Comment on hess-2021-582

Anonymous Referee #1

Referee comment on "Stepping beyond perfectly mixed conditions in soil hydrological modelling using a Lagrangian approach" by Alexander Sternagel et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2021-582-RC1, 2022

This manuscript is a novel contribution to studying diffusive processes in soil. A Lagrangian model is developed to account for heterogeneity in diffusive mixing in soil caused by pore structure. The pore size distribution is accounted for through varying diffusion coefficients. The model has first been tested by comparing it to the recent experiments on effectively non-Fickian diffusive mixing and shown to agree well in terms of time and concentration. Further, simulations were designed to combine diffusion and leaching in a saturated soil column and demonstrate the non-Fickian transport behaviour in this system. While the impact of physical or pore structure heterogeneity has commonly been shown to result in non-Fickian transport, this manuscript systematically increases the level of complexity in terms of diffusive processes studied and shows an interesting workflow to characterize and quantify the non-linear transport behaviour. I can therefore recommend it for publication after the following minor suggestions were considered and addressed:

- Pore space and water retention curve are subdivided using N=200. Did you investigate sensitivity to this number of bins?
- In relation to the previous question how is the bin size related to pore or throat radius that could have been actually measured in this type of soil?
- Can you comment on the expected impact of dimensionality and anisotropy?
- I would leave this to the authors to decide but to me the term "virtual experiment" is quite confusing. Why not simply say that you run your simulations to explore the model predictive capability in a more complex setting after you have demonstrated a good agreement with the experiment.

Minor:

- Line 22 instead of "… comparing…" it should read as "…compared…"