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Enhanced recharge rates and altered recharge sensitivity to climate variability through subsurface heterogeneity

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Karst aquifers in Europe are an important source of fresh water contributing up to half of the total drinking water supply in some countries. Karstic groundwater recharge is one of the most important components of the water balance of karst systems as it feeds the karst aquifers. Presently available large-scale hydrological models do not consider karst heterogeneity adequately. Projections of current and potential future groundwater recharge of Europe's karst aquifers are therefore unclear.

In this study we compare simulations of present (1991-2010) and future (2080-2099) recharge using two different models to simulate groundwater recharge processes. One model includes karst processes (subsurface heterogeneity, lateral flow and concentrated recharge), while the other is based on the conceptual understanding of common hydrological systems (homogeneous subsurface, saturation excess overland flow). Both models are driven by the bias-corrected 5 GCMs of the ISI-MIP project (RCP8.5). To further assess sensitivity of groundwater recharge to climate variability, we calculate the elasticity of recharge rates to annual precipitation, temperature and average intensity of rainfall events, which is the median change of recharge that corresponds to the median change of these climate variables within the present and future time period, respectively.

Our model comparison shows that karst regions over Europe have enhanced recharge rates with greater inter-annual variability compared to those with more homogenous subsurface properties. Furthermore, the heterogeneous representation shows stronger elasticity concerning climate variability than the homogeneous subsurface representation. This difference tends to increase towards the future. Our results suggest that water management in regions with heterogeneous subsurface can expect a higher water availability than estimated by most of the current large-scale simulations, while measures should be taken to prepare for increasingly variable groundwater recharge rates.