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High resolution local subsurface flow velocity measurements using heat- and saline-based injections

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The interface between groundwater and surface water, the hyporheic zone, is a temporally and spatially dynamic ecotone. Subsurface flow velocities and residence times are key to the biogeochemistry of this zone. The ability to accurately measure subsurface flow velocities at high spatial and temporal resolution is fundamental to mapping residence time distribution within the hyporheic zone.

The current work extends the Heat Pulse Sensor (HPS) developed by Lewandowski et al. (2011). The HPS consists of a heating probe surrounded array of temperature sensors. The apparatus is inserted into the subsurface and a short pulse of heat is emitted. The dissipation of this heat signal is used an a tracer to determine the subsurface velocity. The current works adds the ability to use a saline injection in addition to a heat pulse. This is particularly useful for fine-grained sediment where low subsurface flow velocities make using heat as a tracer infeasible.

A prototype was built and tested under laboratory conditions in a purpose-built ‘flow box’ where a range of known subsurface flow velocities were used to test the Heat and Saline Pulse Sensor (HaSP) under a range of subsurface flow conditions known to occur in nature. The HaSP was tested in at an lowland river in Berlin, Germany to demonstrate its field applicability. Additionally an analysis framework was developed which provides useful metrics such as residence time distribution, allows the calculation of soil characteristics (if flow velocity is known) along with parameter uncertainty estimation which adds robustness to results.

The advancement to subsurface flow path measurements will provide a cost-effective solution for river researchers in need of accurate subsurface flow velocity measurements at high spatial and temporal resolution.