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On Stochastic Models for Fine-Scale Rainfall Based on Doubly Stochastic Poisson Processes

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Abstract : Much of the research on stochastic point process models for rainfall has focused on Poisson cluster models constructed from either the Neyman-Scott or Bartlett-Lewis processes. The doubly stochastic Poisson process provides a rich class of point process models, especially for fine-scale rainfall modelling. This paper provides an account of recent development on this topic and presents the results based on some of the fine-scale rainfall models constructed from this class of stochastic point processes. Amongst the literature on stochastic models for rainfall, greater emphasis has been placed on modelling rainfall data recorded at hourly or daily aggregation levels. Stochastic models for sub-hourly rainfall are equally important, as there is a need to reproduce rainfall time series at fine temporal resolutions in some hydrological applications. For example, the study of climate change impacts on hydrology and water management initiatives requires the availability of data at fine temporal resolutions. One approach to generating such rainfall data relies on the combination of an hourly stochastic rainfall simulator, together with a disaggregator making use of downscaling techniques. Recent work on this topic adopted a different approach by developing specialist stochastic point process models for fine-scale rainfall aimed at generating synthetic precipitation time series directly from the proposed stochastic model. One strand of this approach focused on developing a class of doubly stochastic Poisson process (DSPP) models for fine-scale rainfall to analyse data collected in the form of rainfall bucket tip time series. In this context, the arrival pattern of rain gauge bucket tip times N(t) is viewed as a DSPP whose rate of occurrence varies according to an unobserved finite state irreducible Markov process X(t). Since the likelihood function of this process can be obtained, by conditioning on the underlying Markov process X(t), the models were fitted with maximum likelihood methods. The proposed models were applied directly to the raw data collected by tipping-bucket rain gauges, thus avoiding the need to convert tip-times to rainfall depths prior to fitting the models. One advantage of this approach was that the use of maximum likelihood methods enables a more straightforward estimation of parameter uncertainty and comparison of sub-models of interest. Another strand of this approach employed the DSPP model for the arrivals of rain cells and attached a pulse or a cluster of pulses to each rain cell. Different mechanisms for the pattern of the pulse process were used to construct variants of this model. We present the results of these models when they were fitted to hourly and sub-hourly rainfall data. The results of our analysis suggest that the proposed class of stochastic models is capable of reproducing the fine-scale structure of the rainfall process, and hence provides a useful tool in hydrological modelling.

Keywords : fine-scale rainfall, maximum likelihood, point process, stochastic model
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