Geophysical Research Abstracts
Vol. 20, EGU2018-13068, 2018
EGU General Assembly 2018

An Active-Distributed Temperature Sensing method for measuring groundwater flow velocities into streambed sediments at high spatial resolution.

Nataline Simon (1), Olivier Bour (1), Nicolas Lavenant (1), Mikael Faucheux (2), Ophélie Fovet (2), and Laurent Longuevergne (1)

(1) University of Rennes 1, Rennes, France , (2) UMR SAS 1069 INRA, AgroCampus Ouest, Rennes, France

Understanding and quantifying groundwater and surface water interactions are key elements for the management of water quality and quantity but also for the preservation of groundwater dependent ecosystems and riparian habitat. Localizing and quantifying these exchanges remains challenging since exchange processes vary both in time and space leading to an extreme heterogeneity in the distribution of fluid exchanges. Given the interest in characterizing hyporheic flows and quantifying interactions between groundwater and surface water, we developed a new method for measuring groundwater flow velocities in streambed sediments with an unprecedented high spatial resolution.

The experimental setup consists in heating an armored fiber-optic cable, previously deployed along the streambed within the sediments of a first-order and intermittent stream. According to heat transport principle, the temperature increase along the cable depends mainly on the sediments thermal properties and on groundwater flow velocities that may dissipate heat through heat advection. Thus, the temperature reached after a given time and at a given location should be a function of local groundwater flow velocities. Thermal response measured along heated the fiber-optic cable are interpreted by assuming that the heated cable can be modelled as a Moving Infinite Line Source (MILS), i.e. a thermal source, using the analytical solution developed by Metzger et al in 2004. To validate the use of the analytical solution and to estimate the uncertainty and limits associated to the method, a 2D numerical model has been developed. This model simulates steady state fluid flow and transient heat transfer using the Conjugate Heat Transfer module of COMSOL Multiphysics ®.

After few hours of heating, the measured temperature at steady state is particularly variable along the section with temperature increases from 16 to 36°C. By applying the analytical model, we show that it is possible to reproduce field measurements by varying flow velocity only. Therefore, this suggests that the thermal response variability can simply be associated with local variations of groundwater fluxes. These field tests allowed characterizing the groundwater flow velocities distribution into the streambed as a lognormal distribution ranging between 8e-7 and 6e-5 m/s.