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Multivariate regional frequency analysis in hydrology: application to dam safety

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At-site flood estimates show a large uncertainty, as observed flood series are usually short. Regionalization procedures use the available information in a set of nearby catchments where the frequency distribution is assumed to be similar to improve flood estimates. Many studies have dealt with univariate regionalization of flood peaks. However, very few studies have dealt with multivariate regionalization because of its complexity. Nevertheless, a multivariate analysis of floods is required when additional information about the flood hydrograph is needed apart from the flood peak, such as in the case of dams, where a complete hydrograph is required to know the maximum water level reached in the reservoir. A multivariate regional study provides at-site flood estimates with a reduced uncertainty, but also flood estimates at ungauged sites, where no observations are available. In this talk, I will present a complete procedure to conduct a bivariate regional analysis that extends the univariate index-flood to the bivariate case. The procedure selects the multivariate regional distribution composed of the marginal distributions of each variable involved in the study and the copula that best characterizes the dependence between them. As a result, regional quantile curves for given return periods are provided. A quantile curve shows a set of hydrographs with different combinations of peak flow and hydrograph volume that have the same probability of occurrence. The procedure is divided into four steps: (i) screening the observed data to find outliers and discordant sites; (ii) identification of homogeneous regions by a multivariate homogeneity test; (iii) selection of the multivariate regional distribution; and (iv) estimation of flood quantiles and selection of design events. The methodology will be applied to a case study located in the Ebro River catchment in Spain. In addition, the application of copulas to dam safety and design will be presented. In this case, the probability of dam overtopping is given by the maximum water level reached in the reservoir. Consequently, the so-called routed return period will be obtained sorting the inflow hydrographs in terms of their maximum water level reached during reservoir routing.

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