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Ensemble catchment hydrological modelling for climate change impact analysis

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It is vital to investigate how the hydrological model structure affects the climate change impact given that future changes not in the range for which the models were calibrated or validated are likely. Thus an ensemble modelling approach which involves a diversity of models with different structures such as spatial resolutions and process descriptions is crucial. The ensemble modelling approach was applied to a set of models: from the lumped conceptual models NAM, PDM and VHM, an intermediate detailed and distributed model WetSpa, to the highly detailed and fully distributed model MIKE-SHE. Explicit focus was given to the high and low flow extremes. All models were calibrated for sub flows and quick flows derived from rainfall and potential evapotranspiration (ETo) time series. In general, all models were able to produce reliable estimates of the flow regimes under the current climate for extreme peak and low flows.

An intercomparison of the low and high flow changes under changed climatic conditions was made using climate scenarios tailored for extremes. Tailoring was important for two reasons. First, since the use of many scenarios was not feasible it was necessary to construct few scenarios that would reasonably represent the range of extreme impacts. Second, scenarios would be more informative as changes in high and low flows would be easily traced to changes of ETo and rainfall; the tailored scenarios are constructed using seasonal changes that are defined using different levels of magnitude (high, mean and low) for rainfall and ETo.

After simulation of these climate scenarios in the five hydrological models, close agreement was found among the models. The different models predicted similar range of peak flow changes. For the low flows, however, the differences in the projected impact range by different hydrological models was larger, particularly for the drier scenarios. This suggests that the hydrological model structure is critical in low flow predictions, more than in high flow conditions. Hence, the mechanism of the slow flow component simulation requires further attention.

It is concluded that a multi-model ensemble approach where different plausible model structures are applied, is extremely useful. It improves the reliability of climate change impact results and allows decision making to be based on uncertainty assessment that includes model structure related uncertainties.

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