Geophysical Research Abstracts
Vol. 20, EGU2018-8062, 2018
EGU General Assembly 2018

Measurement of the specific discharge up to 50 m depth using heat pulses and DTS

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An approach is presented to determine the specific discharge in an unconsolidated aquifer with a heat pulse response experiment using a heating cable and a fiber optic cable. The cables are installed using direct-push so that the cables are in direct contact with the aquifer and the disturbance of the aquifer due to installation is small. The temperature increase and decrease are measured for multiple days along the fiber optic cable with a Distributed Temperature Sensing system (DTS). A two-dimensional analytical solution is fitted to each of the measurement points along the fiber optic cable and the specific discharge is estimated, resulting in a profile of the specific discharge over depth. With the suggested approach it is not needed to specify the distance between the heating cable and the fiber optic cable. Two case studies are presented. The first case study contains a setup with one heating cable and multiple fiber optic cables inserted at various distances. Similar specific discharges are measured independent of the distance between the heating cable and the fiber optic cable, thereby showing that the approach gives consistent results. The second case study focusses on the ability to measure vertical variation in the specific discharge and the effect of neglecting vertical conduction. A heating cable and a fiber optic cable are installed as a pair up to a depth of 47 m. A thin layer was found at 30 m depth where groundwater moves 2.5 times faster. Variations in specific discharge of such magnitude result in vertical heat exchange. Numerical simulations are used to quantify the effect of vertical heat exchange on the estimated specific discharge.