Geophysical Research Abstracts
Vol. 13, EGU2011-12334, 2011
EGU General Assembly 2011

Reach scale Distributed Temperature Sensing (DTS) and instream temperature modelling of a Danish experimental river basin in Sjælland, Denmark

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Surface water - groundwater interactions performs a vital role in the sustenance of riverine ecosystems through biogeochemical interactions and contribution during low flow periods. The heterogeneous behaviour of these interactions meant that conventional point based measurements often lacks the detail necessary to capture the stream dynamics over required spatial and temporal scales. In recent years, Distributed Temperature Sensing (DTS) technique is used in variety of hydrologic applications such as locating groundwater inflow into the stream. DTS uses conventional fibre optic cable of length in kilometers to provide highly precise (0.01°C) continuous temperature measurements with spatial resolution of 1 m and temporal resolution of 30 s. This research combines new data and model based technologies to improve the spatial parameterization and modelling of catchment hydrological processes. An experimental basin of Stream Elverdamsåen located in the island of Sjælland, Denmark is selected for this study. The stream is 18.15 km long and drains 20.17 km^2 of area. A DTS unit of Agilent (N4385A / N4386A) with 2.2 km fiber optic cable was installed in a reach of Elverdamsåen with flow widths ranging from 1.5 to 4 m. Upstream of the reach comprise of unshaded open meadows while the middle section is dominated by the agricultural lands with significant stream shading from the banks. The reach ends with densely shaded 450 m of forest section. Top soil of most part of the Elverdamsåen catchment is dominated by thick moraine clayey till and outwash sands of glacial origins. Stream bed sediments range from mixture of sand and silt in open agricultural fields to gravel dominated forest section. This 2 km reach represents different land use, shading and geomorphologic characteristics, making it ideal to capture different hydrologic patterns.

DTS Temperature data were collected for 2.2 km reach length with spatial and temporal resolution of 1 m and 5 min respectively at intermittent intervals with the intent of capturing the seasonal stream dynamics. Using these temperature data, two locations of surface water - groundwater interaction exhibiting three distinct thermal regimes within the 2.2 km reach were identified. A focused groundwater inflow into the stream at 308 m from the upstream portion of cable cools the overall system approximately by 10°C and confluence of a stagnant agricultural drainage at 1043 m introduces additional heat input into the stream system. An energy based instream temperature model was used to quantify the effect of these interactions on stream temperature. Model simulated results are compared with the observed temperatures from DTS system. The model predicted significant dampening of stream temperature due to one groundwater inflow source. However, there exists some difference between observed and predicted values confirming the presence of diffuse sources within the reach not detected by the DTS measurements. In addition, the data collection period coincided with stream temperature being in the range of 10 to 13°C, which is close to stable groundwater temperature (8.87°C). It confounded the mixed signal to locate other small scale interactions. Presence of strong temperature signal and proximity of cable to the inflow source in fairly wide stream (4 m at places) are deemed to be important factors in locating other interactions from the DTS measurements.