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Dynamic 3D numerical Simulations of Groundwater Exchange Processes at the Danube Riverbank

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The application of a 3D numerical groundwater flow and transport model at the Danube riverbank is presented. The aim of this work is to investigate the changes of flow rates in-between the river and the groundwater. These changes are initiated by projected measures for a 1:1 pilot test within the Integrated River Engineering Project on the Danube to the East of Vienna (riverbed adjustments, low water regulation structures such as groynes and guide dykes, riverbank renaturation and waterway linkage). For this special task several questions have to be considered such as the influence of dynamic river water tables, alternating dry and wet riverbank regions (a gravel bar), the topography, the subsurface composition and the unsaturated zone.

In order to reproduce the flow situation in a realistic way, a three-dimensional numerical groundwater model with variably saturated flow is applied. After close examination of various software packages, SUTRA2D3D was chosen for the ongoing work and adapted to our specific requirements. Beside the possibility to account for the before mentioned questions, this software allows spatial discretisation adjusted to a detailed digital terrain model by a hybrid finite-element / finite-difference method.

The study includes in particular the groundwater flow directions and velocities at the riverbank in dependency of the river water table and the time. Instead of solving a coupled surface - subsurface approach, our model sets the conditions at the river-groundwater boundary dynamically. These methods allow for solving the non-linear numerical differential equations in a computationally efficient way.

The second part of this work focuses on the simultaneous simulation of energy transport and groundwater flow. The energy transport model is based on the numerical solution of the advection-dispersion equation and accounts for the temperature dependent parameters (fluid density, fluid dynamic viscosity). Based on the different temperature characteristics in the river and the groundwater, the extent of the mixing-zone within the hyporheic zone can be identified. Furthermore we can determine the influence of seasonal temperature variations on the amount of aquifer recharge by infiltration.

The results show that our model can reproduce the complex situation of the Danube river groundwater interaction accurately in three dimensions. Furthermore the energy simulation results indicate the importance of considering temperature dependent factors.