Reply on CC1
Daniel Regenass et al.

Author comment on "It rains and then? Numerical challenges with the 1D Richards equation in kilometer-resolution land surface modelling" by Daniel Regenass et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2021-426-AC4, 2021

We thank Ms de Haan for her careful and thorough review in the form of a community comment. In the following, we will address some of the main points that are raised in the review. We appreciate that Ms de Haan has found our paper to be overall clearly written and thank her for her positive feedback on that matter.

We feel that the following three paragraphs may be addressed together. There seems to be some misunderstanding concerning the coupling of precipitation on the one hand and Richards’ equation as a part of the land surface model on the other hand. Most modern weather and climate models solve the equations for atmospheric motion on a three-dimensional grid (see e.g. Baldauf, 2011), while the land surface model (mainly providing the lower boundary condition for the atmospheric model) is typically one-dimensional (see e.g. Balsamo et al., 2009). This means that the rainfall from an atmospheric grid cell with...
horizontal extent of several kilometers is directly coupled to the one-dimensional Richards equation. In that sense, the solution to Richards’ equation may be seen as the grid cell average downward water propagation in the land surface model. Whether or not this is an adequate representation of the underlying physical system is an interesting research question in itself and there are of course good reasons to believe that the Richards equation is not applicable for such large scales (Beven and Cloke, 2012). However, here we solely focus on numerical aspects of Richards’ equation in order to keep the scope of the manuscript as clear as possible. When we refer to numerical issues that arise in kilometer-scale modelling, we mainly mean their interaction with high precipitation intensities as such precipitation intensities are simply not present in atmospheric models with a lower resolution. In order for the land surface models to keep up with the trends towards kilometer-scale modelling, these issues must be addressed. On a different note, there are approaches to solve the fully three-dimensional Richards equation on continental scales (Maxwell et al, 2015). However such approaches require a considerable amount of computing power which is also required for other parts of fully coupled weather and climate models. Mainly due to the computational constraints, the weather and climate community is so far reluctant to move towards a three-dimensional representation of water transport in the soil matrix. However, we fully acknowledge that more research is required in order to find suitable approximations for soil water transport on horizontal scales of the order of one kilometer.

References


