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On the calibration of point process models for preserving extreme rainfall statistics at hourly and sub-hourly timescales

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Clustered point process-based models have been widely used to generate long-term rainfall time series at a range of timescales for hydrological applications. This type of model represents the temporal rainfall process in a realistic yet simple way, such that the hierarchical structure of rainfall is explicitly incorporated and several parameters have a physical interpretation. Although these models have shown to well reproduce 'standard' statistics (e.g. mean, variance, autocorrelations and so on) at hourly and daily timescales, they have some known deficiencies which are yet to be overcome. These mainly include the incapacity to reproduce standard statistics of sub-hourly rainfall and to preserve extreme rainfall statistics at hourly and sub hourly timescales.

To tackle the first deficiency mentioned above, Kaczmarska et al. (2014) proposed the BLRPRx model, which is an extension of the original random parameter Bartlett-Lewis rectangular pulse model (BLRPR) (Rodriguez-Iturbe et al., 1988; Onof and Wheater, 1993). This new model adjusts the structure of the original BLRPR model by allowing mean rain cell intensity to vary in proportion to the cell duration parameter. In addition, it introduces higher-order moments (i.e. skewness) to the model calibration process. These changes have proven to be effective in reproducing standard statistics at sub-hourly timescales. However, underestimation of the extreme statistics of sub-hourly and hourly rainfall time series still persists.

In this work, based upon the BLRPRx model, we draw attention to the the way of estimating the selected statistics from data during model calibration. In particular, we show the impact upon model performance of concatenating the monthly data from all years into a single time series and calculating the selected statistics from it rather than using the statistics of monthly data from separate years and then obtaining their mean. As expected, this change has a significant impact on the estimation of the fine-scale skewness and, in turn, upon extreme statistics. Five-minute rainfall time series data from a total of 6 rain gauges in Germany (one with 69 years of data; others with 49 years) are used to test the impact of the proposed change. Results show that this change can largely improve BLRPRx's ability to preserve extreme rainfall statistics at sub-hourly and hourly timescales. In addition, our analyses suggest that the inclusion of higher-order statistical moments (e.g. skewness coefficient) into model calibration is the most critical factor for the model to well preserve extreme statistics. However, this improvement in preserving extreme statistics comes at a cost. That is, the proposed change increases the 'difficulty' in model calibration and therefore slightly degrades BLRPRx's performance in reproducing standard statistics. This suggests that the current BLRPRx model structure does not provide sufficient flexibility to preserve all the standard and the extreme statistics at once.