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Effects of subsurface heterogeneity on large-scale hydrological predictions

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Heterogeneity is abundant everywhere across the hydrosphere. It exists in the soil, the vadose zone and the groundwater producing preferential flow and complex threshold behavior. In large-scale hydrological models, subsurface heterogeneity is usually not considered. Instead average or representative values are chosen for each of the simulated grid cells, not incorporating any sub-grid variability. This may lead to unreliable predictions when the models are used for assessing future water resources availability, floods or droughts, or when they are used for recommendations for more sustainable water management.

In this study we use a novel, large-scale model that takes into account sub-grid heterogeneity for the simulation of groundwater recharge by using statistical distribution functions. We choose all regions over Europe that are comprised by carbonate rock ($\sim$35% of the total area) because the well understood dissolvability of carbonate rocks (karstification) allows for assessing the strength of subsurface heterogeneity.

Applying the model with historic data and future climate projections we show that subsurface heterogeneity results (1) in larger present-day groundwater recharge and (2) a greater vulnerability to climate in terms of long-term decrease and hydrological extremes.