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Relating stationary and non-stationary hyporheic travel times with hyporheic chemistry at the Steinlach Test Site, Germany

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Stream-groundwater interaction is believed to significantly contribute to the retention and degradation of pollutants by means of associated biogeochemical processes in the hyporheic zone. The distribution and temporal variability of travel times of water within the hyporheic zone and their relation to hyporheic reactivity are amongst the key parameters for assessing the self-cleaning potential of rivers and hence water quality changes at catchment scale.
In this study we used time series of specific electrical conductivity (EC) of water to delineate the flow paths and travel times of water undergoing exchange between a stream and the adjacent riparian aquifer. The main objective was to interrelate hyporheic travel times with transformations of oxygen and nitrate monitored within the hyporheic zone.
The study is part of a multi-disciplinary monitoring program at the Steinlach Test Site near Tübingen in Southern Germany. The test site covers an area of about 0.6 ha and consists of a river bend underlain by a sandy gravel aquifer. The site is equipped with more than 30 piezometers, most of them containing automatic water level, temperature, and EC probes and in some cases also oxygen probes. Additional field measurements of dissolved oxygen and pH as well as water samples for the analysis of major ions and DOC were taken from March to December 2012.
Travel time distributions and mean travel times were derived using parametric as well as non-parametric (shape-free) deconvolution approaches. In addition to these stationary approaches, we also applied a windowed cross-correlation approach to assess short-term changes in travel time governed by variations in stream discharge.
Mean travel times of 0.5 to 8 days were estimated from EC and δ18O data using a dispersion model for groundwater taken from selected piezometers and at the outlet spring. Application of the non-stationary modelling approach revealed a doubling of travel times between high and low flow conditions. Although no clear relationship between hyporheic travel time and concentrations of dissolved oxygen and nitrate could be observed for the test site in total, we found an increase in oxygen consumption and nitrate reduction with increasing travel time for a small subregion of the test site. The reason for these different biogeochemical behaviours of the otherwise relatively uniform hyporheic sediments is still under investigation.