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Implementation of a multivariate regional index-flood model

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A multivariate flood frequency approach is required to obtain appropriate estimates of the design flood associated to a given return period, as the nature of floods is multivariate. A regional frequency analysis is usually conducted to procure estimates or reduce the corresponding uncertainty when no information is available at ungauged sites or a short record is observed at gauged sites. In the present study a multivariate regional methodology based on the index-flood model is presented, seeking to enrich and complete the existing methods by i) considering more general two-parameter copulas for simulating synthetic homogeneous regions to test homogeneity; ii) using the latest definitions of bivariate return periods for quantile estimation; and iii) applying recent procedures for the selection of a subset of bivariate design events from the wider quantile curves. A complete description of the selection processes of both marginal distributions and copula is also included. The proposed methodology provides an entire procedure focused on its practical application.

The proposed methodology was applied to a case study located in the Ebro basin in the north of Spain. Series of annual maximum flow peaks (Q) and their associated hydrograph volumes (V) were selected as flood variables. The initial region was divided into two homogeneous sub-regions by a cluster analysis and a multivariate homogeneity test. The Gumbel and Generalised Extreme Value distributions were selected as marginal distributions to fit the two flood variables. The BB1 copula was found to be the best regional copula for characterising the dependence relation between variables. The OR bivariate joint return period related to the (non-exceedance) probability of the event$\{Q \leq q \wedge V \leq v\}$was considered for quantile estimation. The index flood was based on the mean of the flood variables. Multiple linear regressions were used to estimate the index flood at ungauged sites. Basin concentration time, drainage basin area and mean annual precipitation were found as meaningful variables. As result, quantile curves in the $Q - V$ space can be obtained at any given ungauged target site. A reduced subset of events in the resulting quantile curves was delimited procuring useful information to practitioners, while allowing flexibility in the decision-making process to estimate the design flood for a given return period.