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A large-scale integrated karst-vegetation recharge model to understand the impact of climate and land cover change

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Karst aquifers are an important source of drinking water in many regions of the world, but their resources are likely to be affected by changes in climate and land cover. Karst areas are highly permeable and produce large amounts of groundwater recharge, while surface runoff is typically negligible. As a result, recharge in karst systems may be particularly sensitive to environmental changes compared to other less permeable systems. However, current large-scale hydrological models poorly represent karst specificities. They tend to provide an erroneous water balance and to underestimate groundwater recharge over karst areas. A better understanding of karst hydrology and estimating karst groundwater resources at a large-scale is therefore needed for guiding water management in a changing world.

The first objective of the present study is to introduce explicit vegetation processes into a previously developed karst recharge model (VarKarst) to better estimate evapotranspiration losses depending on the land cover characteristics. The novelty of the approach for large-scale modelling lies in the assessment of model output uncertainty, and parameter sensitivity to avoid over-parameterisation. We find that the model so modified is able to produce simulations consistent with observations of evapotranspiration and soil moisture at Fluxnet sites located in carbonate rock areas.

Secondly, we aim to determine the model sensitivities to climate and land cover characteristics, and to assess the relative influence of changes in climate and land cover on aquifer recharge. We perform virtual experiments using synthetic climate inputs, and varying the value of land cover parameters. In this way, we can control for variations in climate input characteristics (e.g. precipitation intensity, precipitation frequency) and vegetation characteristics (e.g. canopy water storage capacity, rooting depth), and we can isolate the effect that each of these quantities has on recharge. Our results show that these factors are strongly interacting and are generating non-linear responses in recharge.