Uncertainty assessment of rainfall-runoff simulation of the Reno Italy river basin under climate change scenarios

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Introduction

Uncertainty assessment is crucial for rainfall-runoff simulations in a typical watershed. Generally, three major sources of uncertainty are input forcing, model structure, and model parameterization. The uncertainty of hydrological modelling may become more evident when it estimates unseen conditions. For instance, when studying climate change impacts, using climate projections as input for hydrological modelling brings about an inevitable uncertainty in streamflow predictions. This study aims to investigate the uncertainty of future streamflow using a semi-distributed hydrological model in the Reno basin, Italy.

Materials and methods

The upper Reno River Basin in northern Italy was selected as the case study and divided into three sub-basins: (i) 1316 is Pracchia, (ii) 2580 is Vergato, and (iii) 4240 is Casalecchio (Figure 1). The catchment area is 1055 km^2, and its outlet streamflow is measured at the gauge station of Casalecchio di Reno (latitude: 44.47°, longitude: 11.28°).

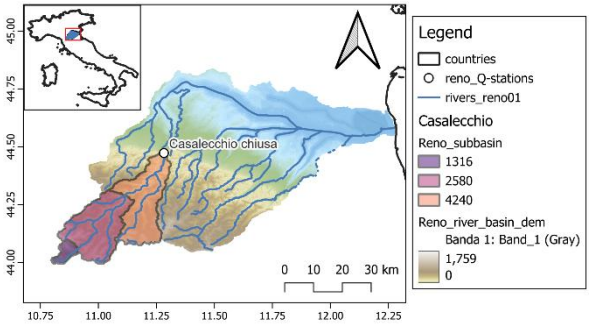

Figure 1. Study area and location of the streamflow gauge station Casalecchio.

For calibrating the hydrological model, high-resolution gridded meteorological data, called the ERG5 dataset (Antolini et al., 2016), was utilized. The 5-km gridded data of daily precipitation and temperature, developed by ARPAe-SIMC, was aggregated and averaged for each sub-basin.

A process-based and semi-distributed Hydrological Predictions for the Environment (HYPE, Lindström et al., 2010) model, which was developed by the Swedish Meteorological and Hydrological Institute (SMHI), was used. The precipitation and temperature of three sub-basins were input data of the HYPE model, while the streamflow measured at the Casalecchio station was considered as output data. The calibration period was between 2001 and 2018, while the data from 2019 to 2022 was used for validation.

The HYPE model achieved high values of the Kling-Gupta Efficiency (KGE) metric for calibration (KGE =0.835) and for validation (KGE= 0.813). Afterwards, the calibrated model simulated 6 future projections for IPCC RCP4.5 and RCP8.5 climate scenarios. Among these projections, 5 of them have coarse resolutions, whereas the CMCC-CM global model (VHR-REA_IT) has a fine resolution, i.e., 2.2 km. So, they were downscaled to a fine resolution, and all projections were aggregated to each sub-basin (Figure 2).

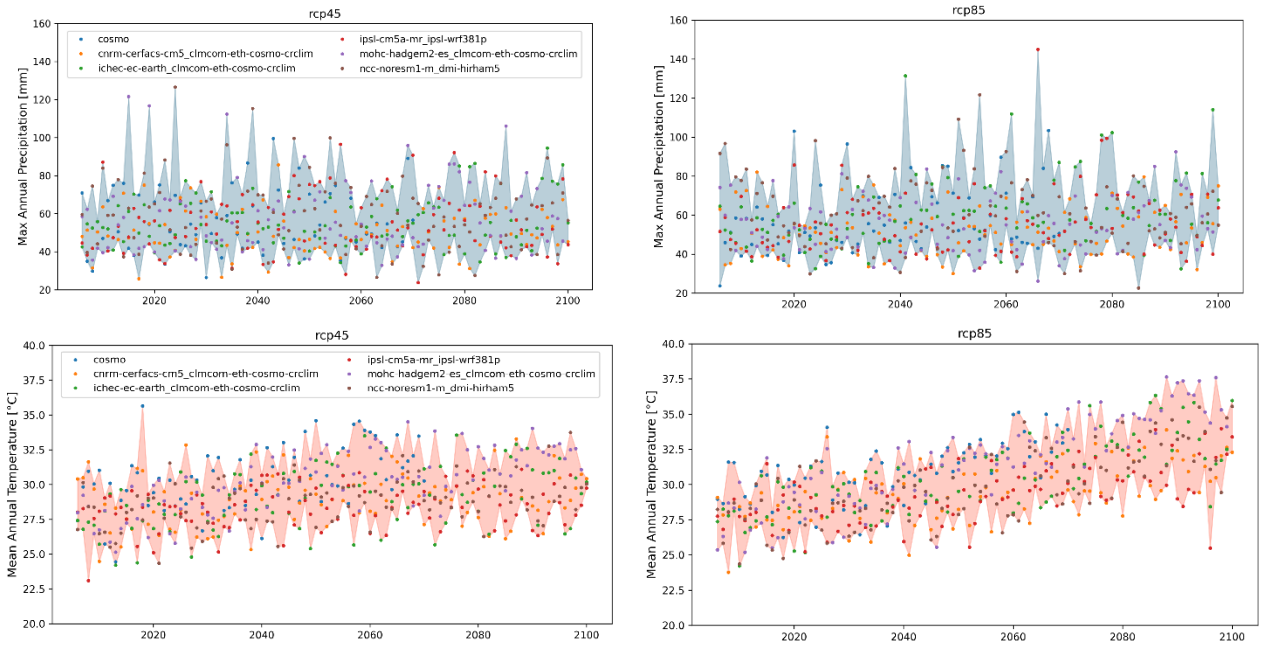

Figure 2. Future projections of maximum annual precipitation and mean annual temperature.

Results and concluding remarks

The maximum annual discharge at the outlet of the basin was obtained from 2006 to 2100 for different future projections (Figure 3). As shown, for both RCP scenarios, all climate models indicate a decrease in the maximum annual discharge in mid-century. Finally, the obtained results revealed that studying the model uncertainty can provide a better understanding of water balance in a typical watershed, particularly when forecasting runoff under climate change scenarios.

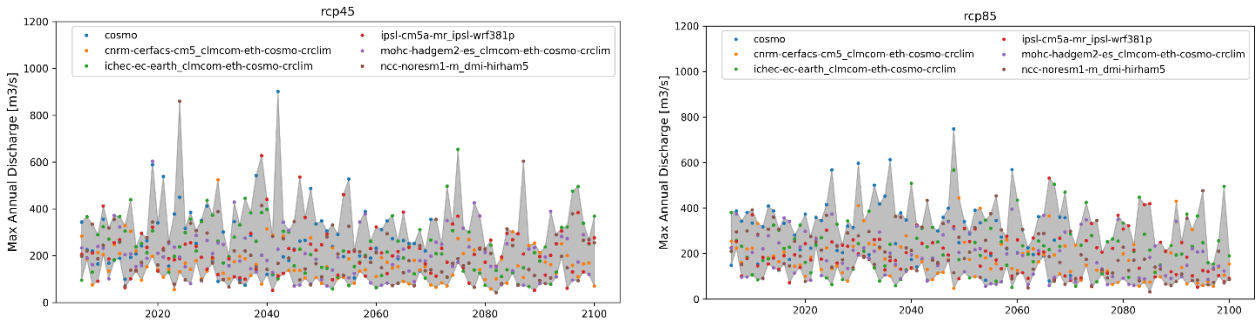

Figure 3. Future projections of maximum annual discharge simulated by the HYPE model.

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References

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