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Comment on hess-2022-73

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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-RC1, 2022

Comments on: Forward and inverse modelling of water flow in unsaturated soils with discontinuous hydraulic conductivities using physics-informed neural networks with domain decomposition.

Summary

This paper presents the results from a comprehensive study using PINNs as a forward and inverse numerical solution for the Richardson-Richards equation. They tested new approaches for applying the PINN method, including a layer-wise locally adaptative function intended to work with layered heterogeneous soil profiles. In addition, the authors compared their approach to well-known numerical solutions for the Richardson-Richards equation, namely Finite Difference and Finite Element Methods (FDM and FEM). The PINNs approach was also validated with soil moisture measurements performed in a soil column in controlled conditions.

The paper appears to be relatively novel, being the first application of PINNs to the Richardson-Richards equation (to my knowledge). The literature proposed and the figures presented are of high quality. I enjoyed reading the paper. The results are encouraging on the applications of PINNs to model hydrodynamics in porous media, even if it takes much more time when compared with the classical approaches. We don't need to impose well-known boundaries and initial conditions, which is attractive once they are difficult to obtain in field applications. The domain decomposition for the layered soils is also very promising. Even classical approaches such as FDM and FEM struggle with heterogeneous soil profiles. So, I think the PINNs with the domain decomposition did quite well in modelling the soil water dynamics in the soil column.

Specific comments/questions (that should be addressed and commented before

publication):

- It would be interesting to test the inverse solution with soil matric potential measurements (data is available if needed).
- What is your opinion on going to 2 and 3D modelling? Could the domain decomposition proposed in the paper be applied to speed up 2 and 3D solutions? I think that would be the actual gain in this methodology. FEM applications for the fully 3D solution of Richardson-Richard's equation are still slow and have many complications with mesh, especially for large domains. This also applies to the boundary and initial conditions imposition.
- What about non-Darcian conditions, macropore flow, very high clay content soils. Do you think the method could be applied?
- What about root-water-uptake? How can this be included in your approach? There exist some analytical solutions for these problems (Yuan and Lu, 2005[1])
- Do you think one day the PINNs could take over the classical approaches? What is limiting it?
- What about practical applications? Irrigation management or contaminant transport in the vadose zone.

Overall, the paper is well written. The sections are balanced, and the flow is good, making the paper enjoyable to read.

[1] Yuan, Fasong, and Zhiming Lu. "Analytical solutions for vertical flow in unsaturated, rooted soils with variable surface fluxes." *Vadose Zone Journal* 4.4 (2005): 1210-1218.