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Importance of heavy-tailed distributions and multi-day aggregation to improve the performance of stochastic weather generators in Mediterranean catchments

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Mediterranean catchments present a long history of devastating floods as a consequence of what is called in Spain "gota fría". These extraordinary events bring huge amounts of precipitation over short periods of time (2-3 days) during the autumn months. The physical complexity of these events with high temporal and spatial variability along with the limited length of the precipitation data series available, make for the stochastic weather generators very complicated to reproduce these meteorological phenomena. This study intends to be a contribution in this sense, comparing the performance of two daily multi-site stochastic weather generators with different approaches in a Spanish Mediterranean catchment. The observed precipitation and temperature data series used were obtained from SPAIN02_v4 (a set of daily observational interpolated data in a regular 0.1º grid) using a control period of 37 years (1961-2007). The area of study selected was La Rambla de la Viuda, a 1522 km2 Mediterranean catchment located in the east of Spain.
The daily multi-site stochastic weather generators employed were MULGETS and EXARGWEX. Both models follow the Wilks approach, where precipitation occurrence and amounts are handled separately. However, while MULGETS fits the simulated precipitation amounts to light-tailed distributions (Multi-Gamma or Multi-Exponential), EXARGWEX applies a heavy-tailed distribution (E-GDP). Furthermore, an extended version of EXARGWEX simulates precipitation at a 3-day scale, to then disaggregate it to a daily scale using a method of fragments. For both weather generators, all necessary parameters for occurrence, intensity and spatial and temporal correlations were estimated for the observed data. Then, 1000 years of daily precipitation and temperature were generated with MULGETS and with the extended version of EXARGWEX.
Firstly, in the case of the precipitation, the daily and the accumulated amounts over 3-day annual maxima were calculated for both the observed data and the two simulations. In order to analyse the results, the empirical distribution functions were calculated for each case and compared. In the case of MULGETS, the Multi-Gamma distribution was shown to reproduce better the annual maximum precipitation and, therefore, the Multi-Exponential fit was dismissed. Even though, these extremes were better reproduced by EXARGWEX, demonstrating that the use of heavy-tailed distributions improve its performance. With regards to the amounts of precipitation fallen over 3-day periods, MULGETS clearly underestimated them, being less appreciable for low values of precipitation amounts and more remarked for higher values. On the other hand, EXARGWEX showed a better performance reproducing this, although still underestimating the higher values.
Lastly, the three series of precipitation and temperature (observed and the two generated) were used as the input for a distributed hydrological model called TETIS. In terms of discharges, the differences between the observed and simulated flows were reduced when using the precipitation generated with EXARGWEX. In particular, the 3-day aggregation contributed to a better representation of the initial soil moisture for the day of higher precipitations.