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Imaging spectral electrical properties of variably saturated porous media

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The spatial distribution of unsaturated hydraulic conductivity in the subsurface is of importance for hydrological modeling. Conventional methods to determine unsaturated hydraulic properties in the field are invasive and typically have a poor spatial resolution. In order to overcome these drawbacks, geophysical methods have received much attention in the last decades. Recent results of electrical impedance spectroscopy (EIS) on a range of saturated and unsaturated porous media revealed promising relationships between spectral electrical and hydraulic properties. Therefore, spectral electrical impedance tomography (EIT) is a promising method to image hydraulic properties in the subsurface. While this approach is emerging for aquifer characterization, unsaturated hydraulic properties have not yet been determined by EIT. In order to do so, a laboratory setup has been developed to perform controlled infiltration, drainage and stationary flow experiments on soil columns. A lysimeter with a height of 50 cm and a diameter of 22 cm is equipped with 40 electrodes and 4 tensiometers. An irrigation device at the top controlled by a peristaltic pump is used for a constant and homogeneous infiltration. Outflow is controlled by a suction plate at the bottom where an adjustable vacuum of up to 500 hPa can be applied. In a first measurement series, spectral EIT measurements were performed on a homogeneous sand column during stepwise drainage of the saturated porous medium using predefined pressure at the bottom. First results show that with decreasing water content the low frequency phase shift of complex electrical conductivity increases. This is consistent with previously reported EIS results. Calibrated relationships between electrical and hydraulic properties were used to convert the resulting electrical into hydraulic conductivity images.