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Deriving variable travel times and aerobic respiration in the hyporheic zone using electrical conductivity as natural tracer

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Determining oxygen consumption (respiration) rates is important for characterizing the ecological functioning of a stream. It is known, that respiration is strongly temperature dependent, but the variability over time and the effects of changing hydrologic conditions are still scarce. Existing respiration measuring methods mostly utilize ex situ respiration chambers, which do not necessarily represent the actual conditions in a riverbed. We present an approach of transient in situ measurements, which utilize changes in the natural stream-EC signal as tracer for the advective transport in the streambed and combine these with precise oxygen measurements.
LTC Logger and optode based oxygen logger were installed in the stream and at 45cm depth beside an in-stream gravel bar. Streambed adapted probe rods with a screened section of 2 cm ensuring a minimized flow-through volume hold the loggers which were programmed to 5min interval measuring interval. Diurnal changes in the EC signal are considered to be quasi-conservative and were tracked in the subsurface. A windowed cross correlation approach was utilized to derive a time-resolved advective travel-time. Assuming a one dimensional flow-path from the stream into the sediment, the time-shift in the EC signal is interpreted as the peak travel time of a tracer breakthrough curve. Additionally a moving average filter of variable length was applied to the stream EC signal, to account for dispersion and further maximize the correlation. For obtaining an experimental respiration rate, the physical transport conditions are then applied to the oxygen data, assuming a first order decay.
The results show that the natural EC signal is applicable as tracer, as long as the measurements show distinctive fluctuations. The cross correlation revealed transient travel times with a range between 1-7h (mean 4h) at the upstream and 8-18h (mean 11h) at the downstream location of the gravel bar. There are strong indications, that the stream level is affecting the travel-time, albeit these effects differ depending on the morphology and strength of the streamflow events. The derived travel times allowed for estimating a transient respiration rate between 3 and 12 mg/l/day. Temperature was found to control over 70% of the variation of the respiration rate. The oxygen concentration in the streambed is more influenced by the variability of the respiration rate than of the travel time.