A Web-Based Intensity-Duration Frequency Tool to Update and Adapt Local Extreme Rainfall Statistics to Climate Change

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INTRODUCTION
Climate change and IDF

- Increase in global temperature
- Change in frequency and intensity of extreme events
- Municipalities
  - Risk of flooding
  - Water supply
  - Urban drainage
- IDF tool research and development path
  - UTRCA 2007 (5,500 downloads)
  - City of London 2011 (5,000 downloads)
  - CWN 2013 (knowledge implementation)
  - [www.idf-cc-uwo.ca](http://www.idf-cc-uwo.ca) public tool March 2015
    - 729 registered users
    - 7,600 sessions/year (400-750/month)
    - 764 EC stations 132 user created stations
    - developed with participation of stakeholders
    - evaluated using survey of March 2016 – 150/370 respondents

- IDF curves: Frequency of extreme events for a variety of return periods and intensities
- Based on assumption of stationarity
- Major reasons for increased demand for rainfall IDF information is climate change
- Updating IDF curves highly technical - municipalities may lack resources

**3 | INTRODUCTION**

**IDF_CC tool**

<table>
<thead>
<tr>
<th>Extreme Rainfall Event</th>
<th>Total Rainfall Amount (mm)</th>
<th>Duration (hr)</th>
<th>1 Hr Max. Intensity (mm/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peterborough (Trent U), July 14-15, 2004</td>
<td>250.0</td>
<td>16.5</td>
<td>87.2</td>
</tr>
<tr>
<td>Toronto (Finch Ave), August 19, 2005</td>
<td>153.4</td>
<td>12.5</td>
<td>116.6</td>
</tr>
<tr>
<td>Hamilton (Stoney Creek), July 25-26, 2009</td>
<td>135.5</td>
<td>35.0</td>
<td>60.8</td>
</tr>
<tr>
<td>Mississauga (Cooksville), August 4, 2009</td>
<td>68.0</td>
<td>1.0</td>
<td>68.0</td>
</tr>
<tr>
<td>Westcentral GTA (Pearson), July 8, 2013</td>
<td>126.0</td>
<td>3.0</td>
<td>96.0</td>
</tr>
<tr>
<td>Hurricane Hazel, 15 October, 1954</td>
<td>285.0</td>
<td>48.0</td>
<td>52.5</td>
</tr>
<tr>
<td>100 Year Design Storm</td>
<td>118.0</td>
<td>24.0</td>
<td>50.0</td>
</tr>
</tbody>
</table>
Methodology

- Choice of climate input (Quantile Regression Skill Score Method)
  - Selection of GCM model
  - Selection of RCP
  - Selection of model run
- Downscaling (Equidistant Quantile Matching Algorithm)
  - Spatial downscaling
  - Temporal downscaling
IDF_CC TOOL OVERVIEW

Methodology

Data Distribution Features

Temporal Features (bias)

GCM

Historical

GCM

Historical
IDF_CC TOOL OVERVIEW

Methodology

[Image of a chart showing model evaluation metrics]
Methodology

1. Historical Observed Sub-daily data
2. GCM Daily Gridded Data
3. GCM Future Daily Gridded Data

Step i: Spatial downscaling

Step ii: Temporal downscaling

Step iii: Updating IDF

Updated IDF
Methodology

Sub-Daily Maximum

Historical

GCM-Baseline

GCM-Future

Daily Maximum

Maximum Precipitation

\[ X^{STN, future} = a_1 \times \left[ \frac{X^{GCM, future} - b_2}{a_2} \right] + b_1 \]
IDF_CC TOOL OVERVIEW

Implementation

User Interface

Mathematical Models

Database and NetCDF Repository
• Database:
  • IDF repository from Environment Canada (700 stations)
  • User provided stations and data
  • Global climate models information and netCDF File repository (24 GCMs; RCP2.5, RCP4.5, RCP8.5; multiple GCM runs)

• User interface:
  • Google maps
  • Data manipulation
  • Results visualization (tables, equations, interactive graphs)

• Models:
  • Statistical analysis algorithms (Gumbel, GEV distributions using Method of Moments)
  • GCM skill score algorithm (the quantile regression skill score – QRSS)
  • IDF update algorithm (the equidistant quantile matching – EQM)
  • Optimization model
Displaying map
- Read user information (account, home location, etc)
- Read and display user created stations
- Read and display information from Environmental Canada

Steps for IDF generation for historical period
1. Read and organize data from the database for the selected Station
2. Data analysis (ignore negative and zero values) and extraction of yearly maximums
3. Calculate statistical distribution parameters (Gumbel and GEV)
4. Calculate IDF
5. Fit IDF equation using optimization (Differential Evolution)
6. Organize data for display (tables, plots, and equations)
IDF_CC TOOL OVERVIEW
Implementation

IDF for historical period

Steps to generate IDF for future period
7. Read the selected GCM model
8. Extract data series from GCM grid points for the selected Station (i.e. using Canadian model: 80 series)
9. Organize series and extract yearly maximums
10. Apply quantile matching algorithm
11. Calculate distribution parameters and IDFs for each future scenario (RCPs and its ensembles)
12. Generate one average IDF from results in step 11
13. Fit equation by optimization for the average IDF from step 12
14. Organize data for display (tables, plots, and equations, uncertainty range plot)
User Manual

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Water Resources Research Report

Computerized Tool for the Development of
Intensity-Duration-Frequency Curves under a
Changing Climate

Users Manual v.1.1

By:
Andre Schardong
Roshan K. Srivastav
and
Slobodan P. Simonovic

Report No: 088
Date: February 2015

Technical Manual

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Methodology:

Overview of tool and methods:

CDN regional analysis:

DSS engagement practices:
IDF_CC TOOL FUTURE

Needs of the practice

- **Input**
  - Workshops and presentations
  - Direct questions by the users
  - Survey (March 2016 – year after the tool release)

- **Issues**
  - Continuous support and maintenance
  - Validation and standardization
  - Uncertainty analysis
  - Ungauged sites
Continuous support and maintenance

- ICLR
- Modest annual budget
- Necessary expertise
Validation and standardization

- Comparison with other available tools (very limited)
- User evaluations
- PEI (Transportation, Infrastructure, and Energy Dept) example:
  "The impact of climate change is to be considered in the planning and design of new subdivisions and developments to prevent any flood related damages to structures and properties. This approach requires the use of future climate data instead of historical data in the design of stormwater systems, as historical data does not represent future climate anymore and it may underestimate climate risk and its impact. Future climate data can be generated or obtained using available resources and studies, the University of Western-Ontario IDF CC Tool is one of these resources and it is recommended for generating future rainfall data. However, if consultant/engineer prefers other resources or specific global climate models to generate rainfall data, TIE will review the proposed information and advise if it coincides with the recommended tool. The Tool can be found at: www.idf-cc-uwo.ca. To generate future data from IDF CC Tool, using an ensemble of all models is recommended to avoid variability in data generated from individual models. Also, future data should be generated based on RCP 4.5 and RCP 8.5 scenarios."
IDF_CC TOOL FUTURE
Uncertainty analysis
Ungauged sites

Precipitation (mm)

- High: 180
- Low: 30

CanESM2 RCP4.5
Year 2100
24 hr 100 year
Ungauged sites

CanESM2  RCP4.5
Year 2100
24 hr 100 year
Ungauged sites

- Development of a gridded short duration maximum precipitation dataset for the Canadian landmass
  - Methodology for historical data
  - 10 km grid
  - Mean annual precipitation, maximum annual precipitation, and mean annual convective available potential energy - regression with 24, 12, 6, 2, 1 hour, 30, 15, 10, 5 minute precipitation
  - Linear Regression (LR), Quantile Regression (QR) and Generalized Additive Model (GAM)
  - Evaluations based on RMSE, precipitation distribution and trend
  - Tested using 526 stations
  - *Climate Dynamics* - under review

Implementation with climate change projections
www.slobodansimonovic.com

Research → FIDS → Projects