion, to convince the reader of the actual usefulness of this new index, a real-data example should be provided, although this option would require converting the technical note into a regular article.

The reference to the gamma shape parameter here is something of a distraction, because there is implication that the gamma distribution has theoretical justification over other distributions for general application to catchment transit time distributions. It does not – and neither does any other parametric distribution. The cited reference shows that the gamma distribution fits data better than its special case of the exponential distribution, which is not surprising when a one-parameter distribution has to compete with a two-parameter alternative to match data. The exponential distribution is also a special case of the Weibull distribution and an equivalent analysis could have been carried out which would have rejected the one-parameter exponential distribution in favour of a two-parameter Weibull alternative. But this would not imply that the Weibull distribution has theoretical justification.

The reviewer point being made therefore is not actually with respect to a gamma distribution shape parameter value, but rather pointing out that it would be useful to have data simulated from a heavy-tailed distribution as such forms are often consistent with observations. The gamma distribution is no less arbitrary than any other for defining a transit time distribution for simulation purposes, so there is no problem with an additional example with a gamma shape parameter <1. The obvious comparison would be to keep the same mean travel time as the original example and see what impact the change in distribution shape has on the lower bound. If it happens that the lower bound in such instances is forced toward zero then the lower bound concept would certainly be restricted in its application, so it is a good review suggestion.

There is no suggestion of attempting in a short communication to convince a reader of the usefulness of the lower bound. Even a single application to real data would not be particularly convincing. The aim is simply to raise curiosity sufficiently for others to try it out and see how it goes. The method is easy to apply and perhaps some example spreadsheets could be included in a revised version to speed the process of use by others. Such application to real data is deliberately avoided here because (i) it is good to illustrate the lower bound with known mean transit times, which are always unknown in reality, (ii) owners of real data will inevitably have some feel for the catchments involved and are in the best position to judge whether the lower bound is useful to them or not. Preference therefore is to maintain the paper in a technical note status.

MINOR COMMENTS

Page 2, lines 5-7: there are some interesting (although simplified) examples in the literature where the shape of the probability distribution is derived theoretically. I would suggest referring to Kirchner et al., (2001) and Leray et al., (2016).

The manuscript text here is:

"Generally speaking, no probability distribution can claim particular theoretical justification in any form of hydrological study unless the situation of the physical environment matches the statistical characterization of the distribution concerned. Such characterization of course excludes fortuitous empirical matching of a given distribution to recorded or simulated data."

In fact there will never be transit time distributions which have mathematical derivation with respect to real-world catchment systems. As noted by Kirchner (2016a), application of any derived distribution to real catchments is simply a "hope" that it might be the right distribution. The literature transit time distributions are essentially irrelevant because they have been derived not for hydrological systems, but for models of hydrological systems. The Leray et al. (2016) paper in fact would have been more correctly titled "Residence time distributions for models of hydrologic systems …" . However, there is certainly value in including references to the two papers concerned as examples of model-derived transit time distributions. The references will be included in any revised version.

Equation (1) and p.4, l.5: it should be stated explicitly why theta can be different from 1, as according to the hypothesis of ideal tracer it should always be equal to 1.

Yes – some added text would be helpful.

P.3, l.6-8: I did not understand this sentence.

The text concerned is:

"The inclusion of $\tau = 0$ may seem unusual because it implies some tracer being instantaneously transported to the recording site. A finite probability of zero time is of practical value, however, because it ensures that any calculated lower bound to μ_T is not slightly higher than need be, as would be the case if all transit times were bounded below at 1.0."

This issue arises because the transit time distribution utilised is a discrete distribution defined over the integers. Assigning a zero probability to $\tau = 0$ would have the effect of slightly increasing the mean of the distribution. On the other hand, permitting a non-zero probability for $\tau = 0$ implies an element of instantaneous tracer movement to the recording site. Faced with these two options, the nonzero probability of $\tau = 0$ was selected because the effect will be to make the lower bound as small as possible. This is all essentially a rounding effect resulting from approximating a continuous distribution with a discrete distribution. Some text along these lines will be added to any revised version.

P.5, l.21-23: this sounds very speculative and it is unclear what could actually be compared from one catchment to the next.

The text concerned is:

" There is therefore a degree of subjectivity with the lower bound because perceptions may differ over what constitutes a just-acceptable fit. Nonetheless, plots of μ_* against $\bar{D}_*$ give useful summaries of the strength of evidence for a given lower bound, which in principle can be compared from one catchment to the next."

The idea here is just that lower bounds might be compared for different catchments. For example, if one catchment happened to have a much higher lower bound than another then that would indicate that there is some degree of confidence (using the word loosely) that the higher-bound catchment has a long mean residence time. On the other hand, there would be less certainty about what the mean transit time might be for the catchment with the lower bound. The text will be reworded in any revised version to make this clearer.

Section 4: the "time-variant" case is actually a very particular case of time-variance. This should be clearly specified everywhere (e.g. in the title of section 4)

The current particular case of time-variance will be replaced with general time variance, with both time-varying distributions and time-varying means.