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Rapid and slow drainage in the Chalk vadose zone and its role in hydrological extremes

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The Cretaceous Chalk is the UK's primary aquifer and a vital water resource for southern and eastern England. Its porous, drainable soils also make it highly suitable for pasture and arable farming. In addition, its distinctive water quality gives rise to a large number of important ecological habitats. The fractured chalk matrix gives the rock its dual-porosity and dual-permeability properties. As a result, its low drainable porosity and dynamic storage mean it is susceptible to both drought and groundwater flooding. The behaviour of the aquifer under these extremes is largely governed by recharge processes in the vadose zone, which, in turn, are affected by heterogeneities in the above properties. Using detailed observations of vadose zone hydrological dynamics, combined with spatial observations of groundwater response and interpreted using detailed physically-based models, a comprehensive understanding of the controls on recharge processes in the Chalk has been developed. This has highlighted the importance of slow summer vadose zone drainage, which can occur even during extreme drought, in providing an additional flux of water not generally accounted for in water balance calculations and groundwater recharge models. At the other extreme, intense rainfall can result in preferential flow via the fracture system causing rapid rises in groundwater level, which can contribute to or result in groundwater flooding. New approaches are therefore needed for modelling recharge in Chalk under extreme conditions if we are to improve our representation of water resource reliability during drought or impacts of water table rise and groundwater emergence during floods, particularly as these are likely to be more frequent under a changing climate.