MANITOBA CLIMATE
RESILIENCE TRAINING

November 4, 2021

Climate Change 101

Presented by: The Prairie Climate Centre

Stephen Muirhead
Danny Blair

MANITOBA CLIMATE
RESILIENCE TRAINING

We acknowledge that we are gathered here today in Treaty 1 Territory, within the traditional territories of the Anishinaabe (Ojibwe), Ininew (Cree), Oji-Cree and Dakota peoples, and in the homeland of the Métis Nation

Overview of content

1. Introduction
2. What is climate change?
3. Current factors
4. Historic overview
5. Climate projections
6. Canadian perspective
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Introduction

Why are we providing a course on climate change fundamentals?

Mission statement: To build the confidence and capacity of professionals to address climate change and educate decision-makers

Survey findings:

Planning Sector - confidence in discussing climate change impacts was self-reported at 3.5/10

60% also cited client/municipal disinterest and a lack of understanding

Infrastructure Sector (Probe Research) - only ¼ of respondents reported being *very familiar* with climate change outcomes (mostly winter-related)

Nearly ½ of respondents reported 'climate change basics' as being a useful training topic

What is climate change?

What is being done internationally to address climate change?

How has Canada been responding to recent reports?

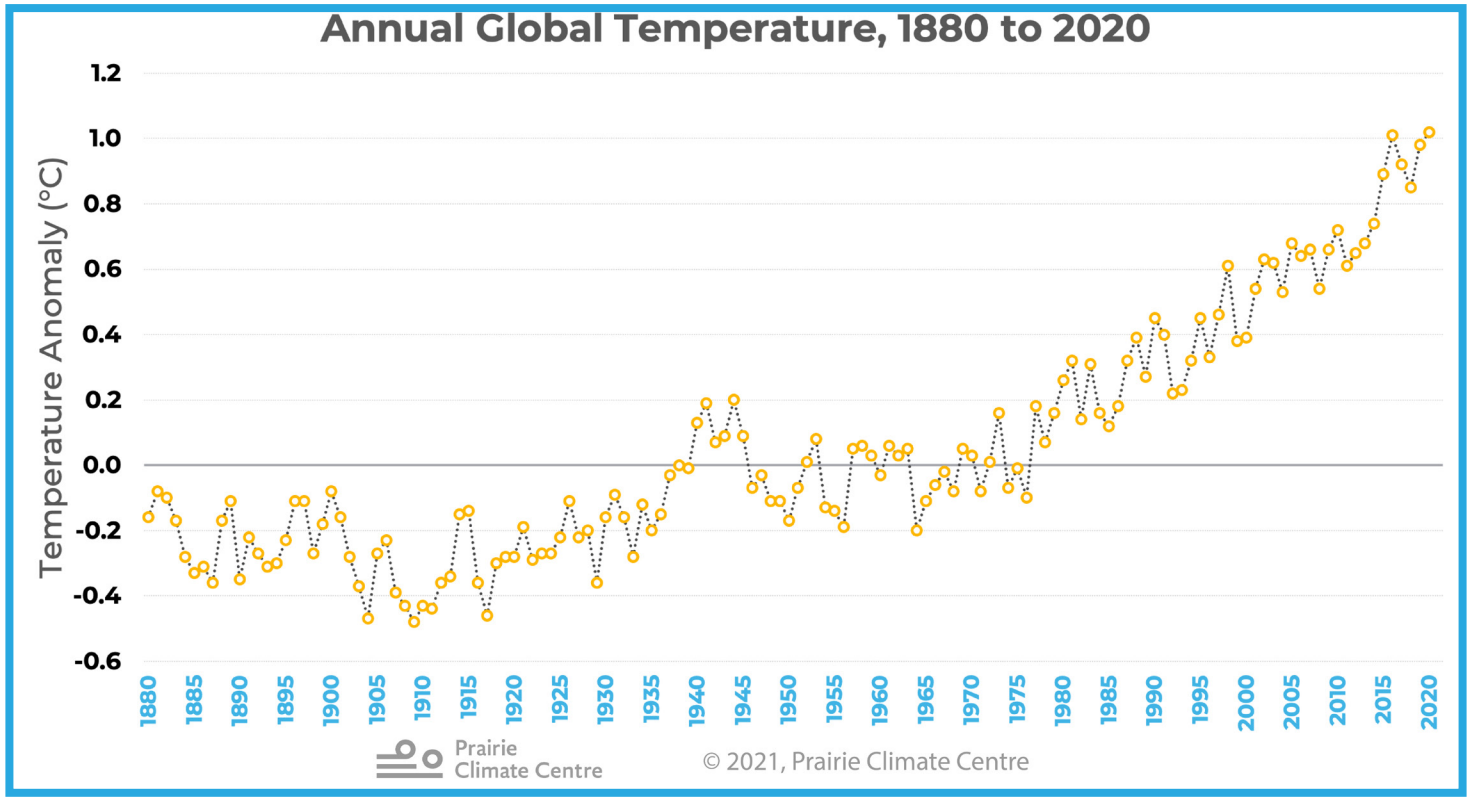
Climate is a synthesis of weather conditions in a given area, characterized by long-term statistics (usually 30-year averages) of the meteorological elements in that area[1]

Weather is the state of the atmosphere at a particular time, as defined by the various meteorological elements[2]

Climate change usually refers to a shift in the global mean temperature. Many other kinds of changes to the climate are triggered by the global warming.

The global mean temperature is now slightly more than 1°C higher than it was in the late 1800s[3]

Twenty of the hottest years since 1880 have occurred in the last 21 years.



Data sourced from https://data.giss.nasa.gov/gistemp/graphs/

fig.i *https://climateatlas.ca/climate-change-basics*

“Global surface temperature will continue to increase until at least the mid-century under all emissions scenarios considered. Global warming of 1.5°C and 2°C will be exceeded during the 21st century unless deep reductions in CO_2 and other greenhouse gas emissions occur in the coming decades.”

IPCC AR6, Summary for Policymakers[4]

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 by the United Nations Environment Programme (UNEP) and World Meteorological Organization (WMO)

> "...to prepare a comprehensive review and recommendations with respect to the state of knowledge of the science of climate change; the social and economic impact of climate change, and potential response strategies and elements for inclusion in a possible future international convention on climate."[5]

Reports: FAR 1990, SAR 1995, TAR 2001, AR4 2007, AR5 2014, AR6 2021-22, and numerous special reports

Canada has signed on to multiple international efforts to reduce our greenhouse gas emissions and curb the impacts of climate change; we have failed to meet our stated national goals.

- **UN Framework Convention on Climate Change (The Earth Summit), 1992**
- **The Kyoto Protocol, 2002**
- **The Copenhagen Accord, 2009**
- **Paris Agreement, 2015**

"...it becomes clear that Canada has actually made significant progress towards controlling its emissions: Canada has reduced the emission intensity of its economic activity by approximately 20 per cent since 1990. In 1990, a billion dollars of economic activity released 0.84 megatons of greenhouse gases into the atmosphere. Today, that same billion dollars of productivity causes just 0.69 megatons of greenhouse gas emissions. This means that each dollar of economic production that occurs in Canada today produces significantly less greenhouse gases than a dollar of production in 1990, even after an adjustment is made to control for inflation."

-Adrian Vannahme[7]

This Agreement, in enhancing the implementation of the Convention, including its objective, aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including by:

(a) Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change;

(b) Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production[6] - excerpt from Paris Agreement

Pan-Canadian Framework on Clean Growth and Climate Change (2016)

Four pillars: carbon pricing, reduce emissions, adaptation and climate resilience, clean economic growth

Reports:

- **Canada's Climate Action for a Healthy Environment and a Healthy Economy (2021)**
- **Canada in a Changing Climate: Regional Perspectives (2020-21)**
- **Canada in a Changing Climate: National Issues Report (2021)**

Legislation:

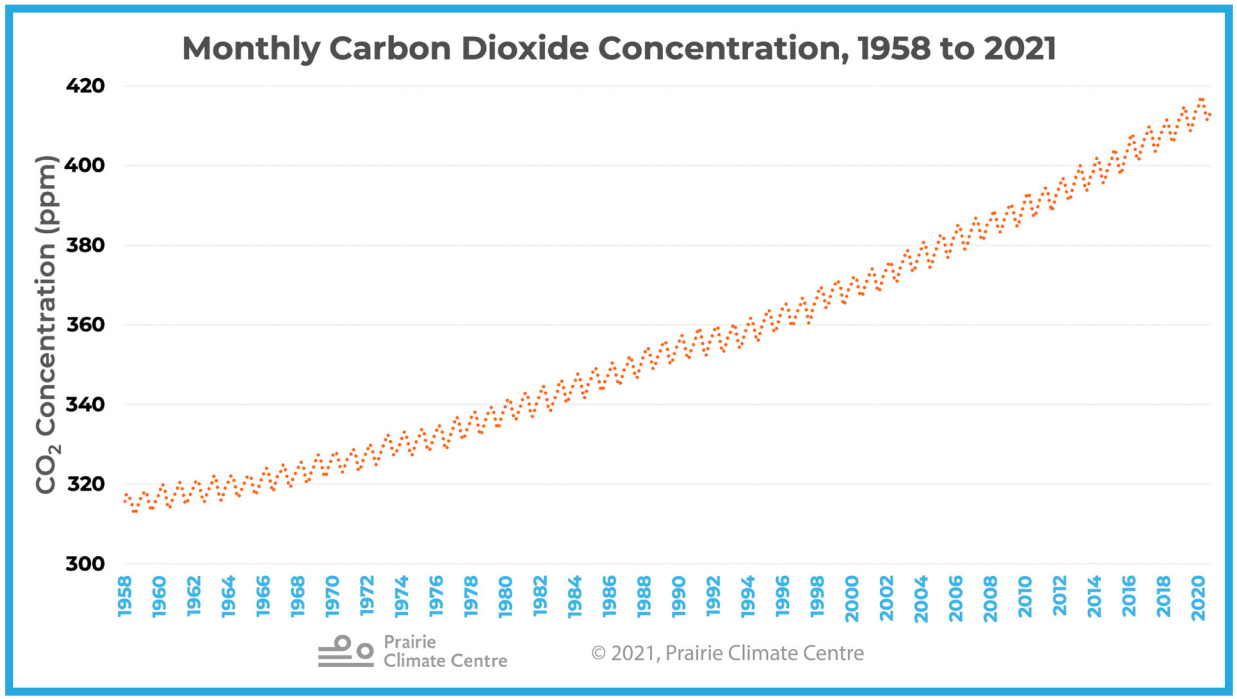
- **Canadian Net-Zero Emissions Accountability Act (2020)**

More detailed information available at: https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/climate-plan-overview.html

Current factors

What is currently causing climate change?

Why are high concentrations of greenhouse gases problematic?



Greenhouse gases from human activities are responsible for most of the change in the Earth's energy budget. Carbon dioxide accounts for about 82% of the change in recent years.

Data sourced from https://keelingcurve.ucsd.edu/

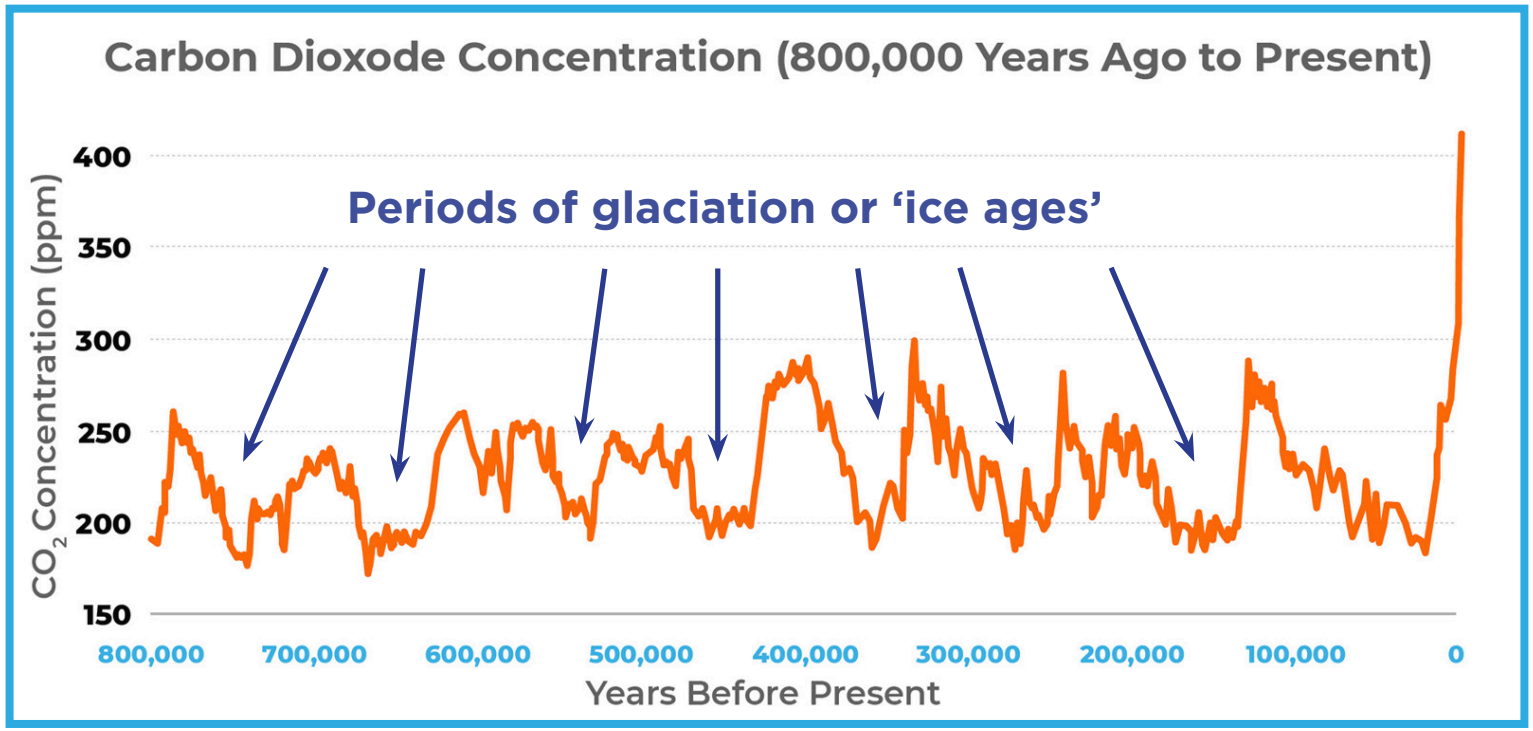
fig.ii *https://climateatlas.ca/climate-change-basics*

In 2020 the average concentration of carbon dioxide at the Mauna Loa observatory[8] was:

414.24 ppm

...and is increasing by 2 to 3 ppm annually

The most recent GHG bulletin is available at: https://library.wmo.int/doc_num.php?explnum_id=10838



The carbon dioxide concentration in the atmosphere today is over 40% higher than it has been at any time in the past 800,000 years

Data sourced from Lüthi et al. (2008), *https://pubmed.ncbi.nlm.nih.gov/18480821/*

fig.iii *https://climateatlas.ca/why-climates-change*

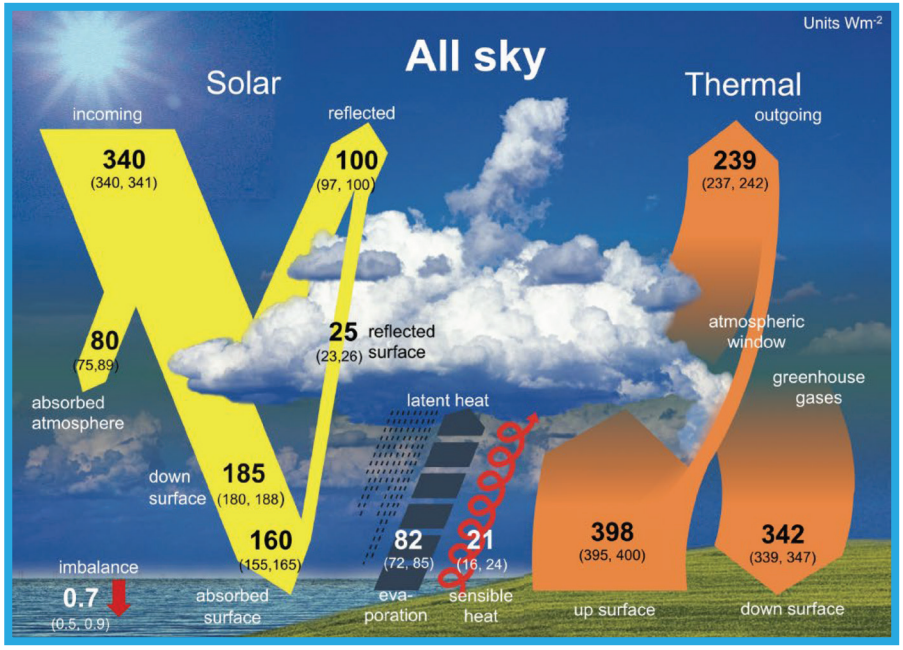
While natural occurring in our atmosphere - and an important factor in why Earth is habitable - the issue with carbon dioxide is that it absorbs energy that would otherwise escape to space. With more carbon dioxide...more energy is kept in the atmosphere...and it warms.

On a per molecule basis, methane and nitrous oxide are better at trapping outgoing energy, but they are much less abundant than carbon dioxide, and they don't last as long in the atmosphere.

Of the CO_2 emitted by human activity that enters the atmosphere:

- 15-40% remains for ≥ 1,000 years
- 10-25% remains for ~ 10,000 years[9]

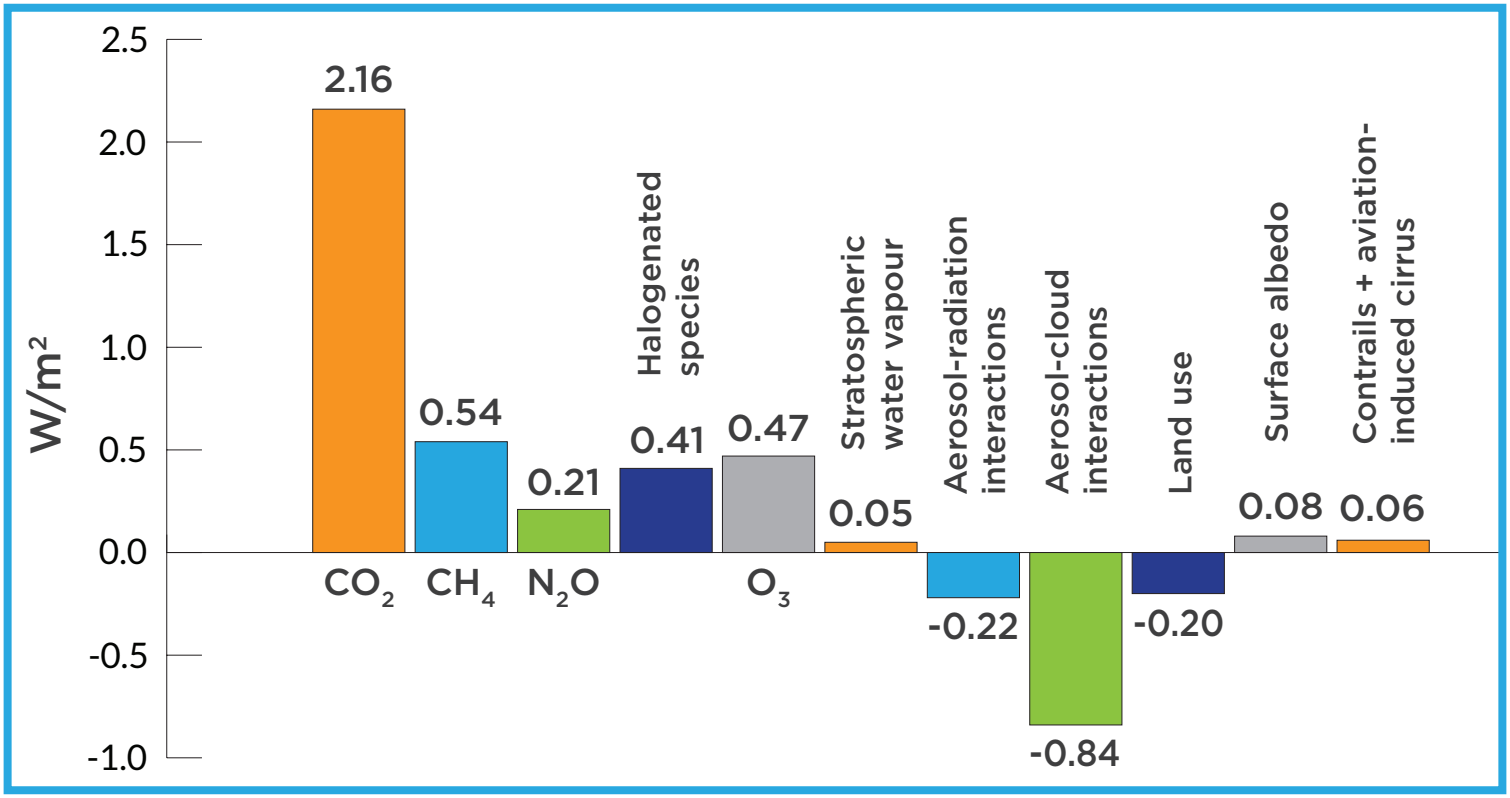
One way to explain how human activity has altered the global climate is with the concept of radiative forcing. This is essentially a measure of how strongly something affects the energy budget of the planet



Graphic attributed to Wild et al. (2015, 2019)

fig.iv *https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter_07.pdf*

Effective radiative forcing 1750 - 2019



Graphic modified from IPCC AR6 Synthesis Report: Climate Change (2022)

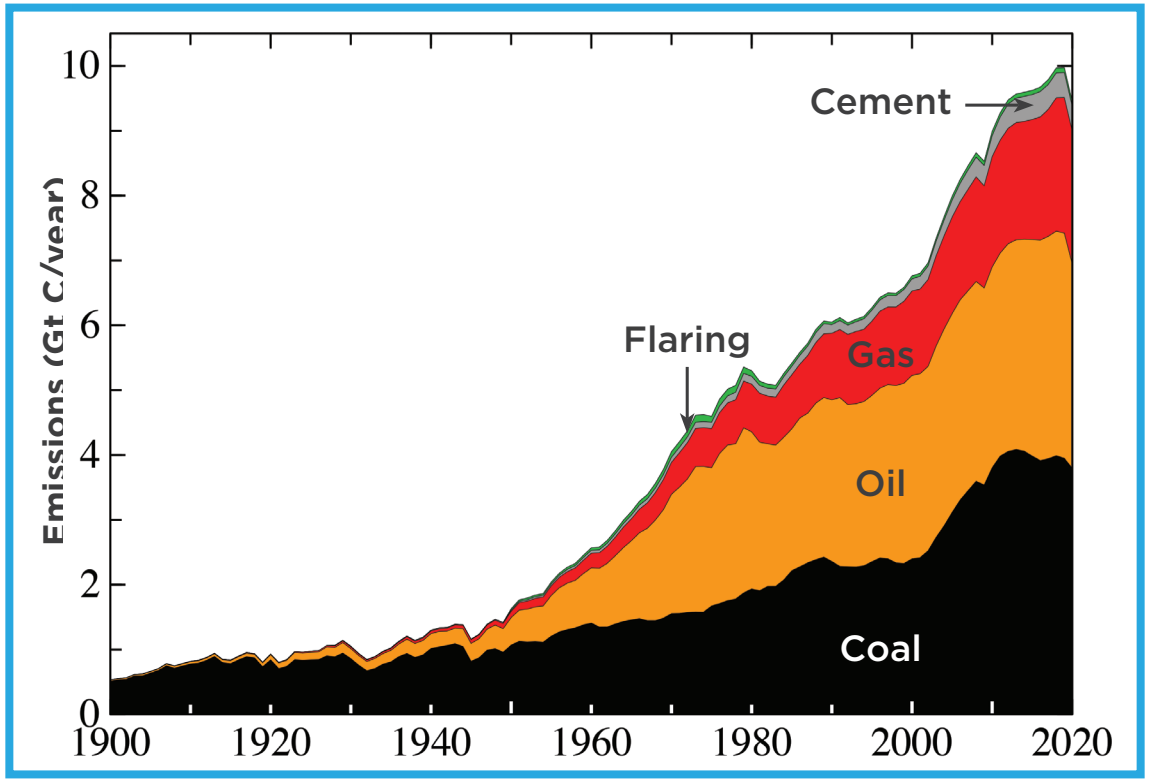
fig.v *https://esd.copernicus.org/preprints/esd-2016-42/esd-2016-42-manuscript-version5.pdf*

Climate changes and observed impacts so far are associated with a human-caused (anthropogenic) increase in radiative forcing of about

$$2.72\ W/m^2$$

This seemingly small change to the energy budget of the planet has caused the global surface temperature to increase by about 1°C

Global Fossil-Fuel Carbon Emissions (1900 - 2020)

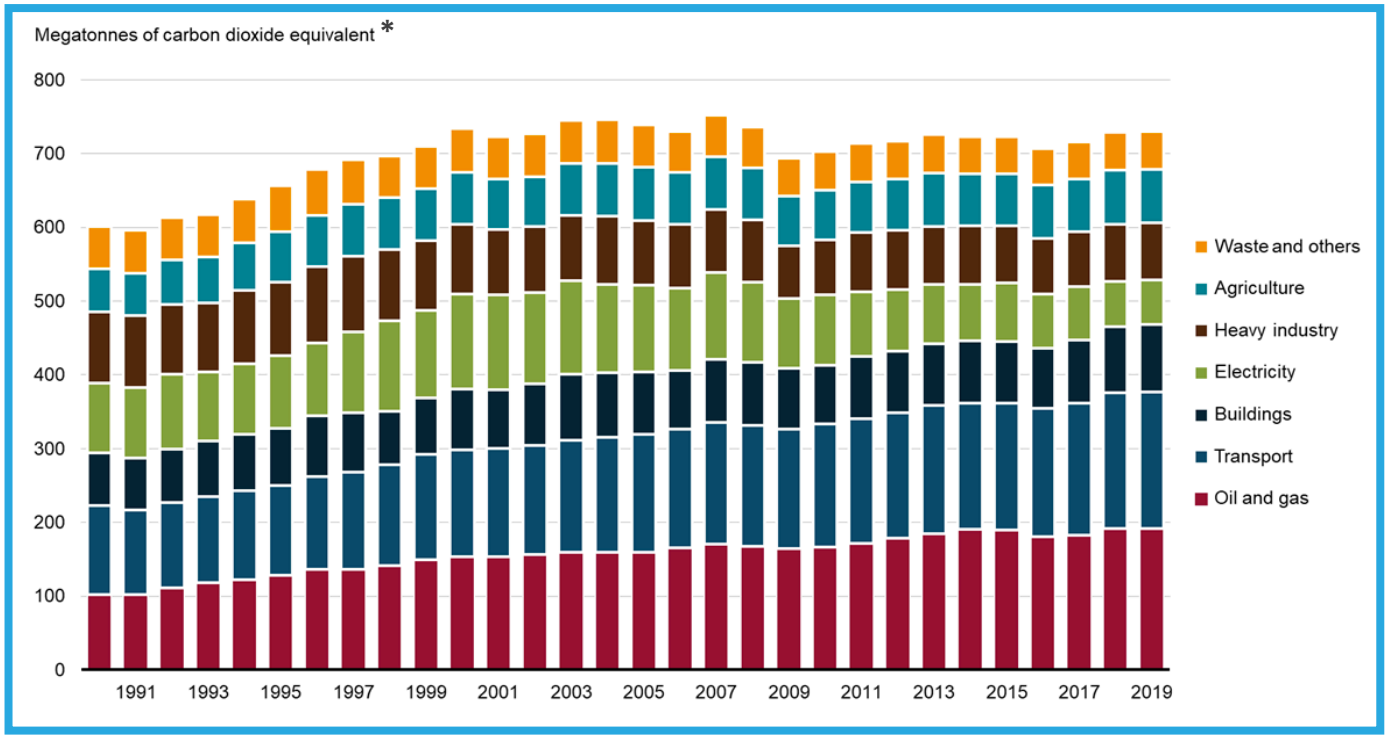


Note: Volcanoes only emit about 0.1 Gt carbon (C) in a given year

Graphic modified from Hansen, J. and Sato, M. (2021)

fig.vi *http://www.columbia.edu/~mhs119/CO2Emissions/*

What are the sources of greenhouse gases in Canada?

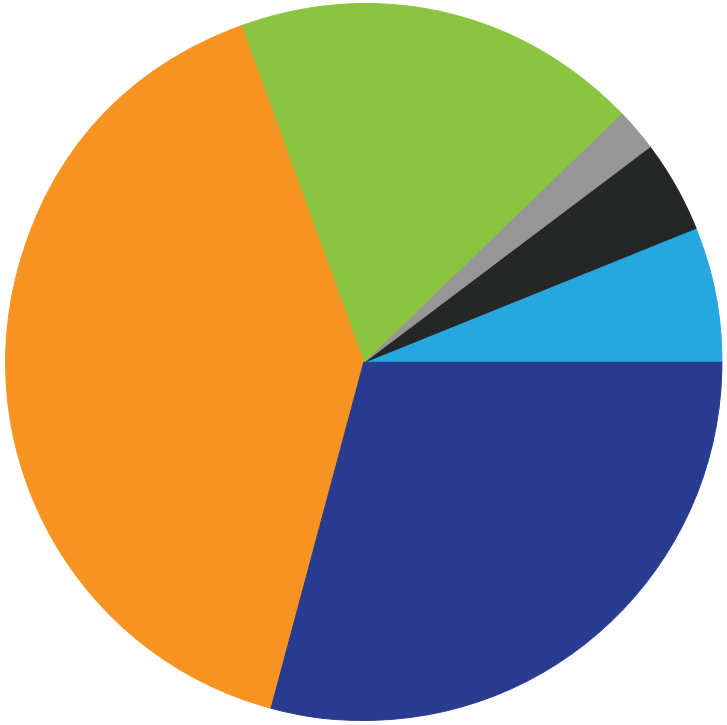


***NOTE: This graph represents CO_2 equivalents. 1000Mt = 1 Gigatonne of CO_2 = 0.2732 Gigatonnes of Carbon**

Graphic attributed to Environment and Climate Change Canada (2021)

fig.vii *https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/greenhouse-gas-emissions.html*

Manitoba's 2019 GHG emissions largely parallel Canada's sectors



40% Transportation

29% Agriculture

18% Stationary Combustion

6% Waste

4% Industrial Processes

2% Fugitive Sources

22.6 Mt CO_2e

Graphic modified from Environment and Climate Change Canada (2021)

fig.viii *https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/sources-sinks-executive-summary-2021.html#table-s-4*

Historic overview

Why has the climate changed before?

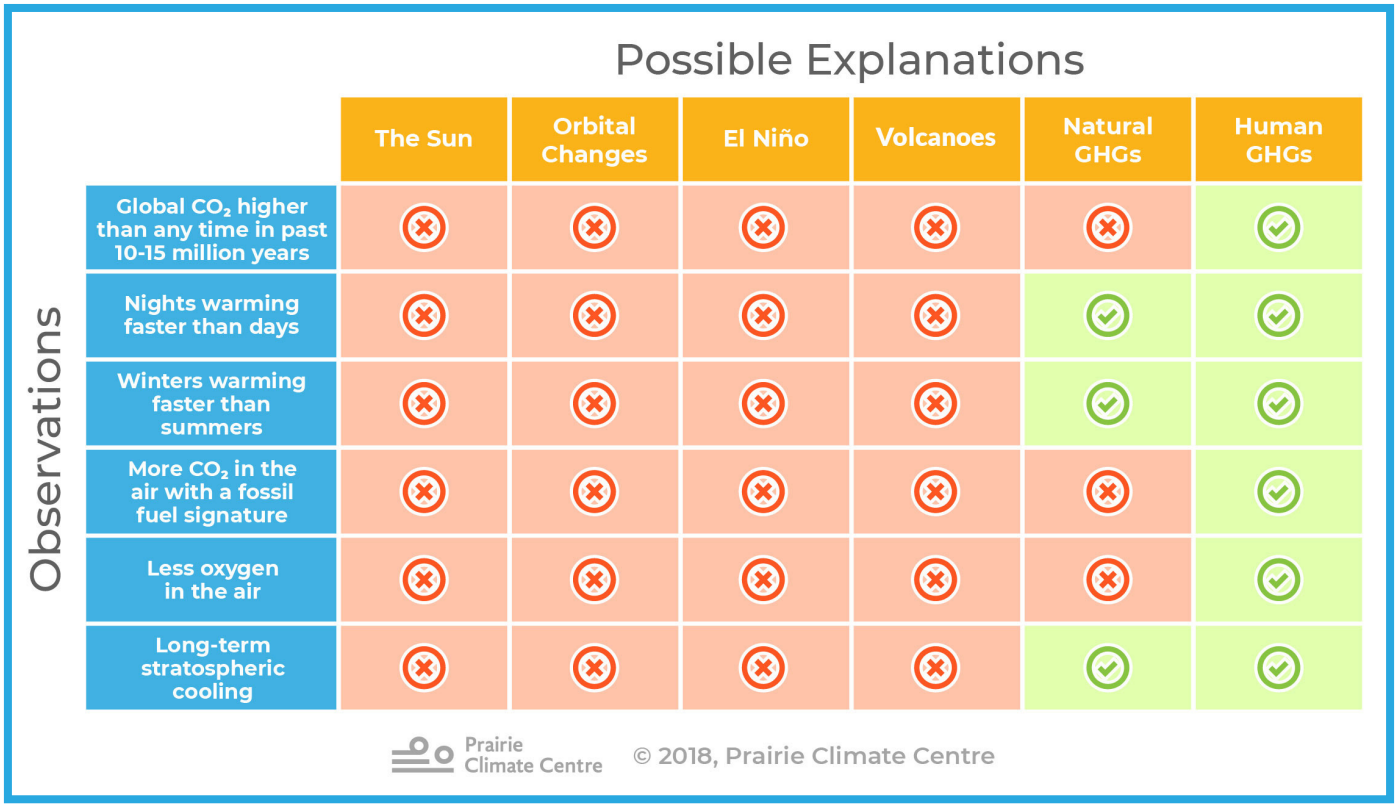
What other factors have lead to historic patterns of climate change?

Earth's climate has changed many times since the planet formed

Prior to human-induced climate change, shifts were caused by natural phenomena such as:

- Solar irradiance
- Orbital variations
- Volcanoes
- El Niño and La Niña
- Natural GHGs

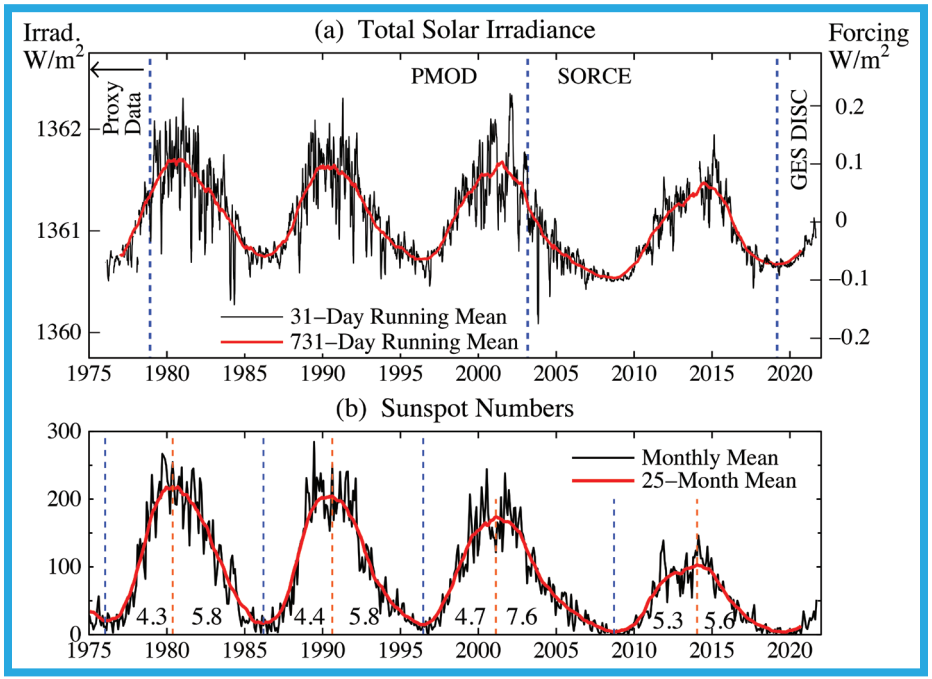
However, none of these can account for the changes in the climate since Industrialization



Graphic attributed to Prairie Climate Centre (2018)

fig.ix *https://climateatlas.ca/climate-change-basics*

Solar irradiance has been comparatively lower in the last decade and yet global temperatures are still increasing. As the Earth's sole external energy input, the sun's output can influence global temperatures

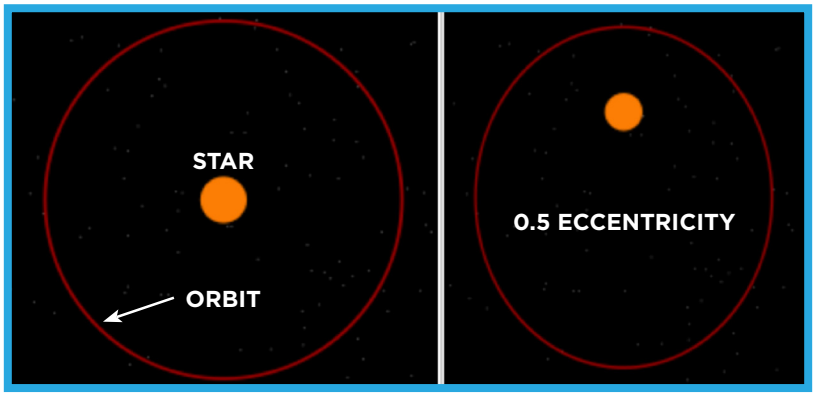


Data sourced from Physikalisch Meterologisches Observatorium Davos, World Radiation Center (2003)

fig.x *http://www.columbia.edu/~mhs119/Solar/*

The **Milanković cycles** are three separate orbital and axial variations that collectively influence climate change on Earth. In the current phase, Earth should be slowly sliding into a period of cooling, however, global temperatures continue to increase

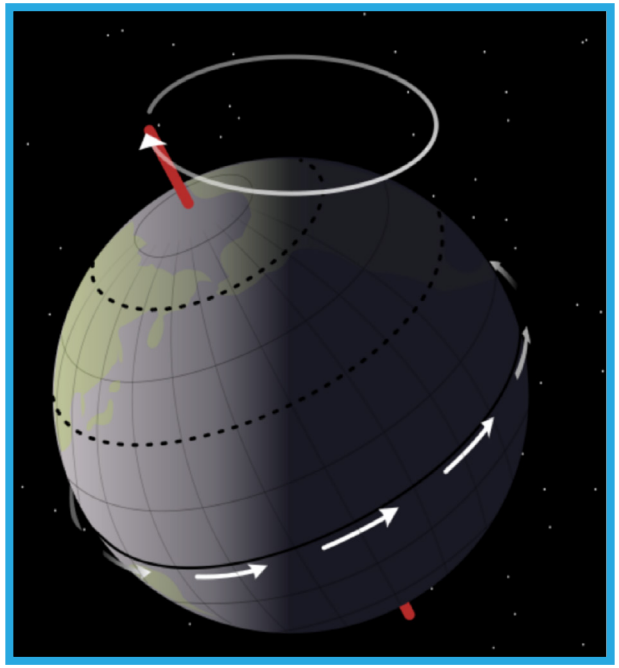
The first of these three cycles is **eccentricity**, which is the shape of the Earth's orbit, affected by the gravitational fields of Jupiter and Saturn, and takes approximately 100,000 years to complete



Graphic attributed to **NASA, Mysid**

fig.xi *https://en.wikipedia.org/wiki/Milankovitch_cycles#/media/File:Eccentricity_half.svg*

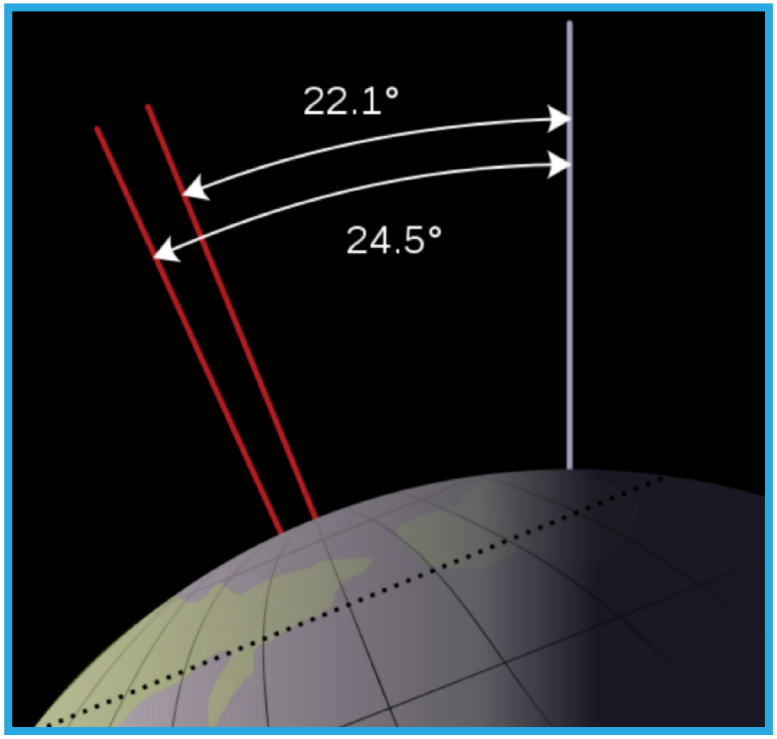
The second cycle alters the point in the sky directly above the North Pole. **Precession** affects the timing and intensity of the seasons in the northern and southern hemispheres. On average, the cycle of axial precession takes 26,000 years to complete



Graphic attributed to **NASA, Mysid**

fig.xii *https://en.wikipedia.org/wiki/Milankovitch_cycles#/media/File:Eccentricity_half.svg*

The third cycle is obliquity or the angle of Earth's axis in reference to its orbital plane. The cycle causes the tilt to vary about 3° and takes about 41,000 years to complete



Graphic attributed to NASA, Mysid

fig.xiii *https://en.wikipedia.org/wiki/Milankovitch_cycles#/media/File:Earth_obliquity_range.svg*

Major volcanic eruptions can cause the global climate to cool

The smoke, ash, and particulates from major eruptions reflect solar radiation back into space, reducing the amount of radiation that is absorbed at the surface

However, these effects are short-lived, as the ejected materials are removed from the atmosphere by natural processes, over a few years or so

Changes to sea-surface temperature (SSTs) can affect the average global temperature. The El Niño and La Niña phenomena affect the jet stream patterns and the weather in many parts of the world

However, these patterns are short-lived, usually lasting for a year or two. El Niño and La Niña account for much of the year-to-year variability in the global average temperature

Graphics attributed to National Oceanic and Atmospheric Administration

fig.xiv, xv *https://scijinks.gov/el-nino/*

“Human-induced climate change is already affecting many weather and climate extremes in every region across the globe. Evidence of observed changes in extremes such as heatwaves, heavy precipitation, droughts, and tropical cyclones, and, in particular, their attribution to human influence, has strengthened since AR5.”

IPCC AR6, Summary for Policymakers[10]

Climate models

How do we know what's going to happen next?

What are climate models projecting?

Climate models are essential tools for scientists. The models allow us to reconstruct past climates, simulate the current climate, and evaluate how future climates may be different

The models produce projections of future climates by determining how the climate is likely to change in response to changes in important variables such as **greenhouse gas** and **aerosol concentrations**, **surface reflectivity**, **cloud cover**, **humidity**, and much more

How do we know climate models work?

Climate models are very good at simulating the climates of the past. Therefore, there is a high probability that their projections for the future are relatively valid

Importantly, the climate of the recent past is only able to be simulated quite accurately when the changes to the atmosphere caused by human activity are entered into the models. In particular, the warming of the last century can only be simulated when GHGs are added to the atmosphere

Instead of relying on a single climate model, ensembles representing multiple models from different nations are combined to capture a more accurate understanding of future climate

The benefits of using ensembles:

1. A better understanding of climate variability

2. Removes the inherent bias of a single model

3. Produces estimates of model uncertainty

The *Canadian Centre for Climate Modeling and Analysis* currently uses several different models

These models are used in the creation of ensembles to help better understand how climate will likely change both locally and globally

In *Manitoba's Changing Climate* the various projections within the context of Manitoba will be explored in greater detail

Uncertainty is an intrinsic part of scientific modeling especially when dealing with complex systems like the global climate

There are three sources of uncertainty within climate projections:

- Natural climate variability
- Model performance
- Future emissions

Under an intermediate GHG emission scenario, it is *very likely* that the end-of-century will be 2.1°C - 3.5°C warmer than the baseline period of 1850-1900 unless meaningul interventions are made[11]

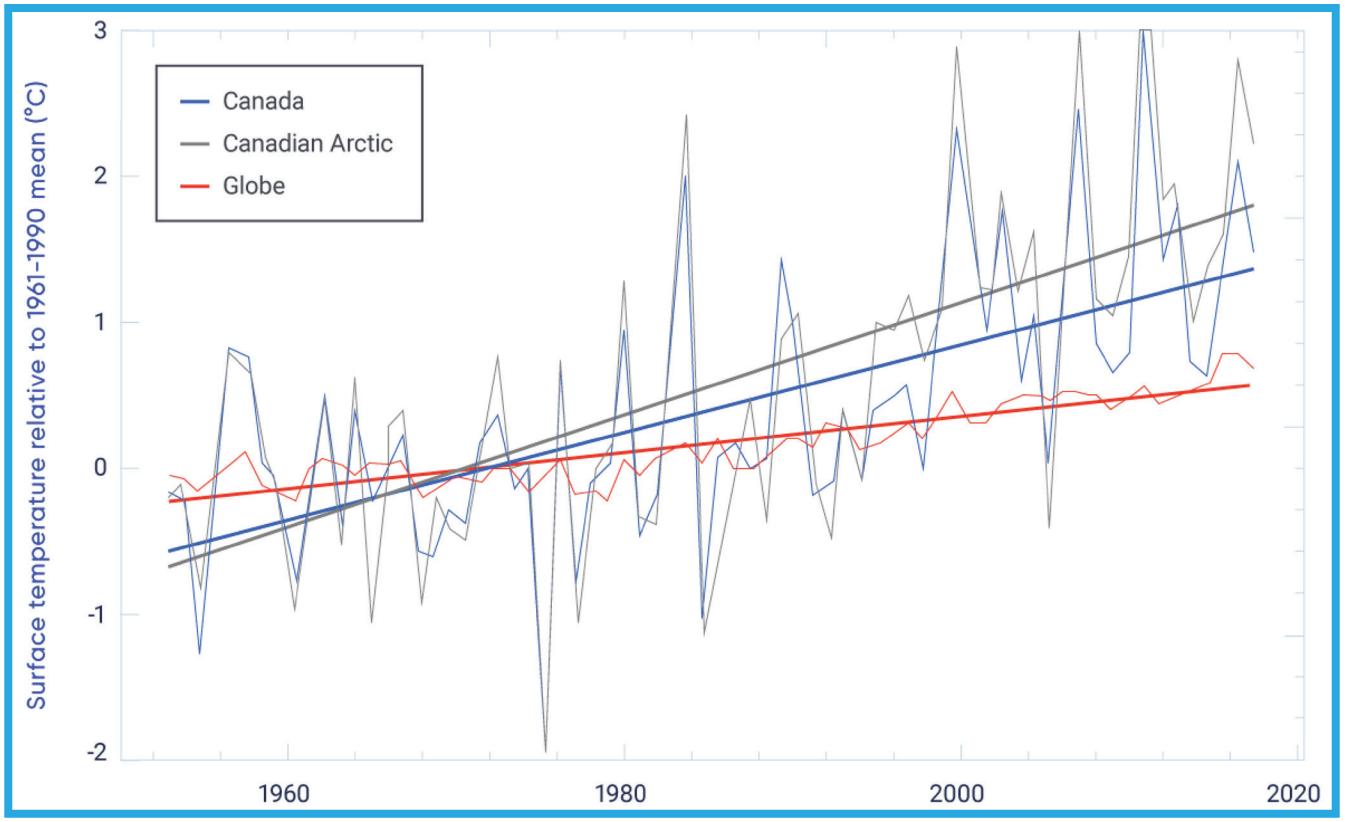
By ignoring the science, we only increase our risk

Canadian Perspective

What are the projected climate trends for Canada?

How is climate change going to affect Canadians differently?

Canada is warming at a rate that is about double the global average resulting in ~1.7°C of warming to date[12]

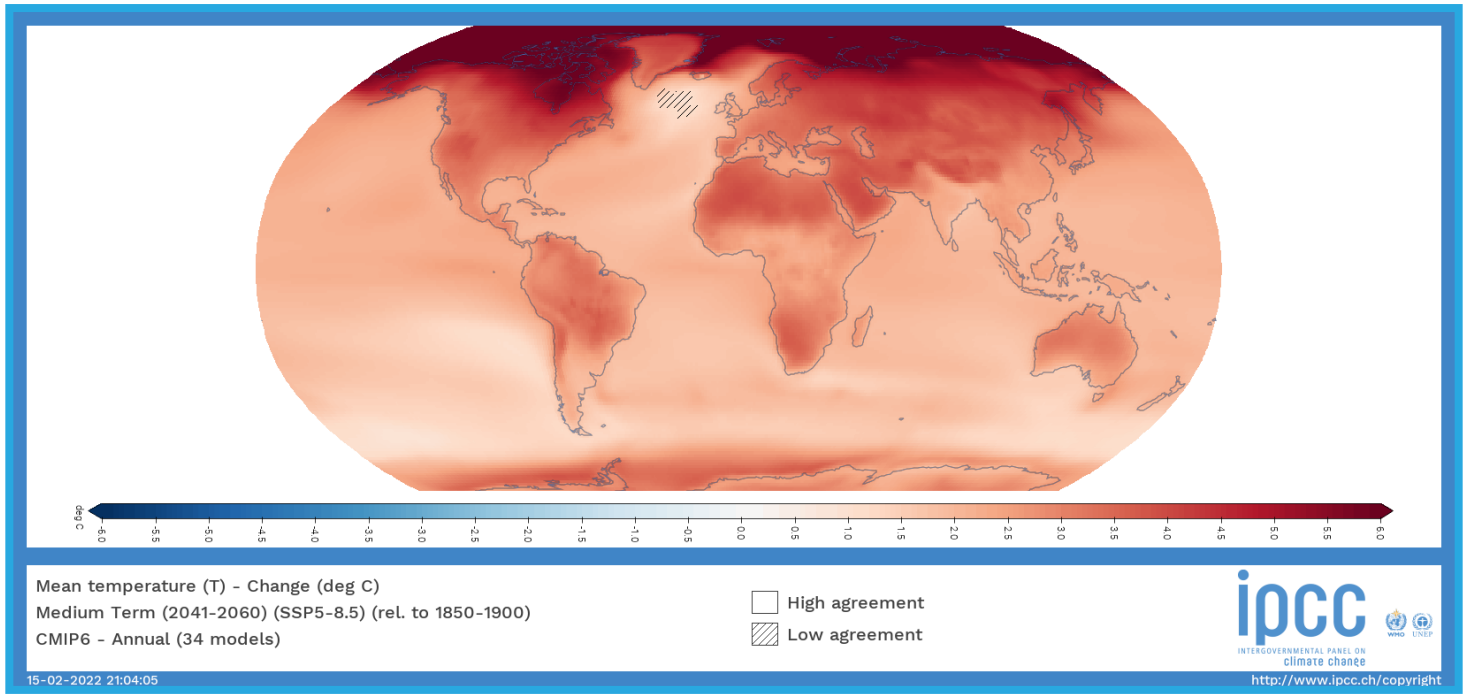


Graphic attributed to Environment Canada Climate Research Division

fig.xvi *https://changingclimate.ca/CCCR2019/graphics/#pr_602*

In the global context we see that patterns of warming are affecting northern regions at an even higher rate

Northern Canada has already warmed by ~ 2.3°C since 1948[13]



Graphic attributed to Intergovernmental Panel on Climate Change

fig.xvii *https://interactive-atlas.ipcc.ch/*

Why does Canada warm faster?

Snow-ice albedo feedback - loss of snow and ice reduces the albedo of the surface

Lapse-rate feedback - warming is close to the surface in the higher latitudes

Planck feedback - cooler temperatures in the atmosphere result in proportionally less outward emission of energy than in warmer latitudes

Cloud feedback - high latitudes getting cloudier, keeping heat near the surface[14]

In general, there are five main trends that climate models consistently project for Canada and that bear consideration in the decisions being made today:

Melting permafrost - threatens built infrastructures in Northern Canada and accelerates the rate of methane release into the atmosphere

Sea-level rise - increased coastal flooding and damage from storm surges leading to higher rates of erosion

Greater weather variability - increase in extreme weather events including droughts and floods

Invasive species - milder winter temperatures increases the spread of pests and diseases that pose new risks to ecosystem health and economies

Hotter summers - increased rates of heat-related complications for at-risk/vulnerable populations and longer forest fire seasons

The intensity of these projected trends will vary considerably depending on where one is located in the country. By accounting for climate change today, we improve our resilience tomorrow

THANK YOU

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Manitoba

Natural Resources Canada | Ressources naturelles Canada | Canada

ICLEI Local Governments for Sustainability CANADA

ENGINEERS GEOSCIENTISTS MANITOBA

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Prairie Climate Centre
From Risk to Resilience

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13. Ibid

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