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Distributed Temperature Sensing as a method to identify groundwater discharge zones and in-stream sedimentation processes in soft-bedded streams

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Fiber optic Distributed Temperature Sensing (DTS) has been shown to be a quick and useful tool to identify spatial variability in groundwater discharge to shallow streams with hard streambed bottoms. Scouring and sedimentation in soft-bedded streams however, may cause the cable to float in the water column in some places and to be buried under sediments in other places. Here we report on a field investigation in a soft-bedded stream using long-term DTS and bed erosion monitoring in order to; (i) understand spatial variability in groundwater discharge, (ii) understand the effects of sediment bed erosion processes on DTS, and (iii) to see if DTS can be exploited to measure erosion and sedimentation processes. The idea is that DTS only provides useful information regarding the location of groundwater discharge zones within a short period of time after installation and when the cable is subsequently buried under sediment deposits, it is isolated from the stream temperature signal. By recording these temperature anomalies the spatial and temporal evolution of newly deposited sediments can be monitored.

The long-term DTS study was carried out at a field site located along Holtum stream in Western Denmark. The 4 m wide stream has a soft sandy streambed, an average discharge of 1068 l/s and a depth of 0.7 m. Contrary to the traditional longitudinal layout, 750 meters of fiber optic cable was fixed to the streambed following a zig-zag pattern in a 70 meter long section providing for a high spatial resolution not only along, but also across the stream with an average 0.4 m distance between the cable rows.

Zones of groundwater discharge were identified on the basis of a 24h DTS survey on 13 October 2011, right after positioning the cable on the streambed surface. The discrete groundwater inflow points were shown as low temperature anomalies during the day and warm temperature anomalies during the night. Continuous streambed temperature data between 18 and 22 October 2011 revealed that the location of temperature anomalies caused by the discharge zones was constant in time over this short period, but due to the streambed sedimentation processes, new anomalies, not related to groundwater discharge, were also discernible.

Additional continuous temperature data from 14 November until 31 December 2011 and streambed elevation surveys carried out on 13 October, 12 November and 12 December 2011 have made it possible to use DTS to observe and correlate longer term natural changes in location of discharge zones to the spatial and temporal evolution in sedimentation due to scouring, migration, and re-deposition This has been confirmed by first installing and then removing an artificial obstruction and then using DTS to image the gradual sedimentation in the scour hole.