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Studying temporal and spatial variations of groundwater-surface water exchange flux for the Slootbeek (Belgium) using the LPML method

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Knowledge of groundwater-surface water interaction is important for the assessment of water resources and for the investigation of fate and transport of contaminants and nutrients. In streams and rivers exchange fluxes of water are sensitive to local and regional factors such as riverbed hydraulic conductivity and hydraulic gradients. Field monitoring in time and space is therefore indispensible for assessing the variability of groundwater-surface water interaction. Not only the complexity of the examined processes demand novel data processing and characterization tools, the amount of acquired data also urges for new modeling tools. These tools should be easily applicable, allow for a fast computation, and utilize the maximum amount of available data for detailed analysis, including uncertainties. Such analytical tools should be combined with modern field equipment, data processing tools, geographical information systems and geostatistics for best results. A simple and cost effective methodology to estimate groundwater-surface water interaction is the use of temperature as an environmental tracer (ANDERSON, 2005). LPML (VANDERSTEEN et al., 2014) is one of the most advanced analytical 1D coupled water flow and heat transport models, combining a local polynomial method with a maximum likelihood estimator. It is flexible, fast and able to create time series of exchange fluxes, as well as model quality and parameter uncertainty. LPML determines frequency response functions from measured temperature time series and an analytical model, and applies a non-linear optimization technique. With this tool the variability of groundwater-surface water interaction of the Belgian stream Slootbeek was assessed. Multilevel temperature sensors were placed in seven locations to obtain temperature-time series. Located at the streambed top and at six depths below, several months worth of data was collected and analyzed. Results identified a high spatial and temporal variability of vertical exchange fluxes for the investigated stream section. Fluxes ranged from strong exfiltration of -450 mm/d to infiltration fluxes of 110 mm/d. Events of high stream stages strongly influenced groundwater-surface water interaction, changing the normally gaining reach into a losing one. Measurements of vertical hydraulic gradients were used for validation. It was possible to relate the flow system of Slootbeek to earlier studies performed in the catchment (e.g. ANIBAS et al., 2009) to further advance the understanding of the regional groundwater flow system. These results show that the presented LPML methodology is flexible, fast and able to create reliable time series of groundwater-surface water interaction and their uncertainties.

References

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