

Building A Foundation

**Deriving Local Climate Change Projections and Guidance for
Use by Durham Region and Greenbelt Municipalities**

2019 Latornell Conservation Symposium

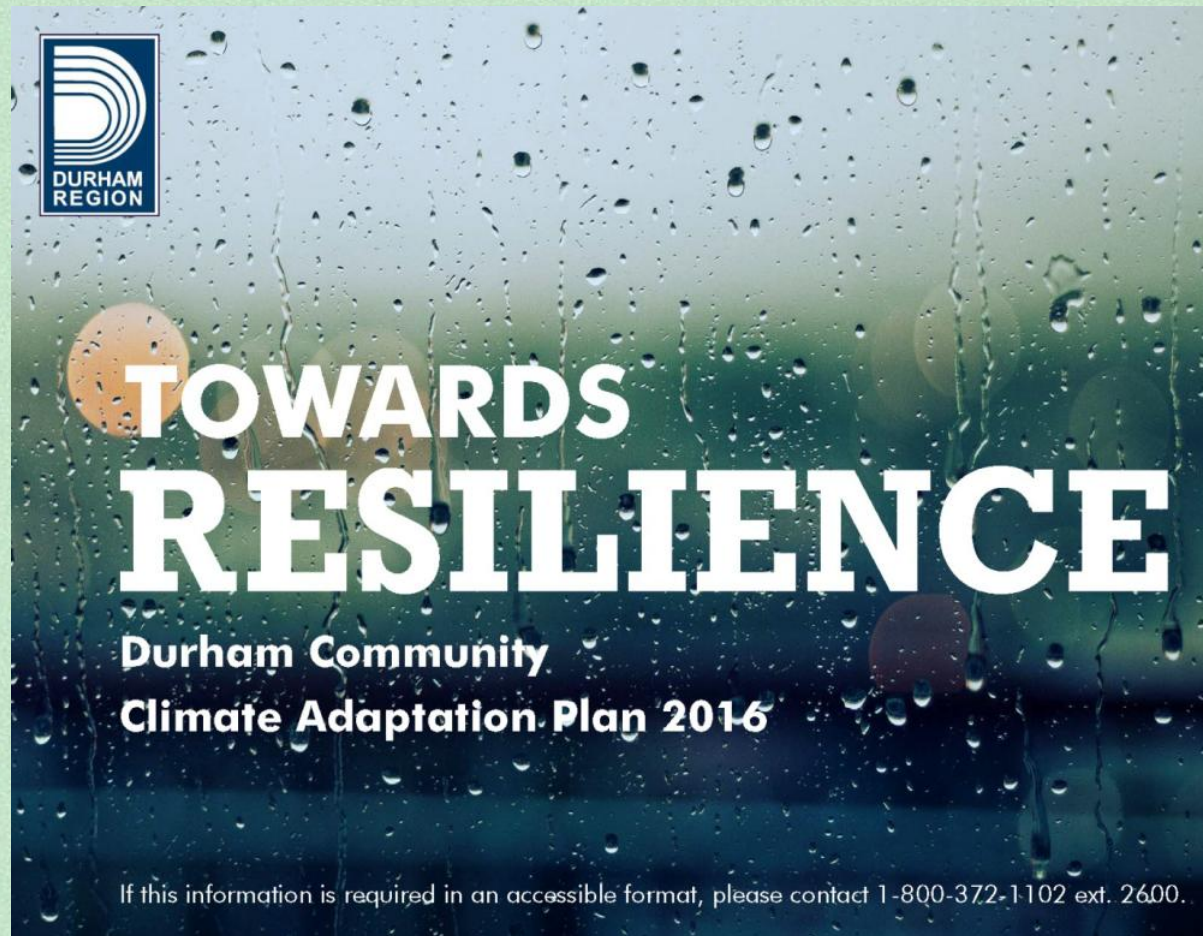
November 21st 2019

Ian McVey
Manager of Sustainability
Regional Municipality of Durham

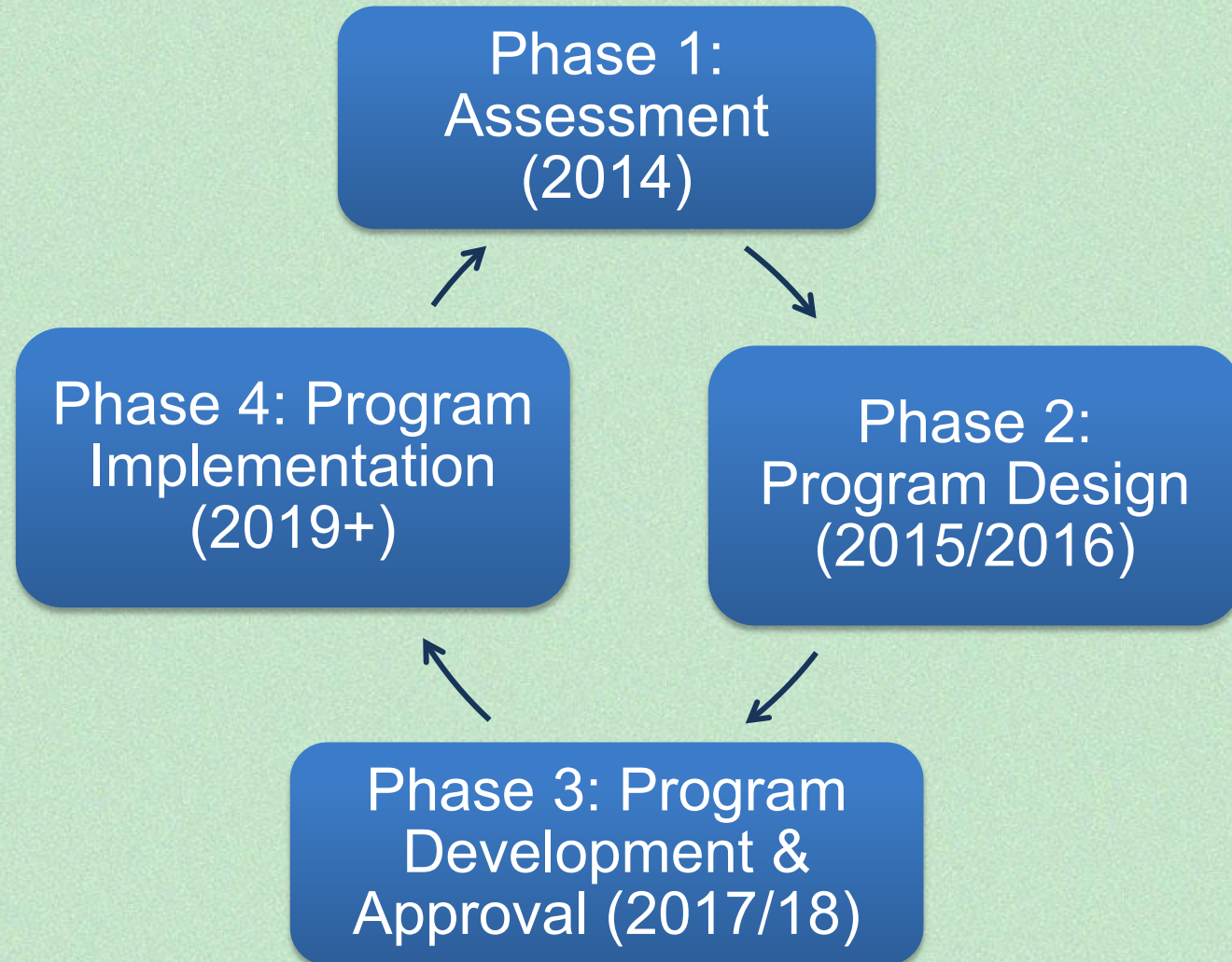
Jade Schofield
Project Manager - Sustainability and
Climate Change
Town of Whitby

Frances Delaney
Acting Project Manager,
Ontario Climate Consortium

Climate Adaptation Planning – The Durham Approach



Phasing and Schedule





Sector-based Expert Task Forces

Buildings

Electrical

Flooding

Food Security

Human Health

Natural Environment

Roads

Risk Assessment – likelihood and consequence

Figure 3: Risk Assessment (Roads)

Legend

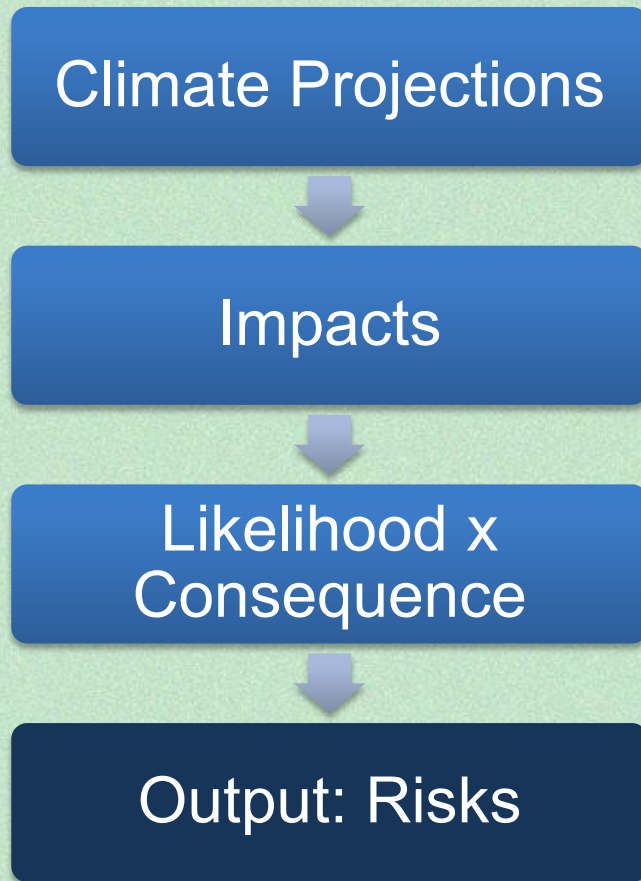
High Risk
Moderate Risk
Low Risk

Likelihood of impact →

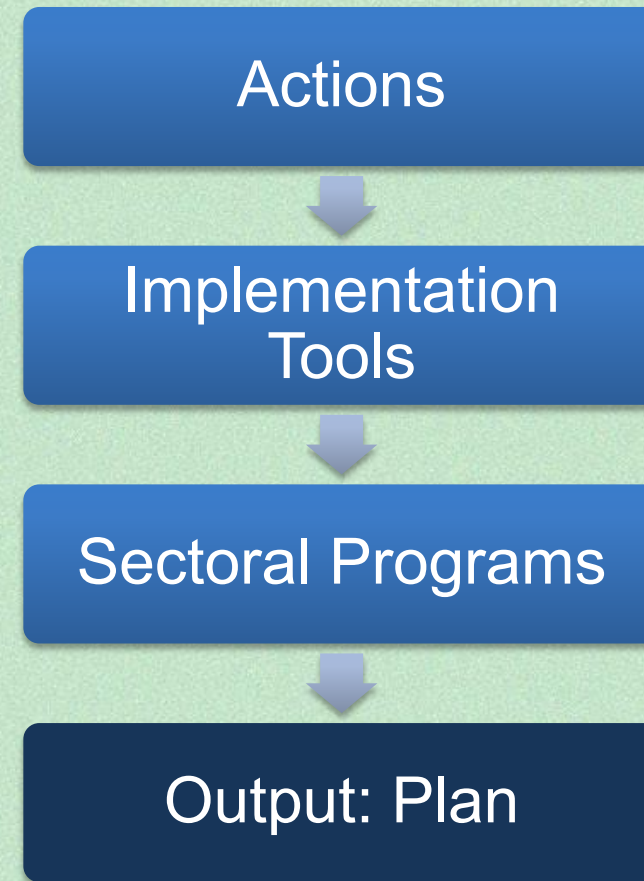
↑ Consequence

	1	2	3	4	5
5					Storm structures/embankments
4					Pavement softening (heat)
3			Pavement structure (storm)	Buckling of concrete structures (heat)	Pavement deterioration (less cold days)
2	Bridges (heat, less cold days)	Potholes (less cold days)		Sanitary sewers (storm)	Waterfront bluffs
1				Signposts/trees (storm)	Reduction in road salt (less cold days)

Phase 1: Assessment



Phase 2: Program Design



Phase 2: Program Design

Inventory Actions

- Literature review to identify best practice actions

Classify Actions

- Group actions according to type (e.g. regulations and plans, education and awareness, standards and codes, operational changes, and capital projects)

Program Concepts

- Combine actions into program concepts that address the needs in the community
- A total of 28 concepts were created

Design Charrette

- Expert task force members collaborated to identify gaps, overlaps, conflicts and improvements to the 28 proposals
- Narrowed down # based on overlaps

Integrated Plan

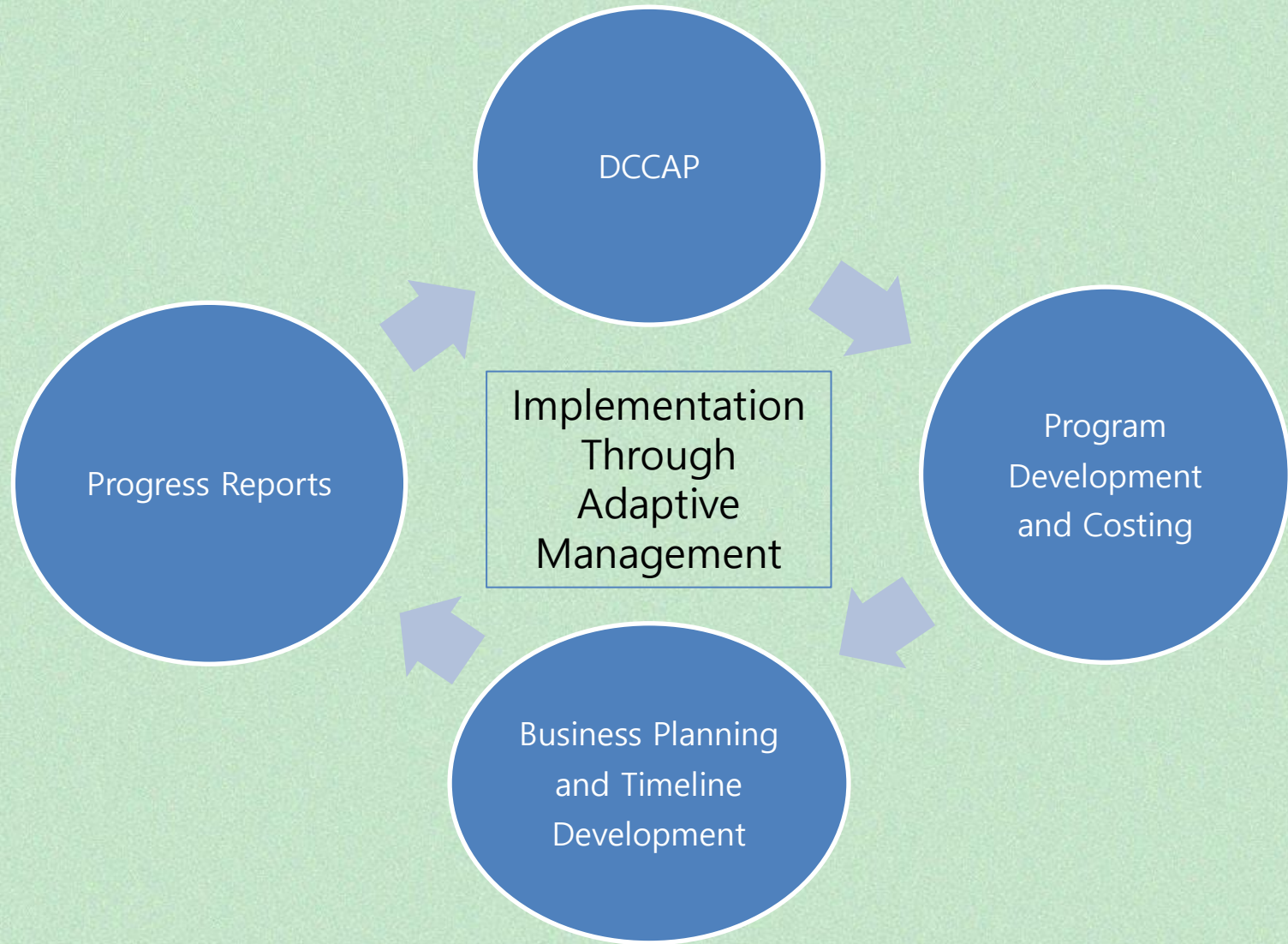
- Finalize program concepts into an integrated plan
- Approval from Regional Council



Phase 3: Program Approval and Funding

- Referral to responsible agencies/partners
- Further joint program development (next steps)
- Costing
- Incorporation into future business plans
- Annual reporting on progress

Phase 4: Program Implementation





Process Characteristics

Scientifically-based – SENES future climate study

Consultative – stakeholders across Durham

Rigorous – risk analysis

Peer-based – best practice analysis among municipalities

Collaborative – experts from stakeholder agencies created program proposals

Comprehensive – six sectors addressed, more to come



Roles and Responsibilities

Responsible Agencies:

- The Region of Durham
- 8 Local municipalities
- 5 Conservation authorities
- 4 Electrical utilities
- Provincial agencies
- Federal agencies
- Private sector

“It is expected that responsible agencies will respond to this Plan in a phased and measured manner consistent with their risk management policies and practices . Ultimately, however, it will be the role of each responsible agency to make informed decisions within its legal obligations and financial resources on whether and how to implement the programs recommended in this Plan.”



Keys To Success

Good Governance

Good data

Great collaboration

1. Durham Region Roundtable on Climate Change (DRRCC)

An official committee of Regional Council with monthly meetings

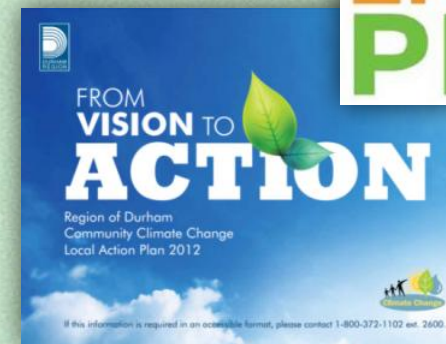
Membership:

- Regional Chair
- 4 Regional Councillors and 4 alternates
- CAO / Commissioner of Planning
- citizen members for small & large business, university, building & development industry, education, students, health, food, and general community

Mandate:

- education & outreach
- advocacy for policies, plans and programs
- leadership

Products:



2. Climate Projections

200 page projection of climate conditions in 2040s in Durham, completed Dec. 2013

Modelled on Toronto study in 2011

Data for all 8 local municipalities in Durham

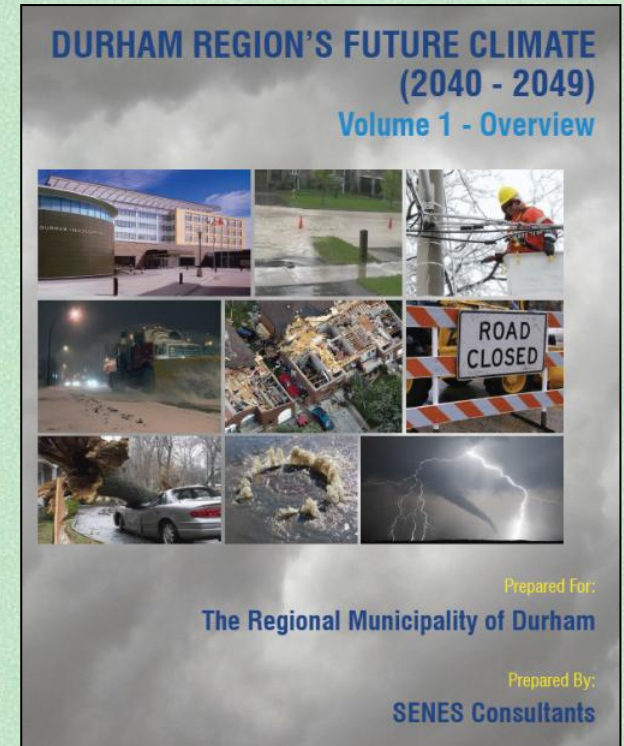
Downscaled to 1 km X 1 km cells (over city halls)

Averages and extremes

Resulted in much better understanding of climate impacts in Durham (removed skepticism)

Warmer, wetter, wilder (pages 15 & 16)

“Climate lock-in” (pages 13 & 14)





3. Expert Task Forces- Our Workhorses

7 Expert Task Forces: Buildings, Electrical Sector, Flooding, Food Security, Human Health, Natural Environment, Roads

63 experts from Region, municipalities, CAs, electrical utilities and private sector (Appendix 3)

Phase 1: Assessment

- Started with SENES Study
- Identified impacts
- Undertook risk assessment (likelihood X consequence) (Appendix 4)
- Joint meeting to compare risk assessments

Phase 2: Program Design

- Identify actions
- Group actions by implementation tools
- Package into proposed programs
- Design Charette

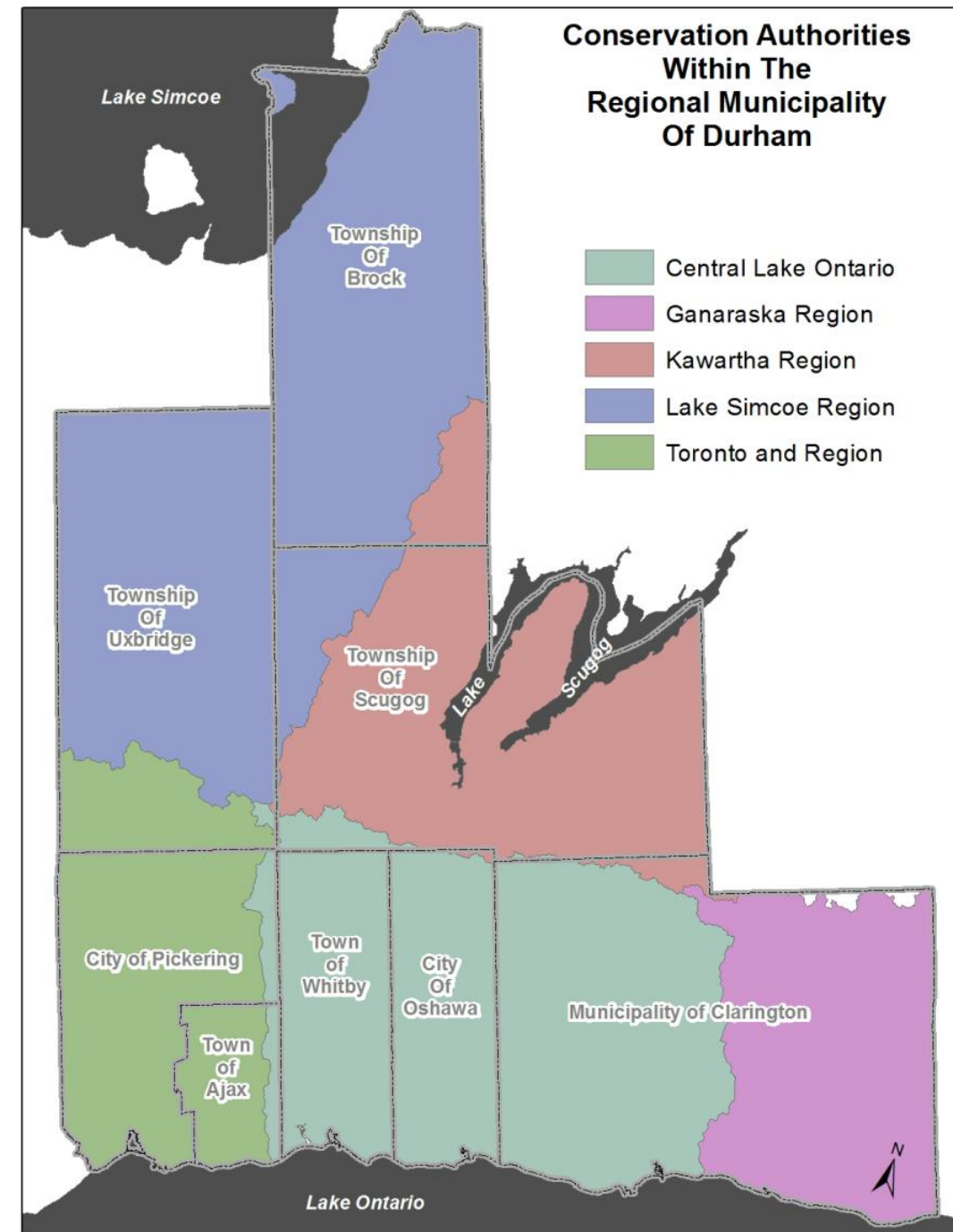


**Natural Environment
Climate Change
Collaborative**

DCCAP: The Natural Environment Sector

Working Group Comprised of Members from the Five Conservation Authorities and 8 Local Municipalities in Durham. The objective of the working group is to:

- Define the scope of the climate vulnerability & risk assessment for the natural environment.
- Identify vulnerabilities and likely impacts resulting from the climate projections in the SENES report, and
- Undertake a risk analysis on each impact and classify it as high, medium, or low risk.



Risk and Vulnerability Assessment

		Consequence				
		1	2	3	4	5
Likelihood	5				H, K, L, P, AA, AC, A	F, J, S
	4				A, G, M, Q*, R, Z, AB	D, E, I, T, U, V, W, X, Y
	3				N, O	
	2				B, C	
	1					

- HIGH RISK
- MODERATE RISK
- LOW RISK

A		Changes in Shallow Aquifers
B	Groundwater Quantity	Changes to Groundwater Discharge Areas
C		Changes to Groundwater Recharge Areas
D		Changes in Pathogen Concentrations
E	Surface Water Quality	Changes in Nutrient concentrations
F		Changes in Background Conditions (e.g., pH, Temp etc.)
G		Changes in Stream Erosion
H	Surface Water Quantity	Changes in Extreme High Flows
I		Changes to Baseflow
J		Changes to Seasonal Flow Regime
K		Changes in Landscape Level Connections
L		Changes to Habitat Matrix (Diversity of Habitat)
M	Terrestrial Habitat	Changes to Abiotic Features of Habitat (e.g., Soil Moisture)
N		Changes to Habitat through Changes in Habitat Succession
O		Changes to Species Range
P	Terrestrial Species (Flora and Fauna)	Changes in Species Presence (extirpation)
Q		Changes Due to Insects or Disease
R		Changes in Life History Traits
S		Changes in Hydrology
T	Aquatic Habitat	Changes in Thermal Regimes
U		Changes to In-stream Habitat
V		Changes in Trophic Structures
W		Changes to Species Range
X	Aquatic Species	Changes in Species Presence (extirpation)
Y		Changes Due to Insects or Disease
Z		Changes in Life History Traits
AA		Changes Due to Insects or Disease
AB	Urban Tree Health	Changes due to Abiotic Features (e.g., increase Cl Concentrations along roads), soil moisture)
AC		Changes due to Extreme Events (wind, ice)
AD		Changes to Species Range

Natural Environment High & Medium Risks

Expert Task Force Area	High Risk Impacts	Medium Risk Impacts
Groundwater Quantity		changes to shallow aquifers, groundwater discharge and recharge areas
Urban Tree Health	changes to: insects or disease, species range, extreme events	changes to abiotic features
Surface Water Quantity	changes to: stream erosion, extreme high flows	changes in base flows, seasonal flows
Surface Water Quality	changes in: background conditions	changes in pathogen concentrations, nutrient concentrations
Terrestrial Habitat	changes to: landscape level connections, abiotic features of habitat	changes to habitat matrix and succession
Terrestrial Species	changes to: species range and presence, insects and diseases, life history traits	
Aquatic Habitat	changes in: hydrology, thermal regimes	changes to in-stream habitat
Aquatic Species	changes in: trophic structures, species range and presence, alien invasive species and disease, life history traits	

Natural Environment Program

GOAL:

To achieve climate change resilience in the natural environment through:

- Adaptive Management of Plans & Policies
- Collaboration
- Stewardship, Education & Outreach





Natural Environment Climate Change Collaborative

Purpose:

“The Natural Environment Climate Change Collaborative/ Committee will support implementation of the Natural Environment Sector Objectives and Programs as contained in “Towards Resilience Durham Community Climate Adaptation Plan 2016”.

The Committee consists of a Chair, Vice-Chair, and Committee members.

The Committee meets quarterly

The Committee receives an annual budget from the Region of Durham to support:

- Coordinator duties
- Meeting costs
- Source funding for projects/grants/funding proposals

Funding & Structure

- Meet Four Times Per Year
- Formal Terms of Reference and Workplan
- Sub Committees can be formed for specific projects
- Funding provided by the Region of Durham to support
 - Coordinator
 - Summit
 - Workplan Items



NECCC Coordinator

Funded by the Region of Durham the role of the Coordinator includes, but is not limited to:

- Providing support and administrative services for the Chair & Committee
- Supporting the implementation of the annual work plan
- Participating on subcommittees of the Committee
- Supporting collaboration & funding opportunities
- Supporting the coordination of key Collaborative events



Natural Environment Summit

First Summit took place in March 2019.

Approx. 120 attendees (primarily staff from CA's and municipalities).

Full day session showcasing projects and case studies that address climate action and help to advance the natural environment.

2nd Summit Scheduled for March 10th 2020





DURHAM REGION ENSEMBLE CLIMATE CHANGE MODEL



- Range of climate projections
- Extremes and averages
- Climate data
- Replicable and transferable

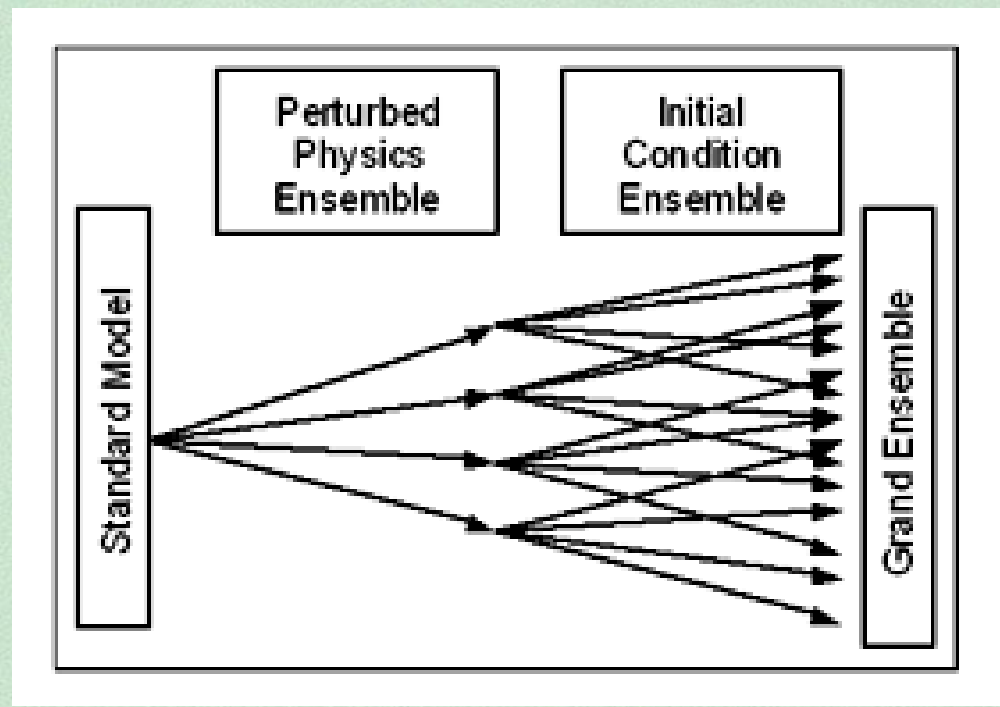


Image credit: Climate Prediction.net



A stylized illustration of a winter forest. The scene is dominated by two large, dark teal trees in the foreground, their branches reaching upwards. The background consists of lighter green and greyish-green trees, creating a sense of depth. The ground is covered in a layer of white snow, and numerous small white dots are scattered throughout the scene, representing snowflakes or frost. The overall aesthetic is clean and modern, with a focus on geometric shapes and a muted color palette.

**Durham Region Climate
Ensemble Model**

Preliminary Results

Presentation Outline



1. Introduction to Climate Modeling
2. Research Scope & Process
3. Methodology
4. Preliminary Results
5. Next Steps and Deliverables

Ontario Climate Consortium



Analyzing and Applying
Climate Information



Providing Planning and
Research Support for
Adaptation and Mitigation



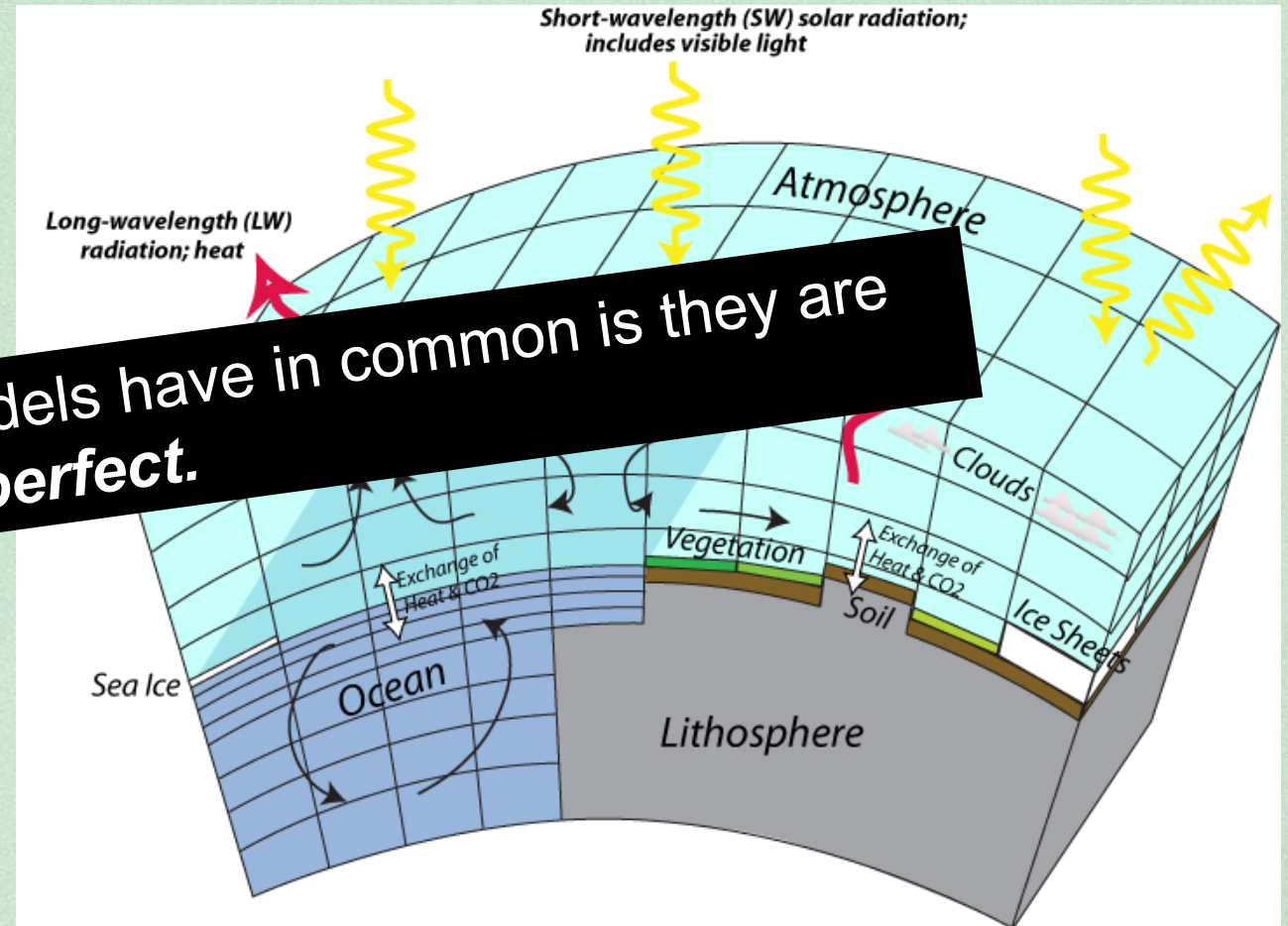
Mobilizing Research through
Communications and
Engagement

The OCC was established in 2011 as a centre of expertise providing research and analysis services to municipalities, conservation authorities, and the broader public sector.

Climate Modeling – Basic Principles

- Based on physical processes used to simulate the transfer of energy and materials through the climate system
- Use mathematical equations to characterize how energy and matter interact
- Use numerical methods, including repeatedly solving the equations using powerful supercomputers

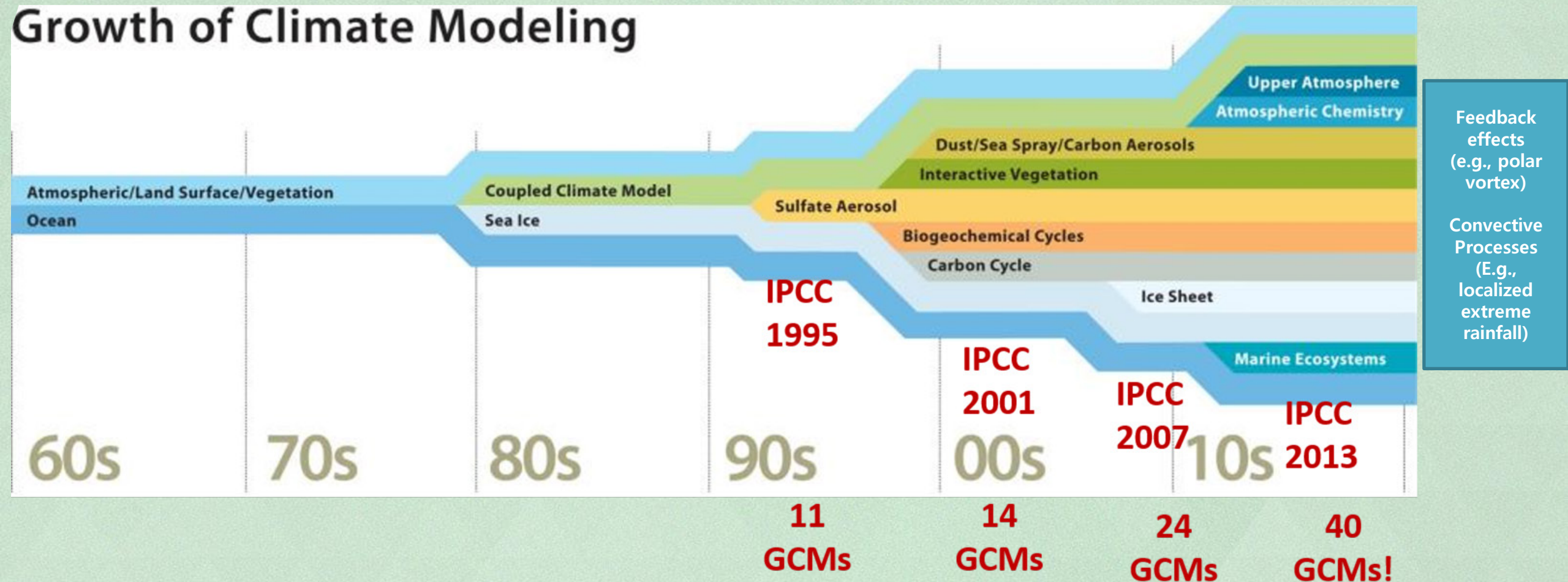
The only thing all climate models have in common is they are imperfect.



A Brief History of Climate Modeling

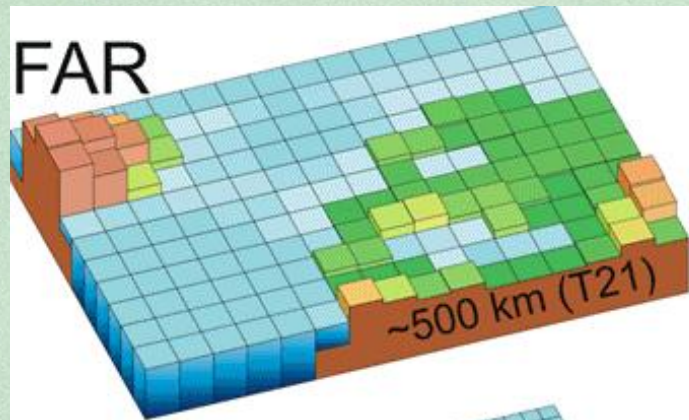


Growth of Climate Modeling

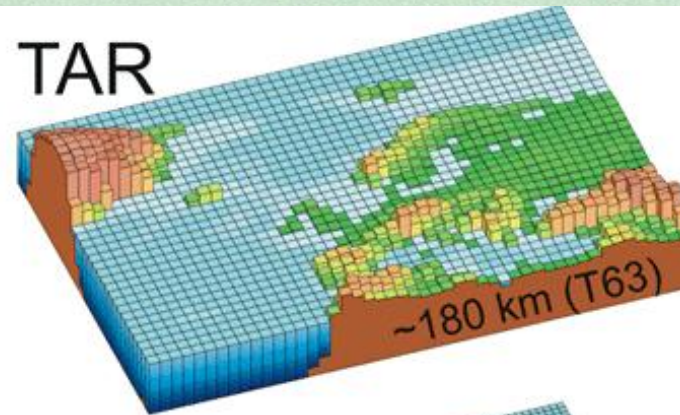


As Global Climate Models have Advanced, so has their Spatial Resolution...

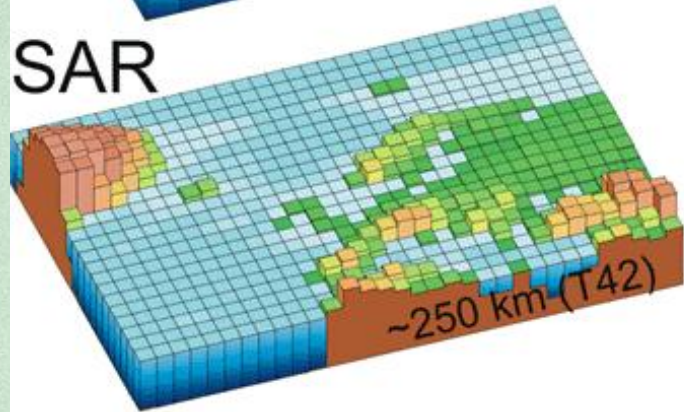
IPCC (1990)



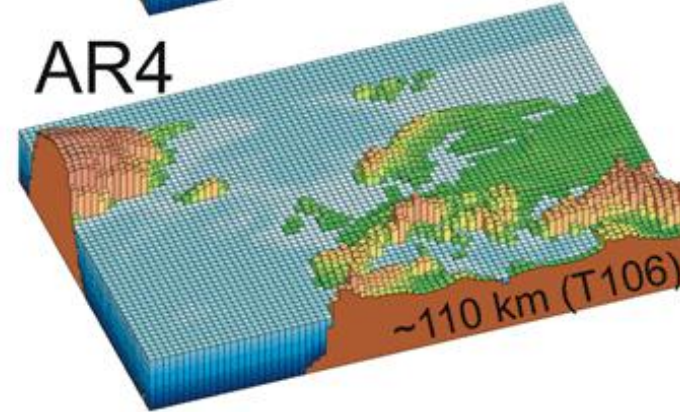
IPCC (2001)



SAR



AR4



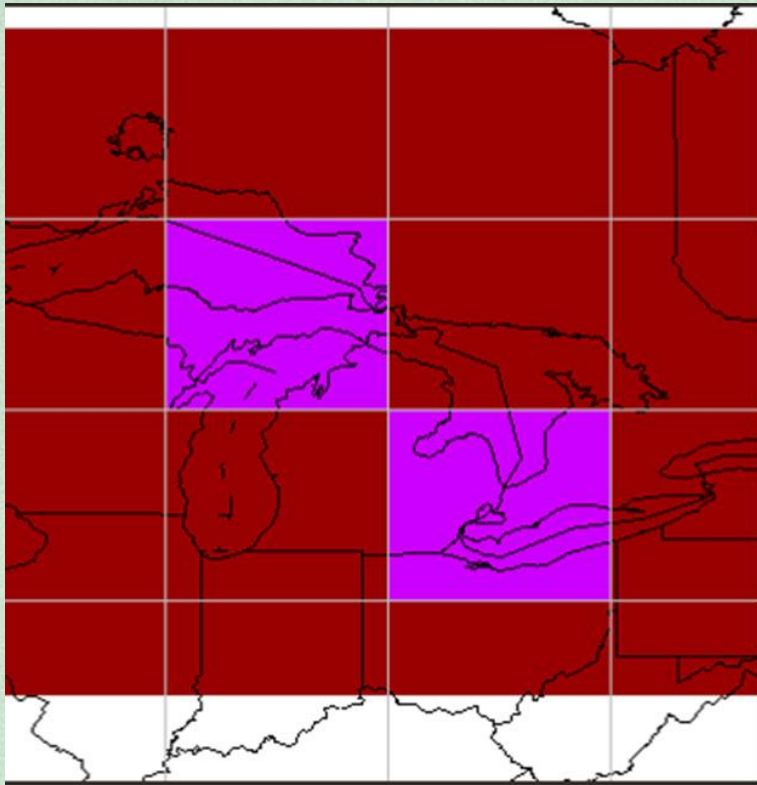
IPCC (1995)

IPCC (2007)

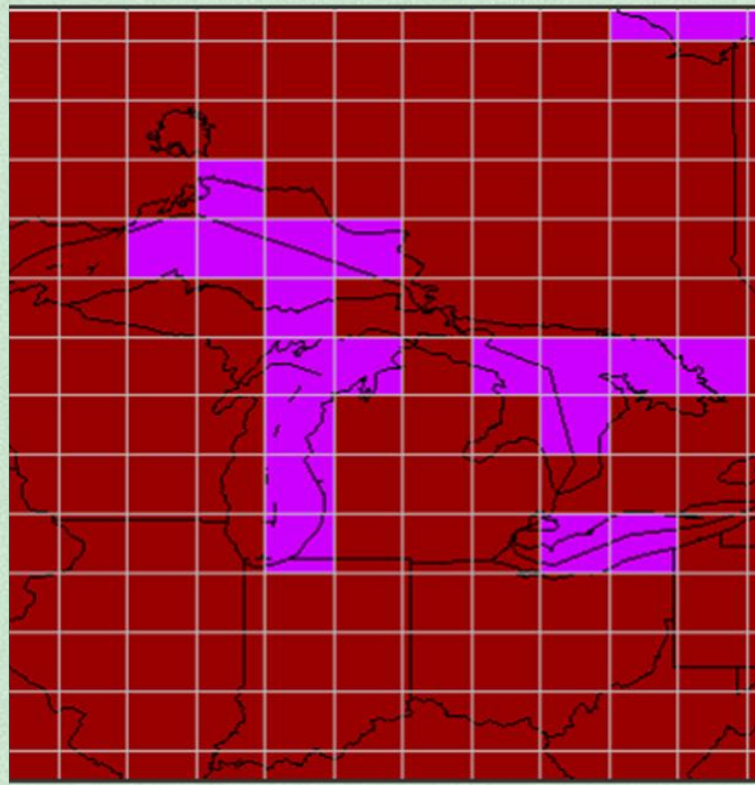


IPCC (2013) – AR5

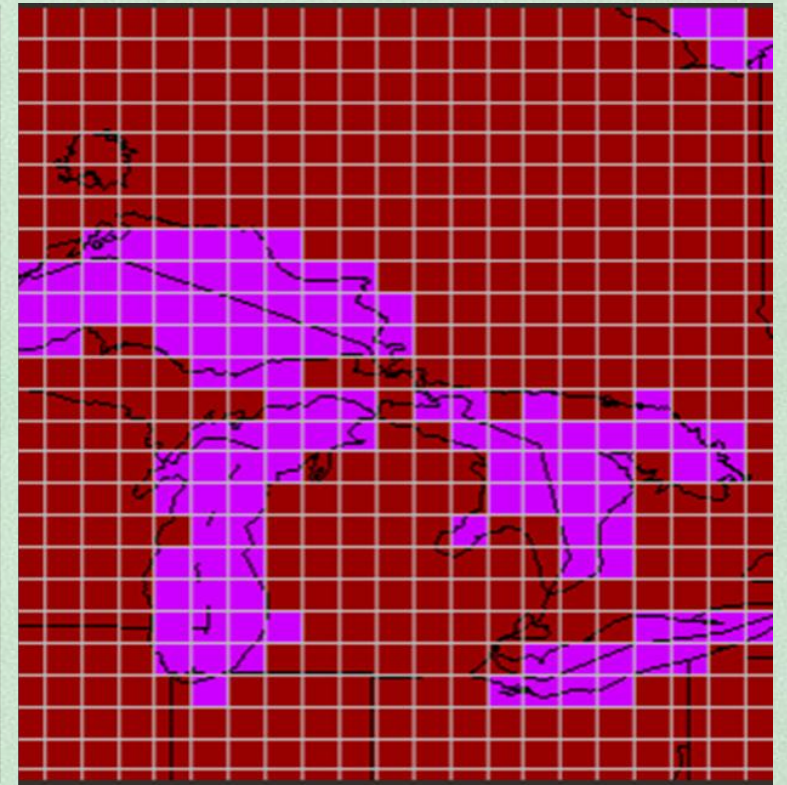
Spatial Resolution Matters, Especially in the Great Lakes Basin...



IPCC 2013 GCM



**Regional Climate Model
(50 x 50km)**

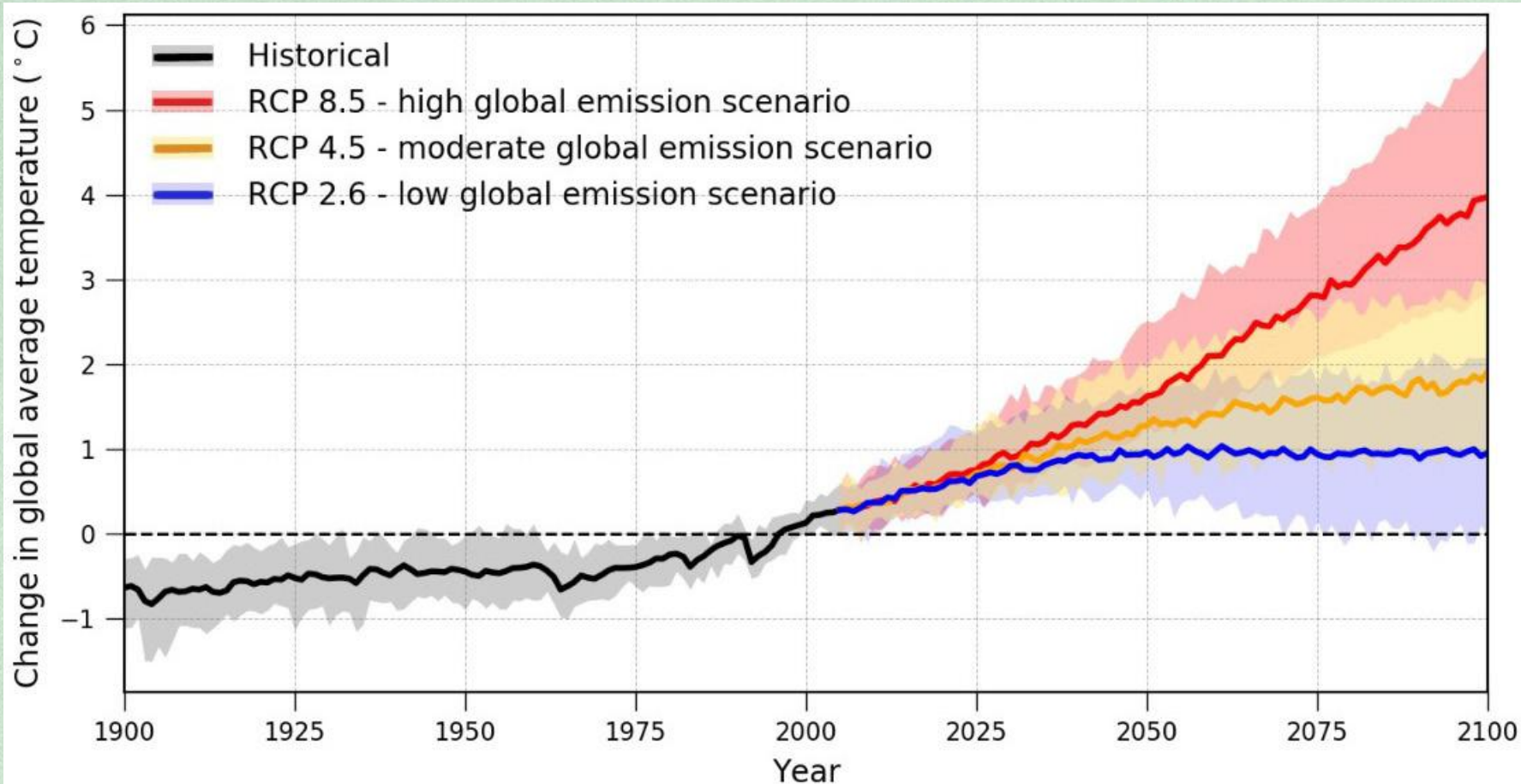


**Regional Climate Model
(25 x 25km)**

Which is Preferable: Using a GCM or RCM?

- It really depends on the region – RCMs likely better for complex terrain, mountains, and lake regions (*IPCC, 2013*)
- Global climate models tend to underestimate thunderstorm activity and rainfall – need finest scale models, current data
- However, increased model resolution does not guarantee superior model performance for all variables and all time-scales (e.g., temperatures) (*Ouranos, 2016*)
- Thus, taking an ensemble approach using a compilation of RCMs can account for uncertainties & provide a balance while also providing a ‘physics-based’ interpretation of climate (i.e., not only mathematical)

Climate Change Scenarios

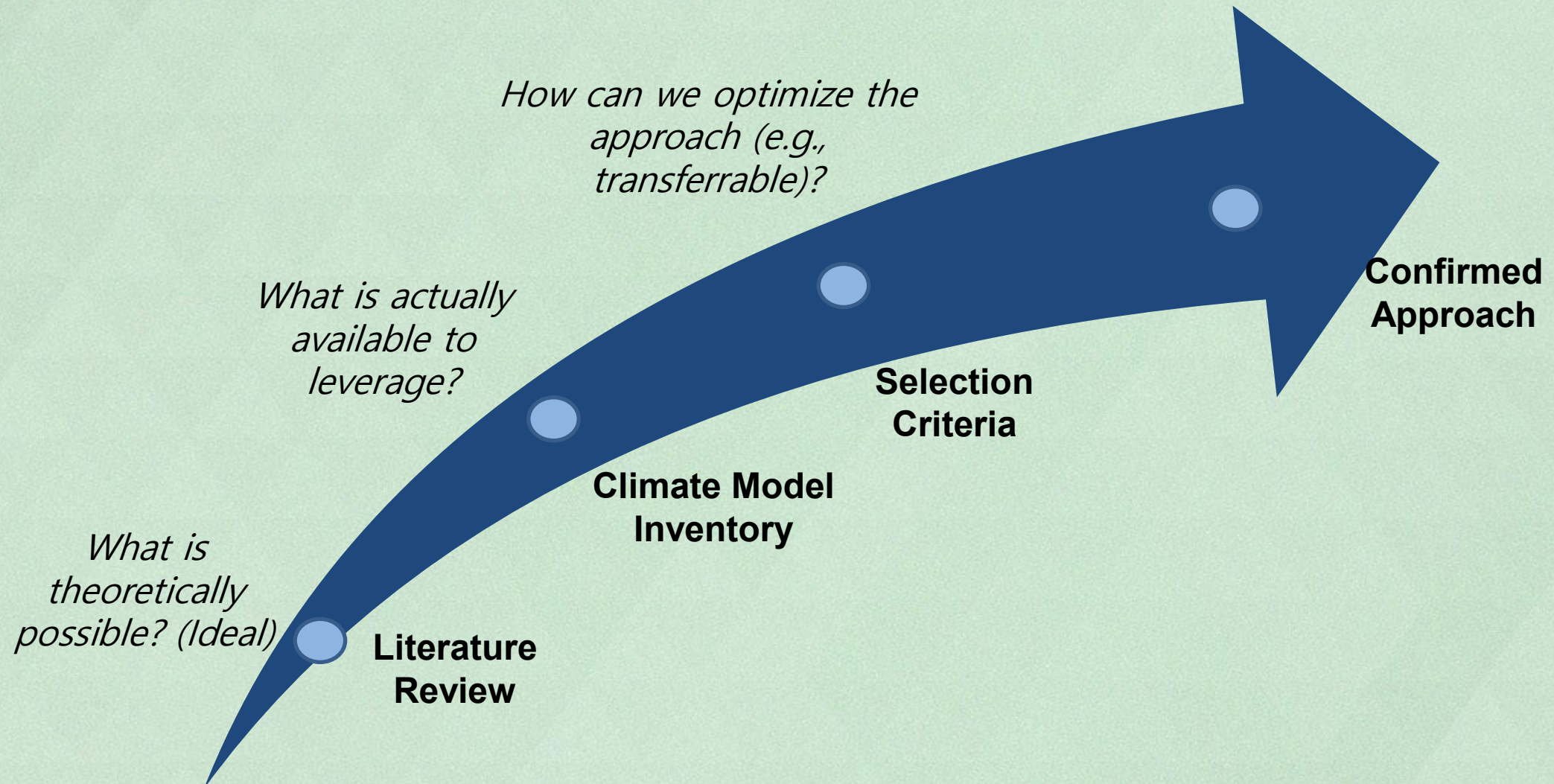


How do we actually achieve these?

What do the impacts and risks look like?

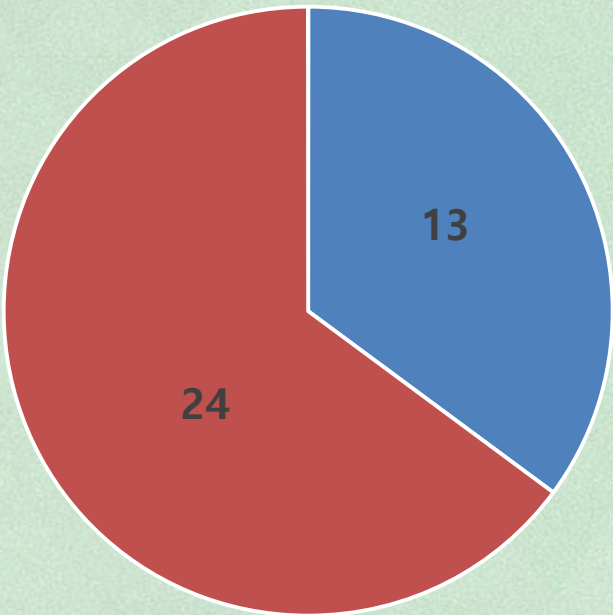
What information do these not include?

Research Scope and Process



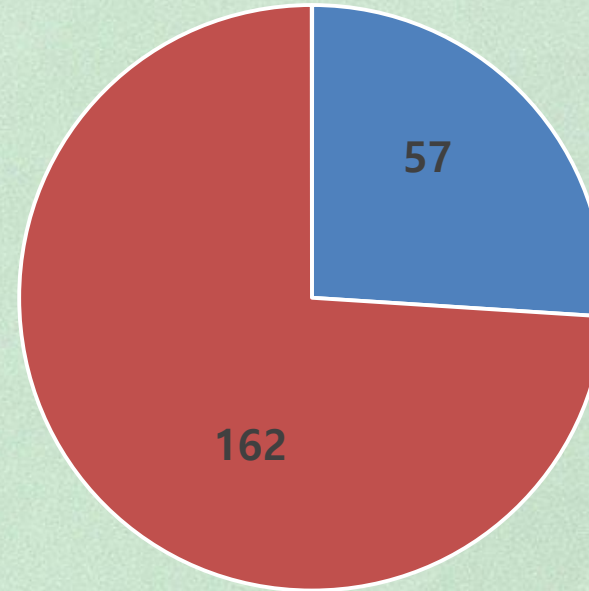
Research Findings (for the Great Lakes Region)

How many Climate *Portals or Sources*
Exist?



■ Historical ■ Future

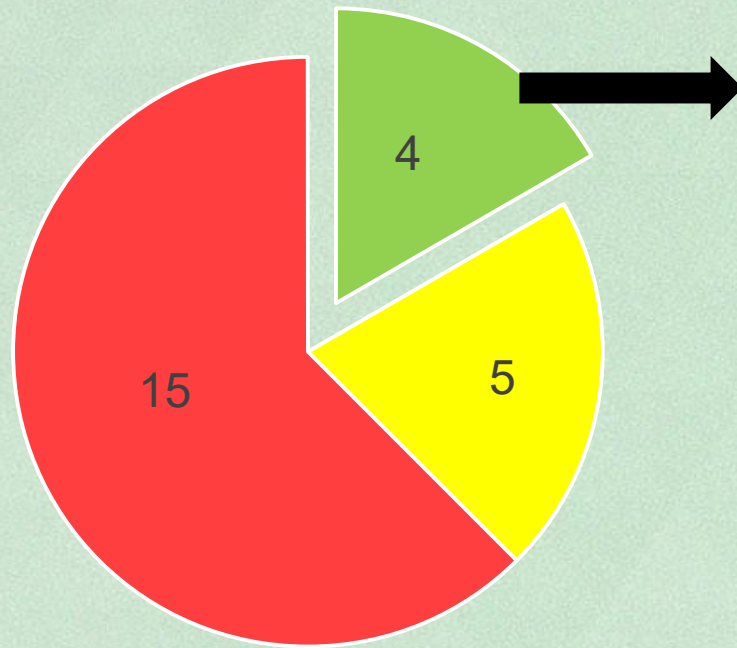
What types of Climate Models have been
Produced?



■ Regional Climate Model Runs ■ Global Climate Model Runs

Refining this for use in Durham

Analysis of Future Climate Data Sources



■ Tier 1 ■ Tier 2 ■ Tier 3

Selection Criteria

1. Great Lakes influences and processes are represented
2. Precedent exists for its use in the Great Lakes and Ontario
3. Spatial Resolution is refined (at least 25km by 25km)
4. Ensemble of models and model runs
5. Data is accessible
6. Daily data is available

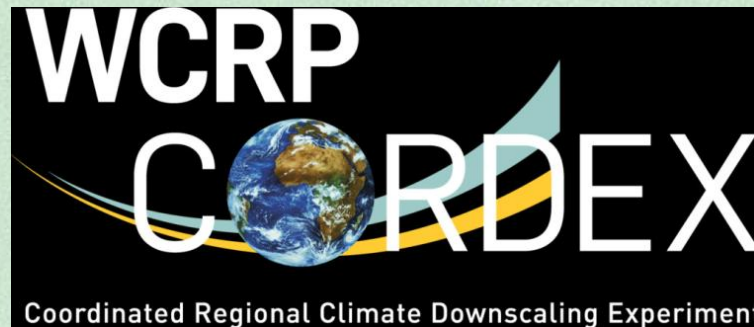
What Climate Data Made it to Tier 1?

Two major sources of data: 5 RCM Ensembles and 32 GCM downscaled runs (209 model runs in total)



15 RCM runs developed to capture lake effects

Ensemble of 16 GCM- RCM runs, including the Canadian RCM

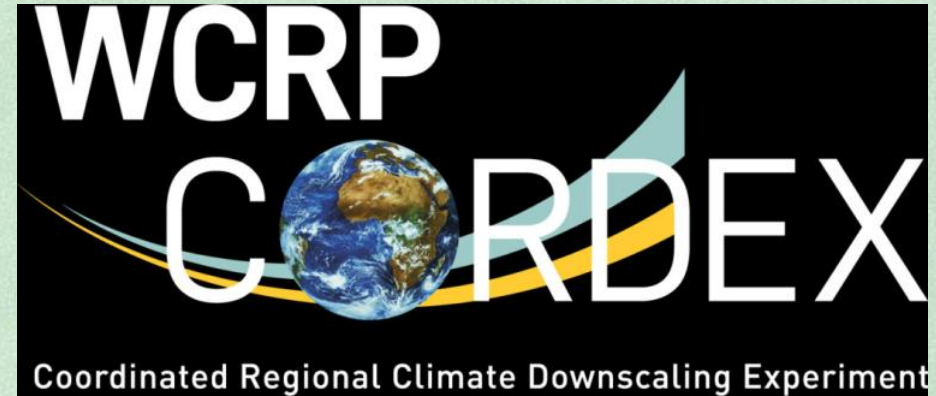


6 RCM Ensembles for use specific to Great Lakes region

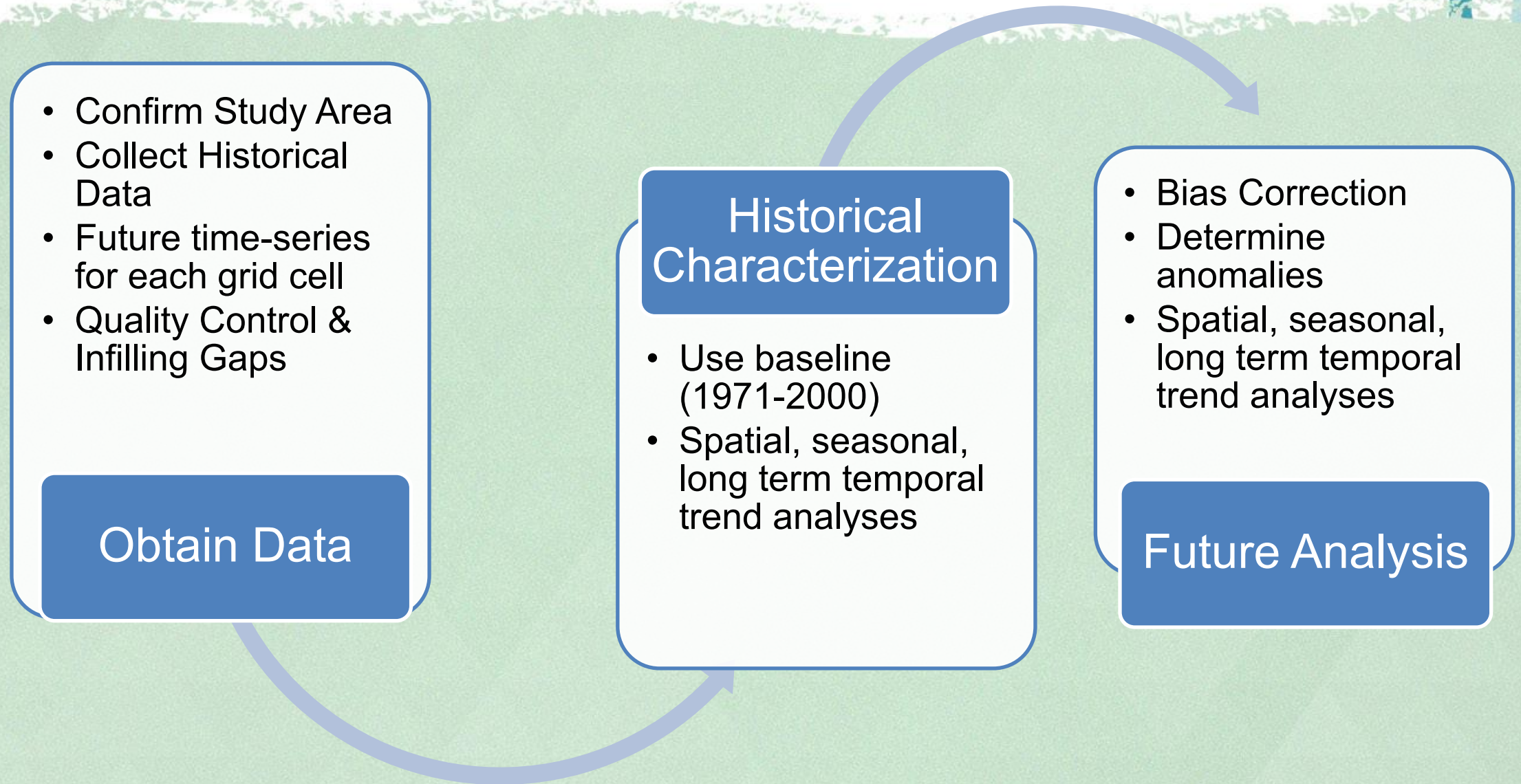
Approach Used for the Region

Checked the most points from the evaluation criteria:

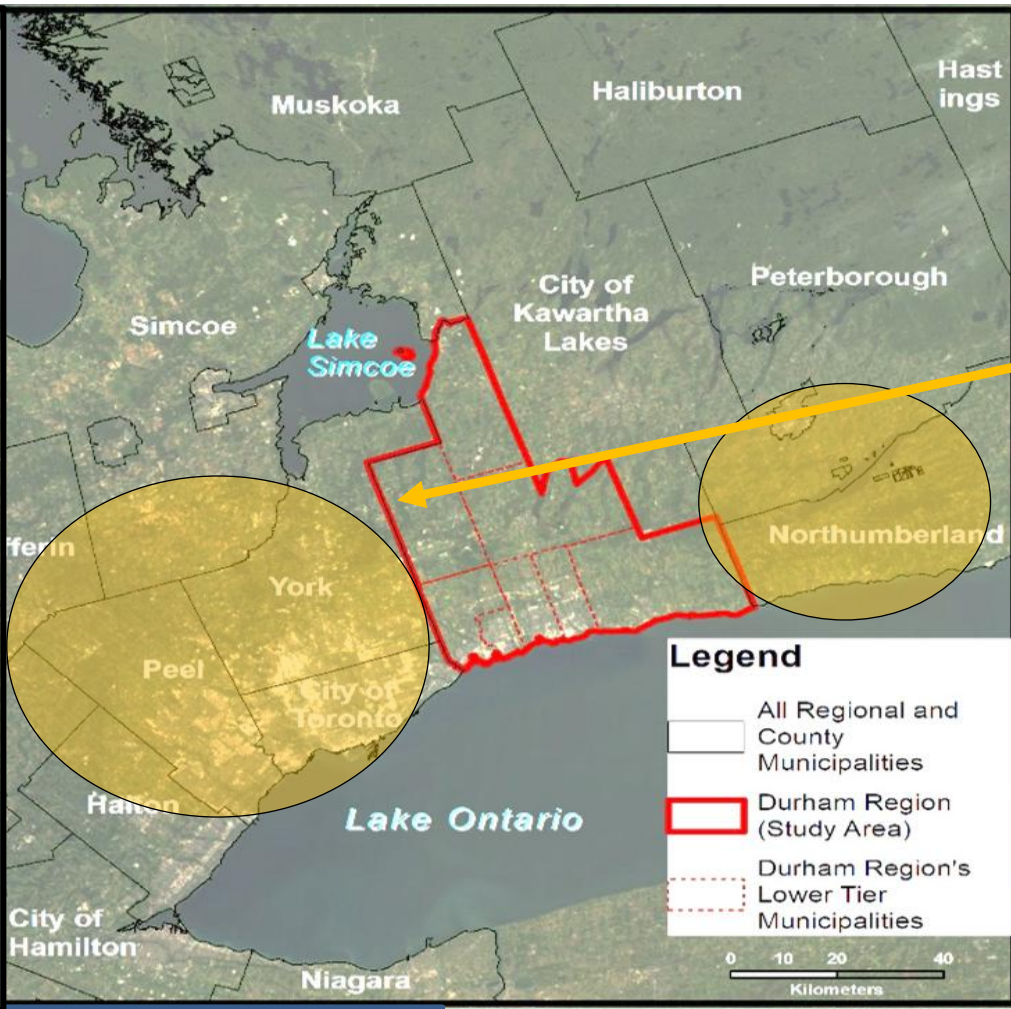
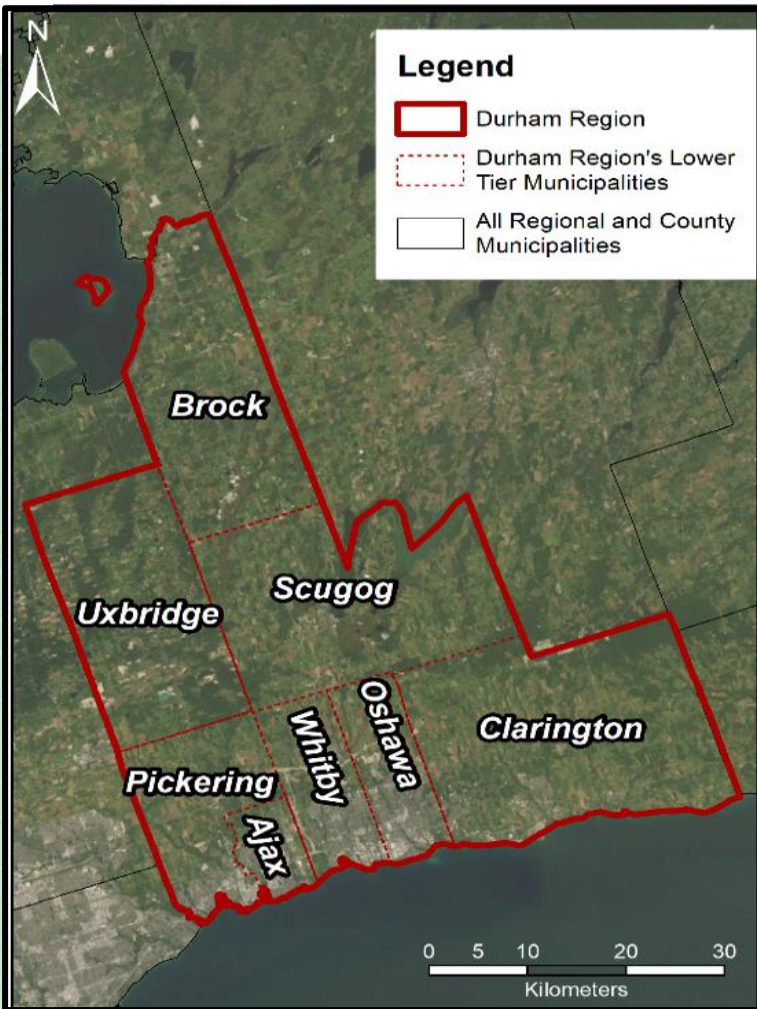
- Easily accessible
- 25 km by 25 km resolution
- Includes RCP 4.5 and 8.5
- Has hourly and daily data
- Includes incorporation of Great Lakes
- Is a robust (good size) ensemble of 16 model runs



Approach



Study Area




TRCA undertaking a similar approach to update their climate data

Ganaraska Region C.A. interested in leveraging the same approach for the remainder of their jurisdiction

Consistent Climate Information builds momentum in Durham Region and Adds Value to Durham stakeholders

Historical Data Accessed for Durham Region...

[Français](#)

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Historical Data

To determine data availability for a custom location and date, please complete and submit one of the following searches:

[Search by Station Name](#) | [Search by Province](#) | [Search by Proximity](#)

[How to Use - Search by Station Name](#)

Name:

contains begins with

with data available between: to

with data on:

Display results per page.

Raw Climate Station data
from Environment Canada

Station Name	Latitude	Longitude	Elevation above Sea Level (m)
Bowmanville Mostert	43.92°N	78.67°W	99.1
Burketon McLaughlin	44.03°N	78.8°W	312.4
Oshawa WPCP	43.87°N	78.83°W	83.8
Tyrone	44.02°N	78.73°W	205.7
Cobourg STP	43.97°N	78.18°W	79.2
Richmond Hill	43.88°N	79.45°W	240
Frenchman's Bay	43.82 °N	79.08°W	76.2

Extracting Future Climate Data

GCMs

RCMs

Downloaded daily temperature and precipitation data for:

- RCP 4.5 and RCP 8.5 Scenarios
- Up until 2100

16 model run Regional Climate Model Ensemble consisting of the following...

- Dynamically-downscaled (physics-based) models run by differing boundary conditions (to account for uncertainties)
- “Raw” climate model output at 25 x 25 km grid cells, downscaled further to 10 x 10 km grid cells

NA-CORDEX Search

NA-CORDEX Documentation: Explanation of Dataset Facets

Variable	Experiment	Driver	Model	Frequency	Grid	Bias Correction
<input checked="" type="checkbox"/> prec	<input type="checkbox"/> eval	<input type="checkbox"/> ERA-Int	<input type="checkbox"/> CanRCM4	<input type="checkbox"/> fixed	<input type="checkbox"/> NAM-11	<input type="checkbox"/> mbcn-METDATA
<input type="checkbox"/> temp	<input type="checkbox"/> hist	<input type="checkbox"/> CNRM-CM5	<input type="checkbox"/> CRCM5-OUR	<input type="checkbox"/> 1hr	<input type="checkbox"/> NAM-22	<input checked="" type="checkbox"/> raw
<input type="checkbox"/> tmax	<input type="checkbox"/> rcp26	<input type="checkbox"/> CanESM2	<input type="checkbox"/> CRCM5-UQAM	<input type="checkbox"/> 3hr	<input type="checkbox"/> NAM-44	
<input type="checkbox"/> tmin	<input type="checkbox"/> rcp45	<input type="checkbox"/> EC-EARTH	<input type="checkbox"/> HIRHAM5	<input type="checkbox"/> 6hr	<input checked="" type="checkbox"/> NAM-22i	
<input type="checkbox"/> huss	<input checked="" type="checkbox"/> rcp85	<input type="checkbox"/> GEMatm-Can	<input type="checkbox"/> RCA4	<input checked="" type="checkbox"/> day	<input type="checkbox"/> NAM-44i	
<input type="checkbox"/> ps		<input type="checkbox"/> GEMatm-MPI	<input type="checkbox"/> RegCM4	<input type="checkbox"/> mon		
<input type="checkbox"/> rsds		<input type="checkbox"/> GFDL-ESM2M	<input type="checkbox"/> WRF	<input type="checkbox"/> seas		
<input type="checkbox"/> uas		<input type="checkbox"/> HadGEM2-ES		<input type="checkbox"/> ann		
<input type="checkbox"/> vas		<input type="checkbox"/> MPI-ESM-LR		<input type="checkbox"/> ymon		
<input type="checkbox"/> hurs		<input type="checkbox"/> MPI-ESM-MR		<input type="checkbox"/> yseas		
<input type="checkbox"/> prhmax						
<input type="checkbox"/> sfcWind						
<input type="checkbox"/> orog						
<input type="checkbox"/> sftlf						
<input type="checkbox"/> pr						
<input type="checkbox"/> tas						
<input type="checkbox"/> tasmax						
<input type="checkbox"/> tasmin						

Search Clear Search

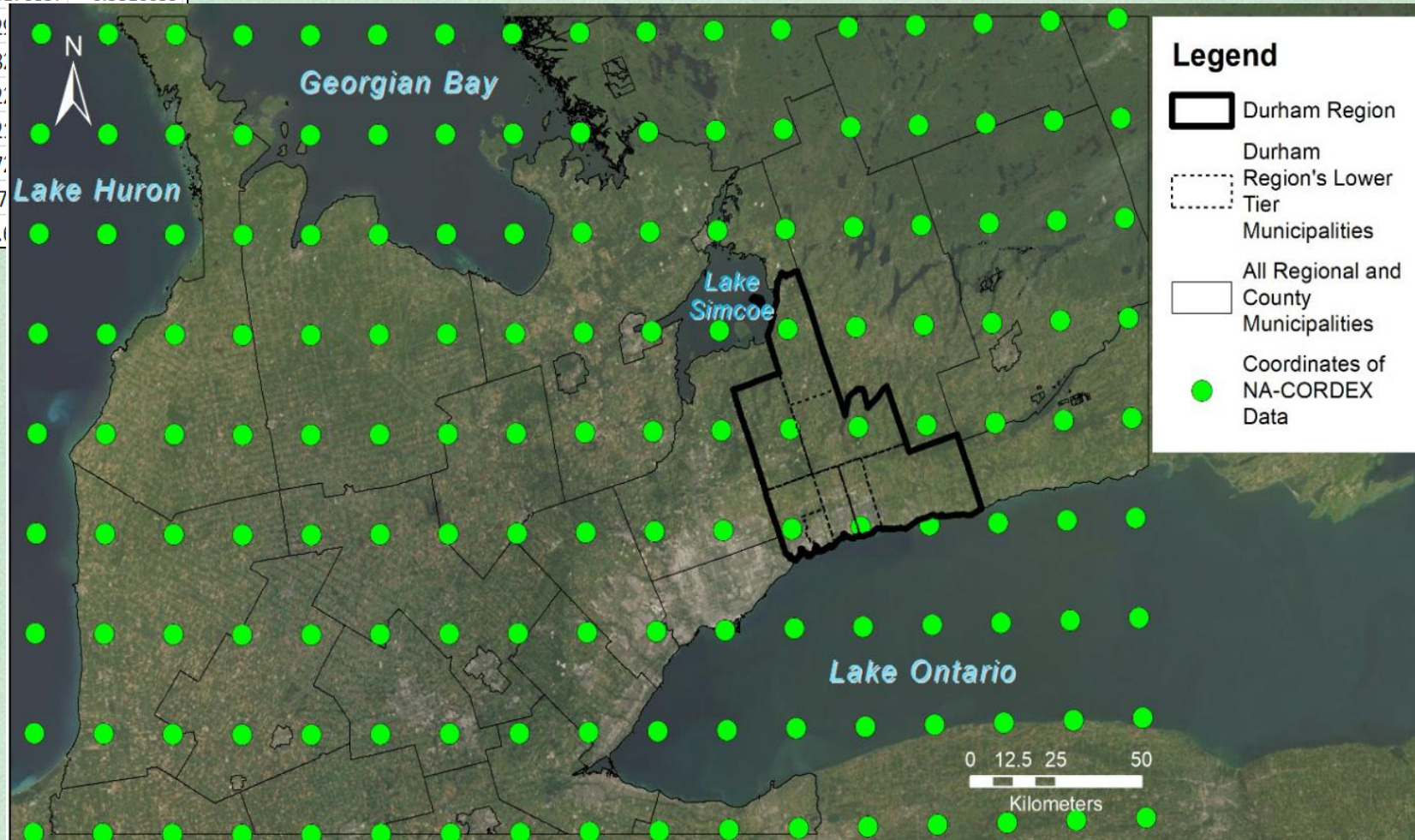
16 files

Download Options For Selection

File	Size	Subset File	NetCDF Header
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<input type="checkbox"/> prec.rcp85.CNRM-CM5.CRCM5-OUR.day.NAM-22i.raw.nc	20.01 GB	<input type="checkbox"/> Subset	View
<input type="checkbox"/> prec.rcp85.GFDL-ESM2M.CRCM5-OUR.day.NAM-22i.raw.nc	20 GB	<input type="checkbox"/> Subset	View

NA-CORDEX Data

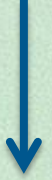
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2	1	-81.875	45.125	6.767374053	-0.790456757	-0.74687766	-3.354208	-4.2099819
3	2	-81.625	45.125	6.288806184	-1.438305633	-1.73731686	-4.5105102	-5.962445
4	3	-81.375	45.125	5.886454443	-1.837147852	-2.31300845	-4.4176837	-6.5316059
5	4	-81.125	45.125	6.175955322	-1.545968506	-1.88355396	-3.29	
6	5	-80.875	45.125	6.975353245	-0.99812698	-1.78596878	-2.8	
7	6	-80.625	45.125	7.396912489	-0.688475695	-2.36425694	-3.2	
8	7	-80.375	45.125	7.300751634	-0.791289381	-3.42889314	-4.2	
9	8	-80.125	45.125	6.021597107	-1.753183166	-5.17154864	-5.7	
10	9	-79.875	45.125	4.301487789	-3.182337895	-6.90417017	-7	
11	10	-79.625	45.125	3.879214494	-3.71197203	-7.16567686	-7.1	



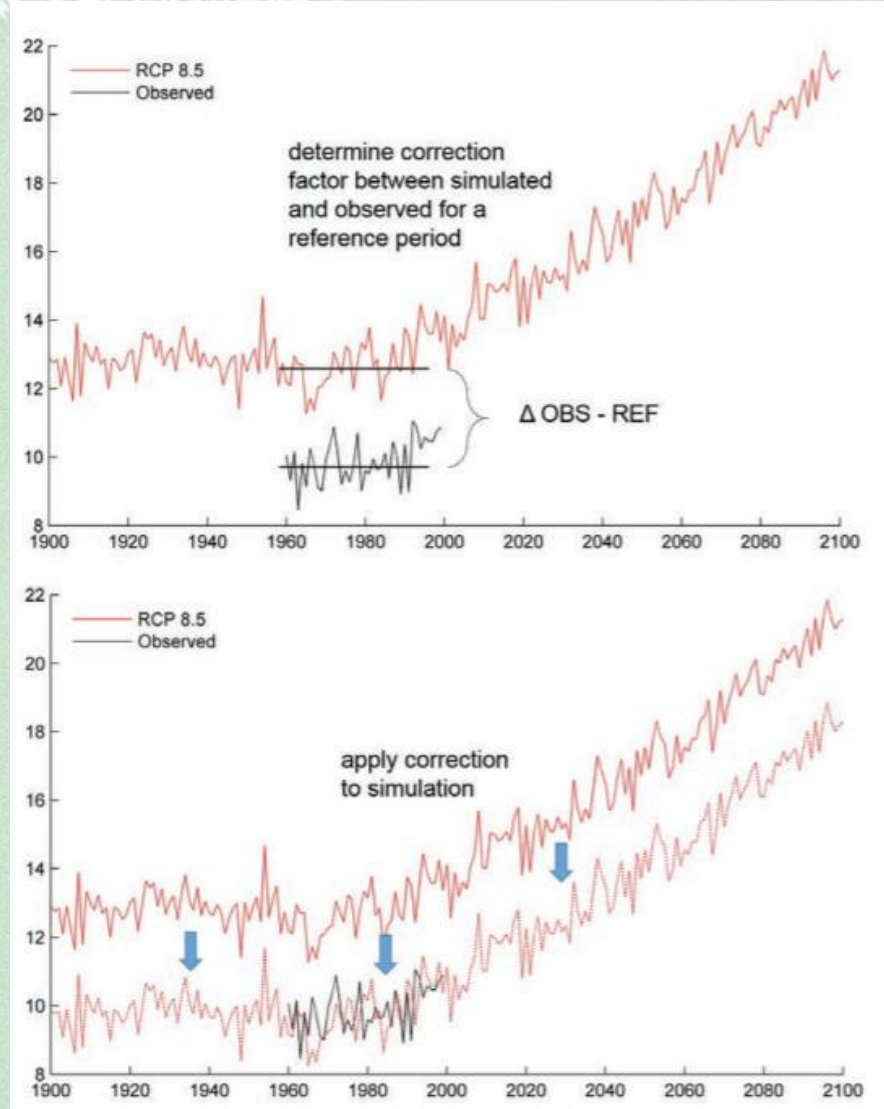
Conducting Bias Correction



Averaged Observed Temperature in Durham Region	Modeled Historical Temperature	Difference between modeled and observed values:
$T_{OBS} = 5.5^{\circ}C$	$T_{RCM \text{ for Baseline}} = 8.5^{\circ}C$	$\Delta T = T_{OBS} - T_{RCM \text{ for Baseline}}$ $\Delta T = -3.0^{\circ}C$



Modeled Future Temperature Data for the RCP 8.5 Scenario for 2041-2070	Bias-Corrected Value for the Modeled Future Temperature value
$T_{RCM \text{ RCP } 8.5} = 15.5^{\circ}C$	$T_{BIAS} = T_{RCM \text{ RCP } 8.5} + \Delta T$ $T_{BIAS} = (15.5^{\circ}C) + (-3^{\circ}C)$ $T_{BIAS} = 12.5^{\circ}C$



Climate Parameters

Direct Model Output (4)

- Mean Air Temperature
- Max Air Temperature
- Min Air Temperature
- Total Precipitation



Inferred or Calculated (52)

- All Threshold-based Parameters
- Extreme Precipitation
- Growing Season
- Dry Conditions
- Freeze-Thaw
- Ice Potential



Preliminary Results (RCP 8.5)

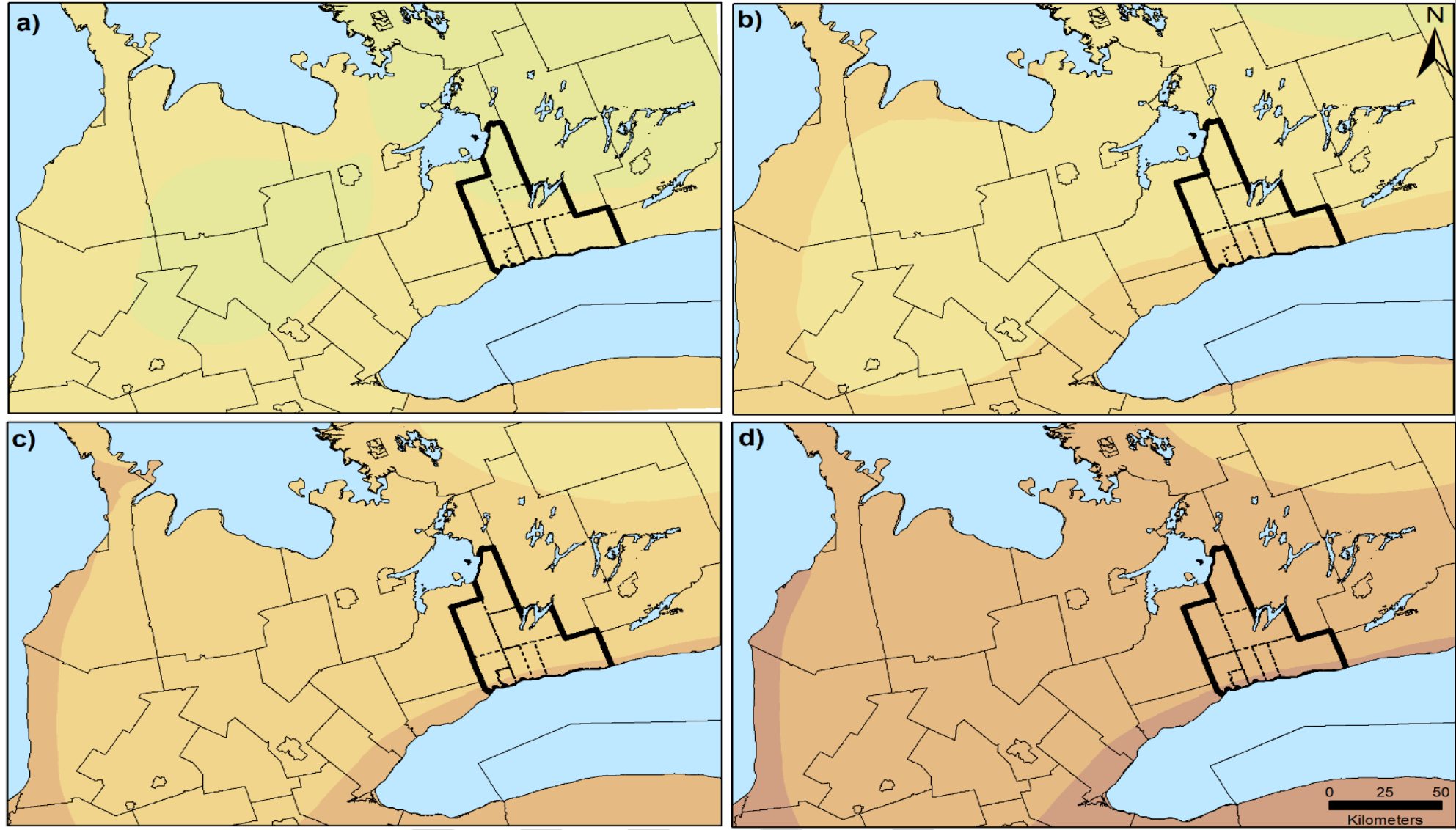


Climate Parameter	Historical (1971-2000)	Short Term (2011-2040)	Medium Term (2041-2070)	Long Term (2071-2100)	Difference from Baseline to Long Term	Trend
Mean Annual Temperature (°C)	7.1	8.6	10.1	12.1	+5	↑
Days above 35°C	0.2	1.2	4.0	10.8	+10.6	↑
Days above 30°C	7.6	15.9	27.4	46.9	+39.3	↑
Days below -15°C	22.7	12.7	7.9	2.6	-20.1	↓
Days below -10°C	49.0	33.3	23.6	11.3	-37.7	↓
Total Annual Precipitation (mm)	952.4	1011.7	1047.4	1148.7	+196.3	↑
Max 1 Day Precipitation (mm)	33.8	35.4	40.4	44.0	+10.2	↑
Max 3 Day Precipitation (mm)	54.9	58.2	61.7	67.7	+12.8	↑

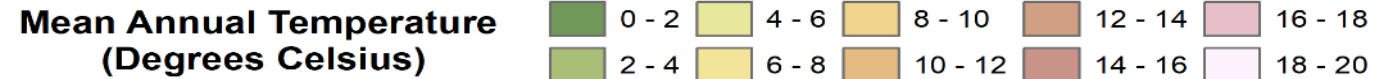
Preliminary Results (RCP 8.5)



- a) 1971-2000
- b) 2011-2040
- c) 2041-2070
- d) 2071-2100



1971-2000 to
2071-2100:
6-8°C to 12-
14°C (a 5-7°C
increase)

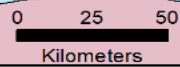
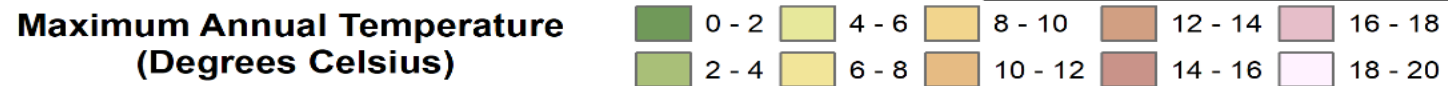
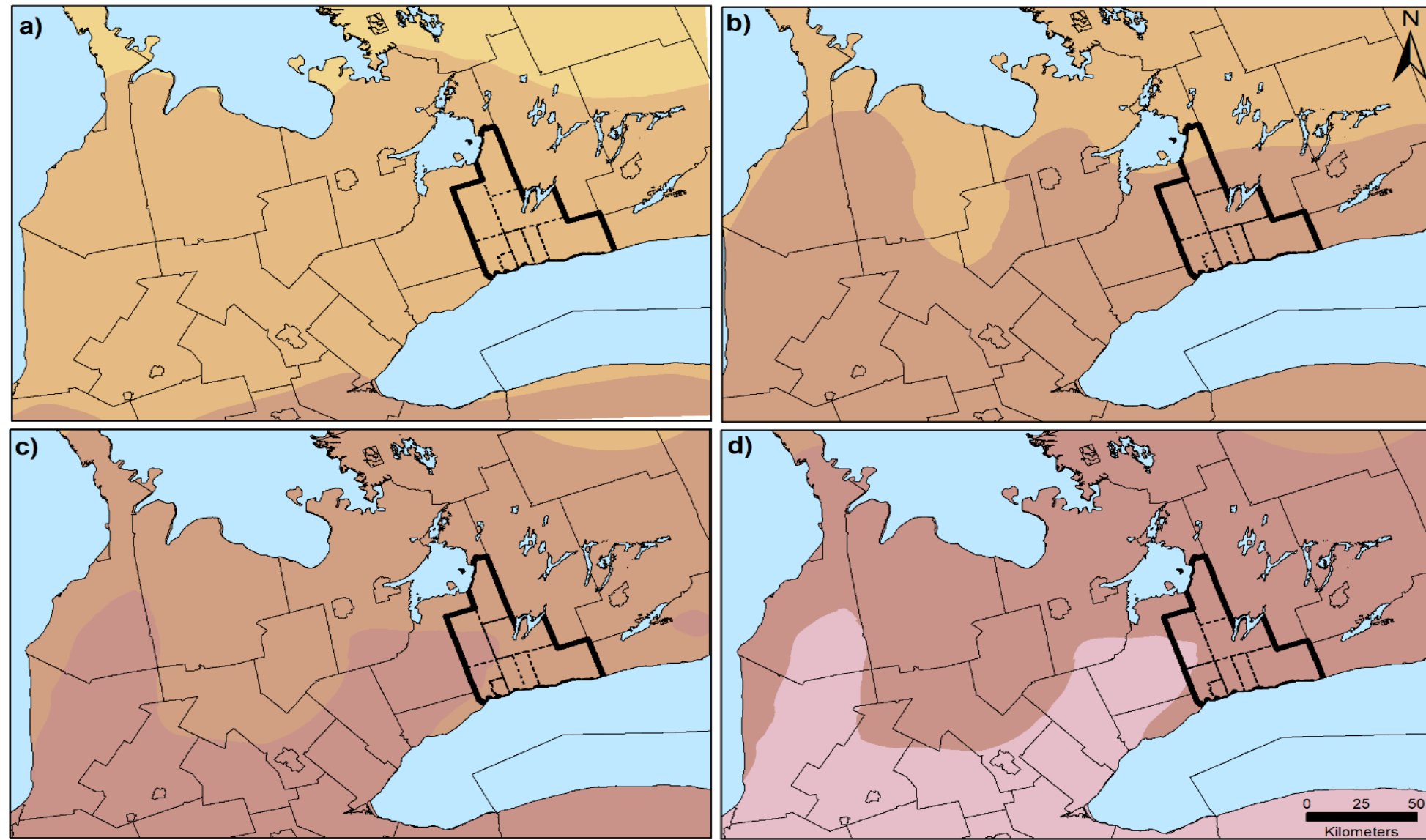


Preliminary Results (RCP 8.5)

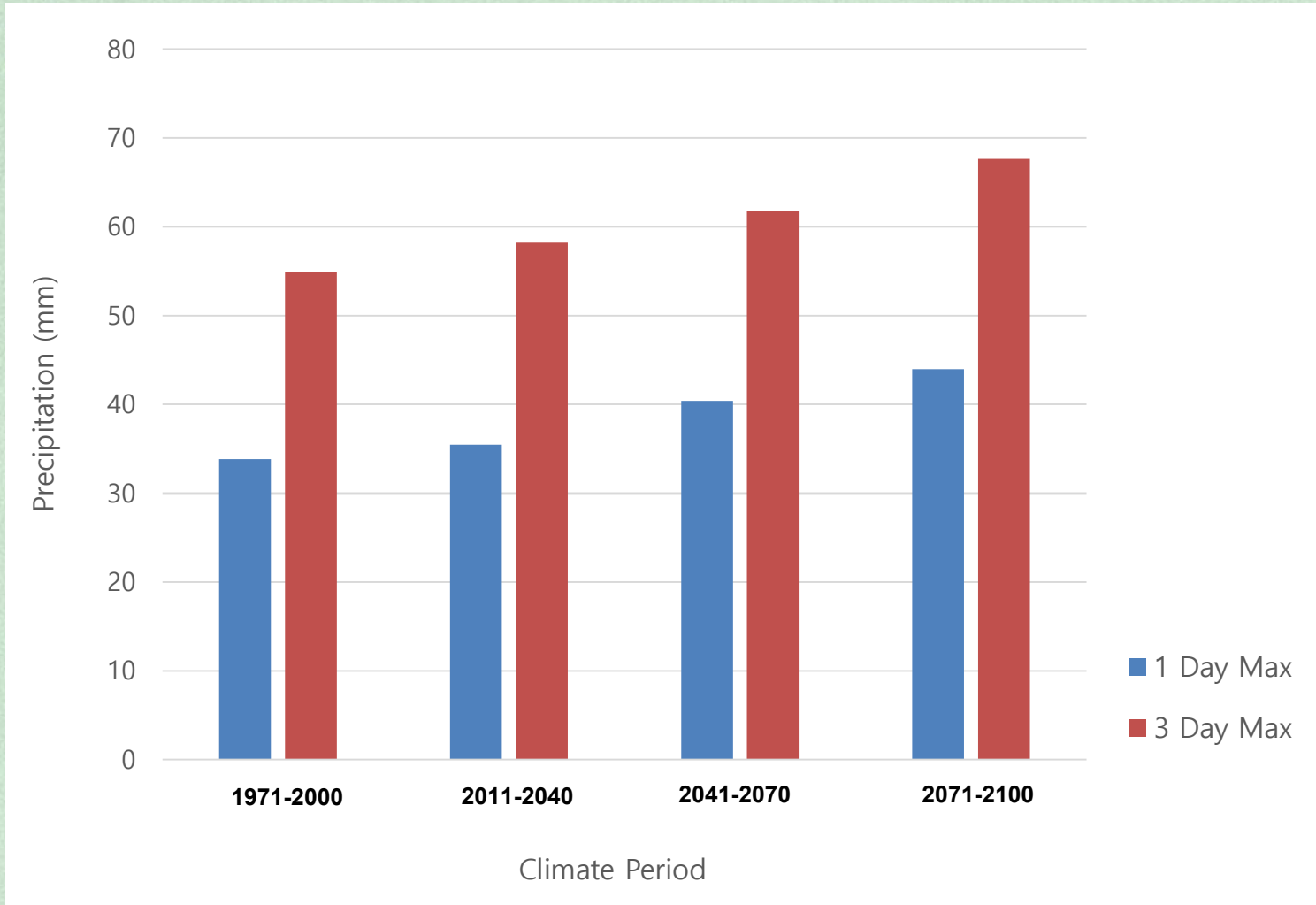


- a) 1971-2000
- b) 2011-2040
- c) 2041-2070
- d) 2071-2100

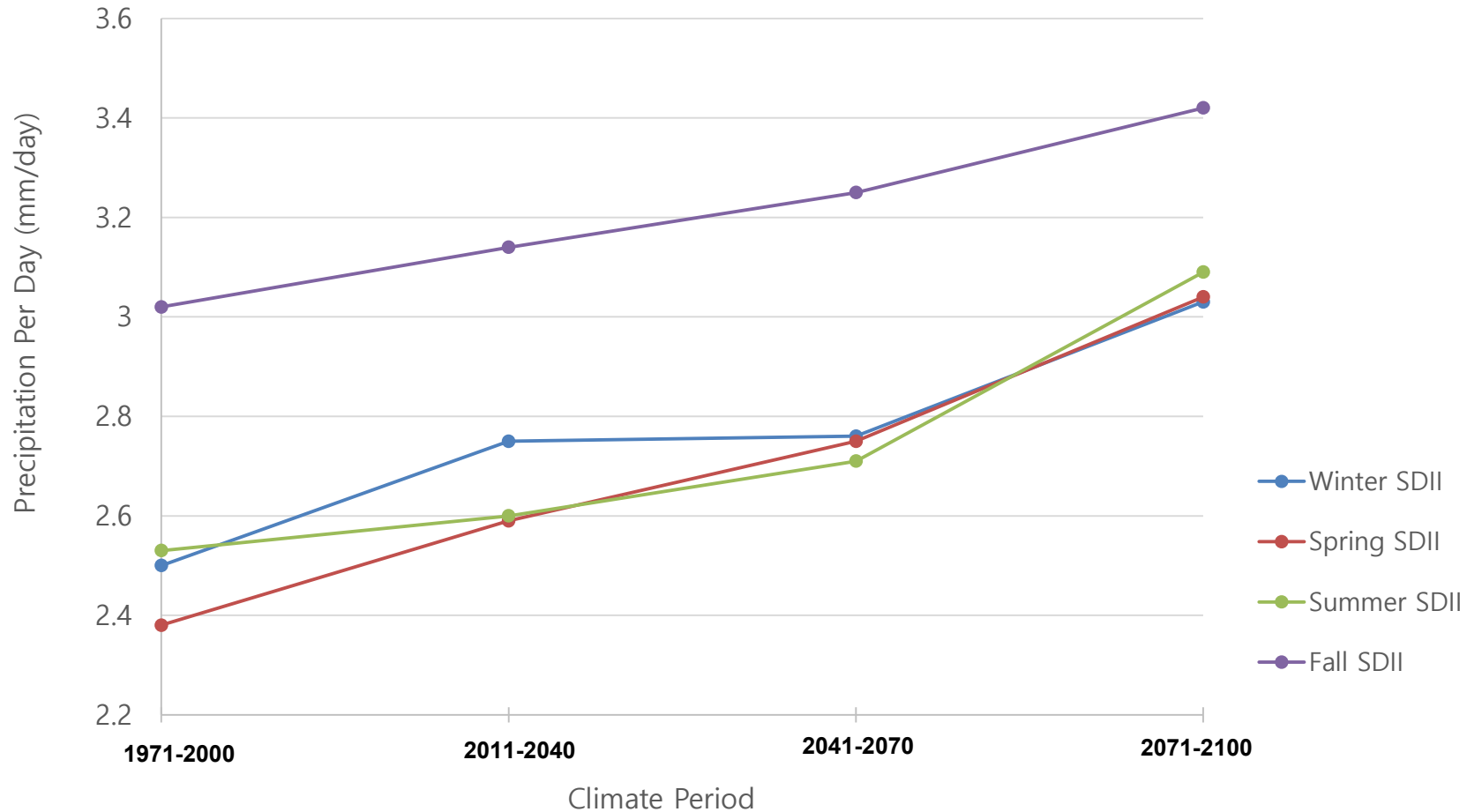
1971-2000 to
2071-2100:
a 4-6°C
increase



Preliminary Results (RCP 8.5)

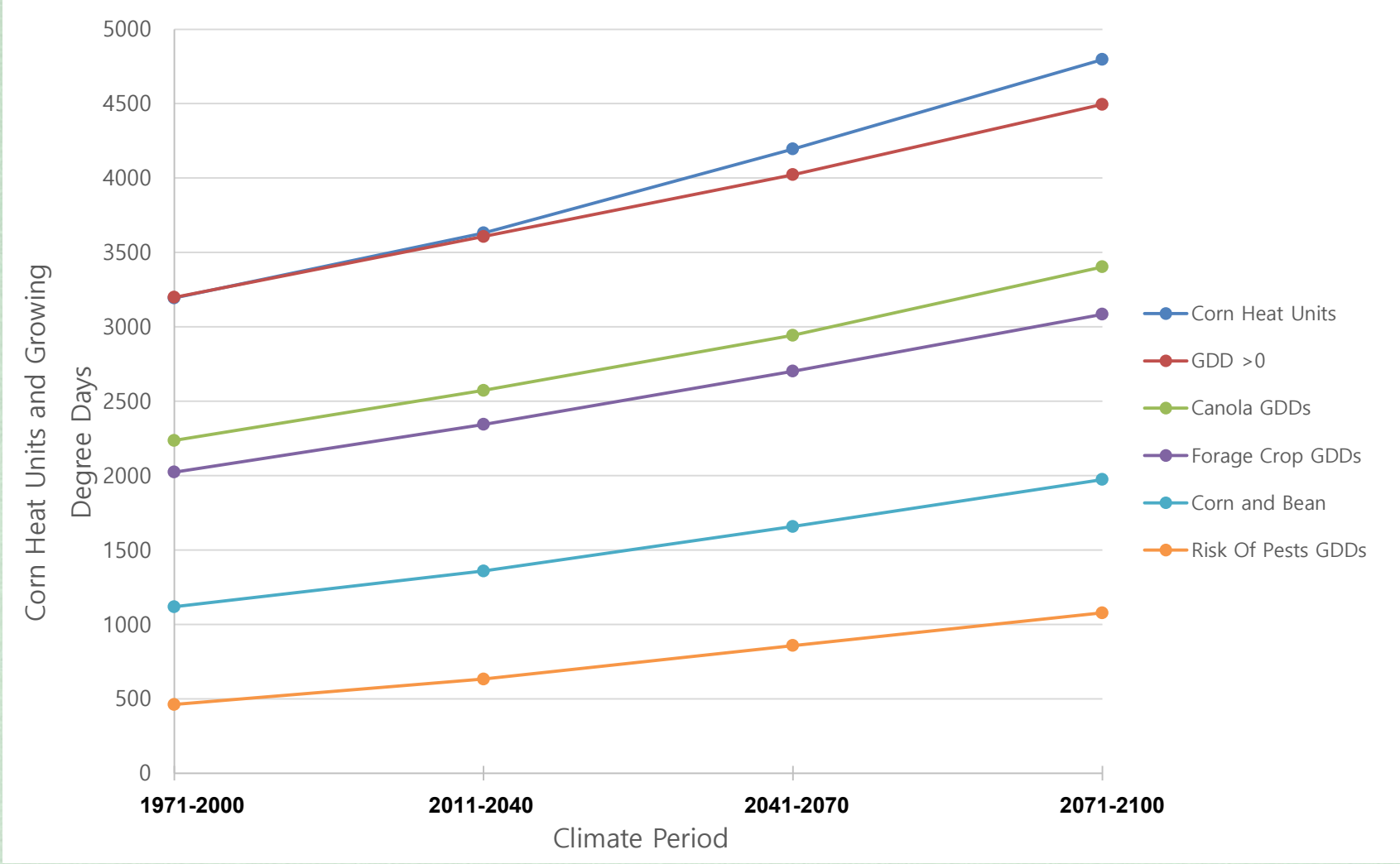


Preliminary Results (RCP 8.5)

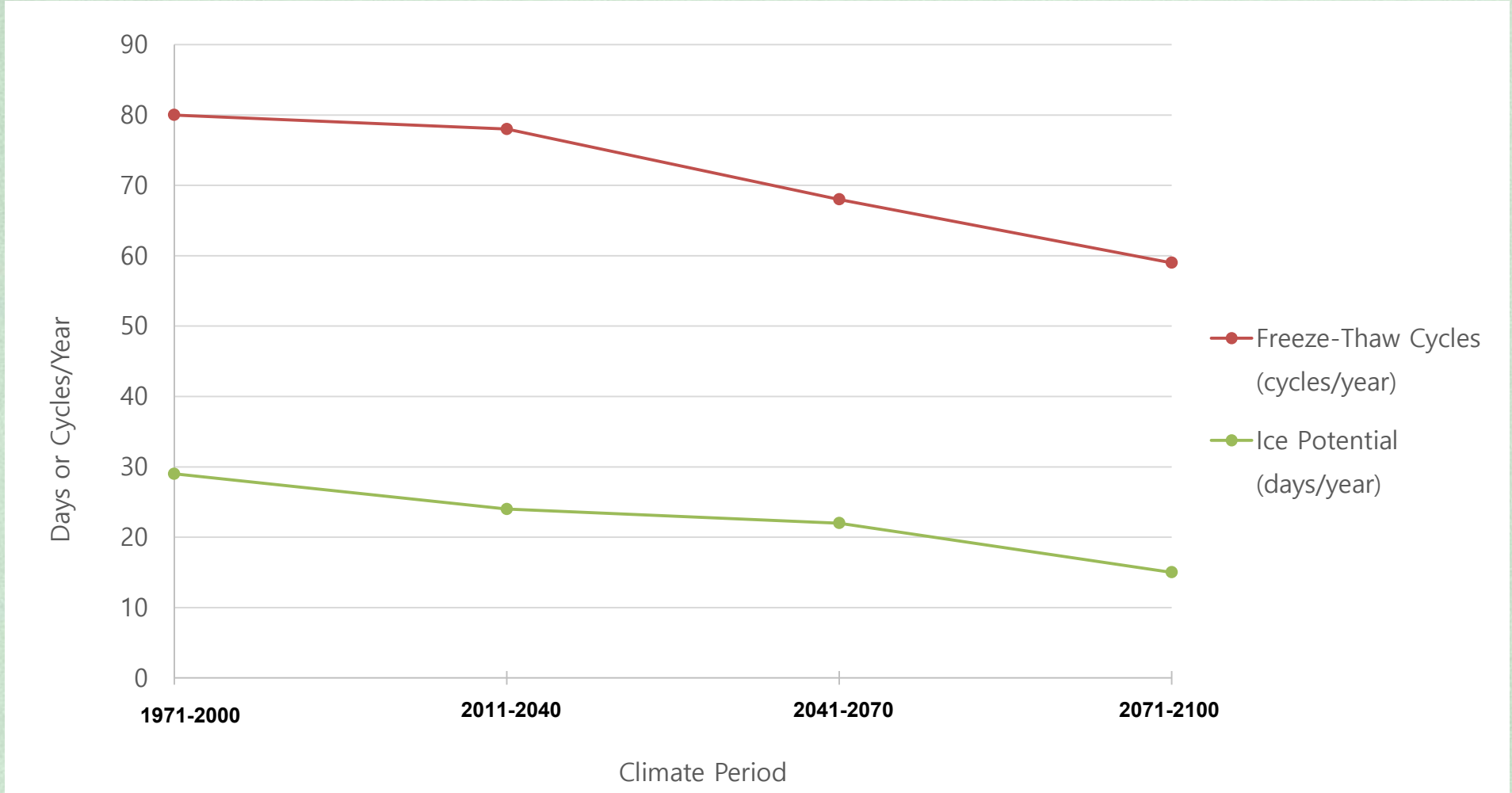


The winter, spring, summer, and fall simple daily intensity index (SDII) (total amount of precipitation in millimetres per day) for each climate period under the RCP 8.5 climate scenario.

Preliminary Results (RCP 8.5)



Preliminary Results (RCP 8.5)



Conclusions



It can be expected by the 2050s, in the RCP 8.5 climate emissions scenario, that Durham Region will be:

- Warmer (~3°C increase)
- Wetter (~11% increase)
- More intense storms (~20% increase in 1-day maximum precipitation)
- Similar trends in freeze-thaw cycles
- Less ice potential
- Opportunities for agricultural crops to thrive, however, pests are at greater risk

Next Steps and Deliverables



- Present Preliminary Findings to NECCC group
- Complete Guidance Document and Summary Report
- Review of Guidance Document (mid-December to mid-January)
- Public Webinar of Final Results late January
- Final Report to be submitted to GBF by mid-February

Thank You

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