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Interactions between spatial complexity and distributed hydrological model response: towards the better identification and handling of structural error in model predictions.

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A rather simple characterisation of the different sources of errors in hydrological modelling is that model uncertainty is induced on the one hand by random and stationary errors and on the other hand by systematic errors typically resulting from a lack of knowledge, and reflected in flaws in model structure (e.g. knowledge over which processes to include) and/or data assimilation and/or model parameters. In this research, we make the hypothesis that these systematic errors are likely to unfold in a spatially meaningful way. We traditionally see this as a problem : spatially rich data fields are amongst the hardest to generate in catchment hydrology ; but here we turn this to an advantage. We take the assumption that any one given and localized rainfall event will produce errors of different magnitudes depending on which portion of the catchment is affected. If we start with the ideal case where the characteristics of this event are known in spatial detail and then we modify the level of spatial representation in the driving data, we can begin to identify those areas of catchment response that become most sensitive to different representations. In turn, this should allow : a more informed understanding of where field measurement needs to be focused so as to reduce the systematic errors revealed by spatial simplifications ; and a deeper understanding of where and when the model is reliable. We illustrate this approach through the combination of a semi-distributed hydrological model (TOPMODEL) with rainfall radar data for the Swiss Alps. The spatially- and temporally-rich data fields provided by the rainfall data are described geostatistically with varying degrees of simplification down to a near homogeneous case. Progressive application of these to different realisations (i.e. parameter sets) of the hydrological model allows us to understand the interaction between simplification (and hence error) in the rainfall field and both the spatial distribution of runoff response and modelled catchment outflow. Comparison with measured outflow show strong compensation for rainfall simplification by model parameterisation but also which areas of the basin require special attention to be given to model parameterisation and rainfall representation.