Geophysical Research Abstracts
Vol. 16, EGU2014-3337, 2014
EGU General Assembly 2014

Full-waveform inversion of crosshole GPR data to investigate spatial connectivity in a heterogeneous alluvial aquifer

Nils Gueting (1), Anja Klotzsche (1), Jan van der Kruk (1), Jan Vanderborght (1), Harry Vereecken (1), and Andreas Englert (2)

(1) Forschungszentrum Jülich, Germany (n.gueting@fz-juelich.de), (2) Ruhr University Bochum, Germany

Geologic media such as soils and aquifers typically display complex heterogeneity. To understand and predict flow and transport in such media, detailed knowledge of the subsurface heterogeneity is indispensable. Of particular importance for flow and transport processes is the spatial connectivity of subsurface structures. Connected structures of high permeability act as preferential flow paths and lead to increased water fluxes and increased transport velocities. Connected structures of low permeability act as flow barriers and lead to decreased water fluxes and decreased transport velocities. Although knowledge of the connectivity structure is critical for flow and transport predictions, its characterization in the field is challenging. To this end, crosshole ground penetrating radar (GPR) is a powerful tool because it yields the spatial distribution of subsurface properties on full planes between boreholes, which makes it possible to assess how structures continue laterally and if specific structures are connected or not.

In this study, we present the first results of an extensive GPR field campaign, recently conducted at the Krauthausen test site, where a total number of 27 crosshole GPR planes were acquired in the uppermost alluvial aquifer. We show full-waveform inversion results for five adjacent crosshole planes covering a total length of 20 m and a depth of 10 m. Although each plane was inverted separately, consistent structures were observed where acquisition planes intersect, which indicates robust inversion results. Using the full-waveform inversion leads to a significantly improved spatial resolution of the inversion results compared to ray-based inversion results. We test the reliability of the subsurface structures derived from GPR by comparing the GPR images with vertical profiles of mechanic cone resistance, natural gamma, bulk density and water content obtained from 13 cone penetration tests (CPT) located within the GPR planes. Thereto, the multivariate CPT data was partitioned into clusters using the k-means algorithm. Our results show that the distribution of clusters in the CPT profiles agrees well with the structures obtained in the GPR images. In particular, a strong increase in permittivity below 4 m depth matches exactly the boundary between two CPT clusters in each of the 13 CPT profiles. Grain size analyses of core samples from one of the boreholes indicate that this boundary represents the abrupt change from gravel to underlying sand. CPT and GPR results are consistent with decreasing grain size and higher porosity of the sand compared to the gravel. It is interesting to note that in contrast to full-waveform inversion results at other sites where a positive correlation between porosity and hydraulic conductivity was observed, here the higher porosity of the sand layer, which is assumed to have a lower hydraulic conductivity than the gravel layer with lower porosity, suggests a negative correlation between porosity and hydraulic conductivity. We expect that an integrated analysis of CPT and GPR data will allow us to identify distinct hydrological facies in the subsurface and to map their architecture and connectivity. This will help to better understand the role of connectivity in natural aquifers and its influence on flow and transport.