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Perturbing the flow duration curve to explore future flow conditions without a hydrological model

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Assessing the robustness of a water resource system to climate change involves exploring a range of streamflow conditions. For this, rainfall-runoff models are routinely to produce future streamflow, using as inputs either climate model projections or modified historical hydro-climatic conditions. However, these models have generally been calibrated and validated under historical conditions, and there is no guarantee that calibrated parameters would still be valid in a different climate. Indeed, recent literature suggests that rainfall-runoff models' predictive skill decreases with changed climatic conditions especially when predicting drier climates. What is more, rainfall-runoff models require time, expertise and input data to calibrate and validate against the historical streamflow record.

With this abstract, we propose an alternative approach based on a near-universal parameterisation of flow duration curves (FDCs), and perturbation of these parameters to simulate a range of futures. Our method represents FDCs with a three-parameter function called the Kosugi model, which has been shown to provide an excellent approximation to FDCs under a wide range of climates. We directly relate these three parameters with three streamflow statistics that are of interest to water resource management: median, coefficient of variation, and first percentile. These values represent central tendency, variability, and low flow characteristics respectively. As a result, a broad range of changes in streamflow can be related to modified parameters, and our method goes through the following steps: (1) Kosugi model parameters are calibrated with a historical FDC, (2) a set of scenarios with modified flow statistics are determined, (3) a new set of coefficients of the Kosugi model are derived for each future scenario, (4) future scenarios are created by using these coefficients.

We apply this method to represent possible climate change impacts on the hydrology of seven headwater basins from different geographical and climatic conditions in Turkey. Preliminary results show that this method provides a dramatically large range of inflows, with increased frequency of high flows and low flows to better represent hydrological variability and extremes. This then supports robustness analyses for rivers for which no detailed hydrological model is available: here, on the financial viability of run-of-river hydropower design in a changing climate. The method supports time series with a large number of no-flow days.