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The significance of spatial variability of rainfall on streamflow: A synthetic analysis at the Upper Lee catchment, UK

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Rainfall, one of the main inputs in hydrological modeling, is a highly heterogeneous process over a wide range of scales in space, and hence the ignorance of the spatial rainfall information could affect the simulated streamflow. Calibration of hydrological model parameters is rarely a straightforward task due to parameter equifinality and parameters' 'nature' to compensate for other uncertainties, i.e. structural and forcing input. In here, we analyse the significance of spatial variability of rainfall on streamflow as a function of catchment scale and type, and antecedent conditions using the continuous time, semi-distributed PDM hydrological model at the Upper Lee catchment, UK. The impact of catchment scale and type is assessed using 11 nested catchments ranging in scale from 25 to 1040 km2, and further assessed by artificially changing the catchment characteristics and translating these to model parameters with uncertainty using model regionalisation. Synthetic rainfall events are introduced to directly relate the change in simulated streamflow to the spatial variability of rainfall.

Overall, we conclude that the antecedent catchment wetness and catchment type play an important role in controlling the significance of the spatial distribution of rainfall on streamflow. Results show a relationship between hydrograph characteristics (streamflow peak and volume) and the degree of spatial variability of rainfall for the impermeable catchments under dry antecedent conditions, although this decreases at larger scales; however this sensitivity is significantly undermined under wet antecedent conditions. Although there is indication that the impact of spatial rainfall on streamflow varies as a function of catchment scale, the variability of antecedent conditions between the synthetic catchments seems to mask this significance. Finally, hydrograph responses to different spatial patterns in rainfall depend on assumptions used for model parameter estimation and also the spatial variation in parameters indicating the need of an uncertainty framework in such investigation.