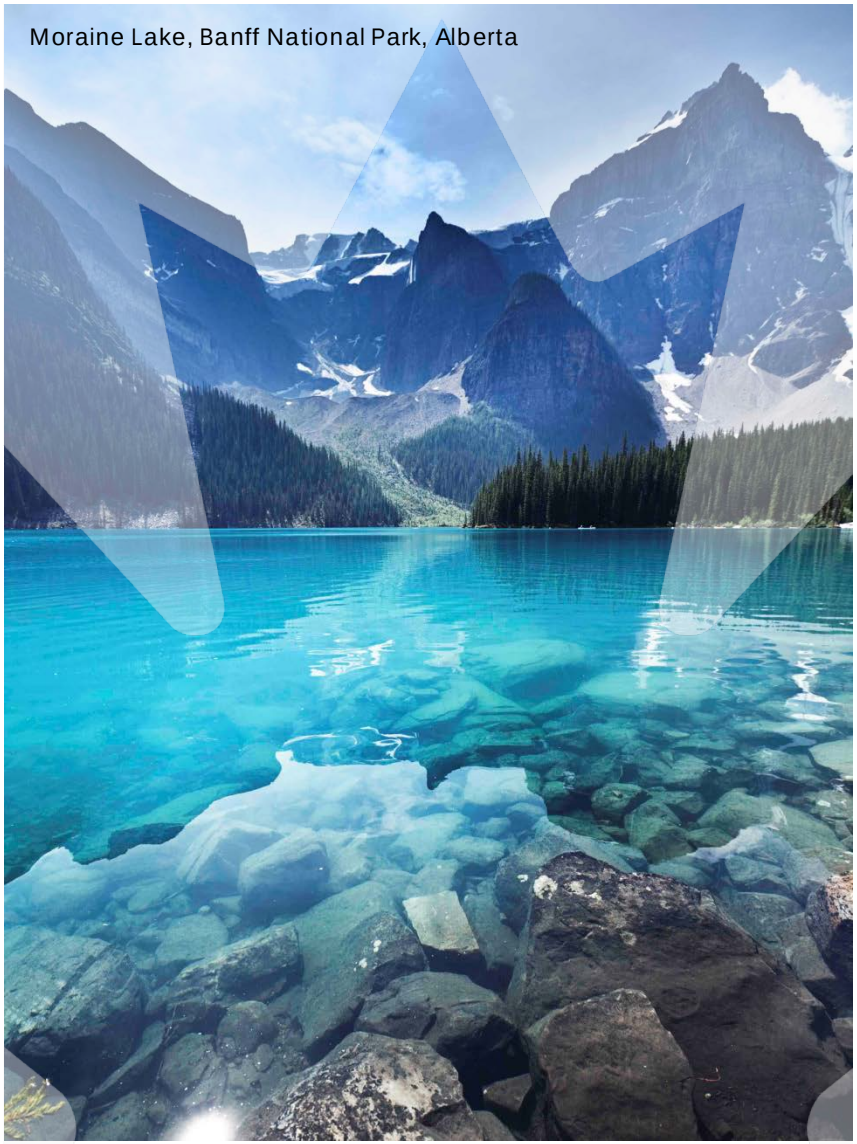
The Science of Climate Change

November 23, 2015


Moraine Lake, Banff National Park, Alberta

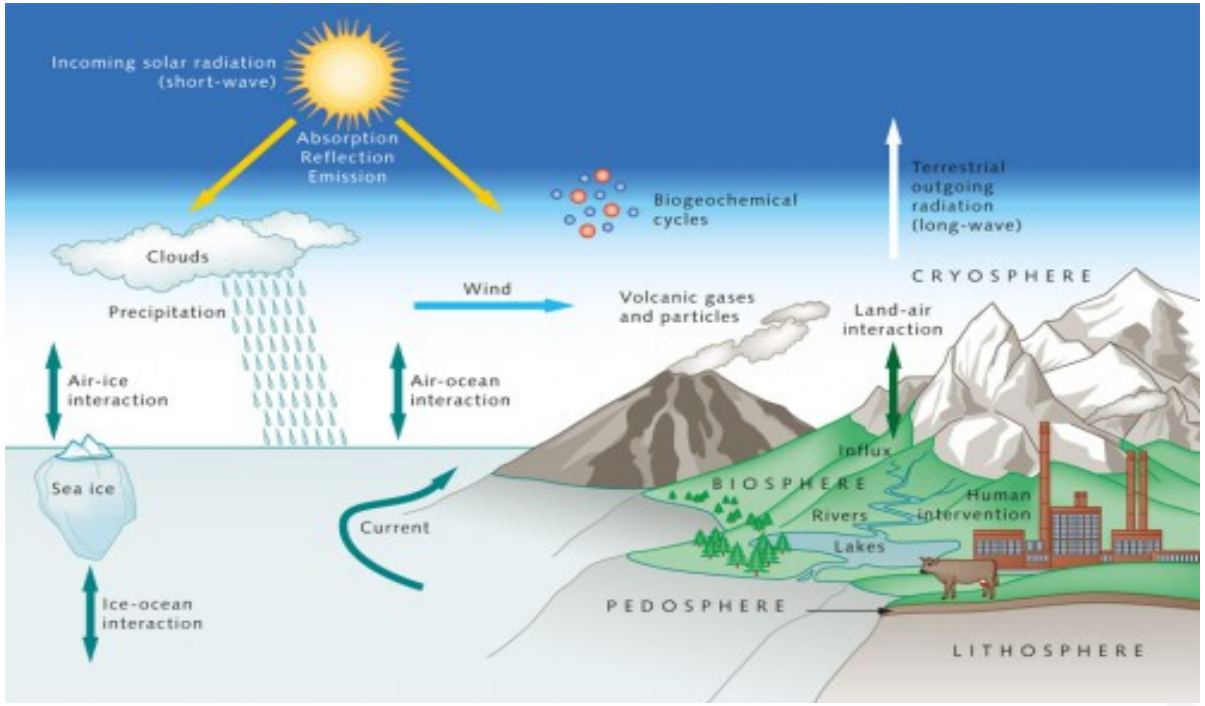
Overview

- Key Messages
- The Climate System
- Evidence of Climate Change
- What is Causing Climate Change?
- Projecting Future Climate Change
- Summary

Key Messages

- Warming over the 20th century is indisputable and largely due to human activities.
- Canada's rate of warming is about twice the global rate: a 2ºC increase globally means a 3 to 4ºC increase for Canada.
- Effects will persist for centuries because greenhouse gases (GHGs) are long-lived and the oceans are warming.
- Cumulative CO_2 emissions largely determine ultimate warming. A 2ºC warming target may still be attainable, but we are already 65% of the way to the associated carbon limit or budget and global emissions must peak before mid-century.
- GHG emissions need to become net zero in order to stabilize climate at any temperature.

The Climate System

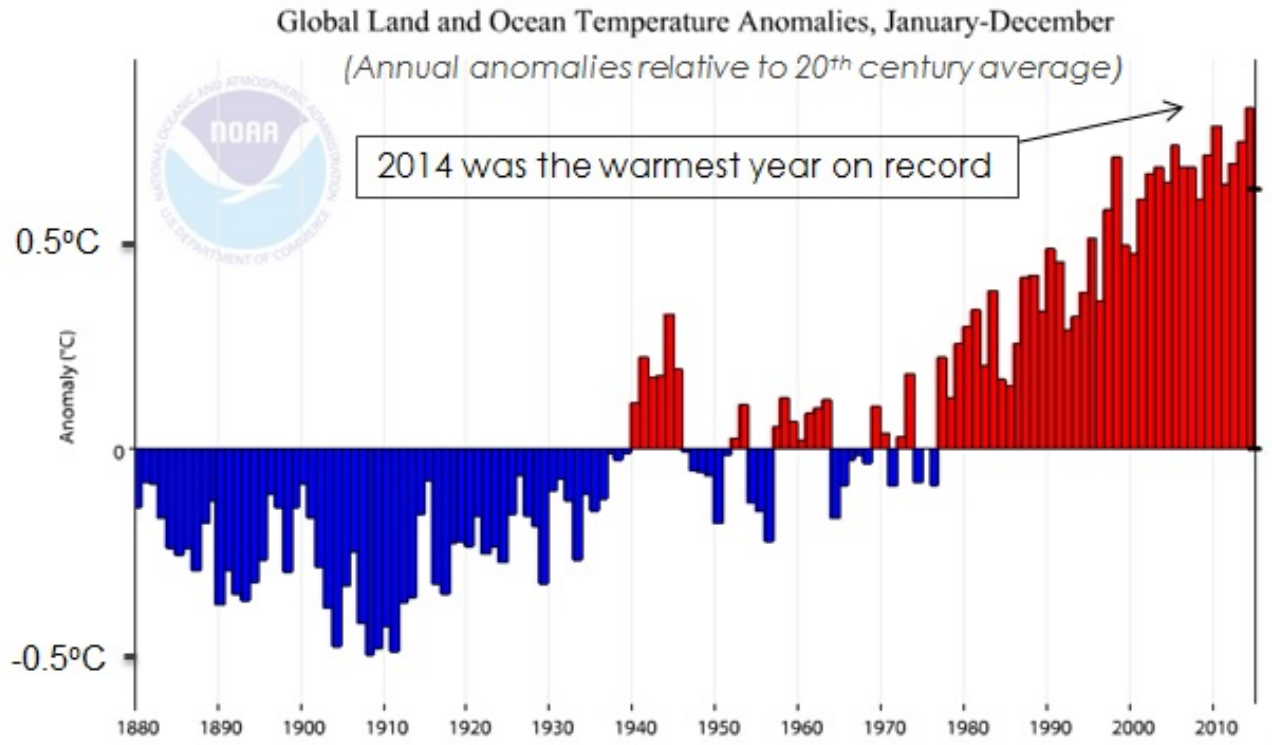


- Energy from the sun is absorbed and re-radiated. The atmosphere acts like an insulator, keeping the surface warm both day and night, providing a life-supporting average temperature of approximately 14ºC.
- Increases to the amount of GHGs in the atmosphere alter the energy balance (increasing energy absorbed) and lead to climate warming.

Image: World Ocean Review

Evidence of Climate Change

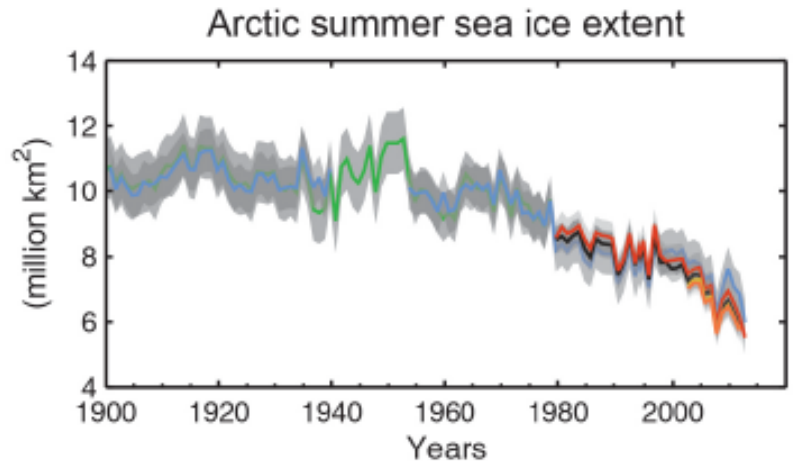
"Warming is unequivocal"*



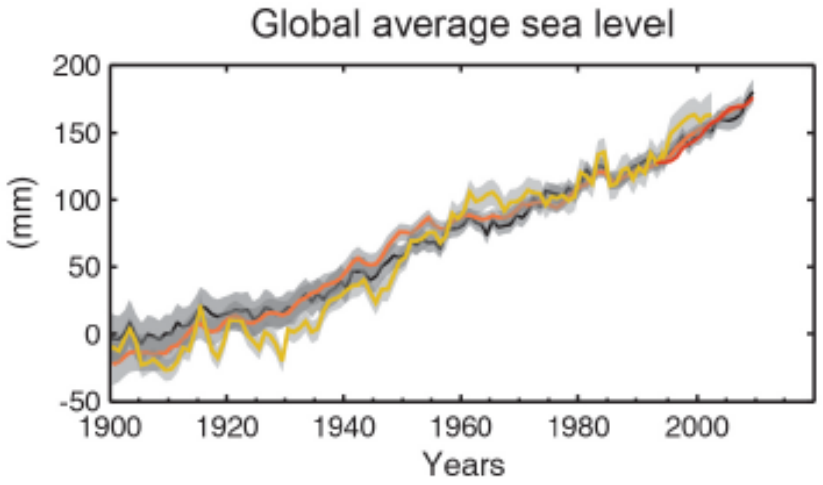
- Global temperature continues to rise; each of the last three decades has been successively warmer than any preceding decade since the 1850s.
- Warming is not uniform; temperature in Canada has been increasing at roughly double the global mean rate. The Arctic is warming even faster.

*Intergovernmental Panel on Climate Change (IPCC) Fourth and Fifth Assessment Reports (AR4/5)

Other indicators of a warming planet



Snow, sea ice, glaciers and permafrost are in decline, consistent with observed warming.



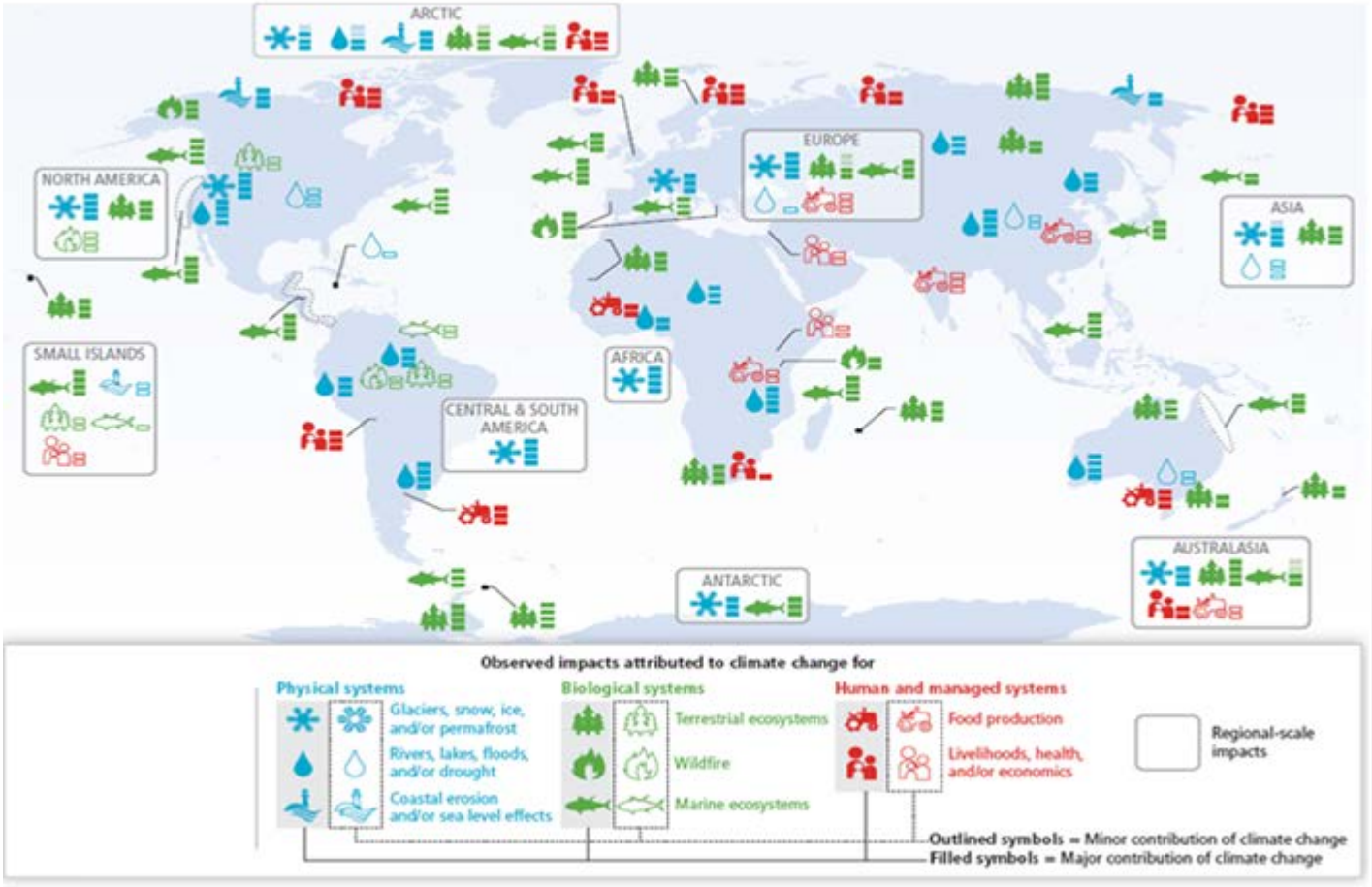
Global average sea level has risen about 20 cm since 1900 due to expansion of warming ocean waters and the addition of water to the ocean from melting land ice.

IPCC AR5, Summary for Policymakers (WG1), Fig. SPM.3

Impacts have been observed globally - climate change will amplify existing risks and create new ones

- Evidence is strongest in natural systems (blue and green).
- Impacts on human systems (red) include food production, local livelihoods and health.

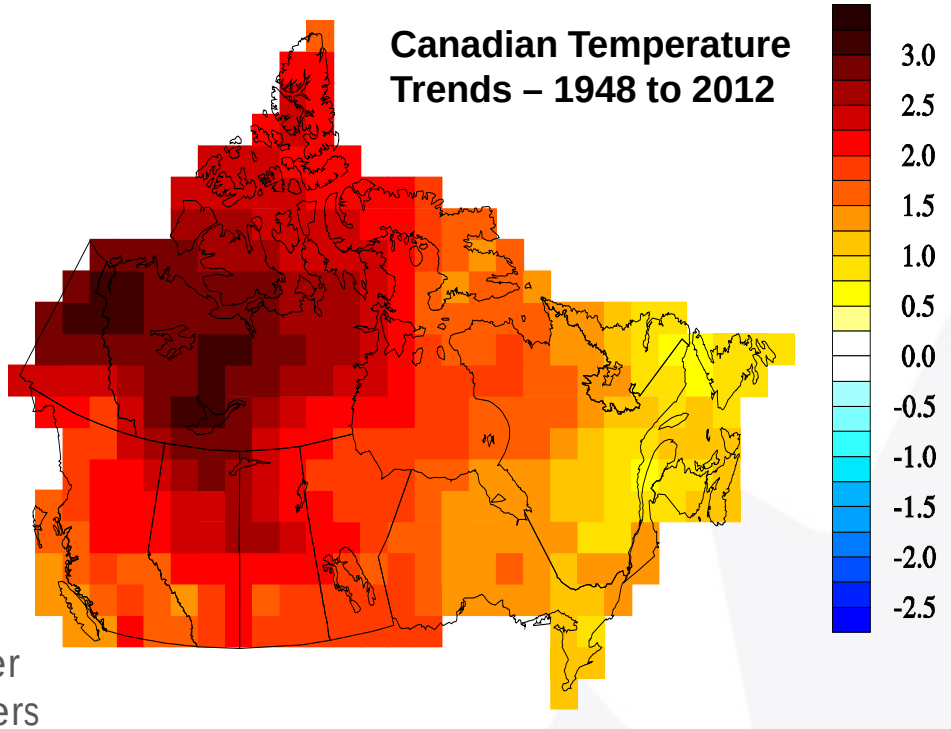
- Bars represent quantity of evidence



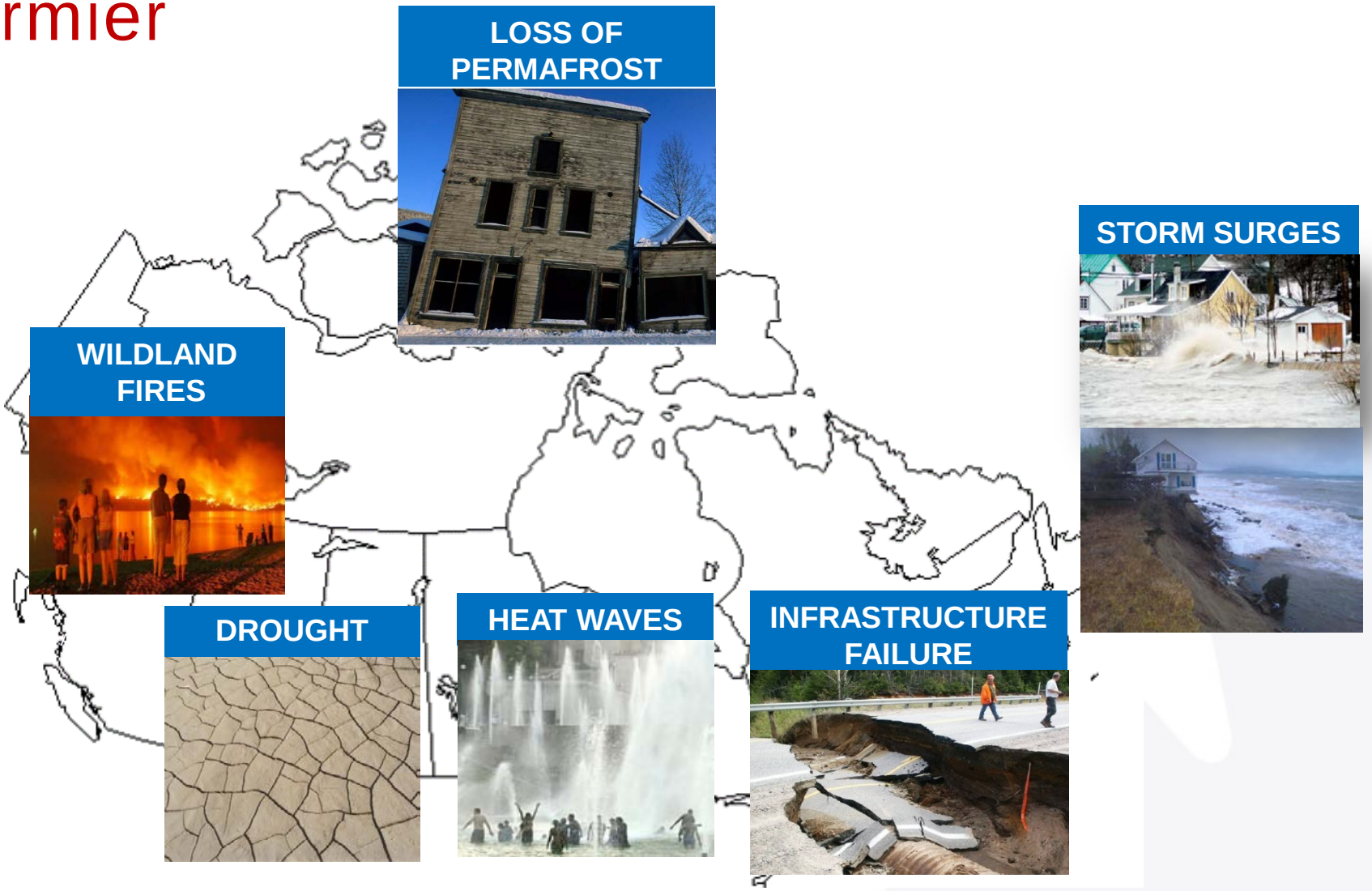
IPCC AR5, Synthesis Report, Summary for Policymakers, Fig. SPM.4

Observed changes in Canada:
Consistent with global changes

- Longer growing season
- More heat waves and fewer cold spells
- Thawing permafrost
- Earlier river ice break-up
- Increase in precipitation over large parts of Canada, more snowfall in northwest Arctic
- Earlier spring runoff
- Earlier budding of trees
- Indigenous people of the Arctic are no longer able to predict the weather as their forefathers did (Society for Ecological Restoration).

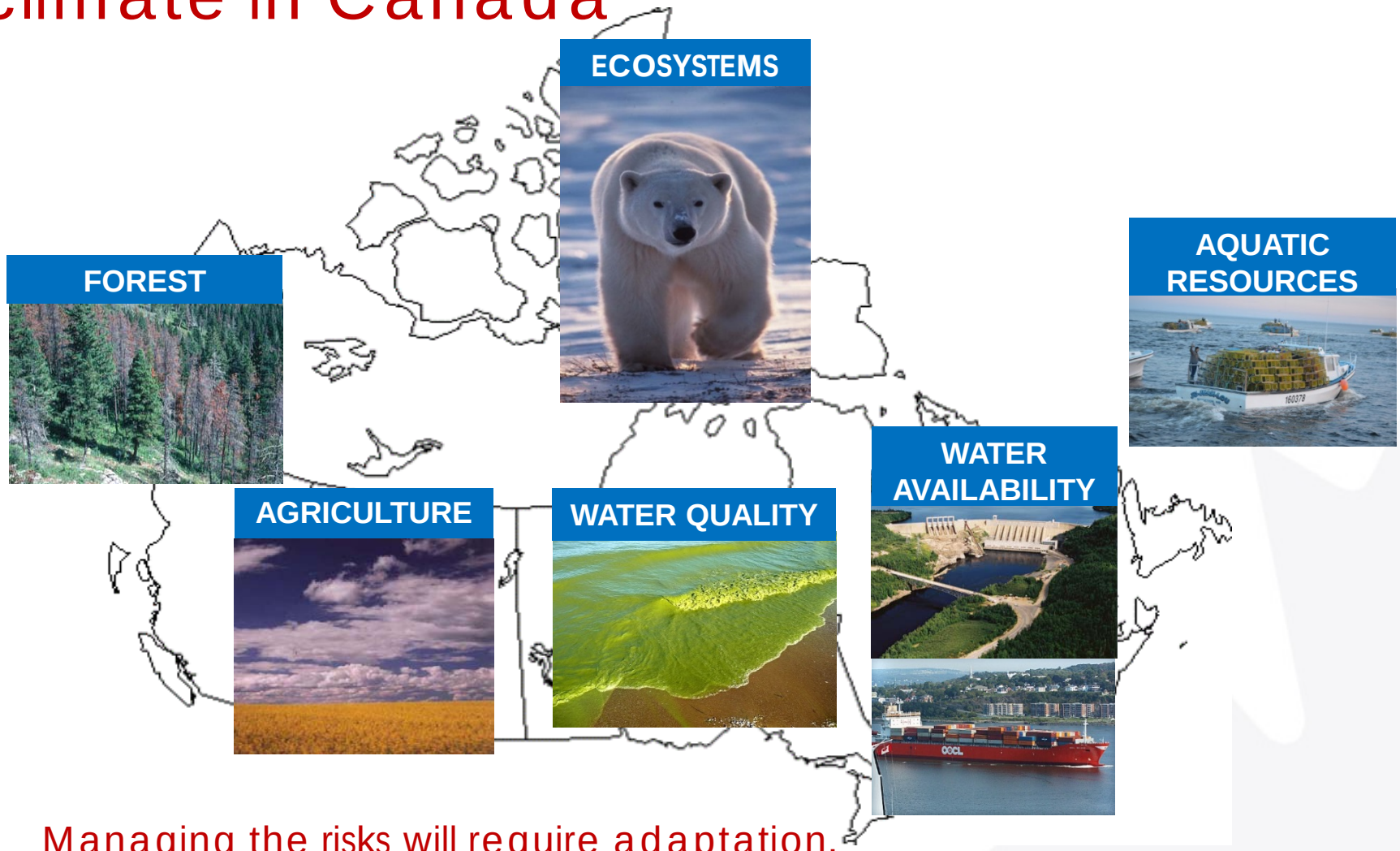


Canada is already warmer, wetter and stormier



Photos: AP Photo, AlaskaPhotoWorld, F. Prevel/AP

Longer-term impacts of a changing climate in Canada

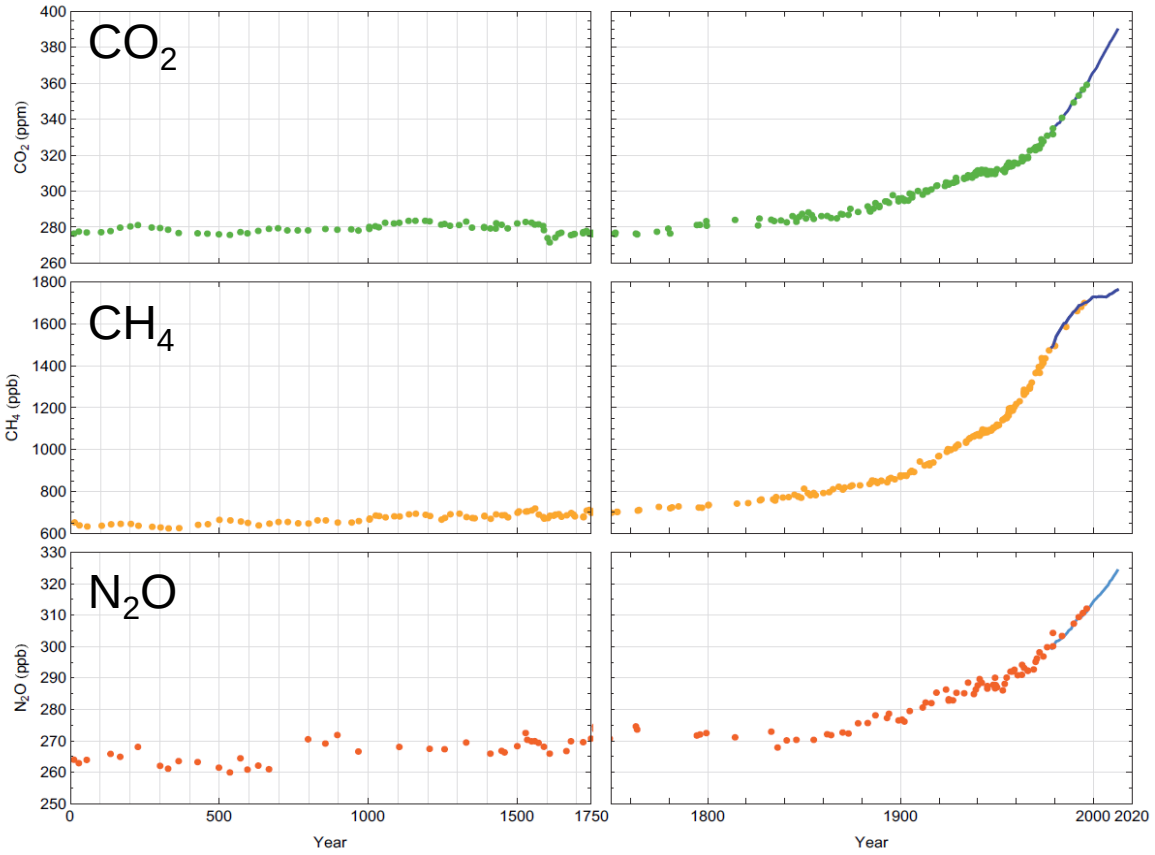


Managing the risks will require adaptation.

Photos: Parks Canada, T.Archer, Hydro-Quebec, Le Soleil, J-M. Dorion

What is Causing Climate Change?

Long-term GHG records show rapid increase since the Industrial Age.



Increases in CO_2 are due primarily to fossil fuel use, with additional contribution from land use change.

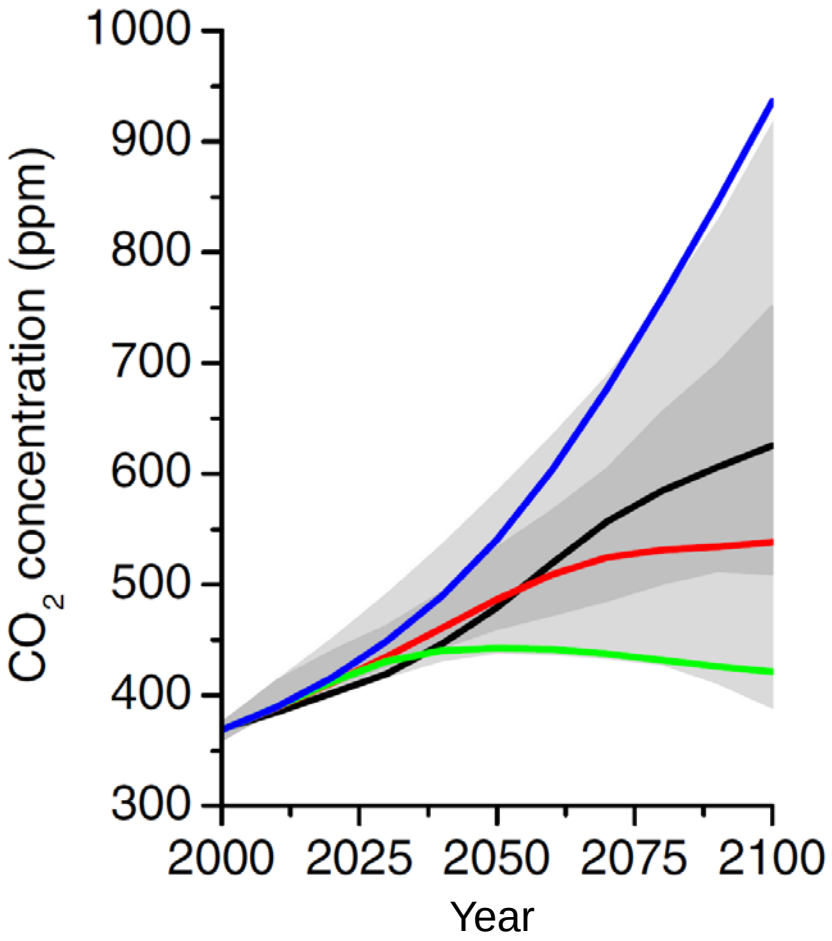
Those of CH_4 and N_2O are primarily due to agriculture.

GHGs like CO_2 are well mixed and long-lived; effects are global

Atmospheric concentrations of GHGs from direct measurements starting in the mid – 20th century, and from air bubbles trapped in glacial ice prior to that.

IPCC AR5, WGI, Fig. 6.11

Projecting Future Climate Change



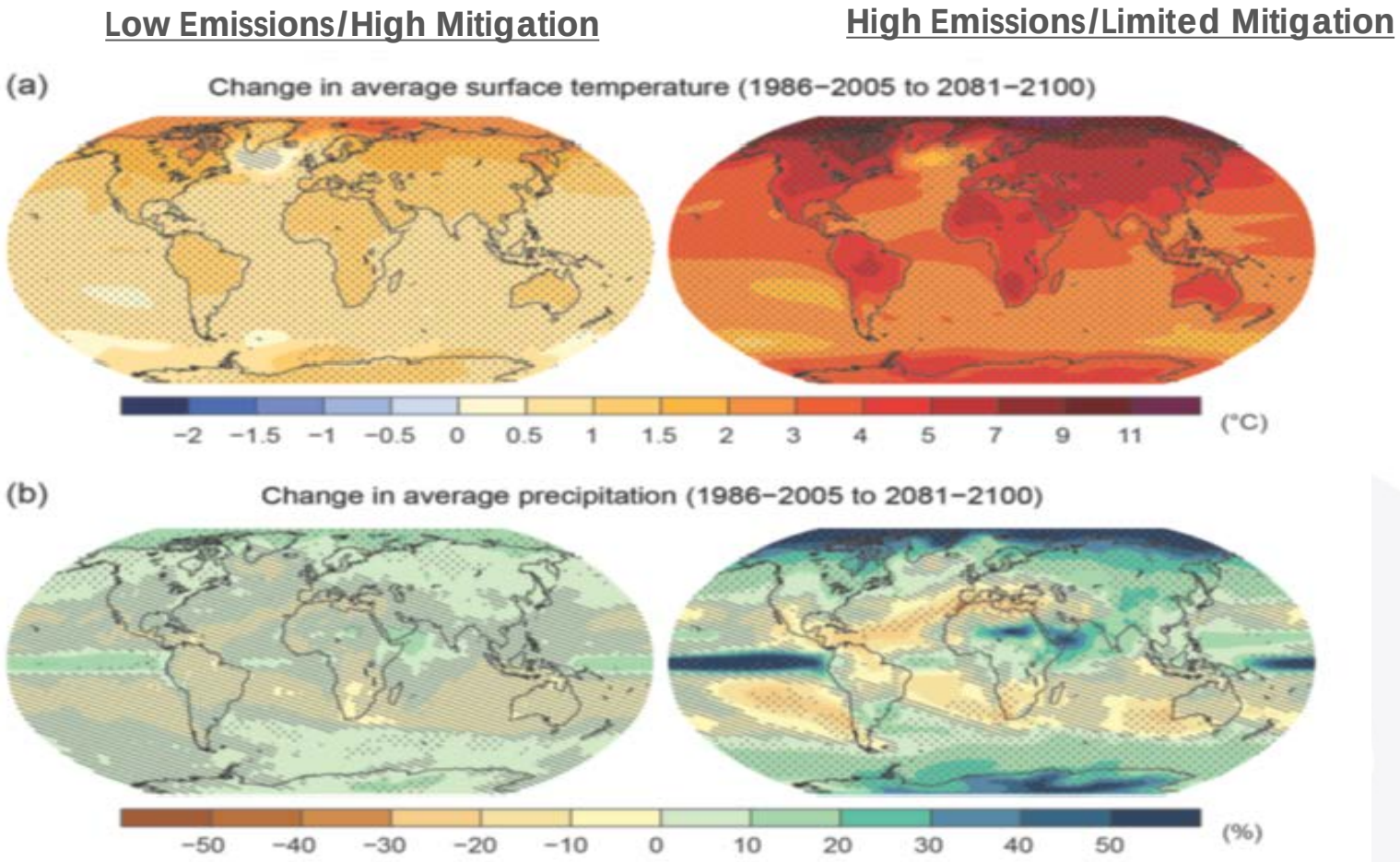
Making projections about future climate requires projections of future greenhouse gas concentrations or emissions.

Four different scenarios have been used; they span a range from low to high emissions (intensive mitigation to limited mitigation).

These scenarios are used as input to global climate models.

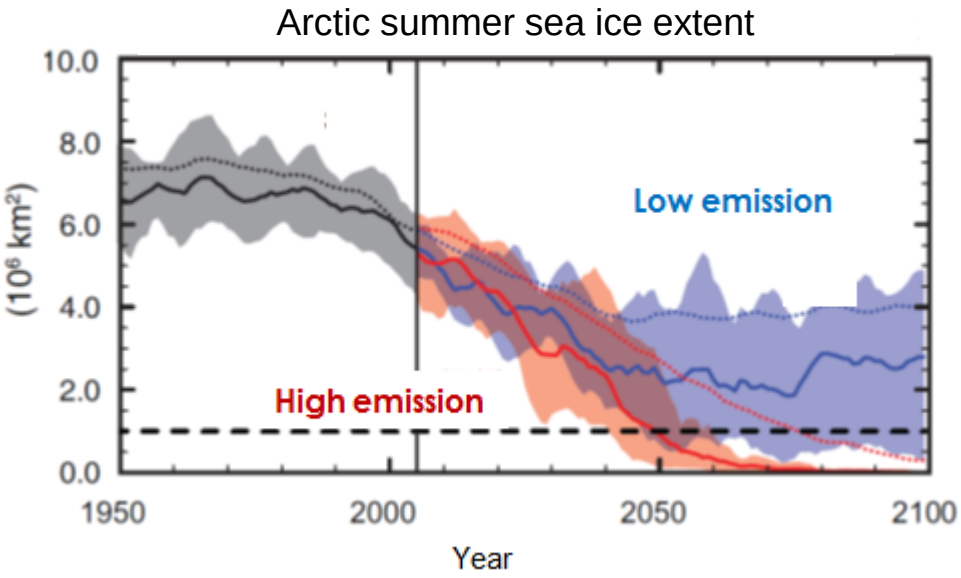
Van Vuuren et al., Climatic Change, 2011

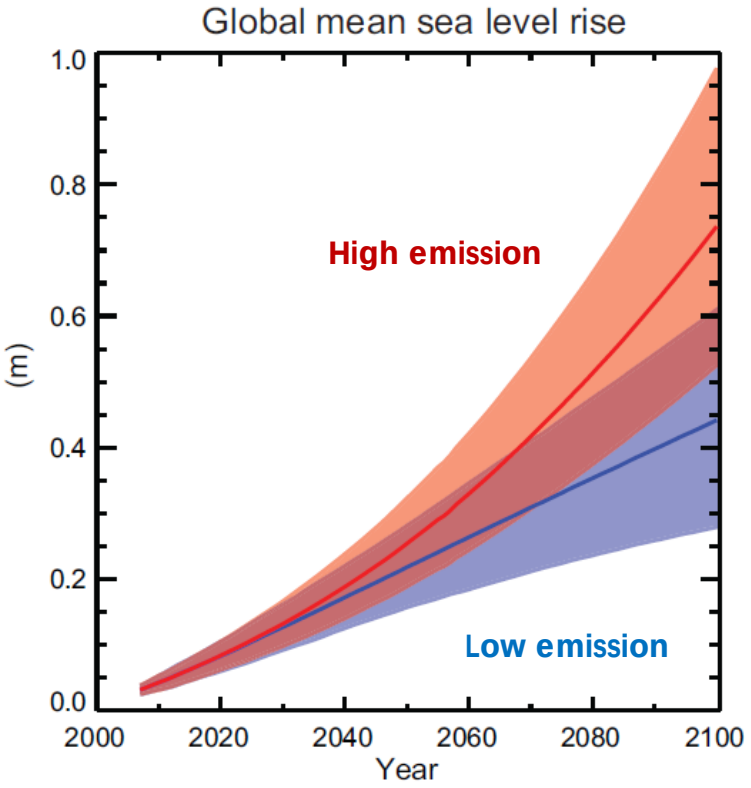
Magnitude of future climate change depends directly on future emissions



IPCC AR5, WGI, Summary for Policymakers, Fig. SPM.8

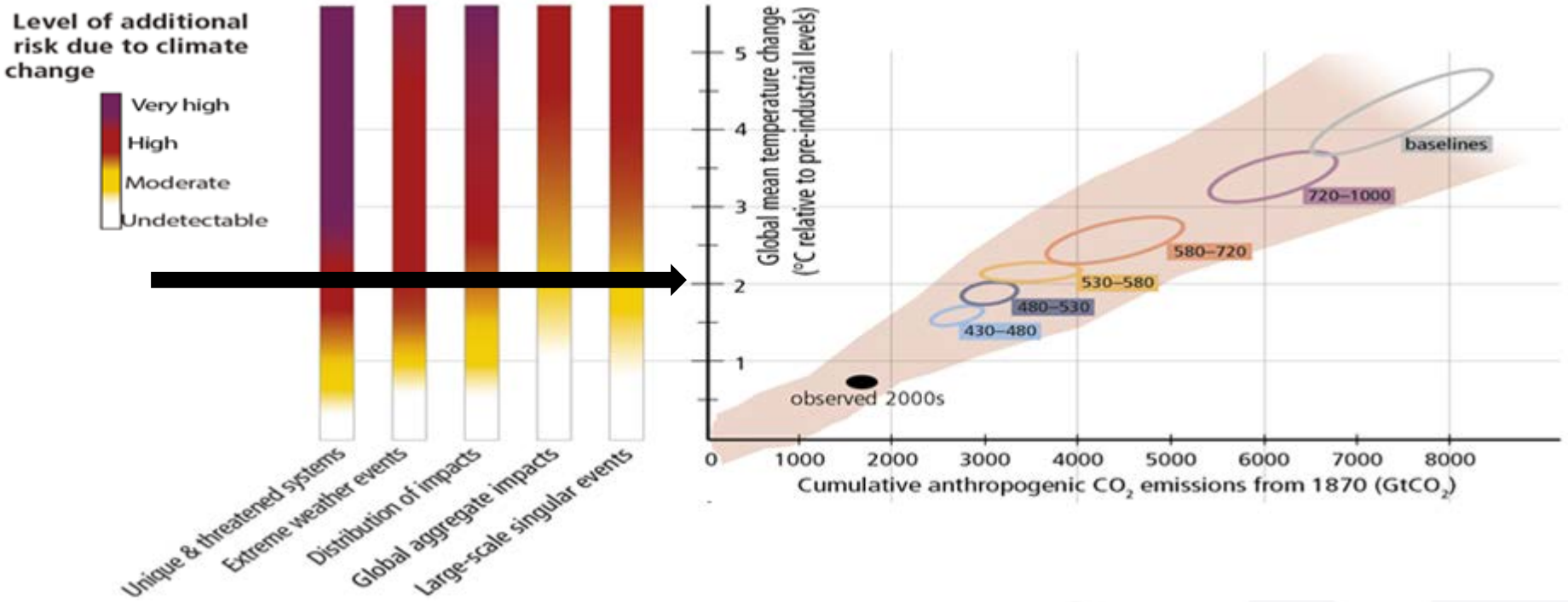
Other indicators are also projected to change





IPCC AR5, WGI, Summary for Policymakers, Fig. 2.1.

Risks from climate change depend on cumulative CO_2 emissions



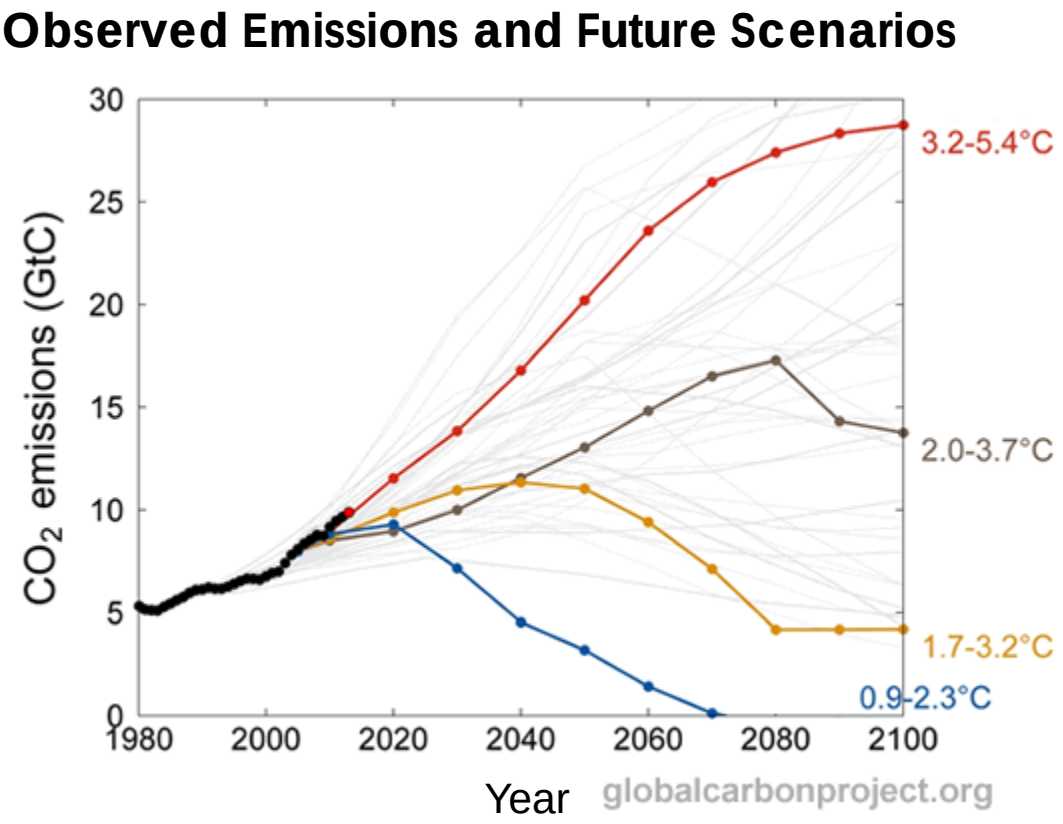
Above 2°C, the UNFCCC* target, risks of severe, widespread and irreversible impacts increase.

We are already about 65% of the way to the cumulative emissions limit consistent with 2°C.

*United Nations Framework Convention on Climate Change

Adapted from IPCC, AR5, Synthesis Report, Fig. 3.1

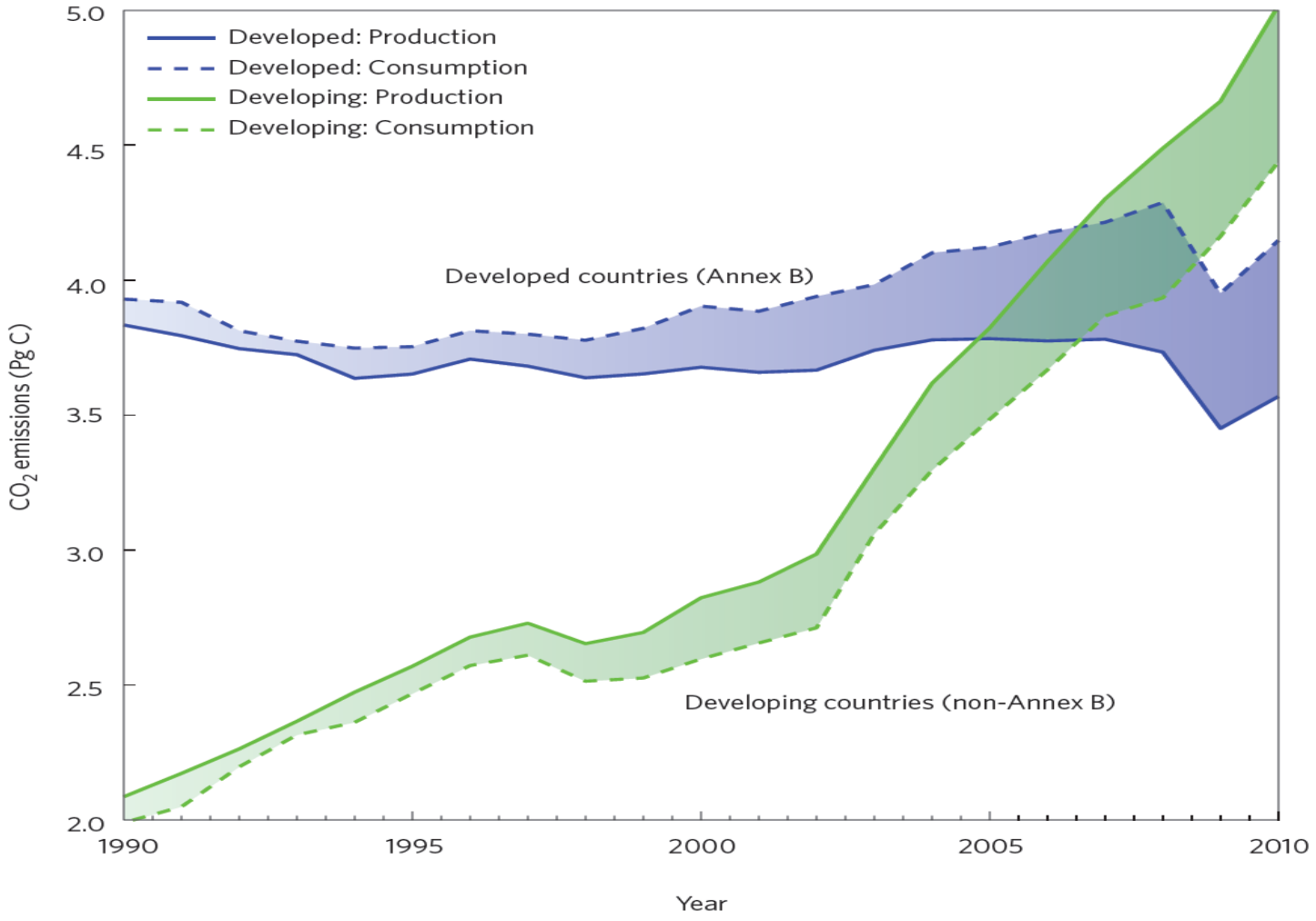
Keeping warming below the 2°C target will require rapid global emissions reductions



The high mitigation scenario is the only one assessed as maintaining temperature change below 2°C. It requires net zero, or even negative, emissions before the end of the century.

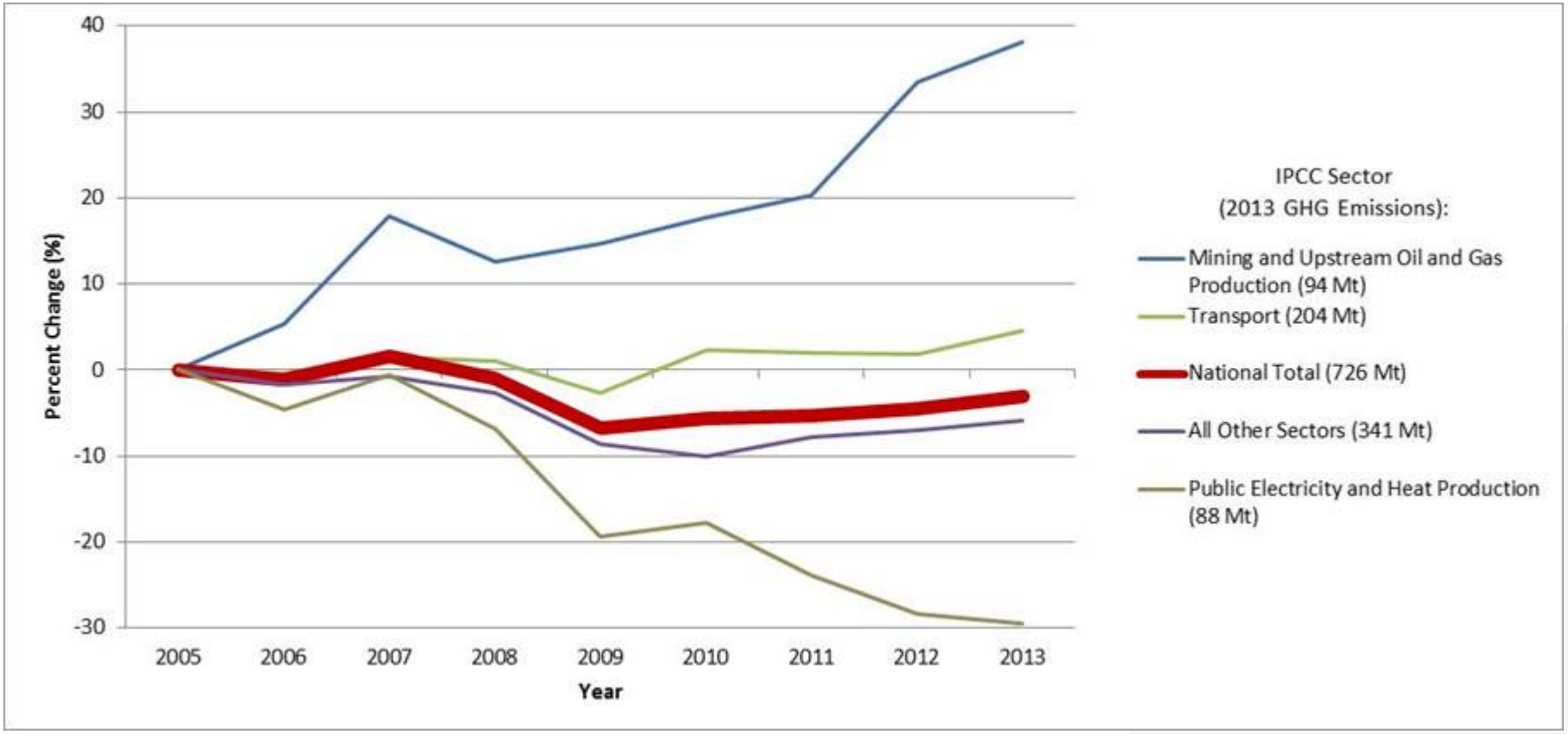
IPCC, AR5

Historical CO_2 emissions from 1990 to 2010 of developed and developing countries



Nature Climate Change, Volume 2, Jan 2012. Figure 2.

2005-2013 trends in Canada's GHG emissions
(National total and key sectors)



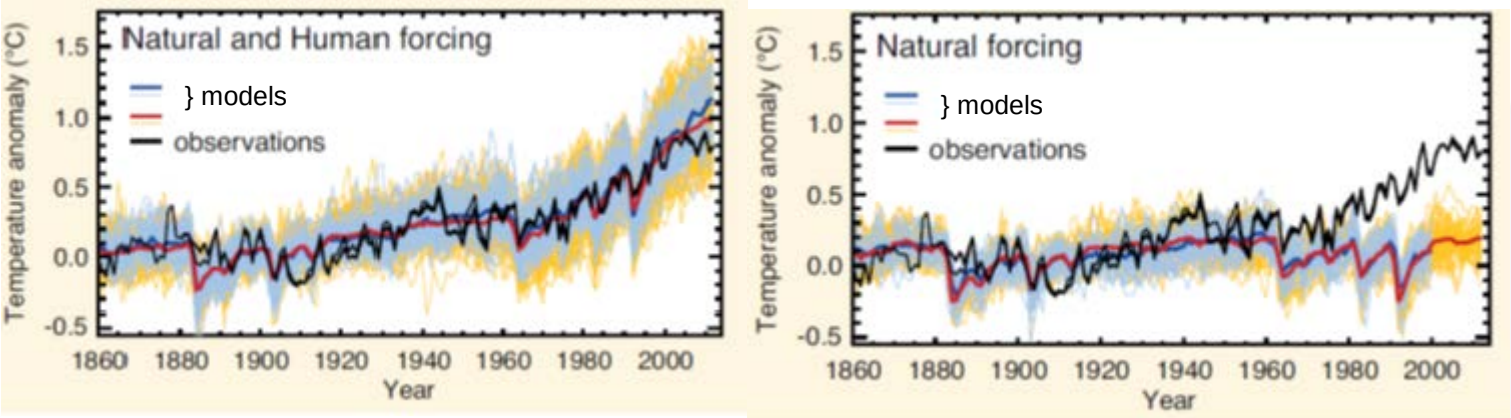
Summary

- The science is conclusive: Warming is unequivocal and human influence on the climate system is clear.
- Impacts of a changing climate are already being felt, and they will increase with further warming. Adaptation will be needed to manage the risks.
- The cumulative total emissions is what determines the ultimate level of warming. To avoid exceeding 2°C, global GHG emissions need to decrease rapidly.
- GHG emissions need to become net zero in order to stabilize climate at any temperature.

Annex 1: Intergovernmental Panel on Climate Change

“Human influence on the climate system is clear” (IPCC AR5)

- This headline statement is supported by increasing GHG concentrations, observed warming and related changes, and scientific understanding based on modelling the climate system.
- Climate models are able to reproduce many of the observed changes when forced with observed GHG concentrations.
  - Natural processes alone cannot explain observed warming.



Climate model simulations of global mean temperature change, compared with observations. Left: with natural and human forcing; right: with natural forcing only.

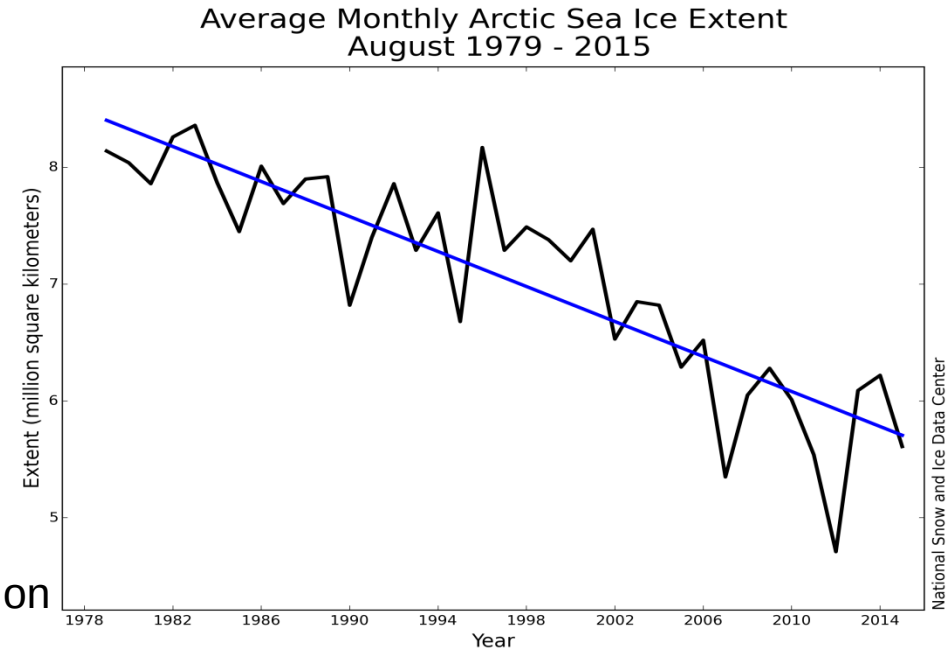
IPCC AR5, WGI, Chapter 10, FAQ 10.1

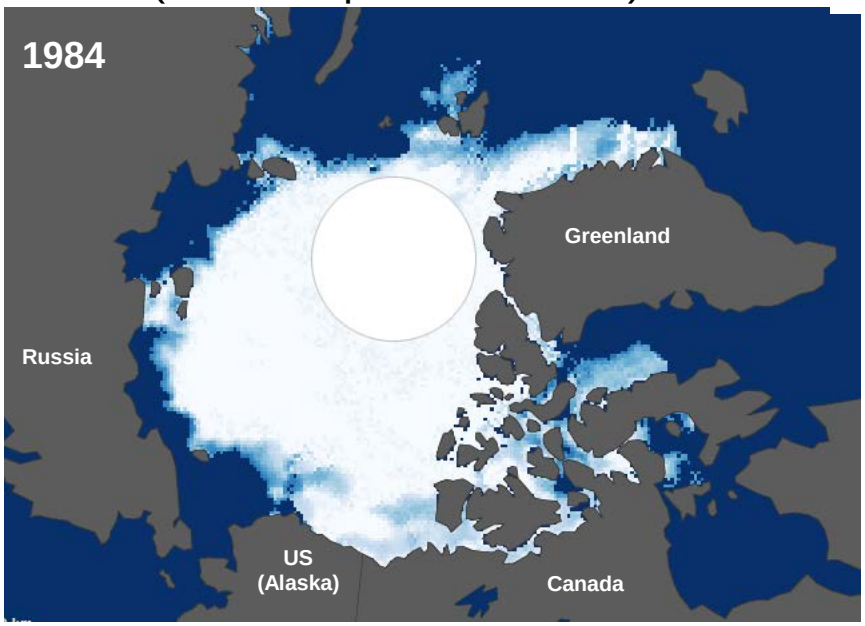
Annex 2: Changes Observed in Canada

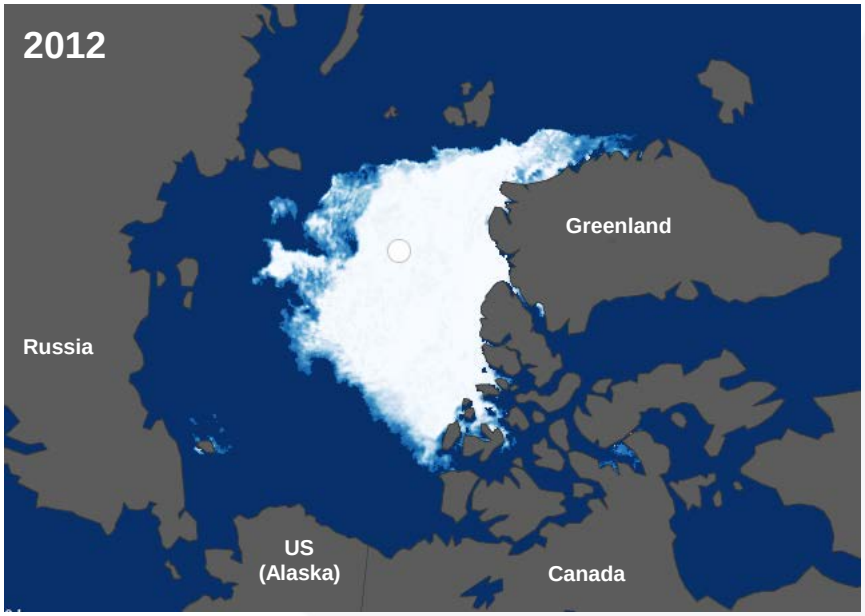
Average September arctic sea ice extent

1979–2012

Note that 2012 had the lowest sea ice extent on record (records updated to 2014).



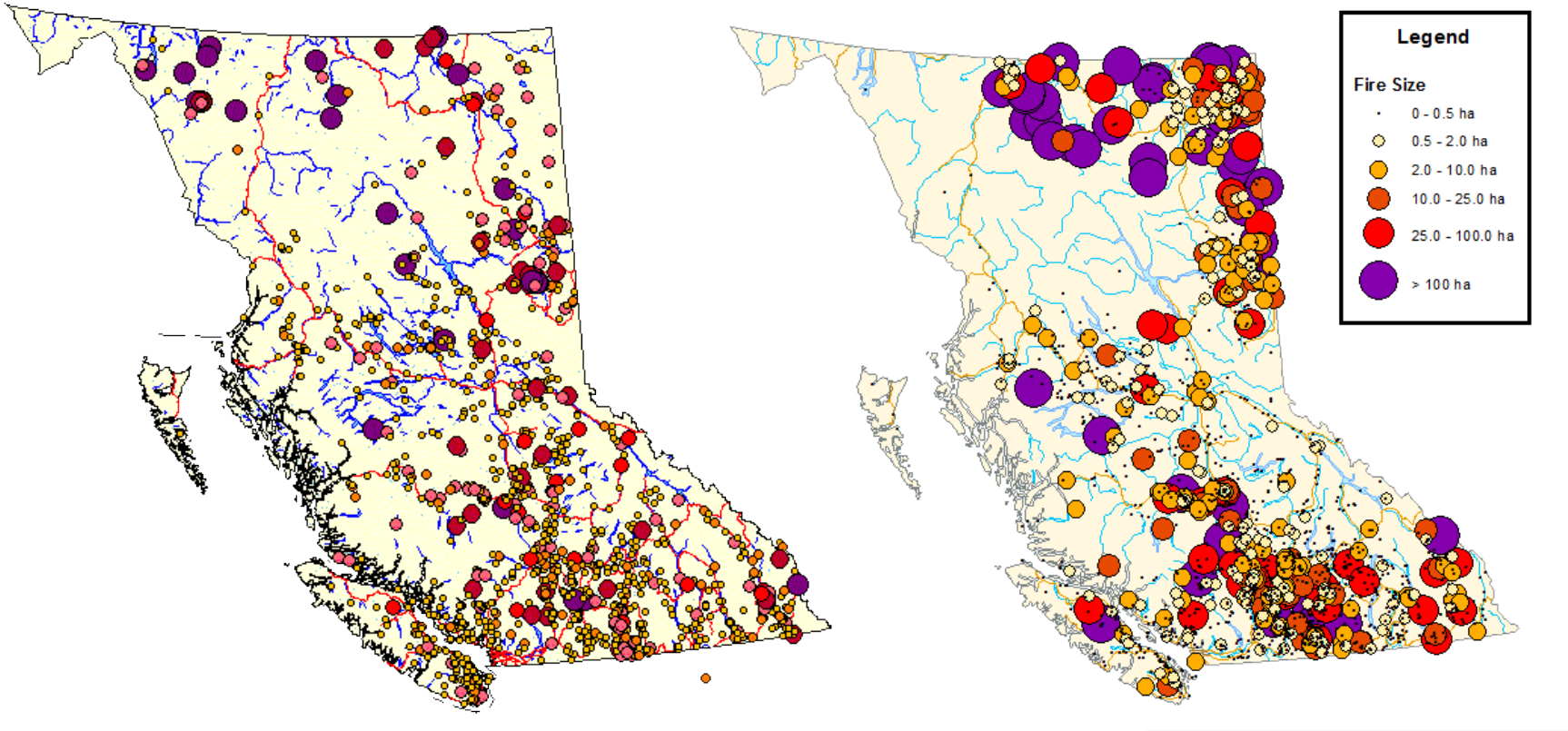




Summary of number and magnitude of wildfires in British Columbia

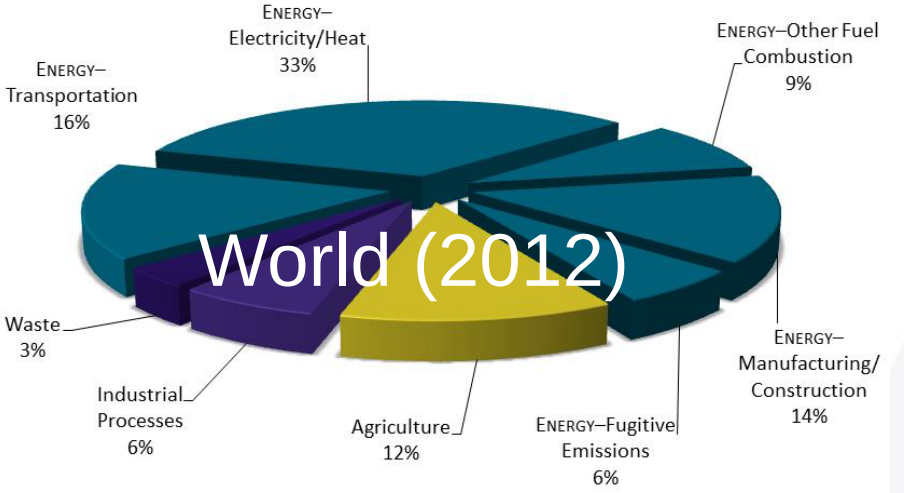
1999

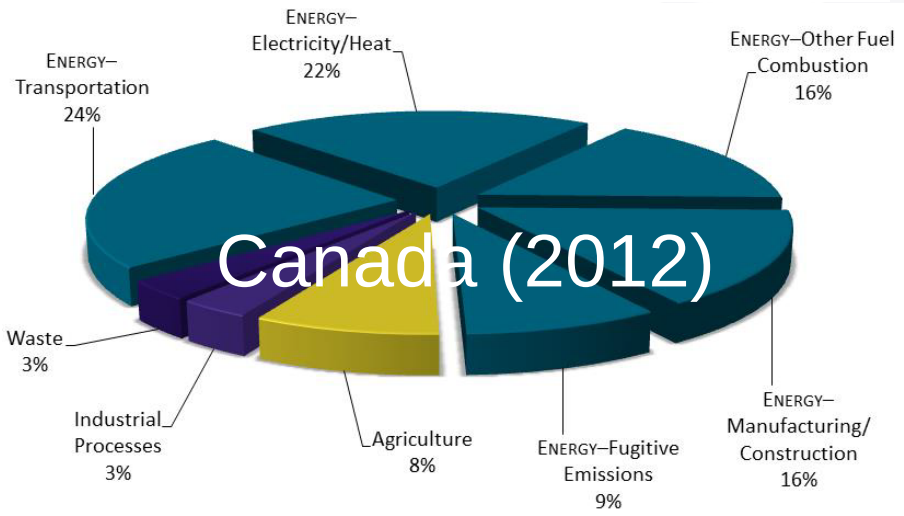
2012



Proportion of GHG emissions by sector (2012)

- Emissions from electricity generation account for significantly less of Canada's total national emissions, compared with the global average.
- In addition, emissions from transportation in Canada contribute more to Canada's total national emissions, compared with the global average.





CAIT Climate Data Explorer. 2015. Washington, DC: World Resources Institute. Available online at: http://cait.wri.org.


Canada