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A simple approach for stochastic generation of spatial rainfall patterns

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The high floods occurred in the last years in many regions of the world have increased the interest of local, national and international authorities on the flood and risk assessment. In this context, the estimation of the design flood to be adopted represents a crucial factor, mainly for ungauged or poorly gauged catchments where sufficiently long discharge time series are missing. Due to the wider availability of rainfall data, rainfall-runoff models represent a possible tool to reduce the relevant uncertainty involved in the flood frequency analysis. Recently, new methodologies based on the stochastic generation of rainfall and temperature data have been proposed. The inferred information can be used as input for a continuous hydrological model to generate a synthetic time series of discharge and, hence, the flood frequency distribution at a given site. As far as the rainfall generation is concerned, for catchments of limited size, a single site model, as the Neyman-Scott Rectangular Pulses (NSRP), can be applied. It is characterized by a flexible structure in which the model parameters are broadly related to the underlying physical features observed in the rainfall field and the statistical properties of rainfall time series over a range of time scales are preserved. However, when larger catchments are considered, an extension into the two-dimensional space is required. This issue can be addressed by using the Spatial-Temporal Neyman-Scott Rectangular Pulses (STNSRP) model that, however, is not easy to be applied and requires a high computational effort. Therefore, simple techniques to obtain a spatial rainfall pattern starting from the more simple single-site NSRP are welcome.

In this study, in order to take account of the spatial correlation that is needed when spatial rainfall patterns should be generated, the practical method of the rank correlation proposed by Iman and Conover (IC), was applied. The method is able to introduce a desired level of correlation between data, keeping its simplicity in the application. Moreover the method can be used for all types of input probability distribution and it allows the marginal distributions to remain intact. The IC method was applied to hourly and daily rainfall time series. In the second case, a temporal disaggregation technique has been carried out to obtain the hourly data.

To test the proposed methodology, rainfall data from one catchment located in the Upper Tiber River Basin was considered. At first, long stochastic rainfall time series were generated through the NSRP model for several sites, then the IC method was applied to generate spatially correlated rainfall time series. The main statistics of these time series were compared both with the observed data and with ones generated by using the more complex STNSRP model. In particular, results were expressed in terms of depth-duration-frequency (DDF) curves obtained for the areal mean rainfall that are of upmost importance for the design flood estimation. The high performance shown by the IC approach in reproducing the observed data along with its simplicity of application make it a valuable tool for the estimation of spatial rainfall patterns.