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Extension of flood series by joining hydro-meteorological and bivariate copula-based models

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Accurate flood estimates associated with high return periods are required for both dam design and flood risk management, for what a long observed flood series would be needed. Though, short flood series are usually available in practice. Synthetic longer flood series can be generated via well-established hydro-meteorological models that simulate the catchment response, yet a long computational time is needed. In addition, statistical models based on distribution functions that fit the observed data, generating large synthetic flood series that satisfy the properties of the initial sample are also used, where the copula-based approach is currently spreading in hydrology. However, a large uncertainty is involved in selecting and fitting marginal and copula functions when short flood series are employed as input. This study seeks to combine the benefits of both hydro-meteorological modelling and copulas in order to obtain a long synthetic flood series, characterised by peak flows and hydrograph volumes. First, a limited flood series is generated by the hydro-meteorological model calibrated with observed data. Then, the simulated flood series is substantially extended by fitting a bivariate copula-based distribution to such synthetic flood series. The shortest required length of the flood series generated by the hydro-meteorological model is selected based on a trade-off between the computation time of the hydro-meteorological model and the uncertainty of the copula-based model estimates. The hydro-meteorological model considered in this study consists of the RainSim stochastic rainfall generator and the Real-time Interactive Basin Simulator (RIBS) rainfall-runoff model. Bivariate copulas such as the Clayton, Frank, Gumbel, Galambos, Plackett and BB1 copula are considered for characterising the dependence structure of the data.

The application of the methodology to a case study located in the centre of Spain is presented. It is concluded that a minimum length of 525 years should be simulated from the

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hydrometeorological model when using a distribution based on the BB1 copula, which is the copula that best characterises the peak-volume dependence structure. As a result, the proposed methodology cuts down the computation time needed, generating an extended sample formed by the limited 525-year-length simulated sample and a larger sample synthetically generated from the bivariate copula-based distribution.

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Keywords: flood frequency analysis, synthetic flood series generation, rainfall-runoff models, bivariate copulas.

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