Geophysical Research Abstracts
Vol. 20, EGU2018-13271, 2018
EGU General Assembly 2018
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Influences of Dam Operations and groundwater pumping in the control of Groundwater-Surface Water Interactions

Nataline Simon (1), Olivier Bour (1), Nicolas Lavenant (1), Alain Crave (1), Christophe Petton (1), Joris Heyman (1), and Mamadou Ndom (2)

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

Localizing and quantifying groundwater/surface water exchanges remains challenging since exchange processes vary both in time and space, leading to an extreme variability in the distribution of fluid exchanges. One difficulty comes from the varying boundaries conditions that are often unknown or not well defined in the field. Here, we studied groundwater – surface water interactions on the Sélune river (20-meter width), a dam-regulated river interacting with an alluvial aquifer used for water supply. As for many rivers in the world, this dam was built for hydroelectric power generation. The fluctuations in river stage control interactions between the river and the alluvial aquifer, where groundwater levels are also controlled by groundwater pumping. Since groundwater and surface water exchanges should be well controlled by dam operations and groundwater pumping, the dam-regulated Sélune river can be used as a field laboratory to quantify these interactions and test innovative methods such as active-Distributed Temperature Sensing method. Moreover, since bed sediments, an alternation of sand and gravels with the local presence of boulders, are associated with a succession of riffles and pools, it allows studying the relationship between hydromorphology and groundwater exchanges. Therefore, the present study aims to i) estimate the distribution of groundwater flow velocities, ii) characterize the effect of the riverbed morphology on flow distribution and river morphology iii) defines the interests and limitations of the different methods to quantify SW-GW interactions at high spatial resolution.

To characterize exchanges between the river and the alluvial aquifer, piezometers were installed in the bank of the river to monitor piezometer levels and groundwater temperature fluctuations. Additional temperature sensors were deployed at different depths within the streambed sediments providing vertical temperature profiles and allowing calculating vertical water fluxes and recording heat transport during river stage variations. To go further, we developed an active-DTS method allowing measuring groundwater flow velocities in streambed sediments. The experimental setup consists in heating a 600 m fiber-optic cable, previously deployed along the streambed within the sediments. The temperature increase along the cable depends on the sediment thermal properties and on groundwater flow velocities that partly dissipate heat through advection. The application of the active-DTS method provides the variability and distribution of groundwater flow velocities within the streambed sediments. The results obtained are compared to estimate groundwater/surface water interactions obtained from others classical methods. These estimates allow investigating the effect of the riverbed morphology on groundwater surface water interactions and demonstrating the effect of dam operations and groundwater pumping. Since three parallel sections of fiber-optic cables have been deployed along the stream from the bank to the middle of the river, we also aim to characterize the lateral variability of exchanges. Lastly, we discuss the temporal variability of exchanges by comparing results obtained at different times of the year.