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Quantifying the relative magnitude of sources of uncertainty in river flow projections under climate change: An assessment for the Mekong River

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Potential hydrological impacts of climate change are commonly assessed by driving hydrological models with climate projections derived from General Circulation Models (GCMs). Sources of uncertainty in the resulting hydrological projections include: definition of emissions scenarios for driving GCMs; GCM structure; downscaling of GCM outputs to finer resolution; hydrological model structure; and hydrological model input data, including choice of meteorological datasets and their spatial distribution for baseline simulations. We investigate the relative magnitudes of multiple sources of uncertainty in climate change river flow projections for the Mekong River. Inter-GCM uncertainty is explored using of a set of climate scenarios based on a 2 °C increase in global mean temperature as simulated by seven GCMs. Inter-hydrological model uncertainty is assessed through comparison of river flow projections simulated for the same seven climate change scenarios by three hydrological models: a quasi-physically based MIKE SHE model, a conceptual, semi-distributed SLURP model and the MacPDM.09 global hydrological model. Three sources of input data uncertainty are also investigated using MIKE SHE. Firstly, six models are developed each employing an alternative, but widely used, potential evapotranspiration (PET) method to evaluate the impact of PET method selection. Secondly, uncertainty related to the spatial distribution of meteorological inputs is explored by changing the number of sub-catchments used to distribute precipitation, temperature and PET and by also distributing these inputs on a 0.5° × 0.5° grid. Finally, the impact of using alternative global gridded precipitation datasets (University of Delaware / CRU TS 3.0) for the derivation of baseline data is investigated. Of all the sources of uncertainty, that related to choice of GCM is the greatest. For all three hydrological models, there are considerable differences in scenario discharge between GCMs, ranging from catchment-wide increases or decreases in mean discharge, to spatially varying responses. Inter-GCM differences are largely driven by differences in precipitation. Inter-hydrological model-related uncertainty is notable; it influences the magnitude and temporal distribution of changes through the year, but in most cases the three models simulate the same direction of change in mean discharge. PET method impacts both MIKE SHE calibration parameter values and scenario discharges. The magnitude of change is conditioned by PET method; larger increases or smaller declines result from methods producing the smallest PET increases. Uncertainty in the direction of change in mean discharge due to PET method occurs for scenarios with spatially variable precipitation change, although this is limited to few gauging stations. GCM-related uncertainty for change in mean discharge is on average 3.5 times greater than PET method-related uncertainty. As with PET method-related uncertainty, the uncertainty associated with the spatial distribution of meteorological inputs and use of alternative precipitation datasets is greater for changes in high and low flows, resulting in some differences in the temporal distribution of river flow, whilst uncertainty in projected mean discharge is relatively small.