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A Spatial-Temporal Approach for the Construction of Intensity-Duration-Frequency Curves for Annual Maximum Precipitation with Climate Change Scenarios Simulated by Global Circulation Model Applied to Quebec Region (Canada)

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Requirement for the Intensity-Duration-Frequency (IDF) curves for annual maximum (AM) precipitation for future periods with impact of climate change has become critical for the assessment of impact of climate change in many applications such as urban hydrology, infrastructure design, flood control. There have been several methods developed for the construction of IDF curves with impact of climate change, some for flood and some for precipitations. Most of them are focused on the description of change in parameters of an underlying distribution that is used to describe the data. Change in parameters with time is fitted to a regression, linear or non-linear form. These methods, however, are developed based on observed data for current period and assume the regressions are stationary to extend the application for future; or some of the methods apply results from GCMs simulation to introduce change in climate simulated by GCMs into their models but they do not show whether the GCMs output for current period are well comparable to observed condition for current period before applying GCMs simulation to observe changes in future. This paper presents a spatial-temporal approach to construct IDF curves for AM precipitation. The approach is a two-step procedure which combines statistical downscaling method to temporal downscaling technique using the generalized extreme values (GEV) distribution for AM precipitation. The approach also introduces the use of a second-order non-linear regression to compensate residuals produced by the statistical downscaling model to improve the accuracy of the estimates. Results from the application shows that AM daily precipitation spatially downscaled from HadCM3A2 predictors is the most comparable to observed AM daily precipitation compared to those downscaled from other GCMs predictors. The HadCM3A2-downscaled AM daily precipitation for current period after adjusted by a second-order non-linear regression became very well fitted to observed data. This suggests the use of predictors simulated under HadCM3A2 scenarios to downscale AM daily precipitation for current and future periods, and the use of HadCM3A2-downscaled AM precipitation for current period as a reference for assessment of change in AM daily precipitation for future periods under HadCM3A2 scenarios. Beside, the temporal downscaling technique proved to

be able to estimate AM precipitation for sub-daily durations and to construct IDF curves for AM precipitation from AM daily precipitation very comparable to observed ones. The spatial-temporal approach was applied to produce IDF curves of AM precipitation at many sites in the Quebec region for current period and future periods of 2020s, 2050s, and 2080s. Investigation on the difference in AM precipitations for current period from those for future periods suggests certain changes in the IDF curves. Results show that at Dorval, for instance, AM precipitations for 2020s almost similar to those for current period, those for 2050s and 2080s decrease. At McGill, for example, AM 5-min and daily precipitations for the period of 2020s tend to increase in values for short return periods but decrease in values for long return periods; AM 5-min and daily precipitations for the period of 2050s are greater than, but those for the period of 2080s are less than those for current period. As to AM precipitations (at McGill) for other durations, those for the period of 2020s are a little bit higher while those for the period of 2050s are clearly higher, and those for the period of 2080s are less than those for current period. This approach provides an image of good agreement between IDF curves for local AM precipitation downscaled from global HadCM3A2 predictors and those observed for the current period. The approach was successful tested using data at many rain gauge stations in Quebec region.