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Exploring the validity of a regionalised hydrological model at various spatial scales

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The application of the integrated land and catchment management paradigm can largely benefit from the increasing understanding of hydrological processes at the mesoscale most relevant for typical catchments. However, use of process-based catchment models can be limited by the lack of time-series data within the catchment to both calibrate and validate the model. This is even more limiting when aiming at calibrating and validating the more spatially explicit semi-distributed models. For ungauged catchments, predictions are made possible by sophisticated regionalisation procedures that relate mapped physical catchment characteristics with the parameters of the conceptual model. Nonetheless, regionalisation procedures require some gauging data for the development of the regional model so that the regionalised equations should apply only to lumped catchments. This can be a limiting factor when modelling land management scenarios often describing changes at a much finer spatial scale.

We have investigated the question of whether the hydrological behaviour captured by the regional model calibrated for lumped scales could remain valid for some finer spatial scales, while acknowledging scale limitations where the dominant hydrological processes described in the model will no longer be sufficient for satisfactory hydrological predictions. We applied a regional model developed for lumped catchments at finer scales, including semi-lumped and semi-distributed discretisation schemes. The latter models allow the use of potentially more realistic forcing data and parameters by increasing representation of their heterogeneity. This is tested on a set of fifteen Irish catchments over a 10-year period using the conceptual rainfall-runoff model SMART in a predictive mode. The conclusions of this study have important implications for the use of catchment models in land management scenarios. In particular, beyond partially overcoming the issue of gauging data availability at suitable sub-catchment scales, bypassing traditional calibration also offers opportunities to investigate future land cover changes in the catchment without assuming stationarity of the catchment system.