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Using electrical resistivity tomography (ERT) to image the topology of soil properties relevant to solute transport characteristics of soils

John Koestel (1), Sarah Garré (2), Mathieu Javaux (2,3), Jan Vanderborght (2), and Harry Vereecken (2)

(1) Swedish University of Agricultural Sciences, Soil and Environment, Uppsala, Sweden (johannes.koestel@mark.slu.se), (2) Agrosphere, ICG 4, Forschungszentrum Jülich GmbH, Leo-Brandt-Strasse, D-52425 Jülich, Germany, (3) GERU, Université catholique de Louvain, Croix du Sud, bte.02 à 1348 Louvain-la-Neuve, Belgium

It is widely recognized that not only the local hydraulic properties but also their topology and connectivity as well as interfaces between soil layers and domains are important to model the effective flow and transport characteristics of soils. In order to fully understand how the structural soil properties are related to solute transport properties, the above discussed features have to be imaged with 3-D spatial resolution. Recent studies have shown that electrical resistivity tomography (ERT) can be used to obtain quantitative information about the structure of solute transport (Koestel et al. 2009. Noninvasive 3-D Transport Characterization in a Sandy Soil Using ERT: 2. Transport Process Inference. Vadose Zone Journal 8: 723-734). In this study we demonstrate that ERT can also be applied to derive the topology of hydraulic property-related parameters, namely (i) the mineral surface electrical conductivity (sigma_s) which is a proxy for the clay content and (ii) the electrical formation factor (F) which is a parameter in which porosity, water saturation, and geometry of wetted and non-wetted pore space are lumped. We apply the method to image sigma_s and F of four large lysimeters (height: 1.4 m, radius 0.58 m), three of them filled with an undisturbed soil sample and one containing a virtual porous medium (generated with Gaussian random fields). We discuss the result with respect to soil texture, water content measurements, and optically derived soil structures. In a next step, we compare the ERT-derived sigma_s and F to the corresponding ERT-derived apparent convection-dispersion parameters. The results of the numerical experiment are used to investigate the accuracy of the ERT images and the benefits and caveats of our approach.