Hydrol. Earth Syst. Sci. Discuss., 12, C1584–C1587, 2015
www.hydrol-earth-syst-sci-discuss.net/12/C1584/2015/

Hydrology and Earth System Sciences
Discussions

Interactive comment on "Aggregation in environmental systems: seasonal tracer cycles quantify young water fractions, but not mean transit times, in spatially heterogeneous catchments" *by* J. W. Kirchner

Anonymous Referee #2

Received and published: 18 May 2015

This paper explores how mean transit times (MTT) derived from seasonal tracer cycles aggregate when scaling up by adding small catchments to represent a larger catchment. Kirchner finds that the MTT does not scale well at all by performing thorough benchmark tests and he proposes a new metric: the young water fraction that by its definition scales as good as possible with spatial heterogeneity. Thus 2 main messages in this paper:1) From heron, do never use MTT again, 2) use Fyw instead. This new metric is interesting, but at the same time challenging to use as its definition contains uncertainty (i.e. the type of transit time distribution, which is always unknown).

Furthermore I fully agree with the call for thorough benchmarking of simple hydrological models in the face of spatial and temporal heterogeneity. The paper is well written and is an important contribution to hydrology. However, several questions remained after reading the paper:

How can I use the Fyw (fraction young water) with my data? Is the approach something like: First guess a range of alphas that are likely to represent my system, Let's say 0.3-1.5. Then derive the Thresholds Times with Eq 14,–> 0.12-0.22 years. Next derive from data the As/Ap. For example 0.3. This then means that around 30% of my stream water is younger than 0.12 to 0.22 years? Next we can refine this approach by including the phase shift? Between catchments we can now compare this Fyw. I think this could be explained more clear in this paper, for example with the data of figure 1. What is the advantage of comparing Fyw over As/Ap between catchments?

What about evapotranspiration? Are the proposed methods valid when half of the water balance goes to evapotranspiration? You convincingly proofed that the MTT does not scale up well, but does FYW still scale well with evapotranspiration? Page 3069, line 9, seems to suggest it does not, but with amplitudes I can imagine it does work. Does this need further benchmarking?

Following your own reasoning on page 3070, line 20, a catchment consists of almost infinite number of flow routes, each with own travel times. All these flow routes are grouped to yield the catchment TTD. You showed that Fyw scales well for 8 sub-catchments, but does it still scale well for 1.000.000 sub-flow routes? Is there any chance that due to the central limit theorem an infinite number of weakly-related gamma distributions for each flow route (log-transforming them, adding them yielding a normal distribution, and back-transforming them to yield a log-normal distribution) yields a log-normal TTD distribution at the catchment outlet of which the MTT does scale well as long as we assume that the central limit theorem holds at all the sub-catchments as well at the catchment? I dont think so, but Im also not entirely sure that the Fyw does much better.

Minor comments: Title: As the authors refers in both papers to “paper 1” and “paper 2”, it would be good to include this number somewhere in the title of the paper as the papers are likely to end up in reverse order on a website (like now on HESSD).

Page 3066, line 16: one can relax... flow-equivalent time. I dont think it is possible to express time as flow-equivalent time when sine wave fitting. Thus this statement is confusing to me in the context of this paper.

Page 3066, line 13: “However in practical applications”: this statement renders all the above references impractical, while the objective of using time variant TTD actually is to be a bit more practical. To me considering a catchment as a stationary flux field is totally theoretical and only suited for catchment intercomparison studies. These stationary studies hardly have any practical relevance in helping to understand how to lower or mitigate solute fluxes.

Page 3078 line 25. Following your reasoning on page 3071, line20, each sub-catchment consists of an almost infinite number of independent flow paths that contribute to stream discharge. Do you think you still get the results of figure 12 for an infinite number of subcatchments? Is this what you are saying on page 3079, line 3?

Page 3080, line 25 MTT values derived from seasonal tracer cycles

Page 3082, line 10. Im not entirely sure what you mean with the time series convolution approach. If it refers to methods that solely use the waterbalance (water storage and water fluxes time series) to calculate the MTT, this aggregation bias is likely to be absent. At a larger or smaller scales this approach leads to a new water balance with new storage and water fluxes, which lead to a new MTT independent of the aggregation (close to [average Storage] / [average precip]. However, I fully agree that MTT is an awful and often meaningless metric to use. Median traveltimes or indeed Fyw are much more meaningful.

Page 8030, line 19. You mean to say that Fyw is more useful than MTT?

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 12, 3059, 2015.