On Modeling of Extreme Rainfall Process for Evaluating the Climate Change Impacts on Hydrological Regime

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In recent years, it has been recognized that society has become more vulnerable to extreme weather and climate events. Continuing population growth, land use changes, and industrial development will further increase vulnerability by creating more potential for catastrophic impacts from climate extremes such as severe flooding or drought events with large loss of human life, excessive economic losses, and uncertain long-term consequences to ecosystems. In view of these important issues, many studies have been carried out to investigate the variation in extreme climatic events. Of particular interest for water management are the investigations of precipitation change that have revealed some empirical evidence of the increase trends in precipitation extremes over many regions of the world. Hence, it is essential to know whether the past extremes could be well extrapolated into the future under changing climate conditions. In other words, it is important to understand not only the current patterns of extreme rainfalls but also how they are likely to change in the future.

Furthermore, General Circulation Models (GCMs) have been recognized to be able to represent reasonably well the main features of the global distribution of some basic climate parameters, but outputs from these models are usually at resolution that is too coarse (generally greater than 200km) for many hydrological impact studies at the regional or local scale. Consequently, different downscaling methods have been proposed to describe the linkage of the large-scale climate variability to the historical observations of the precipitation process at a local site. Of particular importance for the estimation of extreme 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.

In view of the above-mentioned issues, the overall objective of the present study is to propose new methods for modeling extreme precipitation events over a wide range of space and time scales in order to be able to assess the impacts of climate variability and change on hydrological regime at the catchment unit. More

specifically, a detailed statistical analysis of extreme rainfall data available from a network of 15 raingages in Quebec (Canada) has revealed that, according to the L-moment ratio diagrams, these data may be well described by the Generalized-Extreme-Value (GEV) distribution. In addition, this analysis has indicated that a simple scaling relationship between extreme rainfall non-central moments (NCM) and duration can be established. Hence, the scaling General Extreme Value (GEV) distribution 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. Finally, the potential impacts of climate change on extreme rainfalls were assessed using the popular Statistical Downscaling Model SDSM. The changes in the distribution of annual maximum (AM) precipitations were evaluated using simulations from the Canadian GCM (CGCM3) and the UK Hadley Centre GCM (HadCM3) under the A2 climate change scenarios. It was found that AM precipitations downscaled from CGCM3 show a strong increasing trend for future periods, while those AM values downscaled from HadCM3 show a mild decreasing trend.

Keywords: extreme rainfall process, statistical downscaling, scaling Generalized Extreme Value distribution, climate change, general circulation models, climate scenarios.