A comparison of methods for updating IDF curves in the Toronto and Essex Regions

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RESEARCH SUMMARY

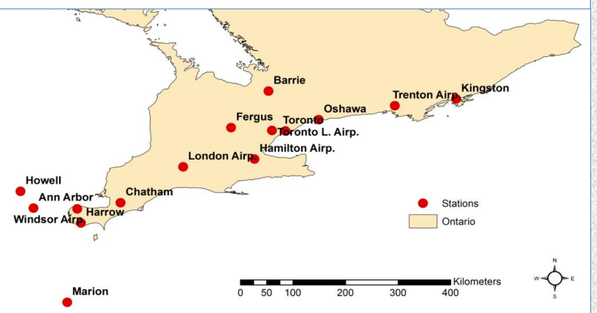
The objectives of this study include:

(i) Review and compare the most robust techniques for updating IDF curves,
(ii) Apply selected techniques for updating IDF curves to the Toronto and Essex regions, and
(iii) Analyze and compare the selected technique results.

A comparative screening of different probability distribution functions was conducted, and this led to the selection of the generalized extreme value distribution (GEV) as the best fit probability distribution function to use. Three time periods, the 2050s, 2070s and 2100s were evaluated, and future rainfall intensities were established with return periods ranging from 2 to 100 years and storm durations from 15 min to 24 hours. Results predicted significant changes in the design storms and varied significantly between the different scenarios studied.

STUDY AREA

15 weather stations were selected from Ontario, Michigan and Ohio to generate the IDF curves. The locations of the selected stations are shown on the map below.



APPLICATION TO INDUSTRY

IDF curves are used in the design of urban drainage systems, dam design, etc. Currently, IDF curves are based on historical rainfall data, which excludes the notion of climate change (CC). Therefore, finding the most fundamental approaches to update IDF curves that accounts for CC is essential, or else municipalities face the risk of infrastructure failure.

METHODOLOGY

Selection of Stations → Several stations were first considered for data analysis, however only 15 were selected to generate the IDF curves. Those were the stations with the longest data record. Stations with the least number of missing records were also considered, along with stations that had data exceeding the year 2000.

Fitting Probability Distribution Functions to Observed Data → After utilizing a combination of different goodness of fit tests, GEV was selected as the best fit distribution function.

Climate Model Selection → Three regional climate models (CRCM3, CanRCM4, HRCM3) and two global climate models (HadGEM2 and MIROC-ESM) were used, along with three emission scenarios (RCP4.5, RCP8.5 and SRES A2).

Downscaling Methods Selection

The delta change (DC) approach and a quantile-based bias correction (BC) method were selected for downscaling. In the DC approach, the projected design storm, I_p, can be expressed in **Eq. (1)**.

$$I_p = I_0 \frac{I_f}{I_c} \qquad \textbf{Eq. (1)}$$

The BC method used here is adopted from Samuel et al [1]. First, the GEV distribution is fitted to the observed and current model maximum annual intensities. Then the CDF of the GEV distribution fitted to the current model data is mapped to the CDF of the observed data.

The bias corrected maximum annual rainfall intensity for the year k2 was calculated by substituting the fitted GEV CDFs into **Eq. (2)**.

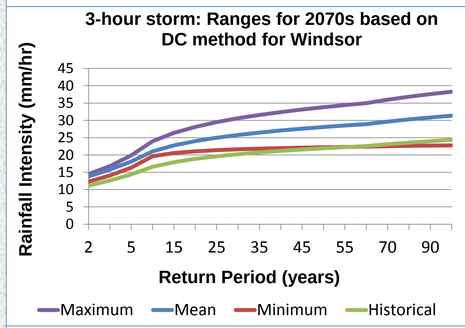
$$I_{f\_bc(k2)} = F_{Io}^{-1}(F_{If(k2)}) \qquad \textbf{Eq. (2)}$$

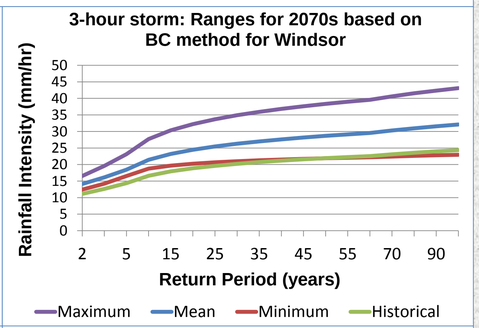
Development of IDF Curves → Generated IDF curves for current and future periods. Future periods include the 2050s (2026-2045), 2070s (2038-2070) and 2100s (2081-2100).

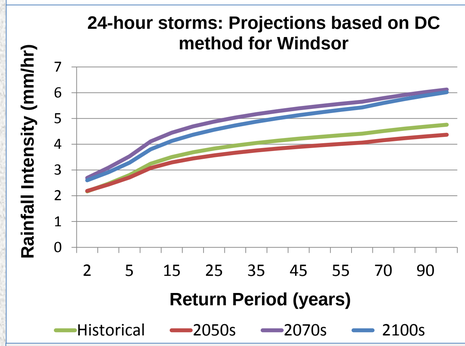
Comparative Analysis → Performed comparative analysis of all models' results for updating IDF curves.

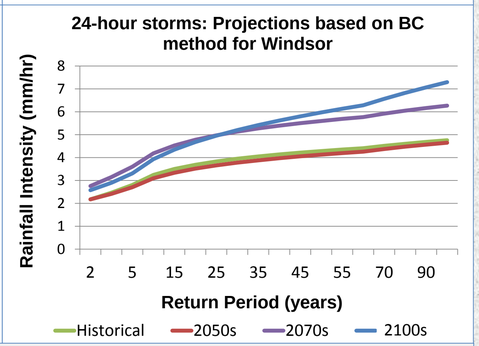
RESULTS

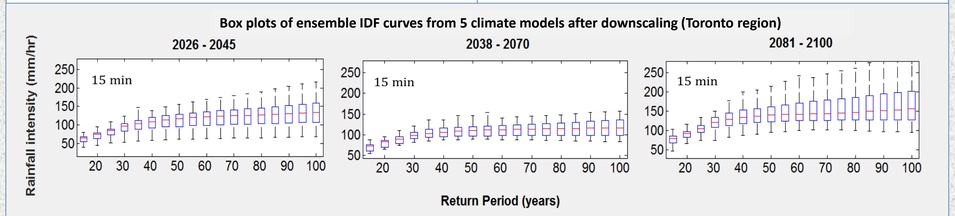
- For the 2050s, change in the projected design storm was mostly negative (decreased) and not very significant (roughly between -10% to +10%).
- For the 2070s and 2100s, most of the stations showed a striking increase in the projected design storms.











- Based on the results of this study, design storms established from historical rainfall data should withstand up to the next two decades.
- However, for infrastructures with a long lifetime (more than 2 decades), the estimation of the design storm should take into account the projected CC scenarios, particularly when the return period considered exceeds 10 years.
- Most historical IDF curves in the study area were established using EV1 distribution, which in this study appeared to be the worst distribution [2].

References

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