Mapping extreme rainfall statistics for Canada under climate change using updated Intensity-Duration-Frequency curves

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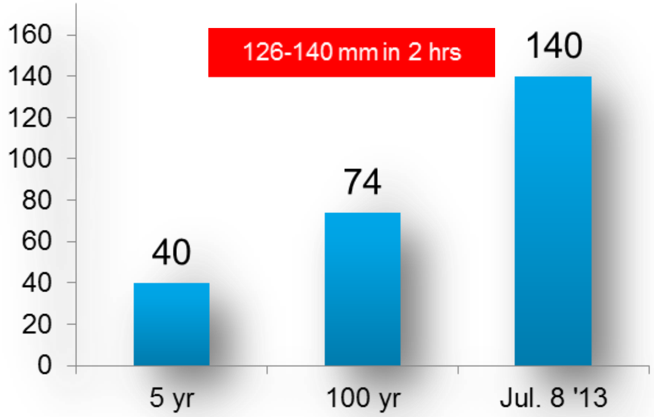
INTRODUCTION
Presentation outline

- Introduction
- Methods
  - IDF_CC tool
  - Mapping methodology
- Analyses
  - to illustrate the use of IDF_CC tool in mapping IDF curve relationships in space;
  - to show spatial variation in extreme precipitation across Canada
  - to show the spatial variation in IDF curve change across Canada Results
- Discussion

- Research team
  - Slobodan P. Simonovic
  - Andre Schardong
  - Dan Sandink


Toronto, ON, Canada, July 2013

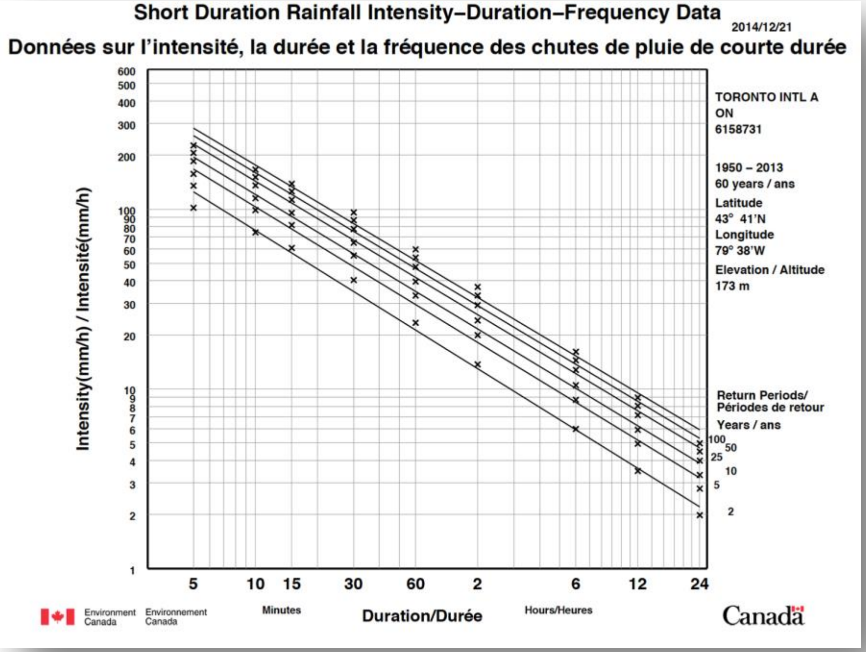


INTRODUCTION
Climate change impacts in Canada

- Current impacts of climate change in Canada
  - Decrease in cold events while warm events continue to increase
  - The annual frequency of cold nights has decreased and the annual frequency of warm days has increased at most locations in Canada with much stronger warming trends in the Canadian Arctic
  - No consistent change in extreme precipitation (precipitation totals changing between -10% and 35%)
  - Across Canada, heavy precipitation has been increasing since 1950 but the patterns have not been spatially uniform.
- Future impacts
  - By the middle of the century all of Canada is projected to warm by roughly 1.5 to 2.5°C in the summer
  - Average wintertime temperatures are projected to increase by ~3 to 7°C towards the end of the century
  - One-in-20-year extreme hot day would become a one-in-5 year
  - Future rainfall predictions vary significantly among climate models. Increases in precipitation are projected for the majority of Canada
  - One-in-20-year extreme daily precipitation event would become a one-in-10 year event by mid-century

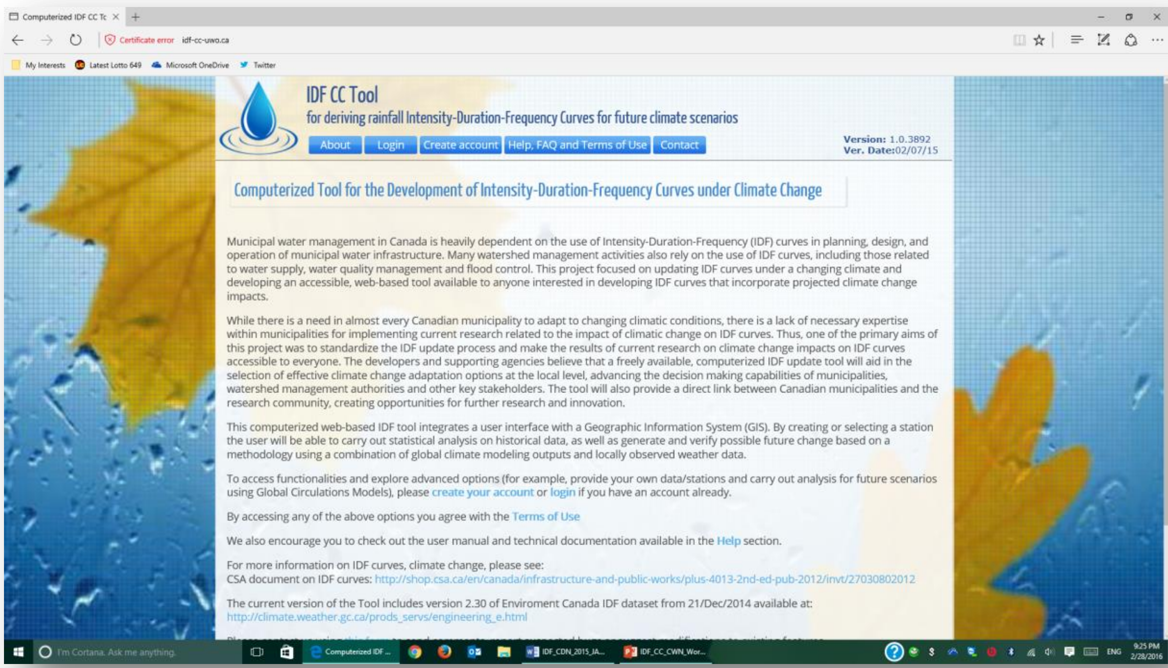
3| INTRODUCTION
IDF_CC tool

- IDF curves: Frequency of extreme events for a variety of return periods and intensities
- Based on assumption of stationarity
- Updating IDF curves highly technical, municipalities may lack resources
- Based on work with the City of London, and IBC MRAT tool



5 | METHODS
IDF_CC tool

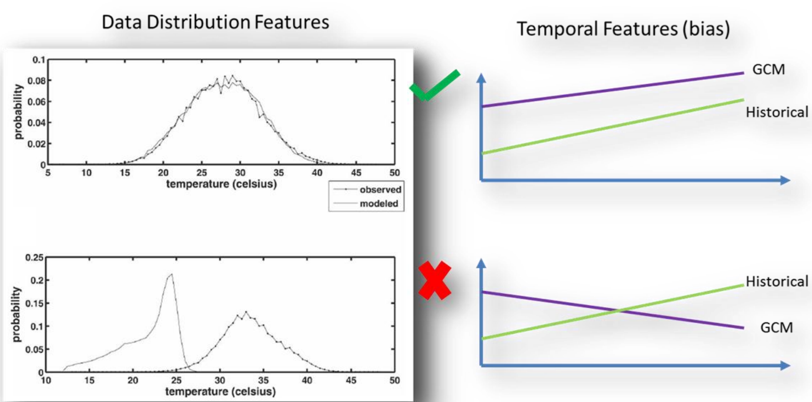
- Knowledge transfer project supported by CWN
  - Developed the generalized methodology for updating IDF curves under climate change
  - Engagement of potential users
  - Implemented web based tool https://www.idf-cc-uwo.ca
- Over 430 registered users
  - Dominant interest of consulting community
  - Serious consideration for mandating the use of the tool (PEI government)

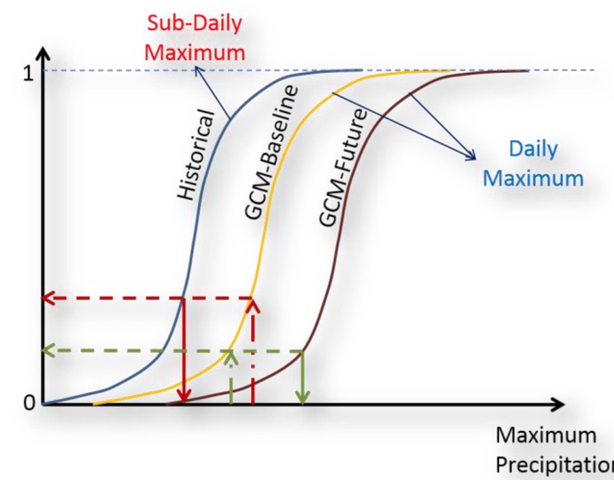


6| METHODS

IDF_CC tool

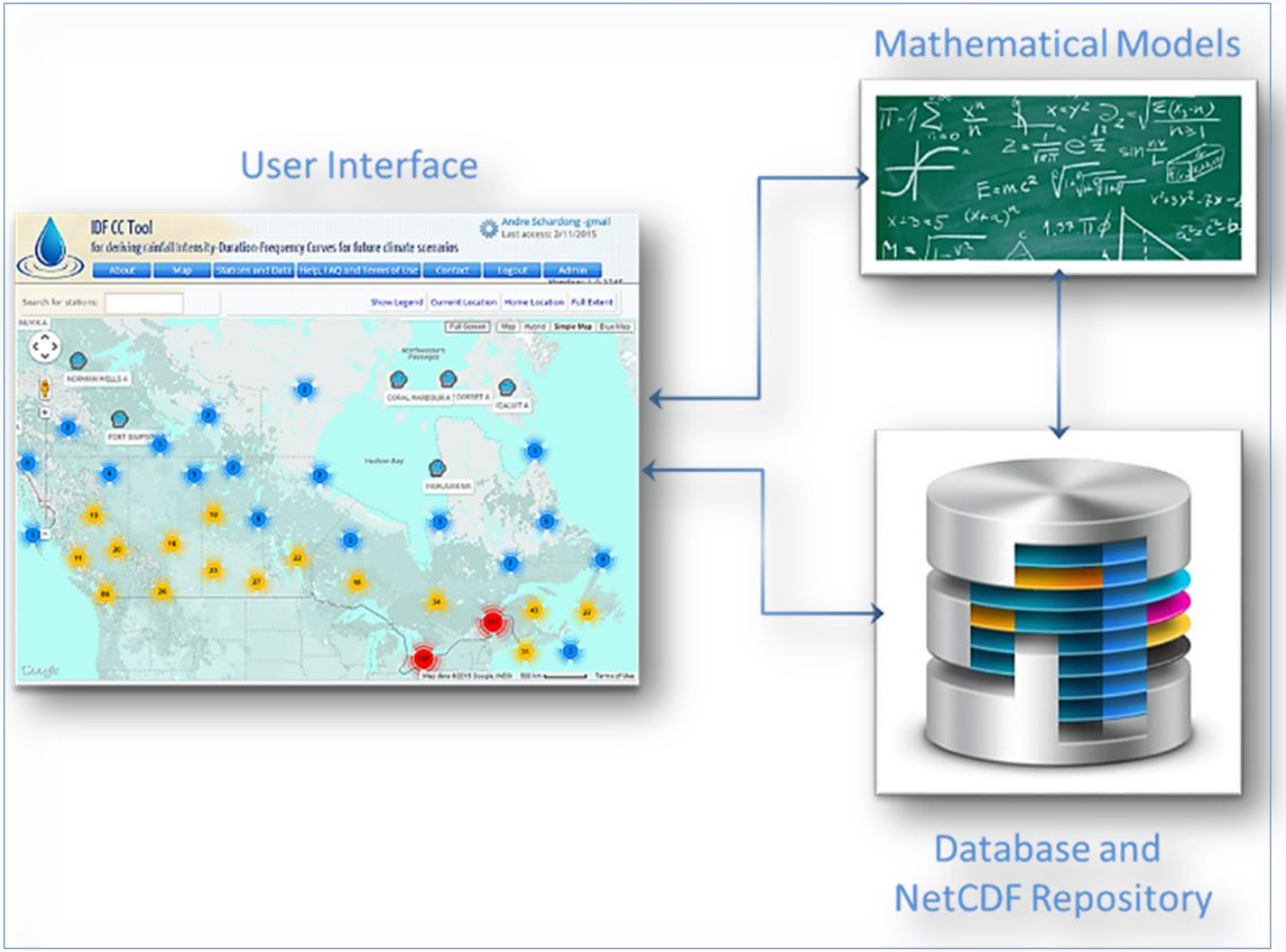
- Choice of climate input (Quantile Regression Skill Score Method)
  - Selection of GCM model
  - Selection of RCP
  - Selection of model run
- Downscaling (Equidistant Quantile Matching Algorithm)
  - Spatial downscaling
  - Temporal downscaling





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

7| # METHODS
IDF_CC tool

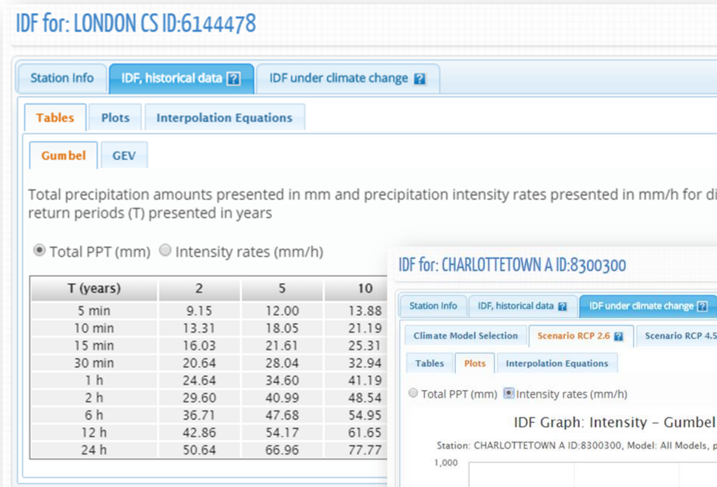


METHODS

IDF_CC tool

- Database:
  - IDF repository from Environment Canada (700 stations – Dec 2014)
  - User provided stations and data
  - Global climate models information and netCDF File repository (22 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 distribution)
  - GCM skill score algorithm (the quantile regression skill score - QRSS)
  - IDF update algorithm (the equidistant quantile matching – EQM)
  - Optimization model

METHODS
IDF_CC tool



IDF for: LONDON CS ID:6144478

Station Info | IDF, historical data | IDF under climate change

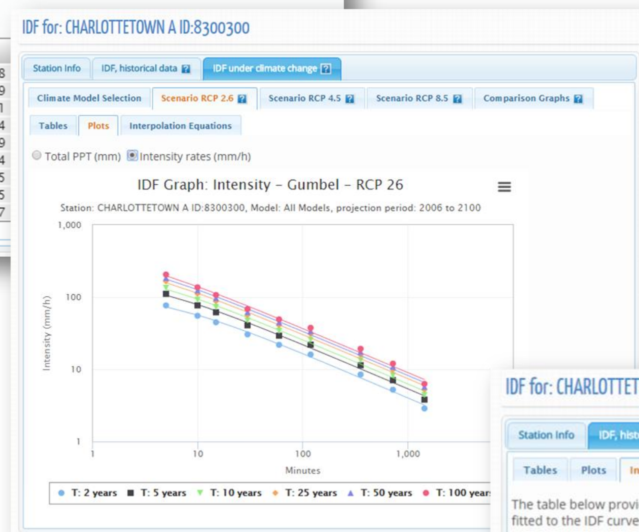
Tables | Plots | Interpolation Equations

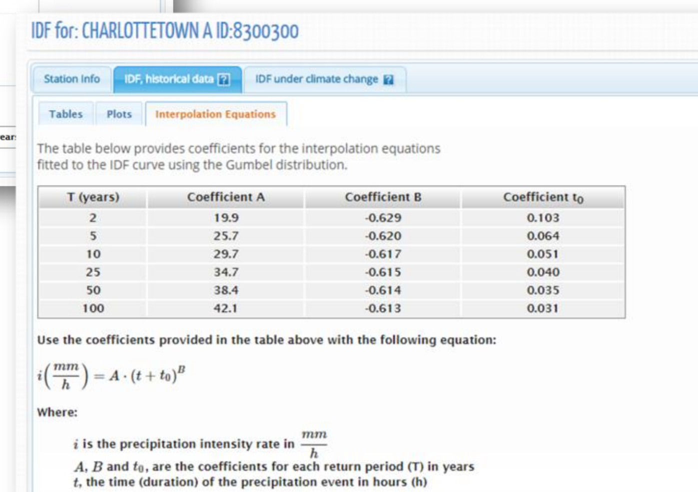
Gumbel | GEV

Total precipitation amounts presented in mm and precipitation intensity rates presented in mm/h for di[...] return periods (T) presented in years

Total PPT (mm) | Intensity rates (mm/h)

T (years)	2	5	10
5 min	9.15	12.00	13.88
10 min	13.31	18.05	21.19
15 min	16.03	21.61	25.31
30 min	20.64	28.04	32.94
1 h	24.64	34.60	41.19
2 h	29.60	40.99	48.54
6 h	36.71	47.68	54.95
12 h	42.86	54.17	61.65
24 h	50.64	66.96	77.77





IDF for: CHARLOTTETOWN A ID:8300300

Station Info | IDF, historical data | IDF under climate change

Tables | Plots | Interpolation Equations

The table below provides coefficients for the interpolation equations fitted to the IDF curve using the Gumbel distribution.

T (years)	Coefficient A	Coefficient B	Coefficient t_0
2	19.9	-0.629	0.103
5	25.7	-0.620	0.064
10	29.7	-0.617	0.051
25	34.7	-0.615	0.040
50	38.4	-0.614	0.035
100	42.1	-0.613	0.031

Use the coefficients provided in the table above with the following equation:

$$i\left(\frac{mm}{h}\right) = A \cdot (t + t_0)^B$$

Where:

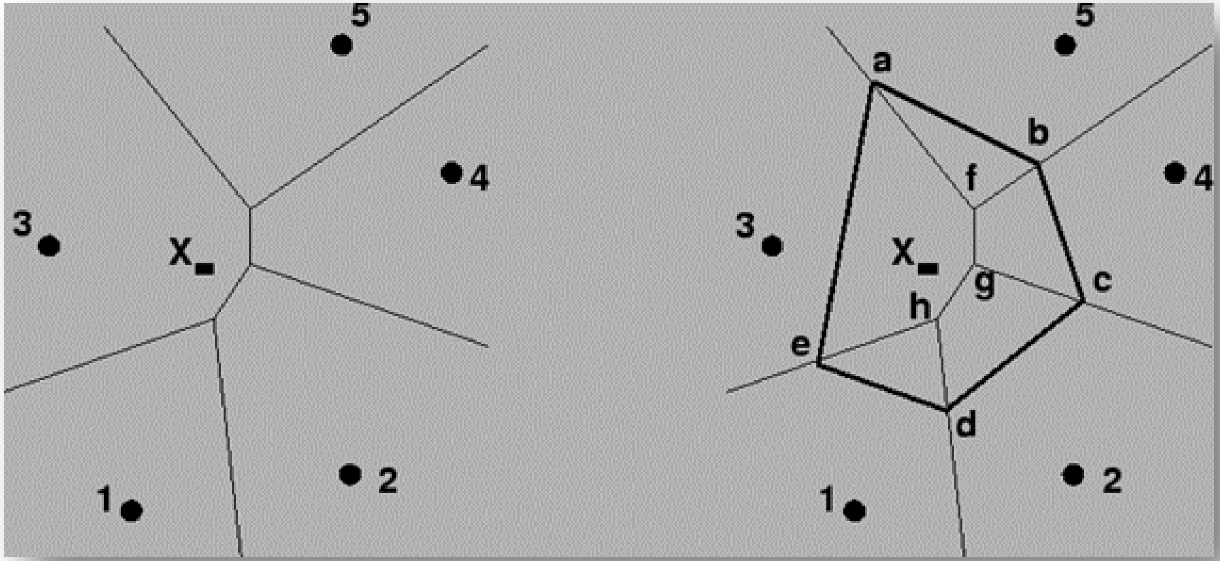
i is the precipitation intensity rate in $\frac{mm}{h}$

A, B and t_0, are the coefficients for each return period (T) in years

t, the time (duration) of the precipitation event in hours (h)

METHODS
Mapping methodology

- Station IDF_CC curves
- Spatial interpolation using Natural Neighbor Algorithm

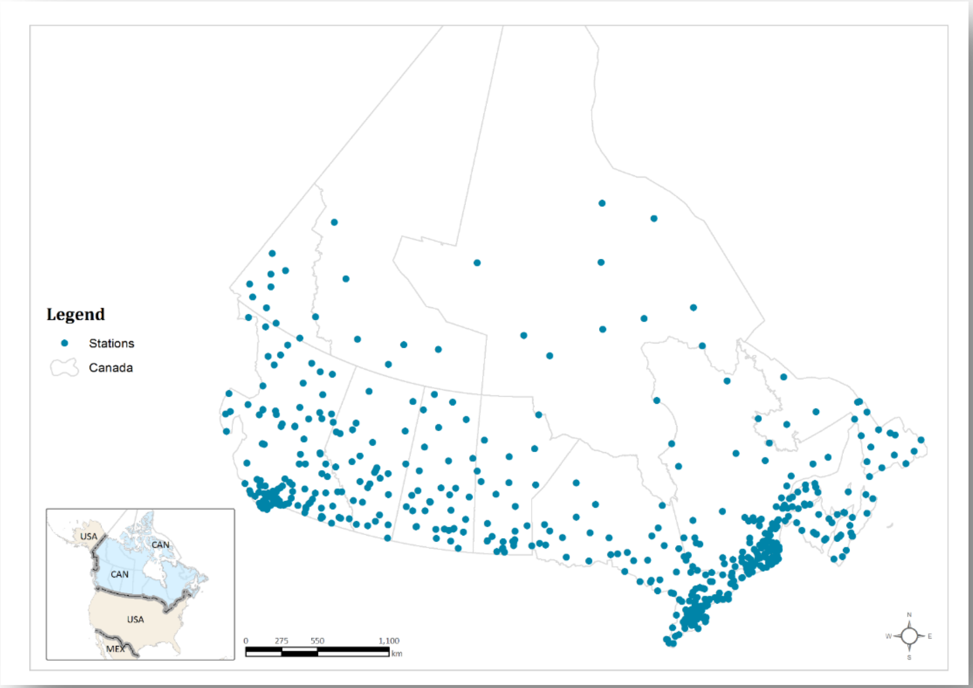


11 | ANALYSES

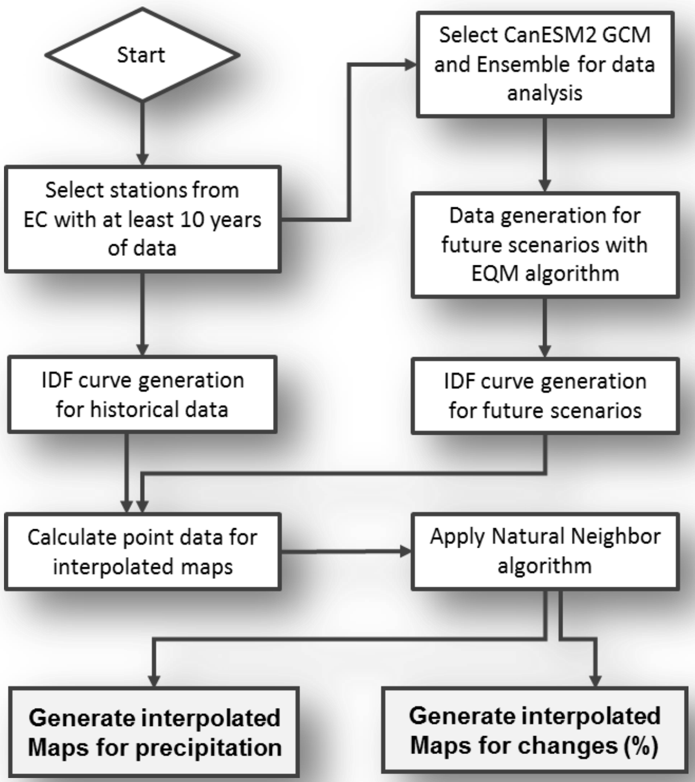
Objectives and scope

- To illustrate the use of IDF_CC tool in mapping IDF curve relationships in space;
- To show spatial variation in extreme precipitation across Canada for selected durations, return periods and GCMs; and
- To show the spatial variation in IDF curve change across Canada for selected durations, return periods and GCMs.
- Two criteria
  - municipal drainage practices (2 hr duration and 5 year return period) and
  - flood risk management (24 hr duration and 100 year return period)

ANALYSES
Objectives and scope



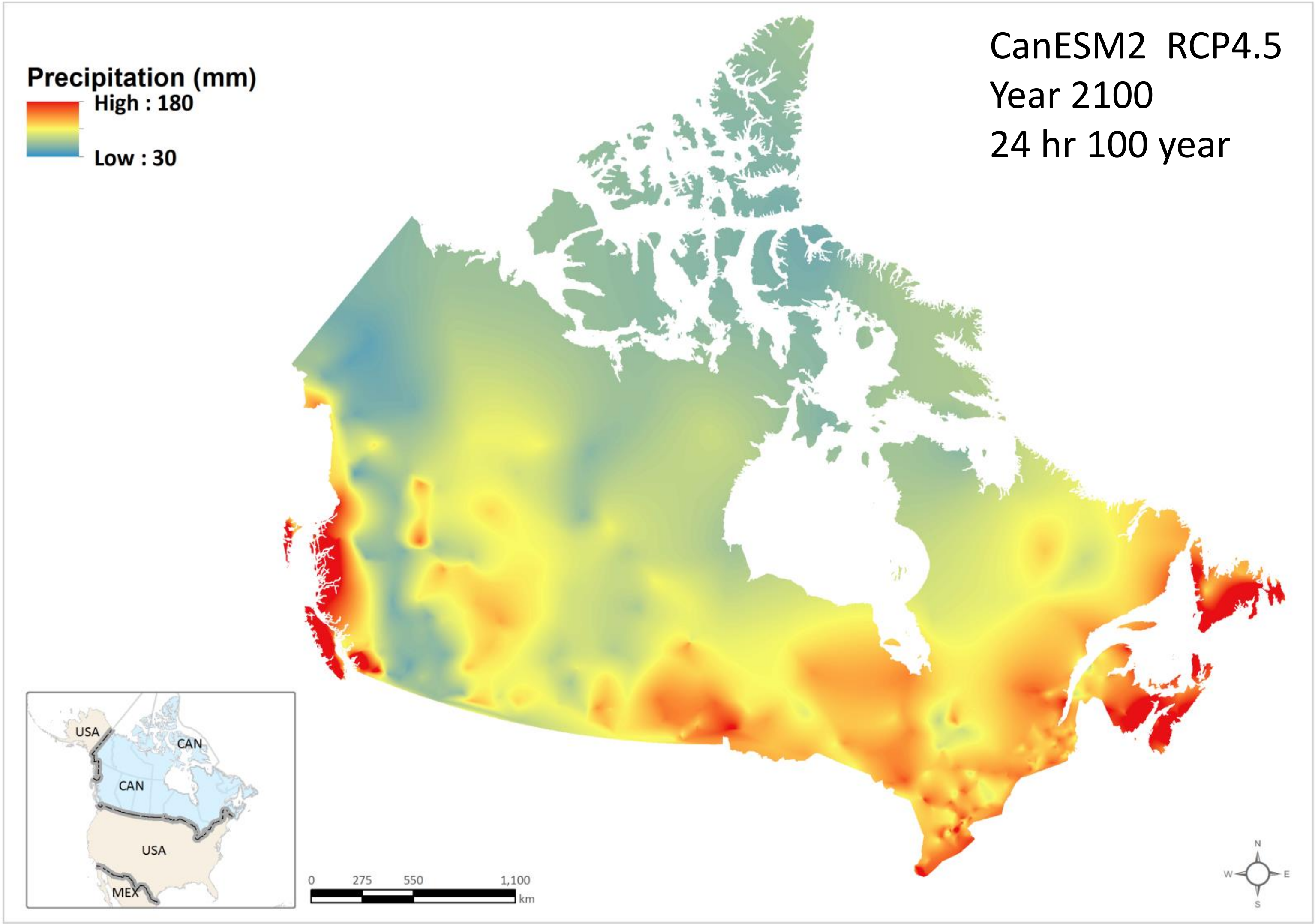
- 567 stations
- length between 10 and 75 years



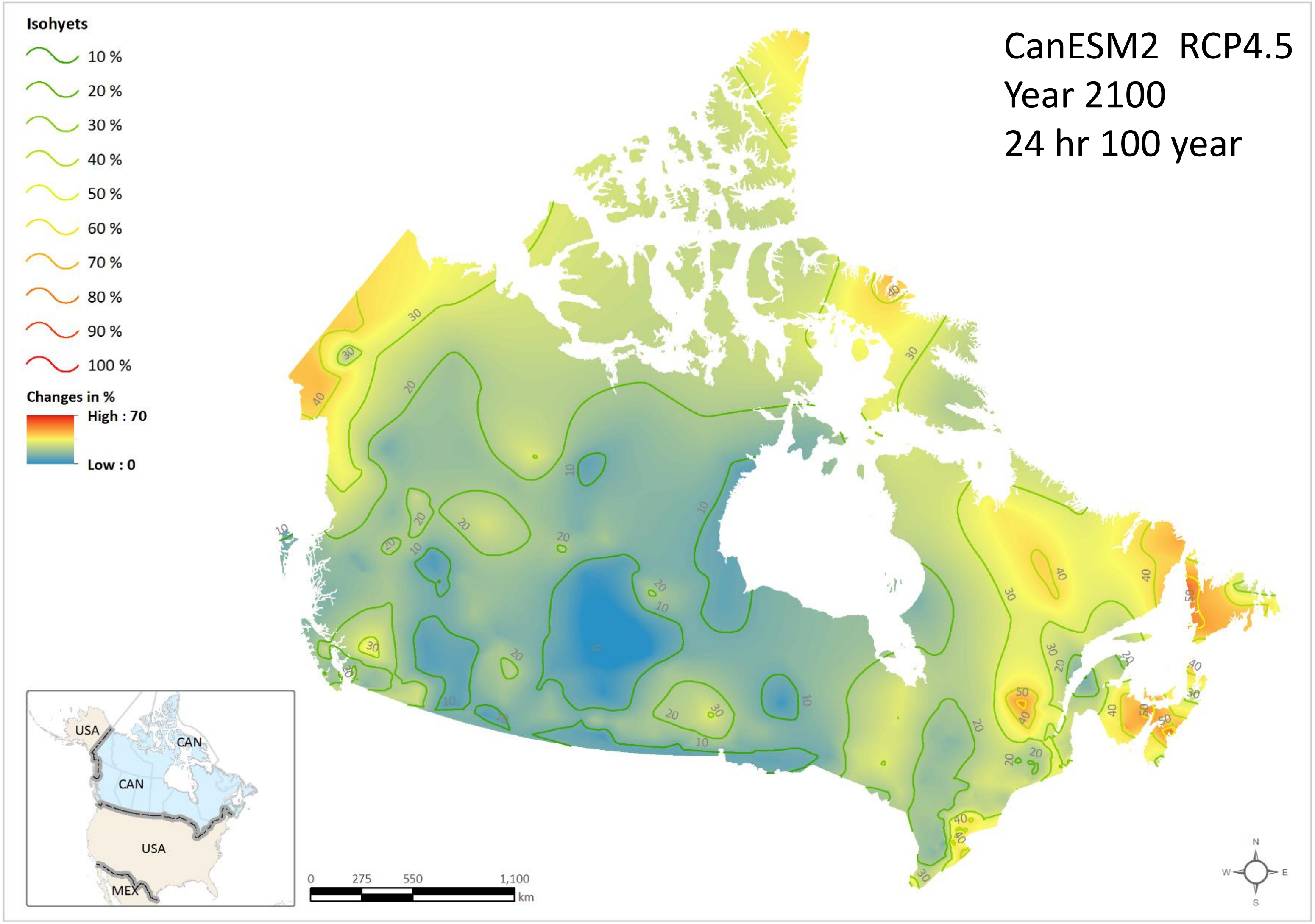
RESULTS
Analyses

Experiment	Climate data		Design criteria		GCM		RCP		
	Historic	Future	2hr 5y	24hr100y	CanESM2	Ensemble	2.5	4.5	8.5
1	√		√						
2	√			√					
3		√	√		√		√		
4		√	√		√			√	
5		√	√		√				√
6		√		√	√		√		
7		√		√	√			√	
8		√		√	√				√
9		√	√			√	√		
10		√	√			√		√	
11		√	√			√			√
12		√		√		√	√		
13		√		√		√		√	
14		√		√		√			√

RESULTS
Mapping IDF for CDN



15 | RESULTS
Mapping IDF change for CDN

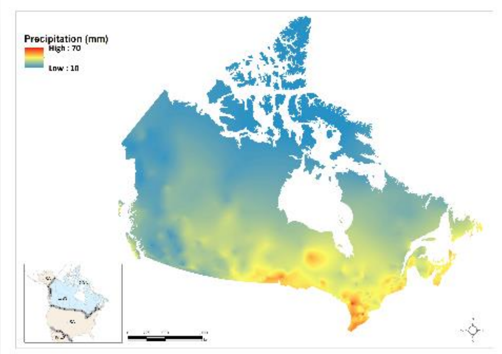


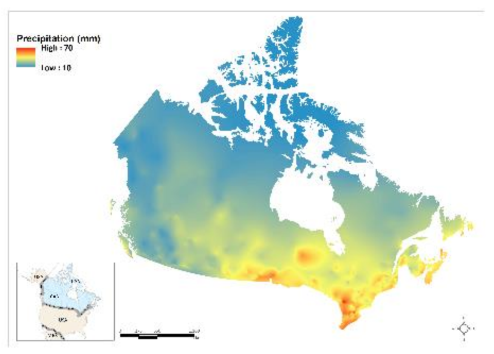
RESULTS
Mapping IDF for CDN

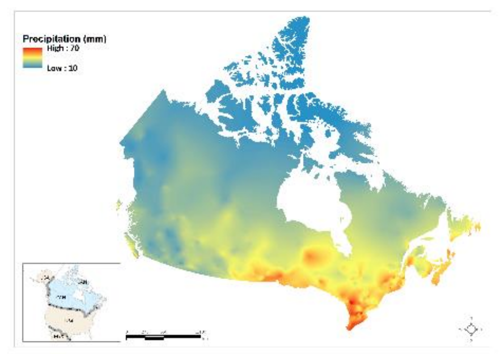
Model	RCP	Duration	Return Period	PPT (mm) Min / Max	Station Name	Province
Ensemble	2.6	2 hours	5 Years	7.2	CLYDE A	NU
				72.3	CYPRUS LAKE CS	ON
		24 hours	100 Years	36.6	CARMACKS	YT
				457.2	MORESBY ISLAND MITCHELL INLET	BC
	4.5	2 hours	5 Years	7.7	CLYDE A	NU
				76.6	CYPRUS LAKE CS	ON
		24 hours	100 Years	38.2	CARMACKS	YT
				479.9	MORESBY ISLAND MITCHELL INLET	BC
	8.5	2 hours	5 Years	8.7	CLYDE A	NU
				85.1	MILTON KELSO	ON
		24 hours	100 Years	42.3	CARMACKS	YT
				541.7	MORESBY ISLAND MITCHELL INLET	BC

17 | RESULTS
Mapping IDF for CDN

Year 2100   2 hr 5 years

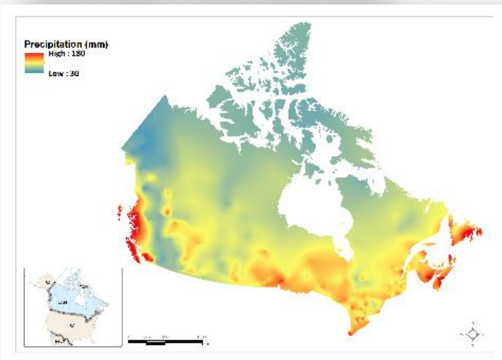


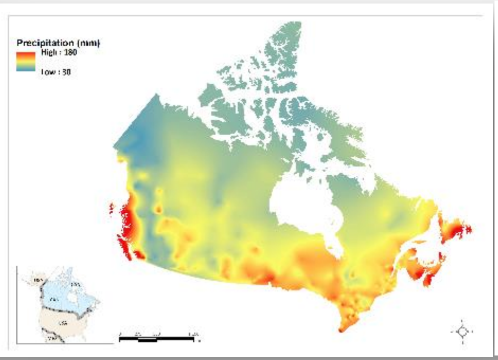


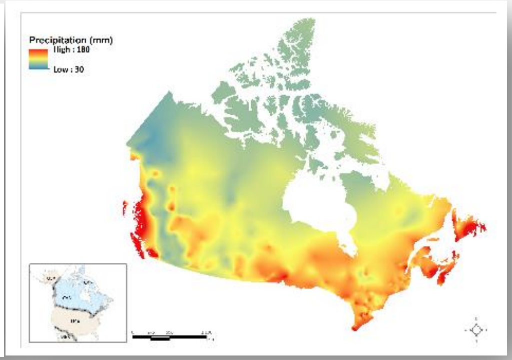


RCP2.6   RCP4.5   RCP8.5

Year 2100 24 hr 100 year







RCP2.6   RCP4.5   RCP8.5

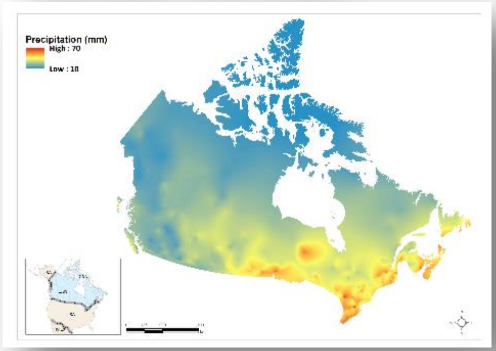
RESULTS

Mapping IDF for CDN

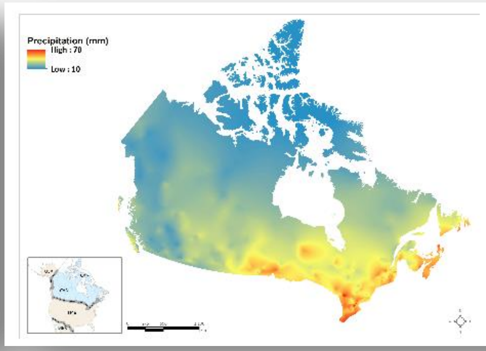
Model	RCP	Duration	Return Period	PPT (mm) Min / Max	Station Name	Station Province
CanESM2	2.6	2 hours	5 Years	7.5	CLYDE A	NU
				75.5	MILTON KELSO	ON
		24 hours	100 Years	42.6	CARMACKS	YT
				470.5	MORESBY ISLAND MITCHELL INLET	BC
	4.5	2 hours	5 Years	8.1	CLYDE A	NU
				83.1	MILTON KELSO	ON
		24 hours	100 Years	44.6	CARMACKS	YT
				464.5	MORESBY ISLAND MITCHELL INLET	BC
	8.5	2 hours	5 Years	9.1	CLYDE A	NU
				87.5	MILTON KELSO	ON
		24 hours	100 Years	47.6	MAYO A	YT
				546.1	MORESBY ISLAND MITCHELL INLET	BC

19 | RESULTS
Mapping IDF for CDN

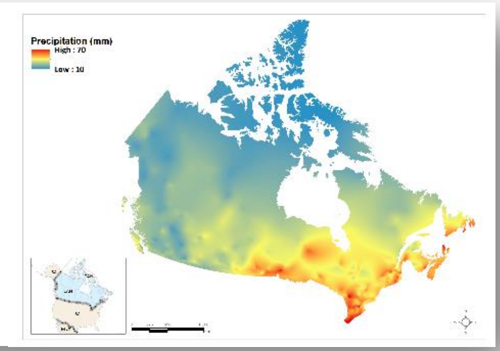
Year 2100 2 hr 5 year



RCP2.6

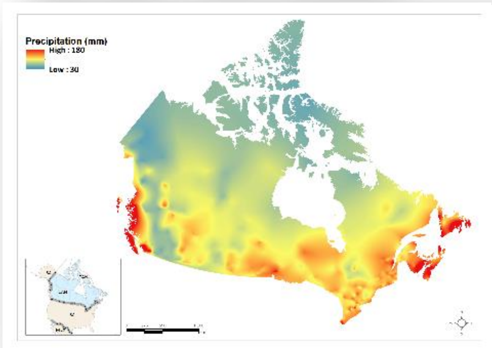


RCP4.5

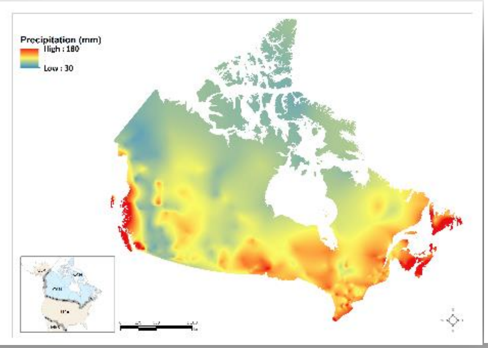


RCP8.5

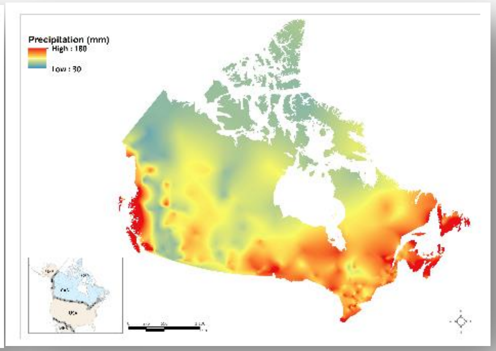
Year 2100 24 hr 100 year



RCP2.6



RCP4.5



RCP8.5

RESULTS

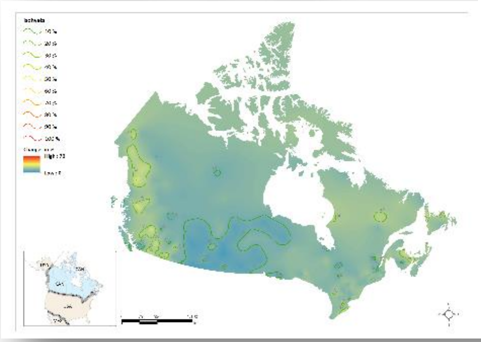
Mapping IDF change for CDN

Model	RCP	Duration	Return Period	Change (%) Min / Max	Station Name	Station Province
Ensemble	2.6	2 hours	5 Years	3.6	WYNYARD	SK
				30.5	TODAGIN RANCH	BC
		24 hours	100 Years	0.2	WYNYARD	SK
				24.6	DANIELS HARBOUR	NL
	4.5	2 hours	5 Years	4.2	MIAMI THIESSEN	MB
				32.3	SALMON ARM A	BC
		24 hours	100 Years	3.8	BERENS RIVER A	MB
				30.3	ARGENTIA (AUT)	NL
	8.5	2 hours	5 Years	9.8	ORMISTON	SK
				57.6	SALMON ARM A	BC
		24 hours	100 Years	9.6	OUTLOOK PFRA	SK
				49.0	TELEGRAPH CREEK	BC

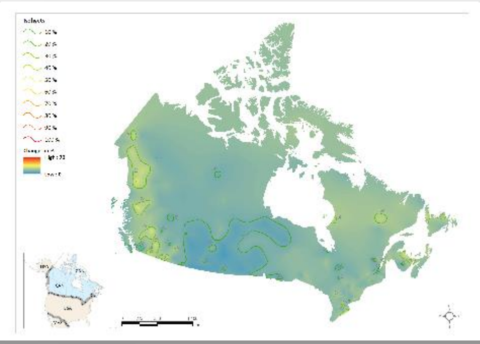
RESULTS

Mapping IDF change for CDN

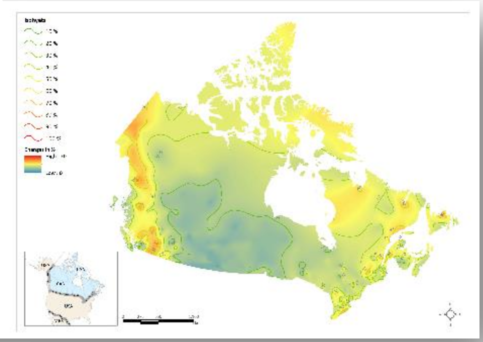
Year 2100 2 hr 5 year



RCP2.6

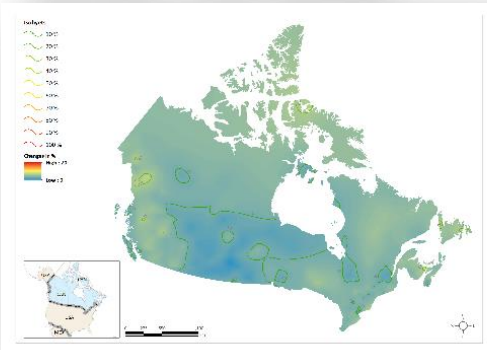


RCP4.5

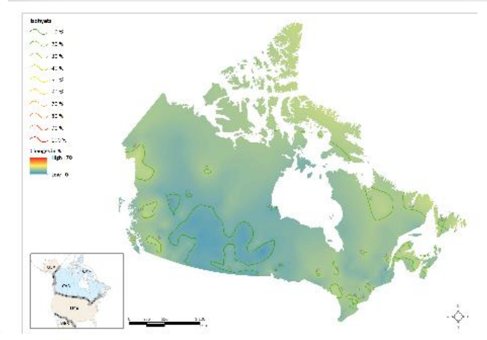


RCP8.5

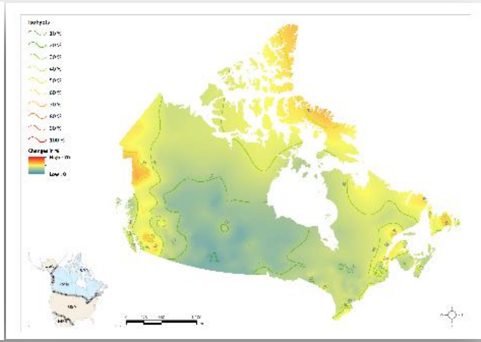
Year 2100 24 hr 100 year



RCP2.6



RCP4.5



RCP8.5

22 | RESULTS

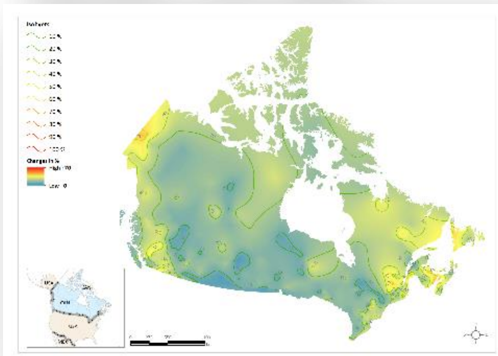
Mapping IDF change for CDN

Model	RCP	Duration	Return Period	Change (%) Min / Max	Station Name	Province
CanESM2	2.6	2 hours	5 Years	2.8	SWIFT CURRENT A	SK
				47.3	SAINT JOHN A	NB
		24 hours	100 Years	0.6	SWIFT CURRENT A	SK
				48.4	MONCTON INTL A	NB
	4.5	2 hours	5 Years	-0.2	NIPAWIN A	SK
				52.6	DANIELS HARBOUR	NL
		24 hours	100 Years	-6.1	LA RONGE A	SK
				62.8	HALIFAX	NS
	8.5	2 hours	5 Years	2.2	WYNYARD	SK
				79.6	DANIELS HARBOUR	NL
		24 hours	100 Years	-1.5	FLIN FLON A	MB
				106.7	DANIELS HARBOUR	NL

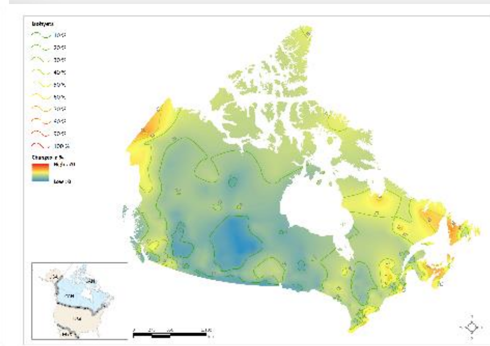
RESULTS

Mapping IDF change for CDN

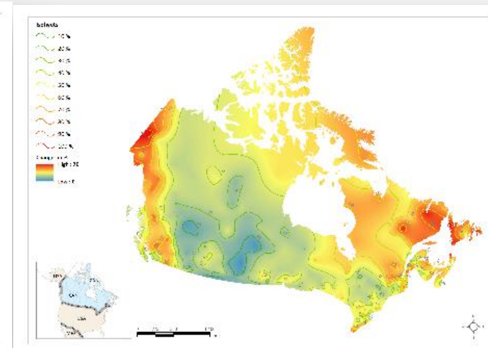
Year 2100 2 hr 5 year



RCP2.6

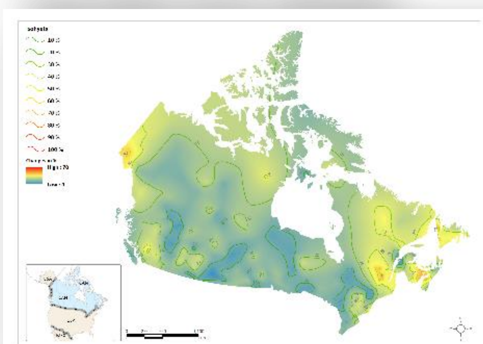


RCP4.5

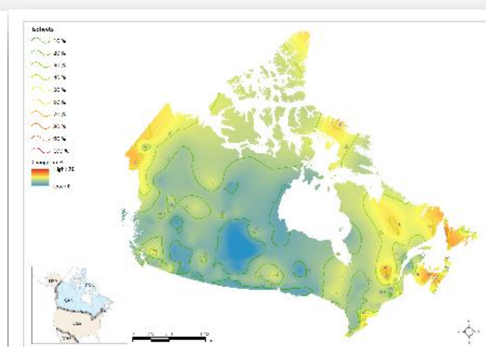


RCP8.5

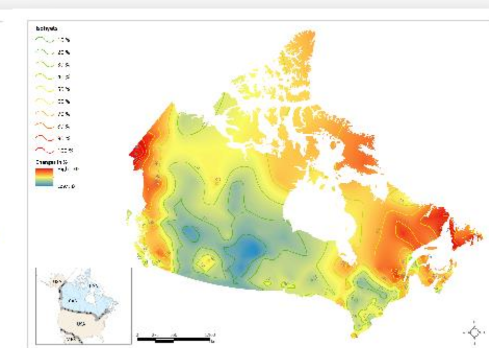
Year 2100 24 hr 100 year



RCP2.6

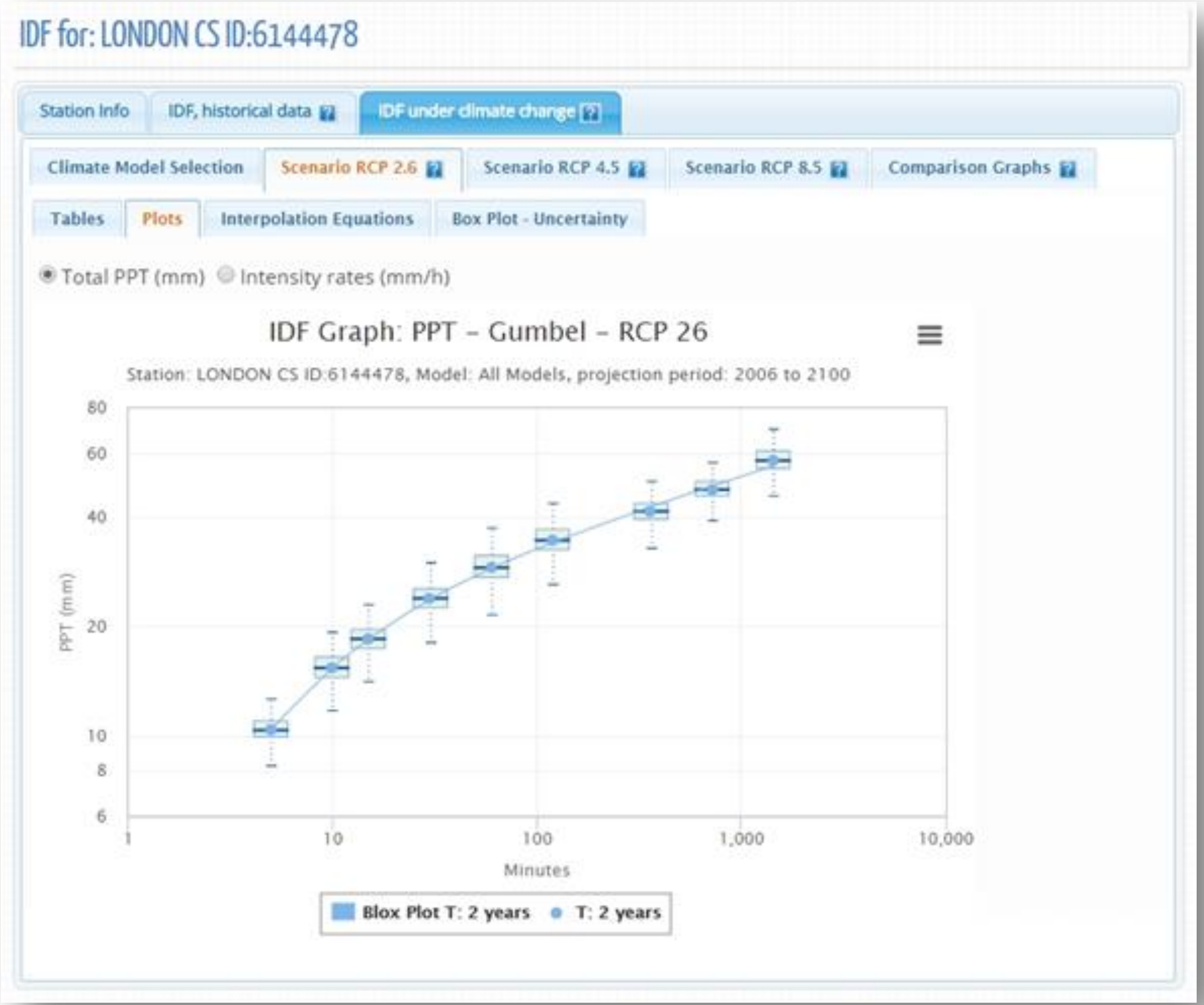


RCP4.5

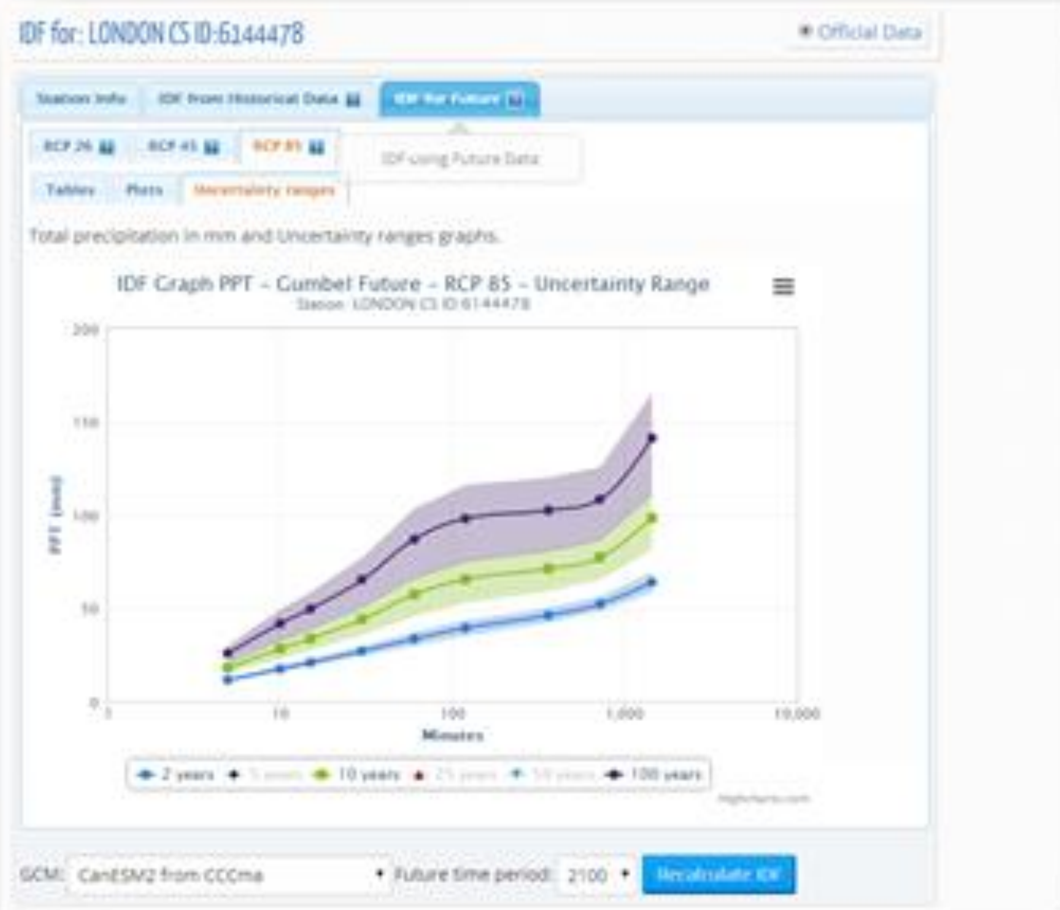


RCP8.5

USE OF THE TOOL
Uncertainty analysis

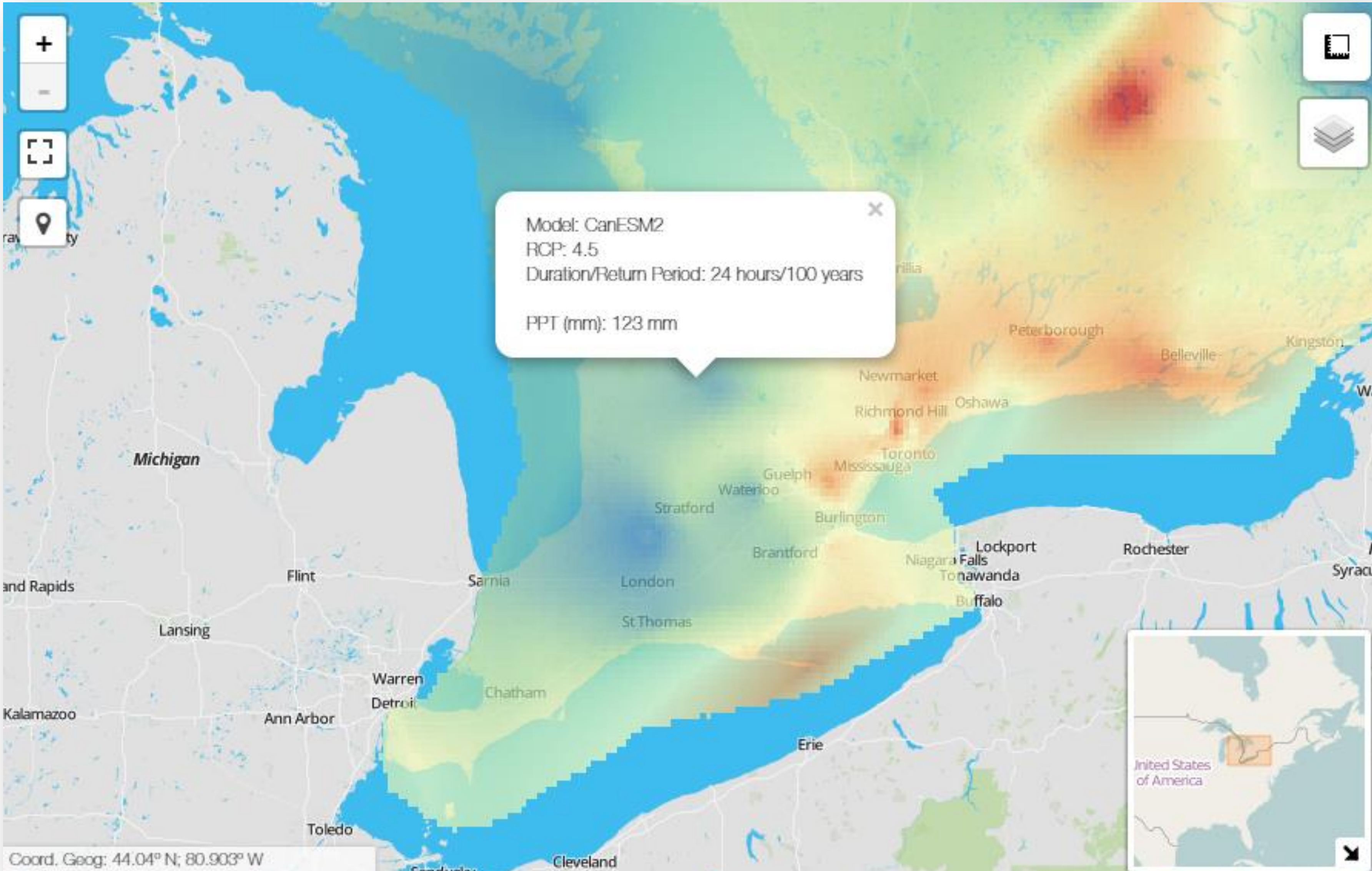


25 | USE OF THE TOOL
Uncertainty analysis



26 | FUTURE

Interactive mapping of IDF



PROJECT RESOURCES

Downscaling method: Srivastav, R.K., A. Schardong and S.P. Simonovic (2014). Equidistance Quantile Matching Method for Updating IDF Curves Under Climate Change. *Water Resources Management*: An International Journal. DOI 10.1007/s11269-014-0626-y

Overview of tool and methods: Simonovic, S.P., Schardong, A., Sandink, D., and Srivastav, R. (under review). A Web-based Tool for the Development of Intensity Duration Frequency Curves under Changing Climate. *Environmental Modelling and Software*.

CDN reginal analysis: Simonovic, S.P., Schardong, A., Sandink, D. (under review). Mapping Extreme Rainfall Statistics for Canada Under Climate Change Using Updated Intensity-Duration-Frequency Curves. *Environmental Modelling and Software.*

DSS engagement practices: Sandink, D., Simonovic, S.P., Schardong, A., and Srivastav, R. (under review). A Decision Support System for Updating and Incorporating Climate Change Impacts into Rainfall Intensity-Duration-Frequency Curves: Review of the Stakeholder Involvement Process. *Environmental Modelling and Software*.

PROJECT RESOURCES

www.slobodansimonovic.com

Research → FIDS → Projects