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Comparison of statistical downscaling methods and their performance in driving hydrological models in climate change study

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Studies of climate change impacts on water resources have been hot topics among hydrologists and meteorologists currently. These studies are commonly done in three steps: (i) simulations of large scale climate scenarios by one or a group of general circulation models (GCMs), (ii) downscaling of large scale climate scenarios into regional or local scale scenarios by using regional-climate models or statistical downscaling techniques, and (iii) the resulting local or regional scale climate data are used to run a selected hydrological model to simulate runoff and other water balance components for a selected catchment or region. This study deals with steps (ii) and (iii) and emphasis will be paid on the rigorous evaluation and comparison of the difference in water balance simulations resulted from using different downscaling techniques, different GCMs, different emission scenarios, and different hydrological models. The study is performed in Hanjiang basin in China. The NCEP/NCAR global reanalysis data are used to calibrate and validate the statistical downscaling techniques, i.e. SSVM (Smooth Support Vector Machine) and SDSM (Statistical Downscaling Model). The A2 scenario from CGCM3 and A2 and B2 scenarios from HadCM3 are selected as background of large-scale climate. The downscaled local scale climate scenarios are used as the input to the Xin-anjiang and HBV hydrological models. Then the simulated runoffs corresponding to various combinations of scenarios, GCMs, downscaling methods, and hydrological models are comprehensively analyzed. The results show that (1) for the same GCM, the simulation results of runoff vary greatly by using precipitation provided by different statistical downscaling techniques as the input to hydrological models; (2) according to the relative error between the simulated and observed runoff, the performance of Xin-anjiang model is more superiority than HBV in responding the climate change impact in this region; (3) by using the same scenario, downscaling technique and hydrological model, CGCM3 is more suitable than HadCM3 to investigate the climate change impact on runoff in this region; (4) although most indictors show SDSM has better performance than SSVM in downscaling precipitation, the runoff simulation efficiency as measured by Nash-Sutcliffe coefficient driven by SDSM rainfall is far lower than by SSVM's; and (5) by comparing different indictors in precipitation and runoff simulation, it can be concluded that Nash-Sutcliffe efficiency between simulated and observed rainfall should be used as a key indicator to evaluate the statistical downscaling models performance.

Keywords: Climate change; statistical downscaling; GCM; hydrological models, Hanjiang basin, China