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Geostatistical prediction of flow-duration curves in an index-flow framework

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An empirical period-of-record Flow-Duration Curve (FDC) describes the percentage of time (duration) in which a given streamflow was equaled or exceeded over an historical period of time. FDCs have always attracted a great deal of interest in engineering applications because of their ability to provide a simple yet comprehensive graphical view of the overall historical variability of streamflows in a river basin, from floods to low-flows. Nevertheless, in many practical applications one has to construct FDC in basins that are ungauged or where very few observations are available. We present in this study an application strategy of Topological kriging (or Top-kriging), which makes the geostatistical procedure capable of predicting flow-duration curves (FDCs) in ungauged catchments. Previous applications of Top-kriging mainly focused on the prediction of point streamflow indices (e.g. flood quantiles, low-flow indices, etc.). In this study Top-kriging is used to predict FDCs in ungauged sites as a weighted average of standardised empirical FDCs through the traditional linear-weighting scheme of kriging methods. Our study focuses on the prediction of FDCs for 18 unregulated catchments located in Central Italy, for which daily streamflow series with length from 5 to 40 years are available, together with information on climate referring to the same time-span of each daily streamflow sequence. Empirical FDCs are standardised by a reference index-flow value (i.e. mean annual flow, or mean annual precipitation times the catchment drainage area) and the overall deviation of the curves from this reference value is then used for expressing the hydrological similarity between catchments and for deriving the geostatistical weights. We performed an extensive leave-one-out cross-validation to quantify the accuracy of the proposed technique, and to compare it to traditional regionalisation models that were recently developed for the same study region. The cross-validation points out that Top-kriging is a reliable approach for predicting FDCs with Nash & Sutcliffe Efficiency measures ranging from 0.85 to 0.96, depending on the model settings, very low biases over the entire duration range, and an enhanced representation of the low-flow regime.