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Application of numerical modelling in order to estimate the interaction between surface water and thermal groundwater use

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In Vienna the thermal use of shallow groundwater usage for heating and cooling purposes is of increasing interest during the past years. In this context the focal areas are located in the vicinity of the Danube River, which intersects the urban area of Vienna. This is a consequence of excellent aquifers, which predominately consist of poorly consolidated gravels of Holocene age deposited by the Danube River. Of course these shallow aquifer systems are hydraulically connected to the Danube. In addition most of the focal areas in Vienna are affected by abandoned meanders and ponds, which correspond the groundwater and eventually to the Danube River. These wide spread ponds remain from abandoned gravel pits, which are directly alimented by the groundwater.
Focusing on these abandoned meanders and ponds the intensity of hydraulic correspondence to groundwater variations is strongly governed by the degree of colmatation. As thermal groundwater utilization is influencing the local hydraulic regime by means of well fields, enforced interflow between surface- and ground water have to be expected at the nearby surrounding of abandoned rivers, abandoned meanders and groundwater ponds. This leads to an attenuation of the capacity of the thermal utilizations as surface water and ground water show different annual temperature variations. Depending on the total pumping rate of a geothermal well field as well as on the spatially varying colmatation of surface waters restricted zones for thermal groundwater use have to be defined in order to avoid inefficient utilizations.
Based on two presented case studies in the city of Vienna we aim to show methods based on numerical modelling and empirical studies (observation of gauges) in order to estimate the degree of colmatation of surface waters and to predict the interaction between thermal groundwater use and surface waters. As the heat budget of shallow surface waters (e.g. small ponds or lentic meanders) is affected by various parameters, such as solar radiation, airflow advection and free convection, we have applied a simplified approach to predict the annual temperature variation. The hydraulic connectivity between surface waters and groundwater has been simplified to a hydraulic resistance, which is represented by the degree of colmatation. The degree of colmatation in turn has been estimated by empirical analyses of the water table of gauges, which are located in the vicinity of surface waters. Finally the interaction of thermal groundwater use and surface waters has been realized based on a transient coupled thermal – hydraulic modelling performed by the software packages Comsol Multiphysics and FEFLOW.