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Shifting of streamflow timing and seasonality under climate change in the Volta River basin

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Global warming is projected to result in changes in streamflow in West Africa with implications for recurrent droughts and floods in the region. This study assesses changes in the timing of low and high flows under climate change in the poorly gauged and transboundary Volta River basin (VRB) in West Africa. The mean annual minimum (MAM) flow of seven consecutive days is considered as low flow, while high flow is calculated as the annual maximum flow (MAF) corresponding to the highest peak flow in a calendar year. The method of circular statistics is used to estimate the timing of AMF and MAM based on the mean date of occurrence (D), and their seasonality based on the concentration of the dates of occurrence (r). River flow is simulated with the fully distributed mesoscale hydrologic model (mHM), which is thoroughly calibrated using a novel multivariate calibration based on streamflow and satellite data. The mHM model is forced with bias-corrected climate projection datasets consisting of 43 RCM and GCM model combinations from CORDEX-Africa under three representative concentration pathways (RCP2.6, RCP4.5 and RCP8.5). The changes in AMF and MAM are analysed over three future horizons (2021-2050, 2051-2080 and 2071-2100) relative to the historical baseline period (1991-2020).

The results show that the date of occurrence of AMF varies between the calendar days 246 and 252 across the three sub-basins (Black Volta, White Volta, Oti), and it is projected to drop by -2 days over the twenty-first century. A strong seasonality of high flows is observed as r exceeds 0.96 on average and hardly change in the future. The date of occurrence of MAM varies between the calendar days 132 and 139. In contrast to the AMF, there is a forward shift in the date of occurrence of MAM as it is projected to increase on average by +4 to +9 days across sub-basins, and up to + 14 days under RCP8.5, which might be explained by the forward shift of the rainy season. The r of MAM is 0.6 and slightly drops in the future, denoting a higher variation in the seasonality of low flows.