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Effects of predicted climate change on groundwater flow systems and its implications for future water management

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Although hydrological observations over the past several decades have provided ample evidence that water resources can be strongly affected by climate change (Bates et al., 2008), our present understanding of how these predicted alterations impact subsurface water resources and flow systems, and our knowledge about the dynamic relationship between groundwater and climate is fairly limited (Taylor et al., 2013).

In this study, the influence of climate change-impacted recharge on groundwater levels and on inter-connected groundwater flow patterns is evaluated, with special emphasis on how flow system fragmentation and hierarchy may change in the future. Moreover, possible consequences of these modifications on groundwater-related shallow surface water bodies and on interaction between groundwater and surface water are examined. The Tihany Peninsula in Hungary was an ideal test side for the study, since no significant anthropogenic impacts have affected the groundwater system of this site.

Three main questions are investigated: i) How might a groundwater system, including groundwater-surface water interaction, be modified by predicted climate change?, ii) Given the variable groundwater levels and flow patterns, how will the water levels and fluxes be impacted around surface water bodies?, and iii) How sensitive are groundwater-related wetlands to these changes, will they be maintained or will they eventually disappear? In order to answer these questions, two-dimensional transient numerical simulations were performed within the Heatflow-Smoker code (Molson and Frind, 2015) based on site-specific measurements and climatic predictions.

Results show that future climate trends can cause dynamic evolution and dissipation of transient groundwater flow systems, and the characteristic flow system hierarchy can change from nested flow systems to a set of single flow cells. A reduction in groundwater levels under climate-driven recharge change could strongly affect ecologically-significant flow regimes. Moreover, since water and nutrient budgets of groundwater-related surface waters are strongly influenced by groundwater, wetland water quality could also change in the future. Therefore, preservation of associated groundwater-dependent ecosystems would be challenging under these conditions since long-term climate change could potentially have serious consequences, including wetland disappearance.

Predictions regarding future subsurface processes are highly uncertain because of the unpredictable degree of climate variability and numerous possible feedback processes. Understanding the effects of changed hydrologic conditions on flow patterns and recharge-discharge relationships with surface water bodies can nevertheless help to better mitigate or prepare for the consequences, e.g. with improved water management plans and policies including the application of managed aquifer recharge.

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