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A stochastic disaggregation algorithm for analysis of change in the sub-daily extreme rainfall

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The statistical characteristics of local extreme rainfall, particularly at shorter durations, are among the key design parameters for urban storm water collection systems. Recent observations have provided sufficient evidence that the ongoing climate change alters form, pattern, intensity and frequency of precipitation across various temporal and spatial scales. Quantifying and predicting the resulted changes in the extremes, however, remains as a challenging problem, especially for local and shorter duration events. Most importantly, climate models are still unable to produce the extreme rainfall events at global and regional scales. In addition, current simulations of climate models are at much coarser temporal and spatial resolutions than can be readily used in local design applications. Spatial and temporal downscaling methods, therefore, are necessary to bring the climate model simulations into finer scales. To tackle the temporal downscaling problem, we propose a stochastic algorithm, based on the novel notion of Rainfall Distribution Functions (RDFs), to disaggregate the daily rainfall into hourly estimates. In brief, RDFs describe how the historical daily rainfall totals are distributed into hourly segments. By having a set of RDFs, an empirical probability distribution function can be constructed to describe the proportions of daily cumulative rainfall at each hourly time step. These hour-by-hour empirical distribution functions can be used for random generation of hourly rainfall given total daily values. We used this algorithm for disaggregating the daily spring and summer rainfalls in the city of Saskatoon, Saskatchewan, Canada and tested the performance of the disaggregation with respect to reproduction of extremes. In particular, the Intensity-Duration-Frequency (IDF) curves generated based on both historical and reconstructed extremes are compared. The proposed disaggregation scheme is further plugged into an existing daily rainfall generator to provide a fully stochastic spatiotemporal framework for downscaling Global Climate Models' (GCMs) outputs. Using future simulations of HadCM3 and CGCM, provided through CMIP5 portal, we realized large ensembles of hourly rainfall for the city of Saskatoon throughout the whole 21st century. The chance of alteration in the extreme rainfall intensities at different durations and return periods are then investigated and discussed.