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Detecting flow processes in cracking clay soils through changes in the anisotropy of resistivity measurements

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Monitoring flow processes in cracking clay soils has remained a challenge. To overcome this, square array resistivity measurements and stable water isotopes were combined to investigate flow behaviour under cracked and non-cracked soil conditions.

Depth profiles of ten 0.05 m spaced coplanar horizontal square arrays were installed in a weighing lysimeter filled with cracking clay soil. The initially dry and cracked soil profile was brought back to field capacity during two irrigation events, which were carried out with two water types with different isotope signatures. During the water applications time lapse series of electrical resistivity measurements with the α, β, and γ square arrays were collected and the anisotropy index and mean apparent resistivity were calculated for each measurement depth.

The stable isotope composition of the collected effluent showed that water from the second irrigation bypassed the soil matrix with limited mixing. The observed bypass showed that even though the cracks at the soil surface were visually closed at the beginning of the second irrigation, preferential flow paths must have remained open. Monitoring changes in the directional dependence of square array resistivity measurements allowed further investigation of the flow processes. These measurements showed that throughout the irrigation events the dominant flow process changed from preferential flow to matrix flow. The use of square array resistivity measurements allowed for the first time to determine the exact timing of this transition. Matrix dominated flow did not occur until ponding water at the soil surface was observed. The onset of matrix flow started at the top of the profile and progressed downwards.

The results show that time series square array resistivity measurements can be used to distinguish between soil moisture and cracking stages as well as between water migration processes within a soil profile. This will provide valuable insight during the investigation of the complex water migration processes in cracking soils.