

Interactive comment on “Water ages in the critical zone of long-term experimental sites in northern latitudes” by Matthias Sprenger et al.

Anonymous Referee #2

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This well written and structured article describes an interesting soil physical based modelling study on water travel times and water ages at four different sites in northern latitudes. The model simulations were done for an extensive period (multiple years) giving insights in both short-term and seasonal dynamics. The topic is in my opinion of interest to HESS readers and after minor revision suitable for publication. Below are my suggestions and comments for improvement of the paper:

Major comments:

1. The description of the data should be more extensive (Methods section 2.2 and 2.3). The soil hydraulic parameters used for the modelling are not mentioned in the text/table. While a reference is made to Spenger et al. 2018, having this information available in this paper really helps with the interpretation (how different are the sites for example)

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without having to refer to Spenger et al. 2018. Furthermore, I suggest to include also other parameter values like maximum canopy storage, infiltration capacity (if applicable or a statement that overland flow does not occur). With respect to infiltration capacity; what about frozen soils at these sites?

Finally, I recommend to add some more info about the model (run), like: - What was the parameter set (it is mentioned in the paper, but not specified)? - Was there a spin up period? - What was the internal time step of the model (I guess it was forced with daily throughfall and evapotranspiration)? - Programming language, open source?

2. In section 2.4 it is not very clear to me how MTT and water ages were derived exactly. In lines 3-4 “Tracer concentrations. . .Figure 1 left.” it is mentioned that tracer concentrations in the output fluxes were normalized by the infiltrated tracer mass ($I_j(t)$). Do you mean that the mass flux (of R, T and E) was normalized by the total mass recovered at these boundaries (of R, T and E)? If so, this could be stated more clearly in my opinion (as equation?). Now it seems the normalization was done by the total infiltrated tracer mass on tracer concentrations O_j . This also applies to the description of the calculation of water ages. In lines 8-10 please state more clearly why MTT analysis was limited to the period 2012-2015.

3. What controls travel times and water ages in the Discussion (and Results) could be expanded to soil hydraulic parameters, for example what about differences in saturated hydraulic conductivity or saturated water content between these four sites? I strongly recommend to include these soil parameters (and advection dispersion parameters) in the analysis, since the focus of the paper is on soil physical based modelling.

4. The SWIS model solves the Richards and advection dispersion equation, and the same set of water flow and transport parameters are used for the slow and fast domain. What about possible preferential flow/ macro-pore flow at these sites, when the Richards and advection dispersion equation are probably not applicable? I recommend that the authors elaborate on this in the Discussion section.

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Minor comments:

1. First sentence in the Abstract, please rewrite the part “undergo intense respond”
2. My suggestion is to move the Study sites description (2.1) from the Methods section, to a new section.
3. There seems to be a lot of overlap in the dots of Figure 2, 3 and 6. Is there a way to avoid this; different markers, make some transparent?
4. Discussion, line 4: please use references instead of “(introduced in section 1)”.
5. Section 4.4 lines 2-3, what about the often observed exponential decay of root distribution with depth?
6. Section 4.2 line 9; “Due to exchange between fast and slow flow domains. . .”, it would be good to mention in the paper on what time scale this exchange works/ how fast is this process?
7. The following publication may be of interest irt the work described in this manuscript: van Verseveld, W. J., Barnard, H. R., Graham, C. B., McDonnell, J. J., Brooks, J. R., and Weiler, M.: A sprinkling experiment to quantify celerity–velocity differences at the hillslope scale, *Hydrol. Earth Syst. Sci.*, 21, 5891-5910, <https://doi.org/10.5194/hess-21-5891-2017>, 2017.

Interactive comment on *Hydrol. Earth Syst. Sci. Discuss.*, <https://doi.org/10.5194/hess-2018-144>, 2018.

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