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HOT OFF THE PRESS –

**Future Projections of Climate Change
for the Atlantic Region of Canada
Using Global Climate Models Used
in the IPCC Fifth Assessment Report (2014)**

Adam Fenech, Ph.D. (Toronto)

Atlantic Coastal Zone Information Steering Committee (ACZISC) Meeting
Charlottetown, PEI

29 May 2013

Outline

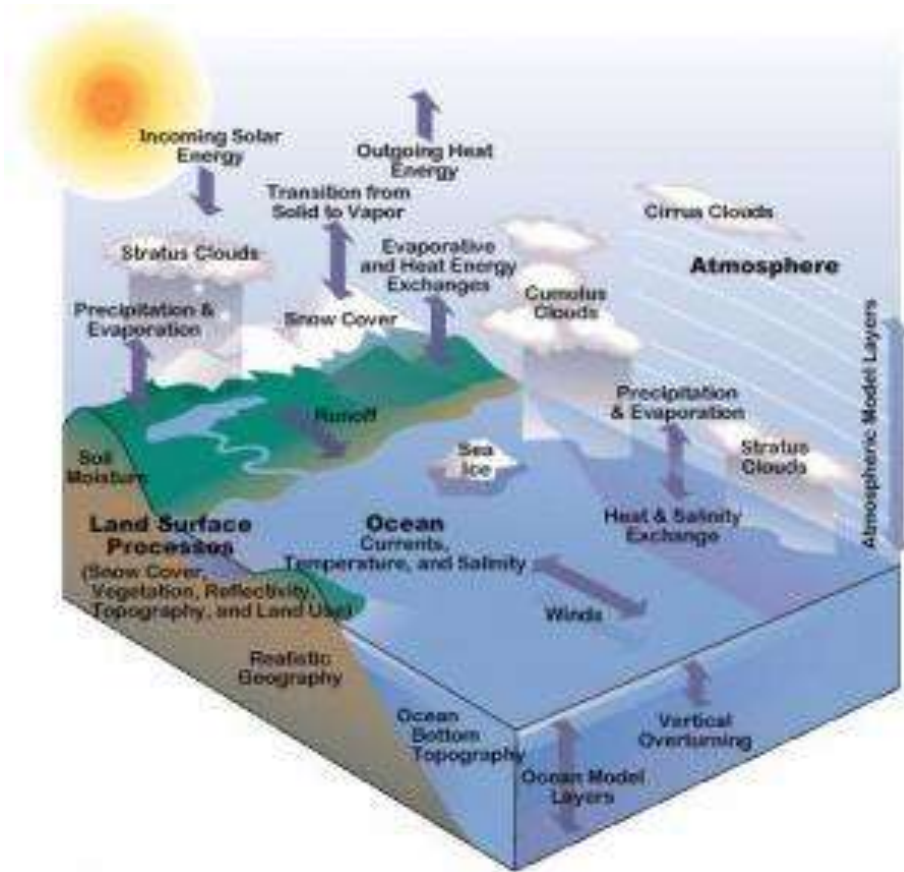
1. Global Climate Models (GCMs)
2. Future Greenhouse Gas (GHG) Scenarios (SRES vs RCPs)
3. IPCC AR5 Future Projections
4. Comparison with Past IPCC Assessments



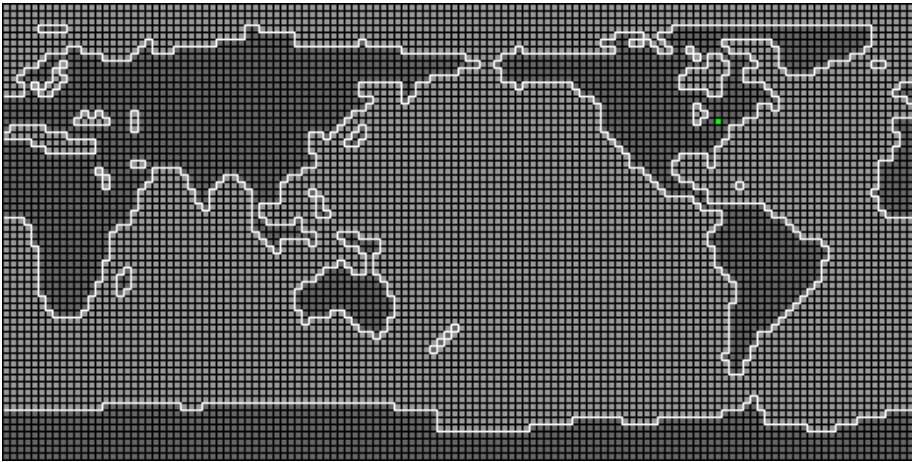
- formed in 1988 under auspices of the United Nations Environment Program and World Meteorological Organization
- function is to provide assessments of the science of climate change (~6 years)
- internationally accepted authority on climate change

What is a Global Climate Model (GCM)?

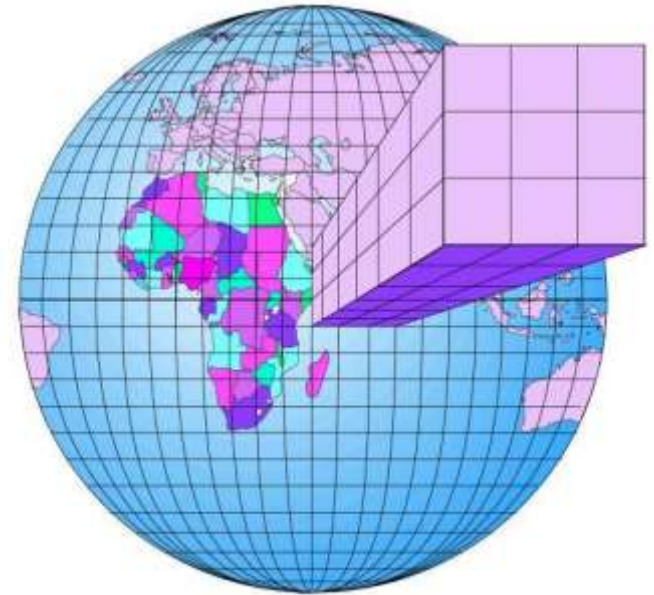
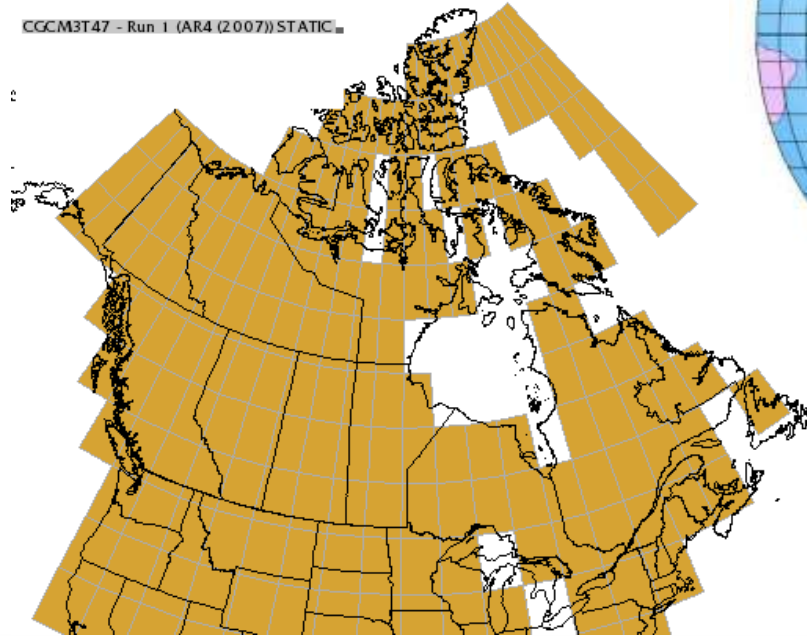
- systems of mathematical equations based on the basic laws of physics, fluid motion and chemistry
- that describe the climate conditions evolving from atmospheric, oceanic, cryospheric and land processes



Climate Model

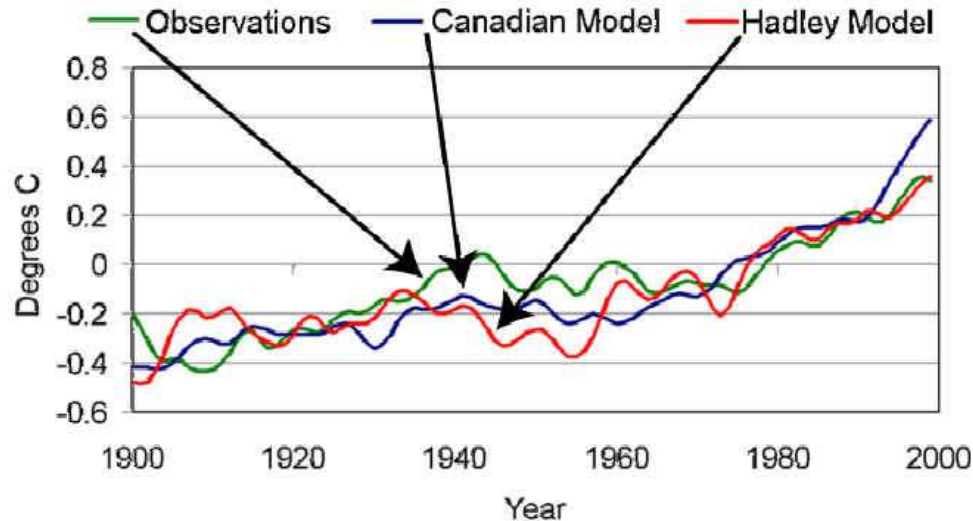


CGCM3T47 - Run 1 (AR4 (2007)) STATIC

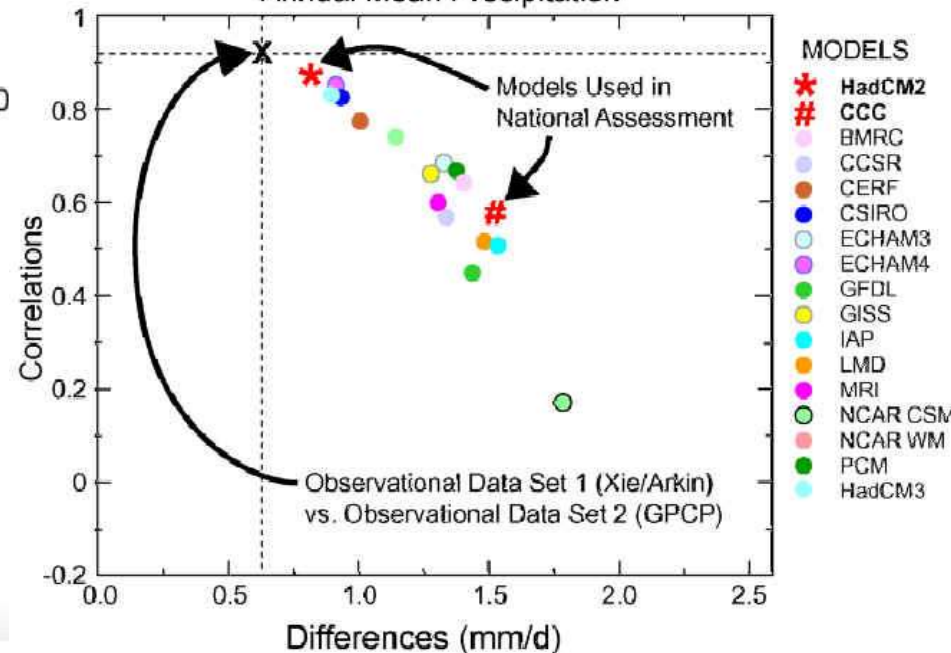


GCM Accuracy

Mean Temperature Anomalies (Global)



MODEL PERFORMANCE OVER NORTH AMERICA
Annual Mean Precipitation



Global Climate Models (GCMs)

- GCMs represent our best science and use of complex, computational equipment
- However, they are still under development and uncertainties remain
- As computer processing units (CPUs) become less expensive, models are refined to allow for closer spatial resolution, more accurate parameterizations, and more runs



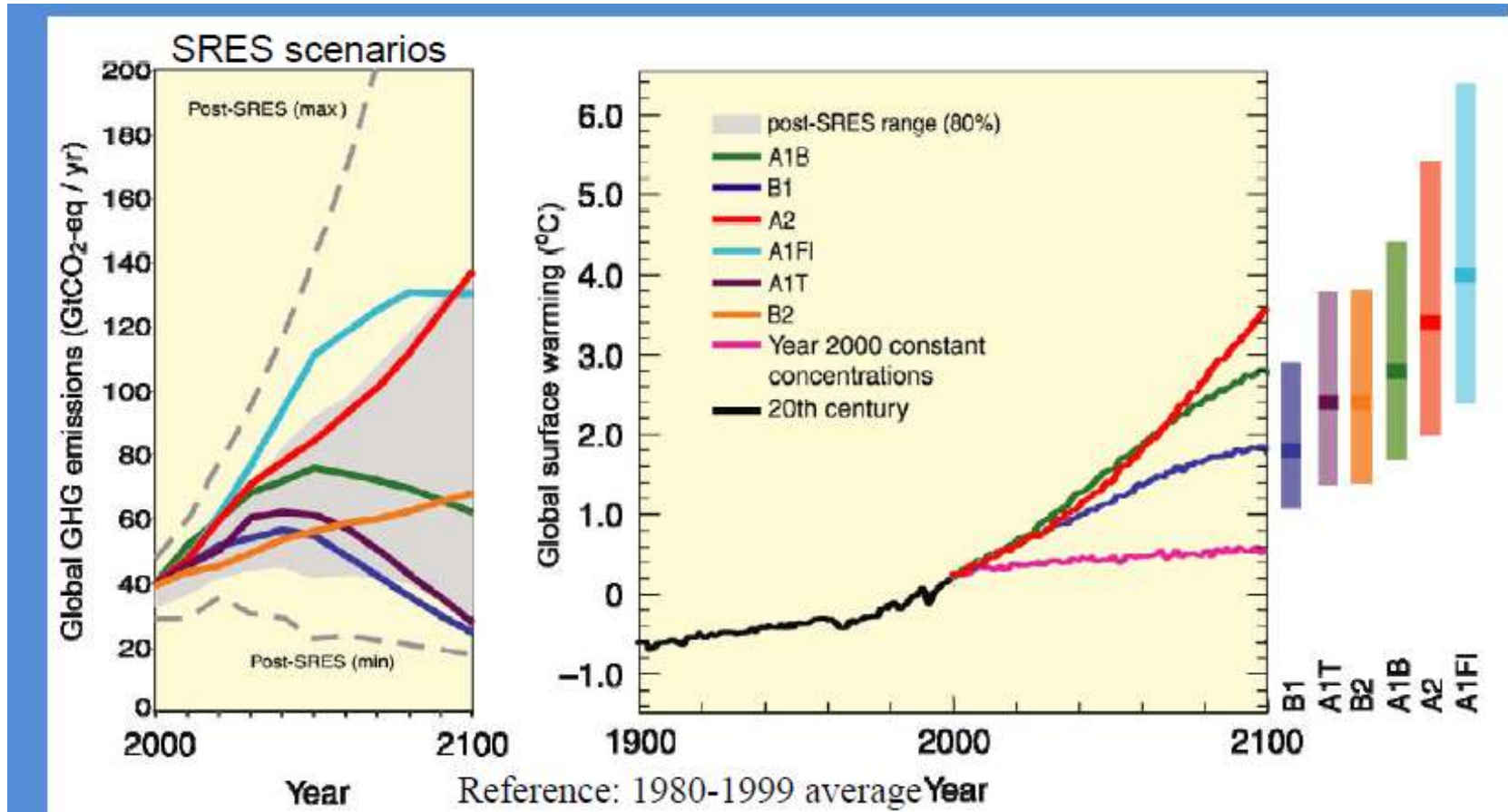
Greenhouse Gas (GHG) Scenarios

- Main source of uncertainty about future climate
- Future climate cannot be “predicted” because future greenhouse gas (GHG) emissions unknown
- 3 primary GHG indicators
 - Human population
 - Global economy type
 - Energy type



SRES (AR4)

A2 = high GHG emissions
A1B = medium GHG emissions
B1 = low GHG emissions



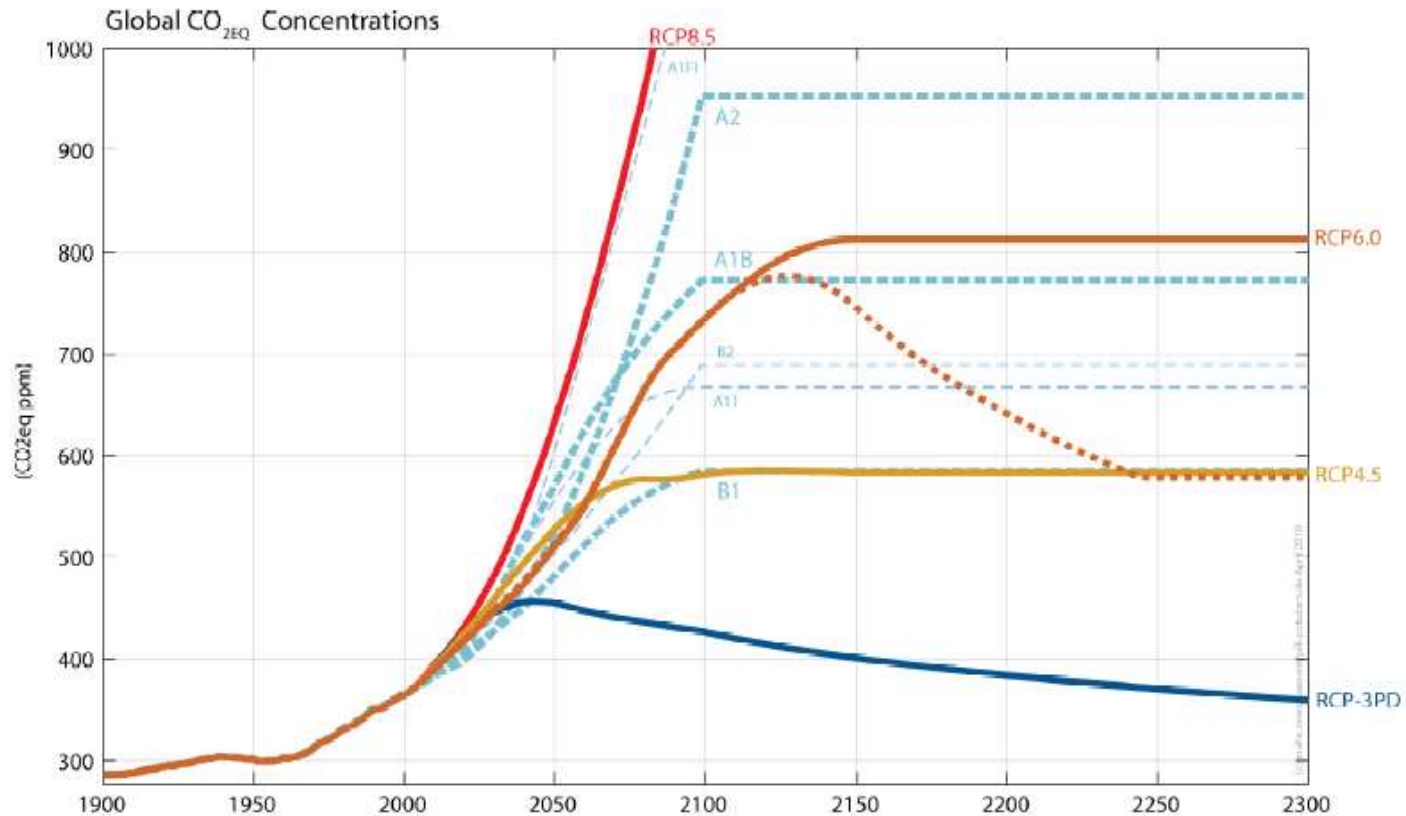
Representative Concentration Pathways RCPs (AR5)

- GHG concentration (not emissions) driven
- RCPs span a large range of stabilization, mitigation and non-mitigation pathways
- RCP2.6, RCP4.5, RCP6, and RCP8.5, named after a possible range of radiative forcing (W/m^2) values in the year 2100



Representative Concentration Pathways RCPs (AR5)

CO₂-eq Concentrations for the RCPs

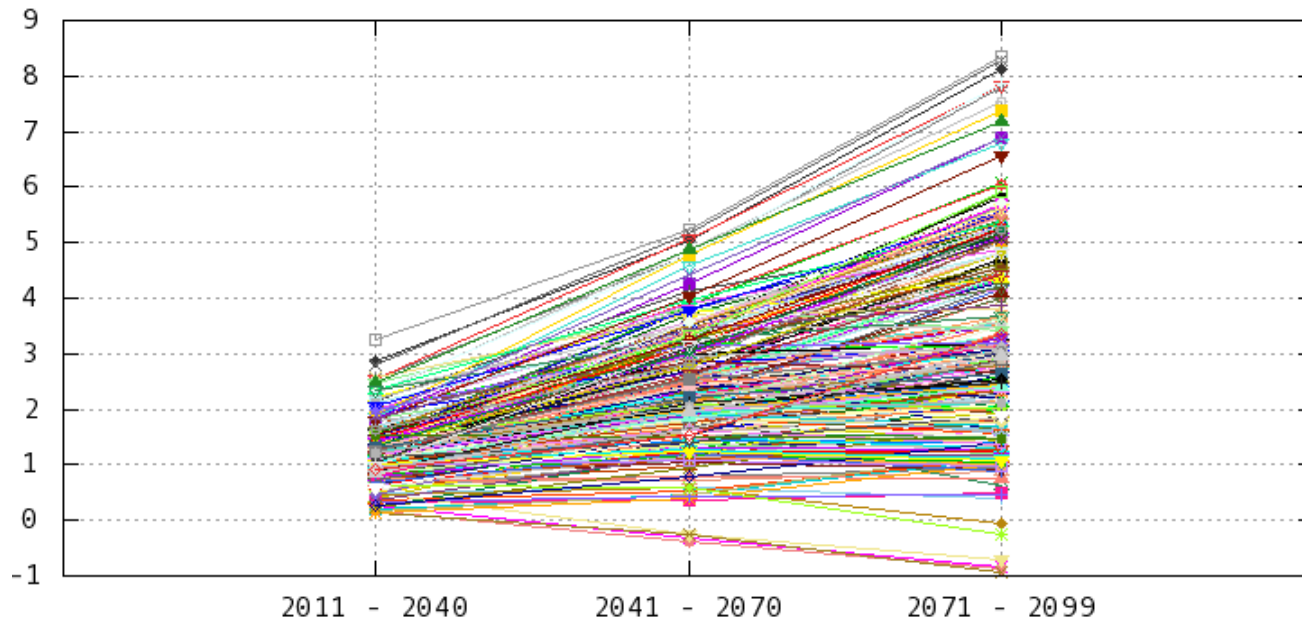


Representative Concentration Pathways RCPs (AR5) Which is Most Likely?



Future Projections

Annual Mean Temperature anomaly (°C)
2020s, 2050s, 2080s (baseline 1981-2010)
All Models, Runs and RCPs IPCC AR5
Charlottetown, PEI, Canada



GCM Ensemble

- ensemble approach uses multi-model means/medians
- demonstrated in recent scientific literature to likely provide the best projected climate change signal
- In effect, the individual model biases seem to offset one another when considered together
- Compared against historical observed gridded data, ensemble results have been shown to come closest to replicating historical climate



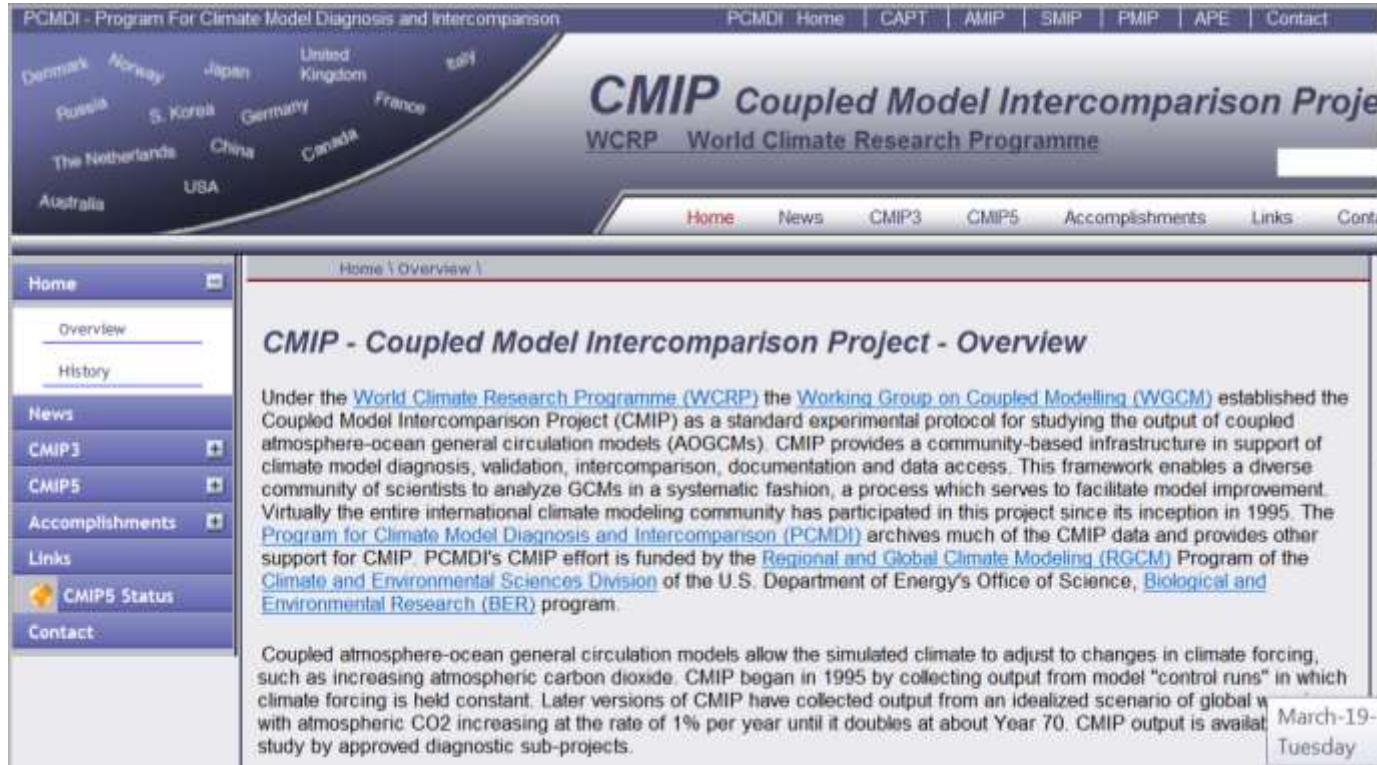
Ensemble Recommended by...

IPCC Expert Meeting on Assessing and Combining Multi Model Climate Projections, 2010. *Good Practice Guidance Paper on Assessing and Combining Multi Model Climate Projections*



CMIP Coupled Model Intercomparison Project

<http://cmip-pcmdi.llnl.gov/>



The screenshot shows the CMIP website interface. At the top, there is a navigation bar with links for 'PCMDI Home', 'CAPT', 'AMIP', 'SMIP', 'PMIP', 'APE', and 'Contact'. Below this is a header section with the text 'CMIP Coupled Model Intercomparison Project' and 'WCRP World Climate Research Programme'. A map of the world is visible on the left side of the header, with various countries labeled, including Denmark, Norway, Japan, United Kingdom, Russia, S. Korea, Germany, France, The Netherlands, China, Canada, USA, and Australia. Below the header is a secondary navigation bar with links for 'Home', 'News', 'CMP3', 'CMP5', 'Accomplishments', 'Links', and 'Contact'. The main content area is titled 'CMIP - Coupled Model Intercomparison Project - Overview'. It contains a paragraph of text describing the project's goals and funding. A sidebar on the left contains a menu with links for 'Home', 'Overview', 'History', 'News', 'CMP3', 'CMP5', 'Accomplishments', 'Links', 'CMP5 Status', and 'Contact'. A date stamp 'March-19- Tuesday' is visible in the bottom right corner of the screenshot.

PCMDI - Program For Climate Model Diagnosis and Intercomparison

PCMDI Home | CAPT | AMIP | SMIP | PMIP | APE | Contact

Denmark Norway Japan United Kingdom
Russia S. Korea Germany France
The Netherlands China Canada
USA
Australia

CMIP Coupled Model Intercomparison Project

WCRP World Climate Research Programme

Home News CMP3 CMP5 Accomplishments Links Contact

Home \ Overview \

CMIP - Coupled Model Intercomparison Project - Overview

Under the [World Climate Research Programme \(WCRP\)](#) the [Working Group on Coupled Modelling \(WGCM\)](#) established the Coupled Model Intercomparison Project (CMIP) as a standard experimental protocol for studying the output of coupled atmosphere-ocean general circulation models (AOGCMs). CMIP provides a community-based infrastructure in support of climate model diagnosis, validation, intercomparison, documentation and data access. This framework enables a diverse community of scientists to analyze GCMs in a systematic fashion, a process which serves to facilitate model improvement. Virtually the entire international climate modeling community has participated in this project since its inception in 1995. The [Program for Climate Model Diagnosis and Intercomparison \(PCMDI\)](#) archives much of the CMIP data and provides other support for CMIP. PCMDI's CMIP effort is funded by the [Regional and Global Climate Modeling \(RGCM\)](#) Program of the [Climate and Environmental Sciences Division](#) of the U.S. Department of Energy's Office of Science, [Biological and Environmental Research \(BER\)](#) program.

Coupled atmosphere-ocean general circulation models allow the simulated climate to adjust to changes in climate forcing, such as increasing atmospheric carbon dioxide. CMIP began in 1995 by collecting output from model "control runs" in which climate forcing is held constant. Later versions of CMIP have collected output from an idealized scenario of global warming with atmospheric CO₂ increasing at the rate of 1% per year until it doubles at about Year 70. CMIP output is available for study by approved diagnostic sub-projects.

March-19- Tuesday



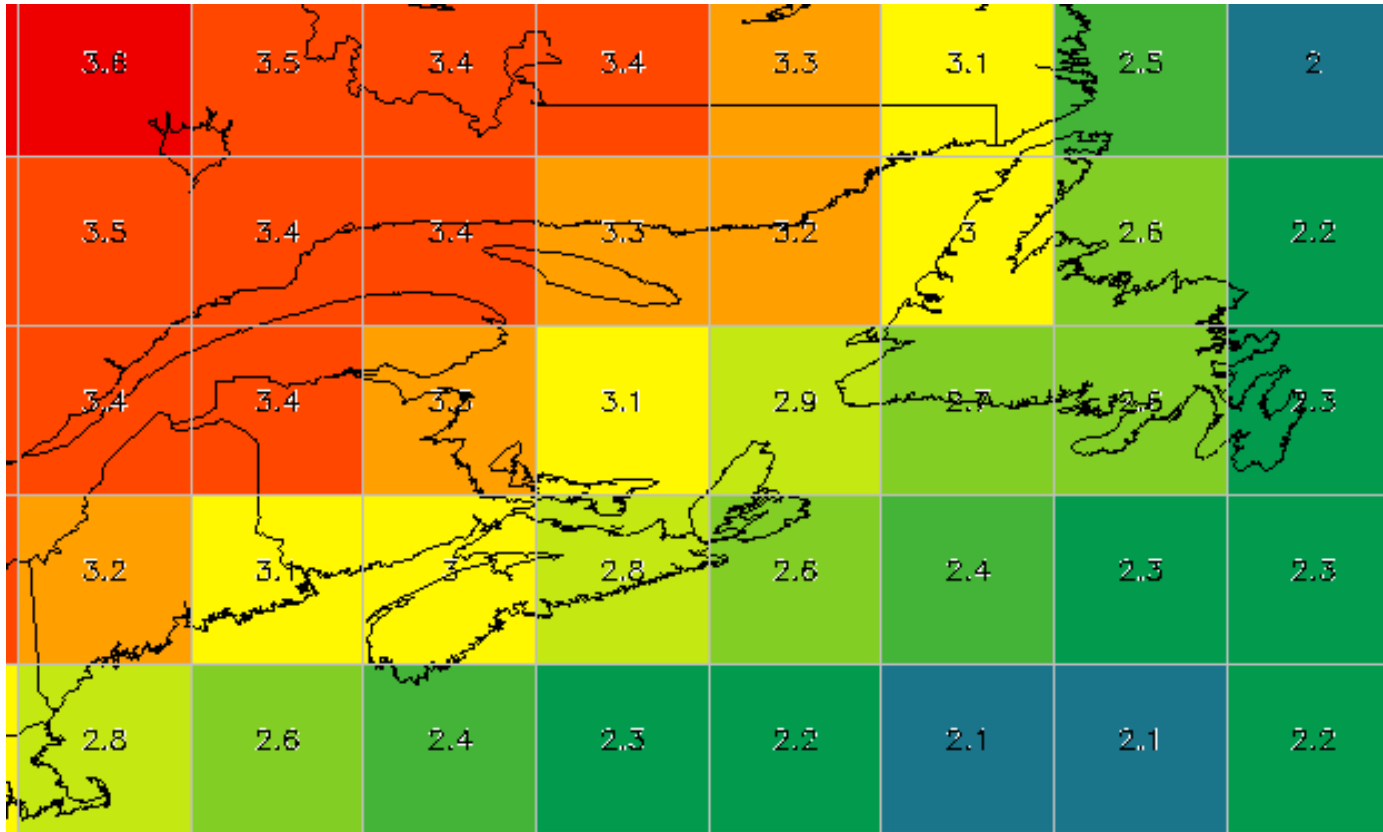
What was done?

- Output from all 40 global climate models (GCMs) used in the IPCC AR5 were downloaded in their native format to the UPEI Climate Database
- Output converted, formatted, interpreted, analyzed and mapped
- 40 GCMs x 4 RCPs = ~160 future projections
- Ensemble approach used



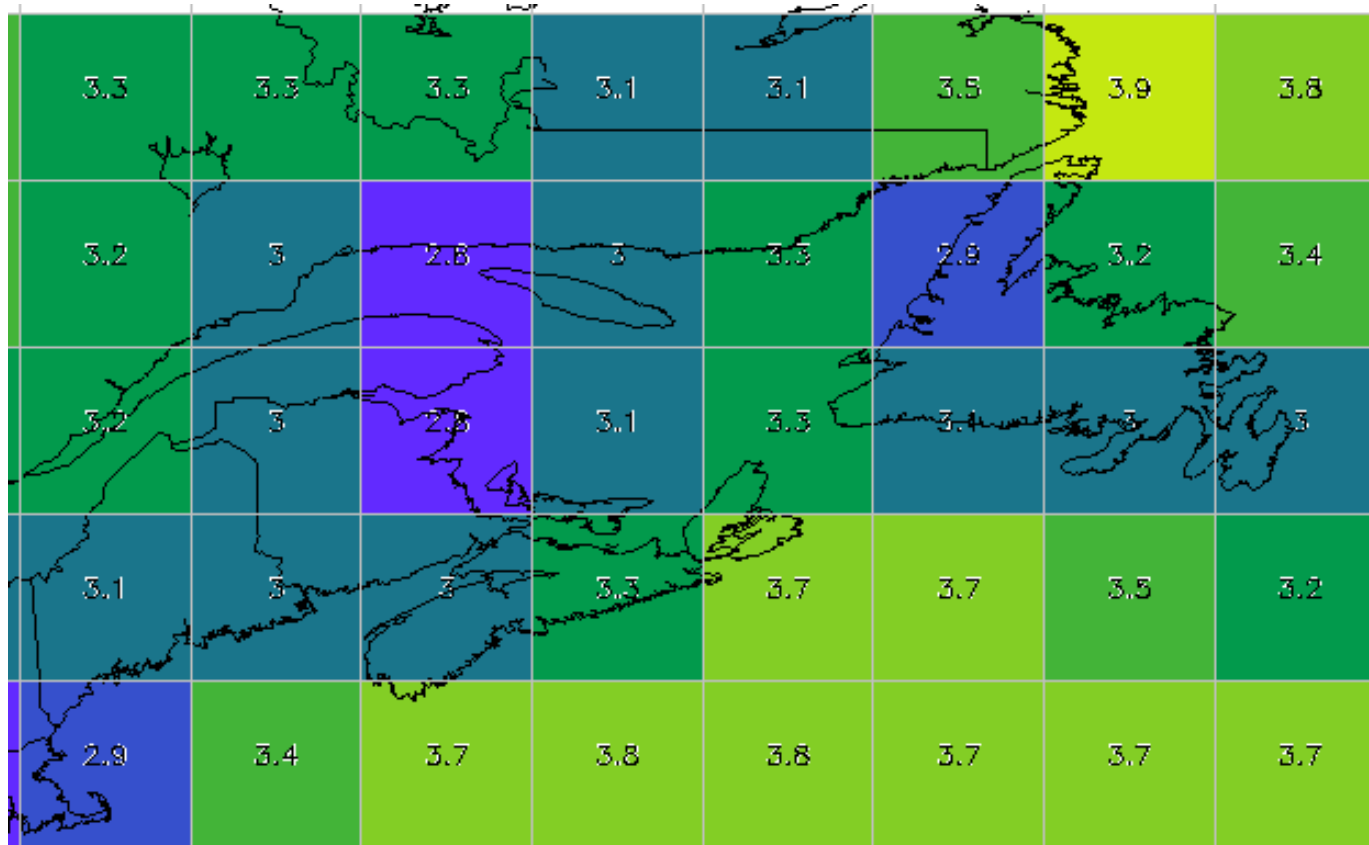
HOT OFF THE PRESS!
IPCC AR5

Atlantic Canada's Future Climate Temperature Change by 2050s (°C) Ensemble of all 40 GCM Runs RCP8.5



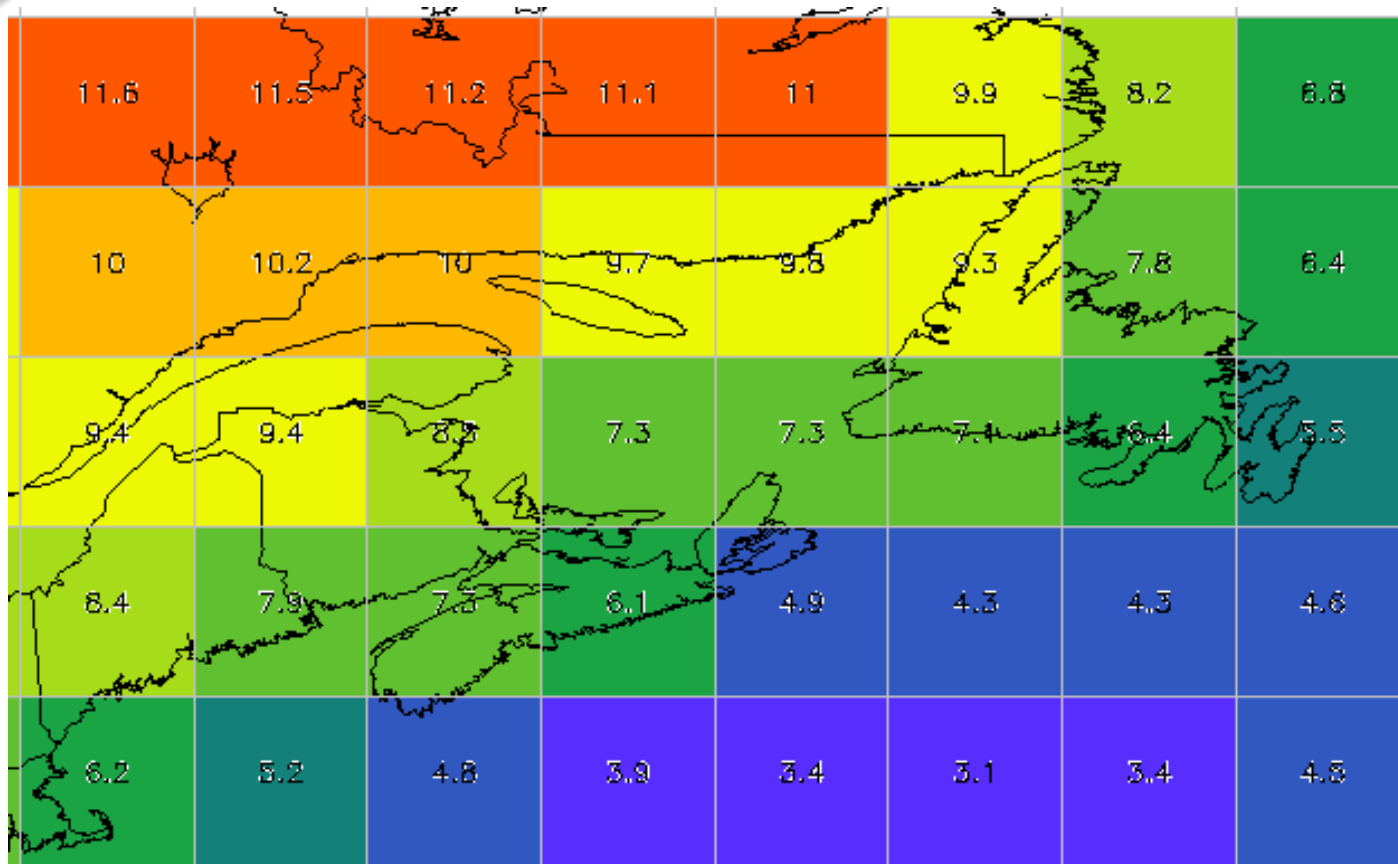
HOT OFF THE PRESS!
IPCC AR5

Atlantic Canada's Future Climate Temperature Change by 2050s (°C) Range of all 40 GCM Runs RCP8.5



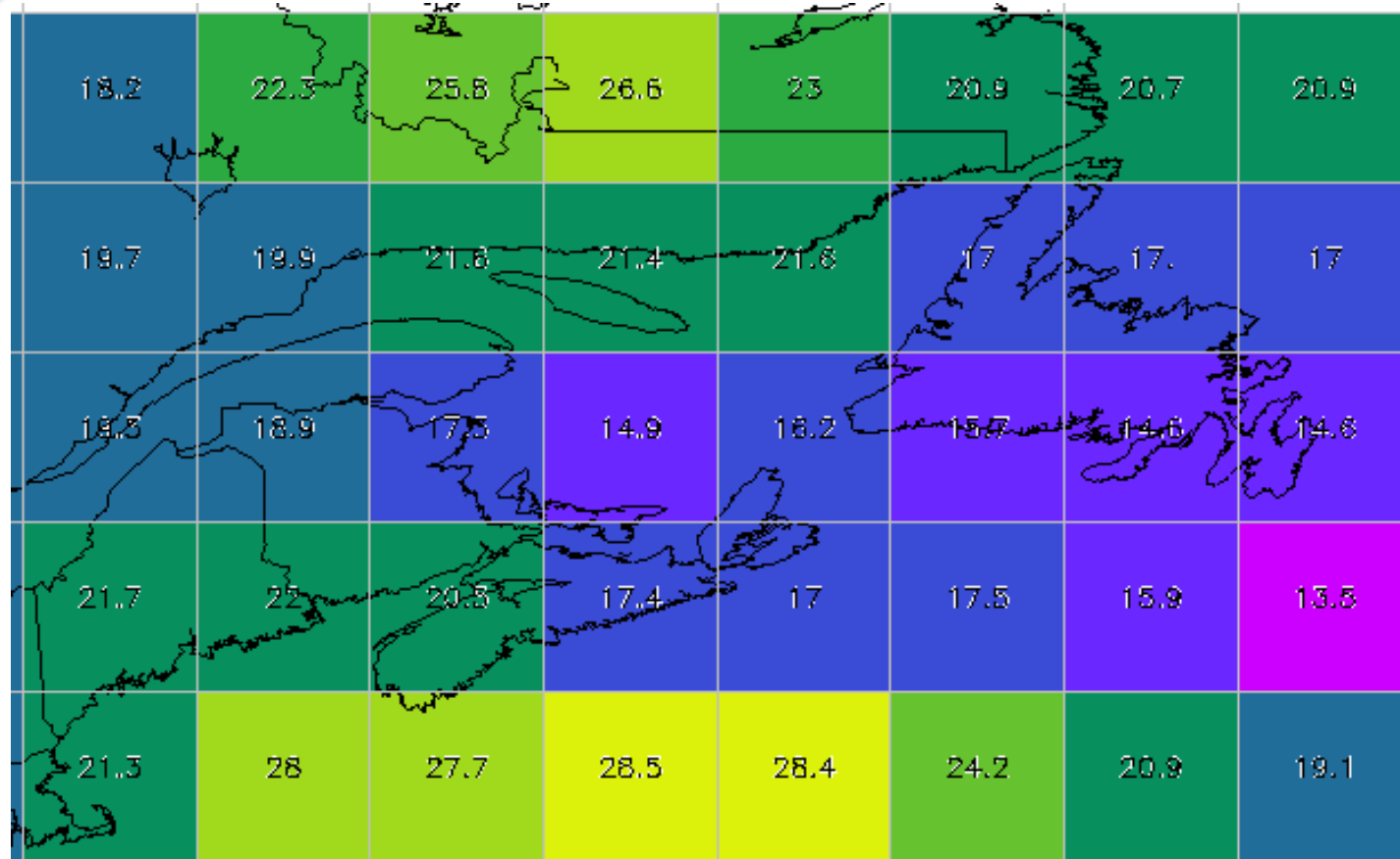
HOT OFF THE PRESS!
IPCC AR5

Atlantic Canada's Future Climate Precipitation Change by 2050s (%) Ensemble of all 40 GCM Runs RCP8.5

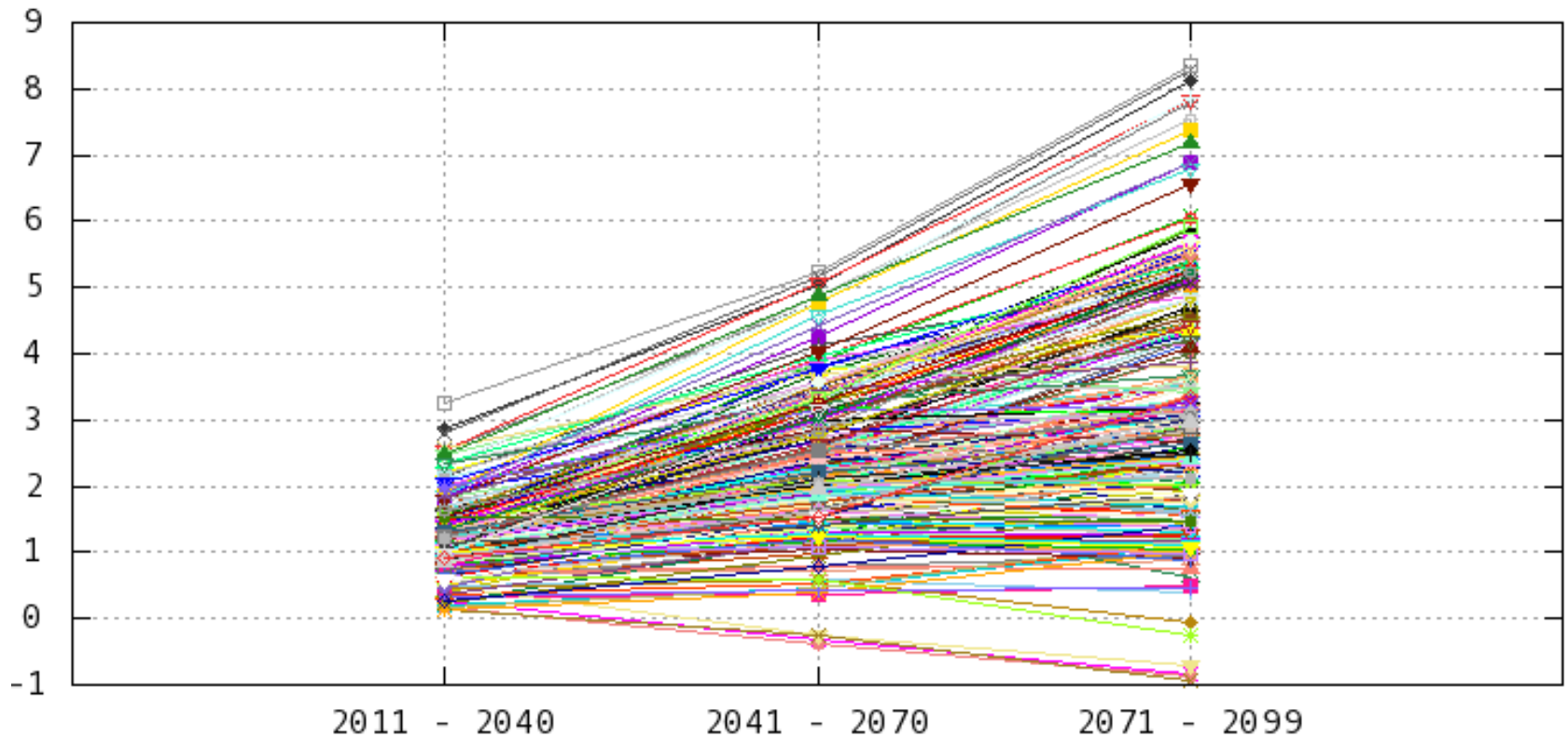


HOT OFF THE PRESS!
IPCC AR5

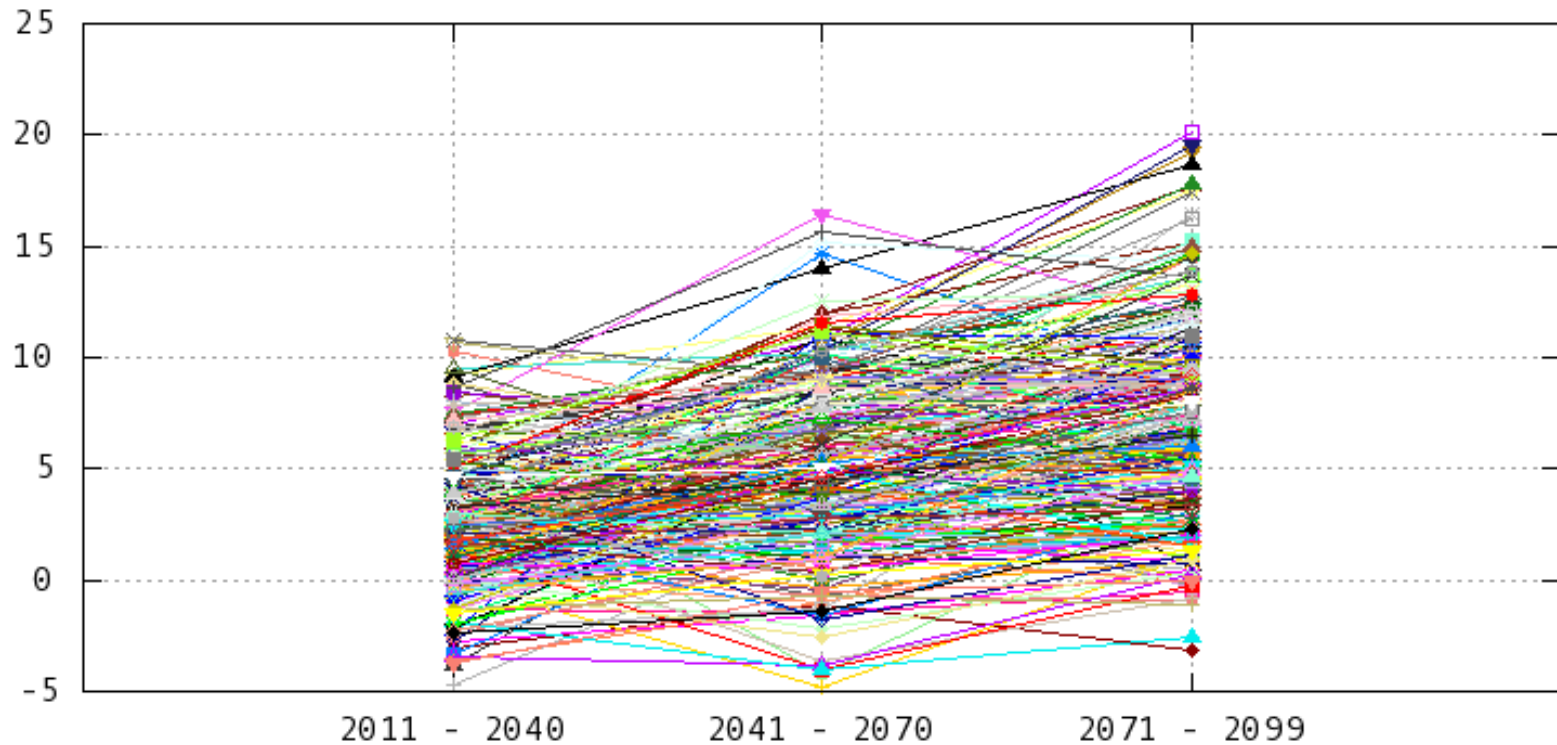
Atlantic Canada's Future Climate Precipitation Change by 2050s (%) Range of all 40 GCM Runs RCP8.5



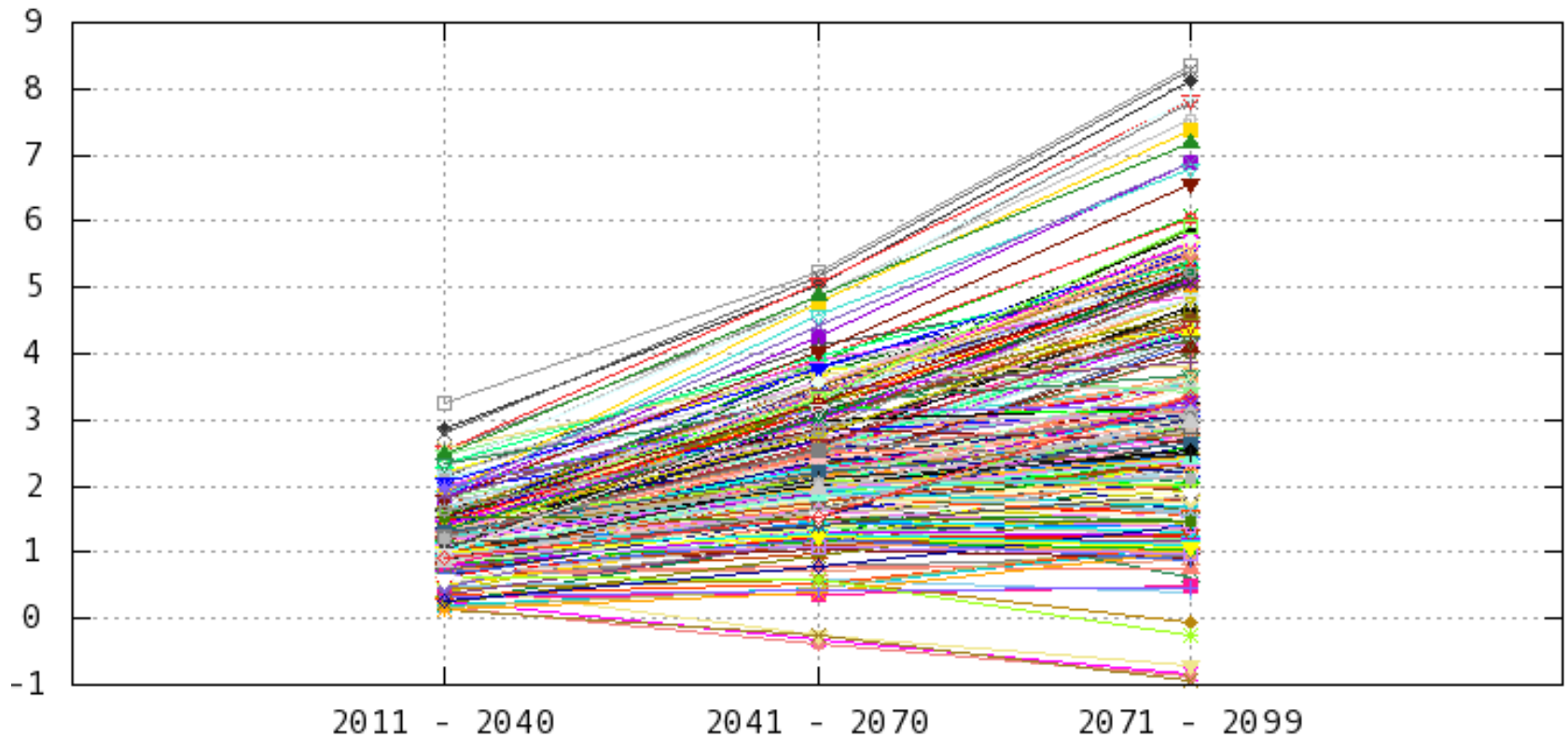
Annual Mean Temperature anomaly (°C)
2020s, 2050s, 2080s (baseline 1981-2010)
All Models, Runs and RCPs IPCC AR5
Charlottetown, PEI, Canada



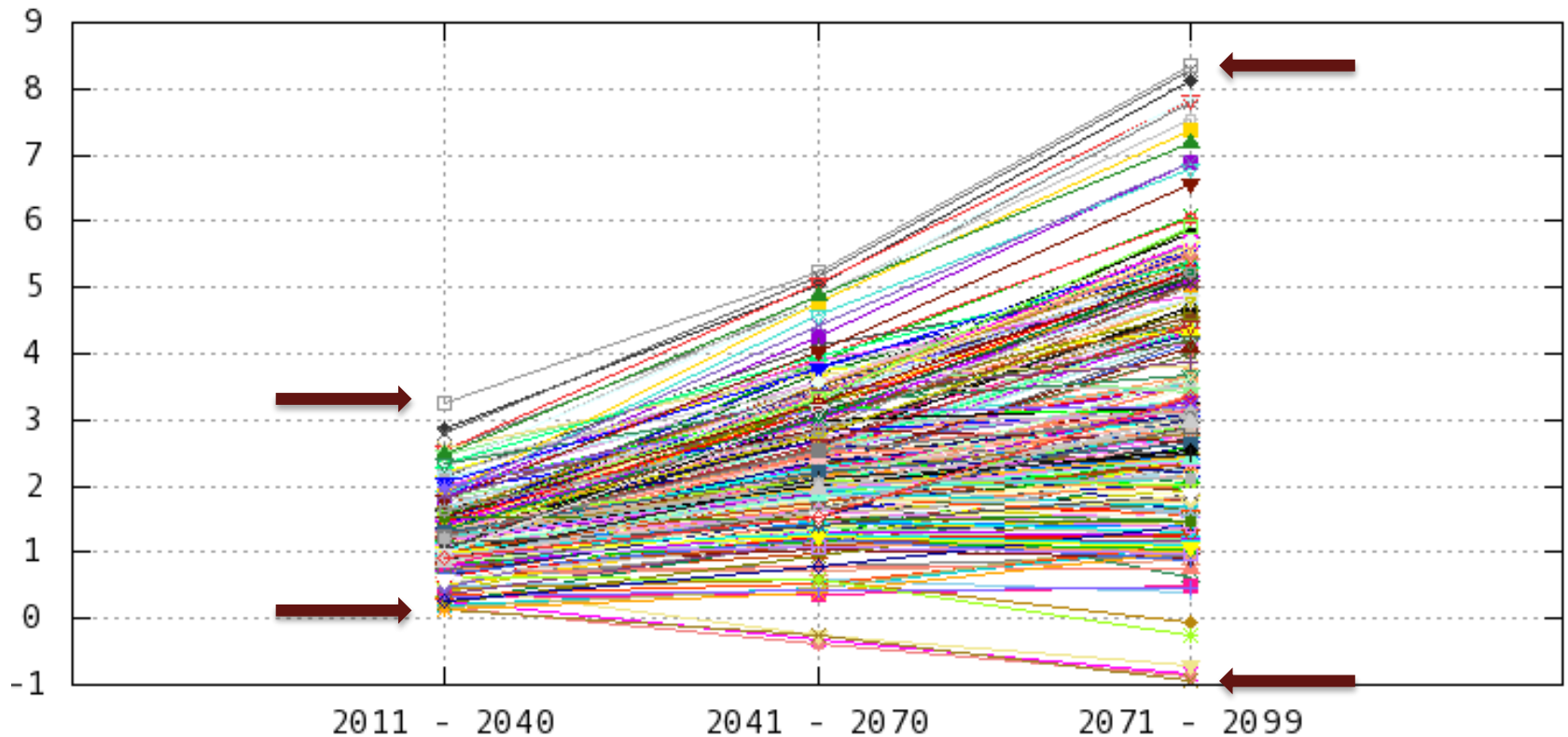
Total Precipitation anomaly (%)
2020s, 2050s, 2080s (baseline 1981-2010)
All Models, Runs and RCPs IPCC AR5
Charlottetown, PEI, Canada



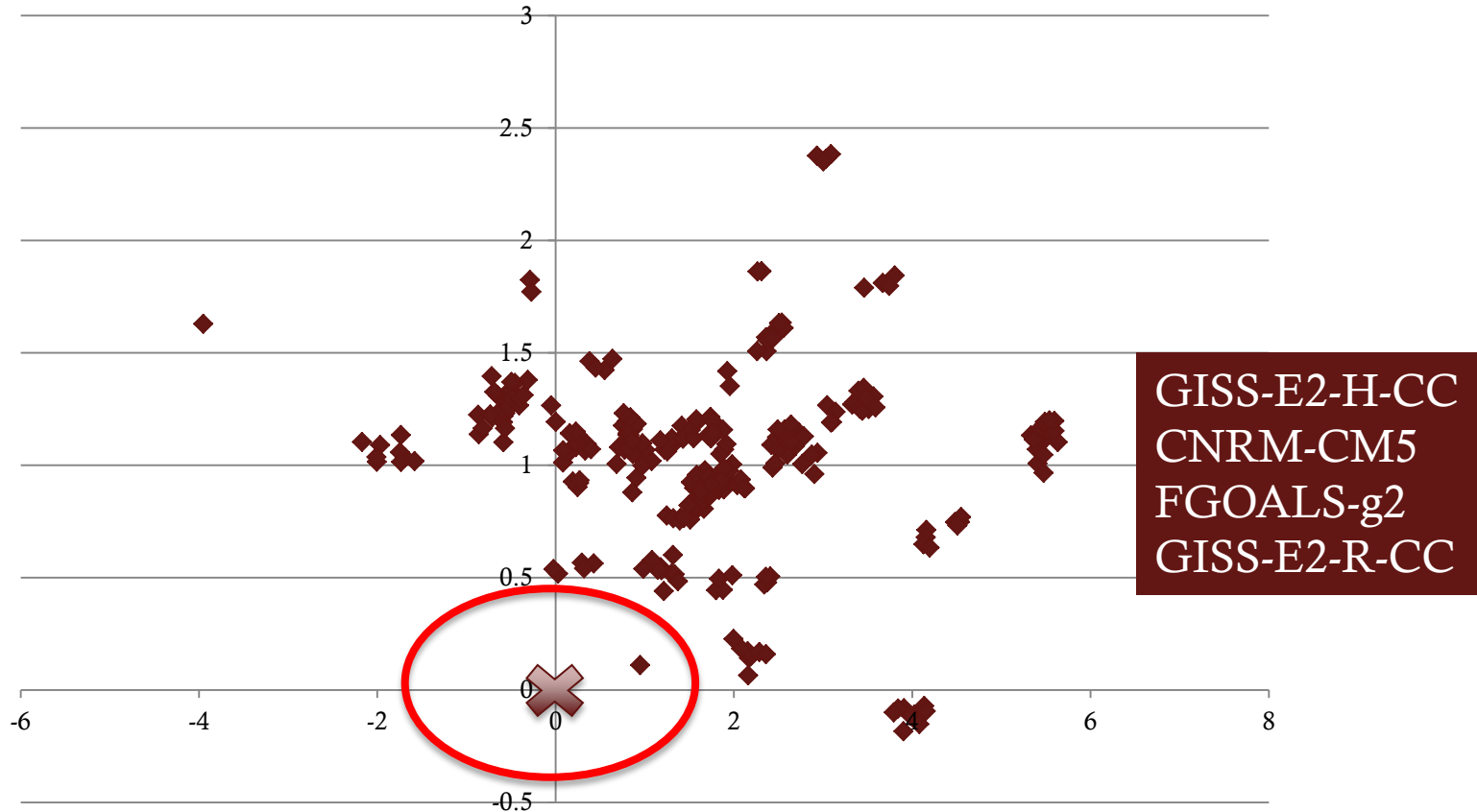
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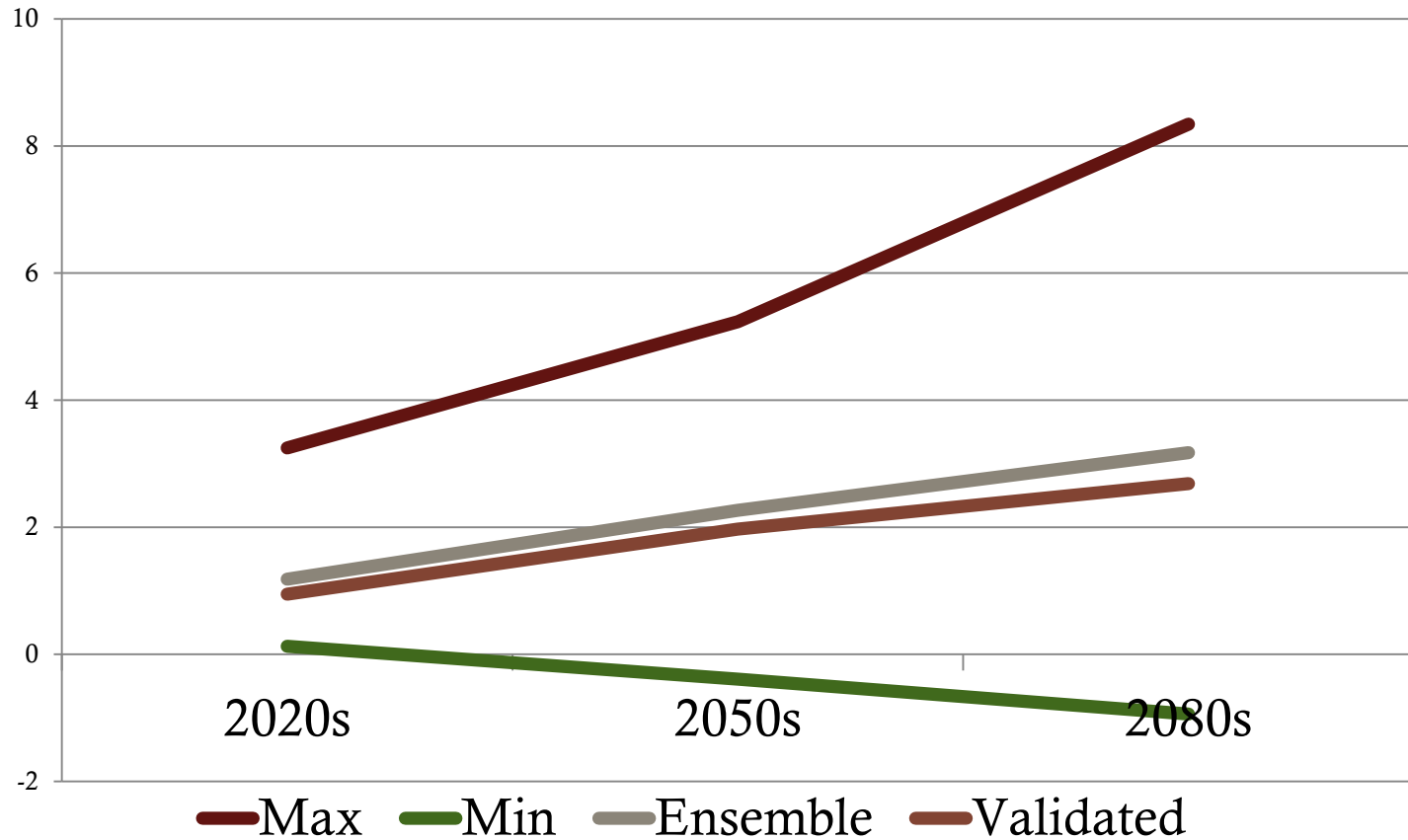
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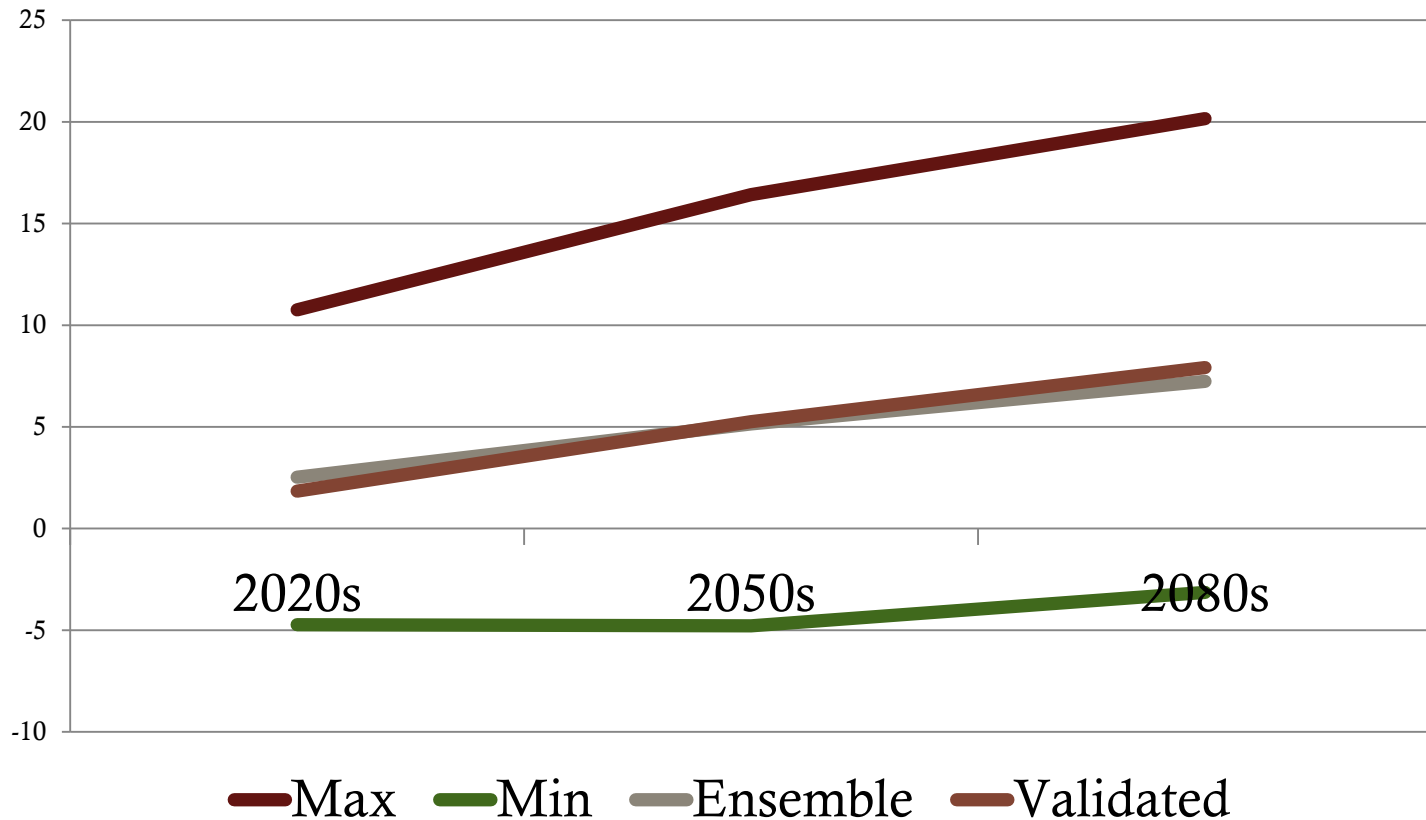
Validation of GCM Projections IPCC AR5 All Models and Runs Charlottetown, PEI, Canada 1981-2010



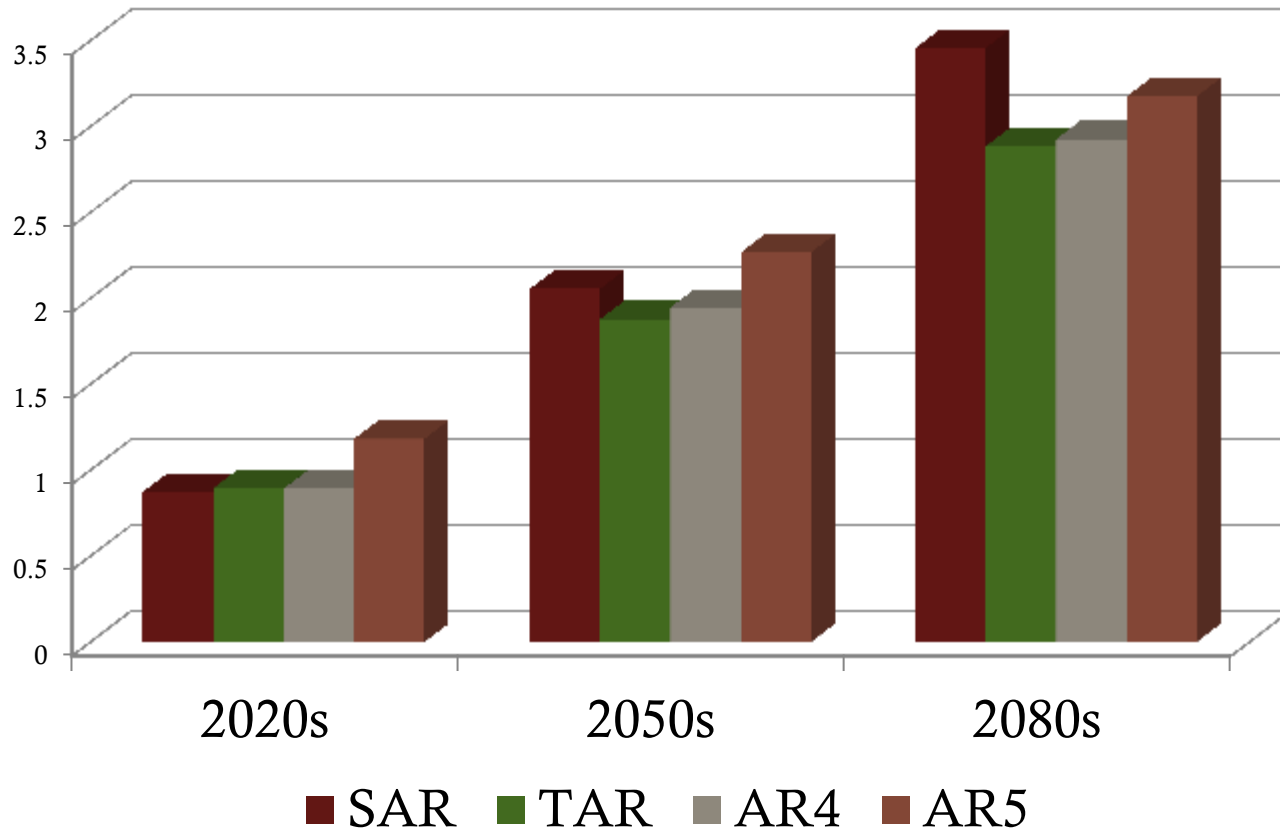
Future Temperature Anomalies (°C) Charlottetown, PEI, Canada



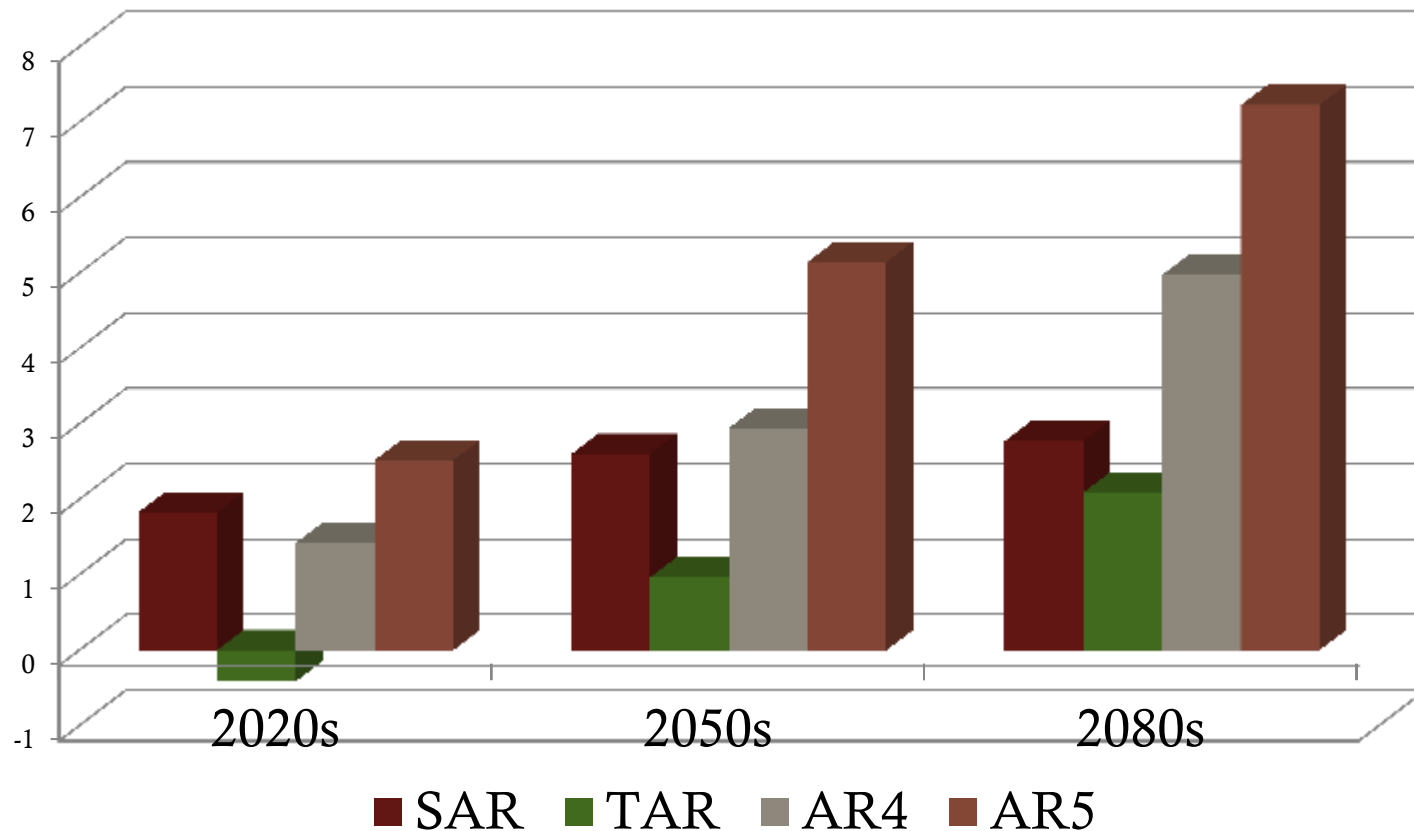
Future Precipitation Anomalies (%) Charlottetown, PEI, Canada



Comparison on Future IPCC Projections Annual Mean Temperature (°C) Charlottetown, PEI, Canada



Comparison on Future IPCC Projections Annual Total Precipitation (%) Charlottetown, PEI, Canada



Conclusions

- IPCC AR5 has over 40 GCMs providing future projections of climate for consideration using 4 RCPs
- While providing no guarantees, an ensemble of all GCMs can best represent historical climate and is more likely to accurately represent future climate conditions
- When compared with previous IPCC assessments, ensemble projections for Charlottetown show slightly increasing temperature projections and increasing precipitation projections



Thanks!



- Adam Fenech, PhD (Toronto)
- Neil Comer, PhD (McGill)

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Carrie Houston
Josh MacFadyn
Adam Irawak
Derek Tsui





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