P1-3: Analysis and applicability of future extreme events in regional and local context

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Background

- Weather and climate extremes have always played an important role in shaping the natural environment

Dawson Creek floods (BC, June 2016)

Gatineau (QC, May 2017)

- Knowledge of changes in weather and climate extremes is essential to manage climate-related risks to humans, ecosystems and infrastructure, and develop resilience through adaptation strategies
- Climate indices is defined as a <u>calculated value</u> that can be used to describe <u>the state and the changes</u> in the climate system
- Climate Indices are driven from: maximum temperature, minimum temperature and daily precipitation

Project Objectives

1) Assess the historical **spatial and temporal patterns and trends** of precipitation and temperature indices in local context

2) Evaluate the capacity of **Regional and Global Climate Models to simulate historical observed** extreme indices series and their trends

3) Explore the applicability of extreme weather indices **for future climatic conditions** at **regional** and **local** scales

4) Develop **new multi parameter** weather indices

Update on Current Progress

- The first **two objectives** are successfully completed, and the obtained results are written and was submitted for publication (**results are presented in the second AGM**)
- **Future projection of climate indices** results are successfully completed, results are written and submitted for publication (a summary of **results are presented here**).
- Work on the **multivariate indices** are **in progress**

Summary of results

Impact of Climate change on climate indices in southern Canada

Climate Indices & Models

- **Climate Indices:**

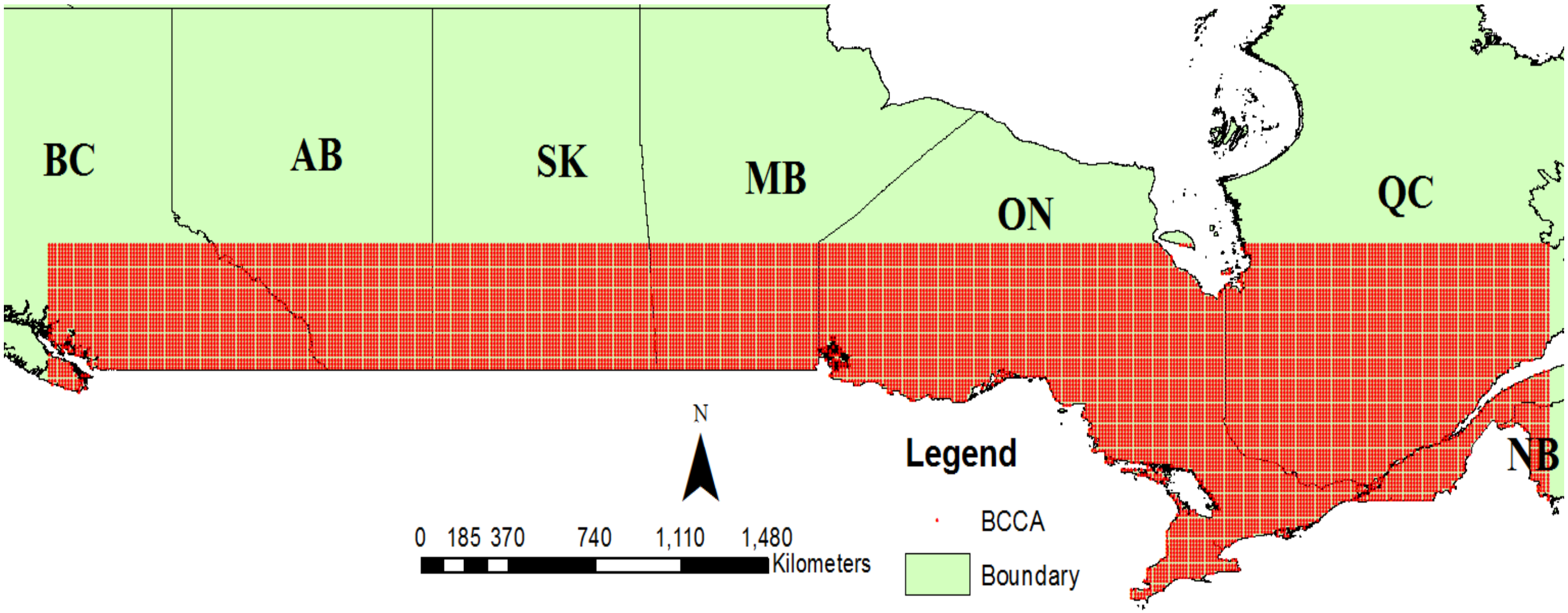
ID	Indicator Name	Indicator Definition	Units
PRCPTOT	Total Precipitation	Annual total precip.	mm
SDI	Simple Daily Intensity	Mean precip. In wet days	mm
CDD	Consecutive Dry Days	Consecutive days precip. < 1 mm	days
R10	Heavy precipitation	# of days precip> 10 mm	days
TN10p	Cool Night	% of days with Tmin<10^{th} percentile	%
TX10p	Cool Days	% of days with Tmax<10^{th} percentile	%
TN90p	Warm Night	% of days with Tmin>90^{th} percentile	%
TX90p	Warm Days	% of days with Tmax>90^{th} percentile	%

- **Climate Models:** 12 CMIP5 models are used

Model Name	Institution
ACCESS1	Commonwealth Scientific and Industrial Research Organization (CSIRO) and Bureau of Meteorology (BOM), Australia
BCC-CSM1	Beijing Climate Center, China Meteorological Administration
CanESM2	Canadian Centre for Climate Modelling and Analysis
CCSM4	National Center for Atmospheric Research (NCAR)
CESM1-BGC	Community Earth System Model Contributors
CNRM-CM5	Centre National de Recherches Météorologiques/ Centre Européen de Recherche et Formation Avancée en Calcul Scientifique
CSIRO-MK3-6-0	Commonwealth Scientific and Industrial Research Organization, Queensland Climate Change Centre of Excellence
GFDL-ESM2G	NOAA Geophysical Fluid Dynamics Laboratory
Inmcm4	Institute for Numerical Mathematics
IPSL-CM5A-LR	Institut Pierre-Simon Laplace
MICROC5	Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies,
MPI-ESM-LR	Max Planck Institut für Meteorologie (Max Planck Institute for Meteorology)

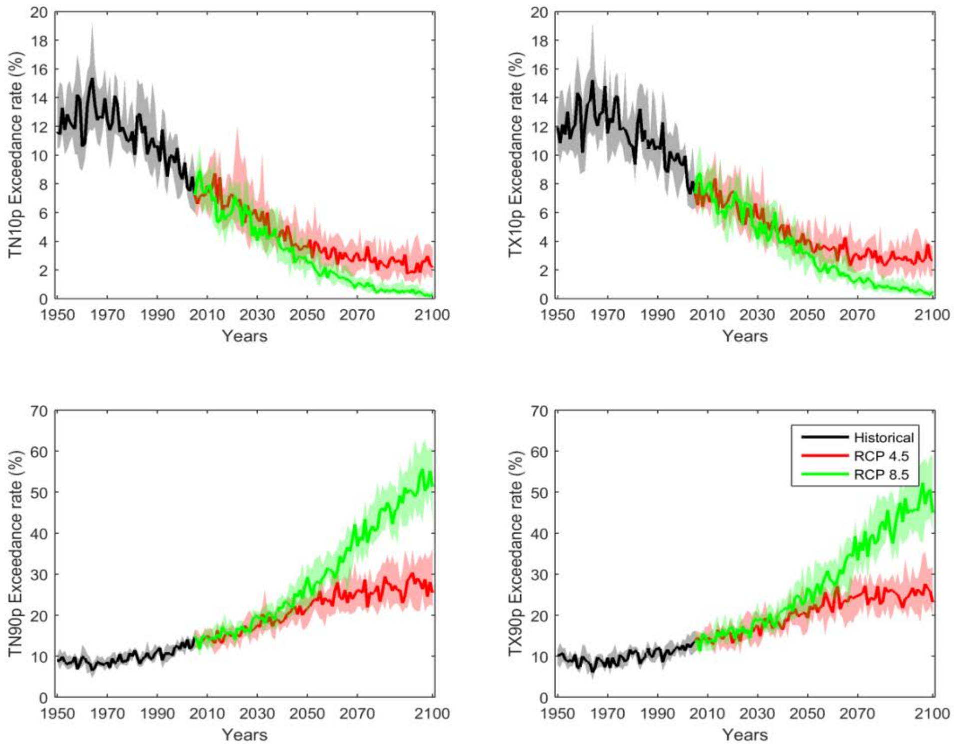
Case Study

- **Region:** Southern of Canada (~18900 grids of 0.125°)



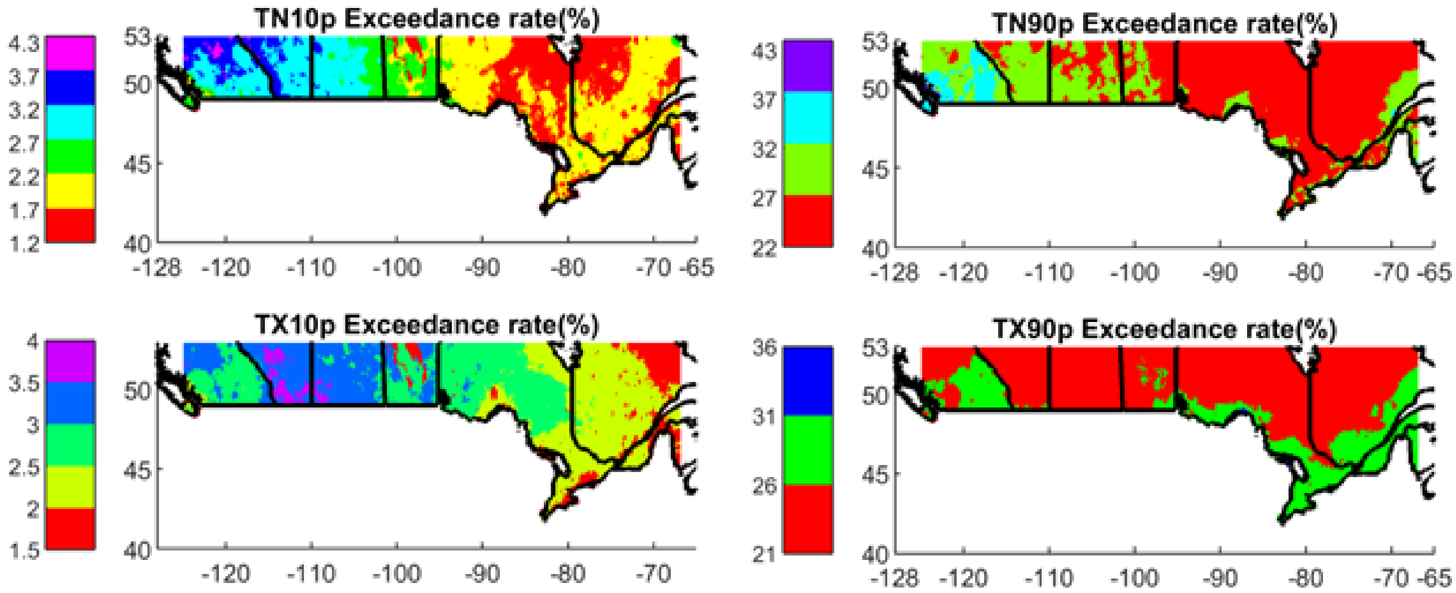
- **Downscaling method**: Bias Correction Constructed Analogue (BCCA) produced by the U.S. Department of the Interior's Reclamation Bureau

Temperature Indices -Temporal Evolution



- For RCP 8.5, by the end of 2100: **No more Cool days or nights**, **Warm Night increase** by 51% and **Warm Days increase** by 49%
- Variation in **the minimum Temp. is larger** than in **the maximum Temp.**
- **Low variation** between the middle and the end of 21 st century under RCP 4.5 comparing to those under RCP 8.5

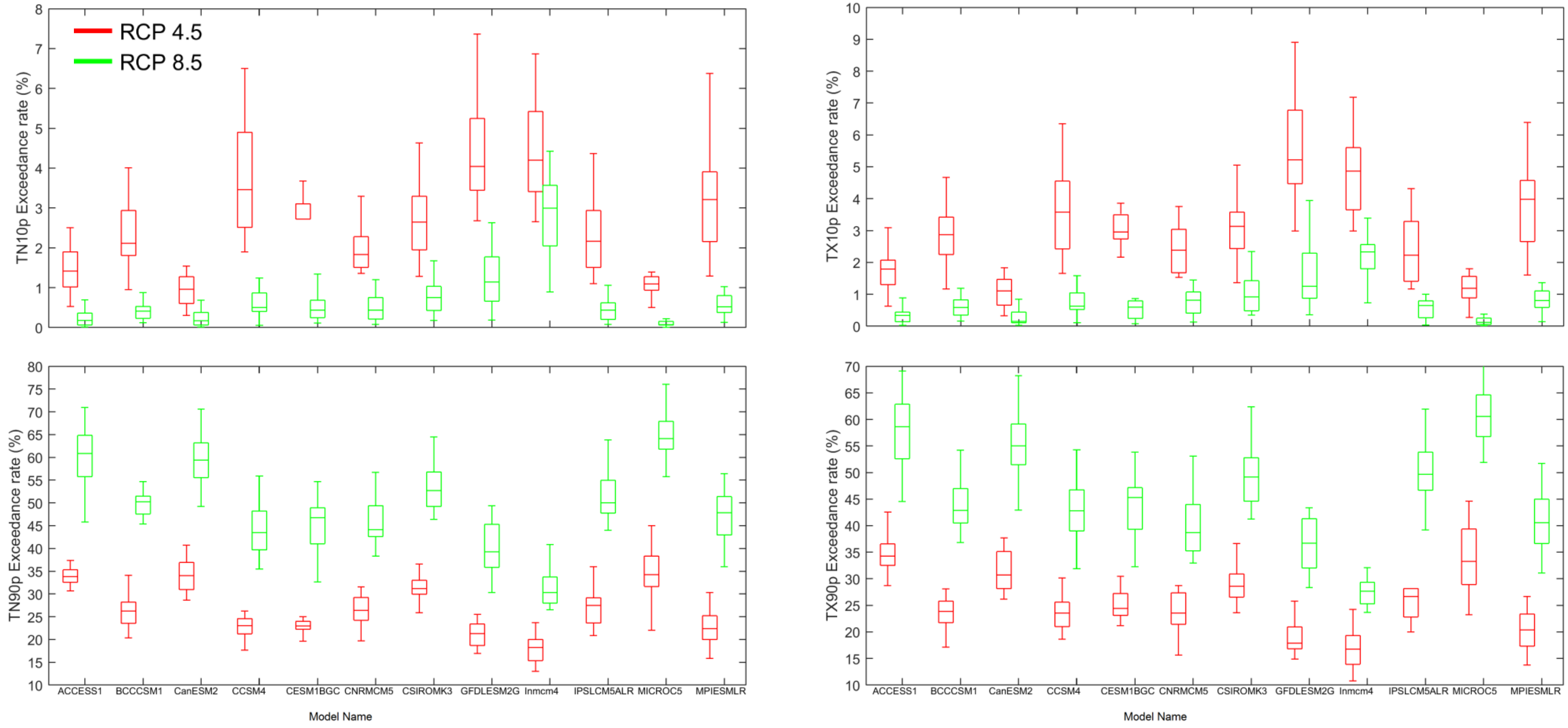
Temperature Indices - Spatial Evolution



The projected changes temporally averaged over 2081-2100 for RCP 4.5 (relative to the reference period 1960-1990)

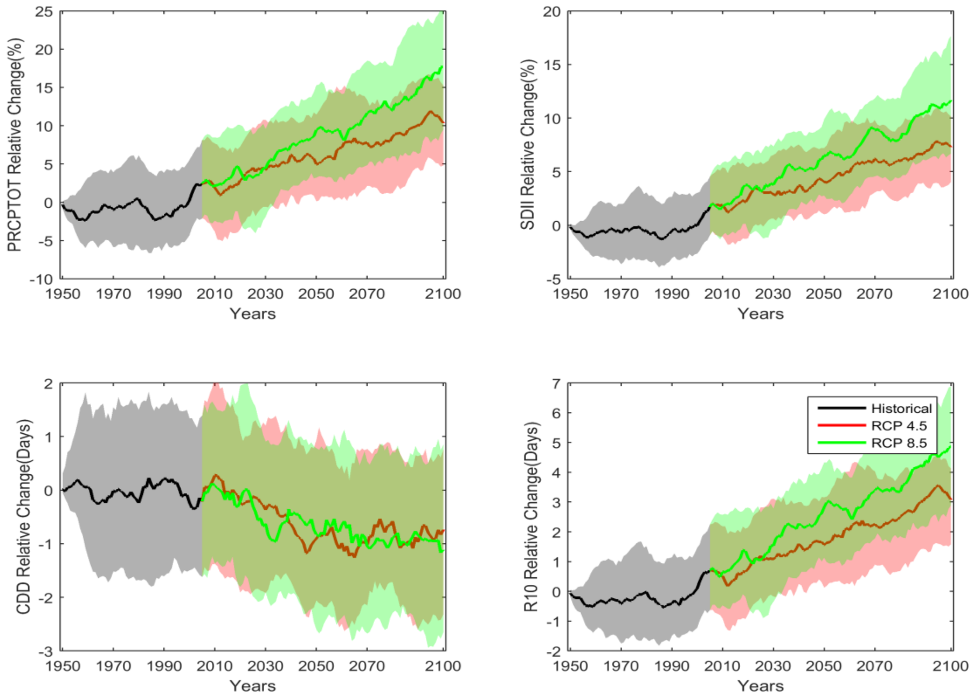
- The **highest decrease** in Cool Days and Nights occurs in **QC** and **ON**
- The **highest increase** in Warm Nights occurs in **BC**
- The **highest increase** in Warm Days occurs in **Great Lakes** and **south BC**

Temperature Indices - Model Evolution



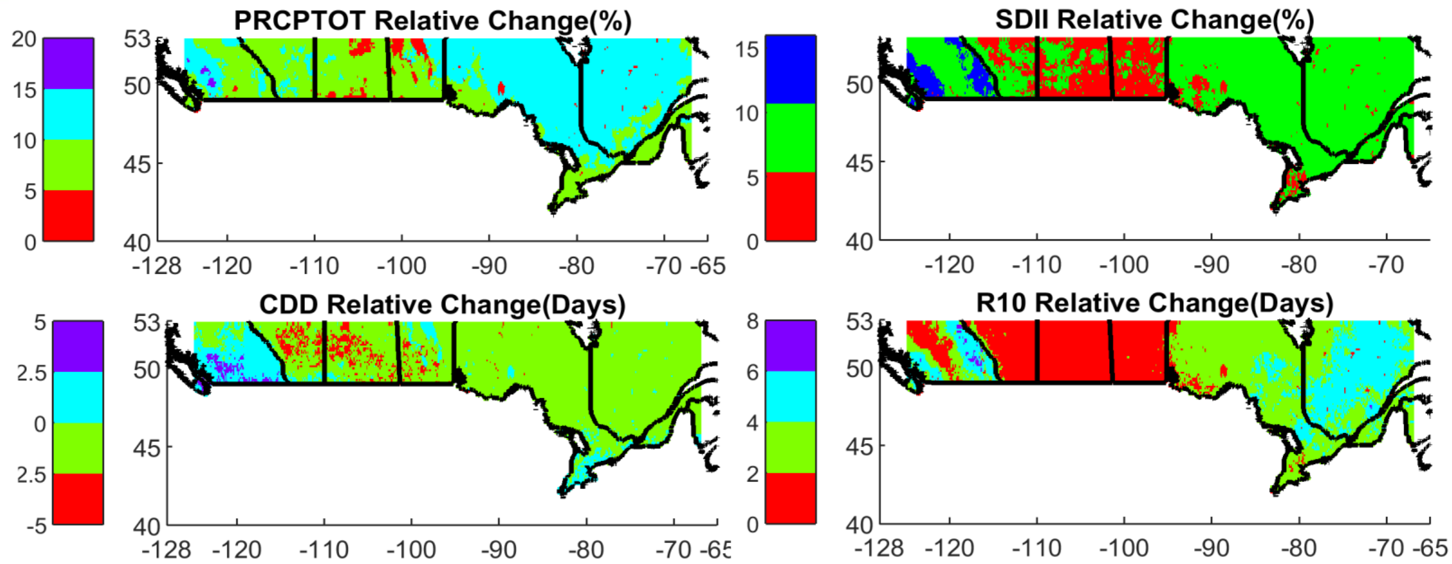
- ACCES1, CanESM2 and MICROC5 are **the warmest models**
- GFDL-ESM2G and Inmcm4 are the **coldest models**
- Variability in cool nights and days **depend** on CMIP5 model (different lower tail)
- Variability of warm nights and days is **close for all CMIP5 models** (shifted upper tail)

Precipitation Indices - Temporal Evolution



- For RCP 8.5, by the end of 2100: Total Precip. **increase** by 17 %, Mean Precip. in wet days **increase** by 11 %, heavy Precip. **increase** by 5 days and Consecutive Dry Days decrease by 1 days
- We found a **significant** variation for precipitation indices between the middle and the end of 21 century
- Generally the change under RCP 8.5 **is higher** than under RCP 4.5

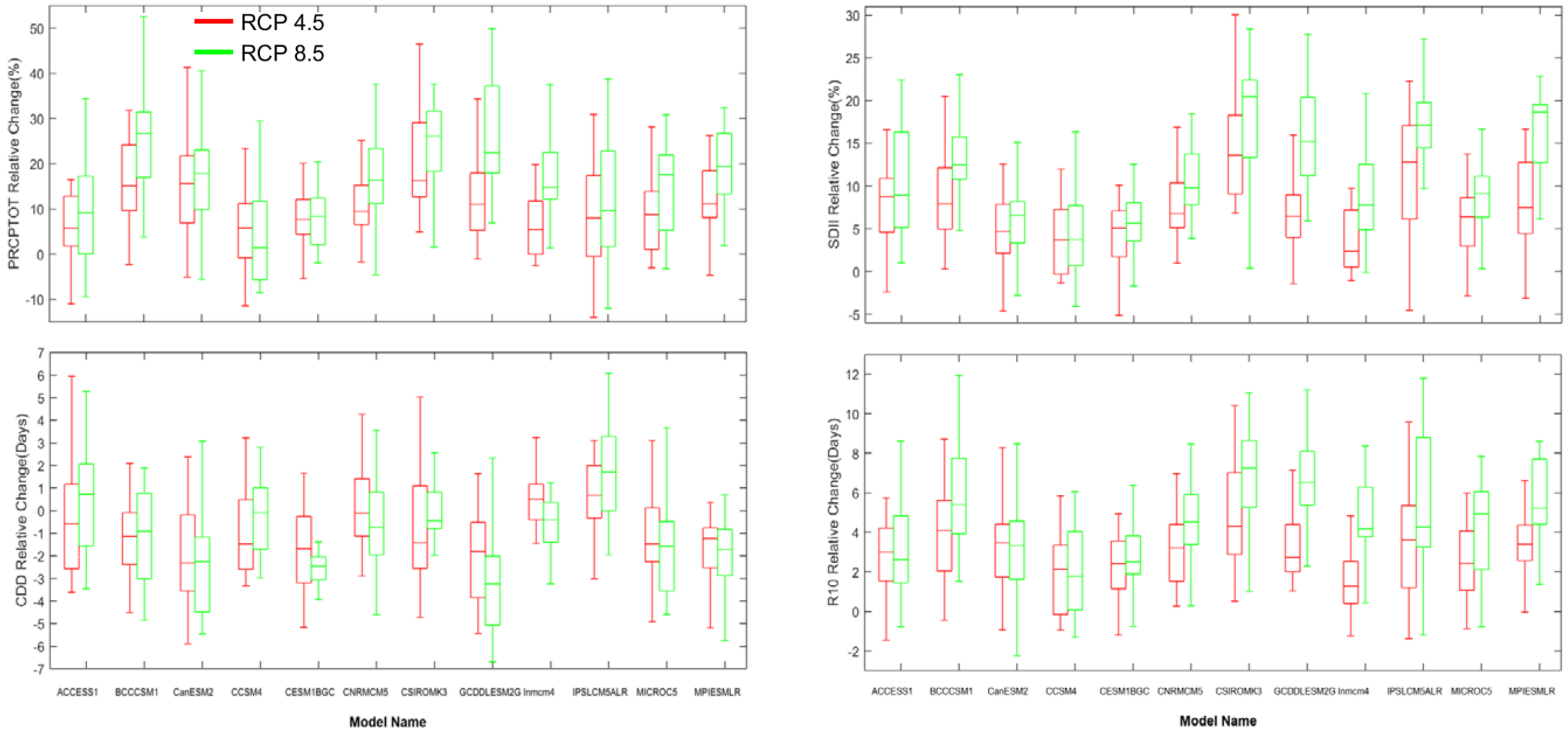
Precipitation Indices - Spatial Evolution



Projected changes temporally averaged over 2081-2100 for RCP 4.5(as relative to the reference period 1981-2000)

- **Lowest** PRCPTOT and SDII increase occurs in the **cente**r of studied region in **MB** close to the **lakes Winnipeg and Manitoba**
- **Highest increase** in PRCPTOT and SDII occurs in the **northern part of QC and ON (rural) and in the western part of BC (mountain region)**
- **Decreasing** CDD is shown in the **most part of southern of Canada**
- **Increasing** CDD is shown in the **south of BC and in ON close to the Lake Ontario**
- The **higher heavy precipitation** projection is shown in the **north east of QC** (rural region with high number of lacs)

Precipitation Indices - Models Evolution



- **Wettest** model is the GFDLESM2G
- The **dryer** model is the CSSM4
- **Non inter-model** agreement on the variation of CDD

Multivariate climate indices

- Prec. (P) and Temp. (T) variations are closely associated due to their thermodynamic relations
- The covariability of P and T may result in the occurrence of joint climate extremes, such as drought and heatwave
- Dependence structure between P and T change between seasons
- Assume $F_i(P)$ and $\mathrm{G}_i(T)$ are the marginal cumulative distribution function of P and T in the season *i*
- The joint probability: $P(P_i < p, T_i < t) = C\left[F_i(P), \mathrm{G}_i(T)\right] = p_i$

C : is a copula (e.., Frank, Gumbel, Clayton)

- Multivariate indices is defined by: $MI = \varphi^{-1}(p_i)$

φ : is the standard normal distribution function.

(Application of *MI* is on progress)

Conclusions

- The intensity and the frequency of extreme precipitation is expected to increase over the studied region
- Frequency of cold temperature extremes is projected to decrease, while the frequency of warm extremes is expected to increase
- Nighttime warming has been greater than daytime warming.
- High spatial variability of projected change of climate indices

Questions??