Climate Change - A Hot Topic

Why Climate Change

Roy Campbell and Don Fournier, January 8th, 2023

Contents for Weekly Group Sessions
Introduction

1. Why Climate Change – An Introduction
2. Fifth National Climate Assessment
3. Remediation
4. Adaptation
5. Politics and Steak Holders
6. What can individuals do?

Introduction -- Why Climate Change

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Moderators

Why Climate Change

Don Fournier: Don has been following climate change issues since the early 1980’s and read many books on the topic and has given lectures and taught courses on climate and the build environment.

Roy Campbell: Roy has been following the science and public debate about the environment and climate change ever since the 1952 Great Smog that smothered London. His interest will be to help explain how science has detailed and predicted the changes that are occurring and the evolving public and corporate response.

Group Members

ZOOM students	
Anastasia	Economy
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Derek	Robinson
Dale	Bauer
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Joseph	Sciacca
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Maureen	McCord
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In-person students	
Margaret	Maurer
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Monica	David
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Robert	Segebart
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In-person students	
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Luis	Cuza
Douglas	Staske
Gregory	Walburg
Alan	Conrad
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Mary	Kuetemeyer
Isabel	Cole
anthony	welsh
Joyce	Eisold
Robert	O'Daniell

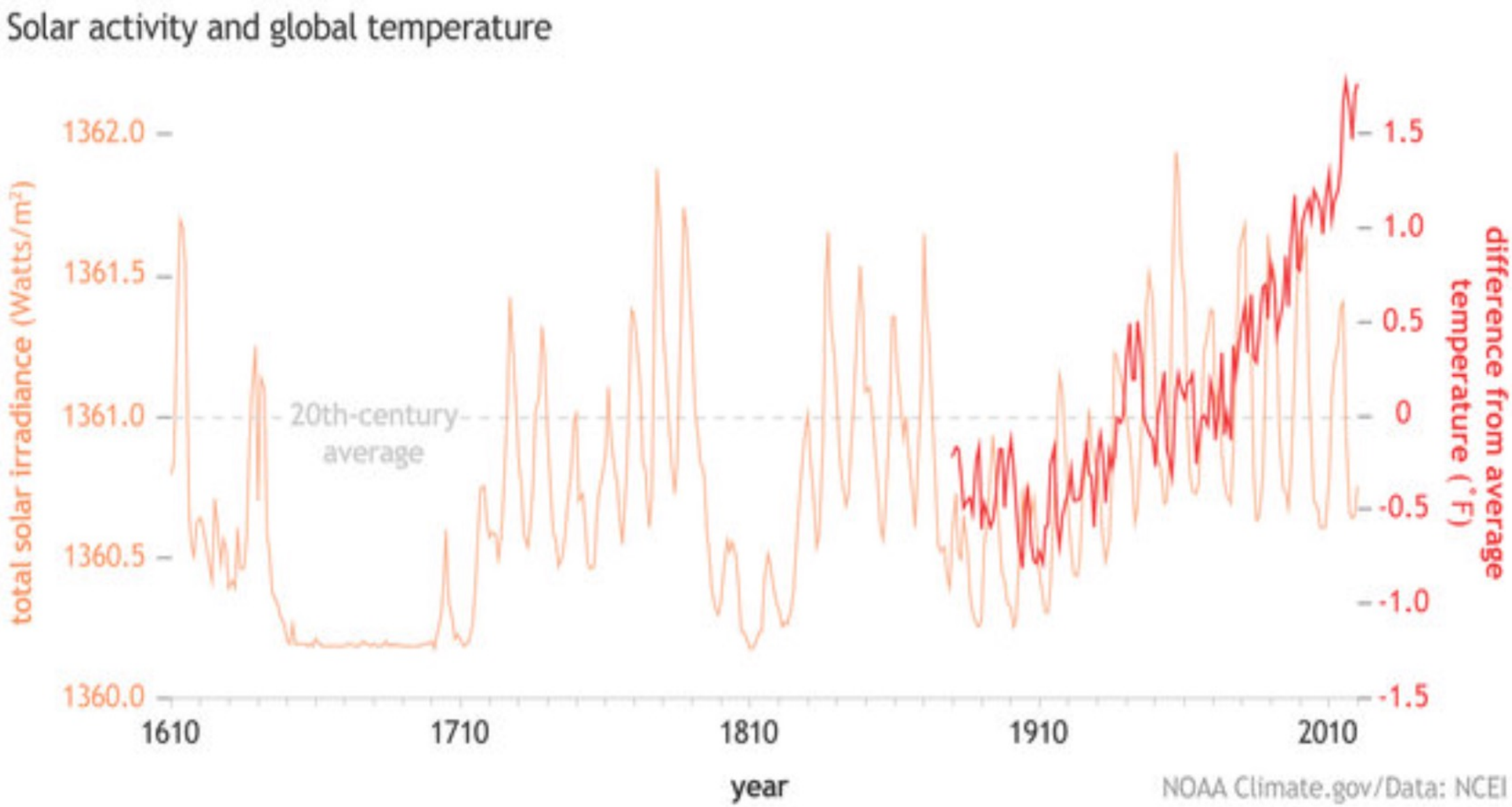
Definition -- Climate

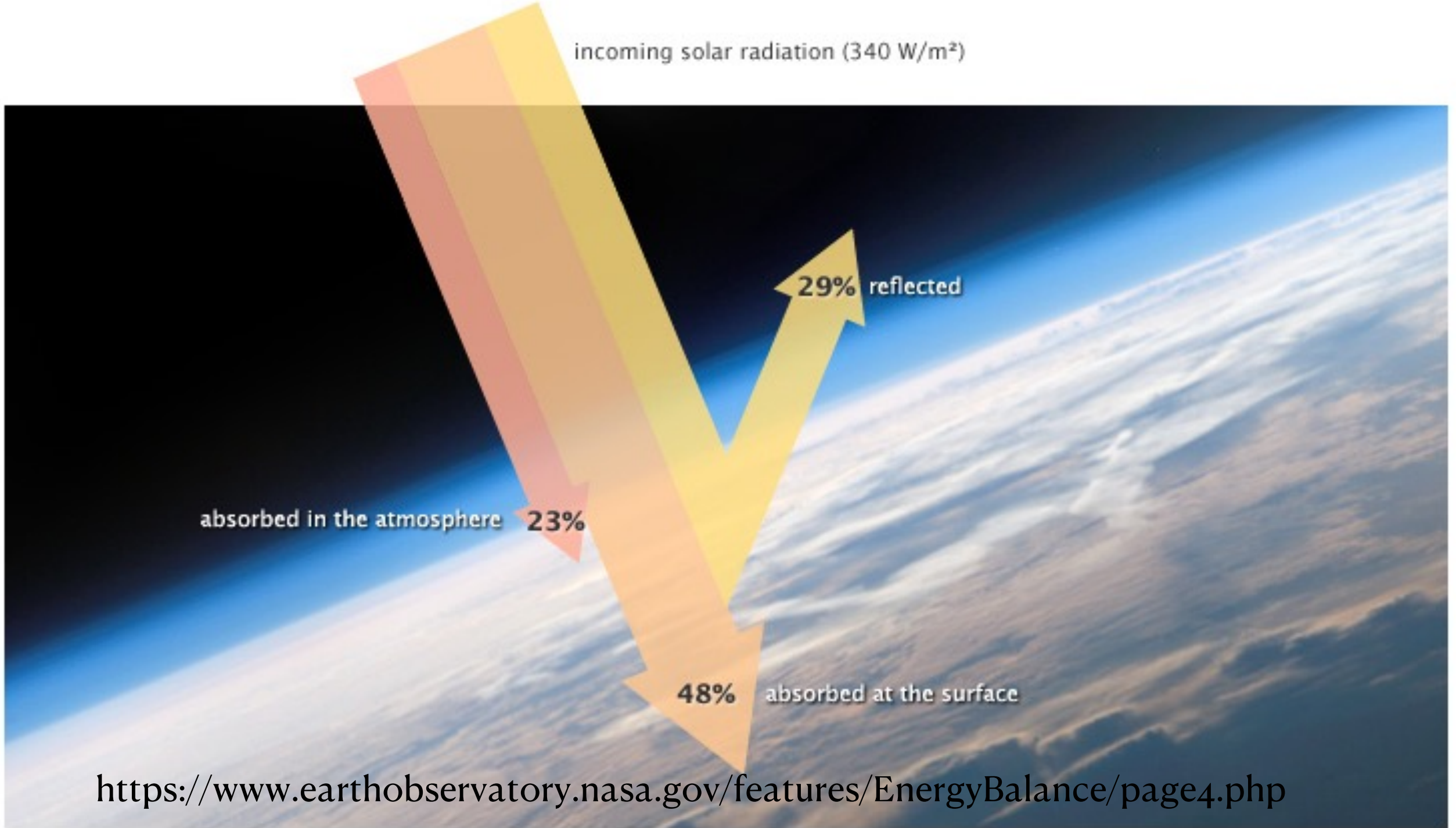
Why Climate Change

Climate change refers to long-term shifts in temperatures and weather patterns. Such shifts can be natural, due to changes in the sun's activity or large volcanic eruptions. But since the 1800s, human activities have been the main driver of climate change, primarily due to the burning of fossil fuels like coal, oil and gas.

United Nations Definition:

https://www.un.org/en/climatechange/what-is-climate-change


Solar activity and global temperature
1362.0
1361.5
1361.0
1360.5
1360.0
total solar irradiance (Watts/m²)
20th-century average
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
difference from average temperature (˚F)
1610
1710
1810
1910
2010
year
NOAA Climate.gov/Data: NCEI

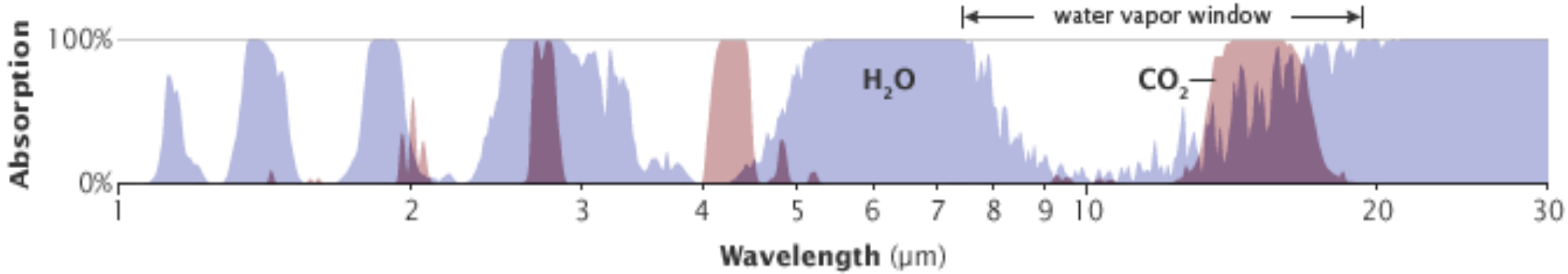


https://www.earthobservatory.nasa.gov/features/EnergyBalance/page4.php

Heat Balance on Earth

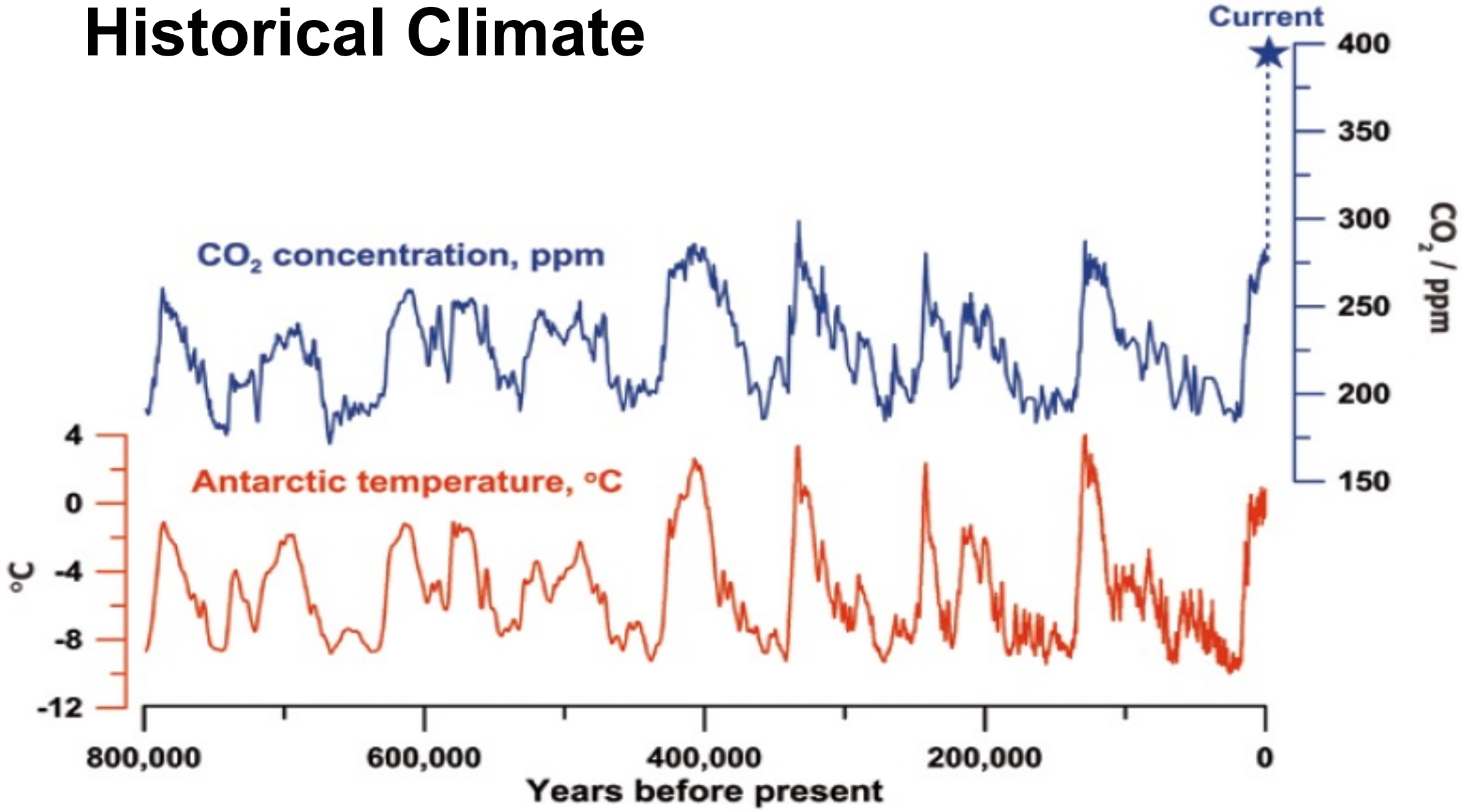
- Temperature doesn't infinitely rise, however, because atoms and molecules on Earth are not just absorbing sunlight, they are also radiating thermal infrared energy (heat).
- The amount of heat a surface radiates is proportional to the fourth power of its temperature. If temperature doubles, radiated energy increases by a factor of 16 (2 to the 4th power).
- If the temperature of the Earth rises, the planet rapidly emits an increasing amount of heat to space.
- This large increase in heat loss in response to a relatively smaller increase in temperature—referred to as radiative cooling—is the primary mechanism that prevents runaway heating on Earth.

How does heat escape from the earth



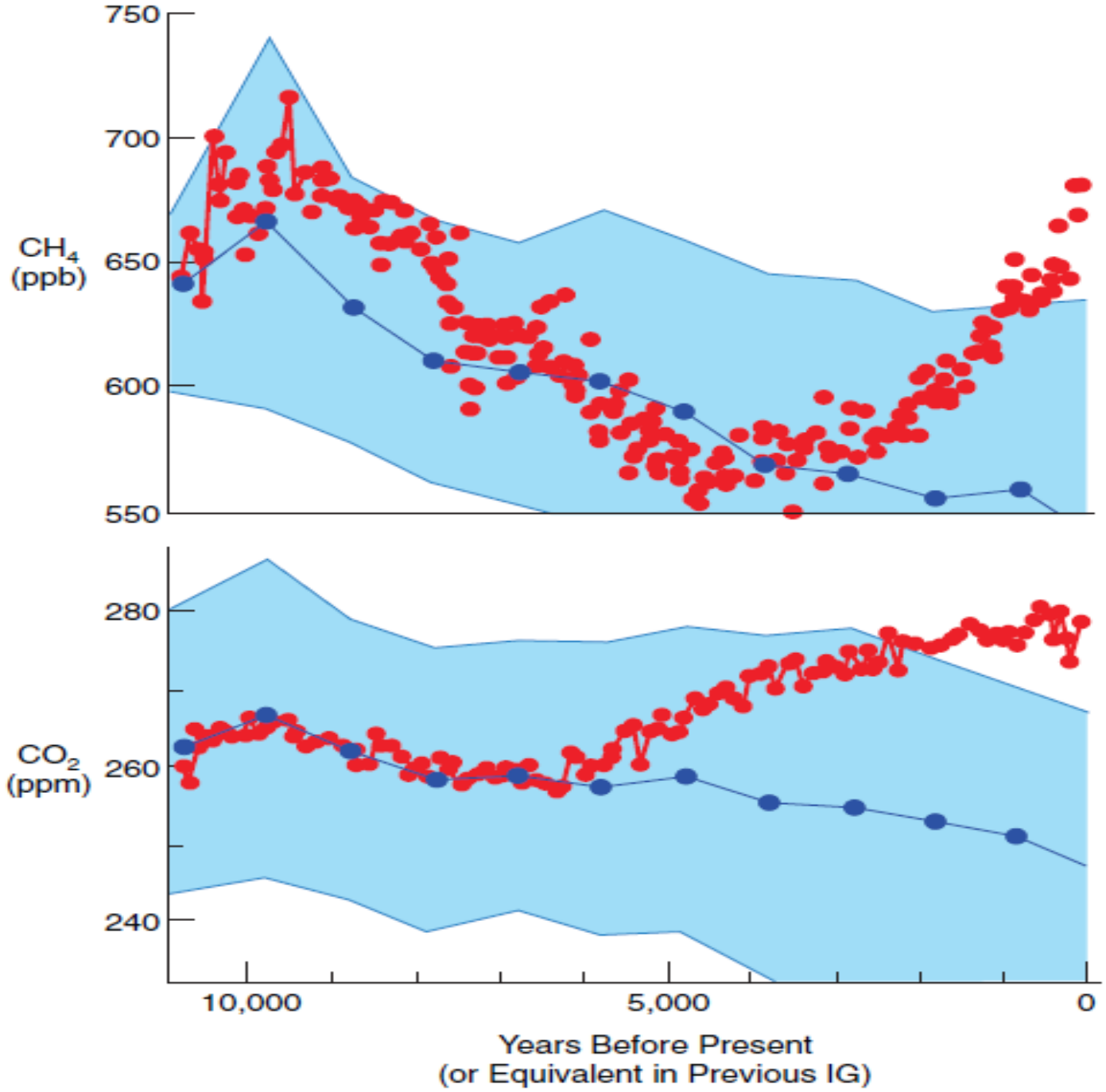
All atmospheric gases have a unique pattern of energy absorption: they absorb some wavelengths of energy but are transparent to others. The absorption patterns of water vapor (blue peaks) and carbon dioxide (pink peaks) overlap in some wavelengths. Carbon dioxide is not as strong a greenhouse gas as water vapor, but it absorbs energy in wavelengths (12-15 micrometers) that water vapor does not, partially closing the "window" through which heat radiated by the surface would normally escape to space. (Illustration adapted from Robert Rohde.)

Historical Climate

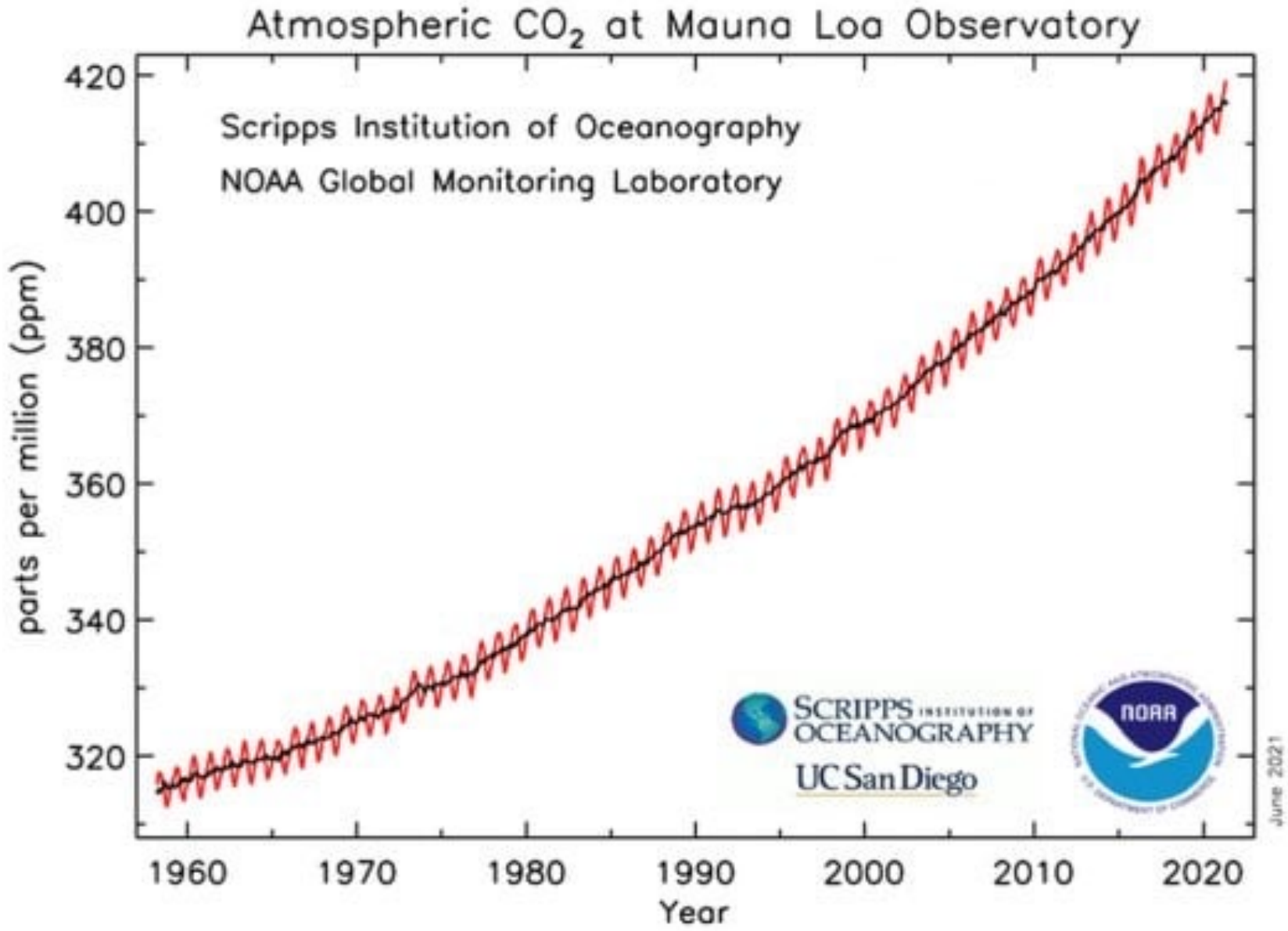


The Holocene

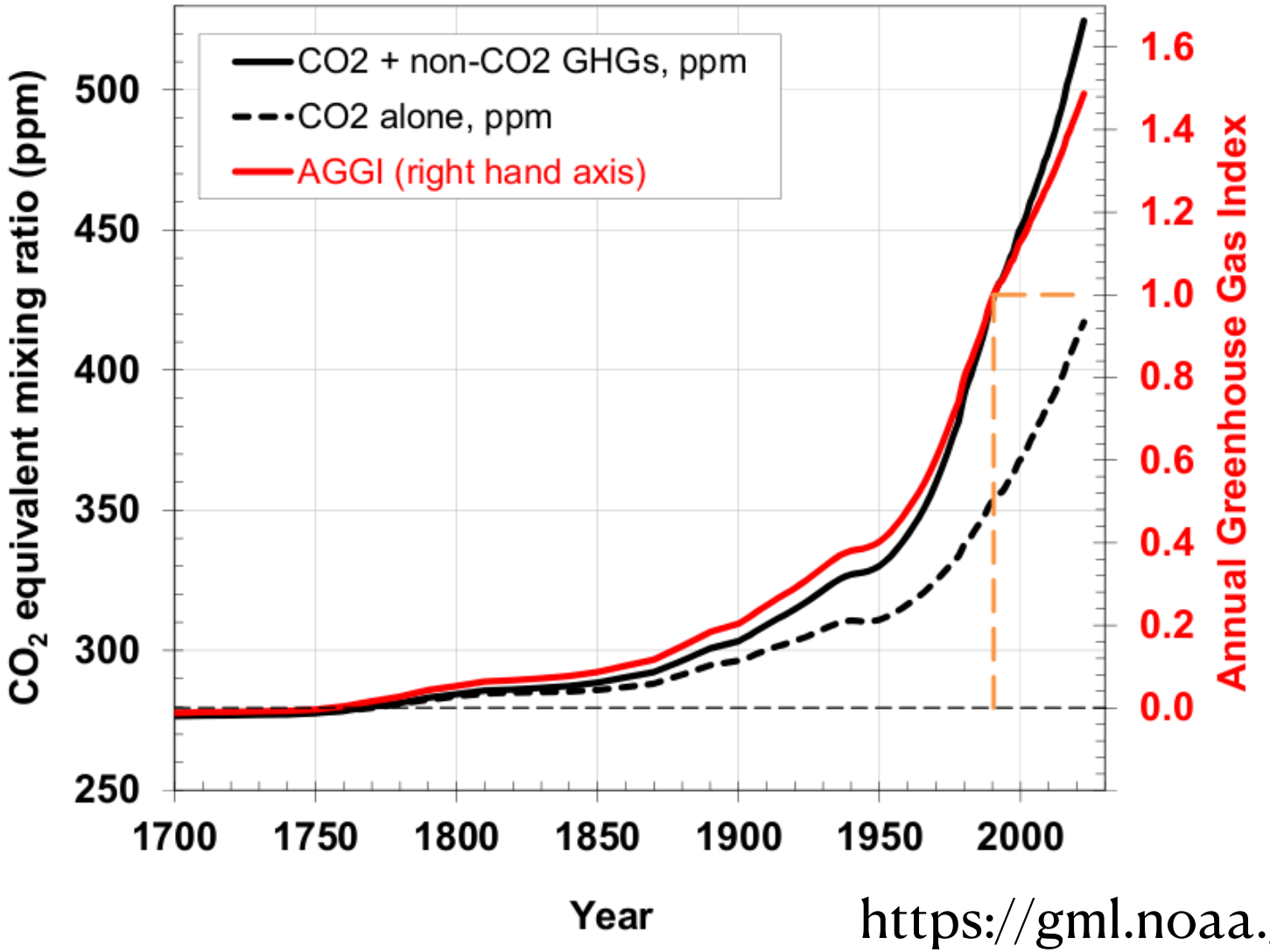
- We are taking a different path than previous 7 interglacial periods.
- For all GHG gasses.
- CO2 & CH4 dominate.
- Current Methane Level is 1912 ppb.
- Current CO2 Level is 419.



Source: Ruddiman et al. 2011

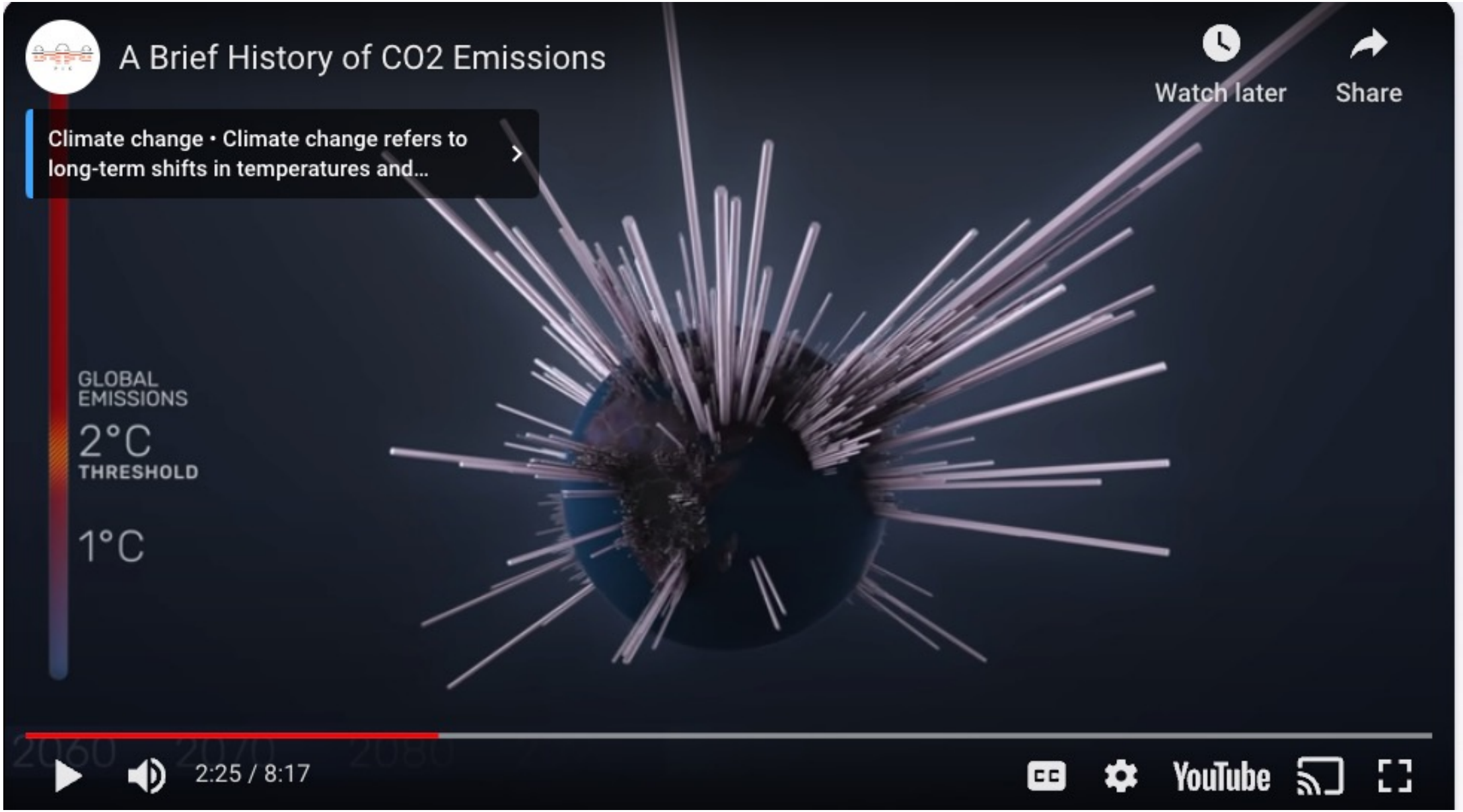

Atmospheric CO_2 at Mauna Loa Observatory
Scripps Institution of Oceanography
NOAA Global Monitoring Laboratory
parts per million (ppm)
420
400
380
360
340
320
1960
1970
1980
1990
2000
2010
2020
Year
SCRIPPS INSTITUTION OF OCEANOGRAPHY
UC San Diego
NOAA
June 2021

Green House Gas in Atmosphere 1700-2020



https://gml.noaa.gov/aggi/aggi.html

https://youtu.be/EQ7S0D1iucY



16 Dimensions of Climate Change Problem

1) Climate change is a multidimensional and interconnected issue that affects various aspects of the environment, society, economy, and geopolitics. The dimensions of climate change include:

2) Temperature Changes:

- Global Warming: The overall increase in Earth's average temperature, leading to changes in climate patterns

3) Extreme Weather Events:

- Heatwaves, Storms, and Droughts: More frequent and intense extreme weather events contribute to climate variability.

4) Melting Ice and Rising Sea Levels:

- Glacial Melting: The shrinking of glaciers and ice caps.
- Sea Level Rise: The increase in sea levels due to the melting of polar ice and glaciers

16 Dimensions of Climate Change Problem

5) Ocean Acidification:
   - Carbon Dioxide Absorption: The oceans absorb carbon dioxide, leading to increased acidity with detrimental effects on marine life.
6) Biodiversity Loss:
   - Ecosystem Disruption: Changes in climate can disrupt ecosystems, leading to shifts in the distribution and behavior of plant and animal species.
7) Water Resource Changes:
   - Altered Precipitation Patterns: Changes in rainfall and snowfall patterns impact water availability.
   - Sea Ice Changes: Melting sea ice affects ocean salinity and circulation patterns.

16 Dimensions of Climate Change Problem

8) Food Security:
   - Crop Yields: Climate change can affect agricultural productivity, leading to potential food shortages and increased prices.
9) Health Impacts:
   - Heat-related Illnesses: Increased temperatures can lead to heat-related illnesses, affecting human health.
   - Vector-borne Diseases: Changes in climate can influence the distribution of disease vectors.
9) Economic Consequences:
   - Losses and Damages: Economic impacts from extreme weather events, affecting infrastructure, agriculture, and industries.
   - Costs of Adaptation and Mitigation: Expenses associated with adapting to climate change impacts and mitigating greenhouse gas emissions.

16 Dimensions of Climate Change Problem

11) Social and Cultural Impacts:
    - Migration and Displacement: Climate-induced migration and displacement of communities.
    - Cultural Changes: Impact on cultural practices and traditions, especially for communities closely tied to the environment
12) Policy and Governance:
    - International Agreements: Frameworks such as the Paris Agreement aim to address climate change through global cooperation.
    - National Policies: Governments develop policies to reduce emissions, promote renewable energy, and enhance resilience.

16 Dimensions of Climate Change Problem

13) Technological Solutions:
    - Renewable Energy: Advancements in renewable energy technologies play a crucial role in mitigating climate change.
    - Carbon Capture and Storage: Technologies to capture and store carbon dioxide from industrial processes.
14) Geopolitical Considerations:
    - Resource Competition: Climate-related resource scarcity can contribute to geopolitical tensions.
    - Climate Diplomacy: International relations influenced by climate change considerations.
15) Educational and Awareness Dimensions:
    - Public Awareness: The importance of educating the public about climate change and fostering a sense of responsibility.
16) Addressing climate change requires a holistic approach that considers these interconnected dimensions and involves collaboration at local, national, and international levels.

Timeline of Climate Change	
19th Century:	
1824:	Joseph Fourier proposes the greenhouse effect theory, suggesting that Earth's atmosphere retains heat.
1896:	Svante Arrhenius publishes a paper on the relationship between carbon dioxide and climate, suggesting that burning fossil fuels could lead to global warming.
20th Century:	
1950s: Scientific interest grows, and early climate models predict potential warming.	
1970s: Concerns about global cooling briefly emerge, but by the end of the decade, focus shifts to global warming.	
1980s: The Intergovernmental Panel on Climate Change (IPCC) is established by the United Nations.	
1990s: The United Nations Framework Convention on Climate Change (UNFCCC) is adopted at the Earth Summit in Rio de Janeiro.	
1992:	The United Nations Framework Convention on Climate Change (UNFCCC) is adopted at the Earth Summit in Rio de Janeiro.
1997:	The Kyoto Protocol, an international

Timeline of Climate Change (cont.)	
2000s:	
2001:	The IPCC releases its Third Assessment Report, emphasizing human influence on climate change.
2005:	The Kyoto Protocol comes into force.
2007:	The IPCC releases its Fourth Assessment Report, stating with high confidence that global warming is due to human activities.
2010s:	
2015:	The Paris Agreement is adopted at COP21, aiming to limit global warming to well below 2 degrees Celsius above pre-industrial
2016:	The World Meteorological Organization announces that 2016 is likely the warmest year on record at that time.
2020s:	
2020:	Despite the COVID-19 pandemic leading to temporary emissions reductions, the year ties with 2016 as the warmest on record.
2021:	The IPCC releases its Sixth Assessment Report, warning of the accelerating impacts of climate change and the urgency of action

Roadmaps to Solving Climate Change

- Reduce the population needing energy
  - Infeasible in the short term
- Reduce the production of greenhouse gases [Session 2, 3, 4]
  - But air, land and sea reservoirs of greenhouse gases and heat
- Increase the albedo of the earth [Session 6]
  - But terraforming the earth could have other dangers
- Pull the greenhouse gases from the air [Session 6]:
  - Carbon sequestration and other approaches

Population

1) Efforts to slow population growth in the short term will have little impact on sustainability,
2) Sustainability can be more rapidly achieved with a focus on:
   a. technological and social innovations,
   b. reducing consumption rates,
   c. treating population planning as a long term goal
3) A fertility-reduction model of one-child per female by 2100 would take at least 140 years to reduce the population to 2 billion people by 2153

Proceedings of the National Academy of Sciences of the United States of America, 2014

World Future Population Projections

Future projections

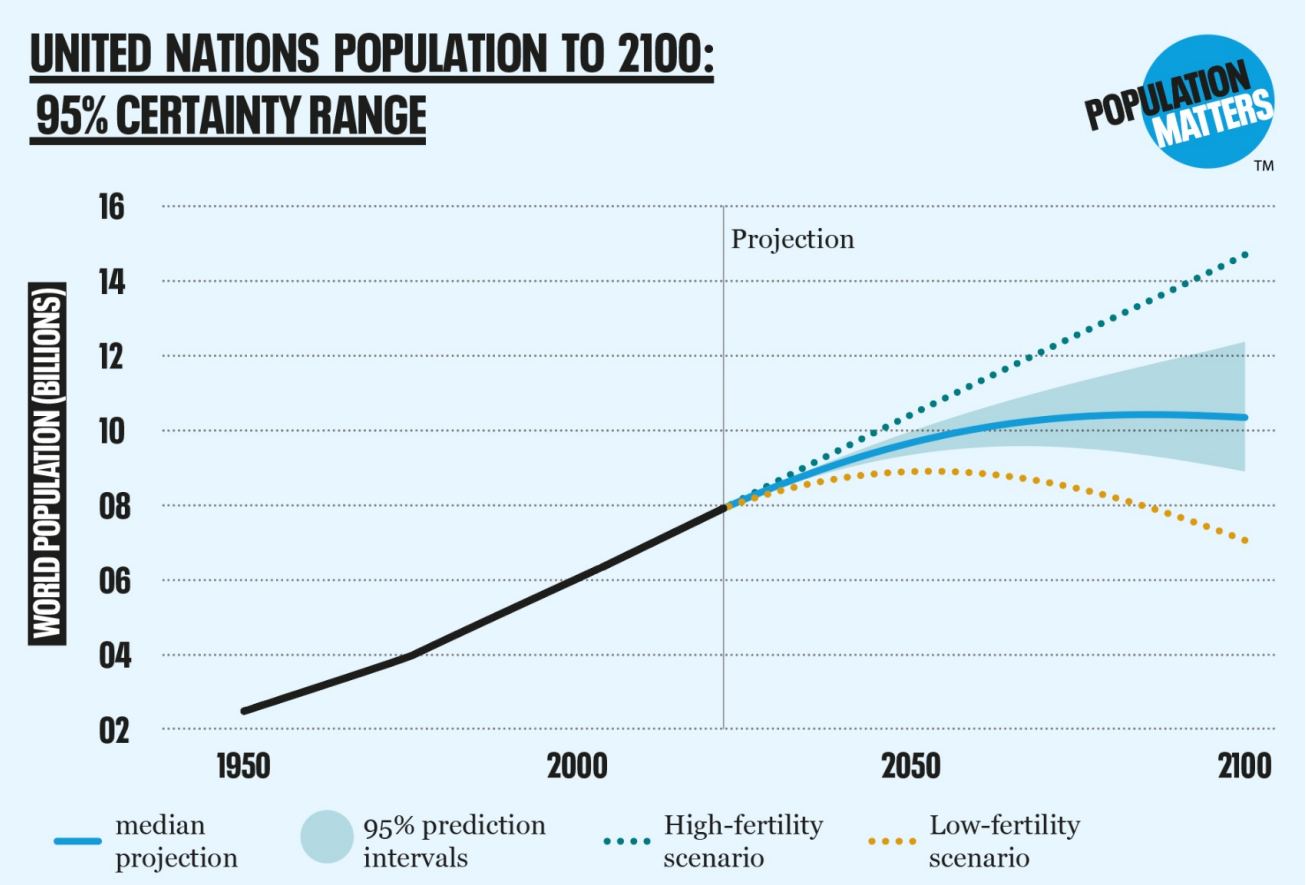
Continent	Projected 2050 population by UN in 2017[87]
Africa	2.5 billion
Asia	5.5 billion
Europe	716 million
Latin America and Caribbean	780 million
North America	435 million

Main article: Projections of population growth

Current North American Population is ~407 million

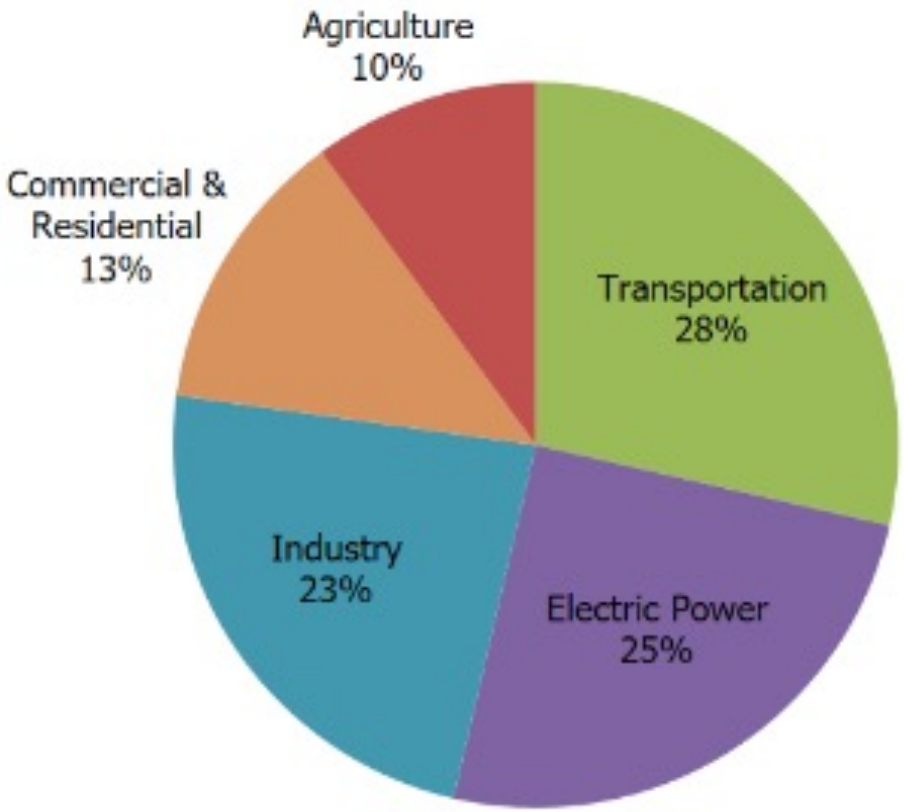
Birth Rates

- World population prospects (2022). Note that half a child more or less per woman would cause a difference of about 8 billion people by the end of the century (blue orange dotted lines).

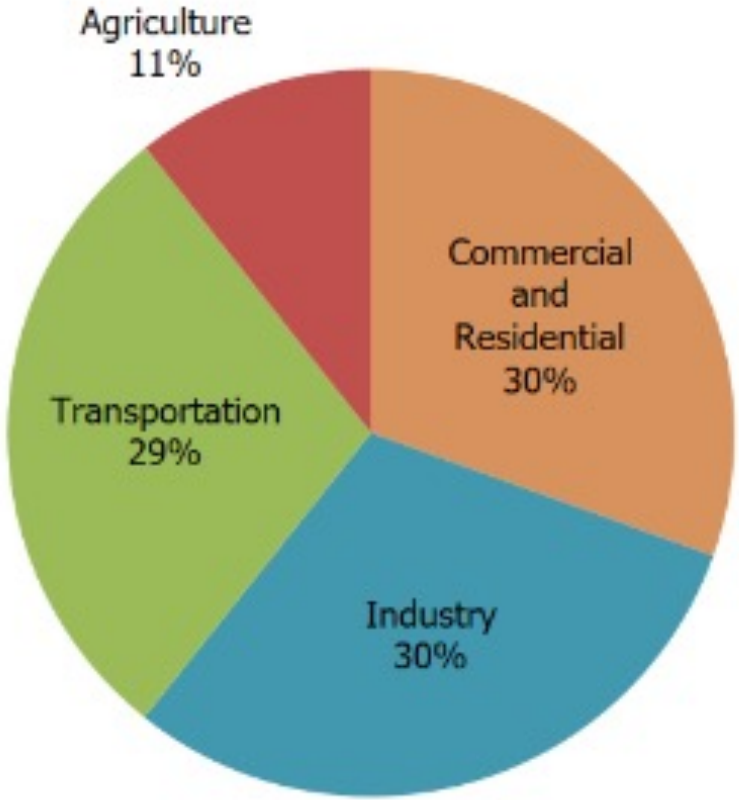


Total U.S. Greenhouse Gas Emissions by Economic Sector in 2021

- EPA



Includes Electricity End Use



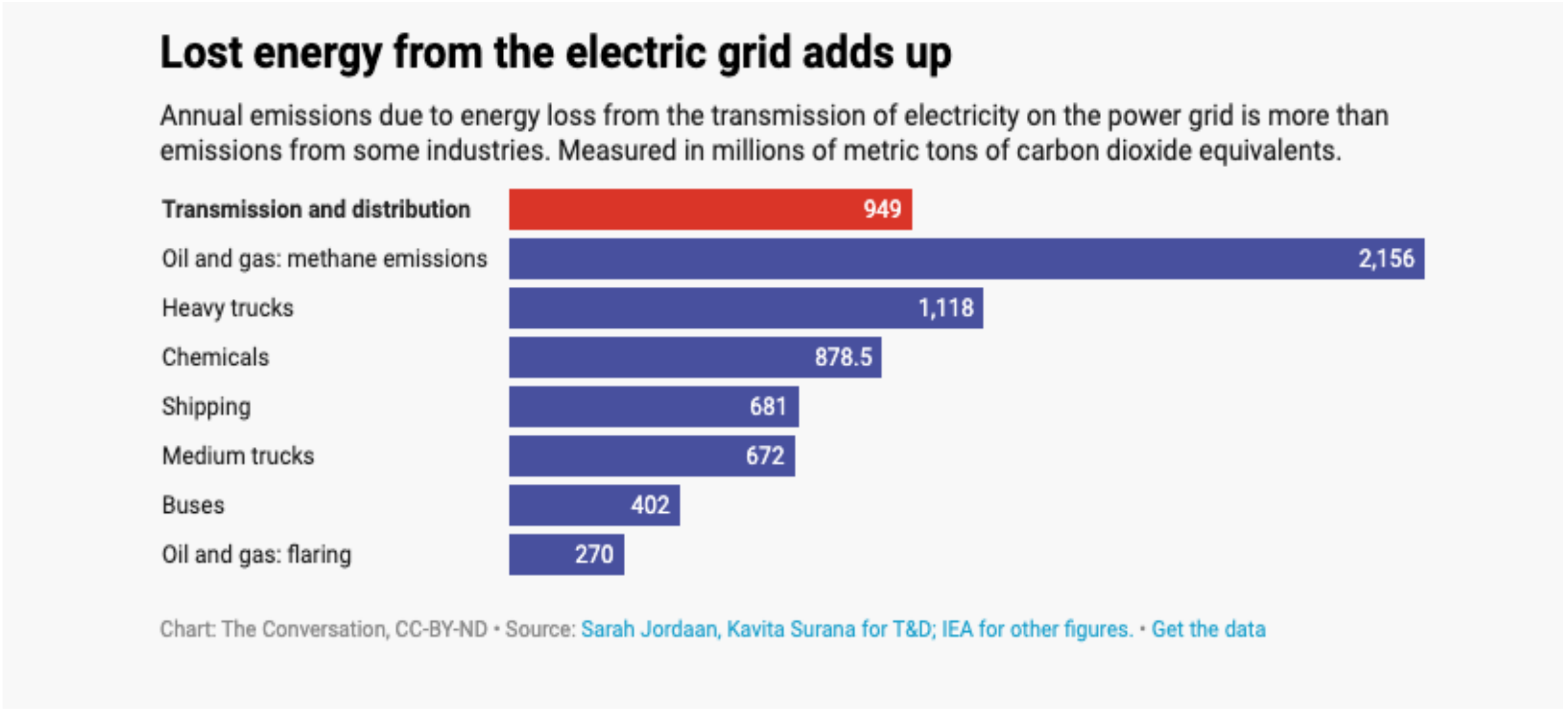
https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions#:~:text=Industry%20

Carbon Emissions per sector

- The Transportation Sector (28%):
- Electricity Production (25%)
  - a billion metric tons of carbon dioxide equivalents a year caused by Grid inefficiencies world-wide
- Industry (23%)
- Commercial and Residential (13%)
- Agriculture (10%)
- Land Use and Forestry (offsets 12%)

Grid losses in Emissions equivalent

Just distributing energy costs emissions right now (world wide)



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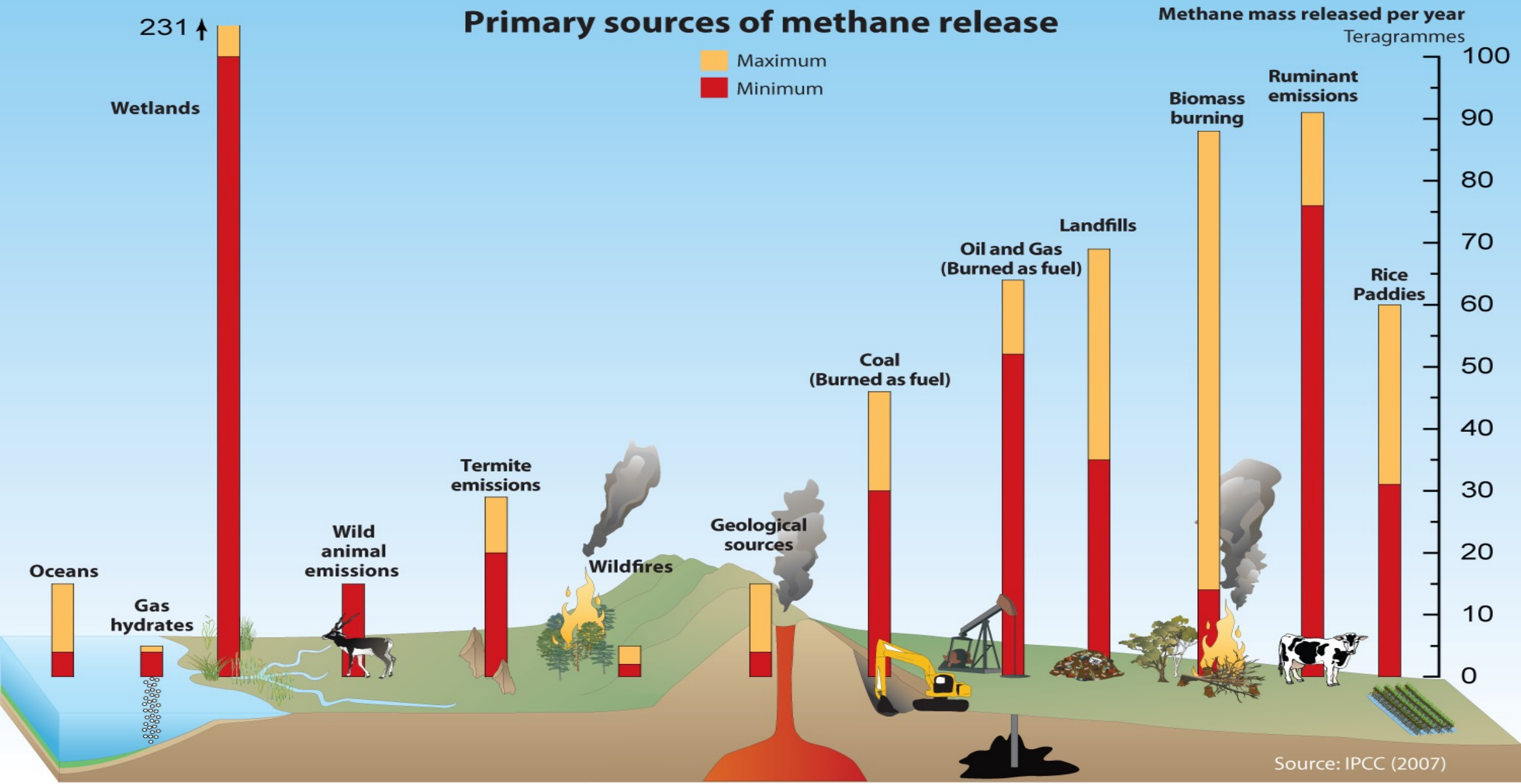
Remediation -- The Great Energy Transition
Session 3

Electrify Everything, Everywhere, All at Once!!

Roy Campbell and Don Fournier, January 29th, 2023

Remediation -- Getting off Carbon

- The Transportation Sector
  - Automobiles
  - Trucks
  - Aviation
  - Rail System
  - Ships
- Electricity Production
  - Nuclear Power
  - Renewables
- The Built Environment
- Industry
- Commercial & Residential
- Agriculture
- Land Use and Forestry


Primary sources of methane release
Maximum
Minimum
Methane mass released per year
Teragrammes
231
Wetlands
Oceans
Gas hydrates
Wild animal emissions
Termite emissions
Wildfires
Geological sources
Coal (Burned as fuel)
Oil and Gas (Burned as fuel)
Landfills
Biomass burning
Ruminant emissions
Rice Paddies
100
90
80
70
60
50
40
30
20
10
0
Source: IPCC (2007)

Remediation – Tackling Methane

- Fossil Fuel Issues
- Agriculture
  - Biomass
  - Enteric Methane
  - Plant Cultivation
- Landfills

Climate Change
- A Hot Topic

Adaptation – Session 4

Roy Campbell and Don Fournier, February 5th, 2023

Adaptation

- Green Infrastructure
- Storm Hardening
- Fire Hardening
- Flood Design
- Sea Level Rise
- Managing Drought Conditions
- Coping with Atmospheric Rivers

Climate Change
- A Hot Topic

Politics and Stake Holders – Session 5

Roy Campbell and Don Fournier, February 12th, 2023

Climate Change- A Hot Topic

- Session 5 will discuss climate change, social systems, and politics.
- Items for Discussion:
  - Climate-social system models – DICE, RICE (See Nature)
  - Producers
  - Lobbyists
  - Big Money
  - Power Struggles
  - Small and Island Countries
  - The Politicization of Science
  - Global Politics
  - State Politics

Climate Conference COP28 Summary - December 13, 2023

COP28 Outcome: Transitioning Away from Fossil Fuels

- Nations approved a roadmap for transitioning away from fossil fuels at COP28 in Dubai.
- However, the deal falls short of a long-demanded call for a phaseout of oil, coal, and gas.
- UN Chief António Guterres emphasizes the inevitability of a fossil fuel phaseout for climate change mitigation.
- The COP28 conference extended due to negotiations on the terms of phasing down or phasing out fossil fuels.

Key Points from UN Chief and Climate Chief Statements

- Limiting global heating to 1.5°C requires the phaseout of all fossil fuels.
- Commitments include tripling renewables capacity and doubling energy efficiency by 2030.
- Progress on adaptation and finance, with the operationalization of the Loss and Damage Fund.
- Calls for a surge in finance for vulnerable countries facing rising seas and drowning in debt.

COP28 Highlights and Achievements (cont.)

- Establishment of the Loss and Damage Fund for climate-vulnerable developing countries.
- Commitments of $3.5 billion to replenish the Green Climate Fund.
- Additional funding for the Least Developed Countries Fund (LDC) and Special Climate Change Fund (SCCF).
- World Bank pledges $9 billion annually for climate-related projects in 2024 and 2025.
- Endorsement of COP28 UAE Climate and Health Declaration and Declaration on Agriculture, Food, and Climate.
- Global Cooling Pledge endorsed by 66 countries to reduce cooling-related emissions by 68%.

What's Next for COPs?

- Next round of Nationally Determined Contributions (NDCs) due in 2025.
- Baku, Azerbaijan, announced as the host for COP29 in November 2024.
- Brazil offers to host COP30 in the Amazon in 2025

Mixed Reactions and Criticisms

- Civil society representatives, climate activists, and small island developing countries express dissatisfaction.
- Concerns about the outcome lacking a clear course correction and incremental advancements.
- Harjeet Singh from Climate Action Network International criticizes COP28's spotlight on fossil fuels but points out loopholes and hypocrisy in the outcome.
- Developing countries dependent on fossil fuels lack robust guarantees for financial support in transitioning to renewable energy.

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What Can Individuals Do - Session 6

- Why individual action is important.
- What can I do?
- How do I make a difference?
- Albedo and sequestration questions
- Round-out Discussions

Climate Change: Hot Topics
9. References (Green items for introduction)

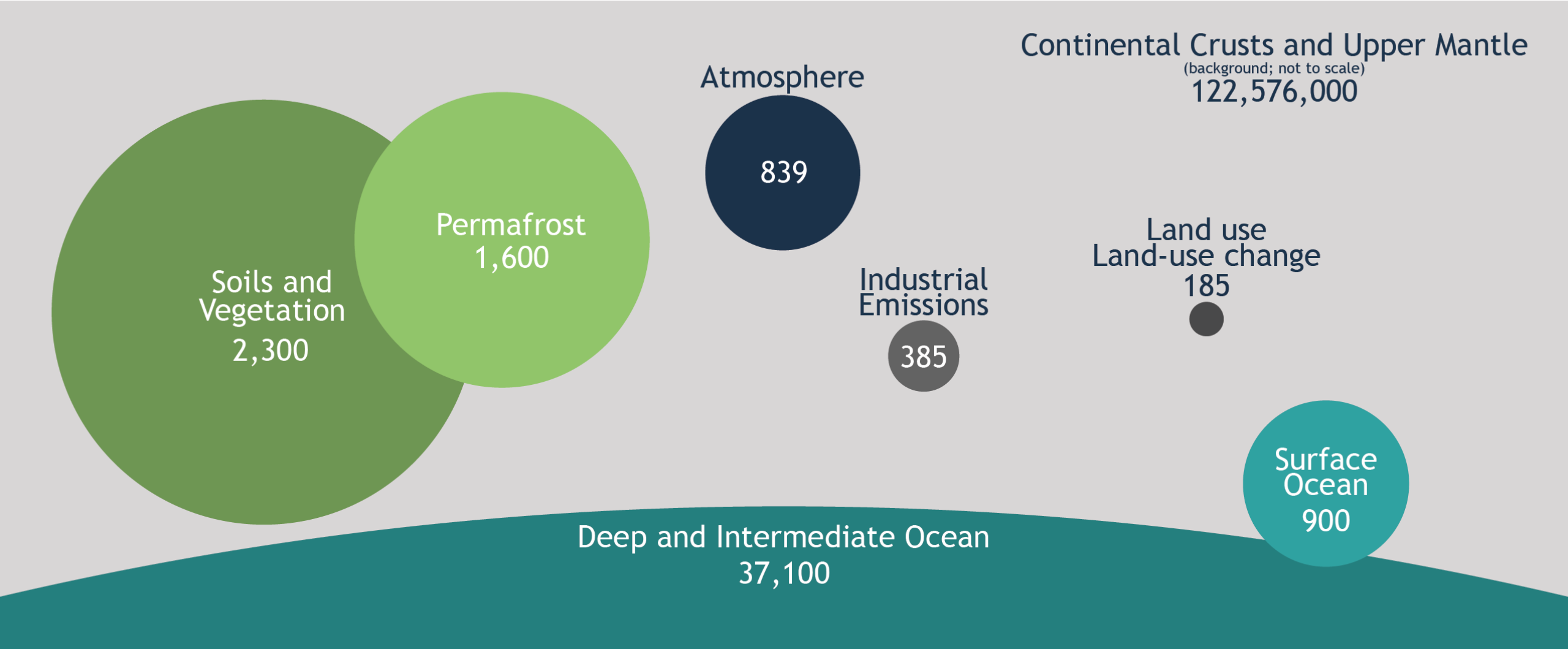
- COP 28 full presentation (verbose) https://unfccc.int/documents/204079
- 5th US Climate Report (detailed) https://nca2023.globalchange.gov/
- Royal Society Climate Change Evidence and Causes(more technical) https://royalsociety.org/~/media/Royal_Society_Content/policy/projects/climate-evidence-causes/climate-change-evidence-causes.pdf
- **The Carbon Almanac: It's Not Too Late Paperback – July 12, 2022 (reference for terms)** The Carbon Almanac Network (Author), Seth Godin
- Determinants of emissions pathways in the coupled climate–social system (technical), *Frances C. Moore, Katherine Lacasse, Katharine J. Mach, Yoon Ah Shin, Louis J. Gross, Brian Beckage, Nature, Vol. 603, 3 March 2022, https://doi.org/10.1038/s41586-022-04423-8*
- EPA Climate Change (nice diagrams) https://www.epa.gov/climate-change
- NASA CLIMATE CHANGE (interesting videos of climate) https://climate.nasa.gov/
- The International Panel on Climate Change IPCC (central scientific world body) https://www.ipcc.ch
- United Nations Climate Action (Summaries of impact) https://www.un.org/en/climatechange
- The European Commision: Energy, Climate change, Environment(European view) https://commission.europa.eu/energy-climate-change-environment_en

Additional materials

Carbon Dioxide Is Still King

- Water vapor provides about 50% greenhouse effect, but it condenses and can easily be removed from the atmosphere.
- Carbon dioxide is responsible for a 33% of the total warming of Earth's climate due to human-produced greenhouse gases.
- Small increases in its concentration have major effects.
- A key reason is the length of time carbon dioxide remains in the atmosphere.
- Methane, carbon dioxide, and chlorofluorocarbons don't condense, and they aren't particularly chemically reactive or easily broken down by light in the troposphere.
- Heating effects on the earth may take centuries to be noticed to their full effect

Wikipedia diagram of how much carbon is around

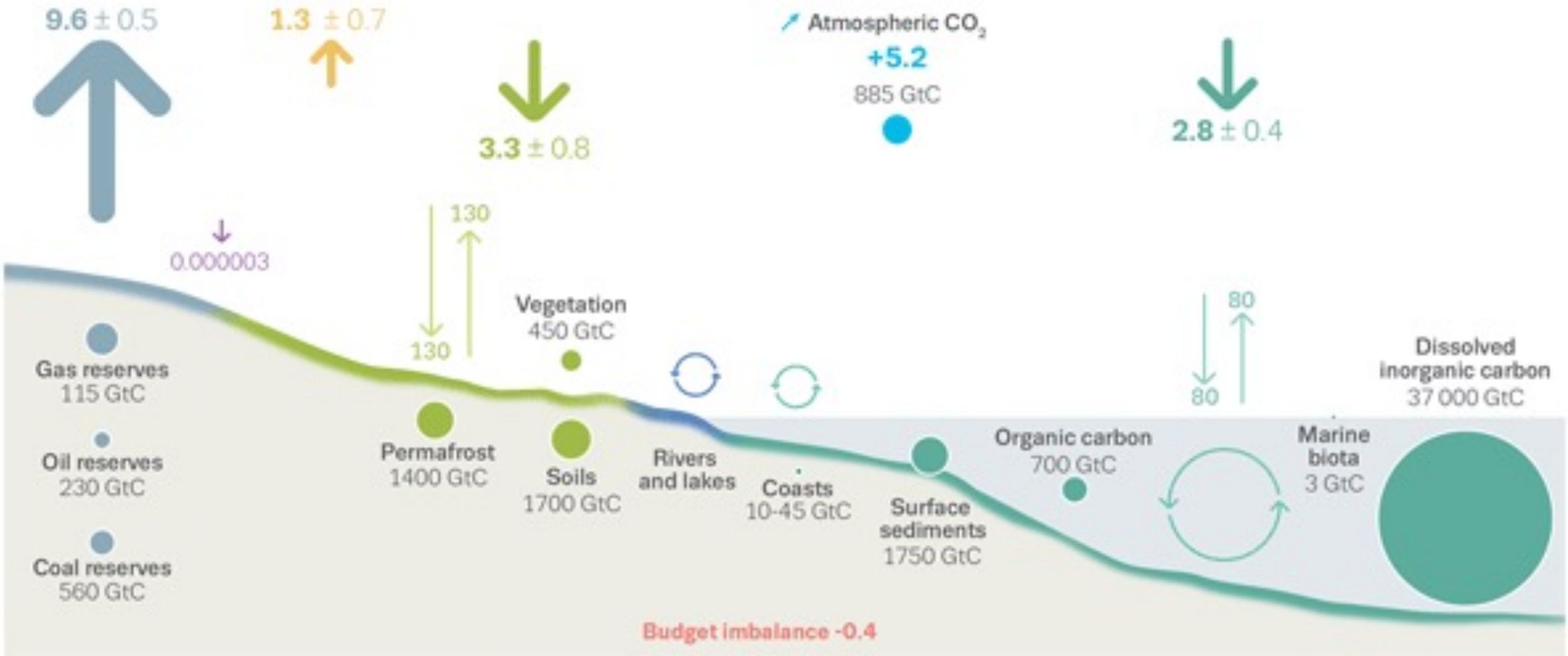


How much carbon in carbon cycle?

Carbon location	Gt C
Atmosphere	885
Land	11.1
Gas reserves	115
Oil Reserves	230
Coal reserves	560
Permafrost	1400
Soils	1700
Ocean	37000
Marine biota	3
Organic Carbon	700
Surface Sediments	1750
Coasts	10-45

1 ppm = 2.124 Gt C
1 Gt C = 3.664 $GtCO_2$
1000 MtC = 1 Gt C
Ballantyne et al., 2012

The global carbon cycle



Anthropogenic fluxes 2013-2022 average GtC per year

- Fossil CO_2 E_{FOS}
- Land-use change E_{LUC}
- CDR not included in E_{LUC}
- Land uptake S_{LAND}
- Ocean uptake S_{OCEAN}
- Carbon cycling GtC per year
- Stocks GtC
- Atmospheric increase G_{ATM}
- Budget Imbalance B_{IM}

Global Rates of Change Emissions

CHANGE IN	2022 Gt C yr^{-1}	2023 Gt C yr^{-1}	2023 Gt CO_2 yr^{-1}
Fossil CO_2 Increase	9.9	10.0	36.8
Fossil CO_2 % Increase	0.9%	+1.1 %	+1.1 %
Land Use Change	1.3	1.1	4.0
Total Anthropogenic CO_2	11.1	11.1	40.9
Atmospheric ppm CO_2	417.1±0.1 ppm	419.3 ppm or 51% more than 278ppm in 1740s	
Atmospheric CO_2 resevoir	5.2	5.1	
Ocean CO_2 sink	2.9	2.9	
Land CO_2 sink	3.3	2.9	
% Total Atmospheric reservoir	Less than 47 % of total emissions		
% Total to Land sink	Absorbs 31 % of total emissions		
% Total to Ocean sink	Absorbs 26 % of total emissions		

US Rates of Change Emissions

US	2023 Gt C yr^{-1}
Fossil CO_2 Increase	1.3 Gt C yr^{-1} (4.9 Gt CO_2 yr^{-1})
Fossil CO_2 Increase	-3.0 %
Coal	-18.3%
Natural Gas	+1.4%
Cement	-4.0%
International Aviation	2.8 % of global emissions +11.9 %

References

Global Carbon Budget 2023, ESSD, Volume 15, issue 12, 5301–5369, 2023
https://essd.copernicus.org/articles/15/5301/2023/