

High Resolution Climate Change Projections for Ontario

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Abstract

In this study, we consolidated a large number (~200) of existing Ontario-specific projections into a common set of climate scenarios, at the ERA-Interim 0.125° grids. The data sets include statistical and dynamical downscaling products (daily Tas, Tmin, Tmax and Pr). The daily ERA-Interim data was used as reference data for bias correction.

Based on this ensemble, changes in climate averages and extremes were projected at provincial, sub-region and grid point scales for 2050s and 2080s relative to 1986-2005. For example, the provincial averaged temperature may rise 1.8, 2.5, 2.2 and 3.2 °C in 2050s, and 1.8, 3.2, 3.7 and 5.6 °C in 2080s under RCP2.6, 4.5, 6.0 and 8.5, respectively. Provincial average precipitation may increase 2~8% in 2050s and 2%-11% in 2080s. Interactive maps and time series that demonstrate changes of the climate averages and extreme indices at these spatial scales will be published online for public access (yorku.ca/occp).

Data

Downscaling Tas, Tmin, Tmax and Pr

- Statistical downscaling (DS) data
 - LAMPS, York University (OI+BC, 0.125°)[1]
 - PCIC (BCCAQ, BCSD, 10km) [2][3]
- Dynamical downscaling data
 - NA-Cordex (0.44°, 0.22°)[4]
 - University of Toronto (10km)[5]
 - CCDP, University of Regina (25km)[6]

Reanalysis: ERA-Interim (1981~, 0.125°)

Daily observations at stations

Normal and extreme indices

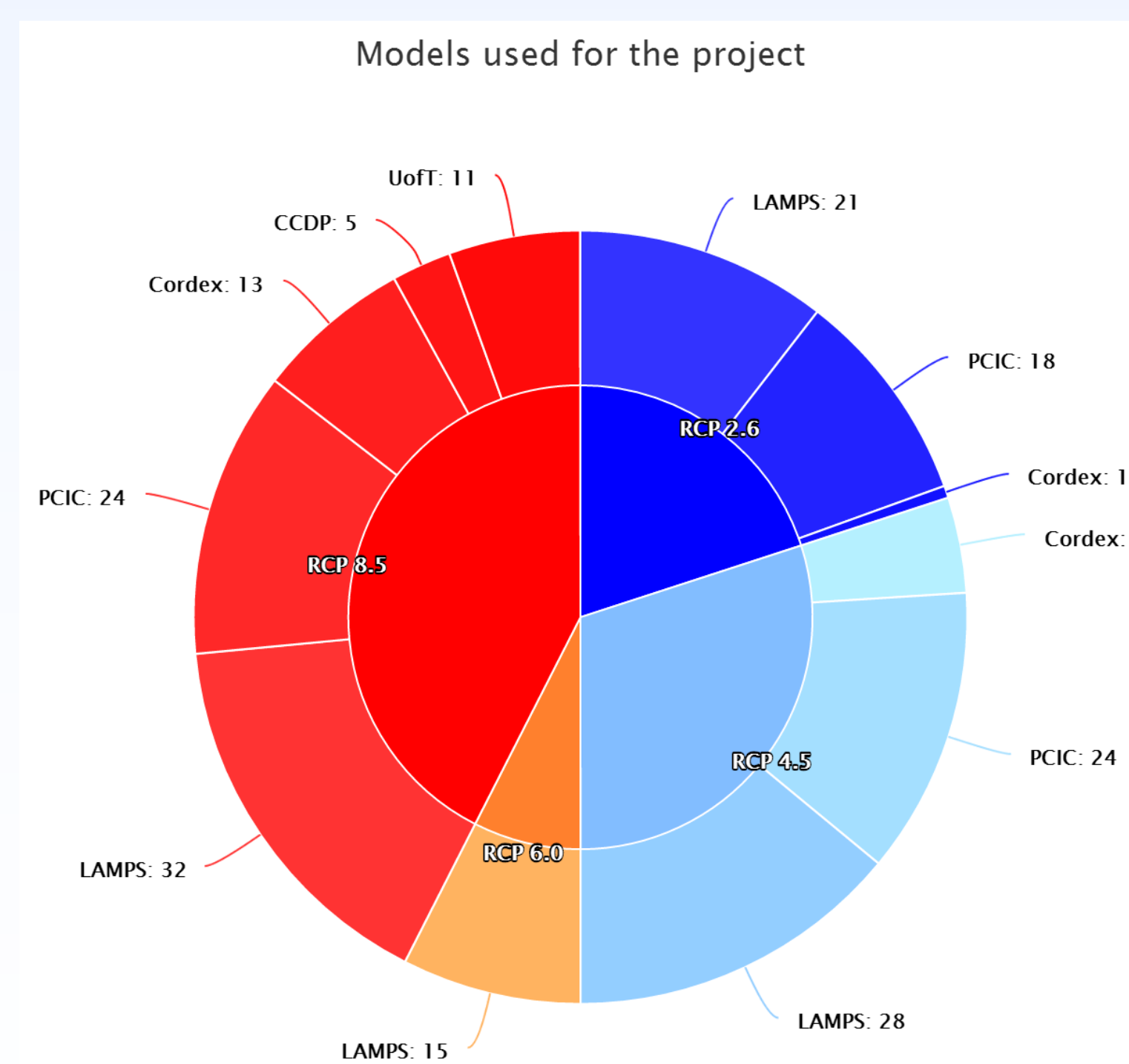


Fig. 1 Downscaled data used for this study (more data will be included as they are available)

Methods

Data quality control

- Errors (Tx<Tm or Tn, or Tn>Tm or Tx)
- Biases: mean and variance check
- Plots (time series, histograms)
- Seasonal cycle check
- Thresholds exceedance for temperatures and Precipitation

Spatial interpolation of downscaled data to 0.125° grids

- k-nearest neighbors (KNN)

Bias correction

- QQ-mapping

$$Y_i = F_{oi}^{-1}(F_{Si}(X^{ai})) \quad (1)$$

- F_{oi} -- CF of the reanalysis daily data for day i,
- F_{Si} -- CF of downscaled data period,
- X^{ai} -- downscaled data
- Y_i -- transformed (bias corrected) data,

- Pareto distribution for extreme values:

$$F(x) = 1 - \left(\frac{x_m}{x}\right)^a \text{ for } x > x_m, a > 0 \quad (2)$$

Post-processing (quality control)

Indices calculation [7]

Data portal development

- Single page web application development
- Interactive climate data web visualization
- Geographic information systems

Results

Changes in 2050s and 2080s were projected at each grid to demonstrate spatial variation. As an example, Fig. 2 shows the changes of several variable in 2080s. Interactive maps of changes for annual, seasonal and monthly means for the four basic variables and annual values for other indicators were generated and published at a temporary website: <http://lamps.math.yorku.ca/OntarioClimate/>. At each grid point, the empirical distribution of the indicators were represented by five percentiles: 5%, 25%, 50%, 75% and 95% (boxplot).

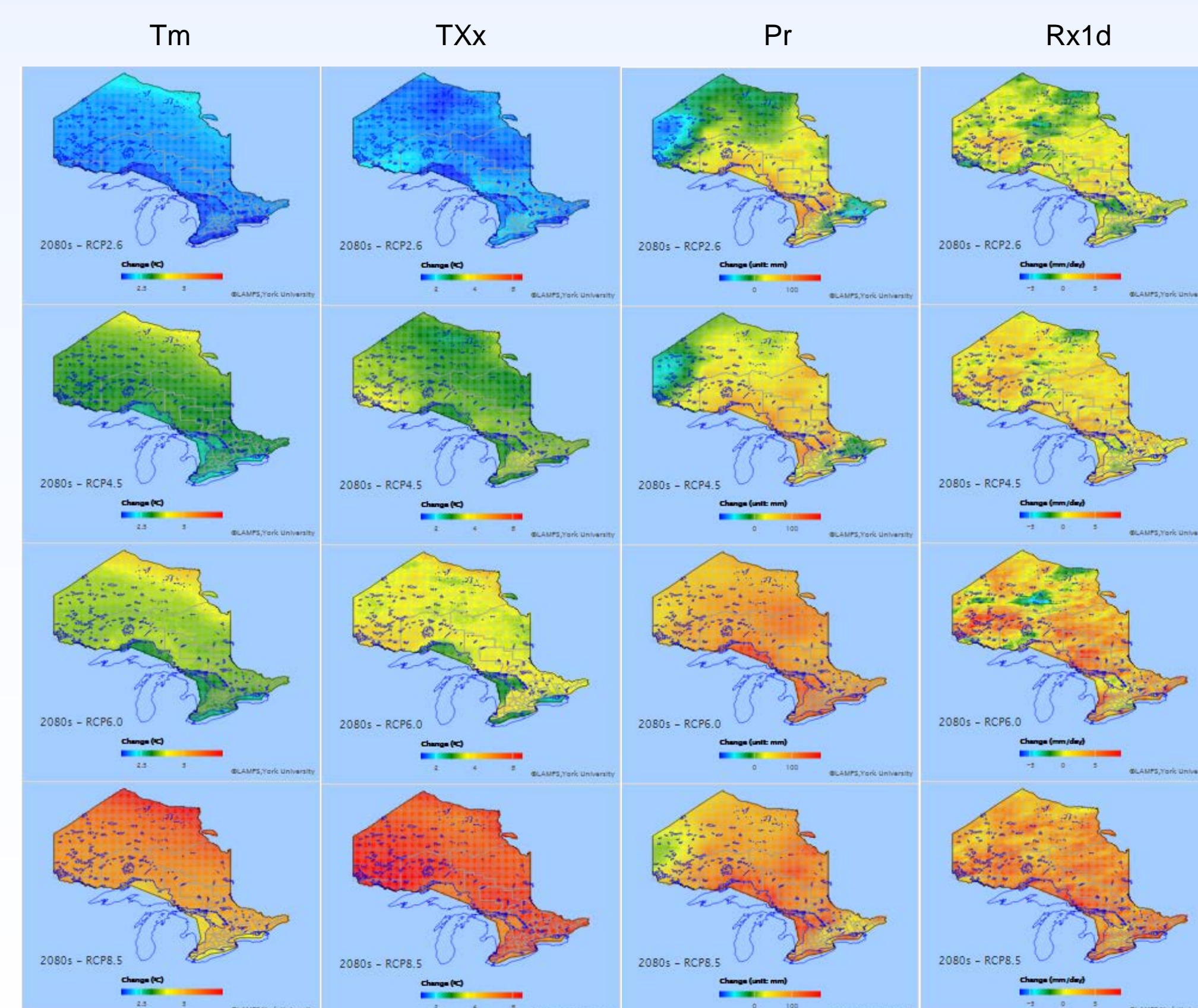


Fig. 2 Projected changes of 30-year averages for 2080s relative to the averages for 1981-2005.

Changes and the likely ranges (5%~95%) of the changes for the 50 municipal areas were obtained. As an example, Fig.3 shows changes in regional average temperature for 2050s and 2080s relative to 1986-2005.

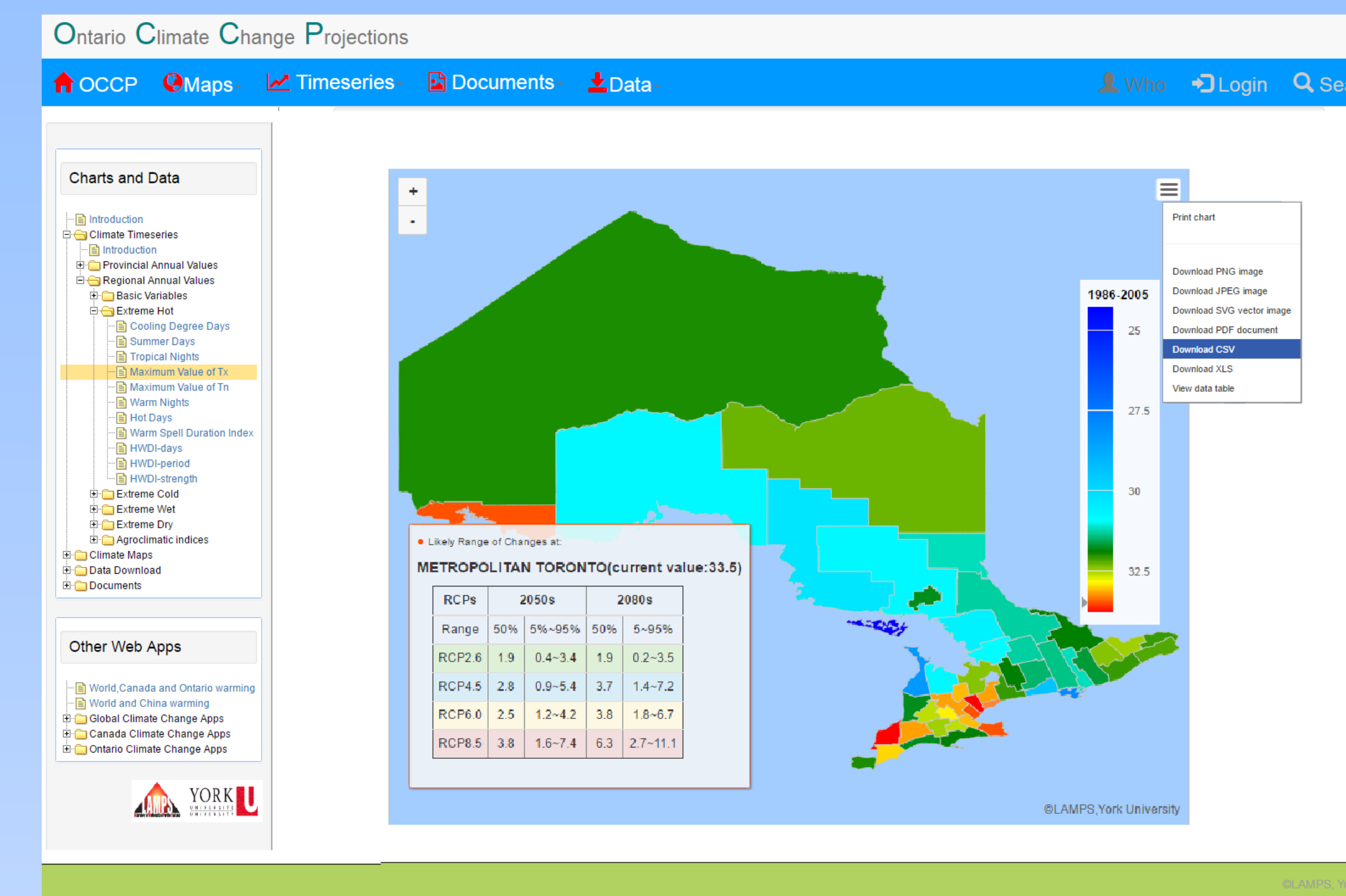


Fig. 3 Sample web pages for sub regional climate change information

Changes and the likely ranges of the changes averaged for Ontario were presented as time series. Ontario temperature may rise 1.8, 2.5, 2.2 and 3.2 °C in 2050s, and 1.8, 3.2, 3.7 and 5.6°C in 2080s under RCP2.6, 4.5, 6.0 and 8.5, respectively. Therefore, all hot extreme events will significantly increase in 2050s and 2080s (table and Fig. 4) and cold event may decrease.

Provincial average precipitation may increase 2~8% in 2050s and 2%-11% in 2080s. Therefore, most wet events may increase in the future. Large uncertainty in numbers of extreme precipitation events were observed.

Table Ensemble means of changes of extreme climate indices in 2050s and 2080s relative to the reference period 1986-2005 under all RCPs

#	Periods	2050s				2080s			
		8.5	6.0	4.5	2.6	8.5	6.0	4.5	2.6
1	CDD	361	214	165	86	173	111	119	84
2	HDD	-1732	-1189	-1029	-599	-1023	-714	-814	-617
3	Cold_day	-27.8	-23.5	-19.4	-9.3	-21.2	-15.3	-17.1	-11.7
4	Cold_night	-29.3	-26.8	-22.1	-12.2	-23.7	-19.5	-19.4	-14.7
5	DTR	-0.6	-0.5	-0.3	-0.2	-0.3	-0.3	-0.2	-0.2
6	FD	-49.4	-33.2	-28.9	-16.6	-28.4	-20.2	-22.0	-17.6
7	GSL	44.1	30.4	25.2	14.6	24.5	18.1	19.1	15.2
8	j111	-21.8	-15.7	-12.5	-7	-11.8	-9	-9.7	-7.6
9	j211	22.3	14.6	12.7	7.6	12.7	9.2	9.5	7.5
10	Hot_day	116	72.5	61	34.8	60.5	40.9	46.1	34.3
11	Hot_night	129.7	81.2	66.1	38.2	66.8	45.4	48.8	37.5
12	HWDI_days	26.8	10.5	11.2	6.7	9.9	5.2	7.4	5.7
13	HWDI_period	131.6	76.9	64.4	35.8	64	39.4	47.3	34.3
14	HWDI_strength	1498	794	687	384	669	395	492	356
15	ID	-37.4	-21.9	-21.4	-11.6	-20.2	-12.9	-17.0	-12.2
16	SU	49.9	33.1	26.6	14.8	27.7	18.7	20.3	14.5
17	tnCSDI	-1.5	-1.9	-0.6	1	-1.3	-1.4	-1.0	-0.3
18	TNn	10.5	6.9	5.9	3	5.7	3.7	4.6	3.0
19	TNx	5.5	3.5	2.9	1.6	3.2	2.2	2.3	1.7
20	TR	25.3	15.4	9.1	3.9	10.5	7.1	6.1	3.8
21	TXn	9.5	6.3	5.2	2.7	5.3	3.3	4.2	2.7
22	TXx	6	3.8	3.3	1.8	3.5	2.3	2.6	1.8
23	txWSDI	82.9	43.2	32.9	17.1	32.5	20.2	22.3	15.8
24	pr95pDays	2.6	1.8	1.5	1	1.6	1.2	1.2	1.2
25	pr95pTOT	78.5	57.1	42.2	28.2	47.3	38.5	34.9	32.3
26	pr99pDays	1.1	0.7	0.6	0.4	0.6	0.5	0.5	0.4
27	pr99pTOT	44.7	31.7	23.1	15.2	25.9	21.0	19.1	17.1
28	prCDD	-1	-0.6	-0.7	-0.6	-0.7	-0.6	-0.7	-0.6
29	prCWD	0.4	0.2	0.2	0.2	0.2	0.1	0.1	0.2
30	PRCPTOT	112.9	80.5	66	49.1	70.7	55.1	53.9	55.3
31	R1mm	6.4	3.9	4.4	4	3.9	2.9	3.4	4.1
32	R5mm	5.7	3.9	3.6	2.8	3.8	2.6	2.9	3.3
33	R10mm	4.1	3	2.3	1.7	2.6	2.0	1.9	2.0
34	R20mm	2	1.5	1.1	0.7	1.2	1.1	0.9	0.8
35	R25mm	1.4	1.1	0.7	0.5	0.8	0.7	0.6	0.5
36	RX1day	7.9	5.8	4.4	2.9	4.9	3.8	3.7	3.3
37	RX5day	11.7	8.5	6.6	4.7	7.3	5.8	5.6	5.3
38	SDII	0.6	0.4	0.3	0.2	0.4	0.3	0.3	0.2

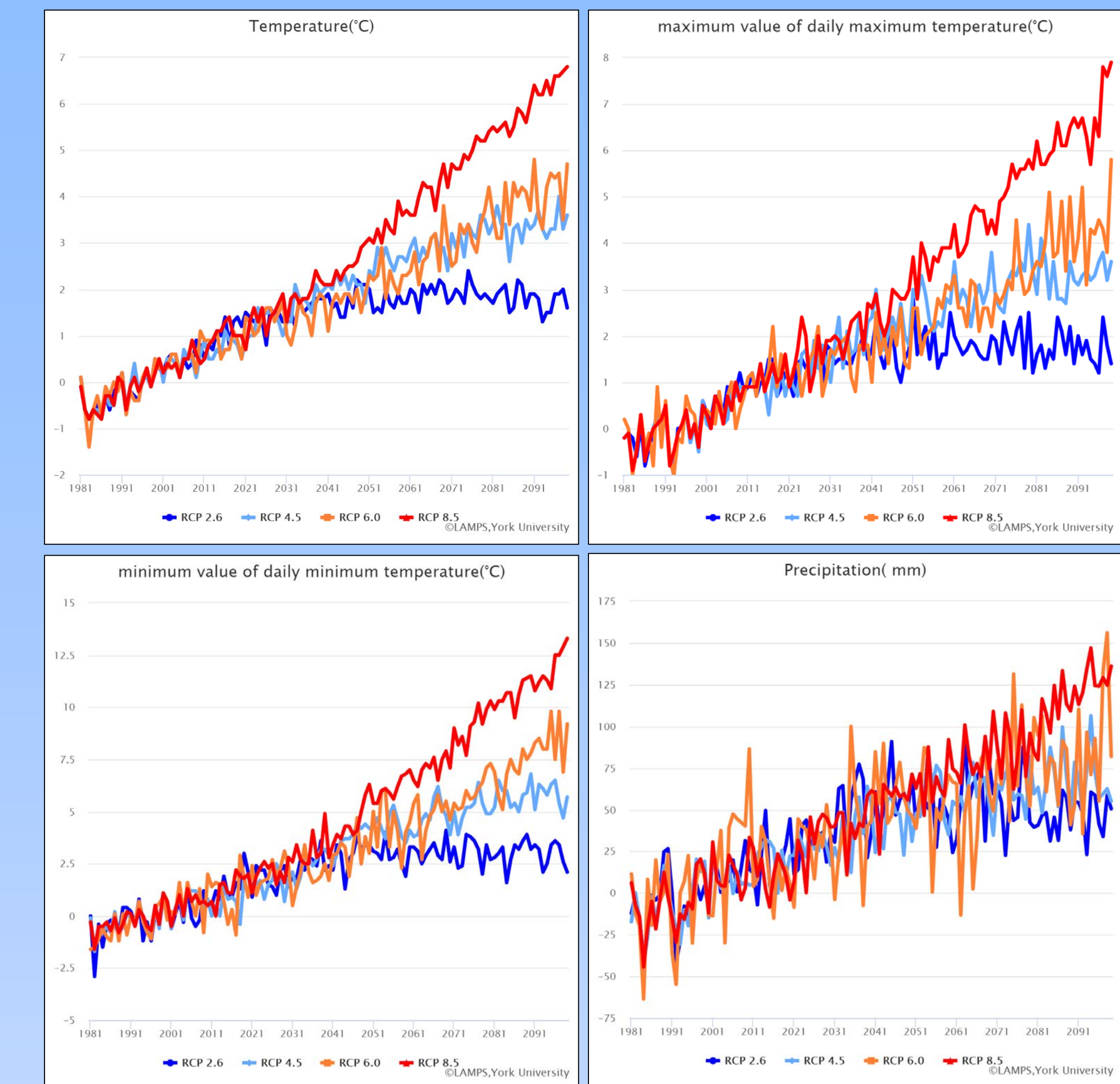


Fig.4 Ensemble median of annual anomalies of Tm, TXx, TNn and Pr relative to 1986-2005

Summary

Based on a large ensemble of downscaled high resolution daily temperature and precipitation data, future projections of averaged variables and extreme indices were produced. The projections for 2050s and 2080s were generated under all RCPs (2.6, 4.5, 6.0 and 8.5). A large number of interactive maps and time series were created and available through a temporary website. Final results (data, maps, figures and reports) will be published at the to be updated website:

yorku.ca/occp/

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* This work was funded by OMOECC

* The project is led by Professor Huaiping Zhu