Uncertainty assessment of streamflow drought index of the Reno river basin under climate change scenarios

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Abstract

Climate change can play a vital role in altering patterns of hydroclimatic variables. Investigating the uncertainty in drought assessment under climate changes is crucial for developing adaptation plans in river basins with a productive agriculture sector. This study assesses variations of Streamflow Drought Index (SDI) in the upper Reno basin, in the Emilia-Romagna region in northern Italy under different climate change scenarios. The region, which is an agriculturally productive area, was severely hit by drought in 2022. For hydrological modeling of the study area, a semi-distributed model, named HYdrological Predictions for the Environment (HYPE), is first calibrated using the observed historical data (2001-2022) as the baseline and then utilized to develop future estimations of streamflow under 30 bias-corrected CMIP5 climate scenarios (rcp26, rcp45, and rcp85). The climate scenarios belong to 13 climate models, which originally have different precipitation and temperature biases before bias adjustment. Therefore, a subset of climate models, whose absolute bias in precipitation and temperature is lower than 20% and 2°C, respectively, are identified. This subset includes 3 climate models and a total of 9 climate scenarios. Simulated streamflow under various climate scenarios are exploited to calculate SDI for various temporal scales (1, 3, 6, 9, 12, and 24 months). Considering all 30 climate scenarios, the SDI comparison between near future projections (2026-2045) and the baseline shows a higher increase in the frequency of severe hydrological drought (i.e., SDI<-1.5) than those of severe agricultural and meteorological droughts. Moreover, the average of SDI values forecasted by rcp85 corresponds to 18% and 11% more droughts than those of rcp26 and rcp45, respectively. Furthermore, the SDI ranges obtained for 30 and 9 scenarios were compared, and the analysis demonstrates that removing climate models with high biases reduced the uncertainty of forecasted SDI values by 15%. The findings of this study highlights the importance of considering biases of climate models and how they can influence the uncertainty when forecasting hydroclimatic variables. This research work was carried out as part of the projects TRANSCEND (GA 10108411) and CLIMAAX (GA 101093864).