Geophysical Research Abstracts
Vol. 18, EGU2016-15066, 2016
EGU General Assembly 2016

Time-lapse 3D ground-penetrating radar during plot-scale infiltration experiments

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In electrical resistive soils, surface-based ground-penetrating radar (GPR) is known as the geophysical tool providing the highest spatial resolution. Thus, 2D and 3D GPR surveys are commonly used for imaging subsurface structures or estimating soil moisture content. Due to its sensitivity to soil moisture and its non-invasive character, GPR provides a large potential to monitor soil moisture variation at high temporal and spatial resolution. As shown in previous experiments, the acquisition of time-lapse GPR data under field conditions requires a high data quality in terms of repeatability as well as spatial and temporal resolution.

We present hydrogeophysical field experiments at the plot scale (1m x 1m), during which we record time-lapse 3D GPR. For GPR data acquisition, we use a pulseEKKO PRO GPR system equipped with a pair of 500 MHz antennas in combination with a specially designed metal-free measuring platform. Additionally, we collect tracer and soil moisture data, which are used to improve the interpretation of the GPR data with special focus on preferential flow paths and their structured advective flow field. After an accurate time-lapse GPR data processing, we compare 3D reflection events before and after infiltration and quantitatively interpret their relative time-shift in terms of soil moisture variations. Thereby, we are able to account for basically all of the infiltrated water.

The first experiments demonstrate the general applicability of our experimental approach but are limited by the number of acquired time steps and measurement during the sprinkling period (the time of the highest temporal dynamics) are not possible at all. Based on this experience we redesign our experimental setup to continuously collect GPR data during irrigation and infiltration. Thereby, we strongly increase the temporal resolution of our measurements, improve the interpretability of the GPR data, and monitor the temporal and spatial dynamics of shallow subsurface infiltration.