

Interactive comment on “A mechanistic model for electrical conduction in soil–root continuum: a virtual rhizotron study” by Sathyanarayanan Rao et al.

Anonymous Referee #2

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The manuscript by Rao et al., present a numerical study that examines the influence of roots on the electrical conductivity of soil and the results of an inversion process obtained from a synthetic ERT data. The numerical study comprises of few steps. First, the authors solved a model for water flow and uptake in the soil-root system (including root architecture, using RSWMS) and obtained the water content distribution. The root system architecture was obtained by imaging a rhizotron experiment. Next, Archie's law is used to convert water content distribution to electrical conductivity distribution. At this stage, the electrical conductivity of roots (measured in a separate experiment) was embedded in the mesh such that to each mesh element soil or root conductivity was assigned. The obtained conductivity maps were used to solve electrical forward

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and inverse models. In addition, the authors also calculate the average electrical conductivity of a soil-root system and discuss conductivity anisotropy due to roots. In general, the authors show that the contrast between soil and root conductivity depends on water content distribution, soil type, and root density. Errors in the estimation of water content distribution were found to be higher when the contrast between soil and root was high. In addition, roots found to cause a non-negligible anisotropy in the soil electrical conductivity.

The topic of the manuscript is important as the ERT method is increasingly used to monitor water content distribution in natural and agriculture systems where roots might influence the soil conductivity. Also, to my knowledge, this is the first attempt to rigorously model the impact of roots on the interpretation of ERT data to map water content. Overall, the manuscript is interesting and the work done is technically sound. Despite the above in my view, important aspects that were omitted (discuss below), weakening the work and limits its applicability. Furthermore, the lack of experimental data to support the model is missing. Specifically:

1. As the author's notes (e.g., L429-443) at the field scale, a 3D model might be needed. This is important because (a) the soil/root volume ratio might be different from the presented 2D case, and (b) the 3D electrical field are expected to differ (perhaps significantly) from the 2D field in the presence of the complex root structure (how this will impact anisotropy?). A 3D analysis seems to be necessary in this case, even if on a simpler root system. In addition, it is important to report the volume of roots in the soil and to compare it to normal field conditions.
2. The authors assume that the electrical conductivity of the pore water is constant, this is, in my view, not adequate. Without considering any complex processes (e.g., L434), the mere fact that the roots take water and leave salts means that the water conductivity around the root is high. How this is affecting the authors' analysis is not clear, but because the bulk electrical conductivity and the water conductivity are strongly coupled, it might be significant (authors are advised to consult Rhoades et al., 1976).

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3. The authors conducted a real experiment with a plant at the rhizotron scale. Taking real ERT measurements at the same opportunity could immensely improve the manuscript and contribute to the validation of the numerical model.

In addition to the above: - It is worthwhile to compare forward modeling with and without roots, and not only the results of the inversion. This comparison could provide an estimation of the root contribution to water content independently of the applied inversion algorithm.

- In line 58, it seems authors do not distinguish between two terms, apparent conductivity and bulk conductivity.

Rhoades, J. D., P. A. C. Raats, and R. J. Prather. 1976. Effects of Liquid-phase Electrical Conductivity, Water Content, and Surface Conductivity on Bulk Soil Electrical Conductivity1. *Soil Sci. Soc. Am. J.* 40:651-655. doi:10.2136/sssaj1976.03615995004000050017x

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