ROBUSTNESS OF HYDROLOGICAL MODELS FOR SIMULATING IMPACT OF CLIMATE CHANGE ON HIGH AND LOW STREAMFLOW IN THE LESSE

Climate change may increase the frequency and severity of problems due to extreme high and low streamflow. Hydrological models are used to simulate the rainfall-runoff transformation to quantify the impact of climate change on extreme streamflow. However, parameters of hydrological models are optimized for historic conditions and may not be valid for future scenarios.

This study evaluated the robustness of the hydrological models HBV and GR6J for simulating impacts of climate change on high and low streamflow in the Lesse catchment, Belgium. Models are defined to be robust when they do not show notable deterioration in performance under changing climatic conditions. To evaluate this, models were evaluated on historic periods that resemble climatic conditions projected by the KNMI'23 climate scenarios of the Royal Netherlands Meteorological Institute.

To determine periods that resemble future conditions, meteorological indicators were defined that summarize the meteorological conditions leading to high and low streamflow. Based on the expected changes of these meteorological indicators in the future, a set of historic years was selected that resemble future conditions for each KNMI'23 climate scenario.

Both models showed a loss in performance in validation periods that resemble future conditions compared to calibration periods with historic conditions. However, both models still performed acceptable, possibly due to the use of a multi-objective function for calibration. The optimal parameter values of the HBV and GR6J model were proven to be different when calibrated on different periods. This advocates the use of a calibration period that closely resembles future climatic conditions for future climate impact studies.

The median change in annual maximum daily discharge was projected to be between -14% and +27% in 2100 compared to 1991-2020. For low streamflow, the median projected change in annual minimum 7-day mean discharge was between -66% and +13% (Figure 1). These ranges covered uncertainties in climate scenario, model structure and calibration approach. The uncertainty in the projected impact of climate change was mainly due to uncertainty in future greenhouse gas emissions and climate response. However, uncertainty subject to model structures and calibration approaches should not be neglected.

Therefore, it is important that the ability of hydrological models to simulate climate change impacts is not taken for granted. Improving model structures, focusing for example on the simulation of summer peaks, may improve robustness of these models and therefore contribute to a projection of the impact of climate change in the future with less uncertainties.

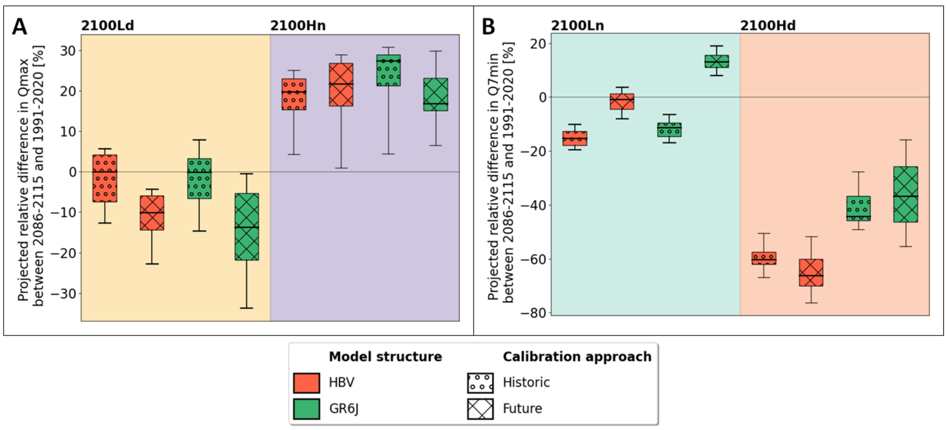

Figure 1: Boxplots of the projected relative difference [%] in (A) annual maximum daily discharge (Q_{max}) and (B) annual minimum 7-day mean discharge ($Q7_{min}$) in 2085-2115 compared to reference period 1991-2020 for combinations of climate scenarios, hydrological model structures and calibration approaches. Dotted and striped boxplots show projections with models calibrated on period 1996-2020 and on periods resembling future conditions, respectively.

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