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Estimating energy fluxes within the stream-aquifer interface of the Avenelles basin

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The understanding of water temperature evolution and its associated energy fluxes is important to follow the aquatic habitats evolution and to predict future modifications induced by climate change. The spatio-temporal energy balance dynamics within the stream–aquifer interface is complex because of the multitude of physical, morphological and meteorological parameters on which it depends. This critical interface is involving numerous physical and bio-geochemical processes which are taking place at different time and spatial scales. The energy balance estimation at this interface depends mainly on the direction, magnitude and variability of water exchanges and the temporal variation of river and aquifer temperatures as well as the thermal porous media properties.

In this work, a combined numerical and experimental approach is used to study the temporal and spatial evolution of the energy budget along 6 km of the stream network of the Avenelles watershed. With an area of 46 km2, the Avenelles watershed is located 70 km east from Paris. The Avenelles river presents different types of connectivity with the underlying aquifers. Five Local Monitoring Stations (LOMOS) have been deployed along the hydraulic corridor to monitor the water and thermal exchanges between the stream and aquifer over years, based on continuous pressure and temperature measurements in the river, the hyporheic zone (HZ) and the underlying aquifer.

A 2D finite element thermo-hydrogeological model (METIS) coupled with a parameters screening script is used to determine the hydrogeological and thermal properties of the HZ and of the underlying aquifers by inversion at five LOMOS. Once the local models are calibrated, water and heat fluxes through the stream - aquifer interface are assessed over years (2012-2015) along the stream network.

This work offers a new understanding of the stream-aquifer interface functioning, shifting from a pure hydrological characterizing toward a more subtle view that accounts for thermal processes. Indeed the two components of the energy flux, conductive and advective, are constraint by different factors: heat fluxes by conduction reveal diel variabilities correlated with atmospheric forcings and modulated by the porous media thermal properties, while heat fluxes by advection indicate a correlation with the intensity of hydrological events.