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Estimation of the unsaturated hydraulic soil properties from joint inversion of tension infiltrometer and ERT measurements: Numerical experiments

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An accurate and time-efficient estimation of unsaturated hydraulic soil properties in the field remains a challenge. Tension-infiltrometry is often used to determine unsaturated hydraulic soil properties and their spatial variability in the field. Due to capillary flow, a 3-D wetting bulb, which depends on the unsaturated hydraulic soil properties, the radius of the infiltrometer disk, and the applied water tension, develops under a tension infiltrometer. In classical tension-infiltrometer experiments only the amount of infiltrated water is measured with time and used to infer hydraulic soil properties. Electrical resistivity tomography (ERT) offers the possibility to image the spatial distribution of bulk soil electrical conductivity, which is related through a petrophysical model to the soil water content. Therefore, ERT data contain information about the 3-D structure of the wetting bulb, which may be exploited to infer hydraulic soil properties. Whether a combination of tension-infiltrometer and ERT data can be used to estimate soil hydraulic parameters was investigated in a numerical experiment. Both 3-D water flow and electrical potential fields were simulated with the SWMS_3-D model (Simunek et al., 1995) using the van Genuchten (1980) hydraulic functions and the Rhoades (1976) petrophysical model. Simulated infiltration and simulated apparent electrical resistivities were subsequently inverted using the PEST software (Doherty, 2003). Three different scenarios were considered (1) estimation of hydraulic parameters (K_s, α and n) from error-free data, (2) from error-contaminated data, and (3) estimation of both hydraulic (K_s, α and n) and the petrophysical parameters from error-contaminated-data. For scenario (3), correlations between parameters are used

in a first step of the inverse process in order to avoid non-uniqueness of the problem (α and $K_s$are tied as well as the two petrophysical parameters) whereas in a second step of the inverse process all the parameters are free. Inversion of the combined infiltration and ERT datasets showed that the hydraulic parameters could be inverted from a single infiltration experiment, which is not possible when only infiltration data are used in the inversion. Also petrophysical parameters could be inverted simultaneously with hydraulic parameters from the combined ERT-infiltrometer data. These results demonstrate the potential of the method by considering additional information about the structure of the wetting bulb which is contained in ERT data.

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