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TITLE: Determining Vertical Groundwater-Surface Water Exchange Using a New Approach to Solve the 1D Heat Transport Equation

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CURRENT SESSION: H033. Groundwater-Surface Water Interactions: Physical, biological, and chemical relevance

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ABSTRACT BODY: In water management it has become common practice to consider groundwater and surface water as coupled parts of the same system. This has led to intensive research into groundwater-surface water interactions. Part of that research is being conducted with the aim to improve delineation and quantification of groundwater-surface water exchange fluxes or vertical Darcy velocities using heat as a natural tracer. In these cases, streambed temperatures can be measured at various depths within the streambed using e.g. multilevel temperature probes. Together with additional information such as hydraulic head, temperature data can then be incorporated into numerical models, which in turn can be used to make sound assumptions on water flow in the hyporheic zone as well as to estimate hydraulic conductivity within the streambed.
As these models are usually complex and data intensive, procedures have been developed that allow for a fast assessment of the vertical exchange flow component based on the 1D heat transport equation for a semi-infinite half-space. So far, most of these 1D solutions make use of the sinusoidal components of the diurnal temperature fluctuations between different depths within the streambed. However, they are limited regarding their use of data in the frequency domain as well as their ability to conduct proper uncertainty assessment.
The authors propose a solution for the 1D case based on the determination of the frequency response function between the input temperature at a point z0 and the temperature at a position z for a given vector containing information regarding thermal and hydraulic parameters as well as sediment properties. This frequency response function and its uncertainty are obtained by using the Local Polynomial Method, a method that uses information regarding the randomness of the input data and the spectral smoothness. With the frequency response function and its uncertainty a maximum-likelihood estimator based on non-linear least-squares optimization techniques is then used to determine model quality, estimate model parameters and determine their uncertainty. Optimized parameters are then back-transformed from the frequency domain to the time domain where they hold information regarding the vertical exchange fluxes as well as thermal parameters.
The methodology was verified using streambed temperature data obtained from multiple locations within a reach of the Slootbeek, a small sidearm of the River Aa in Belgium. It allowed for a reliable quantification of the vertical exchange flux component and its uncertainty and results could be obtained faster as compared to other 1D methods.

INDEX TERMS: 1830 HYDROLOGY Groundwater/surface water interaction, 1894 HYDROLOGY Instruments and techniques: modeling, 1847 HYDROLOGY Modeling, 1872 HYDROLOGY Time series analysis.

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