

Comment on hess-2022-73

Anonymous Referee #2

Referee comment on "Forward and inverse modeling of water flow in unsaturated soils with discontinuous hydraulic conductivities using physics-informed neural networks with domain decomposition" by Toshiyuki Bandai and Teamrat A. Ghezzehei, Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2022-73-RC2>, 2022

Review of "Forward and inverse modeling of water flow in unsaturated soils with discontinuous hydraulic conductivities using physics-informed neural networks with domain decomposition" by Bandai and Ghezzehei.

In this manuscript the authors tested a physics-informed neural networks (PINNs) method to solve the Richardson-Richards equation for simulating unsaturated soil water dynamics. The authors also investigated the capability of the method for obtaining inverse solutions. As coupling data-driven and physics-based approaches have received much attention these days, the topic fits well with the scope of HESS. The authors have done a great job on demonstrating how PINNs performed when simulating unsaturated water flow in soils and showing applicability and limits of the method. Although the paper was well organized and written, I believe the paper has a room for some improvement. I have some comments that should be addressed prior to accepting this paper for publication. For my curiosity, I am wondering if this approach can be applied to simulate preferential type flow in soils. Is it going to be straightforward? Does it require some modifications in the model? If it can be applied to such phenomena, it would be a great breakthrough in the field of soil physics and hydrology.

General comments:

In Fig. 5, the evolution of PINNs solution is plotted. At the initialization, some of the solutions are beyond the limit of the water content as the water content values are greater than the saturated water content. Would it be possible to put some constraints to the solutions in PINNs? If so, would that improve training and overall performance? Any discussions on this matter will be helpful for those who are interested in using this method. A

similar question goes to the inverse solutions. I am wondering if any constraints can be applied to the target parameters that are inversely estimated. There is always a need to put some constraints to the parameters being estimated.

In the demonstration of getting inverse solution with PINNs, the authors used a 2-layered soil system. Why? If the boundary fluxes are being estimated, wouldn't be better to start with a homogenous case? Was there a specific reason that the layered soil system was used in this demonstration?

Specific comments:

L189: It sounds a bit strange to say that soil dynamics is "controlled by the volumetric water content at the bottom."

L193 (Eq.15): A little bit more explanations will be helpful to understand this transformation. I have no idea why the beta value gives better initial guess.

L311: If the logarithmic transformation of water potential is used, the approach is limited to "unsaturated" systems. But there are many cases you will have both positive and negative potential values. How do you deal with that?

Figure 3(b): There are some systematic differences between FDM and PINNs. Why? Are these because of the choice of spatial and temporal discretization in FDM?

Figure 10: Looks like something is wrong with the texts at the top of the figures.

Figure 16: For all three cases, the PINN solutions show that the inversely estimated initial surface flux is much smaller than the true flux. Are there any specific reasons for this?