



Testing in sandbox experiments the potentialities of active-Distributed Temperature Sensing to quantify distributed groundwater fluxes in porous media

Olivier Bour¹, Nataline Simon¹, Nicolas Lavenant¹, Gilles Porel², Benoit Nauleau², Behzad Pouladi¹, and Laurent Longuevergne¹

¹Univ Rennes, CNRS, Géosciences Rennes, UMR 6118, 35000 Rennes, France (olivier.bour@univ-rennes1.fr)

²Université de Poitiers, CNRS, UMR 7285 IC2MP, 86022 Poitiers, France (gilles.porel@univ-poitiers.fr)

Active-Distributed Temperature Sensing is a new method that has been recently developed for quantifying groundwater fluxes in the sub-surface along fibre-optic cables with a great spatial resolution. It consists in measuring and modelling the increase of temperature due to a heat source, dissipated through heat conduction and heat advection, depending on groundwater fluxes. Here, we propose to estimate the applicability and limitations of the method using sandbox experiments where flow rate and temperature are well controlled. For doing so, active-DTS experiments have been achieved under different flow rates and experimental conditions. In addition, we compare three different and complementary methods to estimate in practice the spatial resolution of DTS measurements.

Active-DTS experiments have been conducted by deploying a fiber optic cable in a large PVC tank (1.6m long; 1.2 m width and 0.3 m height) and filled with 0.4-1.3 mm diameter sand. The height of water in water reservoirs on either side of the sandbox can be adjusted to control the head gradient and the flow rate through the sand. Heating was done by injecting during at least 8 hours for each experiment, a well-controlled electrical current along the steel armouring of the fiber optic cable. The three methods for estimating spatial resolution were applied and compared using FO-DTS measurements obtained on the same fiber-optic cable but with two different DTS units having different spatial resolution. Results show that a large range of groundwater fluxes may be estimated with a very good accuracy. Finally, we compare the advantages and complementarities of the different methods proposed for estimating the spatial resolution of measurements. In particular, the spatial resolution estimated using a temperature step change is both dependent on the effective spatial resolution of the DTS unit but also on heat conduction induced because of the high thermal conductivity of the cable. By showing the applicability of the method for a large range of flow rates and with an excellent spatial resolution, these experiments demonstrate the potentialities of the method for quantifying fluid fluxes in porous media for a large range of applications.