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High-resolution monitoring of root water uptake dynamics in laboratory conditions using full-wave inversion of near-field radar

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Root water uptake dynamics at local scale can be studied in laboratory conditions by growing plants in rhizotron containing sand and by imaging the water content evolution of the medium using light transmission. This technique allows to retrieve the water content with high resolution but cannot be applied in opaque media such as leaf-mold or clay, which is a major limitation for more realistic applications.

Recently, ground-penetrating radar (GPR) has proven to be one of the most promising techniques for high-resolution digital soil mapping at the field scale. Particularly, by using full-wave inverse modeling of near-field GPR data with a high frequency antenna, the electrical properties of soil and their correlated water content can be reconstructed with a high spatiotemporal resolution. In this study, we applied the approach by using an ultra-wideband frequency-domain radar with a transmitting and receiving horn antenna operating in the frequency range 3-6 GHz for imaging, in near-field conditions, a rhizotron containing sand subject to different water content conditions. Synthetic radar data were also generated to examine the well-posedness of the full-waveform inverse problem at high frequencies. Finally, we compared the water content obtained by GPR and light transmission measurements.

The results have shown that the near-field modeled and measured GPR data match very well in the frequency and time domains for both dry and wet sands. In the case of the dry sand, the estimated water content based on GPR and light transmission data was retrieved with small differences.

This research shows the potential of the GPR system and near-field full-wave antenna-medium model to accurately estimate the water content of soils with a high spatial resolution. Future studies will focus on the use of GPR to monitor root water uptake dynamics of plants in field conditions.

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