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Statistical Downscaling of Sub-Daily Extreme Rainfall Processes for Urban Water Management in the Context of Climate Change

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Extreme rainfall for a given duration and for a selected return period is often required for the planning and design of various urban water systems. For a site for which sufficient rainfall data are available, a frequency analysis of annual maximum rainfalls can be performed. A great deal of effort during the past three decades has been directed toward the search for the best statistical approach that could provide the most accurate estimation of the extreme rainfall of interest. Several probability models have been developed to describe the distribution of extreme rainfalls at a single site (Nguyen, 2009). Unfortunately, these models are accurate only for the specific time frame associated with the data used. It has necessitated the need for formulating models that could statistically and simultaneously matches various properties of the rainfall process at different levels of aggregations. The most important practical implication of such models is that, from a higher aggregation model we could infer the statistical properties of the process at the finer resolutions that may not have been observed. Another major advantage of such procedure involves the parsimonious parameterisation since these models would normally require a much smaller number of parameters, while traditional models need different sets of parameters for each particular time scale of the rainfall series considered. In particular, Nguyen et al. (2002) has proposed a scaling General Extreme Value (GEV) distribution that can be used to estimate extreme rainfalls for a given return period at a local site for sub-daily time scales (hourly, 30 minutes, etc.) from statistical properties of extreme rainfalls at a daily scale.

Recently, climate change has been recognized as having a profound impact on the hydrologic cycle at different temporal and spatial scales. In addition, General Circulation Models (GCMs) have been recognized to be able to represent reasonably well the main features of the global distribution of basic climate parameters, but outputs from these models are usually at resolution that is too coarse (generally greater than 200km) for many impact studies. Hence, different downscaling methods have been used for downscaling GCM predictions of climate change to hydrologic processes at appropriate space and time scales for hydrological impact studies (Nguyen et al., 2006). Of particular importance for the estimation of design rainfalls for small watersheds are those procedures dealing with the linkage of the large-scale climate variability to the historical observations of the sub-daily rainfall extremes at a local site. If this linkage could be established, then the projected change of climate conditions given by a GCM could be used to predict the resulting change of the local extreme precipitation characteristics (Nguyen et al., 2010).

In this paper, a review of some recent progress in the modelling of extreme rainfall process is presented from both theoretical and practical viewpoints (based on the recent work by an international expert committee to prepare the Extreme-Value Analysis Chapter for the World Meteorological Organization's Guide to Hydrological Practices). In particular, the main topic of this paper is focused on recent methods for estimating extreme rainfalls at a single site using the "scale-invariance" concept and within the context of a changing climate. Examples of various numerical applications using extreme rainfall data from Canada and in other countries will be presented to illustrate the feasibility and accuracy of these methods.

References

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