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A process-based flood frequency analysis using a weather generator and distributed hydrological modelling in a Spanish Mediterranean catchment: the Segura River basin

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In the context of a Flood Risk Management Plan (FRMP), flood frequency analysis is of paramount importance to obtain high return period flood quantiles. However, these estimations still present high uncertainty as a result of the short temporal length of the maximum available flow records; the data recording errors (principally on large floods); the high variance and asymmetry of the maximum flows; the hypothesis considered to evaluate the initial soil moisture conditions and the spatio-temporal variability of storms; the extended use of the iso-frequency hypothesis, among others. One of the prominent approaches to deal with these issues is the use of process-based flood frequency analysis. This way the main hydrological processes are considered at the same time that better information on extreme rainfall and historical floods can be incorporated. In this article, a weather generator (GWEX) and a distributed hydrological model (TETIS) are integrated in a cascade modelling approach, expanding the information to support the frequency analysis in a case study: the Segura River basin (Murcia, Spain) with 14,000 km2. Specifically, the methodology consists of the following steps: a) a regional study of annual maximum daily rainfall; b) Calibration of the WG on a daily scale and generation of a long daily precipitation series (5,000 years); c) Extreme storm selection (698) and temporal disaggregation into sub-daily scale (hourly); d) calibration and validation of hydrological model and simulation of selected synthetic storms with the hourly temporal resolution and a spatial resolution of 200 m; e) flood frequency estimation considering synthetic annual maximum instantaneous floods.

Finally, the methodology was validated with six historical catastrophic flood events since 1825. According to the results, the last major flood in September 2019 in the “Rambla de Abanilla” (one of the main tributaries to the flood prone area via flash flood processes) would correspond with an event with a low probability of flooding (around a 400-year return period). But the rainfall event generating it has an assigned return period ranging from 10 to 1000 years, depending on the geographical point or rain gauge considered in the Abanilla sub-catchment. This result shows that the classical approach of iso-frequency is not feasible to use in this kind of catchments. Using this methodology, it was possible to estimate the effect of the introduction of flood risk mitigation measures via scenario modelling. In this same tributary, the proposed reforestation in the FRMP will reduce the high frequency quantiles in a 10% and the structural measures a 65% the 100-year quantile. Finally, based on the results obtained, it is possible to move towards an analysis of the

efficiency of the measures and to support scientifically sound decision making.