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Quantifying the potential impacts of climate change on streamflow intermittence in Europe

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Even in Europe, rivers and streams cease to flow during some time of the year. Little is known about these intermittent waterways at the continental scale because the spatial distribution of streamflow gauges is biased in favor of perennial river reaches. In our study, undertaken in two phases, we initially employed a two-step Random Forest (RF) modeling approach to predict the monthly time series of streamflow intermittence at a high spatial resolution across approximately 1.5 million European river reaches spanning the period from 1981 to 2019. Important predictors were computed from time series of monthly streamflow in 15 arc-sec (high-resolution HR) cells that were derived by downscaling the 0.5° (low-resolution LR) output of the global hydrological model WaterGAP. To set up the RF model, we utilized daily time series data of observed streamflow from 3706 gauging stations as the target variable, and incorporated a comprehensive set of 23 dynamic and static hydro-environmental variables as predictors. We computed that 3.8% of all European reach-months and 17.2% of all reaches were intermittent during 1981-2019.

In the subsequent phase, we implemented the developed RF model to quantify alterations in streamflow intermittence that may occur due to future climate change. This involved utilizing the bias-adjusted output of five Global Climate Models (GCMs) from the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP3b) and two Representative Concentration Pathway (RCP)-specific runs (ssp126 and ssp585). The reference period spans from 1985 to 2014, with projections for two future periods (2041-2070, 2071-2100).

We downscaled the LR output of WaterGAP runs driven by the different climate model output and recomputed the predictors that depend on WaterGAP output to generate predictor for the climate change impact assessment. Subsequently, we computed the intermittence status (classified as 0, 1-5, 6-15, 16-29, and 30-31 no-flow days in a month) for each reach-month across Europe by applying the developed RF models.

Finally, we established various indicators, such as changes from intermittent to perennial or vice versa, changes in the average annual number of intermittent months or changes in the in the inter-annual variability. Additionally, we incorporated the uncertainty associated with the utilization of five GCMs into our analysis.