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Coupling of a Groundwater and Surface Water Model for integrated Floodplain Water Management

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Surface water - ground water interaction plays an important role in highly permeable streambeds and aquifers. This is the case in many alpine valleys, such as in the Maggia valley in Southern Switzerland. Here, hydropower operation leads to dramatically reduced flow rates, therefore lowering the groundwater table in the downstream riverine corridor, which is about 25 km long and 500 m to 1 km wide with an average slope of 1 %. Changes both in the river flow and morphology, and in the aquifer affect vegetation dynamics in the floodplain. For conservation and restoration strategies, a fully integrated model is needed, which reproduces the space-time variability of the interaction between the surface water and groundwater components.

Here, we present a coupled modelling system consisting of the two-dimensional hydrodynamic model 2dMb for the surface water flow modelling and the two-dimensional groundwater model MODFLOW-2000. Feedback mechanisms between the river and aquifer systems due to infiltration-exfiltration processes are explicitly considered. The topography, scale and hydrological conditions forced the choice of the type of models that can simulate the complex water fluxes dynamics. This includes, among others, streamflow rates varying between less than 1 and about 1000 m3/s, which result in large variations of the inundated area over a complex fluvial morphology that changes from single river channel to a braided system. In addition, groundwater dynamics are dominantly and highly affected by the fast and strong response to changing water levels in the river. Finally, infiltration-exfiltration rates vary in time and space on a small scale.

The hydrodynamic model solves the shallow-water equations in 2D. The wide range of flowrates and the steep slopes require a fine resolution grid of 6.25 m and a robust numerical scheme (finite volumes are used). The explicit scheme requires time steps

in the order of seconds. MODFLOW-2000 solves the Darcy-equations and runs in timesteps corresponding to the dynamics of the processes, which is in the order of 1 hour. The coupling is implemented by comparing the information of the piezometric head in the river and the aquifer cell by cell after each MODFLOW-2000 timestep, and then the exchange rates are calculated for each cell and used as a new boundary condition in both models for the next timestep. This allows a continuous simulation of the entire surface water - ground water system dynamically in space and time. The results show in accordance with field observations that the inclusion of the infiltration-exfiltration process into the modelling system is crucial, and should not be neglected in this type of environment.