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Discussions

Interactive comment on "Nonparametric lower bounds to mean transit times" *by* Earl Bardsley

Anonymous Referee #2

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GENERAL COMMENTS This technical note proposes a method to estimate lower bounds to mean transit time in hydrological systems. The author makes use of non-parametric transit time distributions (TTDs), obtained by fitting tracer data in precipitation and streamflow. In particular, a new index is proposed which represents the minimum value of mean transit time that is compatible with a user-defined goodness of fit of the tracer data. The note is well organized and clearly written, but I have some major concern on the significance of the results. While I believe the use of non-parametric TTDs is an interesting and under-explored topic, the index proposed by the author does not, in my opinion, provide improved understanding of hydrological processes. I summarize below my major points:

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.

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;

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;

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;

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).

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.

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

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

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)

SUGGESTED LITERATURE

Godsey, S. E., Aas, W., Clair, T. a., de Wit, H. a., Fernandez, I. J., Kahl, J. S., ... Kirchner, J. W. (2010). Generality of fractal 1/f scaling in catchment tracer time series, and its implications for catchment travel time distributions. Hydrological Processes, 24(12), 1660–1671. http://doi.org/10.1002/hyp.7677

Kirchner, J. W., Feng, X., & Neal, C. (2001). Catchment-scale advection and dispersion as a mechanism for fractal scaling in stream tracer concentrations. Journal of Hydrology, 254(1–4), 82–101. http://doi.org/10.1016/S0022-1694(01)00487-5

Leray, S., Engdahl, N.B., Massoudieh, A., Bresciani, E., and McCallum, J., (2016), Residence time distributions for hydrologic systems: Mechanistic foundations and steady-state analytical solutions, Journal of Hydrology, 543, 67-87, https://doi.org/10.1016/j.jhydrol.2016.01.068.

Rinaldo, A., Benettin, P., Harman, C. J., Hrachowitz, M., McGuire, K. J., van der Velde, Y., ... Botter, G. (2015). Storage selection functions: A coherent framework for quantifying how catchments store and release water and solutes. Water Resources Research, 51(6), 4840–4847. http://doi.org/10.1002/2015WR017273

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