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Uncertainties of the extreme high flows under climate change impact due to emission scenarios, hydrological models and parameters

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Climate change has exerted a significant impact on the hydrological cycle which is closely related to human's daily life. Due to the fact that the extreme precipitation is happening with increasing frequency and intensity, the study of extreme high flows has been an issue of great importance in recent years.
Normally the future discharges are simulated by hydrological models with outputs from the RCMs. However the uncertainties are involved in every step of the processes, including GCMs, emission scenarios, downscaling methods, hydrological models and etc. In this study, the uncertainties in extreme high flows originating from greenhouse gas emission scenarios, hydrological model structures and their parameters were evaluated for the Jinhua River basin, East China. The baseline (1961-1990) climate and future (2011-2040) climate for scenario A1B, A2 and B2 were downscaled by the PRECIS Regional Climate Model with a spatial resolution of 50km×50km from the General Circulation Model (GCM). The outputs of the PRECIS (daily temperature and daily precipitation) were bias corrected by a distribution based method and a linear correction method. Three hydrological models (GR4J, HBV and Xinanjiang) were applied to simulate the daily discharge. The parameter uncertainty in hydrological models were taken into account and quantified by means of the Generalized Likelihood Uncertainty Estimation (GLUE) method. The GLUE was applied for each hydrological model in three emission scenarios. In total 30000 parameter sets were randomly generated within the parameter ranges, in which about 10% parameter sets were above the pre-assigned threshold and represented as the parameter uncertainty. The annual maximum discharge was used for the extreme high flow analysis.
There was an overestimation for the monthly precipitation in July, August and September and an overestimation of 6.3-7.8 oC for monthly temperature all year round in the PRECIS output. The biases were reduced after bias correction. It is found that the major source of uncertainty is from parameters in hydrological models, followed by the uncertainties from emission scenarios and the hydrological model structures had the smallest uncertainty contribution. The uncertainty intervals become wider as the discharge increased. Compared with the extreme high flows in 1961-1990, those under scenarios A2 and B2 would not change much and there would be a decrease under scenario A1B. As to the uncertainty intervals for different models, sequence of the uncertainty intervals in the extreme high flows from wide to narrow was: HBV, Xinanajing and GR4J. The uncertainties in the extreme high flow assessment cannot be neglected since they could vary from hundreds to thousands cubic millimeters per second contributed by different uncertainty sources. Meanwhile, the uncertainty intervals became larger with an increasing discharge.

Key words: climate change; hydrological models; extreme high flows; parameter uncertainty