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Monitoring Preferential Flow Processes in a Forest Soil with TDR and ERT

C. Oberdoerster (1), J. Vanderborght (1), A. Kemna (2), and H. Vereecken (1)

(1) Institute of Chemistry and Dynamics of the Geosphere, ICG-4, Agrosphere, Forschungszentrum Juelich, Juelich, Germany, (2) Geodynamics/ Geophysics, University of Bonn, Bonn, Germany

A tracer experiment was performed at a forest site with a structured soil. An area of 6 m x 8 m was sprinkled with a calcium chloride solution for 24 hours at an irrigation rate of 4 mm per hour. This solute pulse was subsequently leached out for 40 days using the same irrigation rate. The tracer movement in the soil profile was monitored using horizontally installed time-domain reflectometry (TDR) probes and electrical resistivity tomography (ERT) measurements down to a depth of 3 m. The ERT installation consisted of twelve boreholes equipped with sixteen electrodes each. The tracer breakthrough curves that were observed deeper in the soil profile by both TDR and ERT clearly indicated signs of preferential flow with an early arrival of the peak concentration and a long tail of the breakthrough curve.

The comparison between ERT and TDR showed that ERT underestimated the TDR derived bulk electrical conductivity and this deviation could not be explained completely by different sample locations and spatial variability of the soil properties. Therefore, differences between TDR and ERT are assumed to be caused by regularization effects induced by the geophysical inversion. Nevertheless, the courses of the breakthrough curves that were observed with the two methods were very similar. This indicates that preferential flow through a small part of the pore volume can be observed with ERT. Although the method cannot resolve the tracer movement at the scale of the individual preferential flow paths, it offers the possibility to image spatial distribution of the preferential flow path density and the velocity within the flow paths.