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Estimating residence time distributions in the hyporheic zone using heat

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A key issue when dealing with solute transport in interacting surface water-ground water systems is understanding the exchange between the main channel and different transient storage zones. Exchange of heat and solutes with the hyporheic zone has proven to be important for retaining and attenuating nutrients and other contaminants in the streambed sediment and hence, affecting the stream ecology.

Previous field experiments generally comprise measurements of solute concentration in the main channel to indirectly estimate the influence of transient storage on in-stream processes (e.g. estimation of the storage zone volumes and the exchange rates between zones). Here we use point measurements of temperature directly in hyporheic storage zones to reveal information on the residence time distributions, which can then be utilized in models of longitudinal solute transport on the stream reach scale. The hypothesis is that these measurements of retention in the storage zone leads to an increased overall understanding of the coupled groundwater - surface water system and may improve the understanding of solute and heat transport in streams.

This study aims to quantify the residence time distribution in the hyporheic zone by evaluating the temperature responses at different depths in the streambed sediment of a small agricultural stream in Sweden. The main focus is on the mixing mechanisms of the hyporheic zone and the collected data includes vertical temperature profiles, depth-distributed measurements of both hydraulic conductivity, and thermal properties at 7 cross-sections along the stream reach. A numerical modeling approach is used to evaluate the differences in phase and amplitude of the observed diurnal temperature signals in the stream channel and in the streambed sediment. The methodology is based on optimization of the coupled 2-dimensional heat and pressure fields with sediment characteristics varying with depth. Besides the spatial variation along the stream reach, the high-frequency temperature measurements allows for evaluation of temporal variations in parameters linked to changes in water stage.