Geophysical Research Abstracts
Vol. 18, EGU2016-14872, 2016
EGU General Assembly 2016

Spatio-temporal surface-subsurface water exchanges: from the local to the watershed scale

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Understanding the temporal and spatial variations of the surface-subsurface water exchanges is a prerequisite to achieve sustainable water use in basin. The concept of nested stream-aquifer interfaces (Flipo et al., 2014) is used to simulate the variation of the spatio-temporal surface-subsurface exchanges at the watershed scale from LOcal MOnitoring Stations (LOMOSs) measurements of the stream-aquifer exchanges. This method is applied along the stream network of the Avenelles basin.
The Avenelles basin (46 km2) is located 70 km east from Paris. The basin is composed of a multi-layer aquifer system which consists of two limestone aquifers: the Brie aquifer (Oligocene) and the Champigny aquifer (Eocene) separated by a clayey aquitard. The meandering river is shallow, connected with the Brie aquifer in its upstream part and the Champigny aquifer in its downstream part.
A high-frequency hydrologic monitoring network was deployed on the basin from 1960. The network measures water levels and water temperatures in the aquifers, and in-stream discharge rates. Five LOMOSs have been operating since 2012 along the stream-network (two upstream, two intermediate, and one downstream site) to monitor spatio-temporal stream-aquifer exchanges over years. LOMOSs are composed of one or two shallow piezometers to monitor the temperature and the hydraulic head variations in the aquifers, two hyporheic zone (HZ) temperature profiles located close to each river bank and one water level and temperature monitoring system in the river.
A local 2D thermo-hydro model is used to determine hydrogeological and thermal properties of the aquifer and the HZ by inversion and to quantify the stream-aquifer exchanges at the local scale. We performed a pseudo 3D hydro(geo)logical simulation, over 23 years, at the Avenelles basin scale by the used of CAWAQS modelling platform. The CAWAQS platform is composed of four spatially distributed modules (Surface, Sub-surface, River and Groundwater), corresponding to four components of the terrestrial water cycle. The surface parameters are calibrated by the method of Labarthe et al., (2014). The transmissivities values of the aquifers are estimated by the adjoin inversion method using a piezometric map corresponding to low flow regime. The storage and drainance coefficients are optimized based on the comparison between simulated and observed piezometric data. The hydrogeological parameters obtained by the 2D local model are used to evaluate the conductance along the stream-network. Eventually the water budget is calculated as well as the spatial distribution of stream-aquifer water exchanges along the stream network.

References :
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