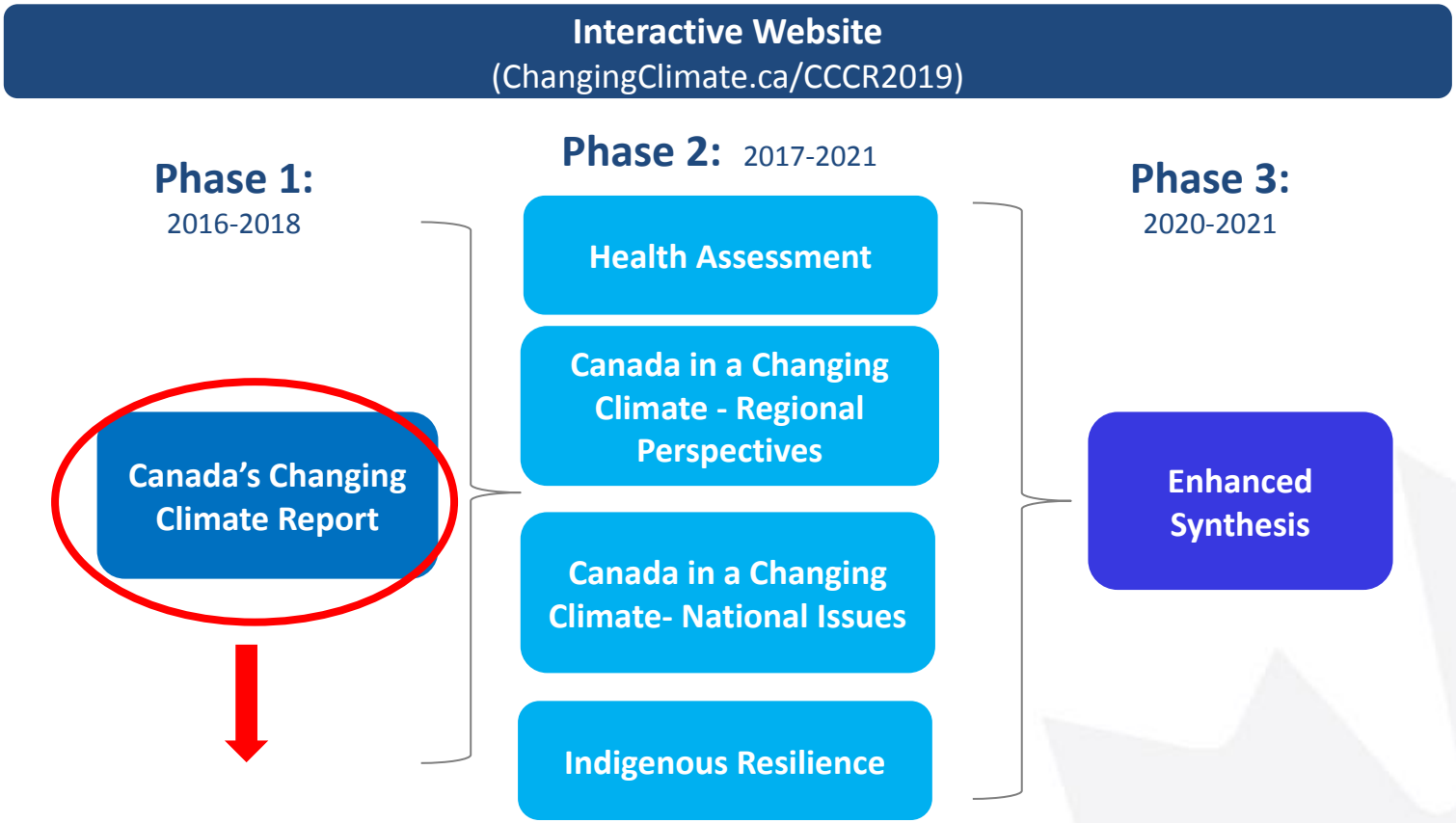
A collaborative effort:
Environment and Climate Change Canada
Fisheries and Oceans Canada
Natural Resources Canada
University experts

September 2021

Canada

Canada's National Assessment on Climate Change

Canada in a Changing Climate: Advancing our Knowledge for Action



Laying a climate science foundation for the forthcoming reports of the national assessment.

10 HEADLINE STATEMENTS FOR THE WHOLE REPORT

Statements all associated with high confidence or more

KEY MESSAGES FOR EACH MAJOR CHAPTER

Assessed confidence in findings and likelihood of results

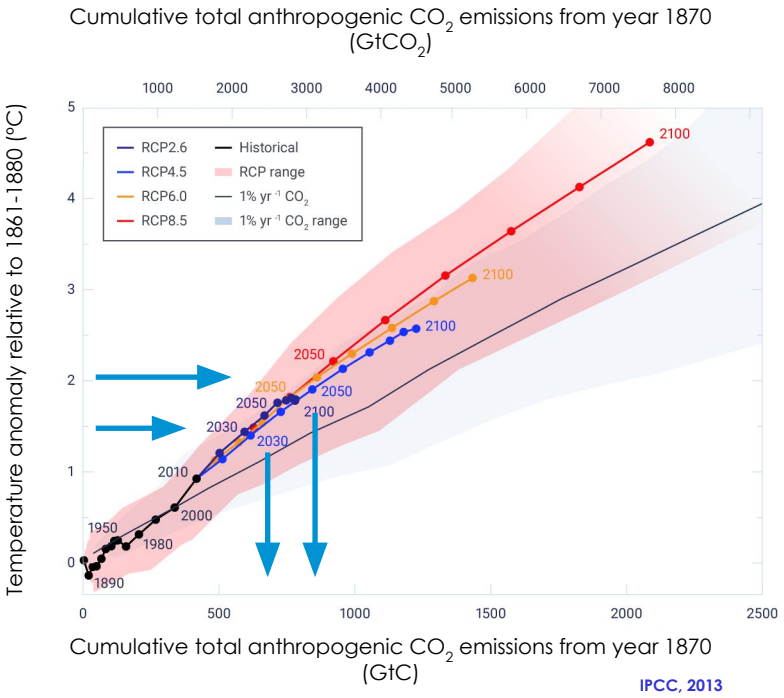
Canada's Changing Climate Report Headline statement #1

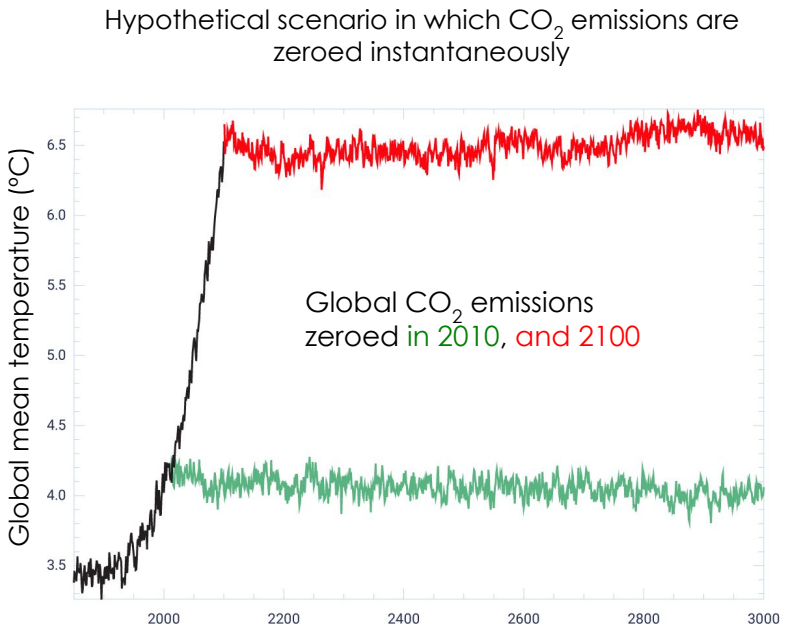
Canada's climate has warmed and will warm further in the future, driven by human influence.

Global emissions of carbon dioxide from human activity will largely determine how much warming Canada and the world will experience in the future.

This warming is effectively irreversible.

Human Influence on Global Climate



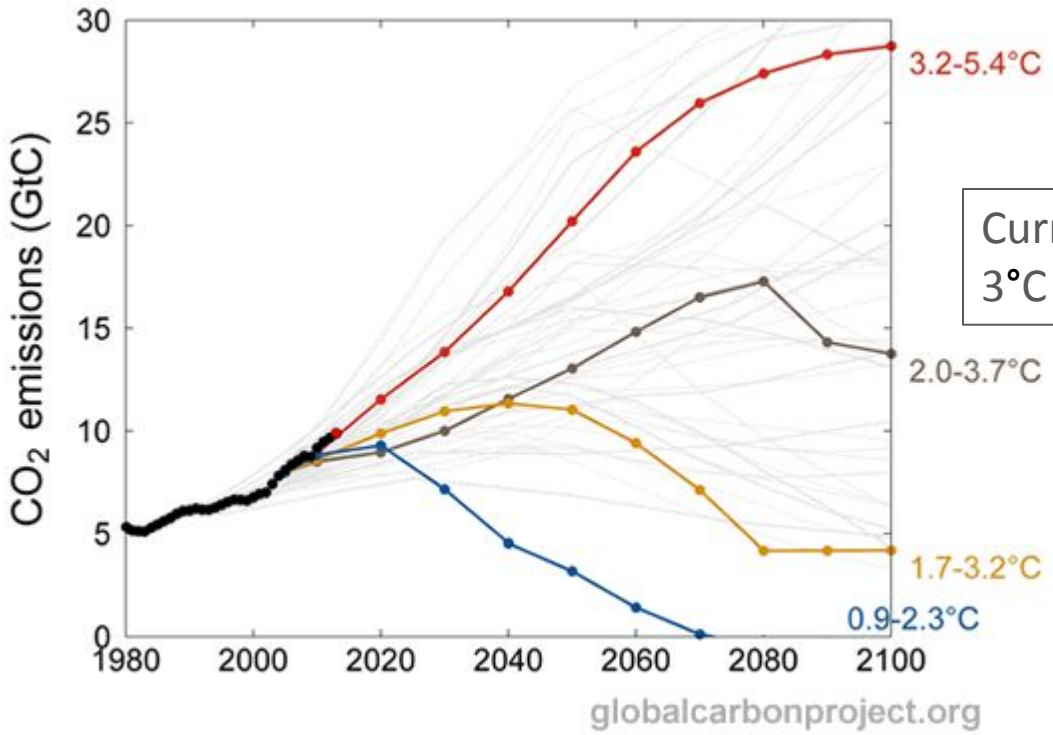


- Human emissions of CO_2 are the main determinant of future warming
- Different temperature limits have different 'carbon budgets' – total remaining cumulative CO_2 emissions

- A finite carbon budget implies CO_2 emissions must achieve 'net zero'
- Global warming will persist for centuries to millennia after emissions are zeroed

Keeping warming well below 2°C will require rapid global emissions reductions

Observed Emissions and Future Scenarios



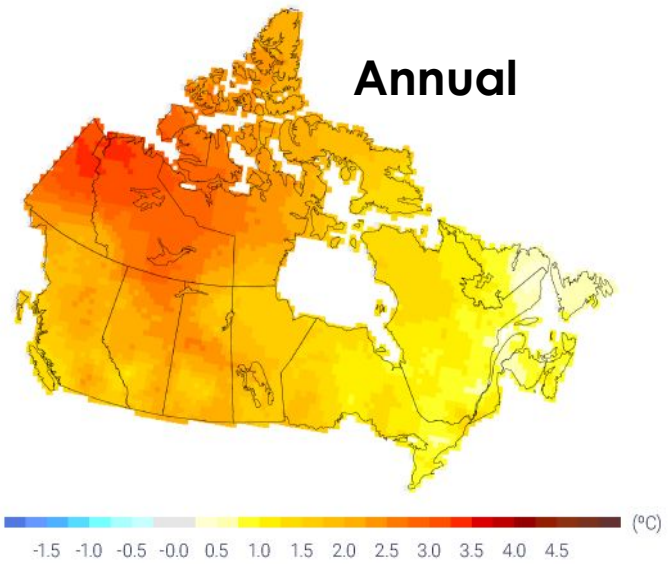
High emissions
No climate policy
Mean warming of ~4.3°C

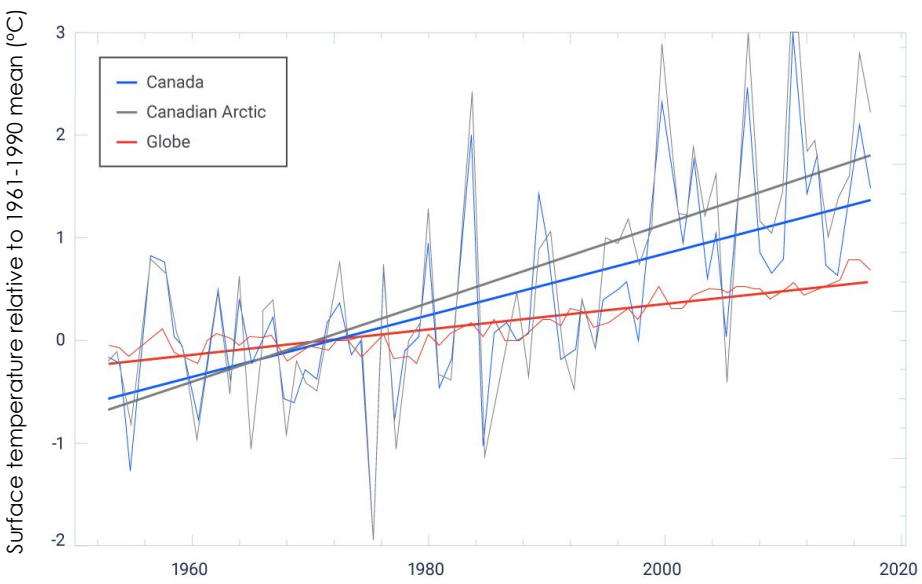
Current commitments lead to ~ 3°C by 2100 (IPCC, 2018)

Low emissions
Ambitious policy
Mean warming of ~1.6°C

- The low emission scenario will *likely* keep global temperature change < 2°C. Net zero CO_2 emissions occur around 2070. (IPCC, 2013)
- 1.5°C emission pathways reach net zero CO_2 emissions around 2050. (IPCC, 2018)

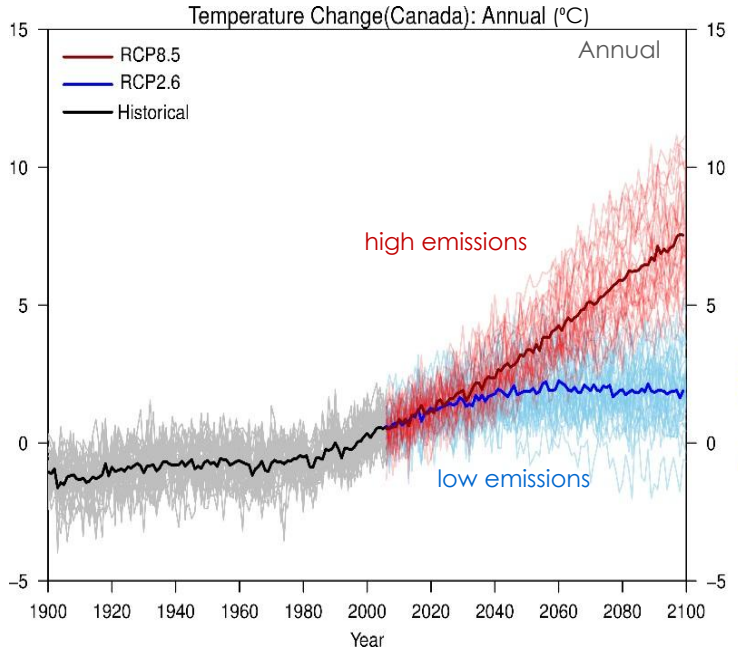
Both past and future warming in Canada is, on average, about double the magnitude of global warming

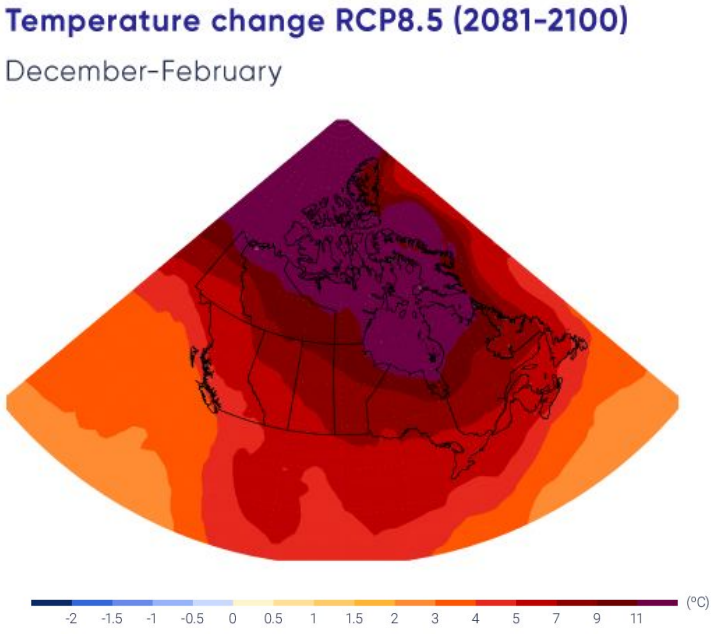




- Annual average temperature in Canada has increased by 1.7°C between 1948 and 2016.
- Canada has warmed about two times the global rate.
- Warming is not uniform across Canada. Northern Canada has warmed by 2.3° C, about three times global warming.
- Most of the observed increase in annual average temperature in Canada can be attributed to human influence.

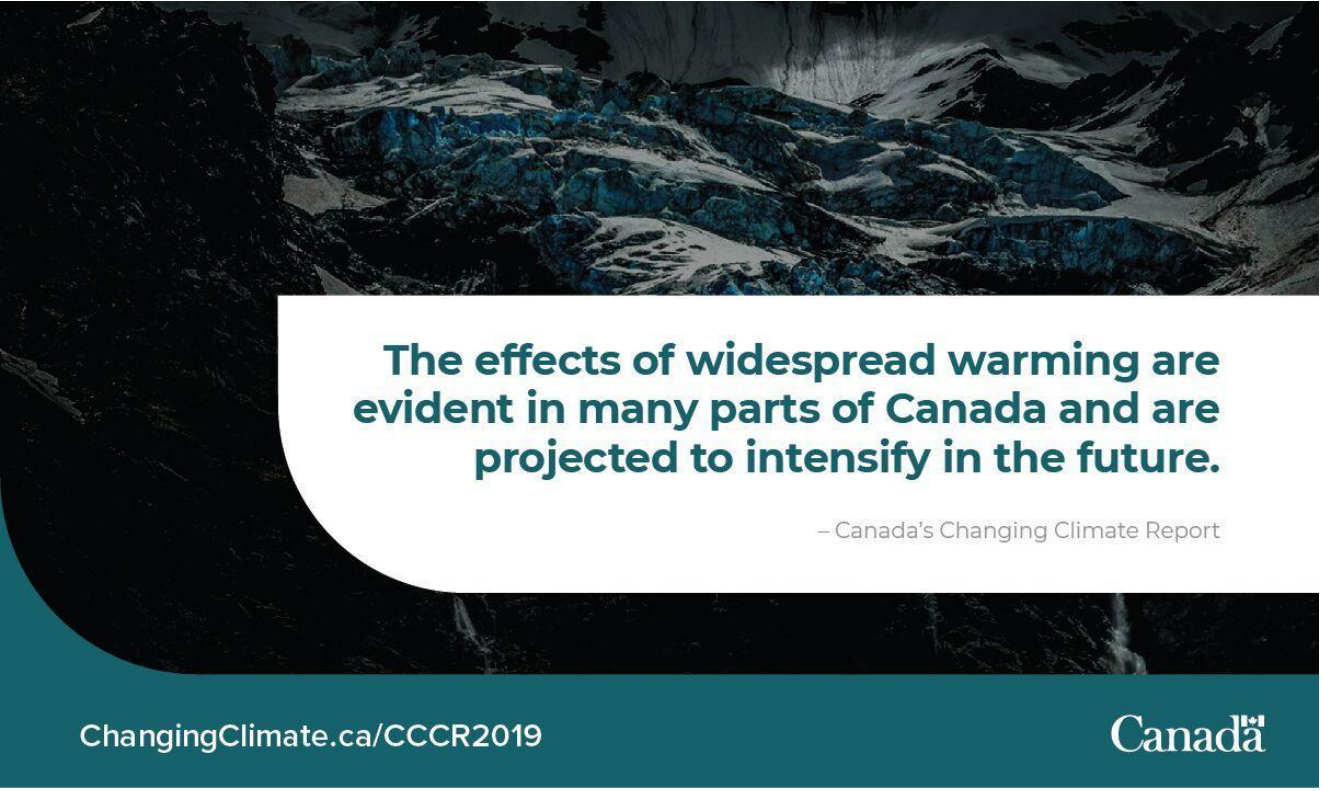
Future warming in Canada depends directly on global emissions





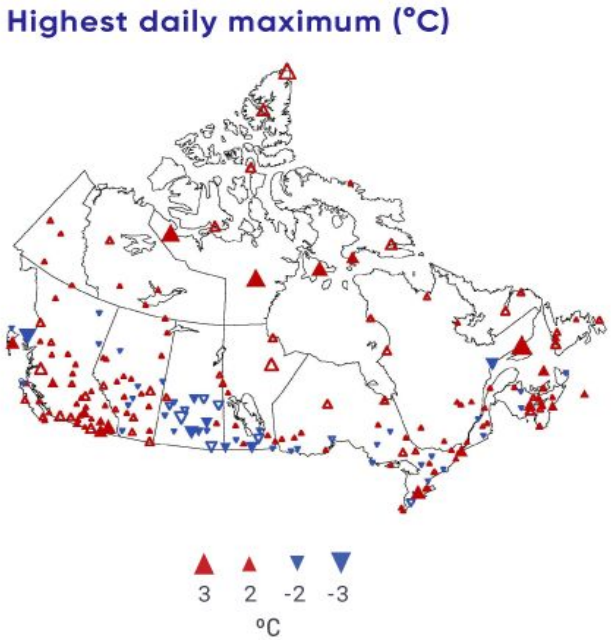
- Low emission scenario: an additional annual warming of about 2°C is projected by mid-century, with temperatures steady after that
- High emission scenario: temperature increases will continue, reaching more than 6°C by late century

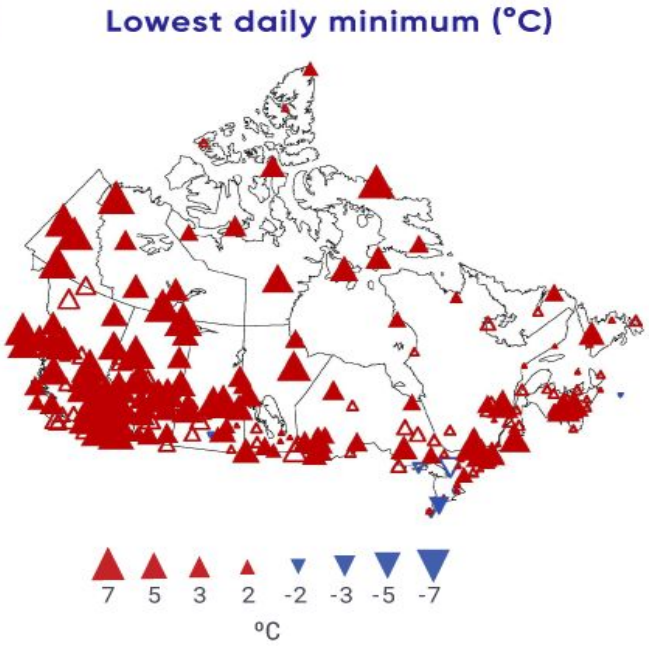
- Consistent with observed warming, future warming will be strongest in winter and in northern Canada
- Changes shown are for the late 21st century, under a high emission scenario, relative to the 1986-2005 reference period



- Across Canada, we are experiencing:
  - more extreme heat/less extreme cold
  - longer growing seasons
  - shorter snow and ice cover seasons
  - earlier spring peak streamflow
  - thinning glaciers
  - thawing permafrost
  - warmer and more acidic oceans
  - rising sea level
- Because some further warming is unavoidable, these observed trends will continue.

More extreme heat and less extreme cold have been observed in Canada

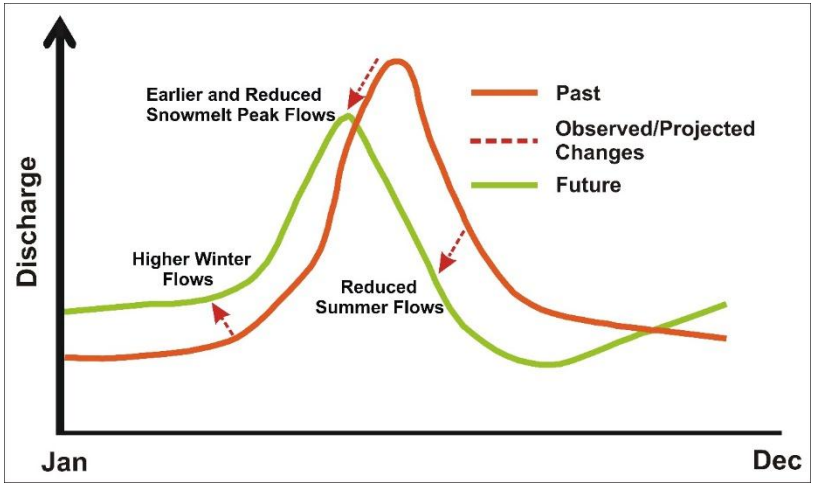




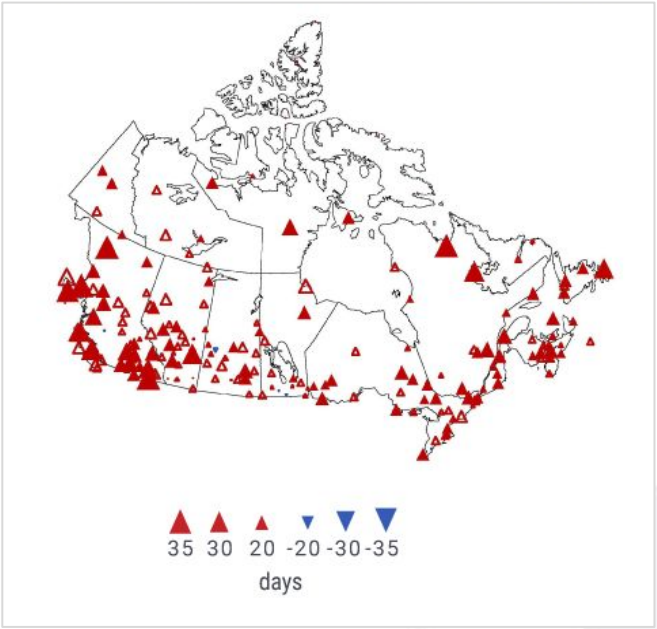
- The annual highest daily maximum temperature, averaged over Canada, increased by 0.61°C between 1948 and 2016
- The annual lowest daily minimum temperature, averaged over Canada, increased by 3.3 °C between 1948 and 2016
- Most of the observed increase in the coldest and warmest daily temperatures in Canada can be attributed to human influence

The effects of widespread warming are evident across many indicators

Changes in annual streamflow schematic

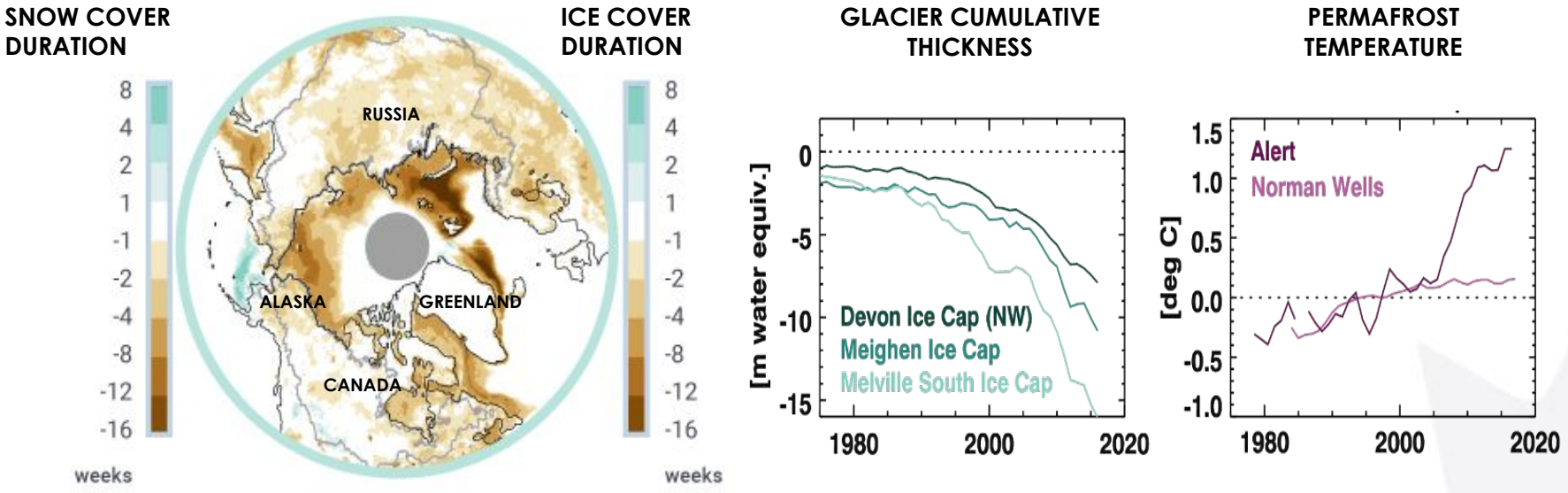


Length of growing season (days)



- Over the last several decades, spring peak streamflow has been earlier, with higher winter and early spring flows. In some areas, reduced summer flows have been observed.
- An increase in growing season length of about 15 days between 1948 and 2016 has been observed.

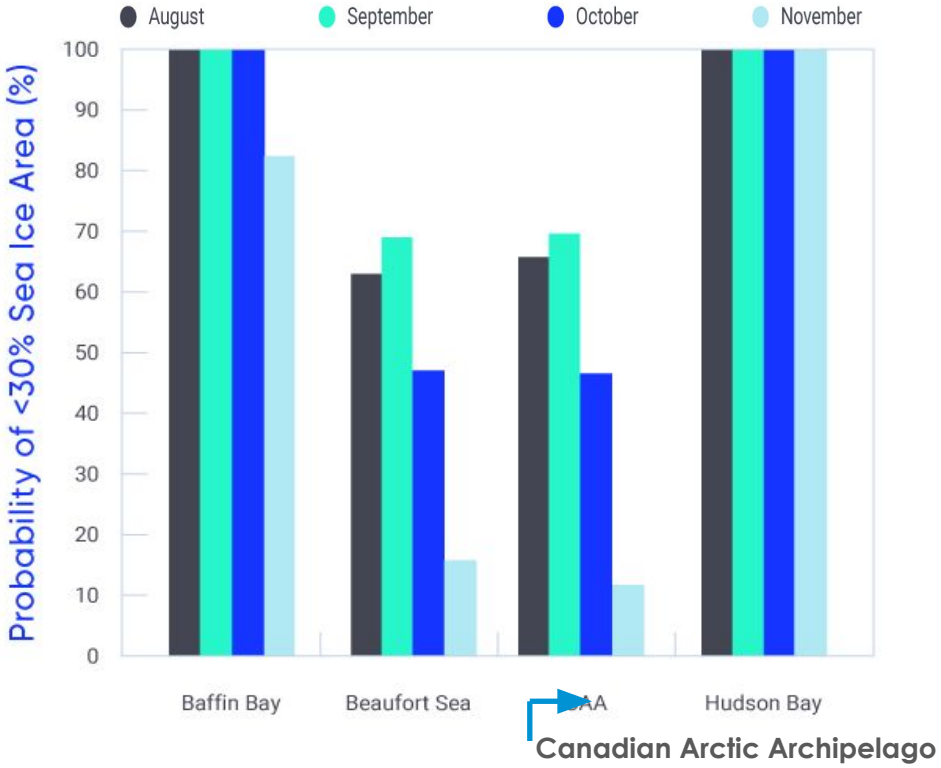
A warmer world – declines in snow, ice, and permafrost



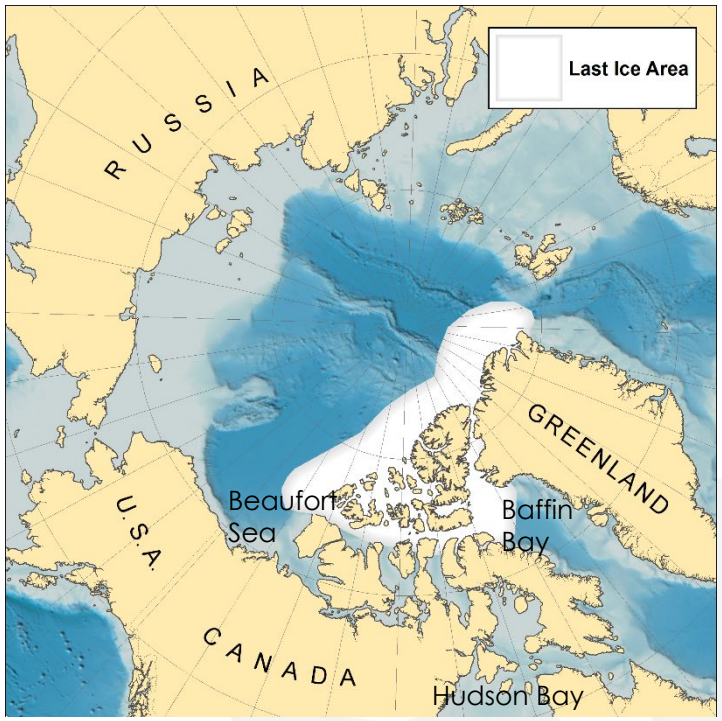
Over the past three decades, the proportion of Canadian land and marine areas covered by snow and ice have decreased, permafrost temperatures have risen, and Arctic and alpine glaciers have thinned at rates unprecedented for several millennia

Extensive ice-free periods are also projected for the Canadian Arctic Ocean

Probability of sea ice–free conditions by 2050



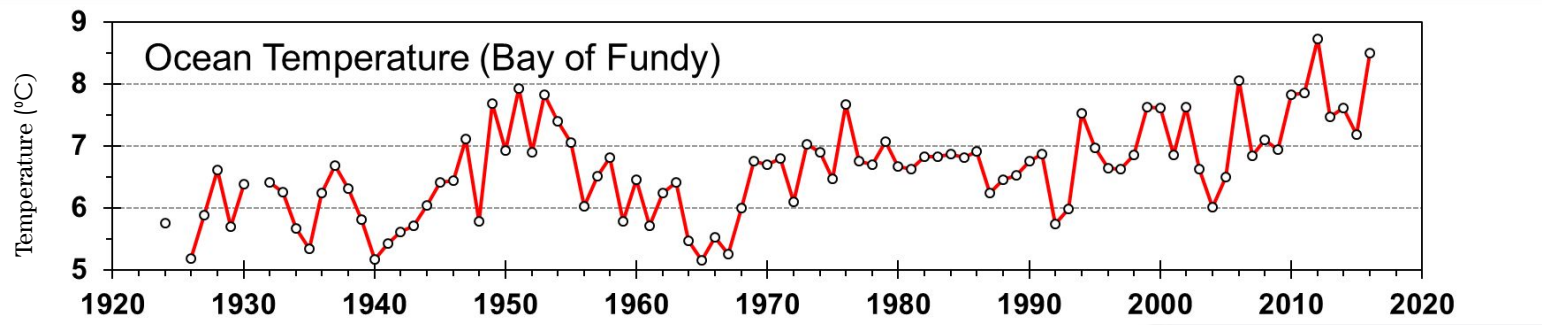
Schematic: last ice area of the Arctic Ocean



- Probability of ice-free conditions in different regions of the Canadian arctic under a high emission scenario
- The likelihood of summer ice-free conditions in the central Arctic rises with the magnitude of global temperature increases

Oceans surrounding Canada have warmed, become more acidic, and less oxygenated, consistent with observed global ocean changes over the past century

- Ocean warming and loss of oxygen will intensify with further emissions of all greenhouse gases.
- Ocean acidification will increase in response to additional carbon dioxide emissions.
- These changes threaten the health of marine ecosystems.



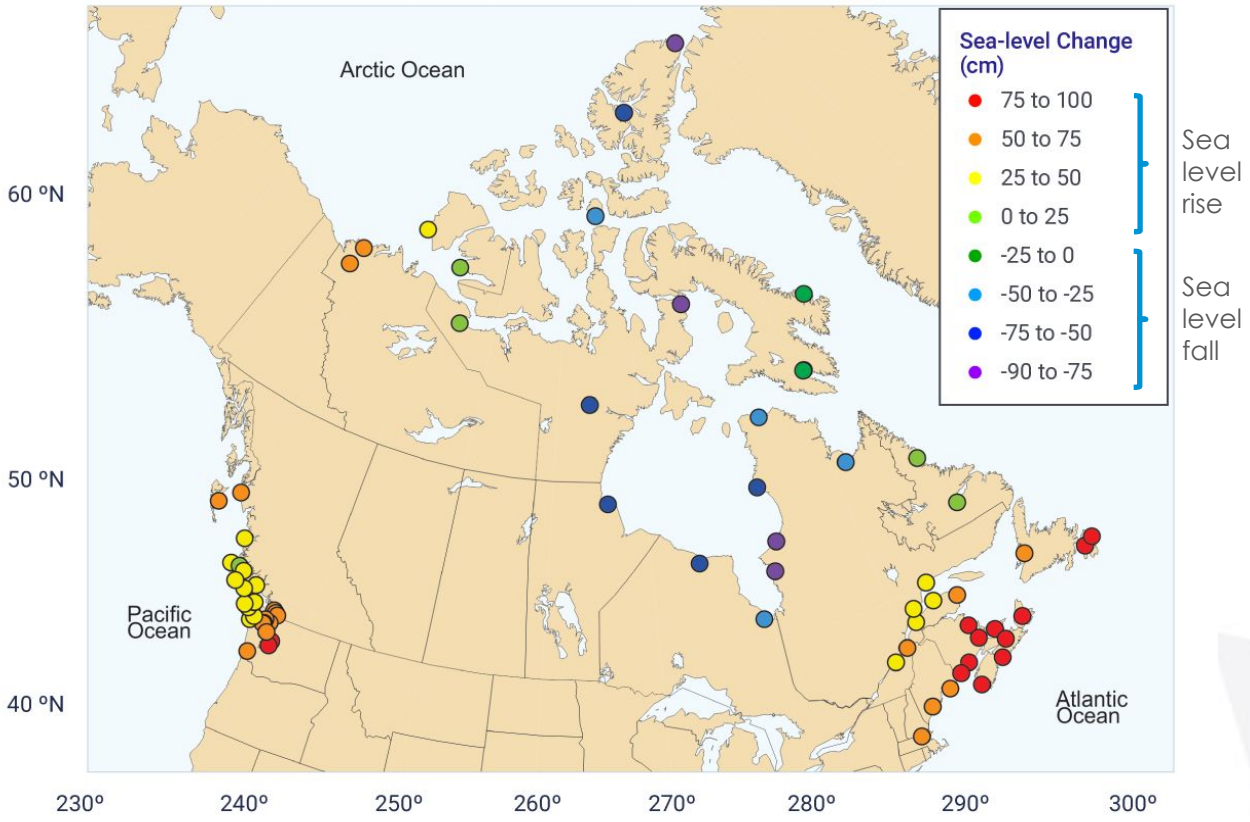
Coastal flooding is expected to increase in many areas of Canada due to local sea level rise

- Changes in local sea-level are a combination of global sea level rise and local land subsidence or uplift.
- Local sea level is projected to rise, and increase flooding, along most of the Atlantic and Pacific coasts of Canada and the Beaufort Sea coast in the Arctic.

Davis Bay, B.C. Photo courtesy of B. Oakford.

- The loss of sea ice in Arctic and Atlantic Canada further increases the risk of damage to coastal infrastructure and ecosystems due to larger storm surges and waves.

Global mean sea level is projected to rise, but along Canada's coastlines, sea level will rise in some places, fall elsewhere

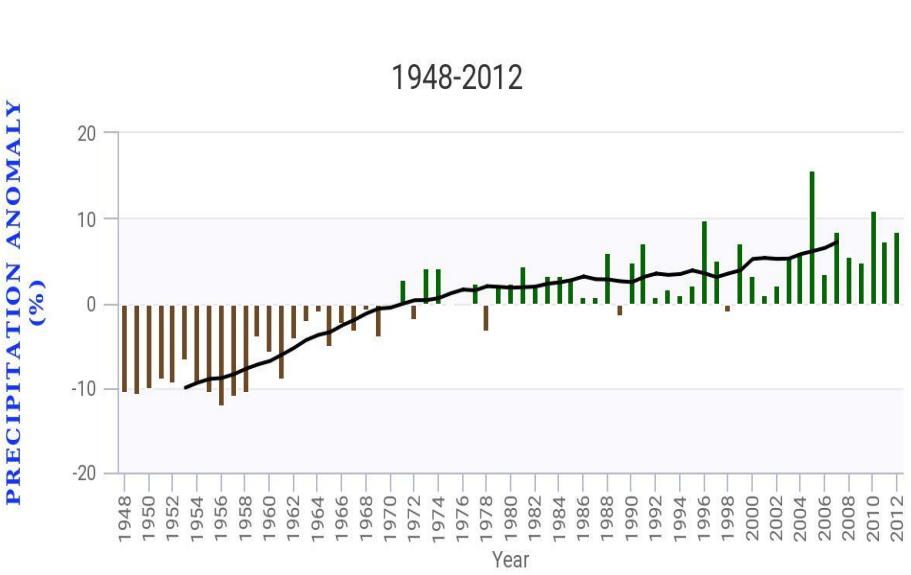


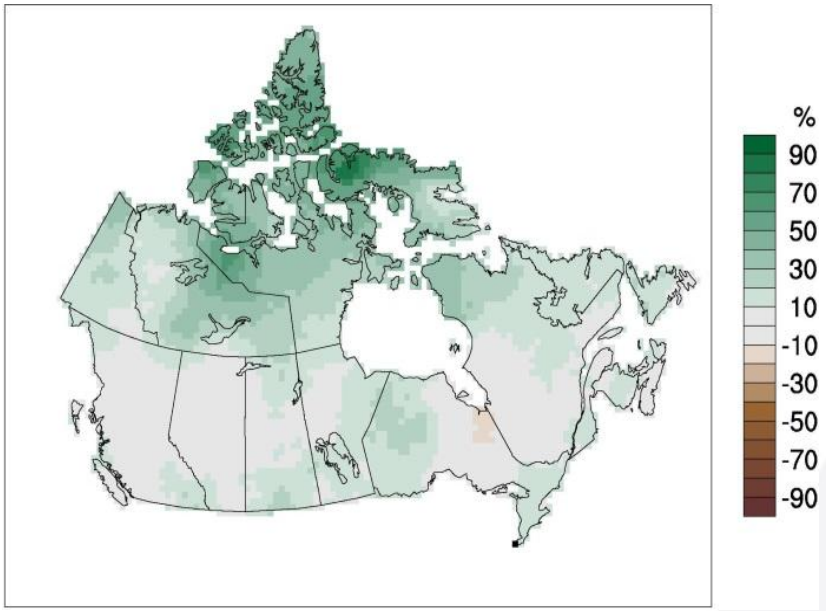
End-of-century projected relative (local) sea-level change under a high emission scenario, relative to 1986-2005 reference period

In southern Atlantic Canada, relative sea level rise is expected to be close to 1 m

A warming climate has been associated with more precipitation on average

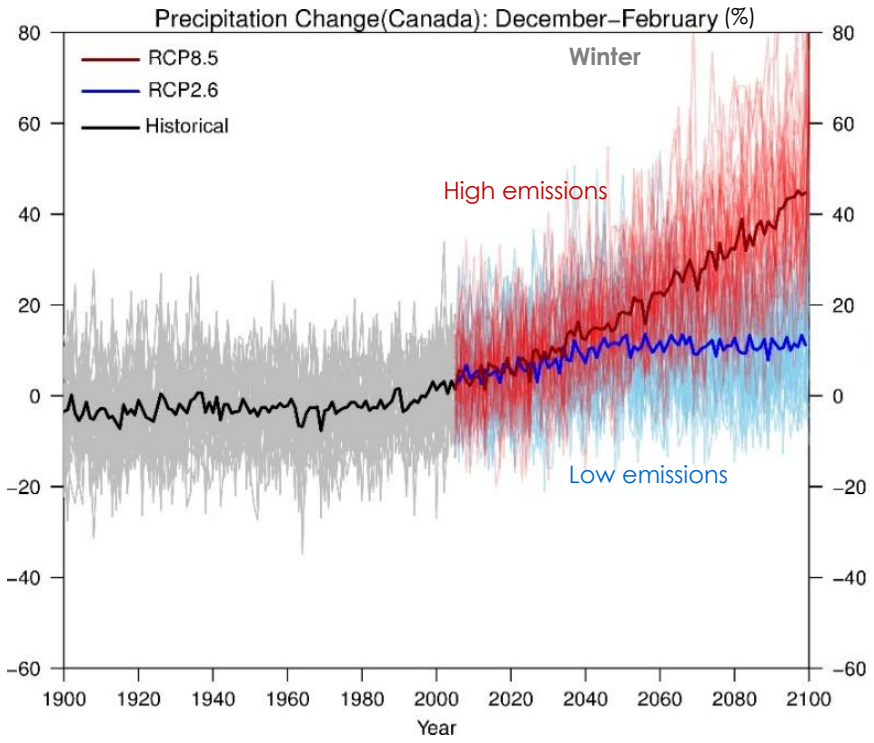
Changes in annual precipitation, 1948–2012





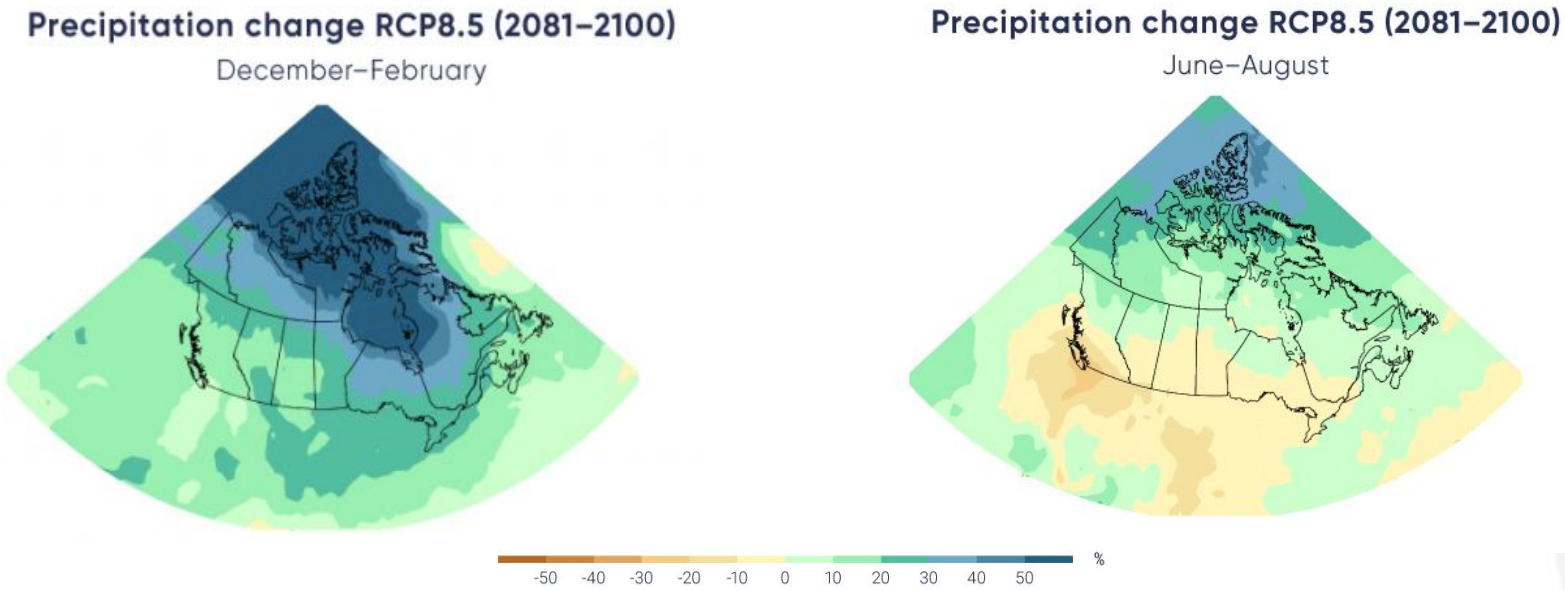
- Annual precipitation has increased in many regions since 1948, with larger percentage increases in northern Canada.
- Averaged over the country, normalized precipitation has increased by about 20% from 1948 to 2012.
- There is less confidence in observed changes in precipitation than temperature but observed increases are consistent with physical expectations.

A warmer climate will bring more precipitation on average



- Annual and winter precipitation is projected to increase everywhere in Canada over the 21st century, with larger changes under a high emission scenario.
- Larger percent changes are projected for northern Canada.

Important seasonal differences in precipitation projections



- Temperatures remain sufficiently cold at high latitudes that projected increases in winter precipitation will fall as snow
- Increased rain/decreased snow during fall/spring due to warming

- Unlike for temperature, which is projected to increase everywhere in every season, precipitation has patterns of increase and decrease
- Summer precipitation is projected to decrease in southern Canada under a high emission scenario toward the end of the century

The seasonal availability of freshwater is changing with an increased risk of water supply shortages in summer

- Warmer winters and earlier snowmelt will combine to produce higher winter streamflow.
- Shallower snowpack and loss of glacier ice this century will combine to produce lower summer streamflow.

Spring freshet at Eakin Creek in BC

- Warmer summers will increase evaporation of surface water and contribute to reduced summer water availability in the future despite more precipitation in some places.

A warmer climate will intensify some weather extremes in the future

- Extreme hot temperatures will become more frequent and more intense. This will increase the severity of heatwaves, and contribute to increased drought and wildfire risks.
- While inland flooding results from multiple factors, more intense rainfalls will increase urban flood risks.
- It is uncertain how warmer temperatures and smaller snowpacks will combine to affect the frequency and magnitude of snowmelt-related flooding.

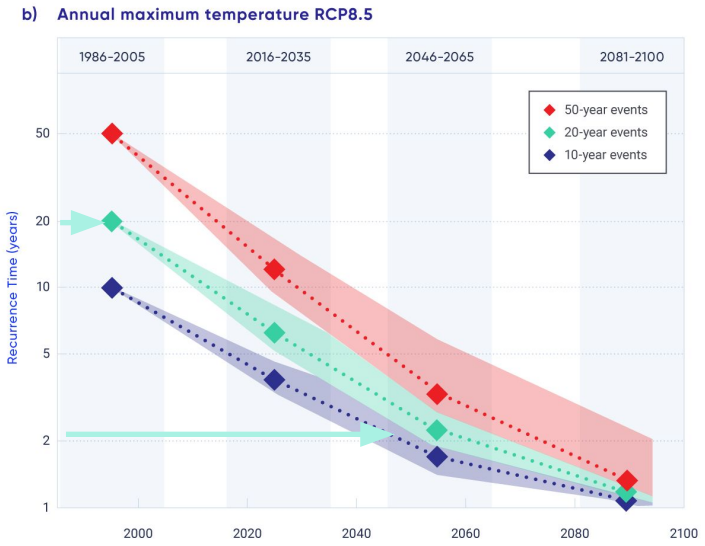
HEAT WAVES

WILDLAND FIRES

URBAN FLOODS

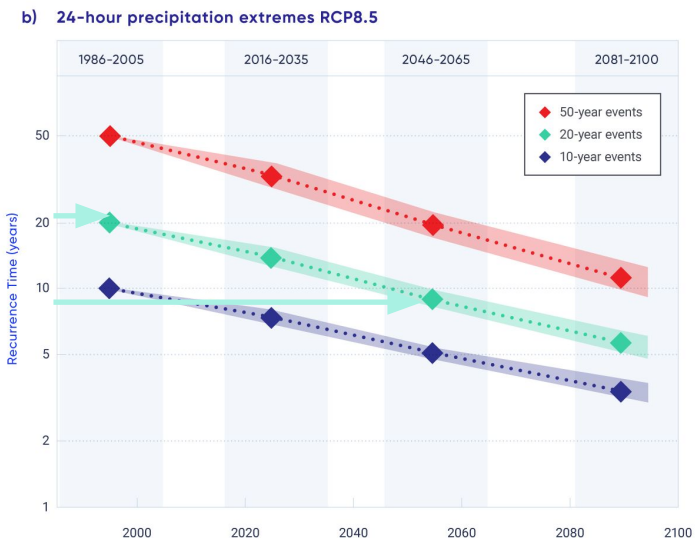
Future increases in the frequency and intensity of extreme events

Change in temperature extremes High emission scenario



- A current 1 in 20-yr hot extreme will become a once in 2-year event by mid-century under a high emission scenario (a ten-fold increase in frequency).

Change in precipitation extremes High emission scenario



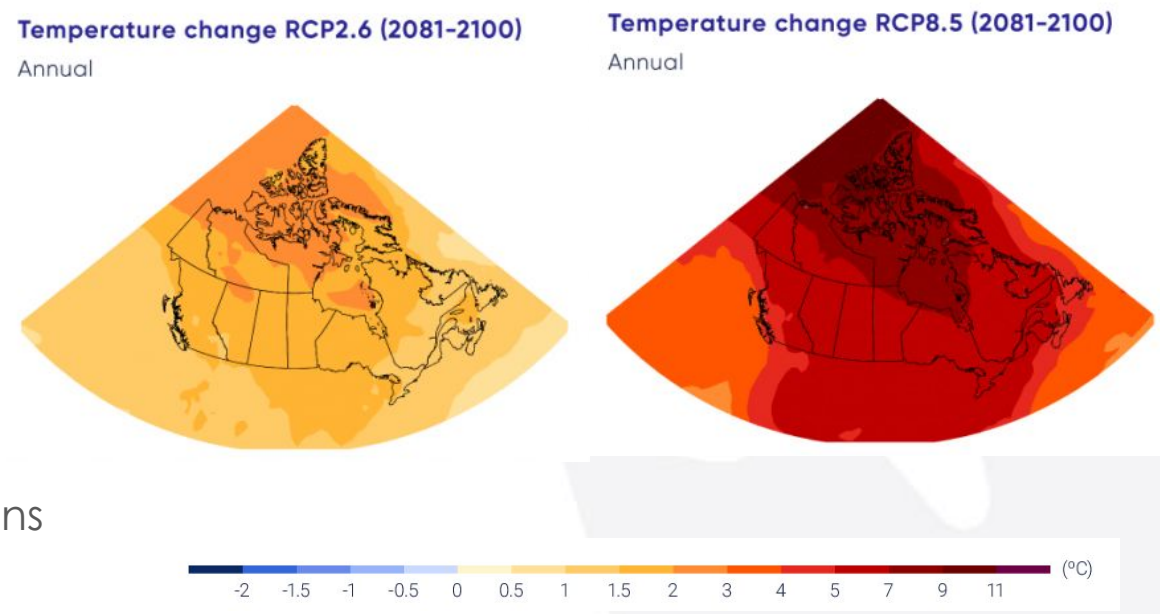
- A current 1 in 20-yr rainfall extreme will become a once in 10-yr event by mid-century under the high emission scenario (a two-fold increase in frequency).

The rate and magnitude of climate change under high versus low emission scenarios project two very different futures for Canada

- Scenarios with large and rapid warming illustrate the profound effects on Canadian climate of continued growth in GHG emissions.
- Scenarios with limited warming will only occur if Canada and the rest of the world reduce carbon emissions to near zero early the second half of the century and reduce emissions of other GHGs substantially.

Low global emissions limited warming

High global emissions large warming



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