Geophysical Research Abstracts
Vol. 18, EGU2016-14398, 2016
EGU General Assembly 2016

Conditioning of Flow Projections under Climate Change on Hydrologic Signatures within the GLUE Framework

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Climate change impact on water resources is generally quantified in terms of relative changes in characteristic flows (e.g. annual runoff, median annual flows, etc.) over a future period compared to the baseline one. These changes are estimated under the assumed emission scenarios and with one or more modelling chains (combinations of the Global and Regional Climate Models, and a hydrological model). Since different modelling chains yield different projections, estimates of these relative changes are uncertain. High prediction uncertainty is reflected in a wide 90 per cent prediction uncertainty band (90PPU) or in a distribution that resembles the uniform distribution. Therefore, research in robustness of the modelling chains has been conducted. The goal of the research is to appoint higher probabilities to the projections obtained by the more robust chains, and in that way reduce the uncertainty in flow projections under climate change.

In this research, the hydrologic projections are conditioned on the hydrologic signatures within the GLUE framework. Namely, a relative change obtained with a modelling chain is assigned a likelihood depending on the performance of the chain in terms of the hydrologic signatures over the baseline period. High flow projections (2nd percentile of the daily flows) are conditioned on the high-segment of the flow duration curve (FDC), projections of the median flows are conditioned on the FDC mid-segment slope, and the projections of the low flows are conditioned on the FDC low-segment. The projections of total annual runoff are conditioned on the entire FDC. The likelihoods are quantified in terms of Nash-Sutcliffe efficiency coefficient (NSE) evaluated from the FDCs of the flows simulated by the modelling chains and the observed FDC.

The methodology presented is applied to develop flow projections in the Kolubara River catchment in Serbia over the mid 21st century (2041-2070). Hydrologic projections are obtained by the HBV-light hydrologic model with input from five climate models (combinations of the Global and Regional Climate Models), all run under A1B emission scenario. The outputs of the climate models are bias-corrected to reproduce distributions of the precipitation depths and temperatures observed in the baseline period (1961-1990). The best twenty parameter sets out 25,000 sampled ones are kept in the analysis, resulting in 100 modelling chains.

The GLUE conditioning did not significantly affect the median values of the projections, but only the width of the prediction bands. All modelling chains perform equally well in terms of the entire FDC and its mid-segment. Therefore, the GLUE-conditioned projections of annual runoff volume and median flows are similar to the unconditioned ones (i.e. GLUE conditioning yields slightly narrower 90PPUs). Model efficiency in the high flow domain differs between the modelling chains: however, the GLUE conditioning leads to somewhat narrower 90PPU. Only few modelling chains performed well in the low flow domain, therefore the width of the 90PPU was considerably reduced by conditioning (from 61.5% to 36.8%).