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The role of unsaturated hydraulic-property estimation in modelling coupled surface-subsurface flow processes

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Variably-saturated dynamics in the near surface reflect the complex interactions between atmospheric and terrestrial processes, and are also important for quantifying runoff generation, groundwater recharge, solute fluxes, and soil-water-plant interactions. Despite the importance of unsaturated hydraulic properties in controlling the coupling between surface and subsurface processes, the impact of estimation methods is rarely considered in comprehensive modelling studies. Pedotransfer functions are widely used for assigning water retention and unsaturated hydraulic conductivity characteristics, but this method generally relies on core samples and properties that are indirect proxies for the physical controls on soil-moisture dynamics (e.g., soil textural class and percent organic matter). In-situ measurements and inverse methods provide alternative approaches that can improve parameter estimation and hydrologic process representation for a given location. Soil-hydraulic property estimates from several field-based studies are used in conjunction with a sophisticated physics-based model of fully-coupled surface / subsurface flow to demonstrate how these different methods for estimating soil-hydraulic properties can have a substantial impact on simulated hydrologic response at the catchment scale. Overall, results suggest that estimation methods based on a larger support volume, with measurements under both wetting and drying conditions, more accurately incorporate the influence of porous-media structure on effective hydraulic property values. The implication of this finding is that simulation errors and model uncertainty can be reduced by using commensurable scales of parameter estimation and model application.