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Modelling the impact of water management in former lignite pits on groundwater regime and catchment boundaries in the Central German Lowlands

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The Selke River Basin is a mesoscale catchment (about 456 km^2) in central Germany which is dominated by forests in the upper parts of the catchment (35% of the total area) while the lowland parts are dominated by agriculture use (53% of the area). In the lowlands, groundwater shows elevated nitrate concentration, partially above the threshold of the WHO of 50 mg/L. Since these high concentrations may act as a threat to both surface and subsurface water bodies, in this study we aim to derive groundwater flow direction and residence times to understand better the nitrate inputs and outputs in the catchment. Interestingly, the hydrology of the lowland part of the catchment are dramatically influenced by the former lignite pit lake Concordiasee in the eastern part of the catchment where flooding has been interrupted after the occurrence of a landslide in the year 2009.
In this study, we present a numerical 2D groundwater flow model, which comprises the lower part of the Selke Basin as well as parts of the neighboring basins using the Software OpenGeoSys. The groundwater model was coupled with a hydrodynamic flow model to simulate the water flow of the Selke River and the exchange fluxes between both models. Groundwater flow paths and travel times between the surficial aquifer system, the Selke River and the pit lake were calculated using numerical backward particle tracking. The groundwater flow model was calibrated using groundwater level data measured in 20 monitoring wells that had been installed in the surficial aquifer of the study region.
Our modelling results revealed that the spatial extension of the sub-surface catchment boundaries differ significantly from the catchment boundaries derived commonly from the digital elevation model. A considerable amount of water from the recharge areas in the western and southern parts of the catchment is partially mixed with water from the Selke River before entering the pit lake, though in some areas the Selke River is exclusively gaining water from the surficial aquifer. In addition, the majority of groundwater recharge from the northern and eastern parts of the basin does not reach the Selke River but drains directly into the former mining lake. Considering that both, nitrate concentrations are high in the surficial aquifers of the study area and estimated subsurface travel times are in the range of years, we propose that the existence of an only partially flooded pit lake might have been positively affected the water quality of the Selke River during the last decades. However, our simulations demonstrated that once flooding will be completed, groundwater discharge into the Selke River will increase and the differences in catchment boundaries of surface and subsurface catchment will diminish.