Transportation: Adapting to a Changing Climate Webinar Series

Understanding and using the latest climate data to build resilience in the transportation sector

Tuesday, March 14, 2023, 1:00 pm to 2:30 pm ET

Presenter:

Ryan Smith
Climate Service Specialist, Canadian Centre for Climate Services

Environment and Climate Change Canada | Environnement et Changement climatique Canada

Canada

Understanding and using the latest climate data to build resilience in the transportation sector

Ryan Smith, Climate Scientist & Senior Outreach Officer, Canadian Centre for Climate Services

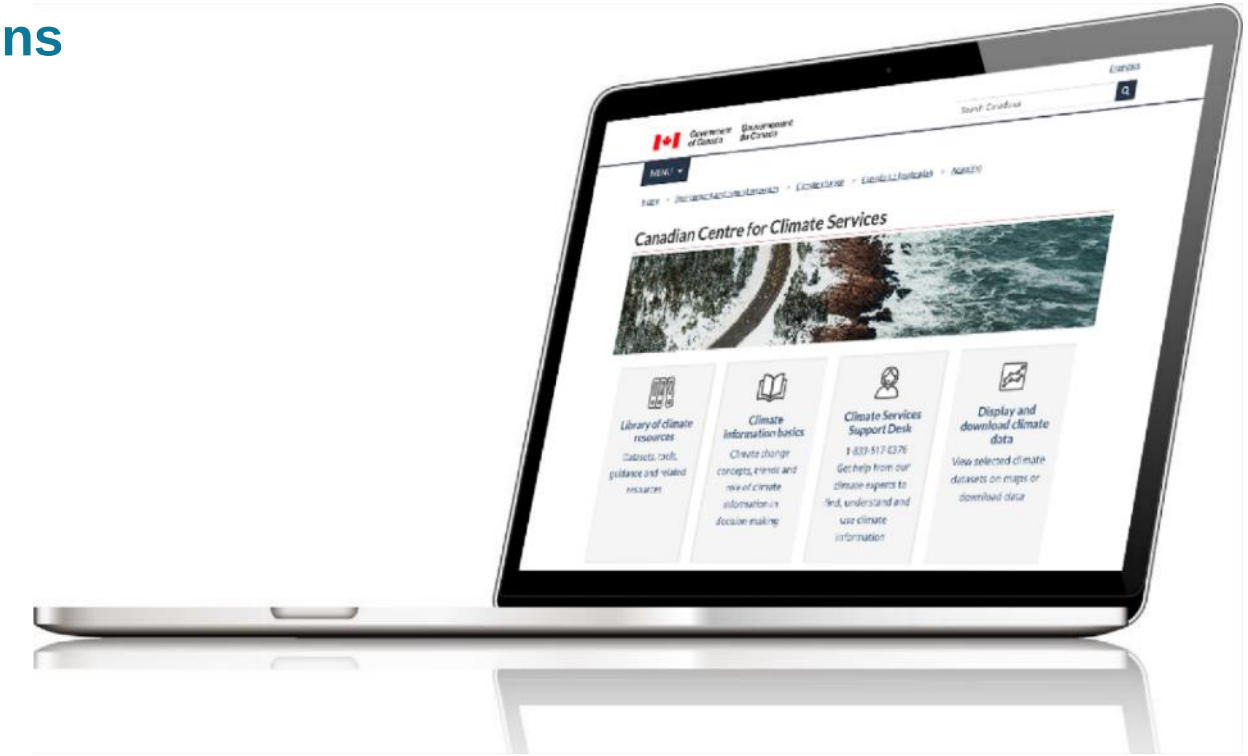
Transport Canada Climate Adaptation Webinar Series

March 14, 2023

CANADIAN CENTRE FOR **CLIMATE SERVICES** | **CENTRE CANADIEN** DES **SERVICES CLIMATIQUES**

Canadian Centre for Climate Services

Provides Canadians with information and support to consider climate change in their decisions



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Canada.ca/climate-services

Our Services

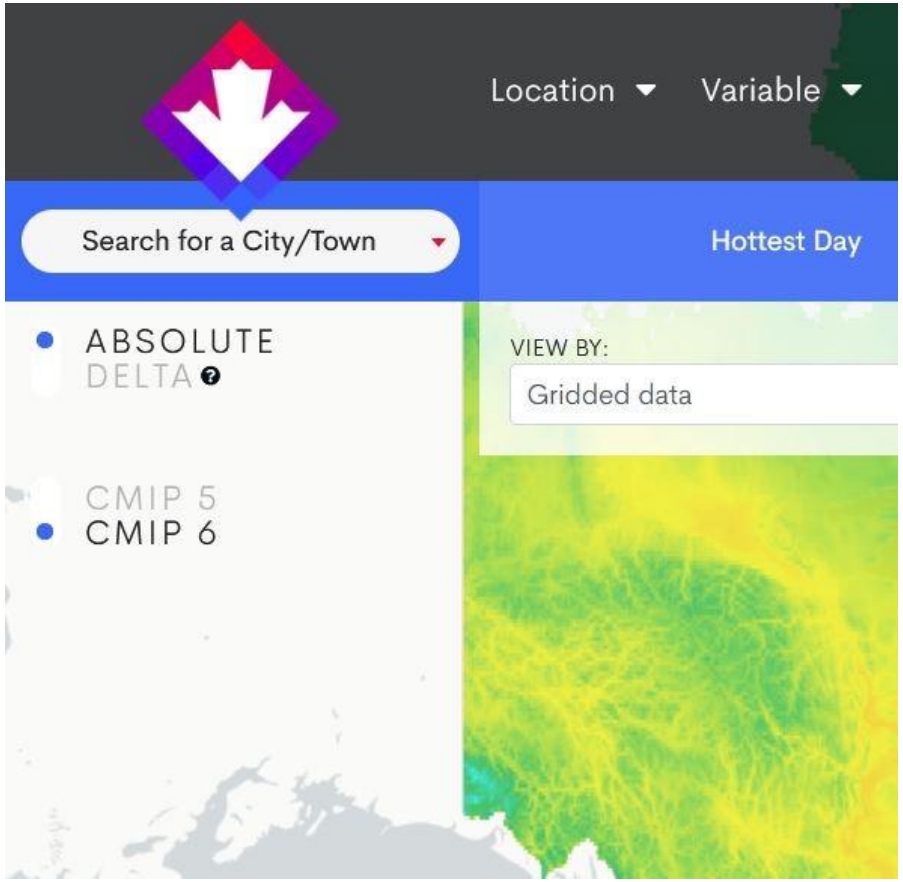
- **Increasing awareness and access** to climate data and information
- **Providing training and guidance** on using climate data
- **Engaging with users** to understand needs
- **Developing new products** by collaborating with experts and users

Outline

- CMIP6 climate model projections
  - What is CMIP6?
  - What are the SSP scenarios?
  - How do I find CMIP6 data?
- Global Warming Levels
  - Why are data providers increasingly providing GWL-based data?
  - How can GWLs be used to understand future, local climate changes and impacts?
- Design Value Explorer
  - Launched Feb 27th 2023
  - A new tool for extracting future climate design values
  - Intended applications for infrastructure projects
- What's coming next?

Introducing CMIP6 on ClimateData.ca

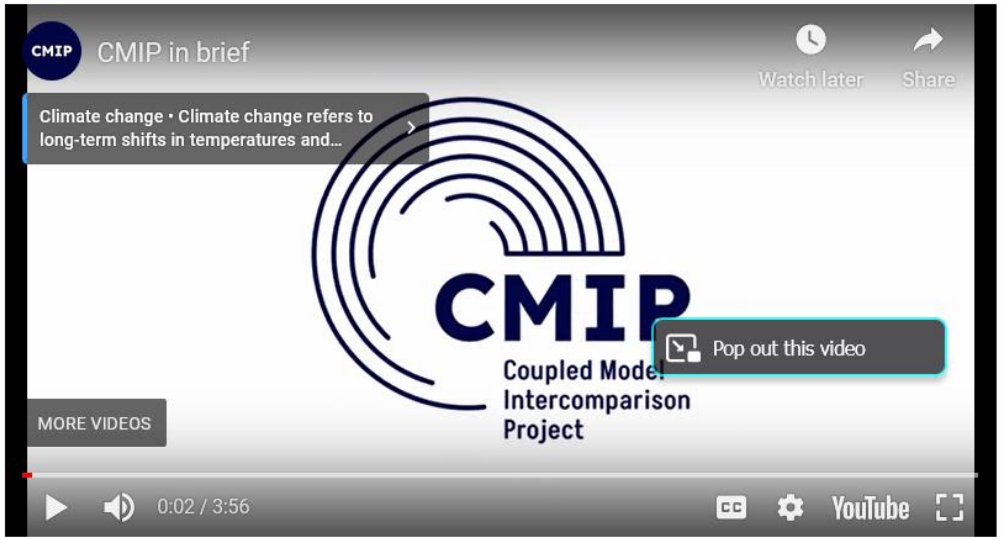
- The new default dataset on ClimateData.ca
- New scenarios called SSPs
- 26 models, downscaled to 6 x 10 km, daily data
- Temperature and precipitation-based indices



What exactly is CMIP6?

- Coupled Model Intercomparison Project
- “Bridging science and policy to meet the climate challenge”
- United Nations World Climate Research Programme
- Recommends core set of experiments for the climate modelers

WCRP Coupled Model Intercomparison Project (CMIP)



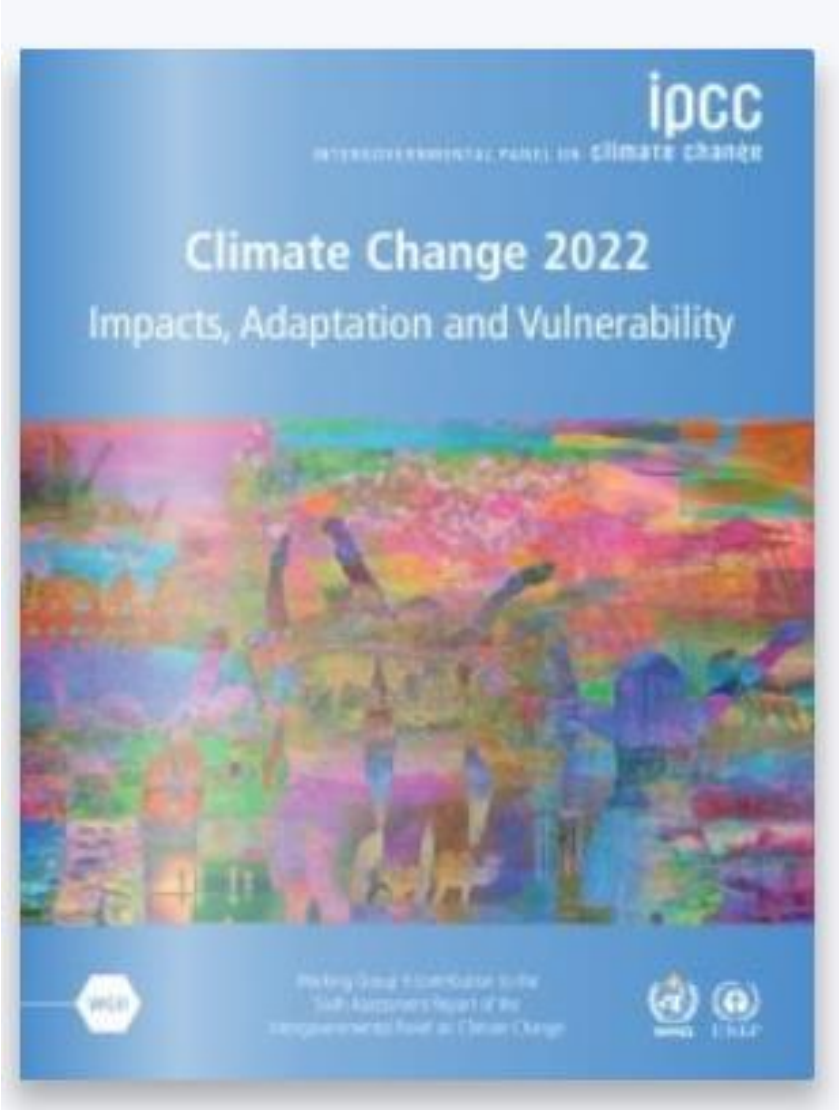
This short movie gives insight into the world of climate modelling, particularly WCRP's initiative CMIP. CMIP provides climate projections that support essential WCRP activities and climate science worldwide, decision and policy-makers communities, in its objective to understand past, present and future climate changes. CMIP and its associated data infrastructure have become essential to the Intergovernmental Panel on Climate Change (IPCC) and other international and national climate assessments.

Why do we need CMIP?

- Climate modelling is resource intensive
- Many decision to make
  - Temporal and spatial resolution
  - Future GHG concentrations
  - Long-term feedbacks and geochemical processes
  - Parameterization of microphysics (clouds, etc.)
  - And many, many more
- Need for standardization so models can be compared

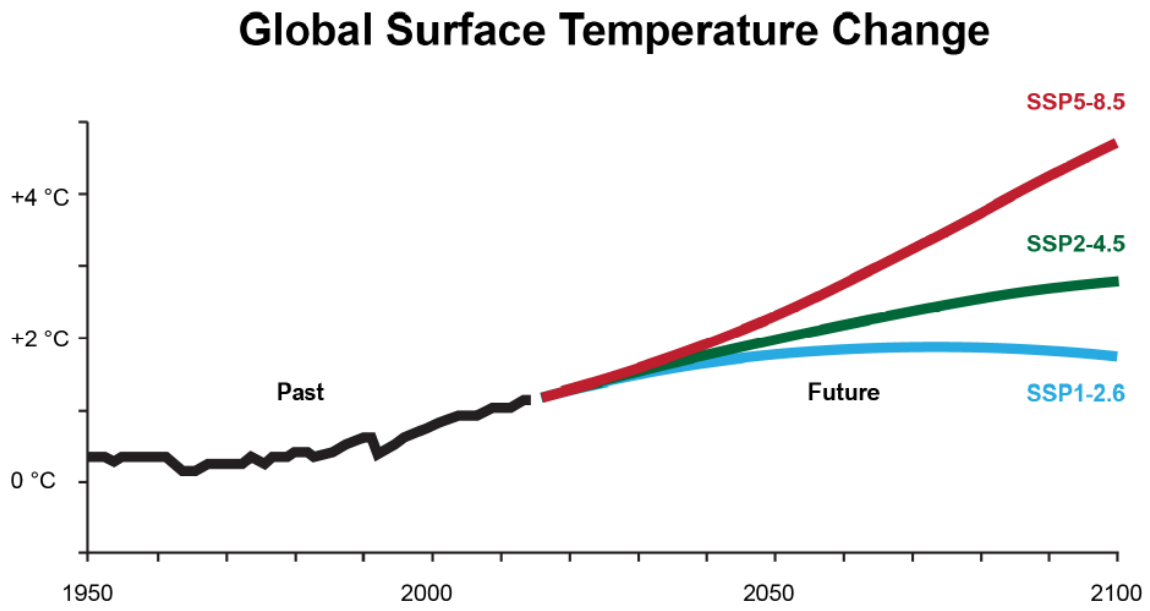
CMIP6 data is used by the IPCC

- The Intergovernmental Panel on Climate Change (IPCC) is the international body for assessing climate science
- Sixth Assessment Report (AR6), 2022
- AR6 Synthesis Report: Climate Change 2023
- Special report on Global Warming of 1.5 ºC (2021)



Standardized Scenarios

- Models run a standard set of future scenarios
- SSPs (shared socio-economic pathways)
- Replace RCPs (representative concentration pathways)
- Range of futures depending on GHG emissions (and other factors)

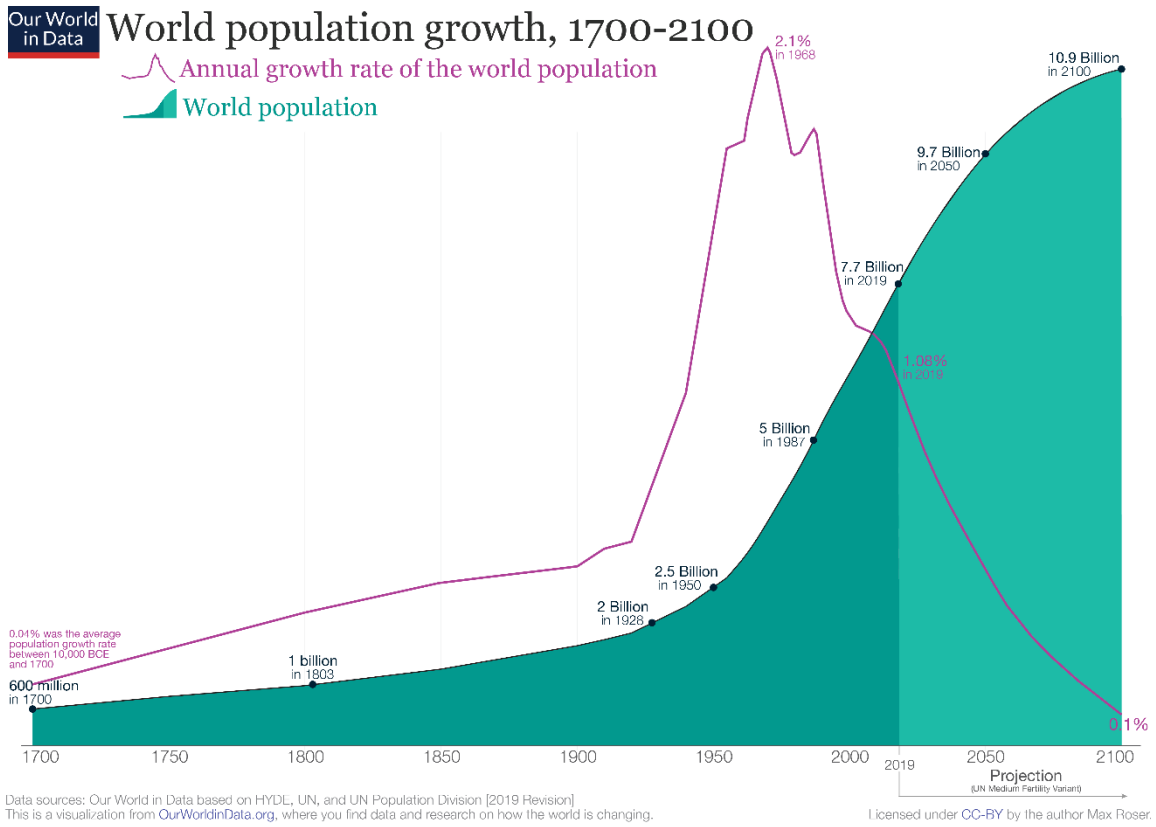


Why do we need to use scenarios?

- Climate models are not “crystal balls”
- We typically cannot ascribe a probability to any one scenario
- Analogy: banking investment, accepting risk based on range of projections

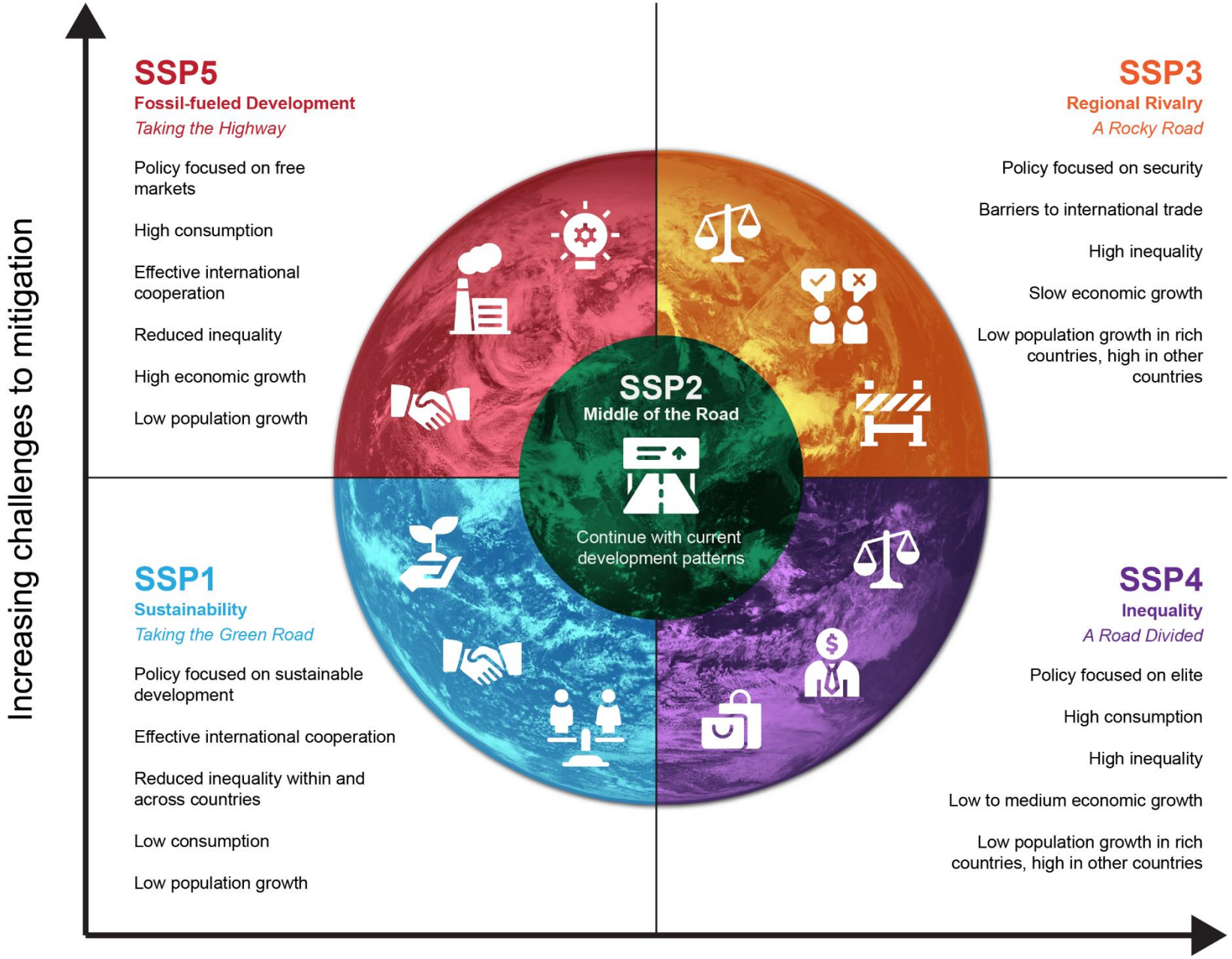
Shared Socio-economic Pathways (SSPs)

- Possible future development pathways
- Assumptions about population, education, energy use, technology, and more
- Data are fed into Integrated Assessment Models to compute future GHG levels



SSP Narratives

Read our Learning Zone article to learn more about SSPs



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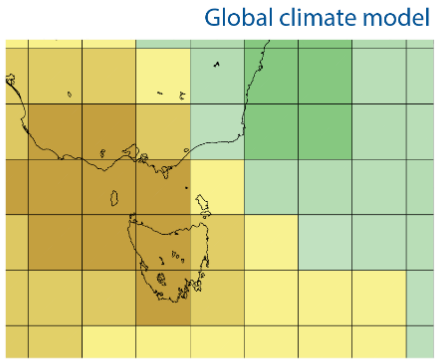
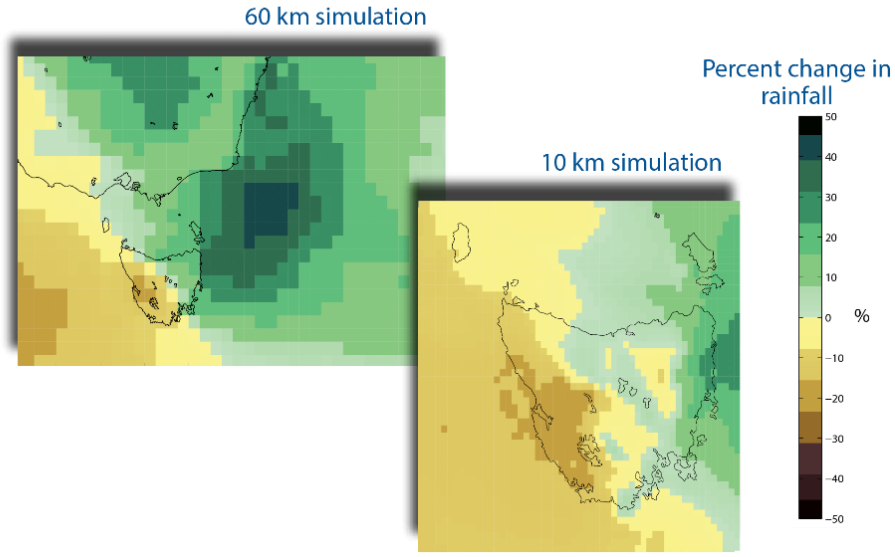
CMIP6 on ClimateData.ca

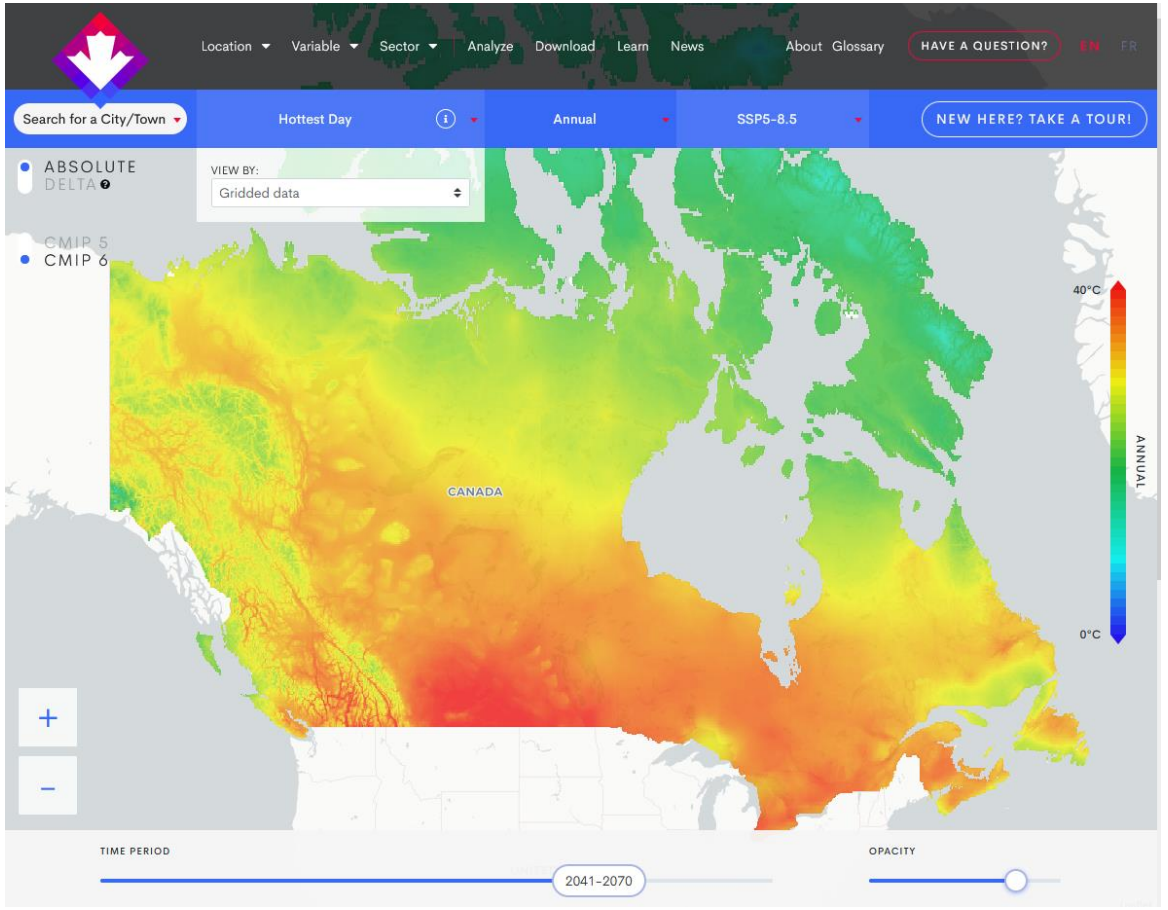
- Raw climate model data is coarse (100+ km)
- Desirable to *downscale* these data to better understand local climate change
- Statistical or dynamical?
- Dynamical is *expensive* typically can't do a full ensemble of models + scenarios
- ClimateData.ca: statistical method called BCCAQv2



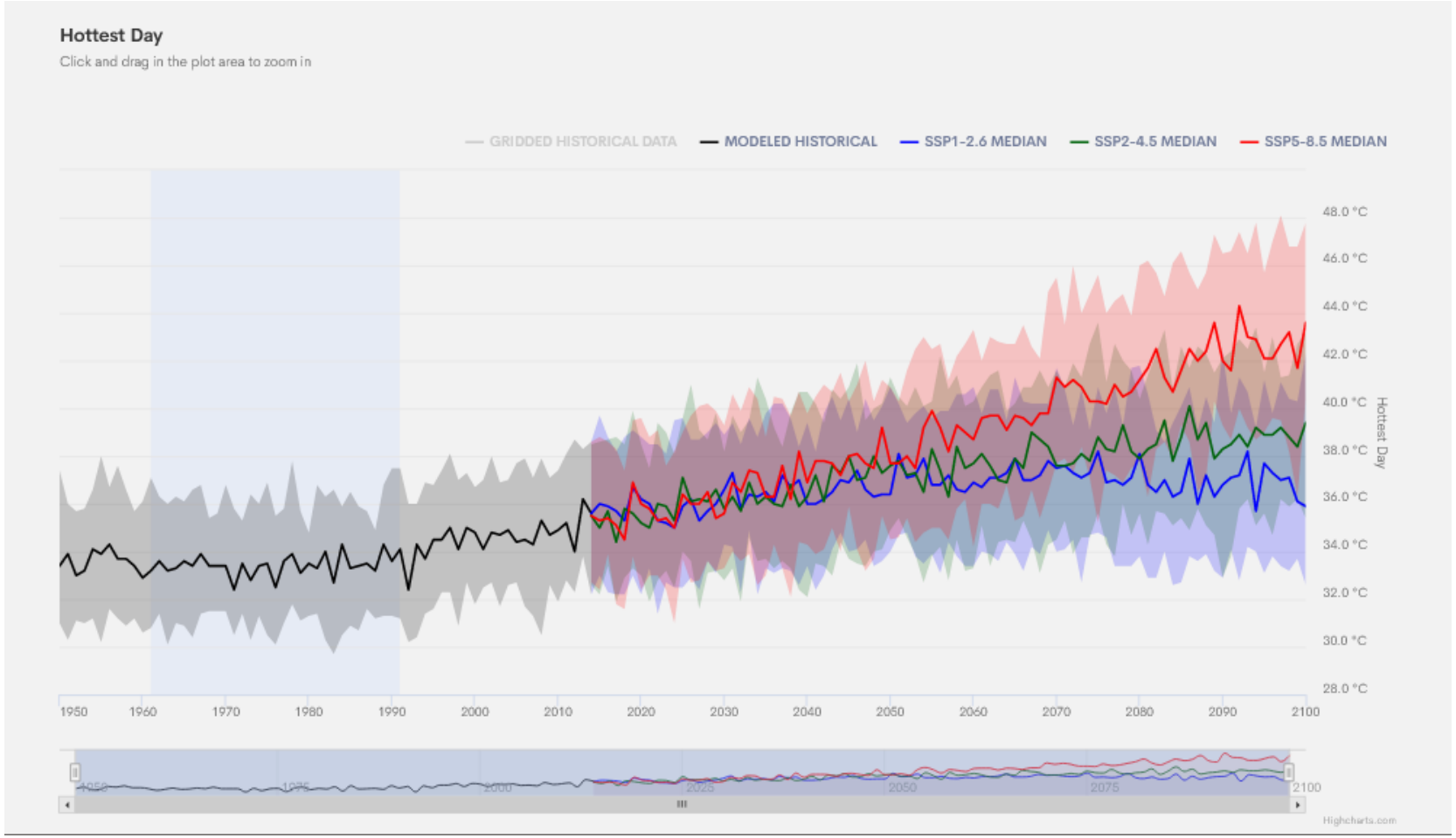


CMIP6 on ClimateData.ca

- Temperature and precipitation-based indices, e.g.:
  - Hottest day of the year
  - Days with more than 10 mm of precipitation
  - Number of dry spells
  - Etc.
- National maps
- Zoom in to access local data



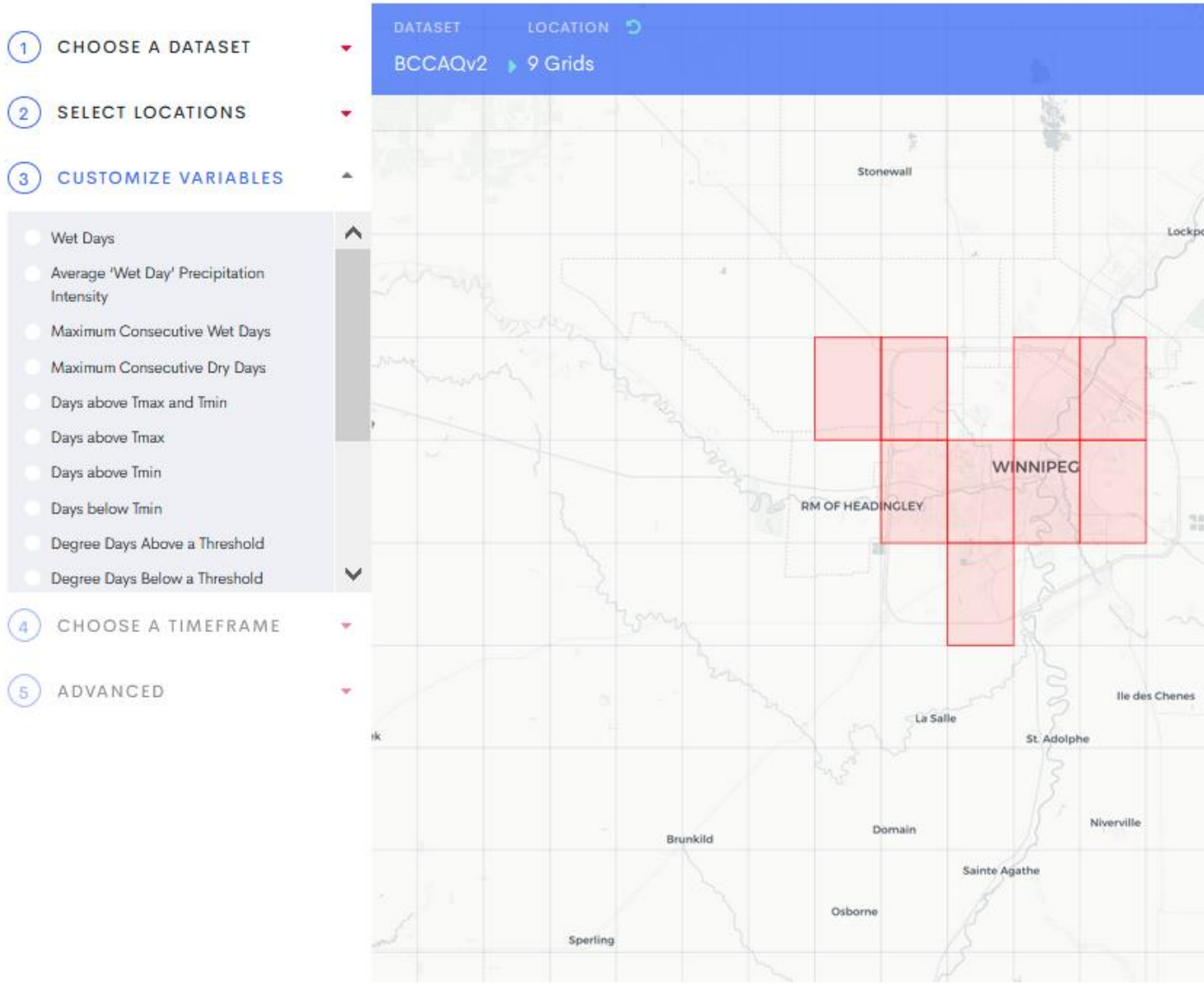
CMIP6 on ClimateData.ca



ClimateData.ca
Analysis Page

ClimateData.ca/analyze/

- Choose data set
- Select locations
- Customize variables
- Choose a timeframe
- Select advanced options
- *More coming soon!*

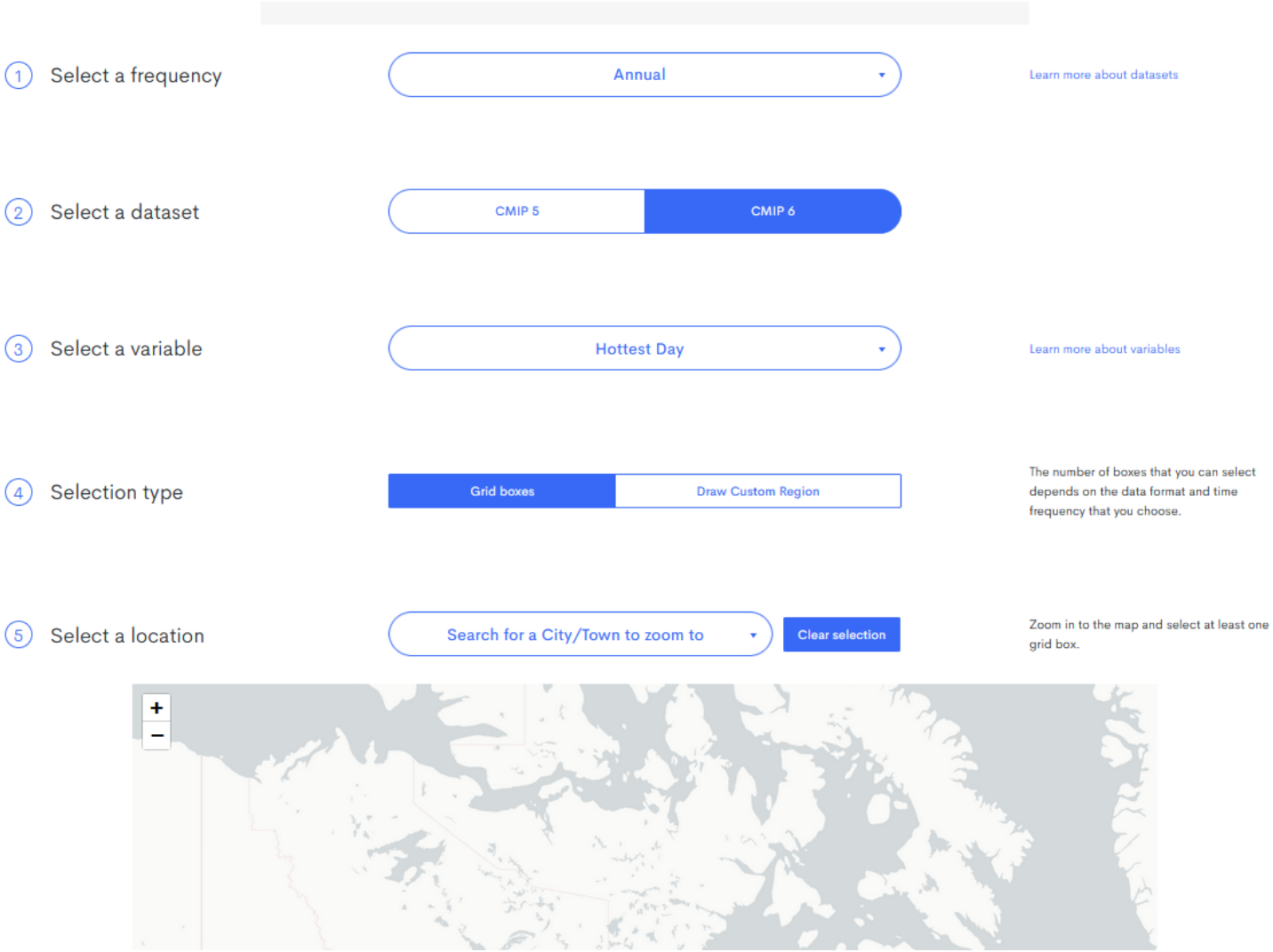


Mode	Component	Hazard	Threshold	Impact
	Rail/track	Extreme heat	≥ 37.7 °C	When track temperatures on the Metrolinx (ON) rail network exceed the Preferred Rail Laying Temperature (37.7°C), the track can buckle and kink, requiring slower travel speeds for safety. This can cause commuter delays.[6]
	Rail/track	Extreme cold	≤-23 °C	When southern Ontario experiences extreme cold temperatures, this can cause railway track to crack. This poses safety concerns and leads to increased maintenance costs.[7]
	Runway asphalt	Freeze-thaw	5 to >30 per year	Increasing freeze-thaw cycles can cause airport runways to prematurely degrade, shortening their life span, and costing more for maintenance and replacement.[8]
	Aircraft lift	High temperatures	-	In hotter air, planes generate less lift, increasing fuel costs or decreasing the safe airplane weight (see example to the right).
	Concrete	Extreme heat	~ 36.5 °C	When the City of Winnipeg experiences extreme heat, this can cause strong internal temperature gradients to form within Jointed Plain Concrete Pavement slabs, which in turn can lead to transverse cracking of, or other damage, to the concrete. This can cause mobility delays and increased maintenance and replacement costs.[1,2,3]
	Road safety	Precipitation	10 mm	Precipitation can cause the flooding of roadways, pavement washouts, reduced mobility, and an increasing risk of vehicle collisions. Studies have shown that for every 10 mm of rainfall, the risk of collision increased by 3%.[4,5]

ClimateData.ca
Download Page

ClimateData.ca/download/

- Full datasets
- Future projections
- Weather Stations
- IDF Curves
- AHCCD
- More coming soon…



How are CMIP6 data different from CMIP5?

- CMIP6 has increased spatial resolution, representing processes such as clouds, water vapor, and aerosols in more detail.
- Extreme precipitation found to be more realistic
- Some models have higher climate sensitivities than CMIP5

Read more : https://climatedata.ca/news/

Do you have to redo your work now that CMIP6 is out?

- That depends.
- CMIP6 model results exhibit many similarities to those of CMIP5
- CMIP5 data are still valid
- It is recommended use CMIP6 for new work requiring future climate projections and that you examine the similarities/ differences with CMIP5.

Read more: https://climatedata.ca/learn/

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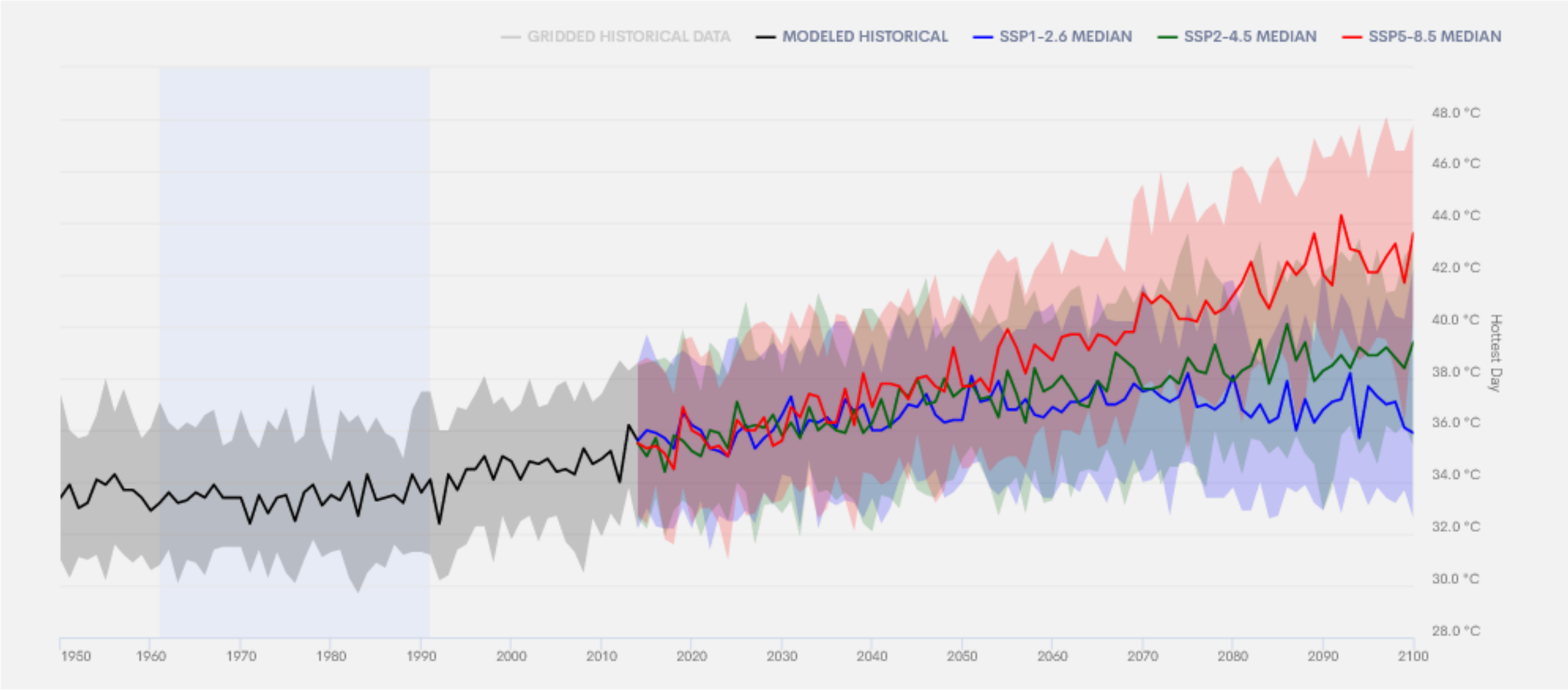
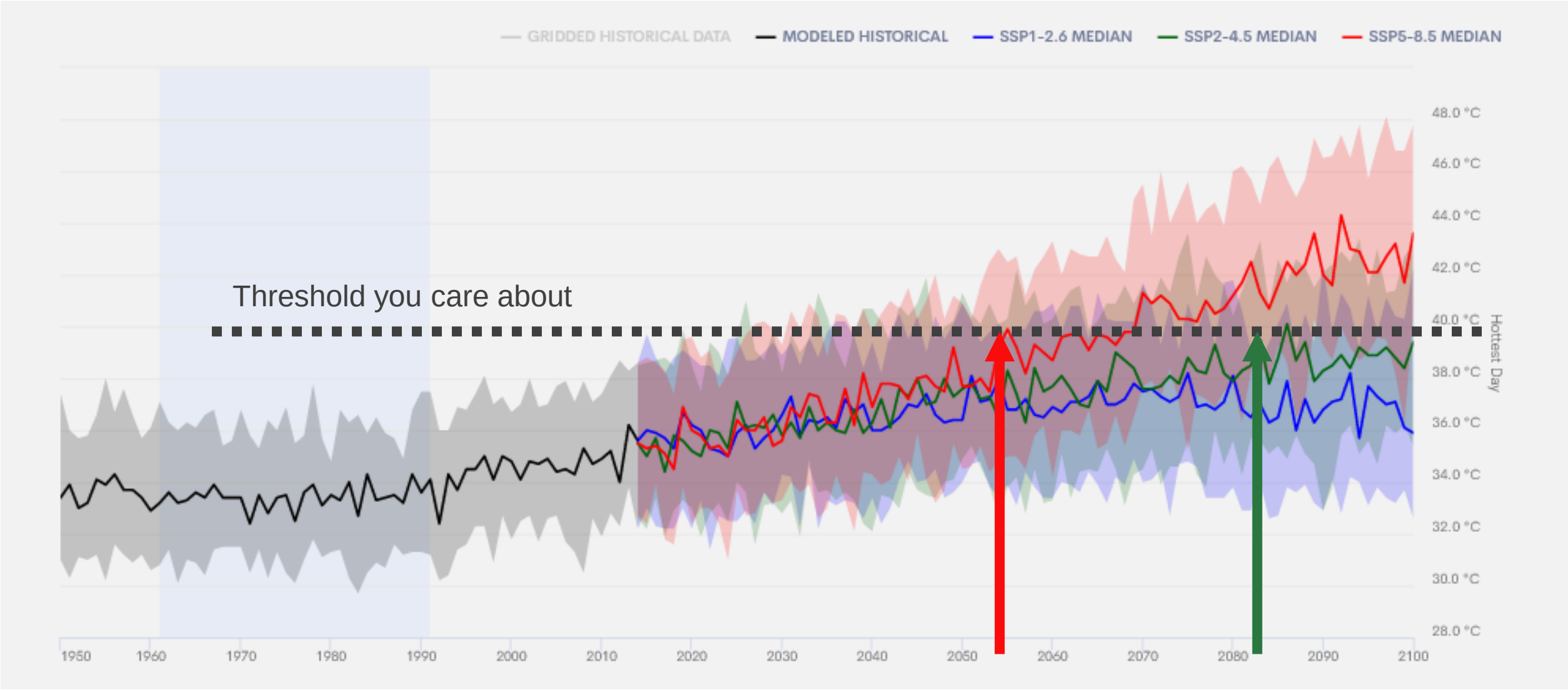

GRIDDED HISTORICAL DATA
MODELED HISTORICAL
SSP1-2.6 MEDIAN
SSP2-4.5 MEDIAN
SSP5-8.5 MEDIAN
48.0 °C
46.0 °C
44.0 °C
42.0 °C
40.0 °C
38.0 °C
36.0 °C
34.0 °C
32.0 °C
30.0 °C
28.0 °C
Hottest Day
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100

Challenges in using scenario-based data: common questions

- “The range of values between scenarios is very large – should I plan for the whole range?”
- “Are some scenarios more or less likely to occur than others?”
- “What scenario should I use for my work?”
- “What happens after 2100?”

These questions don’t necessarily have standard answers, and will depend on many factors.


GRIDDED HISTORICAL DATA
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Threshold you care about
48.0 °C
46.0 °C
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42.0 °C
40.0 °C
38.0 °C
36.0 °C
34.0 °C
32.0 °C
30.0 °C
28.0 °C
Hottest Day
1950
1960
1970
1980
1990
2000
2010
2020
2030
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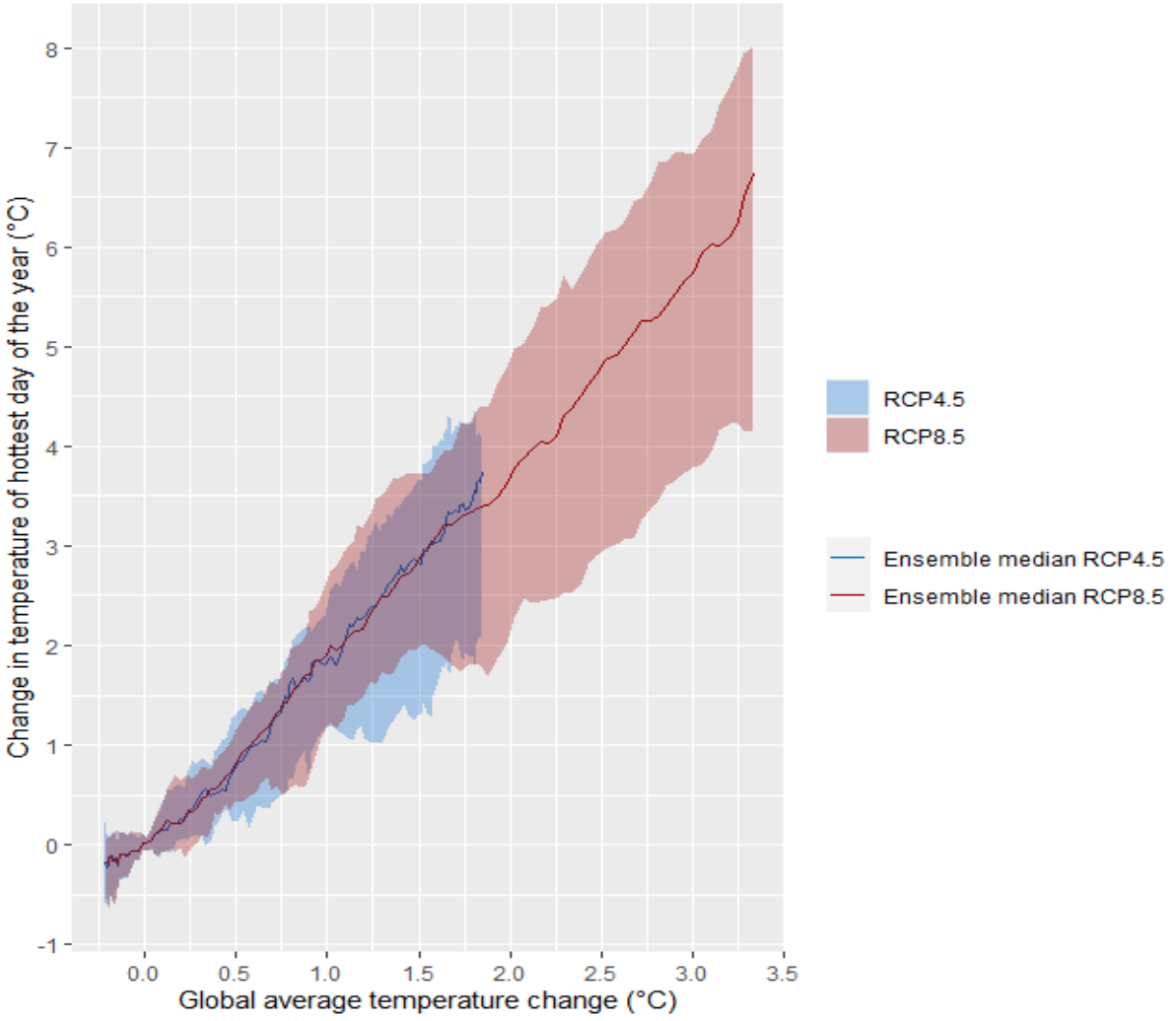
2100

Not an “if”, but a “when” question

- For temperature-dependent processes, *impacts* scale based on the *magnitude of warming, not the pathway*
- The timing of impacts will depend on the speed of warming, i.e. GHG emissions
- Warming continues beyond 2100 under most scenarios, even low-carbon scenarios can result in large changes

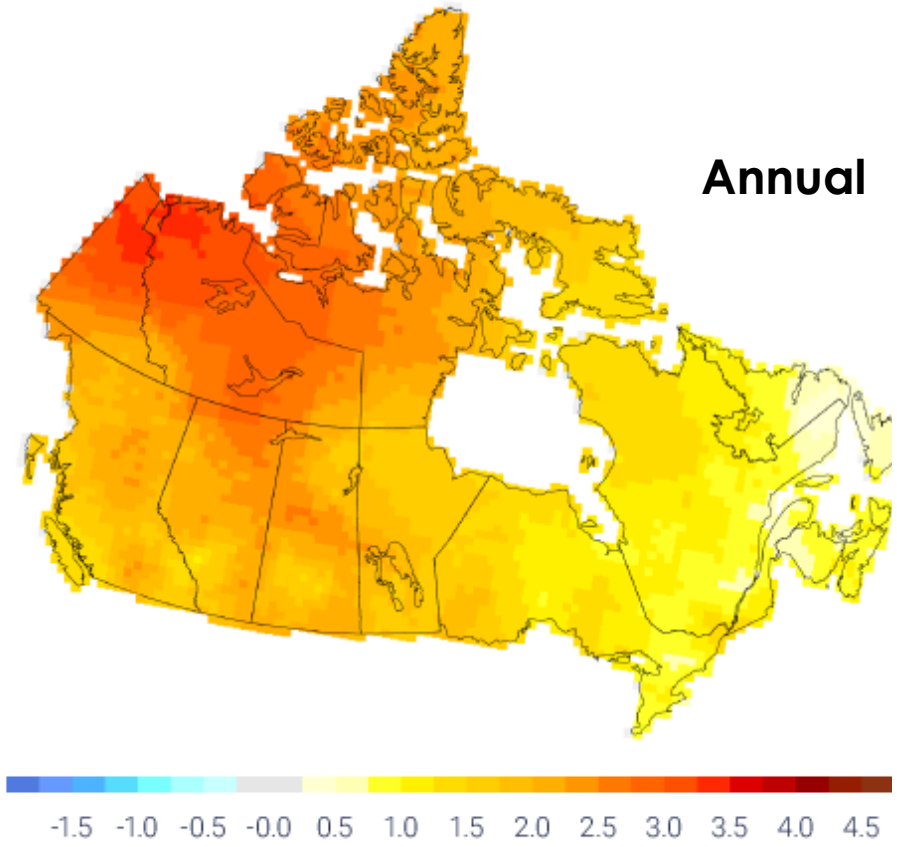


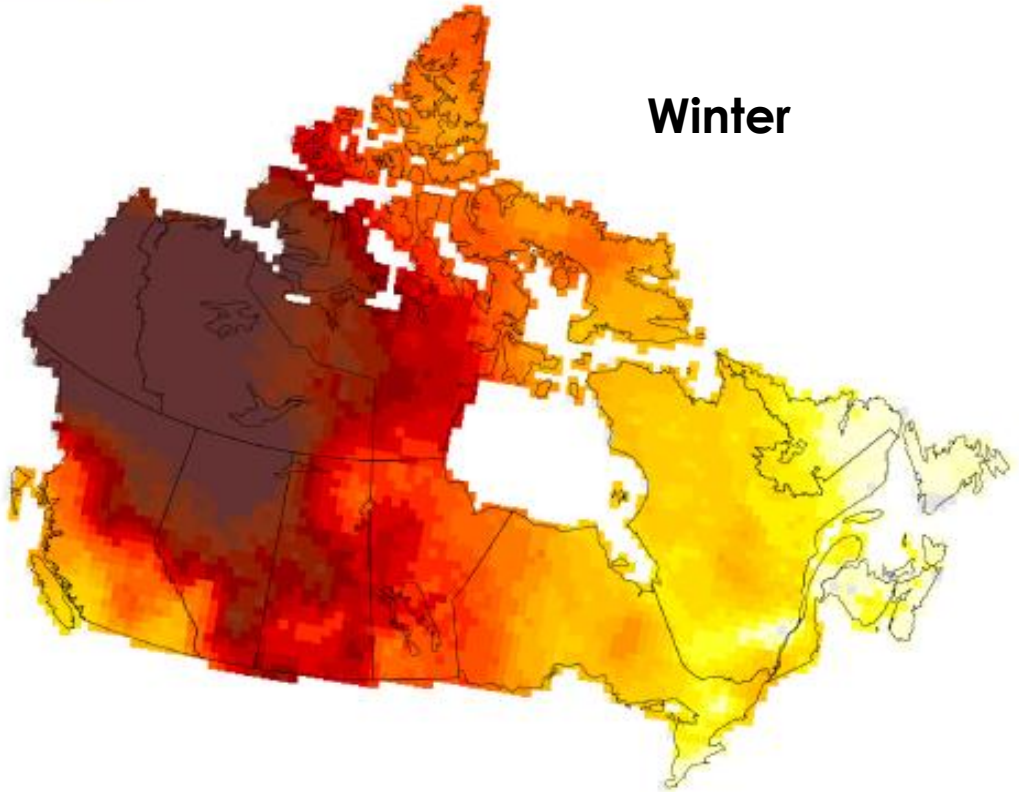
What do we mean by ‘level of global warming’?

- Presenting climate changes according to the global average temperature, not a specific scenario
- **Question: how much future global warming might be expect?**

How much global warming has happened?

- **Globl temperature** has increased 1.1˚C in past 120 years
- **Canada** has warmed 2X the global rate, 3X in the North, in the past 120 years





How much global warming should we expect?

- A.1. Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C. **Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate. (high confidence)**

- IPCC 2021, Special Report: Global Warming of 1.5°C

- The chance of temporarily **exceeding 1.5°C** has risen steadily since 2015, when it was close to zero. For the years between 2017 and 2021, there was a 10% chance of exceedance. That **probability has increased to nearly 50% for the 2022-2026 period**.

WMO update, May 2022

How much global warming should we expect?

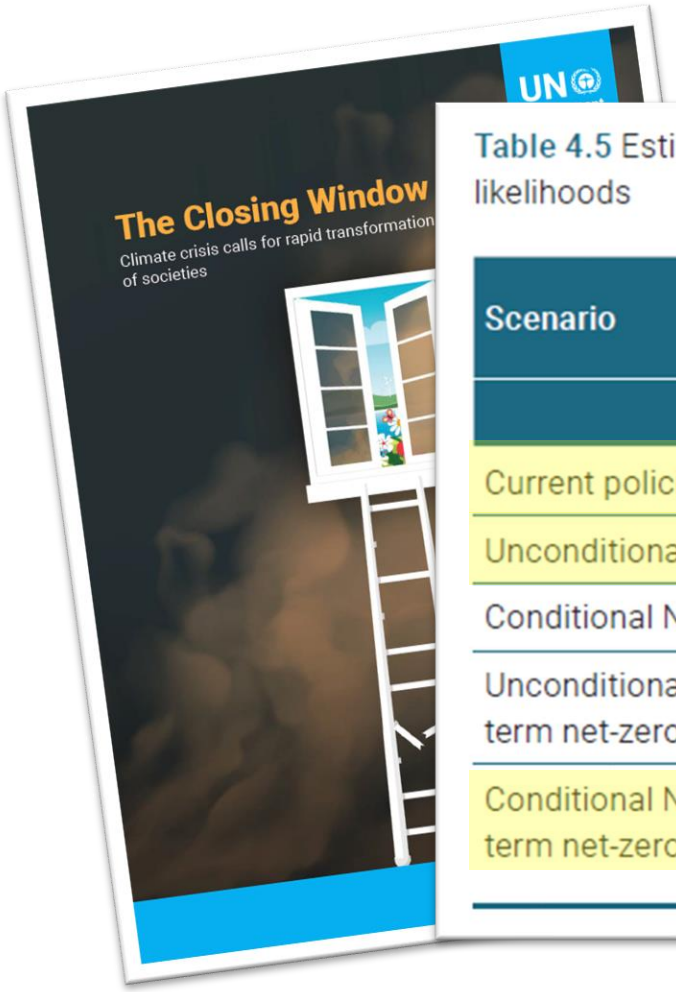


Table 4.5 Estimated global warming implications over the course of the twenty-first century under different scenarios and likelihoods

Scenario	Estimated global warming over the twenty-first century with various chances (median and range)		
	66%	50%	90%
Current policies	2.8°C (range: 1.9–3.3°C)	2.6°C (range: 1.7–3.0°C)	3.3°C (range: 2.3–3.9°C)
Unconditional NDCs	2.6°C (range: 1.9–3.1°C)	2.4°C (range: 1.7–2.9°C)	3.1°C (range: 2.3–3.7°C)
Conditional NDCs	2.4°C (range: 1.8–3.0°C)	2.2°C (range: 1.7–2.7°C)	2.8 (range: 2.2–3.5°C)
Unconditional NDCs and long-term net-zero targets	1.8°C (range: 1.8–2.1°C)	1.7°C (range: 1.7–1.9°C)	2.1 (range: 2.0–2.5°C)
Conditional NDCs and long-term net-zero targets	1.8°C (range: 1.7–1.9°C)	1.7°C (range: 1.6–1.8°C)	2.0°C (range: 2.0–2.3°C)

https://www.unep.org/resources/emissions-gap-report-2022

Extreme Impacts – Flooding

British Columbia, November 2021

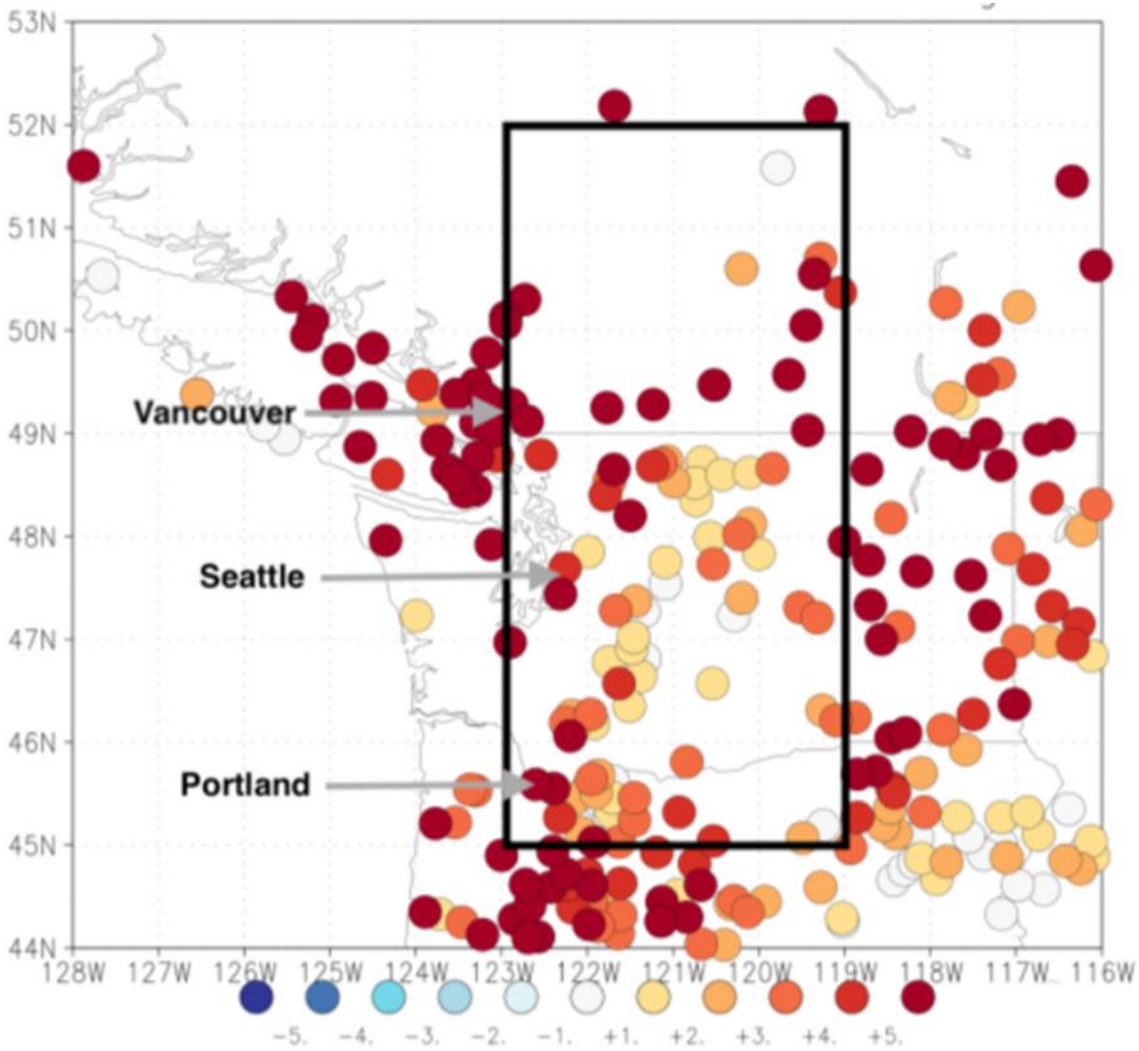
- Flooding was 2-4 times more likely as a result of human climate change
- In a future of **3℃ of warming** relative to preindustrial: atmospheric river events similar to 2021 event will double in likely occurrence

Extreme Impacts – Heat

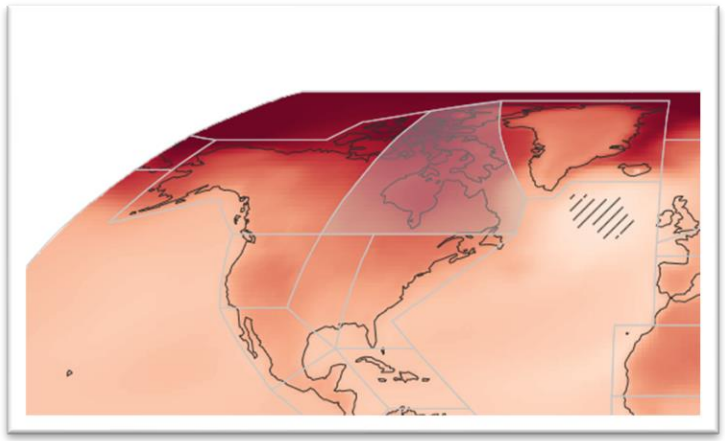
2021 BC Heat Dome

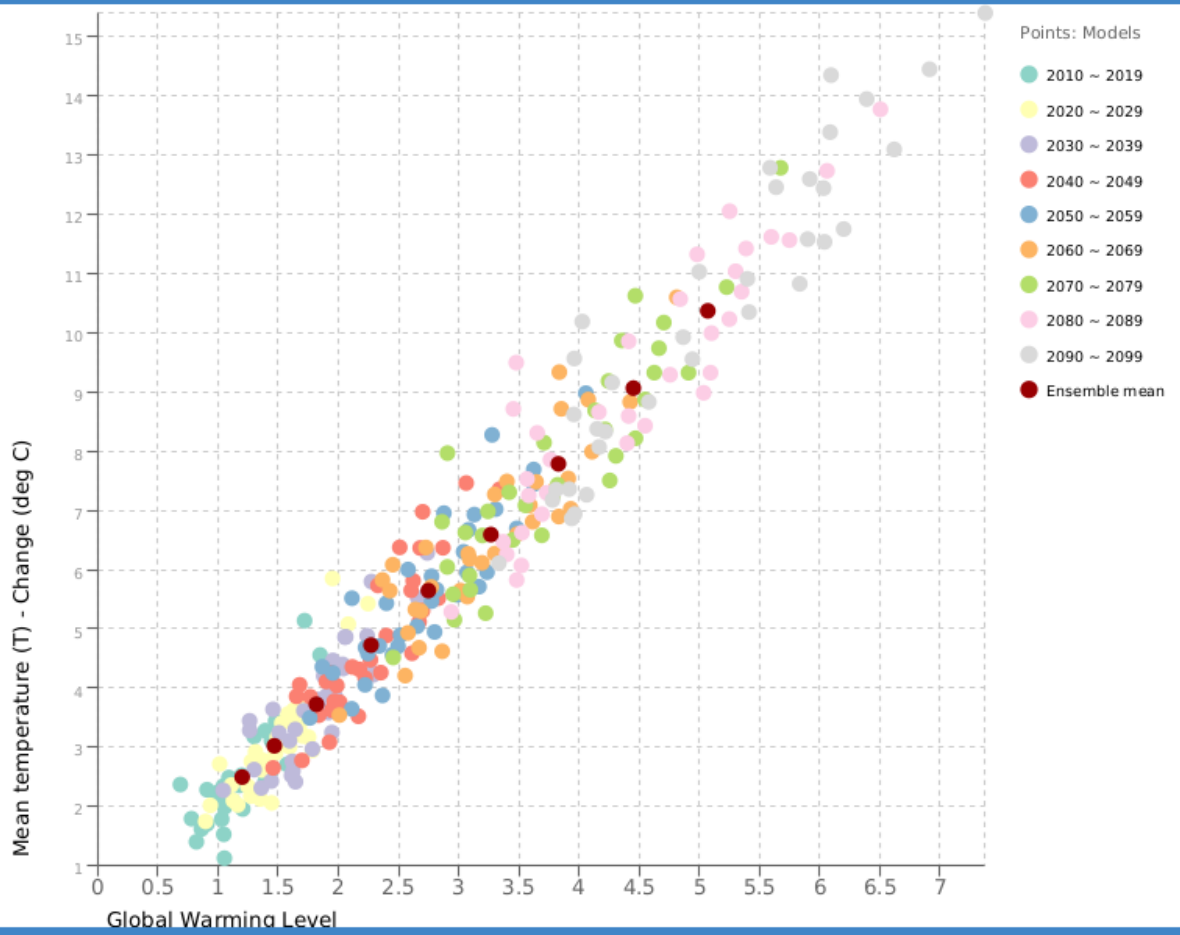
- In the summer of 2021, observed temperatures at many locations were far outside the range of historically observed temperatures
- roughly once in a thousand years in today's climate
- **In a future world, with global average temperatures 2 °C above preindustrial, such an event could occur once every 5 to 10 years**

Attribution results and figure from: www.worldweatherattribution.org – an international group of climate scientists who undertake rapid extreme event analyses.



IPCC Interactive Atlas





Mean temperature (T) - Change (deg C)
SSP5-8.5 (rel. to 1850-1900)
CMIP6 - Annual (34 models)-North-Eastern North America

https://interactive-atlas.ipcc.ch/

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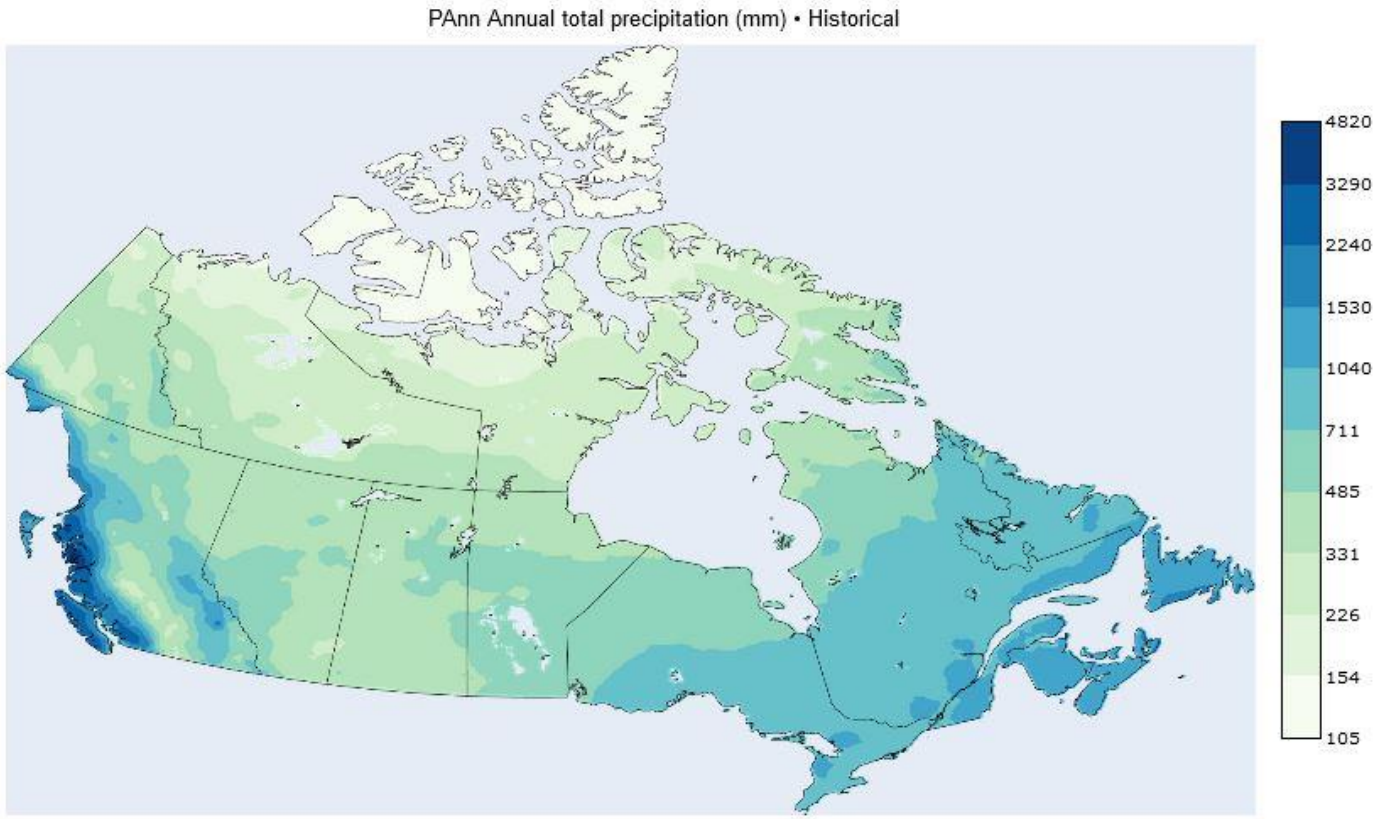
The Design Value Explorer

- New data tool launched February 2023
- 19 climate design values
- Historical values
- Future projections
  - GWL
- Partnership between INFC, NRC, ECCC, and PCIC



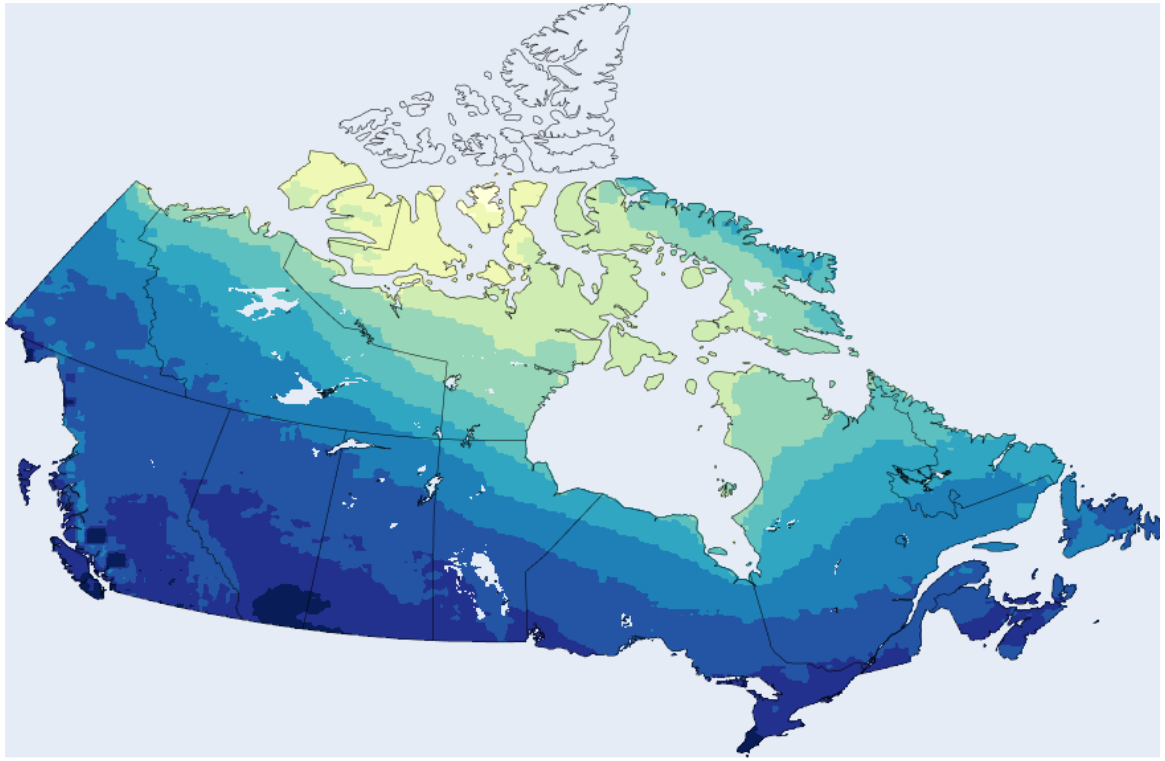
What are Design Values?

- Values used in code
  - National Model Building Code of Canada (Table C-2)
  - Canadian Highway Bridge Design Code
- 600+ locations
- Spatial interpolation

Design value	Units	Interpolation value
DRWP5	Pa	120
HDD	°C-day	5830
IDFCF	ratio	n/a
MI		0.637
PAnn	mm	525
R1d50	mm	90
R15m10	mm	20
RAnn	mm	390
RL50	kPa	0.2
RHAnn	%	74
SL50	kPa	2.3
TJan1.0	°C	-34
TJan2.5	°C	-32
TJul97.5	°C	29
TwJul97.5	°C	23
Tmax	°C	25
Tmin	°C	-30
WP10	kPa	0.2
WP50	kPa	0.3

What makes this information so innovative?

- Regional Climate Model
  - CanRCM4
- Sub-hour sampling (i.e. 15-minute rainfalls)
- Spatial interpolation
- Tier I, II, and III variables
  - Confidence



Future design values

- Future values are *change from baseline.* GWLs are used:
  - 0.5 → 3.5 °C
- Note: Baseline 1986-2016 (~0.7 °C above pre-industrial baseline)

Design value	Units	0.5°C	1.0°C	1.5°C	2.0°C	2.5°C	3.0°C	3.5°C
DRWP5	ratio	1.021	1.053	1.083	1.101	1.136	1.142	1.145
HDD	°C-day	-260	-450	-680	-890	-1110	-1460	-1460
IDFCF	ratio	1.059	1.11	1.17	1.23	1.297	1.361	1.427
MI	ratio	n/a	n/a	n/a	n/a	n/a	n/a	n/a
PAnn	ratio	1.019	1.05	1.075	1.107	1.131	1.159	1.187
R1d50	ratio	1.059	1.11	1.17	1.23	1.297	1.361	1.427
R15m10	ratio	1.059	1.11	1.17	1.23	1.297	1.361	1.427
RAnn	ratio	1.03	1.071	1.106	1.151	1.19	1.235	1.28
RL50	ratio	0.99	1.024	1.035	1.026	1.017	1.006	0.971
RHAnn	ratio	1	1.002	1.004	1.007	1.008	1.011	1.014
SL50	ratio	0.981	0.956	0.957	0.924	0.894	0.854	0.817
TJan1.0	°C	2	3.3	4.3	5.4	5.4	8.7	8.7
TJan2.5	°C	2.1	3.2	4.4	5.6	5.6	8.9	8.9
TJul97.5	°C	1.2	2.1	2.9	3.7	3.7	5.1	5.1
TwJul97.5	°C	0.9	1.5	2.2	2.8	2.8	3.9	3.9
Tmax	°C	1	1.8	2.6	3.4	4.2	4.9	5.6
Tmin	°C	1.4	2.7	4.1	5.5	7	8.5	10.1
WP10	ratio	0.991	0.998	1.004	1.016	1.023	1.028	1.032
WP50	ratio	0.992	1.002	1.01	1.027	1.038	1.044	1.053

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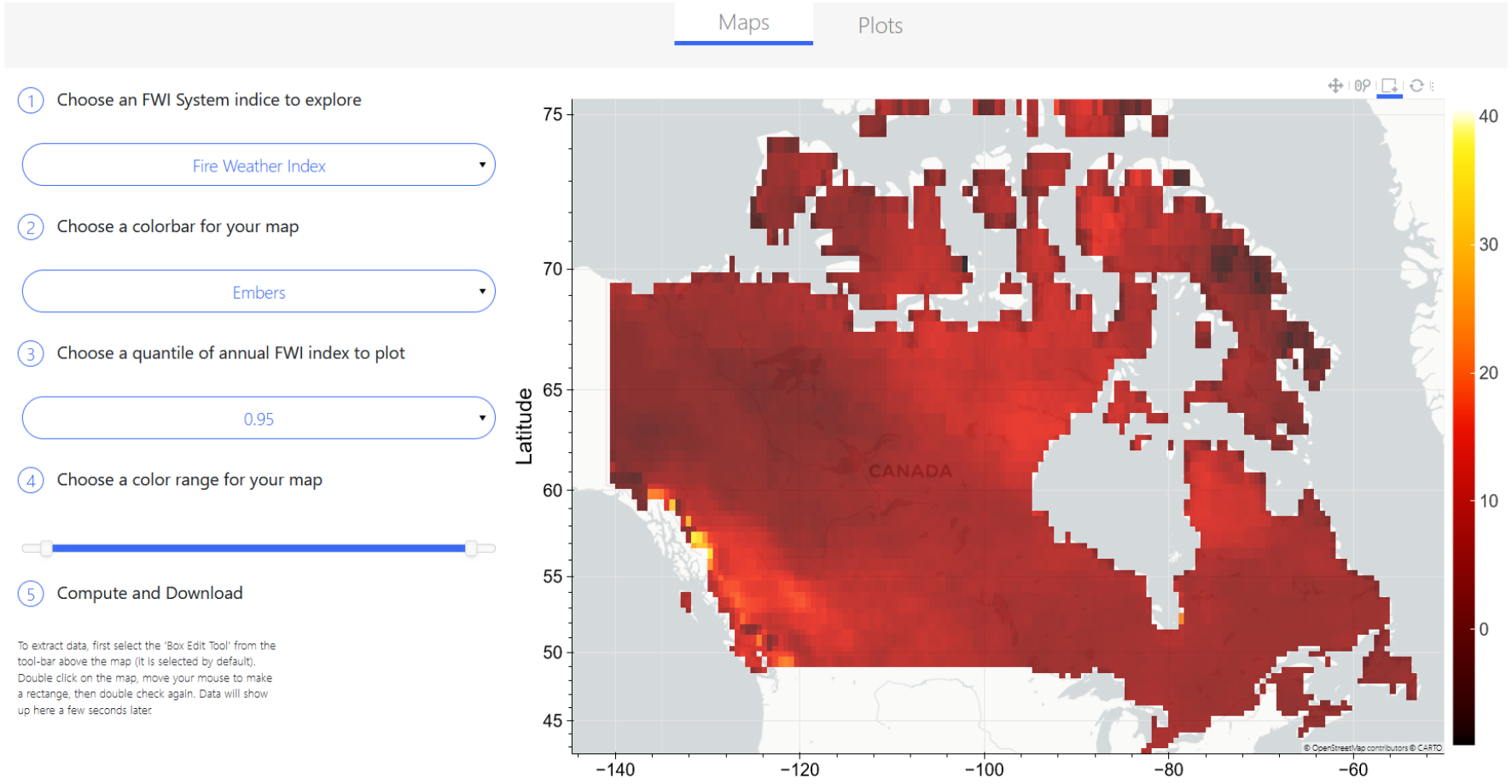
- What's coming next?

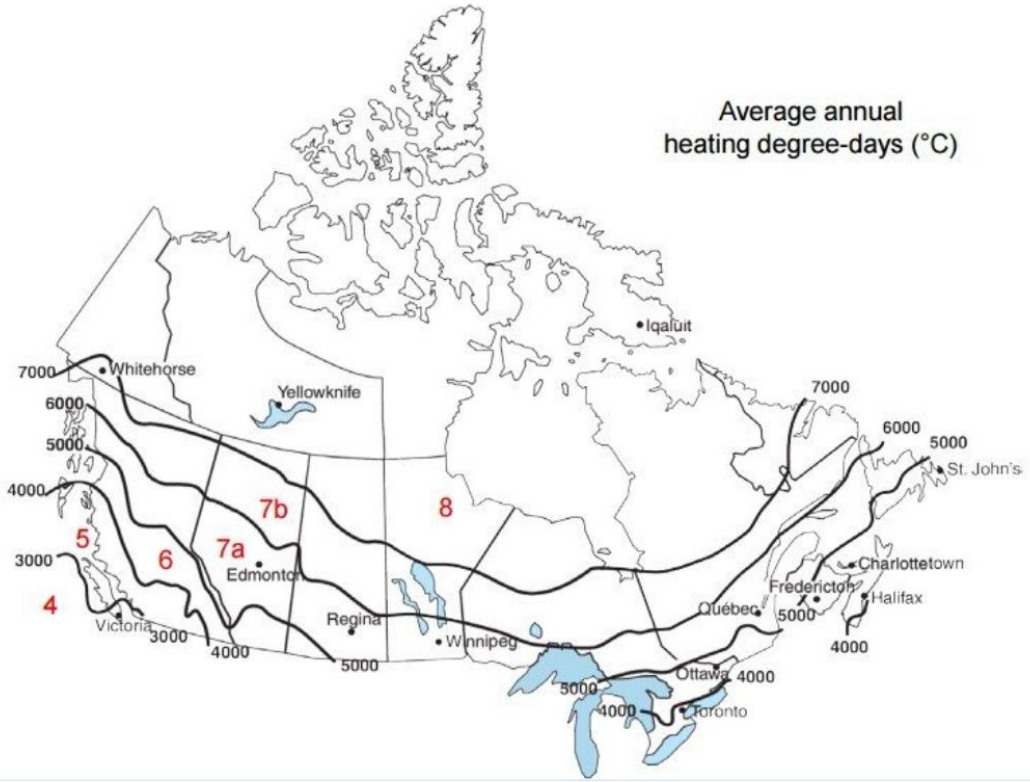
What's coming next?

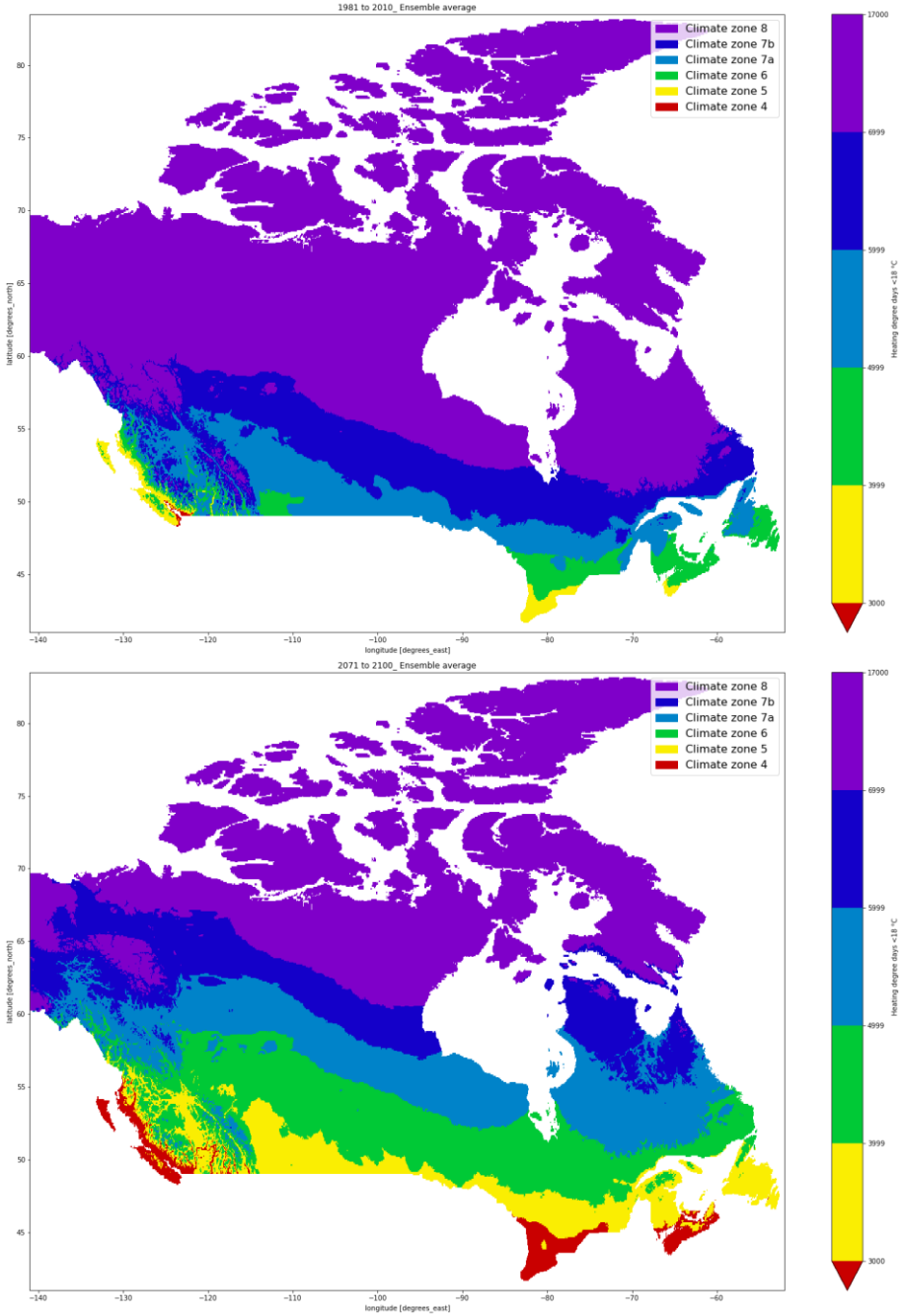
- ~~Future IDF Data~~ (*now live!*)
- Fire Weather Index
- Buildings Climate Zones
- Humidex
- Expanded learning zone content
- More sector modules
- New data extraction tools
- And more!

Fire Weather Index Projections



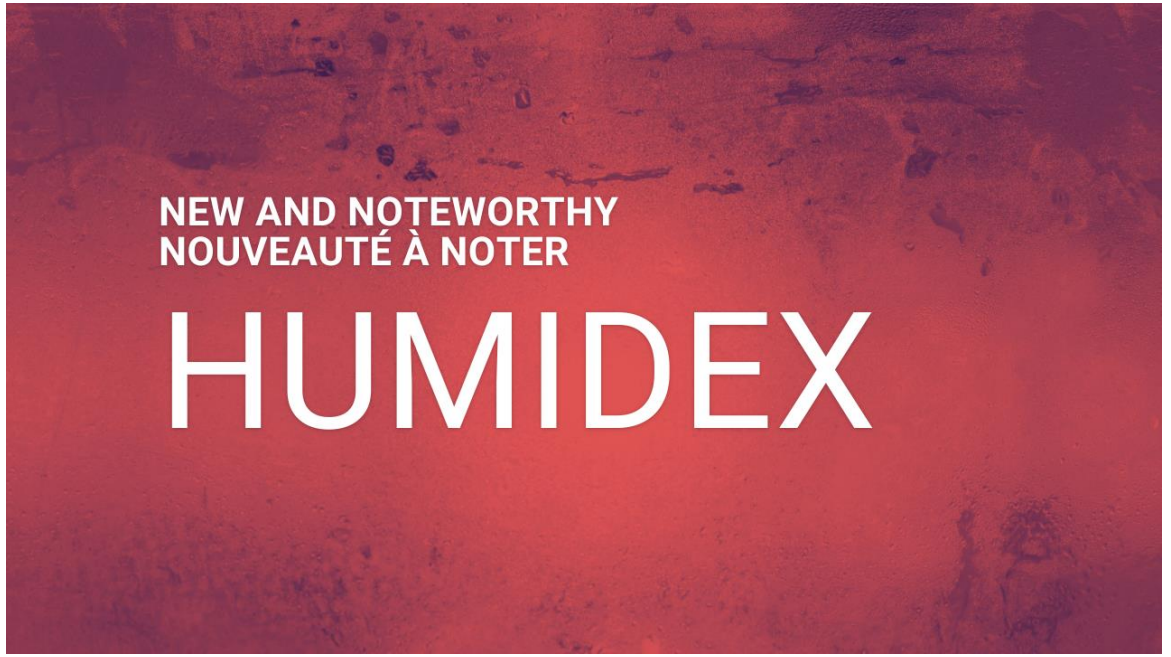
Buildings Climate Zones





Humidex Projections

- Humidex
- Monthly and annual averages and thresholds (i.e. Hx30, 40, etc.)
- Likely launching by end of this month



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- Provides **guidance** for understanding and using data
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Q&A

Please ask your questions via the Q&A box

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