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Quantification of the groundwater-surface water interaction by analysing temperature gradients in the streambed of the Aa river, Belgium

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The aim of this research is to gain better insight in the diverse physical and biological processes in margins, inundation areas and the hyporheic zone of water courses on a local scale. Data and results presented are from a multidisciplinary study on exchange processes in river ecosystems in which biologists, hydrologists, ecologists and engineers cooperate.

Groundwater and eco-biochemical models are integrated in order to determine the exchange of water, dissolved compounds and particulate matter. Several of these processes occur simultaneously and result in feedback to other processes; hence most of the investigations aim to determine net rates of exchange. GIS is used for data management, while FEMME (Soetaert et al., 2002) serves as a platform for the integration of the different models such as MODFLOW, DAFLOW, Delft3D, and WetSpa.

An innovative but cost-effective method for field investigation is the measurement of streambed temperatures profiles, which lead to a delineation and quantification of the groundwater discharge on a local scale. For the Aa River site in Belgium, a typical low land river system, combinations of longitudinal and cross-sectional measurements of temperature profiles have been conducted. Along a 1400 m long section, 5 vertical measurements of up to 80-100 cm deep into the river bottom have been performed

bi-monthly between August 2004 and February 2007 at 14 measurement points and 5 cross-sections. With this information we assessed the vertical component of the groundwater flux and the spatial and temporal variability of the groundwater-surface water exchange.

A streambed temperature survey does not lead directly to an estimation of the groundwater flux. Additional information, especially thermodynamic parameters of the soil-water matrix are necessary.

The groundwater fluxes were calculated as point values at the measurement locations on basis of an analytical solution presented by Arriaga et al. (2006), and which is solved with the help of Microsoft Excel Solver and MATLAB. The fundamental heat flow equation was also introduced in a diagenetic model, setup in FEMME and used to compare with the Arriaga et al. (2006) solution. Interpolation of the point estimates results in net groundwater fluxes on the scale of the surveyed area. These results show discharge as well as recharge dependent on the location along the section and the season. The upper reach shows in general higher discharge rates and no change in direction of the groundwater flow, whereas the lower reach is characterized by lower flow rates and a change of direction of flow.