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Quantification of the effects of the streambed on the advection of heat along the stream

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To investigate the potential of heat as a tracer to quantify lateral inflows in space and time, an energy balance model has been developed. We confronted this model with high resolution temperature observation made with DTS (Distributed Temperature Sensing) in a first order stream in Luxembourg.

One important aspect of the energy balance model is the advection of heat along the stream. The discharge in the stream is small and the cross-sectional area consists of abundant platy and angular pebbles and cobbles. Therefore, the stream water flows through the rock clasts present in the streambed. Consequently, the transport of heat is slower than that of the stream discharge. This is the result of the fact that in the modeling schematization the storage of heat is in the whole cross-sectional area, while storage of solutes is only in the part of the cross-sectional area which is water. We hypothesized that quantifying and implementing the effect of the streambed on the advection of heat in our model, will improve the modeling results significantly.

In this research we carried out a tracer experiment in the stream to determine the advection of heat. We doubled the discharge in the stream for ca. 20 minutes, by emptying a reservoir upstream. Three tracers were added to the reservoir, namely deuterium, salt and heat (the temperature of the reservoir was 0°C, while the stream temperature was ∼8°C). The deuterium and the electric conductivity were respectively sampled and measured at three locations downstream, while the temperature was measured with a resolution of 2 m and 3 minutes, using the DTS.

The breakthrough curves of salt and deuterium arrived earlier downstream than the breakthrough curve of heat. This difference is used to quantify the relative volume of rock clasts in the stream. This was implemented in our energy balance model and showed good results compared with the observed temperature along the stream.