3D crosshole ERT for aquifer characterization and monitoring of infiltrating river water

Ilaria Coscia[1], Stewart Greenhalgh[1], Lasse Rabenstein[1], Niklas Linde[2], Alan Green[1], Thomas Günther[3] and Tobias Vogt[4]

[1] Institute of Geophysics, ETH Zurich, Switzerland.
[2] Institute of Geophysics, University Lausanne, Switzerland.
[3] Leibniz Institute for Applied Geophysics, Hannover, Germany.
[4] Swiss Federal Institute for Aquatic Science and Technology, Dübendorf, Switzerland.

rabenstein@aug.ig.erdw.ethz.ch

We have investigated the hydrogeological properties and hydrological responses of a productive aquifer in northeastern Switzerland. For this purpose we used 3D crosshole electrical resistivity tomography (ERT) to define the main lithological structures within the aquifer (through static inversion) and to monitor the water infiltration from an adjacent river. During precipitation events and subsequent river flooding, the river water resistivity increases. As a consequence, the electrical characteristics of the infiltrating water can be used as a natural tracer to delineate preferential flow paths and flow velocities. The monitoring system comprises 18 boreholes each equipped with 10 electrodes straddling the entire thickness of the gravel aquifer. A multichannel resistivity system programmed to cycle through various four-point electrode configurations of the 180 electrodes in a rolling sequence allows the measurement of ~15,500 apparent resistivity values every seven hours on a continuous basis. The 3D static ERT inversion of data acquired under stable hydrological conditions provides a base model for time-lapse inversion studies and the means to investigate the resolving capability of our acquisition scheme.

The analysis of the ERT time series highlight the presence of several time-varying phenomena which simultaneously affect, and with comparable intensity, the measured apparent resistivity. In particular these are river water electrical resistivity variations and groundwater table fluctuations. In addition to these primary effects, the seasonal water temperature trend creates a non-negligible drift in the data. The need to correct for temperature and water height variations on the apparent resistivity (leaving only the groundwater resistivity component of the signal) led us to develop a deconvolution filtering method to separate the effects.

Our time-lapse resistivity models indicate rather complex flow patterns as a result of spatially heterogeneous bank filtration and aquifer heterogeneity. Time series of the reconstructed resistivity models match groundwater electrical resistivity data recorded on borehole loggers in the upper and middle parts of the aquifer, whereas the resistivity models display smaller variations and delayed responses with respect to the logging data in the lower part. This study demonstrates that crosshole ERT monitoring of natural electrical resistivity variations of river infiltrate can be used to image and quantify 3D bank filtration and aquifer dynamics at a high spatial resolution.