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Unravelling dynamic first order stream behaviour by applying stepwise modelling approach and high resolution stream temperature observations

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Tracer studies are used a lot to unravel discharge generating processes in catchments. Many (in-stream) tracer studies have the disadvantage that the spatial or temporal resolution is generally low. Therefore, different fluxes are often lumped. The overall objective of our research is to quantify the spatial and temporal dynamics of stream flow during a summer rainstorm using Distributed Temperature Sensing (DTS).

To obtain high-resolution temperature observations we installed a 565 m long Fibre Optic cable in a first order stream in Luxembourg. The temperature observations are derived from changed wave characteristics after reflection of laser light and have a spatial resolution of 2 m and a temporal resolution of 3 min. The accuracy is $\sim$0.1°C. By coupling a transport model with 2 transient storage zones and an energy balance model, we were able to reproduce in-stream water temperatures during steady state discharge conditions during 2 consecutive warm summer days.

In this study we extend our research by focussing on the dynamic effects that occur during and after a small intensive summer rainstorm. These dynamics include gains and losses of stream water as well as side channels that become active and hyporheic exchange fluxes that may change.

Using a top-down approach, we stepwise altered the different in- and outgoing fluxes until a good fit was obtained for in-stream temperatures as well as for downstream discharge. We show that during this summer rainstorm, the gains of water remain constants over time, the losses become higher with a higher discharge, while the hyporheic exchange fluxes are most likely to remain constant over time. We also show that during the peak discharge, a side channel becomes active which is connected to the stream further downstream.

Although, an energy balance model is needed to interpret the observed stream water temperature properly, DTS observations, combined with classical discharge observations, can be used to generate detailed information on spatial and temporal discharge dynamics. This can be an important step forward in detailed understanding of discharge generation.