The quantification of exchange fluxes across streambeds has become an integral part of many studies interested in interaction processes between aquifers and streams. In the field, fluxes can be directly measured with seepage meters. Alternatively, tracers such as heat have been widely applied. Using heat as a tracer to quantify fluxes, it has become standard to obtain temperature data at different depths in the streambed with multi-level temperature measurement devices. The measured temperature data is then used as input to numerical or analytical models. Over the past decade several analytical methods (e.g. Hatch et al., 2006; Keery et al., 2007) have been developed for the quantification of vertical exchange fluxes, which make use of the amplitude ratio and phase shift between two temperature signals at different depths. Here we present two recently developed methods, the LPML method (Vandersteen et al., 2015) and then LPMLE3 method (Schneidewind et al., in review) that allow for the quantification of exchange fluxes by solving the 1D partial differential equation for water flow and heat transport in the frequency domain. Both methods use a maximum likelihood estimator for quantification of the vertical exchange flux and its uncertainty. A local polynomial method is used to split the raw temperature signal into its periodic and transient parts and to isolate the additive noise. However, whereas the
LPML method is applicable for a homogeneous semi-infinite streambed assuming only an upper boundary condition (the lower boundary is in infinity), the LPMLE3 method can quantify fluxes for finite streambed subdomains by assigning an additional lower boundary condition. Both methods can use a range of frequencies (e.g. from day-night to seasonal variations) for flux quantification and simultaneously integrate data from many vertically distributed temperature sensors.

The theory behind both methods is presented together with results (Anibas et al., 2015) obtained from the Slootbeek, a small Belgian lowland stream. Here, the vertical streambed flux was quantified at several locations of a small stream section to study its spatial and temporal variability. Additionally, both methods have been tested against the numerical model STRIVE using synthetic data.

References


