

Climate Change Workshop Introduction to Climate Science

Toronto / December 4 & 5, 2019



**FIRST NATIONS
LAND MANAGEMENT
RESOURCE CENTRE**

Workshop Learning Objectives:

- Discuss the fundamentals of climate science, the predicted scope and severity of the climate emergency
- Introduce the International context of climate change and the intersection of climate change and indigenous rights
- Explore the importance of the law-making authority of the Framework Agreement in setting out climate-informed plans, laws and targets
- Hear the success stories from other FA signatory communities in responding to the climate emergency



Parking Lot!







Understanding the Basics of Climate Science and Earth's Climate System

“Scientific evidence for warming of the climate system is unequivocal.”

- Intergovernmental Panel on Climate Change

- Definitions & Basics of Earth Climate System
- Overview of Greenhouse Effect and GHG's
- Temperature Records and Climate Models
- Observations and Impacts of Climate Change

Definitions: Weather vs Climate



Weather refers to what conditions we experience outside locally and on a day-to-day basis.

“It’s snowing outside my house today. So much for global warming!”



Climate refers to trends in weather patterns over long time scales and at regional, national and global scales. Climate refers to the statistical properties of weather over time (ranging from months to decades or more), and includes average conditions and the range of variability, as well as the frequency of extreme events.

“Even though it’s snowing outside my house today, I’ve noticed a trend in our Territory that we’re getting less snow every winter and the snow appears later in the season.”

Global Mean Temperature is a statistical expression of the average Global temperature. Climate statistics are usually calculated based on thirty-year intervals.

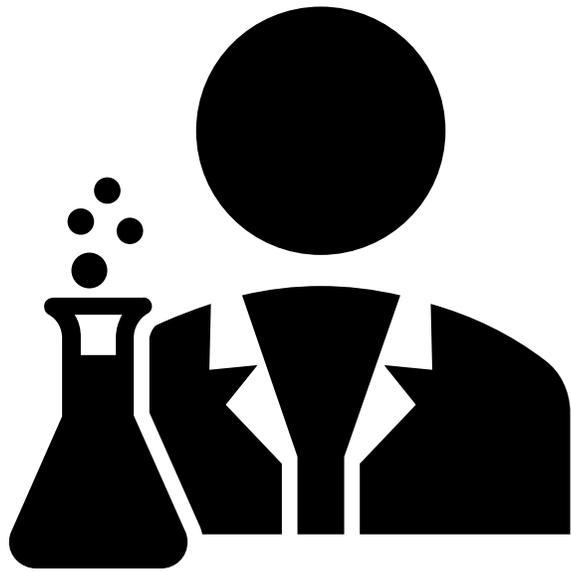
Definitions: Global Warming vs. Climate Change



Global Warming refers to the long-term heating of the Earth's climate system observed by scientists since the pre-industrial period (ca. 1850) due to human activities, primarily the burning of fossil fuels.



Climate Change refers to long-term changes in the average weather patterns in local, regional and global settings. Climate change can be caused by natural processes but since the industrial revolution and the burning of fossil fuels, human activities are accelerating climate change.

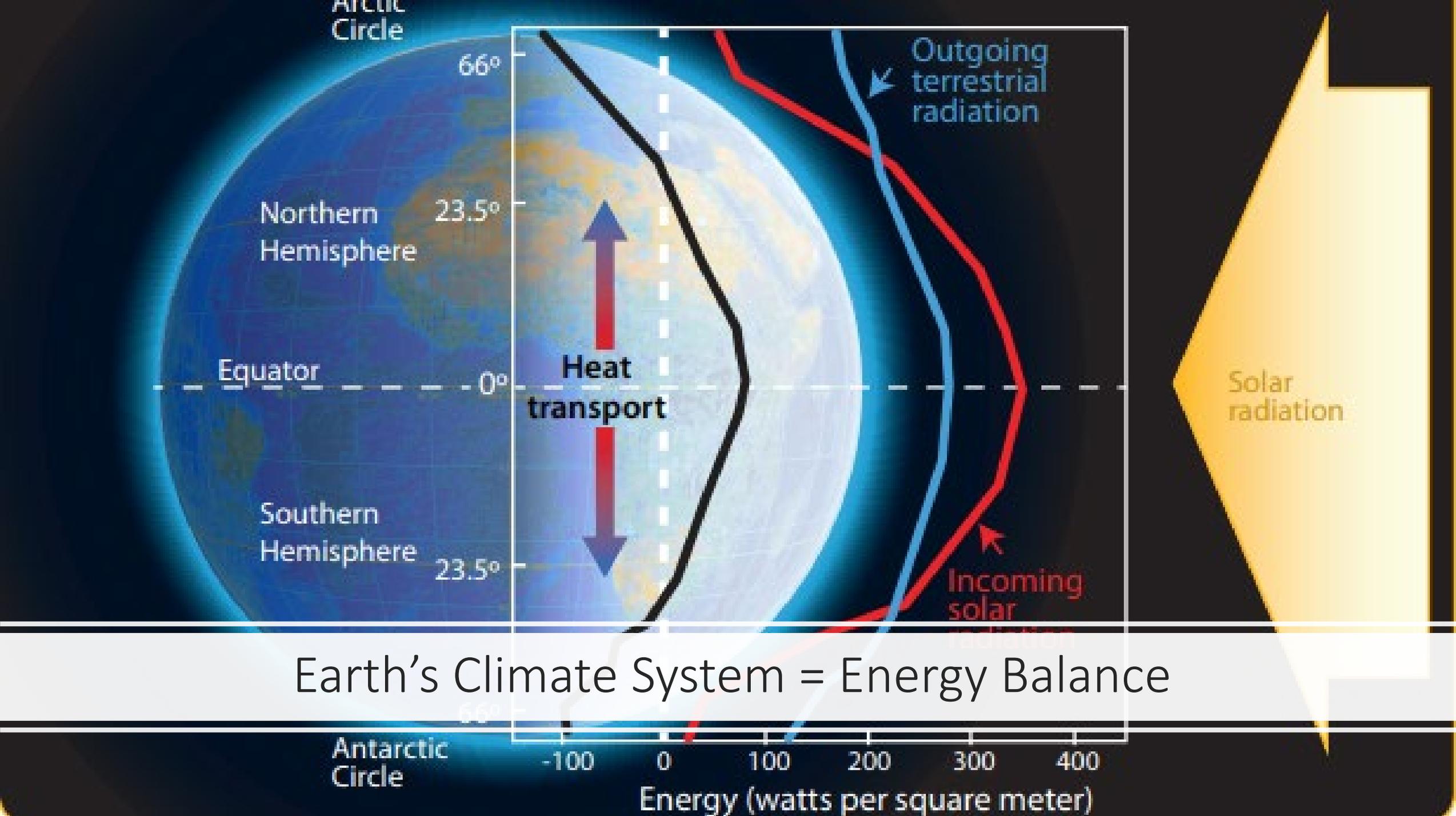


Definitions: Science

Science provides an explanation of the natural world that can be repeatedly tested and verified in accordance with accepted protocols of observation, measurement and evaluation of results.

An Introduction to Earth's Climate System

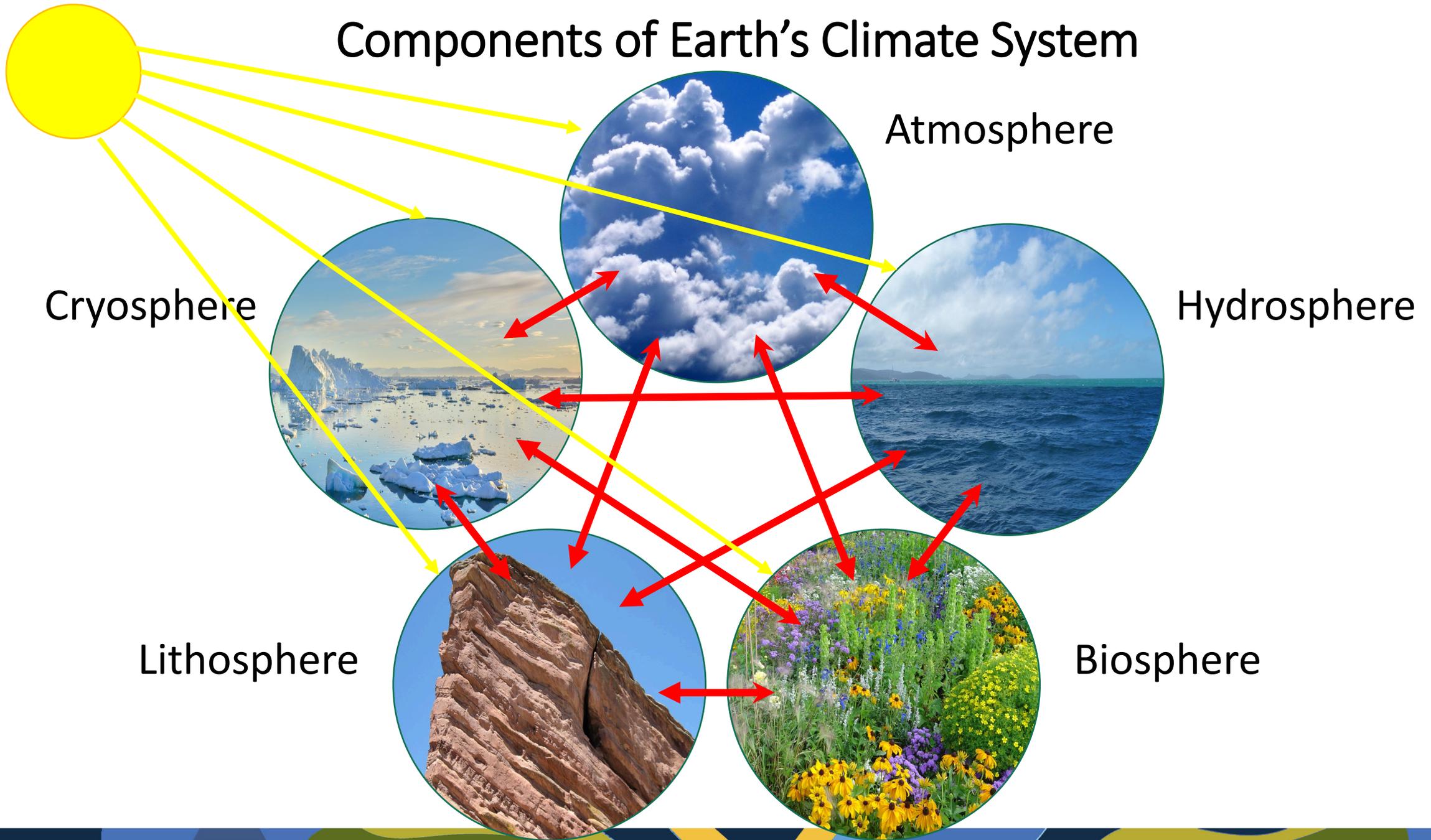
A view of Earth from space, showing the Americas and the Atlantic Ocean, set against a starry background.



Earth's Climate System = Energy Balance

Energy (watts per square meter)

Components of Earth's Climate System

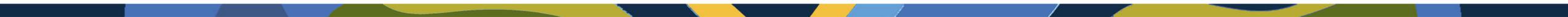


Climate Change is a natural phenomenon...

The four main influences of change (i.e. climate forcing agents) in Earth's climate are:

- 1) changes in Earth's orbit around the Sun
- 2) variations in the output of energy from the Sun
- 3) fluctuations in the upwelling of deep cold ocean water
- 4) changes in **atmospheric composition**.

...but human activity is accelerating it



Our Atmosphere

- Nitrogen (78%)
- Oxygen (21%)
- Argon
- Others (ozone, water vapour, GHG's, etc.)

Greenhouse Gases

Carbon Dioxide

77%

Tens of thousands of years

Methane

15%

10-12 years

Nitrous Oxide

7%

100+ years

(Water vapor)

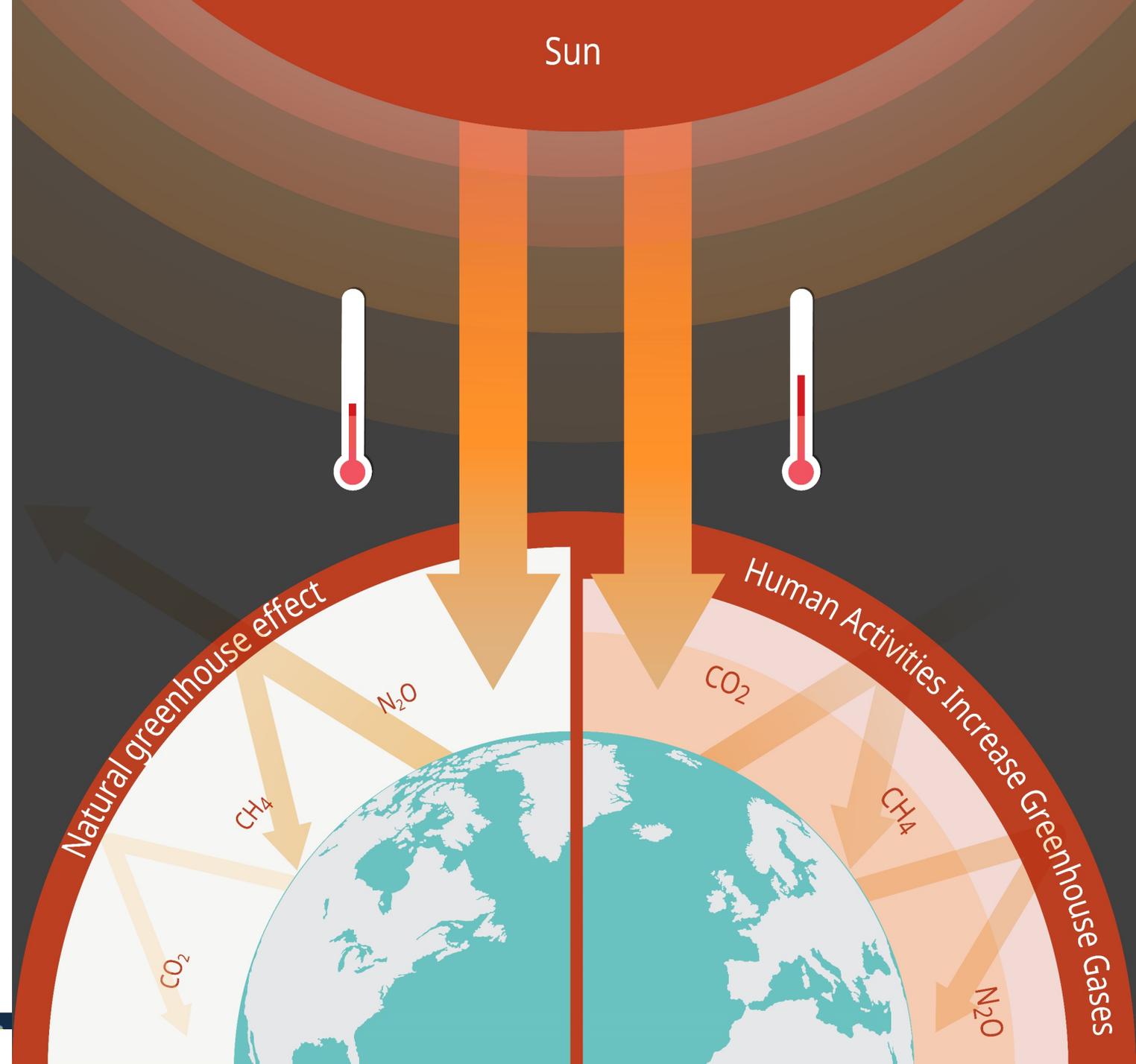
These gases absorb and emit radiant thermal energy (heat) at different rates, they remain in the atmosphere for different amounts of time, and are emitted by human activities at different rates.



The “Greenhouse Effect”

is a function of Earth’s atmosphere whereby **greenhouse gases (GHG)** such as carbon dioxide retain heat from the Sun on Earth; historically this has made the planet habitable for life. Natural factors that contribute to atmospheric composition and the concentration of greenhouse gases include volcanic activities and forest fires.

However, over the last 200 years, human activity has resulted in an increased concentration of greenhouse gases in the atmosphere, causing an intensification of the greenhouse effect, which results in **accelerated global warming**.



The Greenhouse Effect



The diagram illustrates the greenhouse effect. A bright yellow sun is in the upper left corner. A blue arc represents the Earth's atmosphere, with the word "Atmosphere" written along it. Below the atmosphere is a detailed map of the Earth showing continents and oceans. The Earth is shown from a perspective that highlights the atmosphere's role in trapping heat.

Atmosphere

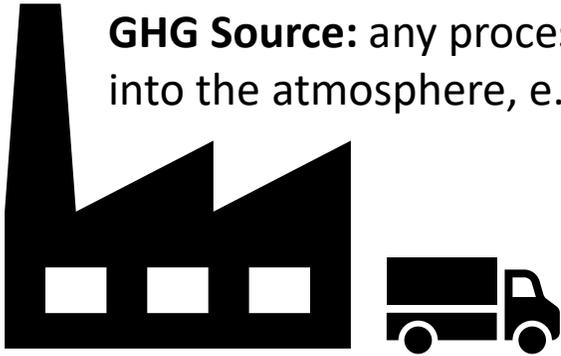
climate.nasa.gov

Tula like's the
greenhouse
effect

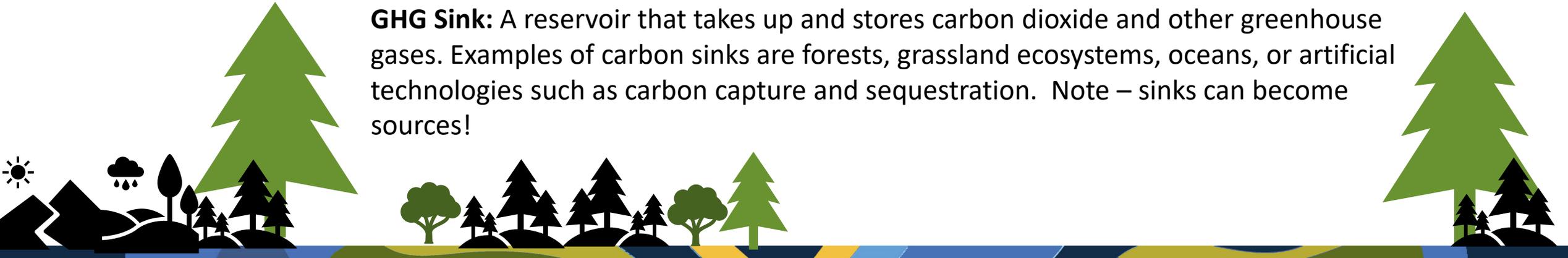


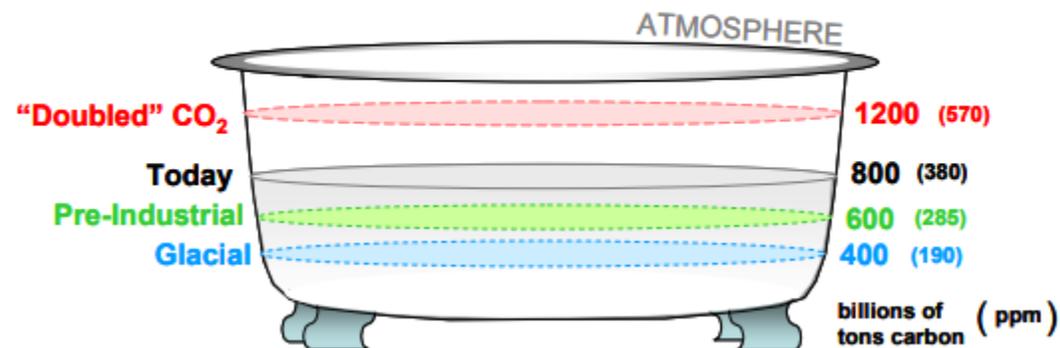
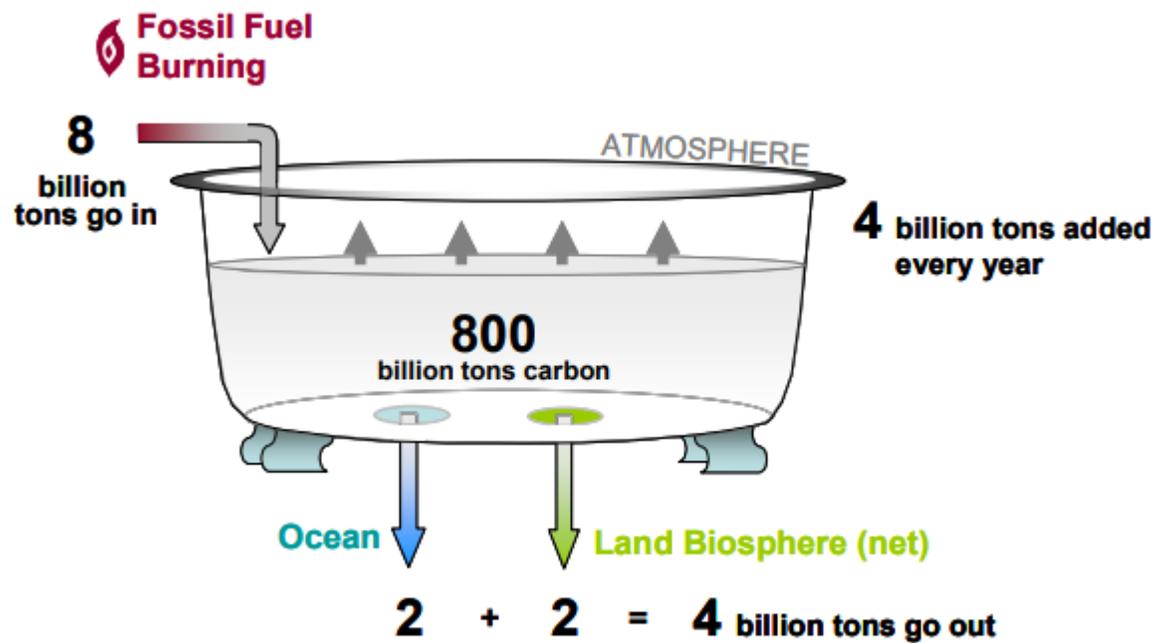
GHG Sources and Sinks

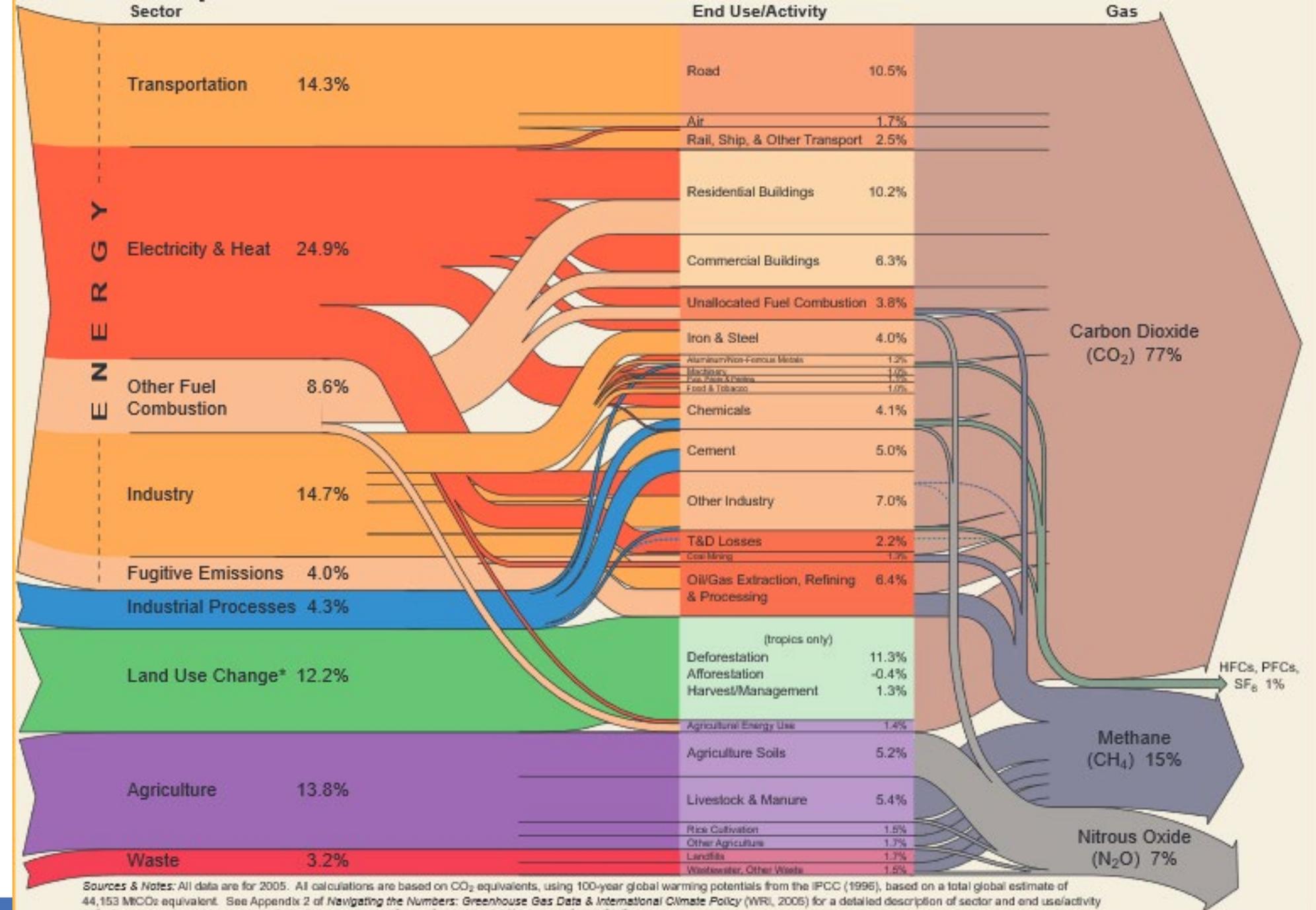
GHG Source: any process or activity, natural or human, that releases a greenhouse gas into the atmosphere, e.g. volcanoes, forest fires, fossil-fuel combustion.



GHG Sink: A reservoir that takes up and stores carbon dioxide and other greenhouse gases. Examples of carbon sinks are forests, grassland ecosystems, oceans, or artificial technologies such as carbon capture and sequestration. Note – sinks can become sources!

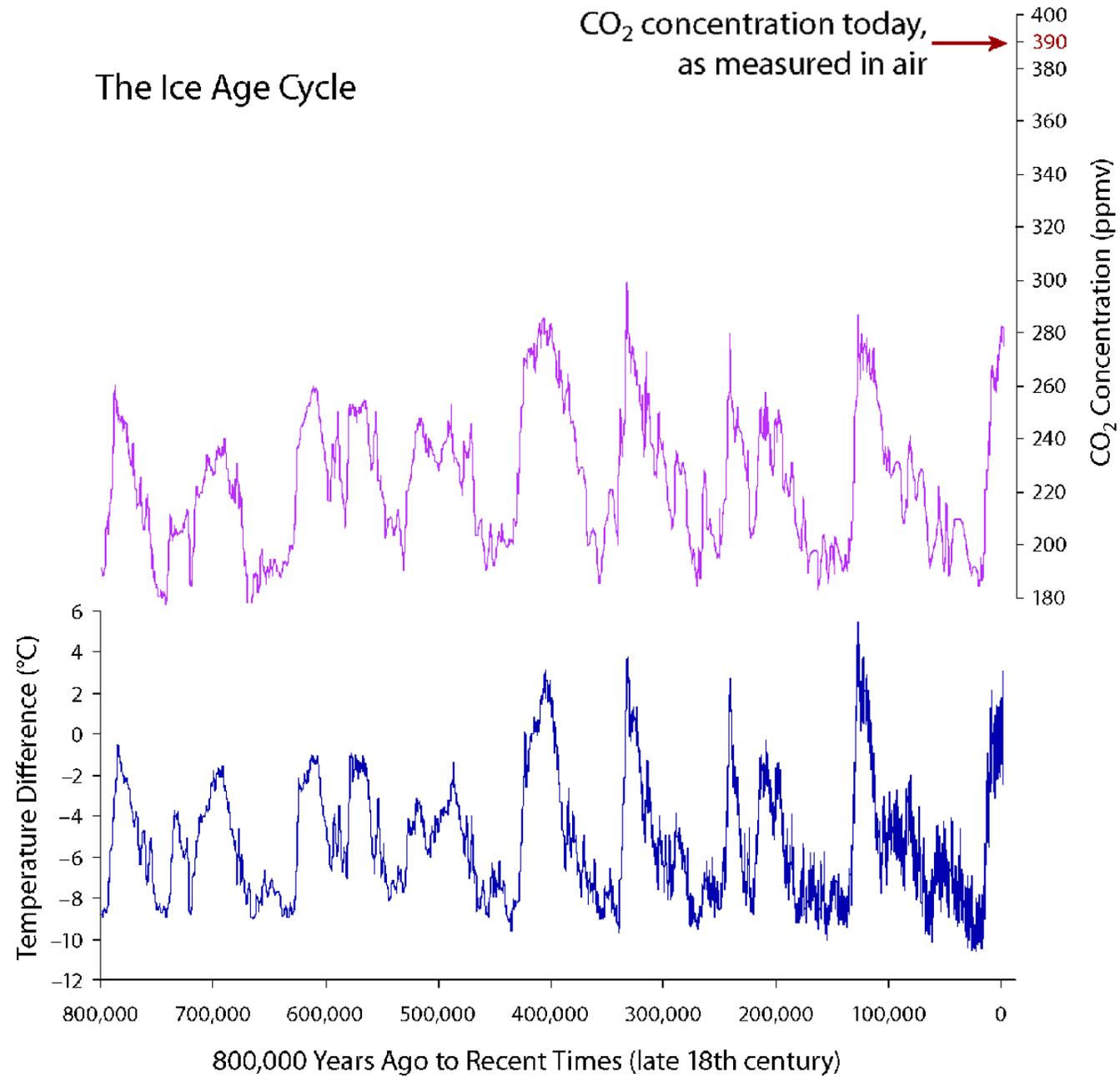




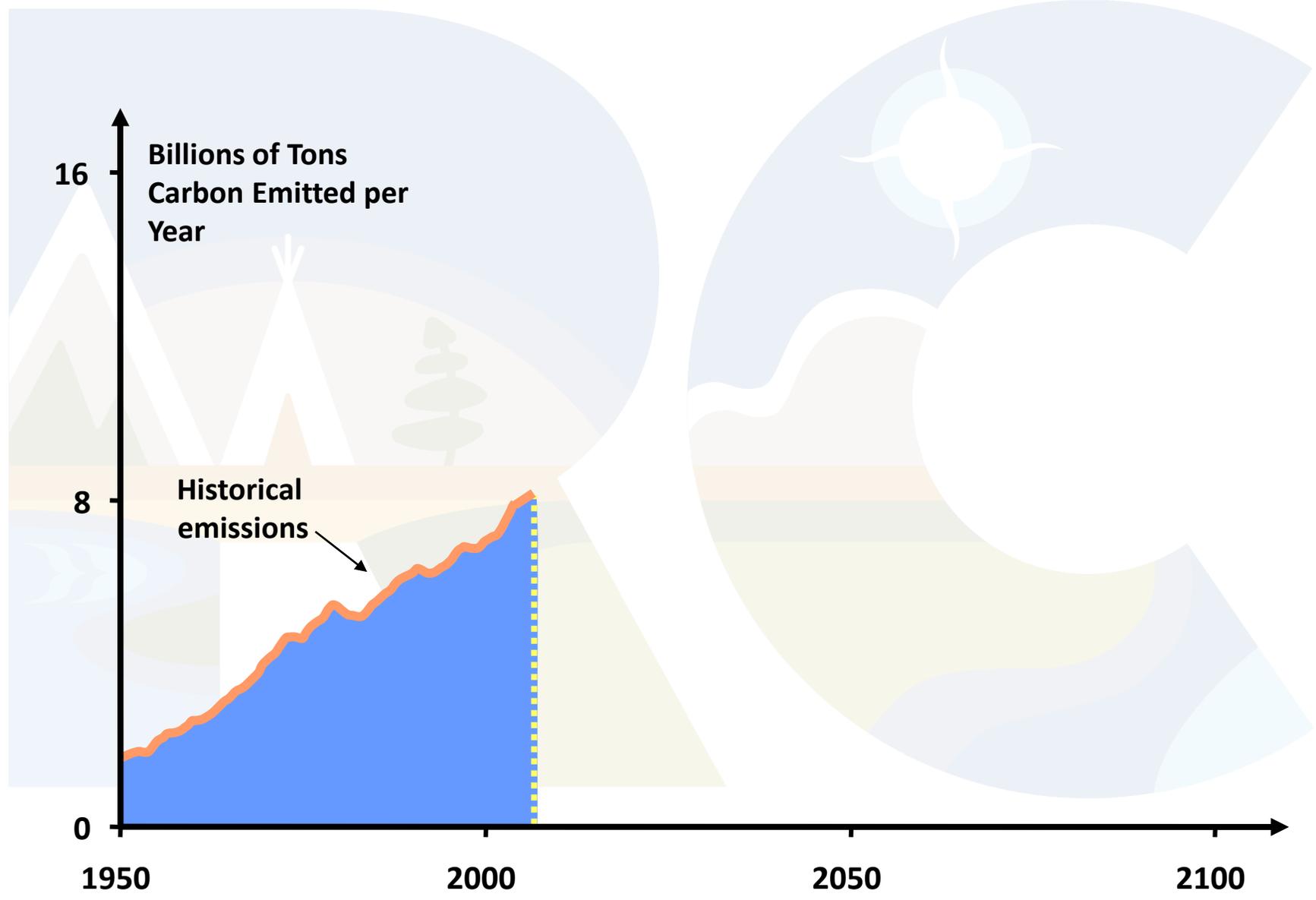


Sources & Notes: All data are for 2005. All calculations are based on CO₂ equivalents, using 100-year global warming potentials from the IPCC (1996), based on a total global estimate of 44,153 MTCO₂ equivalent. See Appendix 2 of *Navigating the Numbers: Greenhouse Gas Data & International Climate Policy* (WRI, 2006) for a detailed description of sector and end use/activity definitions, as well as data sources. Dotted lines represent flows of less than 0.1% percent of total GHG emissions.
 * Land Use Change includes both emissions and absorptions, and is based on analysis that uses revised methodologies compared to previous versions of this chart. These data are subject to significant uncertainties.

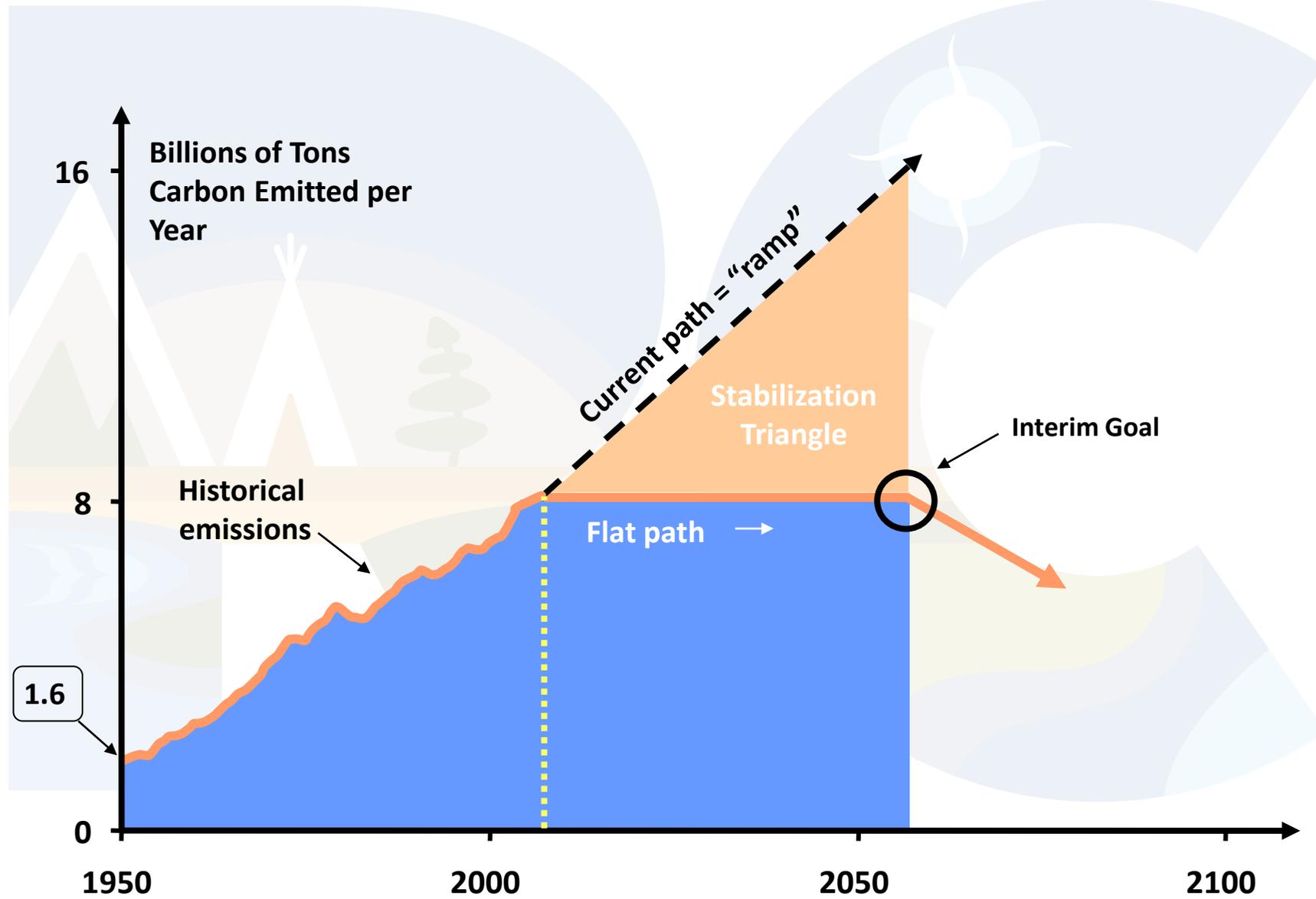
The Ice Age Cycle



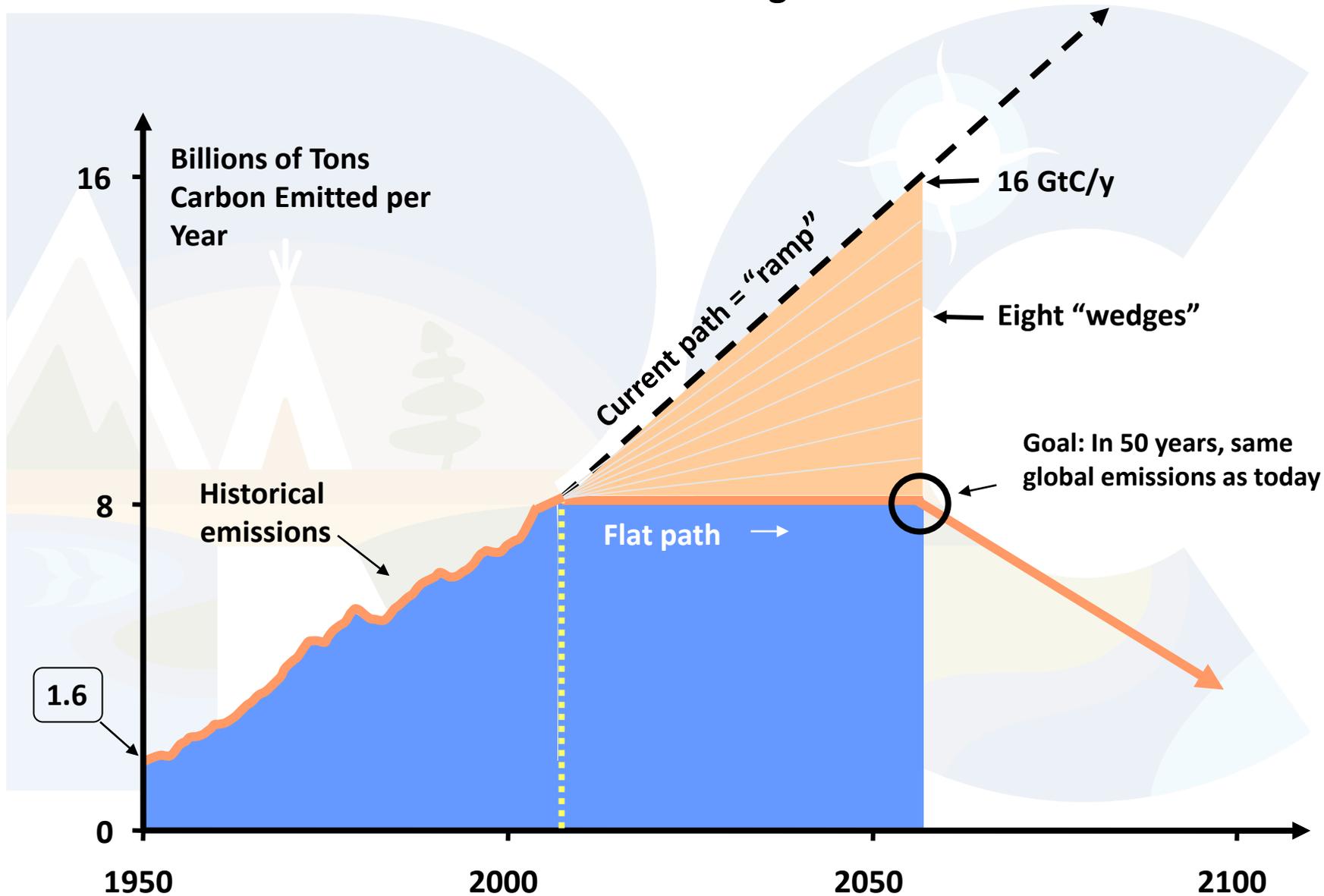
Historical Emissions



The Stabilization Triangle

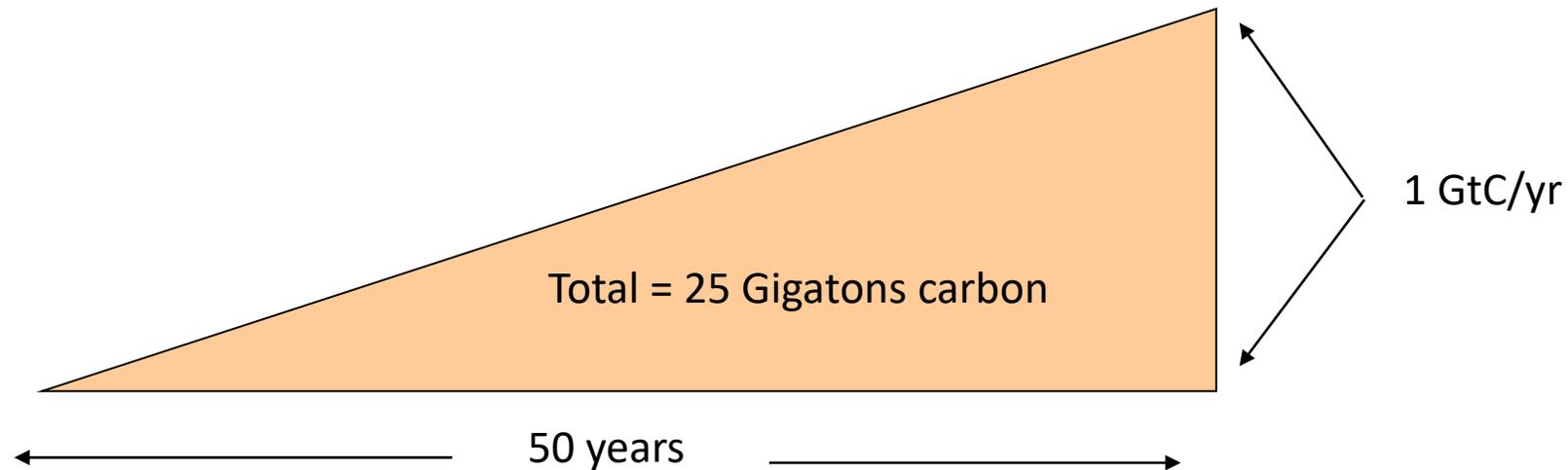


Stabilization Wedges



What is a “Wedge”?

A “wedge” is a strategy to reduce carbon emissions that grows in 50 years from zero to 1.0 GtC/yr. The strategy has already been commercialized at scale somewhere.



Cumulatively, a wedge redirects the flow of 25 GtC in its first 50 years.
This is 2.5 trillion dollars at \$100/tC.

A “solution” to the CO₂ problem should provide at least one wedge.



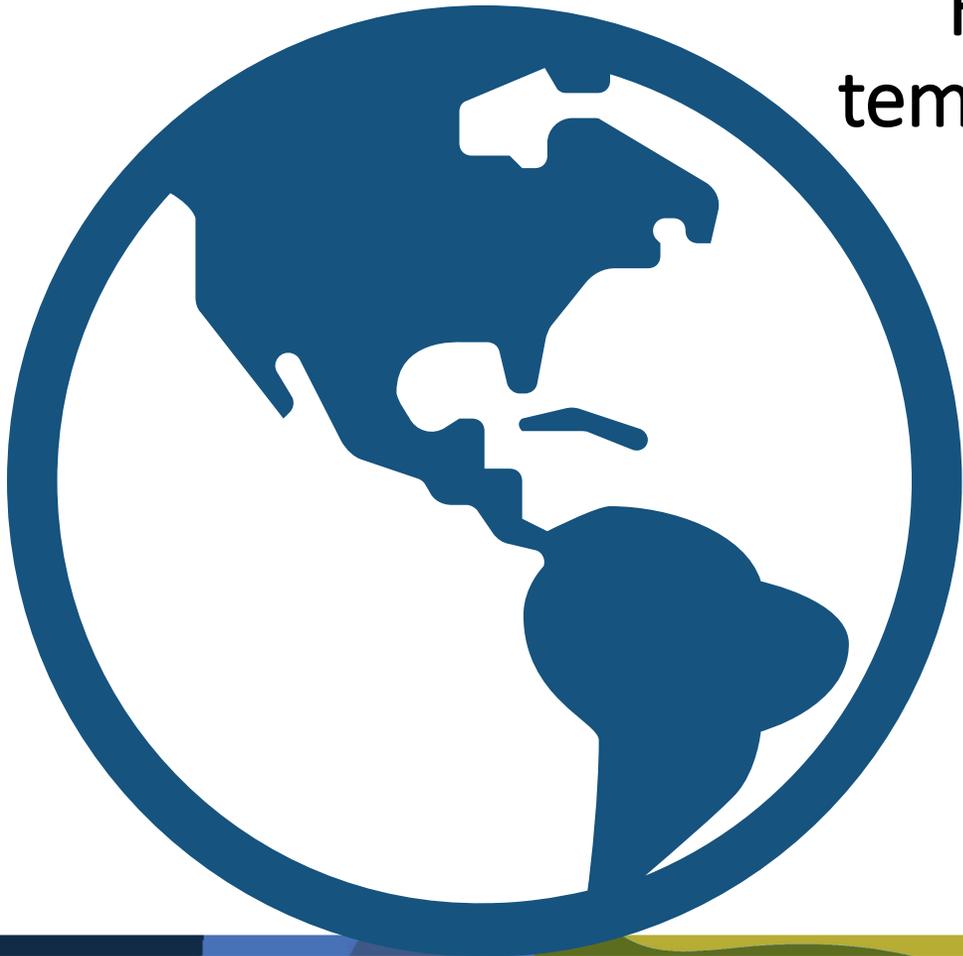


What are some solutions to
the CO₂ problem?



Tula says don't buy so much stuff!

Past, present and future Climate



How do scientists estimate the global mean temperature (GMT) of the Earth's distant past?

How do scientists calculate the current GMT of the Earth?

How do scientists estimate the GMT of Earth's future?



Paleoclimatology: The Study of Earth's Ancient Climate History & Evolution



Paleoclimatology – the study of past climates

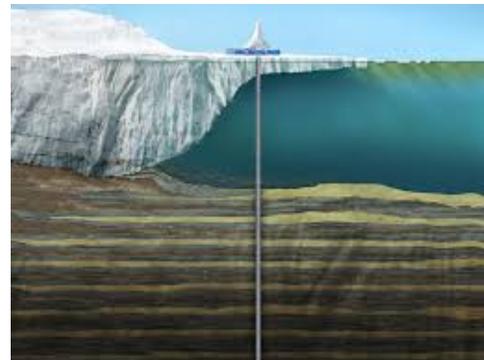
Earth's Natural Archives!

Arctic and Antarctic Ice Core samples

Deep Sea and Lake sediment samples

Tree rings and fossil pollen

Coral Reefs

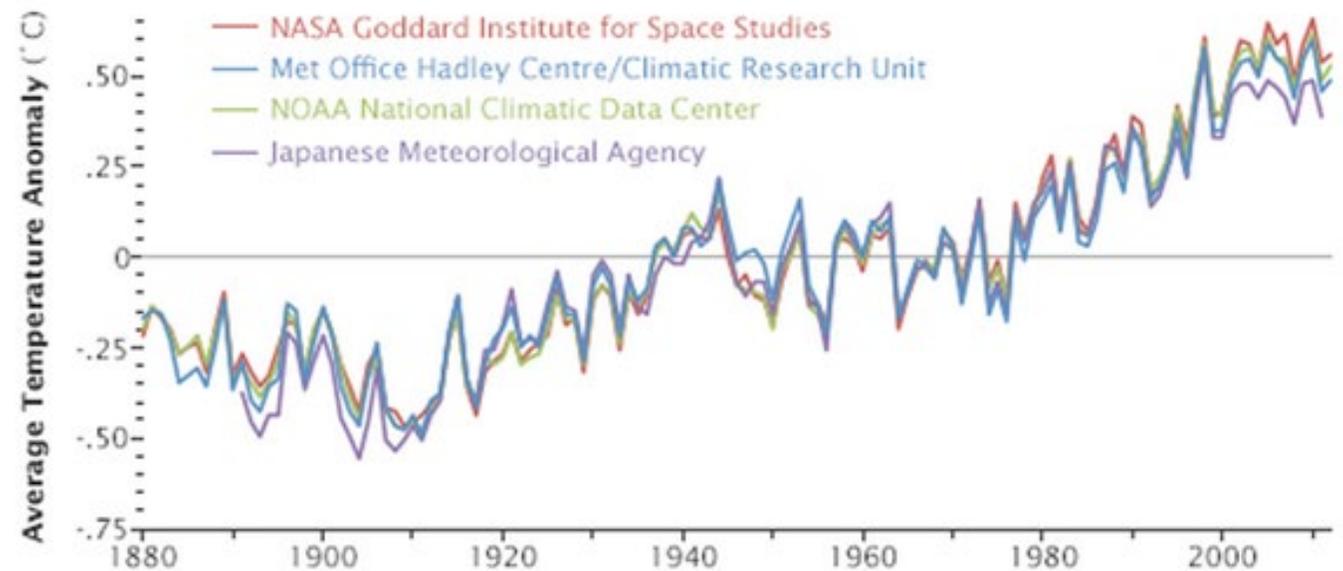




Measuring Earth's current temperature

Measuring Earth's current temperature

- Scientists combine temperature measurements from land, sea and air across the globe. These are collected from weather stations, boats, buoys, and satellites placed all over the globe
- Temperatures recorded at each location are compared to a 30-year average and anomalies reported
- 4 primary global datasets
- GMT represents a global average!



Source: NASA Earth Observatory



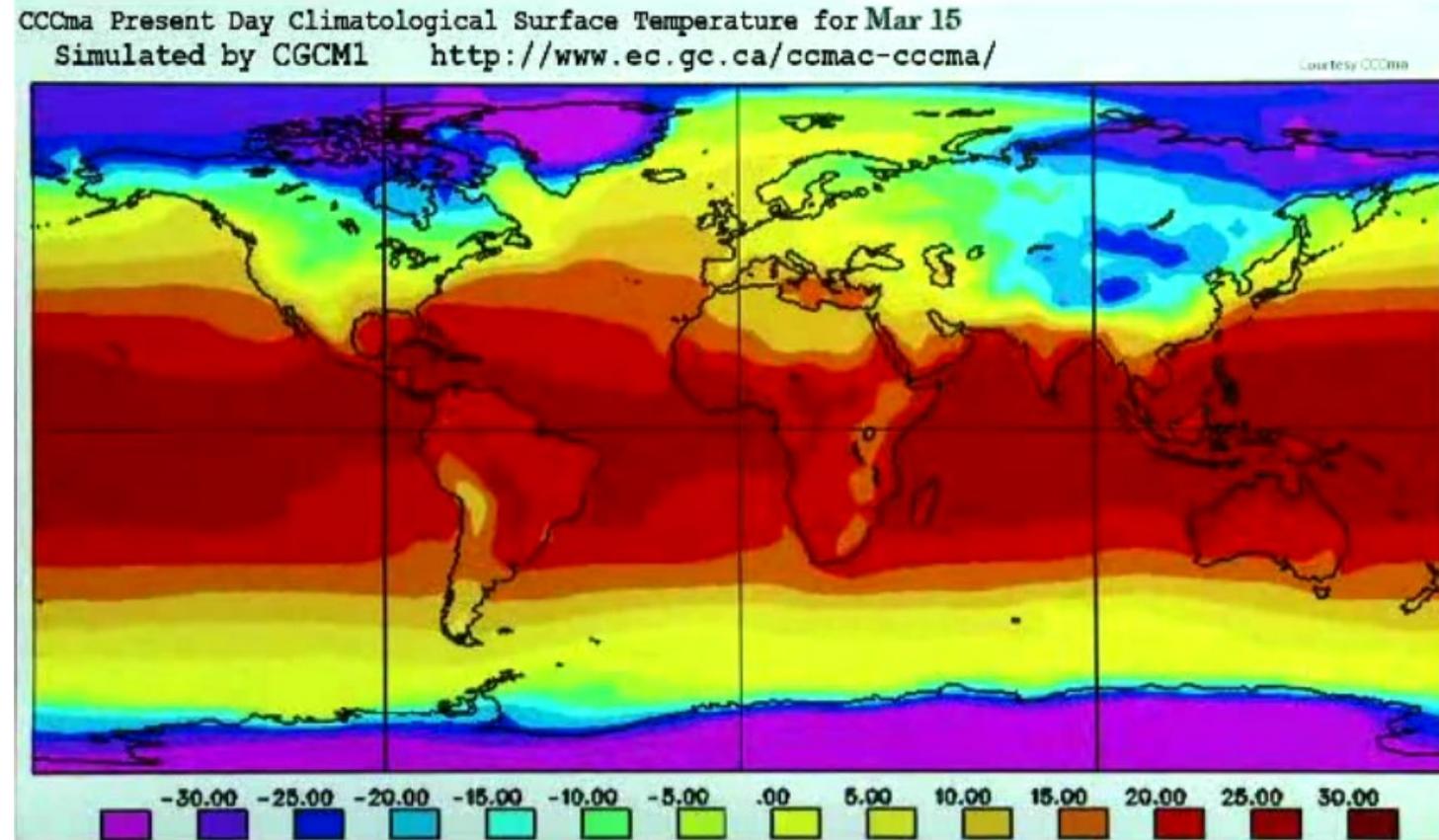
Predicting Earth's future climate: Climate Models

Understanding Climate Models

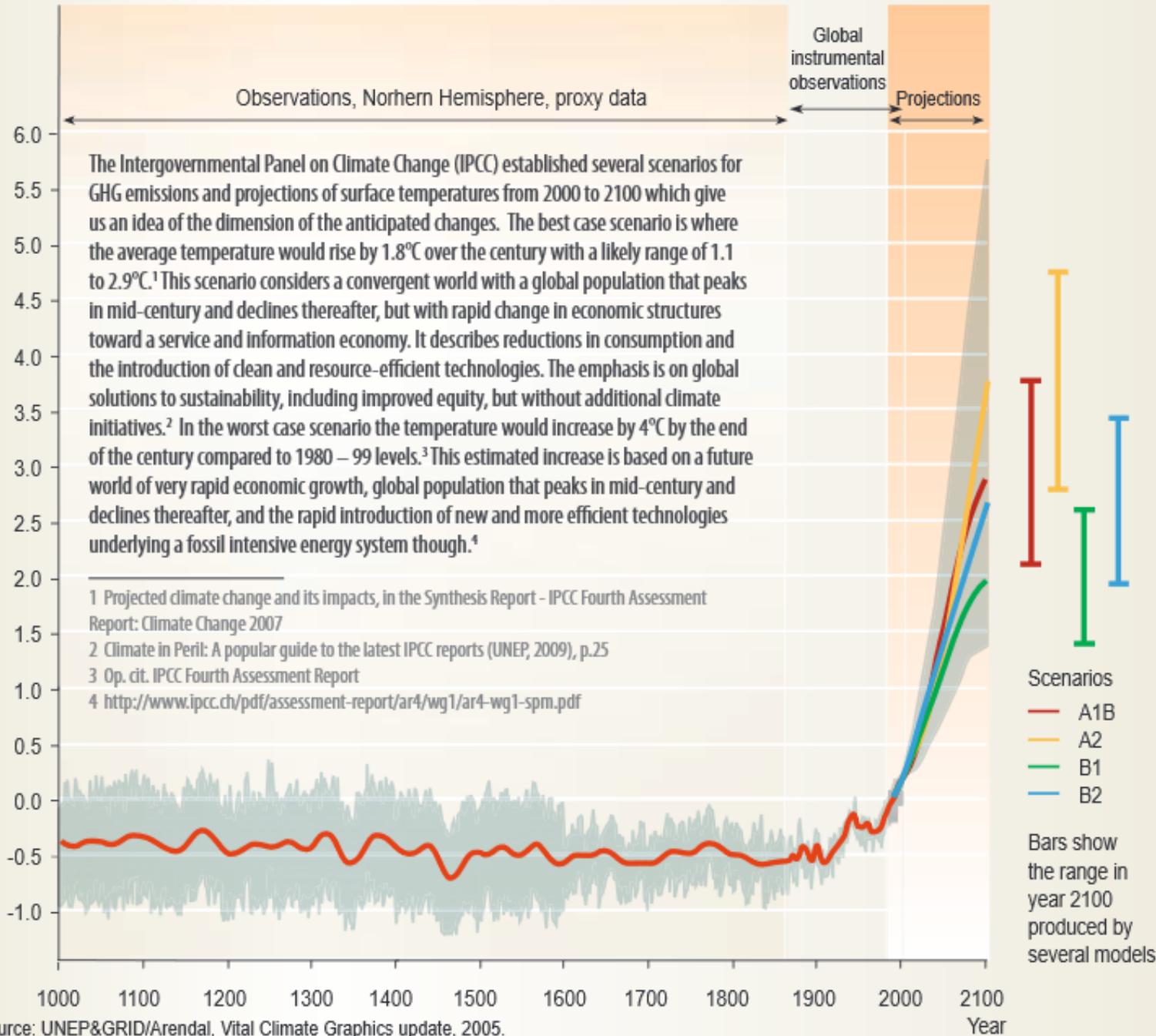
- Extraordinarily complex, utilizing supercomputers
- Climate models aren't used to predict weather. What's important is the statistical likelihood of the predicted climate-related events (e.g. overall changes in precipitation patterns, temperature changes, etc.) from the model matching the observed or real climate record
- Climate models are like “virtual Earth's” – computer models of the Earth's surface that simulate the different processes (climate components – e.g. atmosphere, hydrosphere, cryosphere, etc.) at work on regional, continental and international scales
- They help us understand potential impacts from a changing climate, e.g. water systems, forests, etc., how we may need to adapt, and what emission reductions scenarios we need to consider
- Used to inform policy at regional, national and international stages

Understanding Climate Models

- Rooted in hard science, based on the laws of thermodynamics that govern the interrelationship and interactions of energy and matter, utilizing mathematical equations to describe these interactions in the atmosphere, land and oceans
- Key climate processes are represented mathematically. A 3 dimensional grid is mapped over the Earth's surface and up into the atmosphere. Mathematical equations are solved for each grid cell – requiring millions of computations
- Climate model predictions about future climate depends on emissions scenarios



Deviation in °Celsius (in relation to 1990 value)



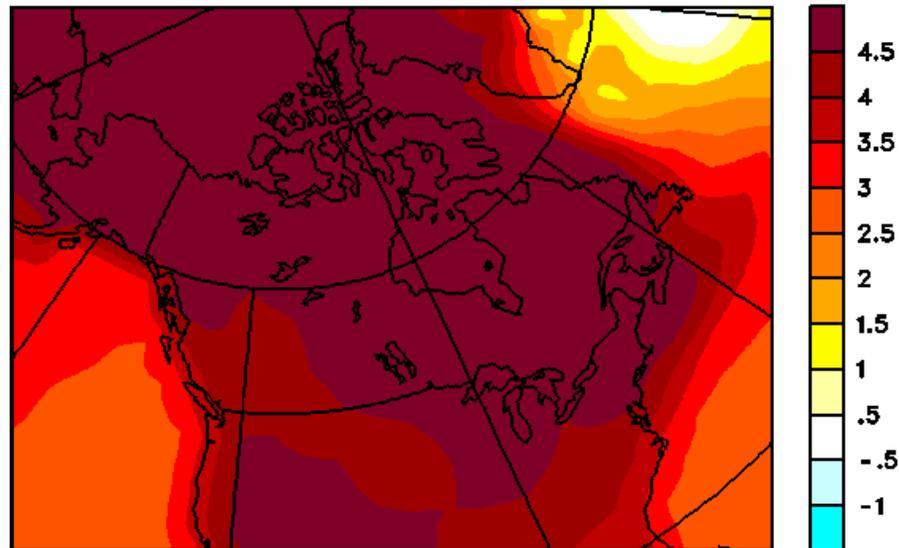
Emission Scenarios

Canadian Centre for Climate Modeling and Analysis (CCCma)

- Temperature Change Projections: http://climate-modelling.canada.ca/climatemodelgraphics/cgcm3-t47/animation_sresa2_st_pcan.shtml

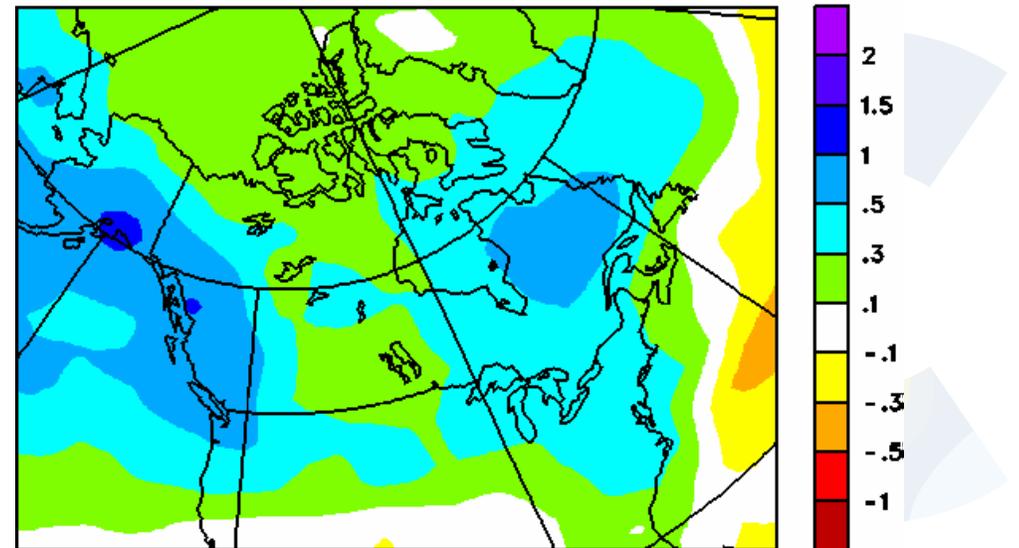
- Precipitation Change Projections: http://climate-modelling.canada.ca/climatemodelgraphics/cgcm3-t47/animation_sresa2_pcp_pcan.shtml

CGCM3/T47 A2 5-yr mean temp. change yr=2100 vs 1981-2000



Year:
2100

CGCM3/T47 A2 5-yr mean precip. change yr=2100 vs 1981-2000



“Hind-Casting”

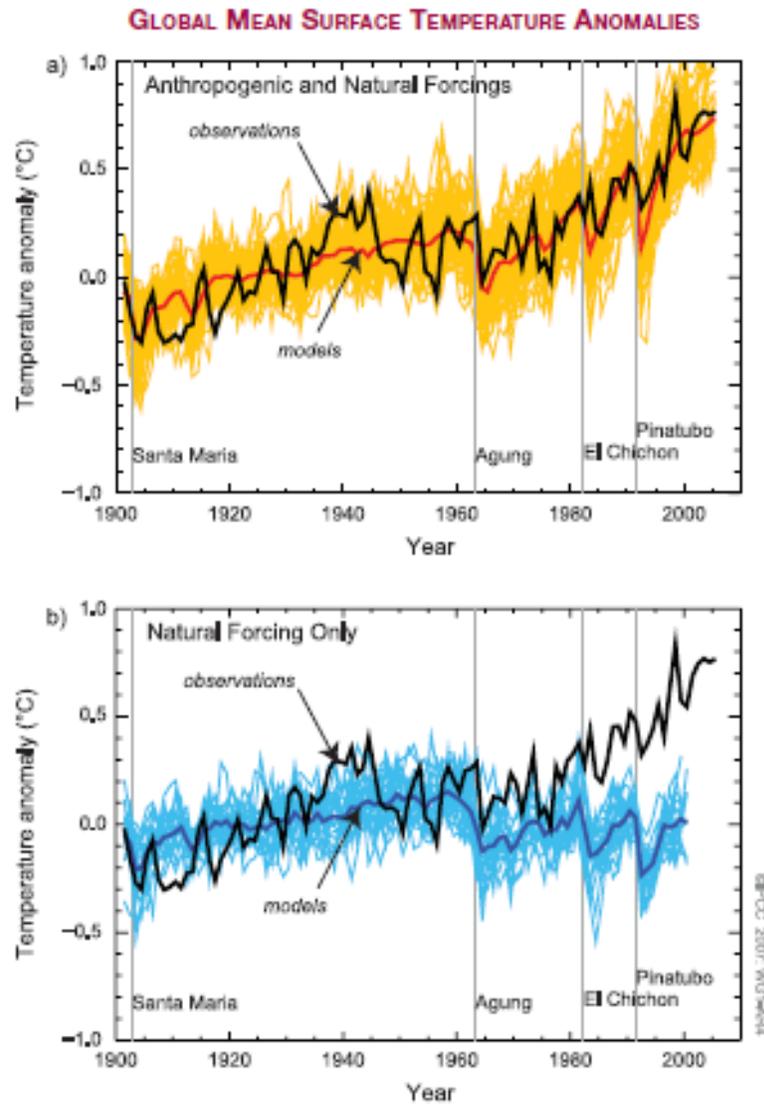
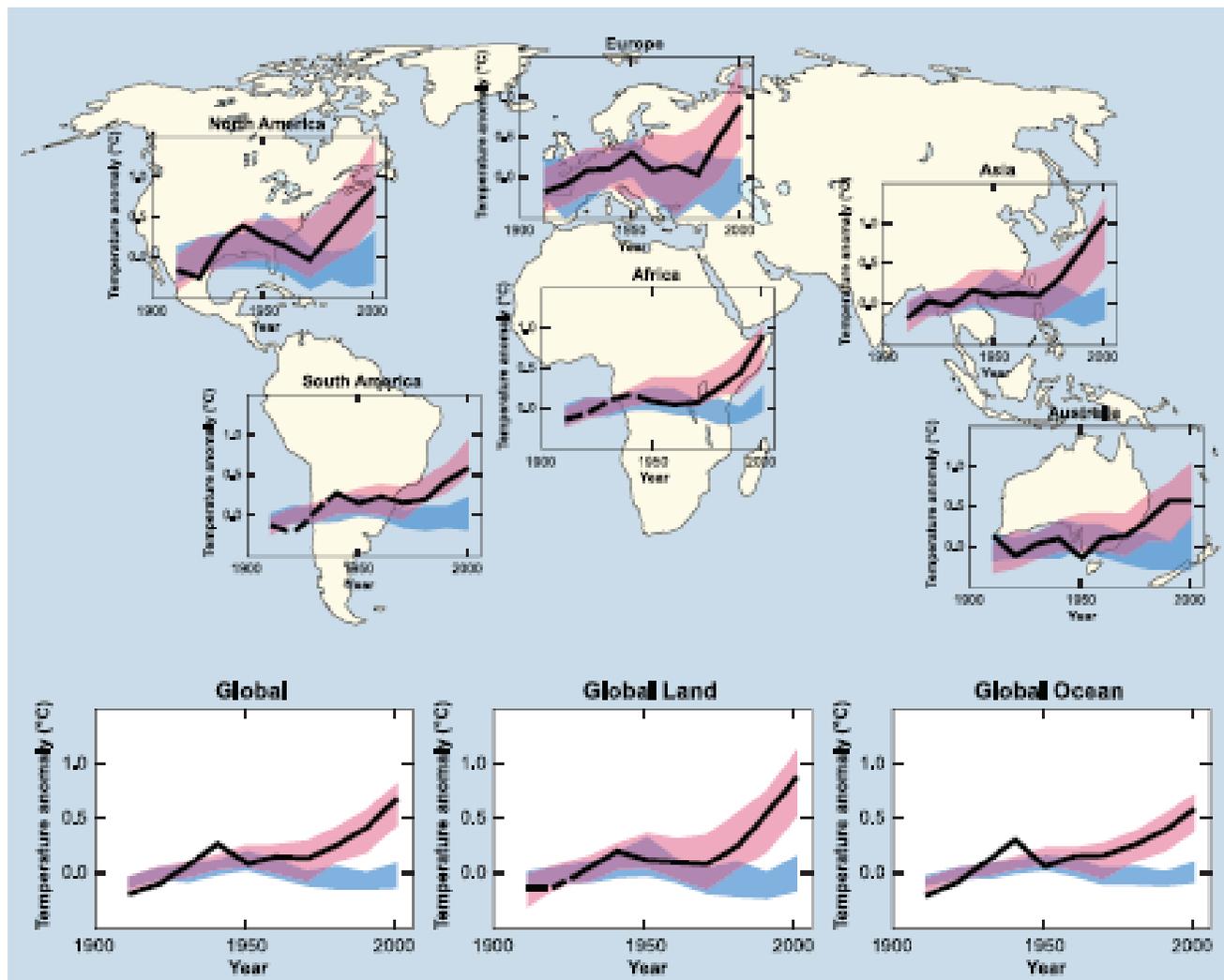


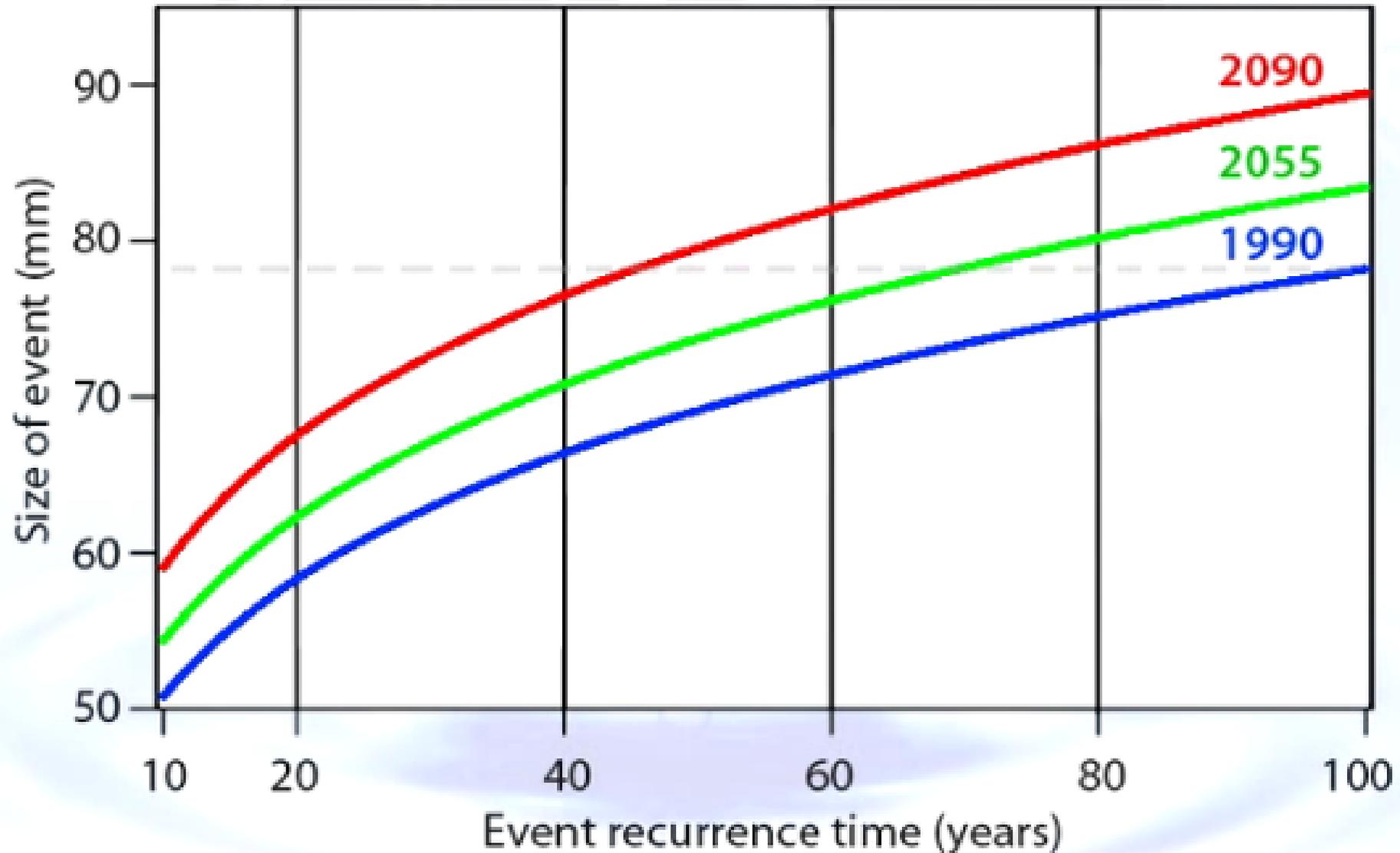
Figure TS.23. (a) Global mean surface temperature anomalies relative to the period 1901 to 1950, as observed (black line) and as obtained from simulations with both anthropogenic and natural forcings. The thick red curve shows the multi-model ensemble mean and the thin yellow curves show the individual simulations. Vertical grey lines indicate the timing of major volcanic events. (b) As in (a), except that the simulated global mean temperature anomalies are for natural forcings only. The thick blue curve shows the multi-model ensemble mean and the thin lighter blue curves show individual simulations. Each simulation was sampled so that coverage corresponds to that of the observations. [Figure 9.5]

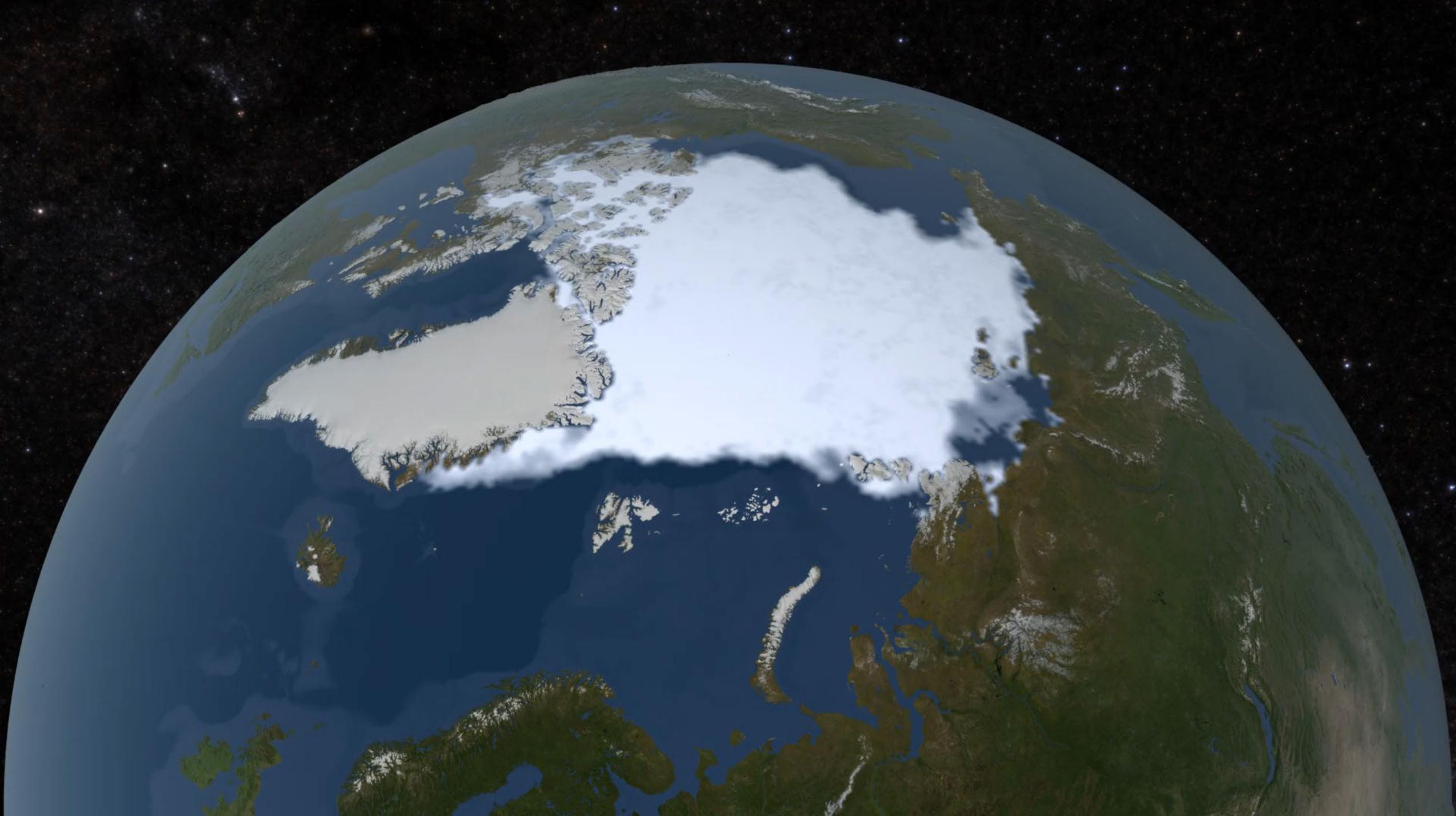


models using only natural forcings
 models using both natural and anthropogenic forcings

observations

24-hour Precipitation Extremes North America (25N-65N)



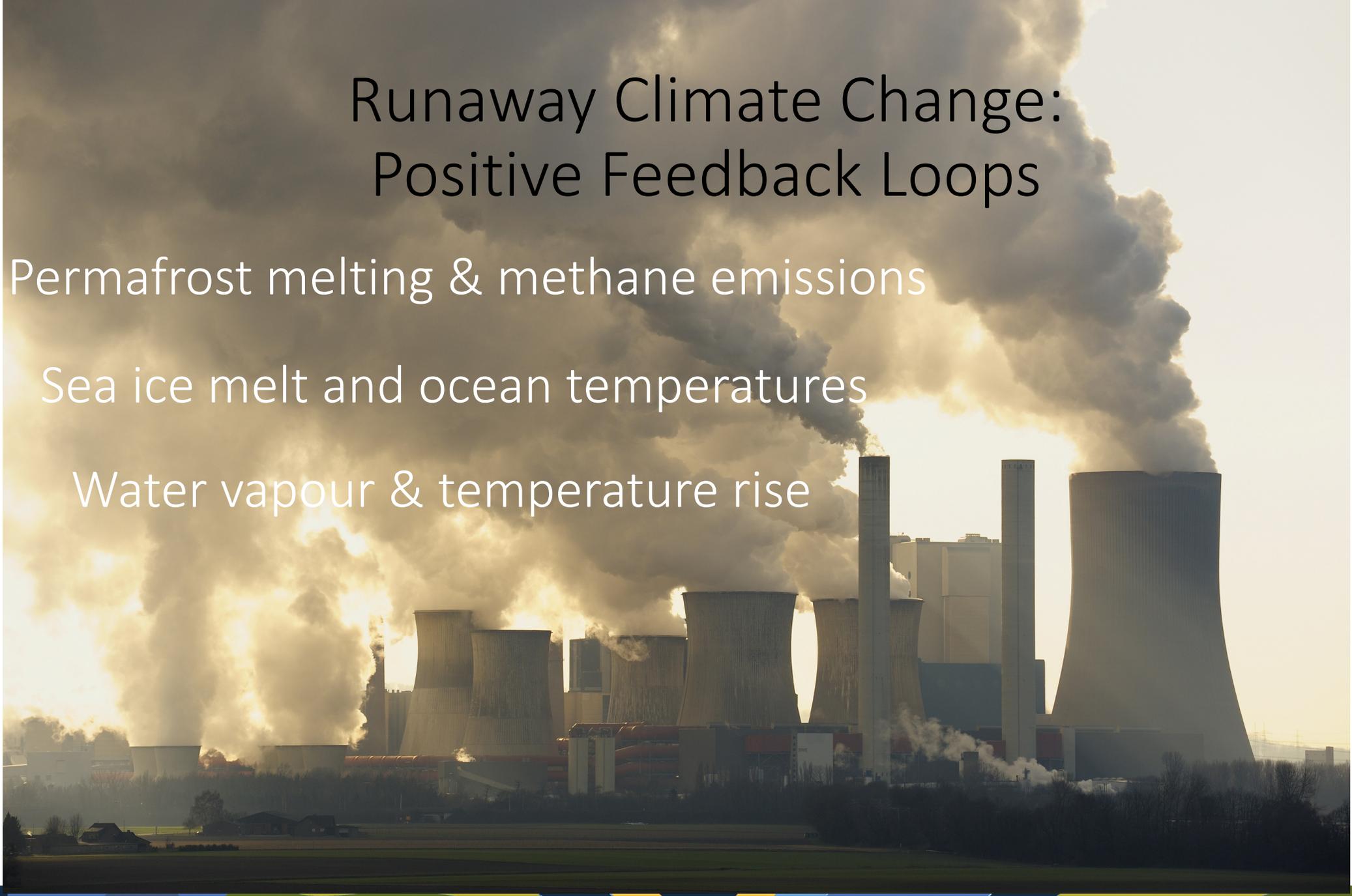


Runaway Climate Change: Positive Feedback Loops

Permafrost melting & methane emissions

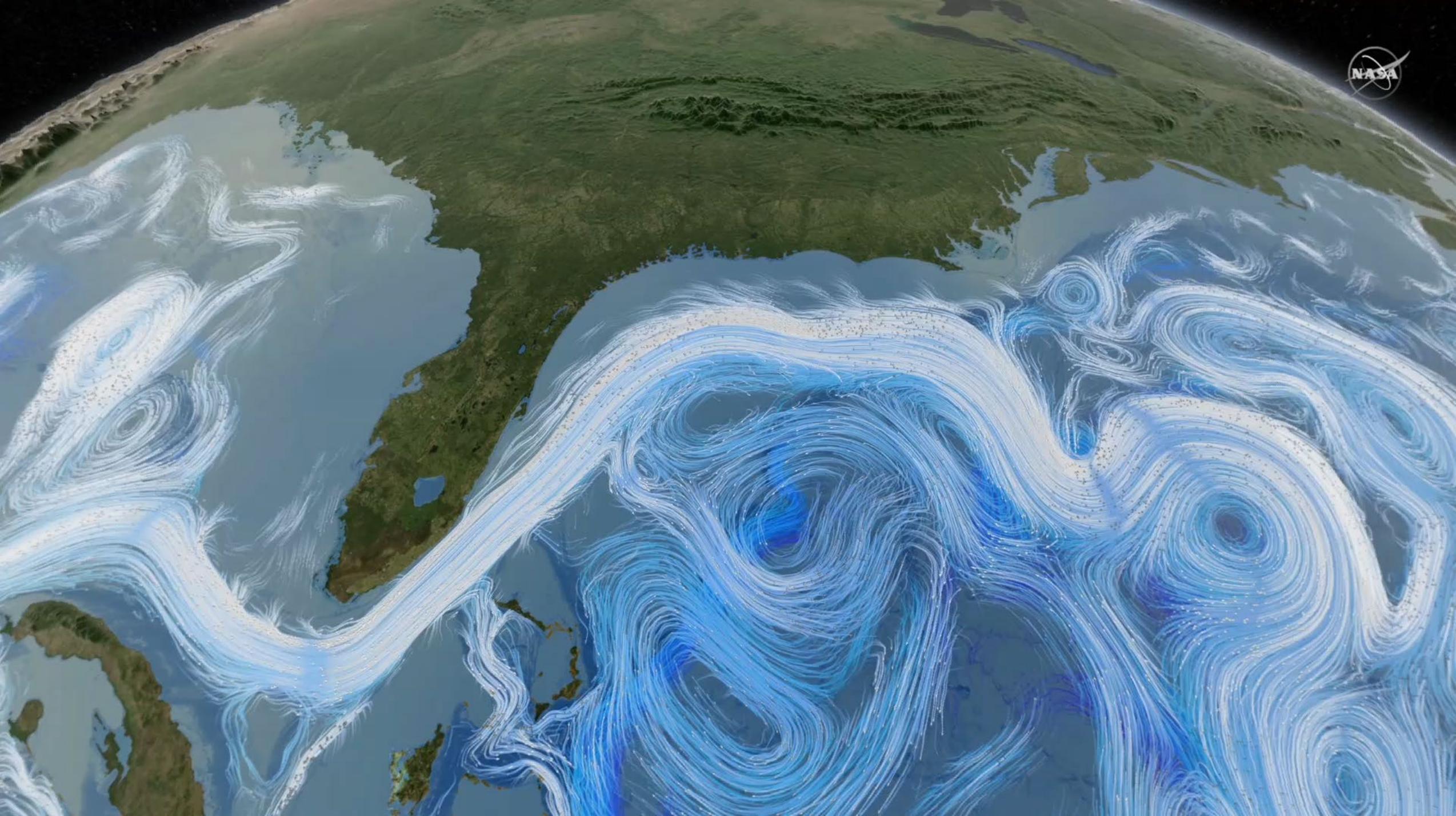
Sea ice melt and ocean temperatures

Water vapour & temperature rise





Runaway Tula



So what?

Observable Changes

Predicted impacts



Indicators of Climate – what's changing?



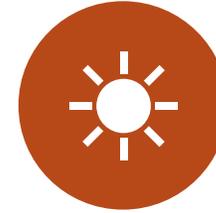
TEMPERATURE



PRECIPITATION



FROST-FREE DAYS AND
GROWING SEASON



DROUGHTS AND HEAT
WAVES



HURRICANES AND
OTHER EXTREME
WEATHER



SEA LEVEL RISE



ICE FREE ARCTIC AND
GLACIAL RETREAT



OCEAN ACIDIFICATION

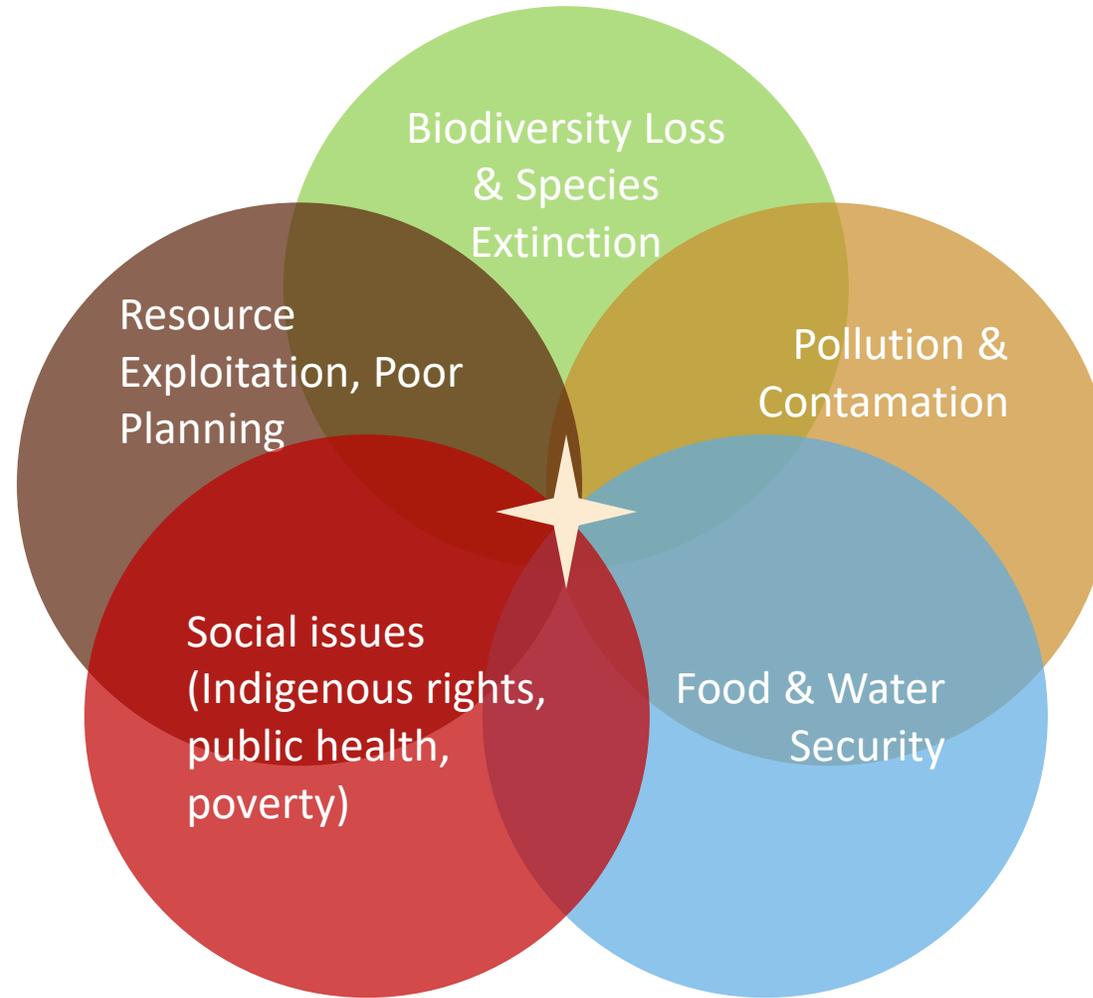


ECOLOGICAL SHIFTS
AND SPECIES AT RISK



FOOD & WATER
SECURITY

Climate Change is not the only challenge we're facing...



Climate Change
is a “**Threat
Multiplier**”

...but it **exacerbates** nearly every existing Environmental, Social and Economic issue

Breakout session

“Community experiences with climate change”

