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Observed exacerbation of the European water-budget deficit during multi-year droughts

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In Mediterranean climates, prolonged droughts lead to a significant shift in the precipitation -runoff relationship, usually in the direction of proportionally less precipitation allocated to runoff compared to wet periods. This shift may impact discharge predictions, as many hydrological and land surface models assume that hydrological processes are stationary even under a significant change of the climate (i.e., multi-year droughts) and are generally calibrated with more weight on discharge peaks than low flows.

Here, we investigate whether multi-year droughts result in a change in the precipitation-runoff relationship over continental European climates (which has never been fully explored before). 30-year records of annual rainfall and runoff from a dataset (>200) of small- and medium-scale (150 to 10000 km2) European catchments were used to test the existence of statistical shifts in the precipitation–runoff relationship. This was achieved by fitting a multivariate regression across annual cumulative full-natural flow, basin-wide annual precipitation, and a categorical variable denoting multi-year drought and non-drought years.

Results demonstrate that multi-year droughts cause a shift in the precipitation–runoff relationship regardless of predominant climate , with the magnitude of this shift ranging between 20 and 80%. We explore mechanisms of these shifts and potential explanatory factors, including catchment properties and characteristics.

Understanding changes in the precipitation-runoff relationship is paramount to make models and water resource management more robust to droughts, especially in a warming and more variable climate.