Geophysical Research Abstracts
Vol. 19, EGU2017-12861, 2017
EGU General Assembly 2017

Characterization of shallow aquifers using hydraulic traveltime tomography based on crosswell pumping and recovery tests

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Hydraulic tomography (HT) has been developed for more than twenty years, which is mainly used for providing the spatial information of hydraulic parameters in the subsurface. Similar to geophysical tomography, HT utilizes hydraulic tests as the sources, and head measurements in different locations (receivers) are recorded for inverting hydraulic parameters. Among various inversion algrithoms, hydraulic traveltime based method is comparably efficient, as the inversion does not require complete head readings. However, in the practical aspect, to find out traveltime diagnostics can be readily hampered by data noise during the in-situ hydraulic tests, such as pumping tests. In this study, we use the data from recovery tests to complement and improve the original method. In order to examine hydraulic traveltimes derived from both pumping and recovery tests, we first simulate multilevel pumping and recovery tests in several three-dimensional synthetic models with different heterogeneity degree. Simulation results show that hydraulic traveltimes obtained from pumping tests are equal to which from recovery tests, in the case that pumping reaches to quasi-steady/steady state.
Sebquentially, we derive hydraulic traveltimes from the crosswell pumping and recovery tests in a real field site, Stegemühle, in Göttingen, Germany, and then invert these traveltimes to deplict the distribution of hydraulic conductivity and specific storage in the aquifer. Results with and without traveltimes from recovery tests imply that adding more traveltimes from recovery tests into the inversion procedure could improve the resolution and reduce result uncertainty. Finally, we compare the HT results with several previous electrical resistance tomography (ERT) results. Comparison indicates that, in general, the aquifer structures from HT and ERT are similar. Nevertheless, HT has higher resolution due to the denser tomographic arrays. Moreover, values of hydraulic conductivity and specific storage derived from HT are more accurate than ERT, as HT directly relates to these hydraulic parameters.