

Hydrol. Earth Syst. Sci. Discuss., author comment AC3  
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## Reply on RC2

Daniel Regenass et al.

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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-AC3>, 2021

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We thank the reviewer for their careful review and their comments on our manuscript. In the following, we will discuss their major comments:

- The first major comment addresses the use of the saturation-form of the Richards equation (as used in our paper), as opposed to the head-based formulation. We fully agree with the reviewer that the mixed-form of Richards' equation is to be preferred over the saturation form – mainly because of the issues pointed out in the appendix. We are currently working on an implementation of the mixed form and plan to revisit our analysis once the new solver is ready. It is however important to stress that most European weather centers/ weather and climate modelling consortia use the saturation form of Richards' equation (see manuscript lines 147-150). The aim of this paper is not to suggest a novel approach to the numerical solution of the Richards equation, but rather to raise awareness on the (poor) convergence of Richards' equation as used in weather and climate models and to shed light on the associated errors. Concerning the upper boundary condition (i.e. the formulation of infiltration): We read the corresponding formulation (Eq. 21) in Tubini and Rigon (2021) and think that our numerical implementation is adequate in the saturation form (Eq. 9) as it is a flux boundary condition prescribed by the precipitation flux. Note however, that in the saturation form, an upper limit for this flux must be prescribed as the available pore volume is finite and the flux cannot exceed saturated hydraulic conductivity, because the suction (diffusive) term must vanish at saturation.
- The term 'successfully' might indeed be misleading. Here we mean that land surface models using the saturation form of Richards' equation are used in land surface models and yield physically meaningful results. This does however not imply that the mathematical/ numerical implementation is correct in a rigorous sense. We will try to clarify this issue in the revised version of the manuscript.

## References

Tubini, N., & Rigon, R. (2021). Implementing the Water, Heat and Transport model in GEOframe WHETGEO-1D v. 1.0: algorithms, informatics, design patterns, open science features, and 1D deployment. *Geoscientific Model Development Discussions*, 1-47