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## Flow simulation in karst regions from the scale of single aquifers to entire continents

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Large-scale hydrological models have been widely used for water resources management, such as studying human impacts (e.g., pumping and irrigation) on groundwater. Currently, most of these models do not explicitly include karst features for the recharge and groundwater simulations. However, the geological properties in karst regions substantially differ from non-karst areas, which makes recharge and groundwater flow behaviors distinctly different between the two types of systems. Due to challenges of combining karstic and non-karstic processes, of simulating inter-catchment groundwater flow, and of parameterizing karstification over large areas in karst regions, global karst groundwater flow models currently do not exist. In this study, we propose a general approach to integrate karstic and non-karstic processes and a hierarchical approach to confine the karstic groundwater flow parameters over large domains. First, we selected six karstic catchments (with different catchment sizes and climates) with adequate observations to test the combination of karstic and non-karstic simulations at the aquifer and catchment scale. We show that using system signatures helps to identify the necessary model structures and to integrate karstic and non-karstic processes. Second, we defined an Inter-catchment Groundwater Flow index (IGF) to quantitatively address groundwater flow crossing topographic boundaries. Third, we classify the level of karstification based on spring and catchment properties and evaluate different strategies for parameterization of karstic groundwater flow processes at varying degrees of karstification. Overall, our study provides a solid basis for a continental-scale karstic groundwater flow model, complementary to current global scale hydrologic modeling efforts where this process is still missing.