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Discussions
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Interactive comment on "Spatially Distributed Characterization of Soil Dynamics Using Travel-Time Distributions" *by* F. Heße et al.

Anonymous Referee #2

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This manuscript uses the theory of travel time distributions in time variant flow systems and a spatially distributed hydrological model (mHM) to analyze the spatial distribution of mean travel times and life expectancies in a German catchment. TO the best of my knowledge, this is one of the first attempts of using spatially explicit formulations to analyze the main physical controls on travel time distributions.

Overall, I'm in favor of publication of this manuscript in HESS. The topic is timely and interesting, the technical analysis of the authors is largely robust, and the paper is quite clear (event though some improvements in the presentation are recommended, see below).

In what follows I provide a list of general suggestions and comments that need to be considered before the acceptance of the manuscript.

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Discussion paper

Title: i'm wondering if "soil moisture dynamics" would be a better choice instead of "soil dynamics"

Page 5, section 2.2: I suggest adding more information about the rationale behind these equations, and the assumptions (e.g. random sampling)

page 6, line 10: maybe it is worth adding more info about the nature of these global parameters gamma

equation (5b): need to add "if x5 > TV"

page 7 line 28: better specify where the runoff data are gathered (only at the outlet)

page 8, lines 3-4: maybe it is worth to show the result mentioned here, or provide explicit reference about where these results can be found in the existing literature

Figure 5: units are missing

Equations (7), (2) and results: it has been shown that the storage involved in solute circulation is much bigger than the hydrological storage that can be estimated using a rainfall runoff model. Most of the existing tracer data suggest this instance in many place around the world (Plynlimon, Hubber Brook, etc). This would imply the use of a larger storage in the denominator of eq (7) for the calculation of TTD. While I think this issue can not be addressed in the absence of chemical data, I think it would be important to make a discussion on this point and clarify the assumptions underlying the analysis (i.e. absence of residual storage).

When you apply the formulation to the scale of a single grid cell, then you have to include the effect of input and output lateral fluxes. Maybe it is worth to specify how the TTDs are calculated in a spatially distributed setting.

Page 10, lines 2-4: gamma models for stationary TTD are much more widespread than exponential models in the literature. Moreover, the ref to rodriguez-Iturbe anfd Valdez can be misleading, as in that case only the IUH is concerned.

Page 10, lines 22-24. SAS functions have been introduced before Rinaldo et al., 2015 - only the name has been introduced later in those papers.

PAge 10, line 33: "the most simple SAS" should read "uniform SAS" with some references.

Page 11, lines 1-4: I would suggest to expand this discussion and provide more arguments / clarify your reasoning. Maybe the point here is that the mixing taking place at spatial scales smaller than 2 km X 2 km is not relevant?

Pages 13 -20: It would be good to see more discussion here about the physical interpretation of the results. this would increase significantly the breadth of the paper.

Page 20, equation not-numbered. Iì'm wondering why this equation is used to introdcude Figure 15 as the life expectancy in not involved (unless I'm missing something)

Figure 15: physical interpretation of these results? units are missing

Page 21, line 1 and Page 23, line 29: which is the underlying physical interpretation of these results?

Page 21, line 10: in a geenral cell the influx is just precipitation of this include also lateral fluxes?

Page 27, equation (8): I think there is an extra _Q before the "=" sign.

Page 28, last line: why does this happen?

Appendix A, equations (a1) and (a2): I guess the signs of the Q terms are wrong.

Appendix A, lines 14-17. MKVF equations are expressed in a different form, in which TTDs and output fluxes are grouped together. This "caveat" makes a huge difference: the explicit presence of the hydrological fluxes in eq. (a1) allows for the use hydrological models for TTD inferences - as done in this nice paper - and the coupled modeling of flow and transport at catchment scale, which is the next step foreseen by the authors (page 29, lines 25-30).

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