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FACULTY OF
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KOSOVSKA MITROVICA

## D5.4 Undergraduate/Master Curricula Implemented

## Title of Course

# Introduction to Climate Change Management

## Title of the presentation

# The science background of climate change and global warming


## др Ирма Дервишевић



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**Partnership for Promotion and Popularization of Electrical Mobility through Transformation and Modernization of WB HEIs Study Programs/PELMOB**

Call: ERASMUS-EDU-2022-CBHE-STRAND-2

Project Number: 101082860

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https://pr.ac.rs/


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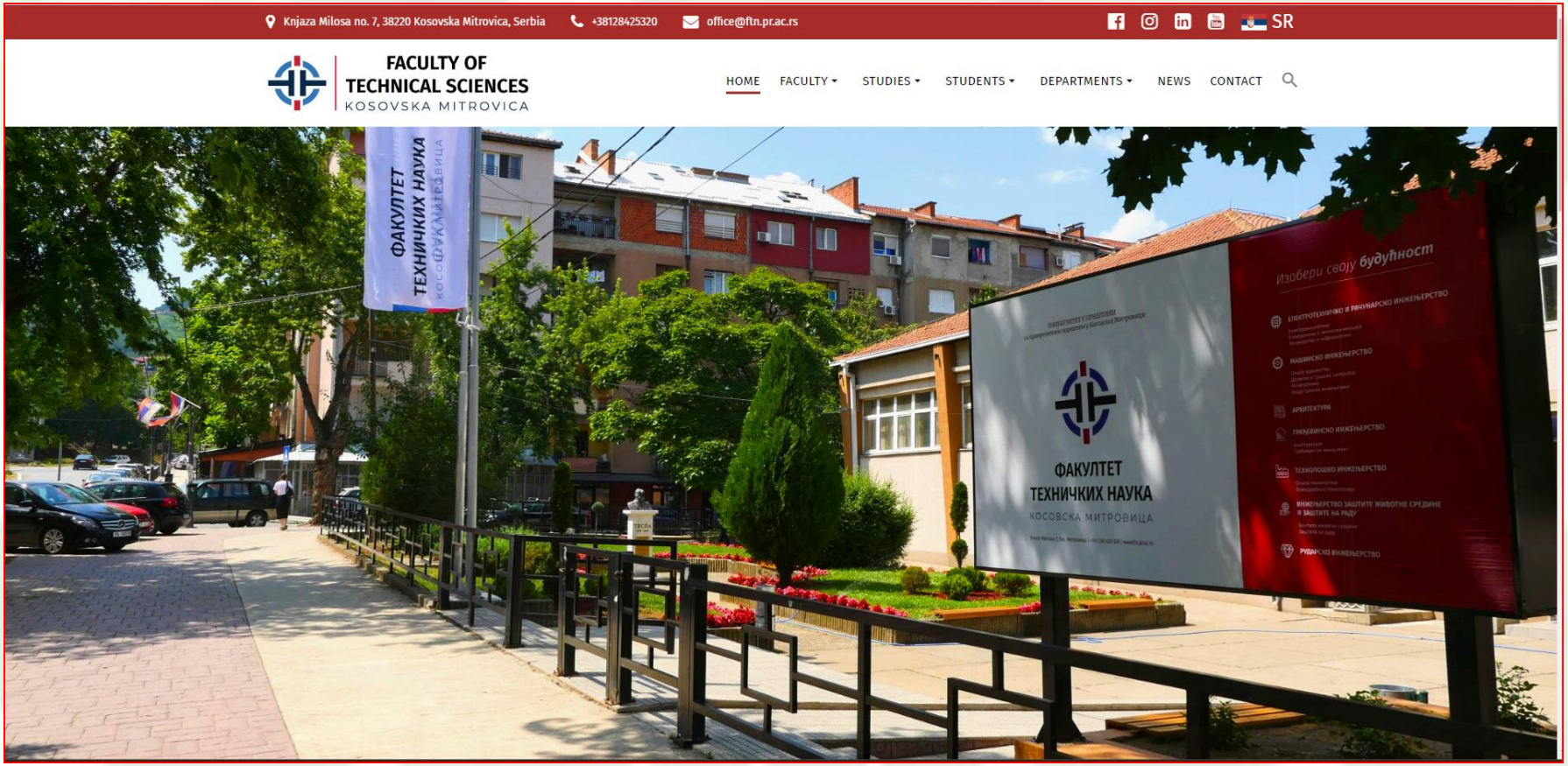

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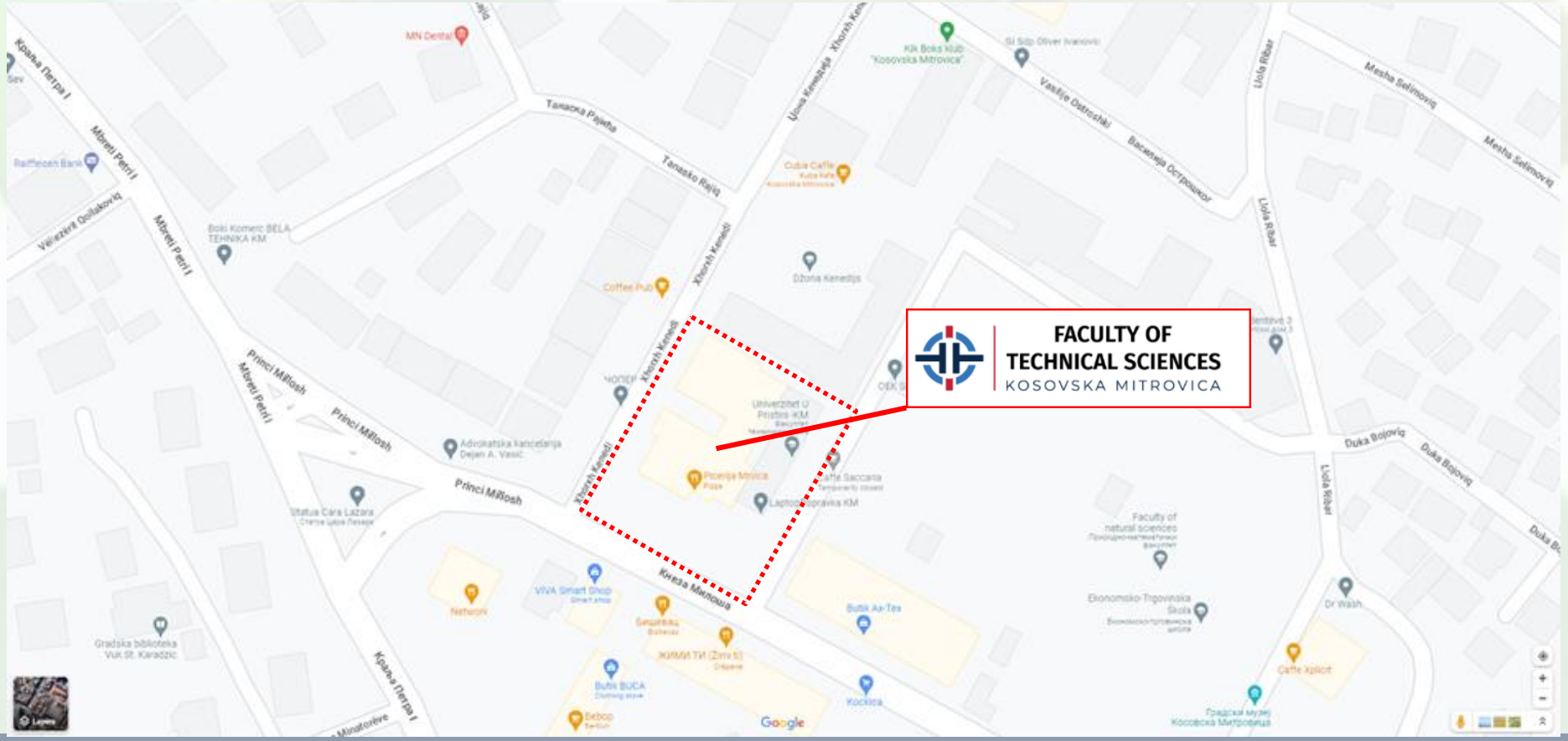

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# The science background of climate change and global warming

## Introduction

The implications of climate change and global warming are profound: they threaten ecosystems, disrupt food and water supply chains, and pose severe risks to human health and livelihoods. Addressing these issues requires urgent, coordinated efforts at local, national, and global levels to mitigate impacts and adapt to an evolving climate.

## Key Differences

**Global Warming**

Focuses on temperature rise.

A symptom of human activity.

*Example*: +1.2°C since 1850

**Climate Change**

Encompasses all climate impacts.

The collective consequence of warming.

*Examples*: Hurricanes, droughts, Arctic ice loss.

# The science background of climate change and global warming

## Definition of Climate Change

Broader changes in Earth's climate systems caused by global warming.

Includes rising temperatures, melting ice, sea-level rise, extreme weather, and shifts in ecosystems

Climate change refers to significant, long-term changes in the global climate, encompassing shifts in temperatures, precipitation patterns, and other atmospheric conditions. While climate change can occur naturally over large periods, human activities, especially since the Industrial Revolution, have accelerated these changes, leading to unprecedented impacts on our environment.

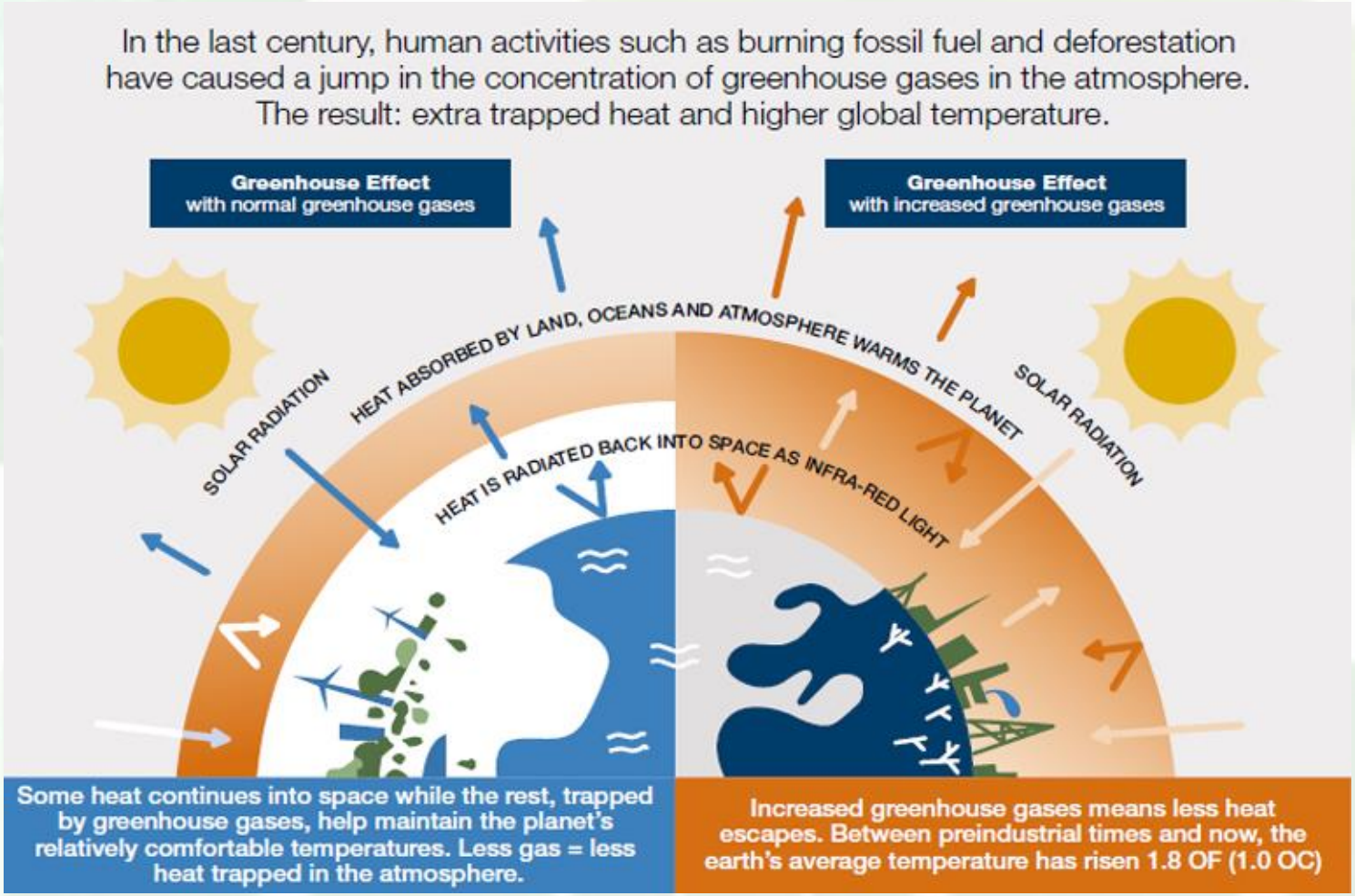
# The science background of climate change and global warming

## Definition of Global Warming

Global warming, a key aspect of climate change, specifically refers to the increase in Earth's average surface temperature due to the buildup of greenhouse gases (GHGs) in the atmosphere. These gases, such as carbon dioxide, methane, and nitrous oxide, trap heat from the sun, creating a “greenhouse effect.” This phenomenon is primarily driven by human actions—such as burning fossil fuels for energy, deforestation, and agricultural practices—resulting in rising temperatures and altered weather patterns around the globe.

# The science background of climate change and global warming

## The Greenhouse Effect




https://www.man.com/insights/data-driven-approach-to-climate-change

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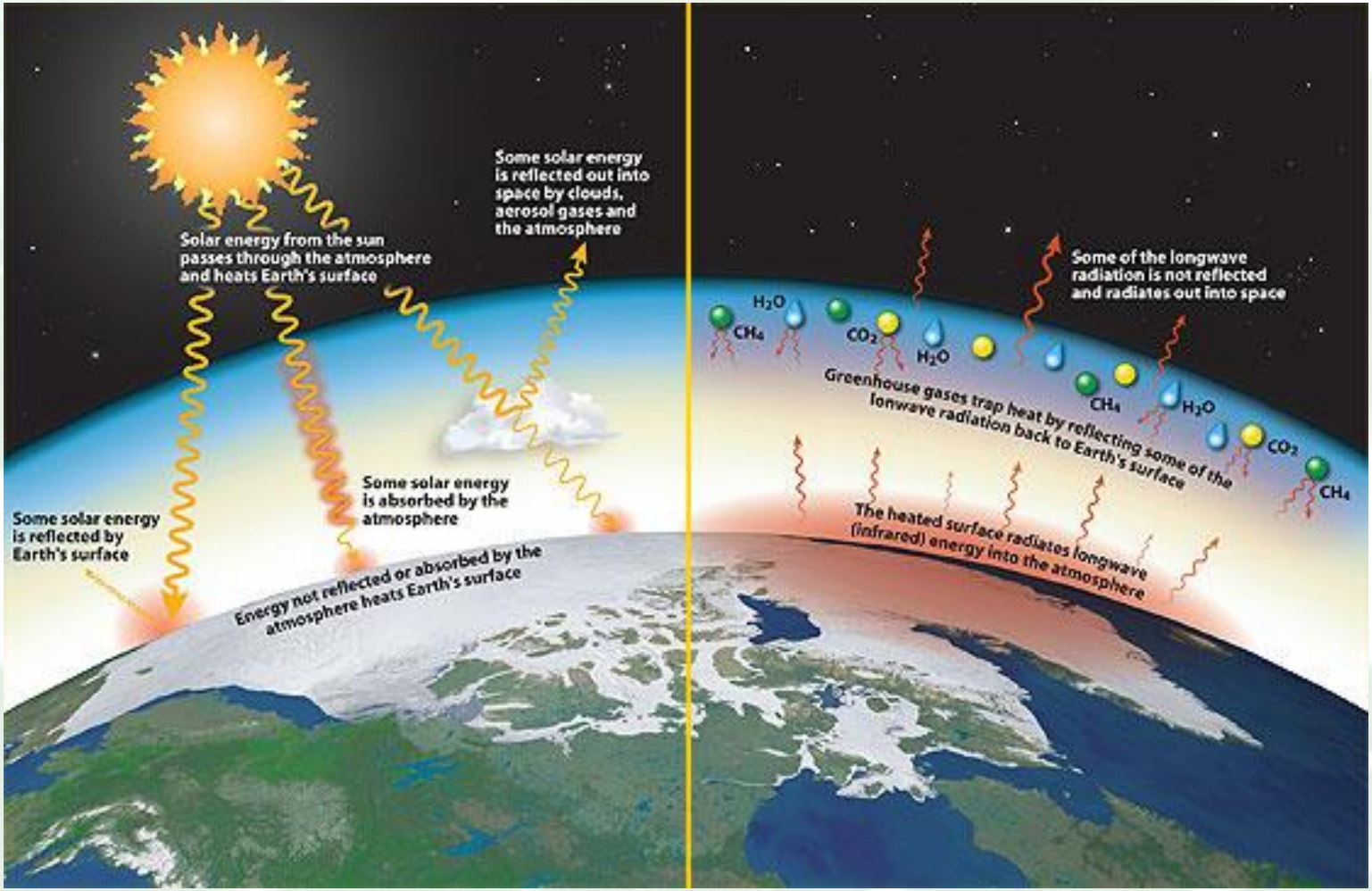
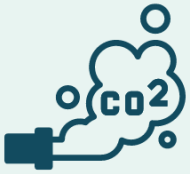
## The science background of climate change and global warming

## The Greenhouse Effect




https://forces.si.edu/atmosphere/02_04_07.html

# Five Major Greenhouse Gases




Carbon dioxide (CO2)


Methane (CH4)


Nitrous Oxide (N2O)

Fluorinated Gases


Water Vapor (H2O)

carbon collective

# The science background of climate change and global warming

## The Greenhouse Effect


| Greenhouse Gas | Formula |
|---|---|
| Carbon dioxide | $CO_2$ |
| Methane | $CH_4$ |
| Nitrous oxide | $N_2O$ |
| Sulphur hexafluoride | $SF_6$ |
| Hydrofluorocarbon-23 | $CHF_3$ |
| Hydrofluorocarbon-32 | $CH_2F_2$ |
| Perfluoromethane | $CF_4$ |
| Perfluoroethane | $C_2F_6$ |
| Perfluoropropane | $C_3F_8$ |
| Perfluorobutane | $C_4F_{10}$ |
| Perfluorocyclobutane | $c\text{-}C_4F_8$ |
| Perfluoropentane | $C_5F_{12}$ |
| Perfluorohexane | $C_6F_{14}$ |

# Sources of greenhouse gases

| Gas | Main source | Greenhouse factor | Relative abundance |
|---|---|---|---|
| $H_2O$ | Evaporation of oceans and lakes | 0.1 | 0.10 |
| $CO_2$ | Combustion of fossil fuels | 1 | 0.036 |
| $CH_4$ | Anaerobic decay or organic matter by livestock | 30 | 0.0017 |
| $N_2O$ | Artificial fertilizers | 160 | 0.0003 |
| CFCs | Refrigerants and solvents | 20000 | 0.00001 |

https://www.youtube.com/watch?v=14cenIACfew

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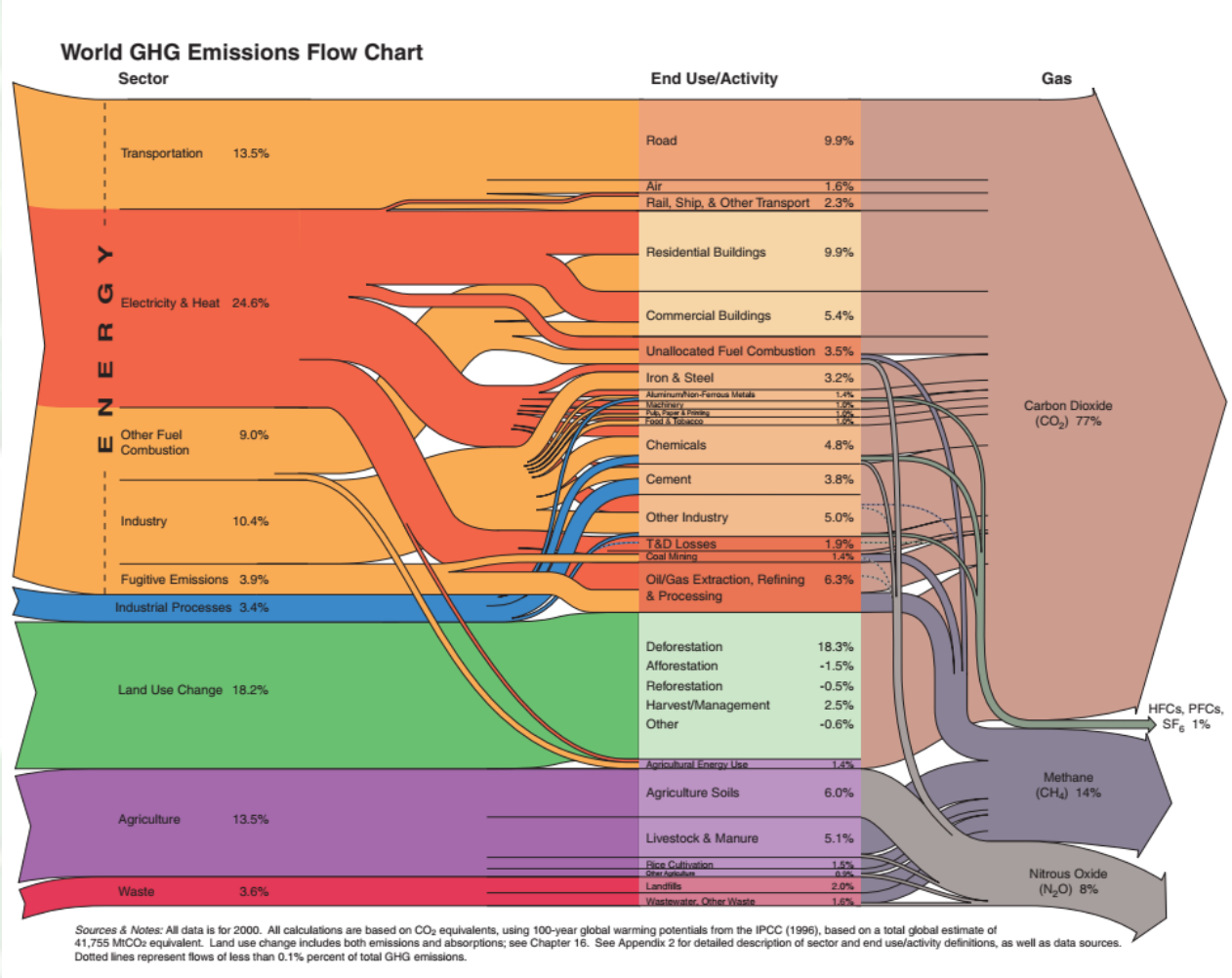
## Sources of Greenhouse Gases




http://pdf.wri.org/world_greenhouse_gas_emissions_flowchart.pdf

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# The science background of climate change and global warming
## Sources of Greenhouse Gases

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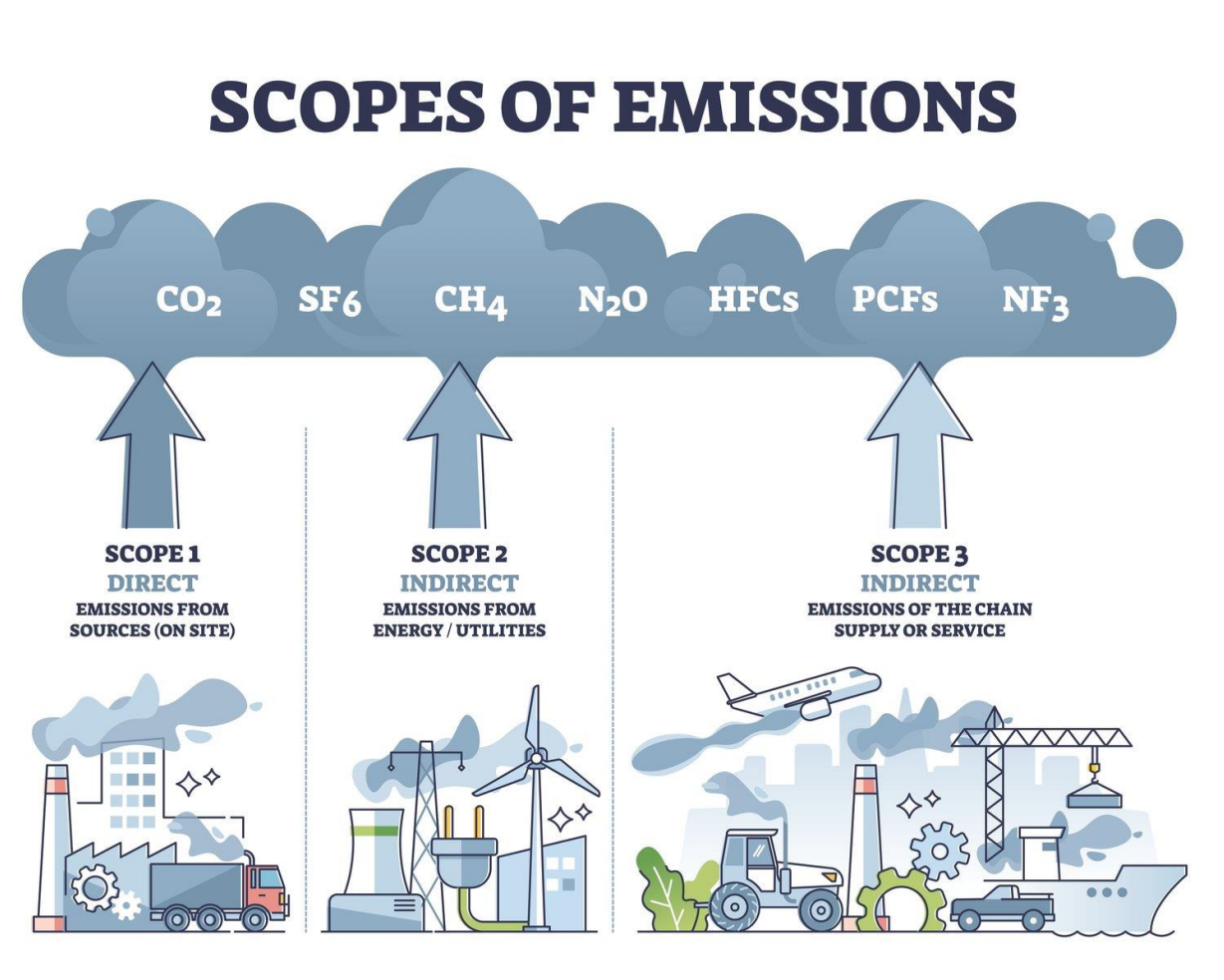


https://www.kvaroyarctic.com/the-3-most-common-greenhouse-gasses

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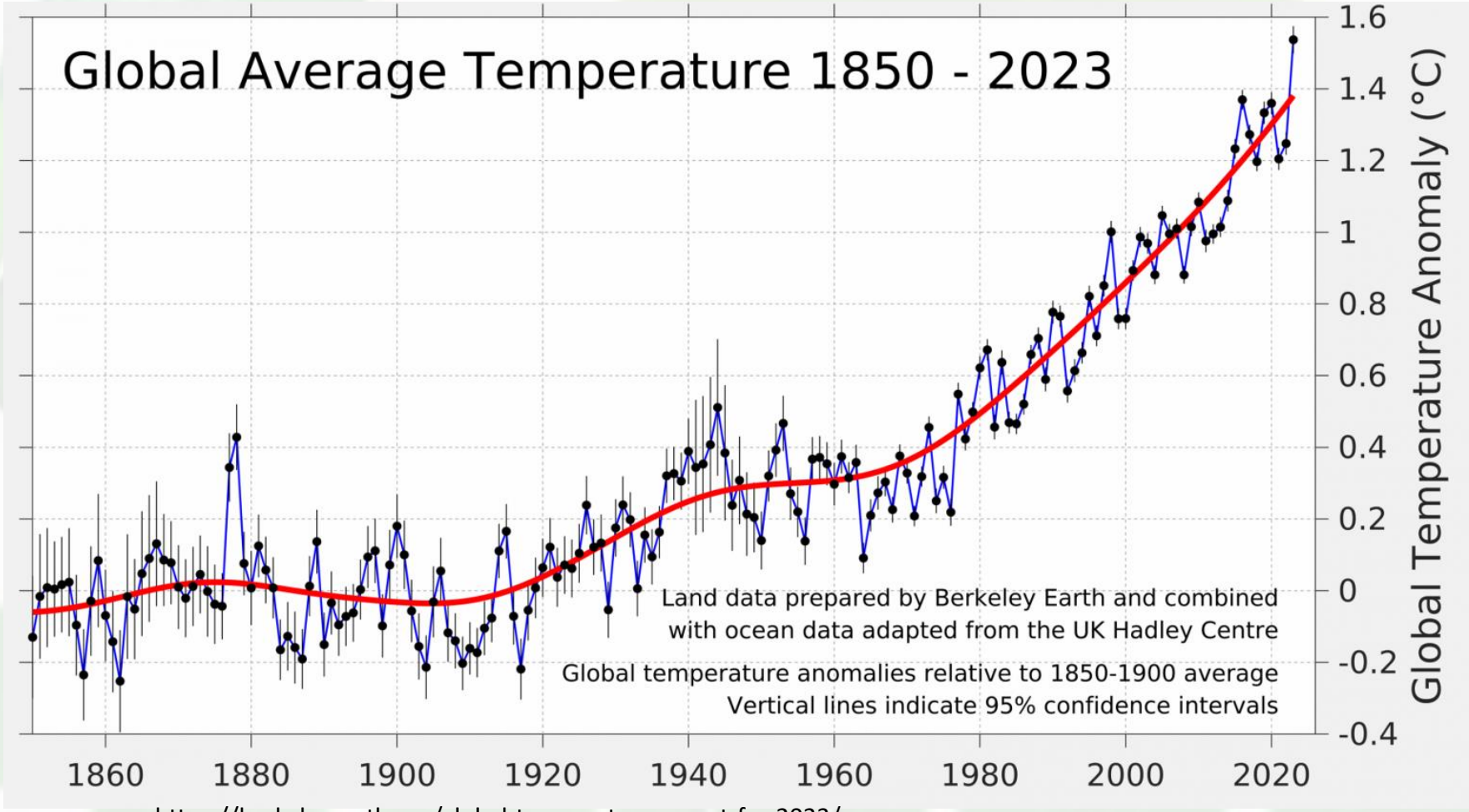
## The science background of climate change and global warming

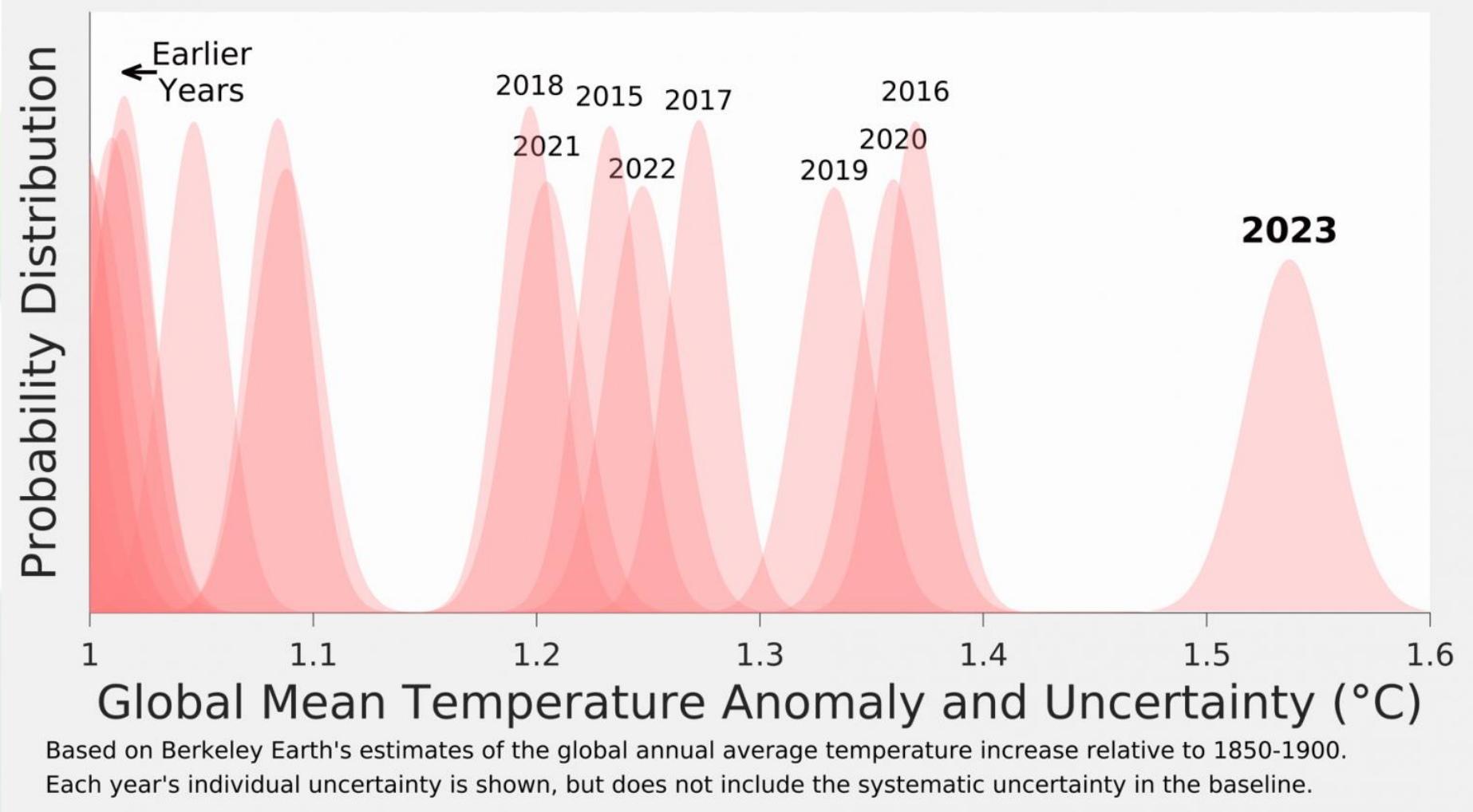
## Evidence of Climate Change




https://berkeleyearth.org/global-temperature-report-for-2023/

# The science background of climate change and global warming

## Evidence of Climate Change




Based on Berkeley Earth's estimates of the global annual average temperature increase relative to 1850-1900.
Each year's individual uncertainty is shown, but does not include the systematic uncertainty in the baseline.

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## The science background of climate change and global warming

## Evidence of Climate Change

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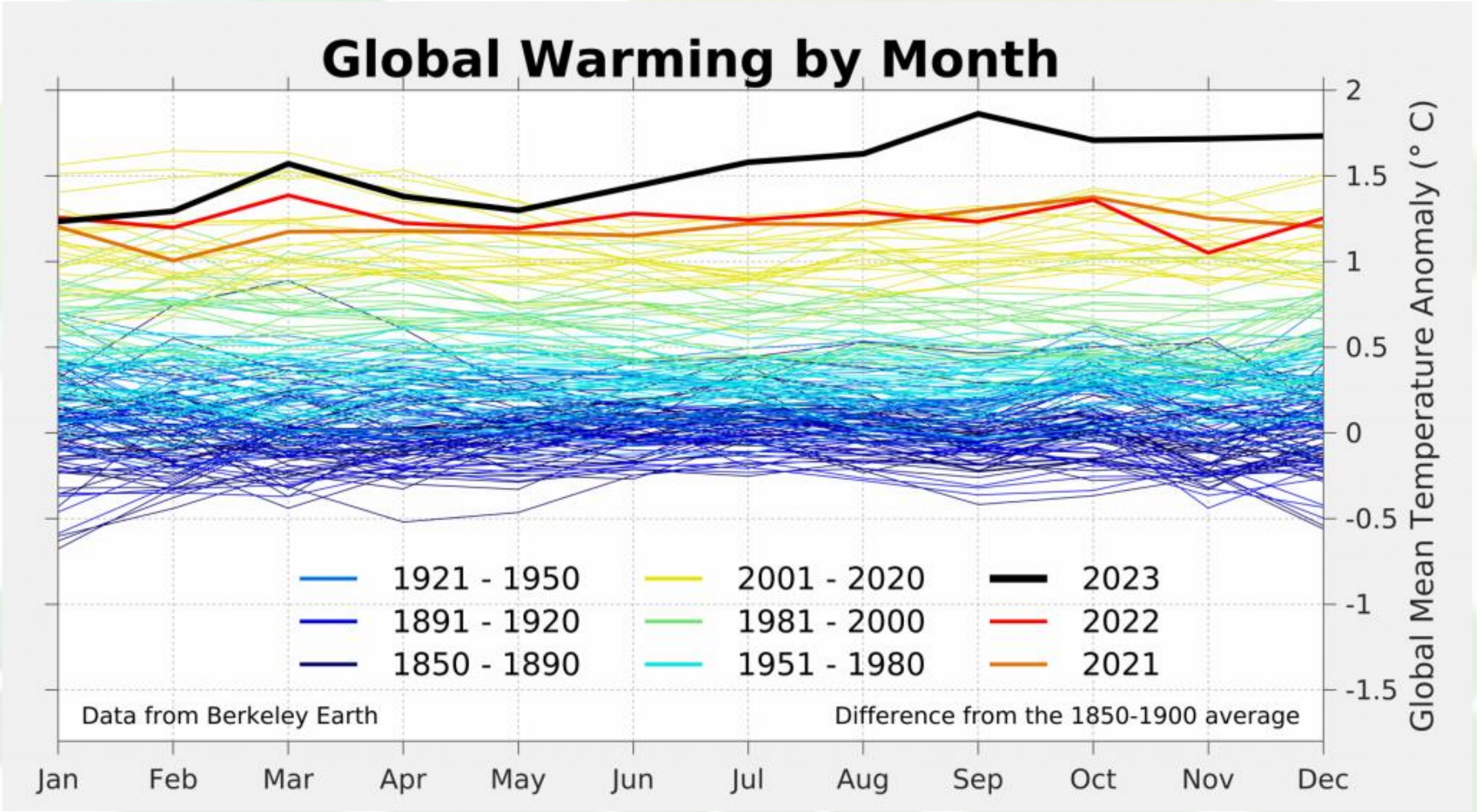

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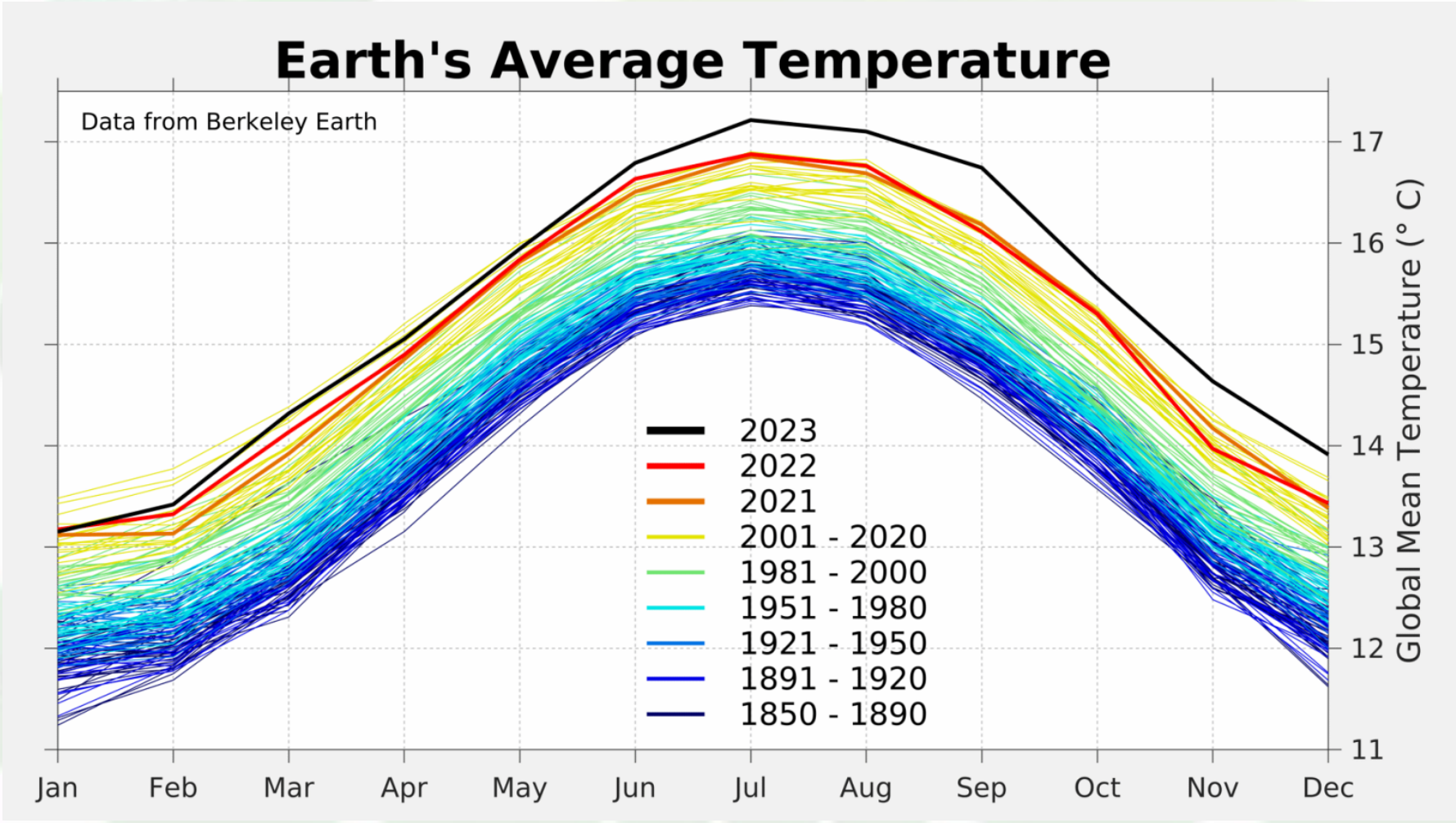

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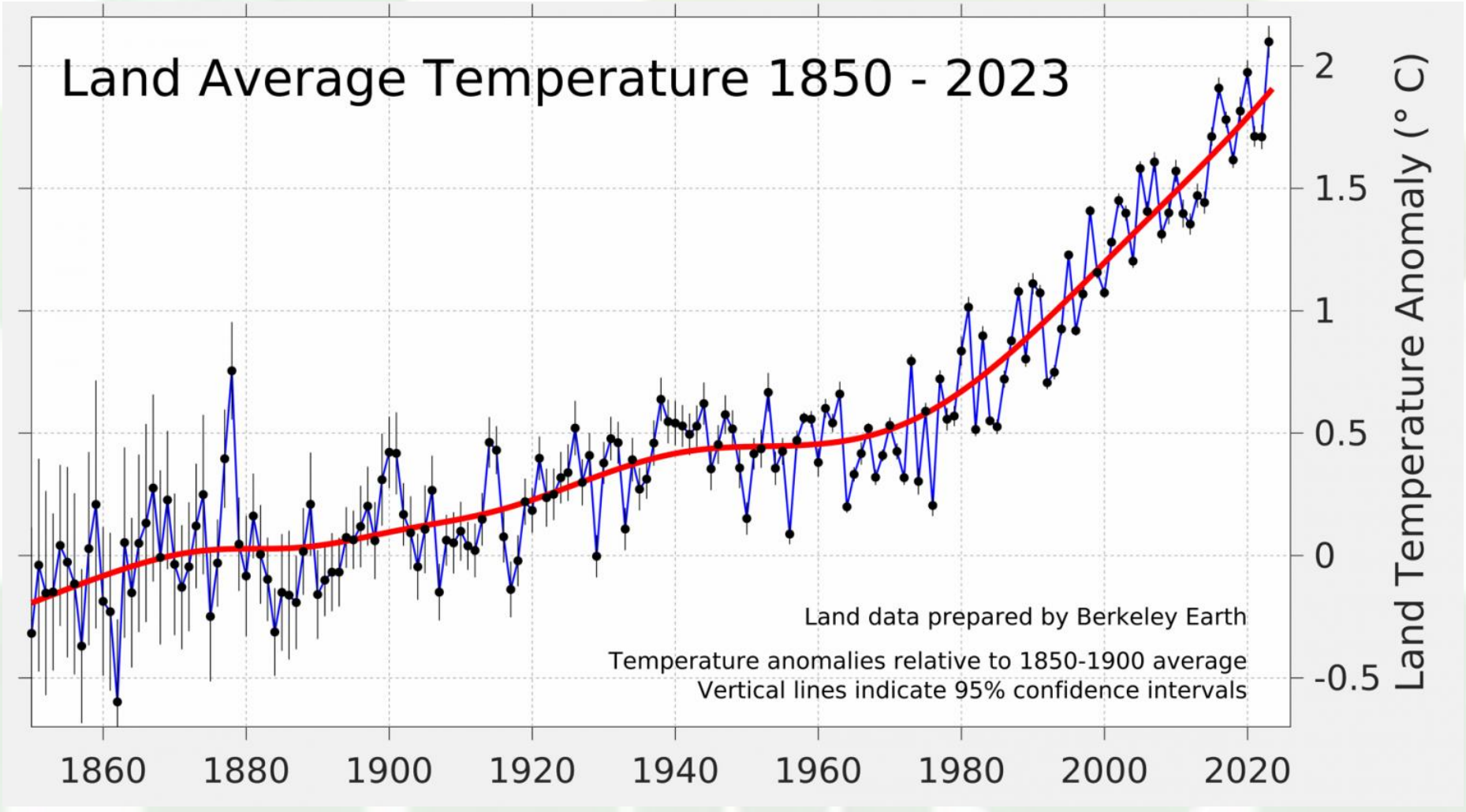

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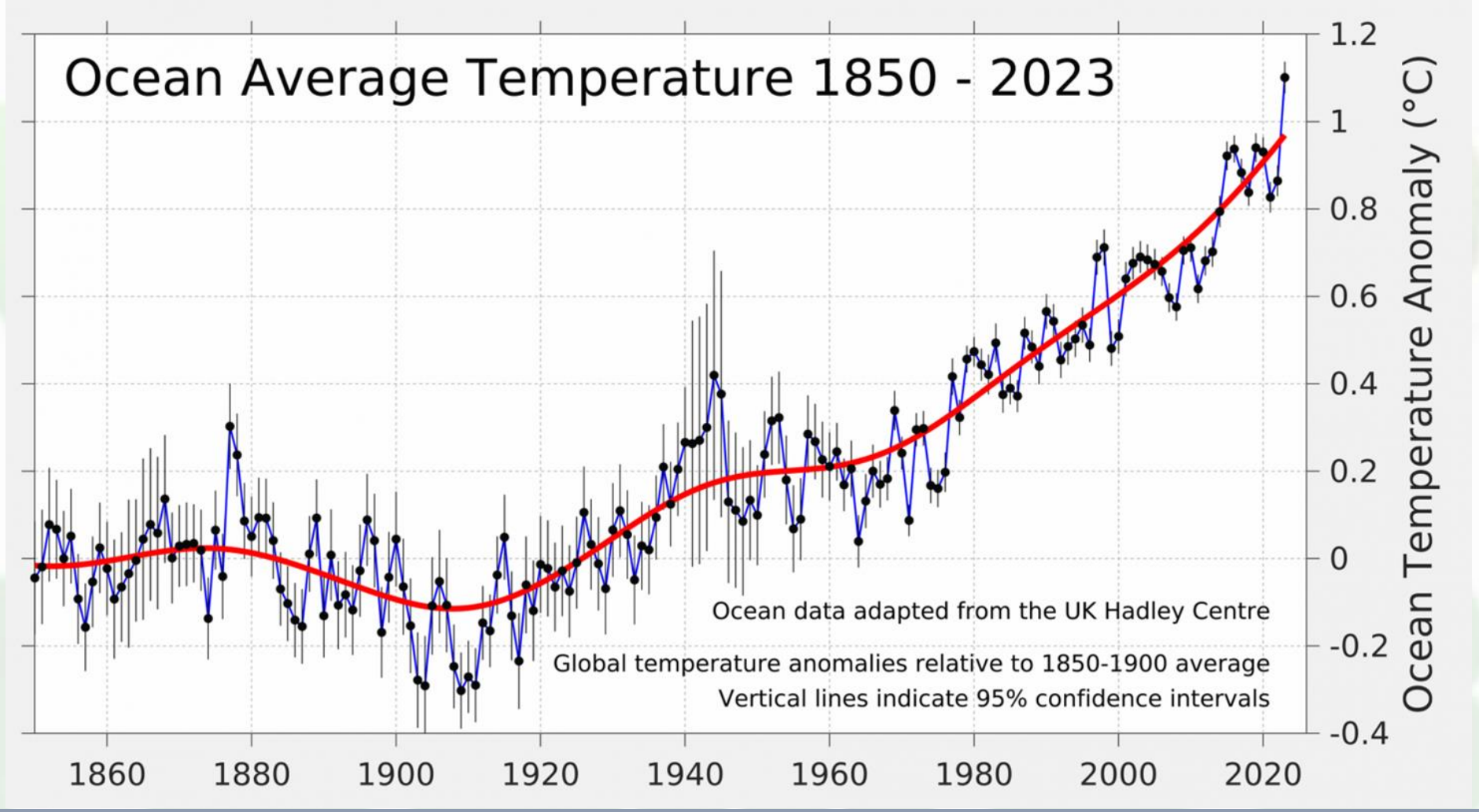

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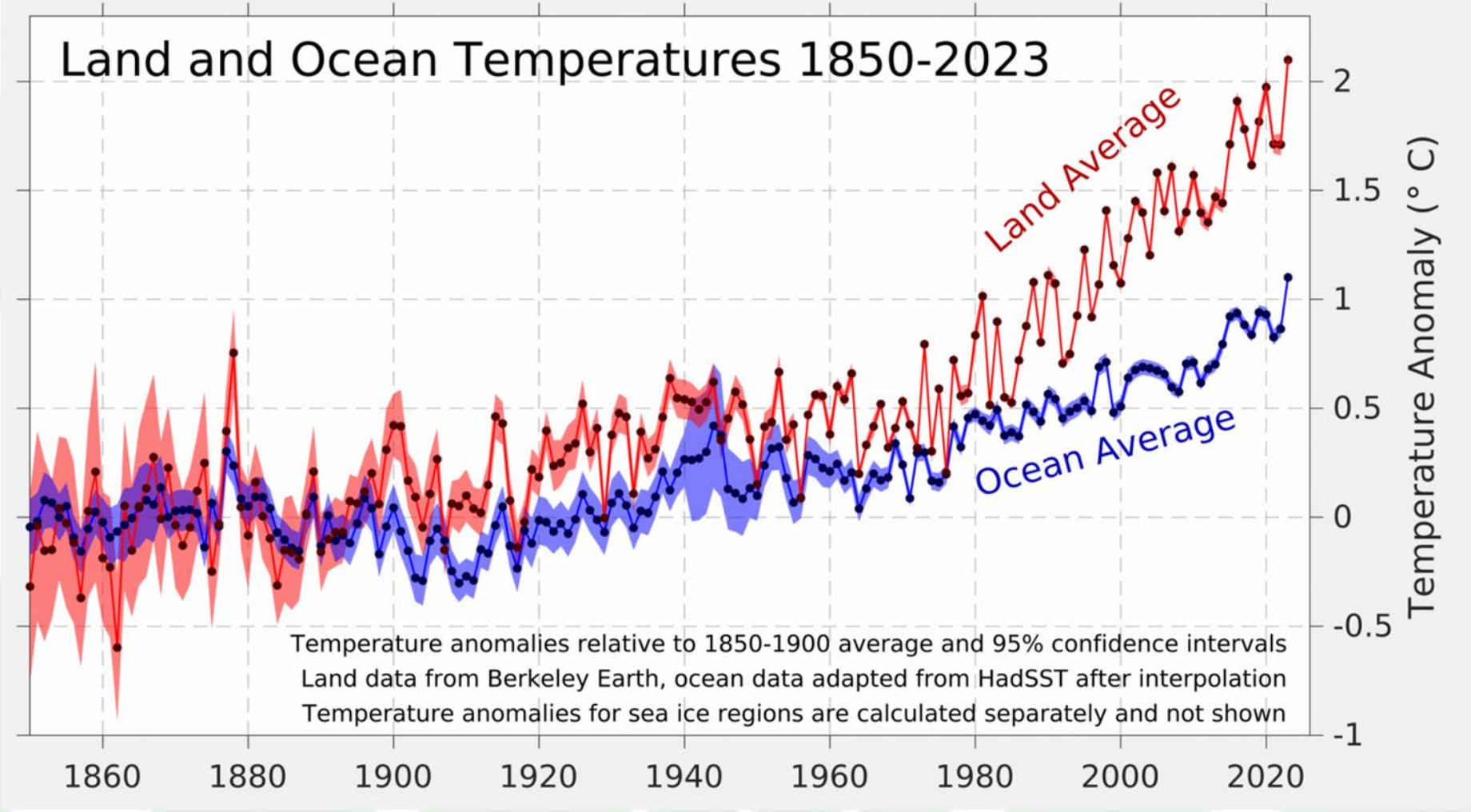
## Evidence of Climate Change



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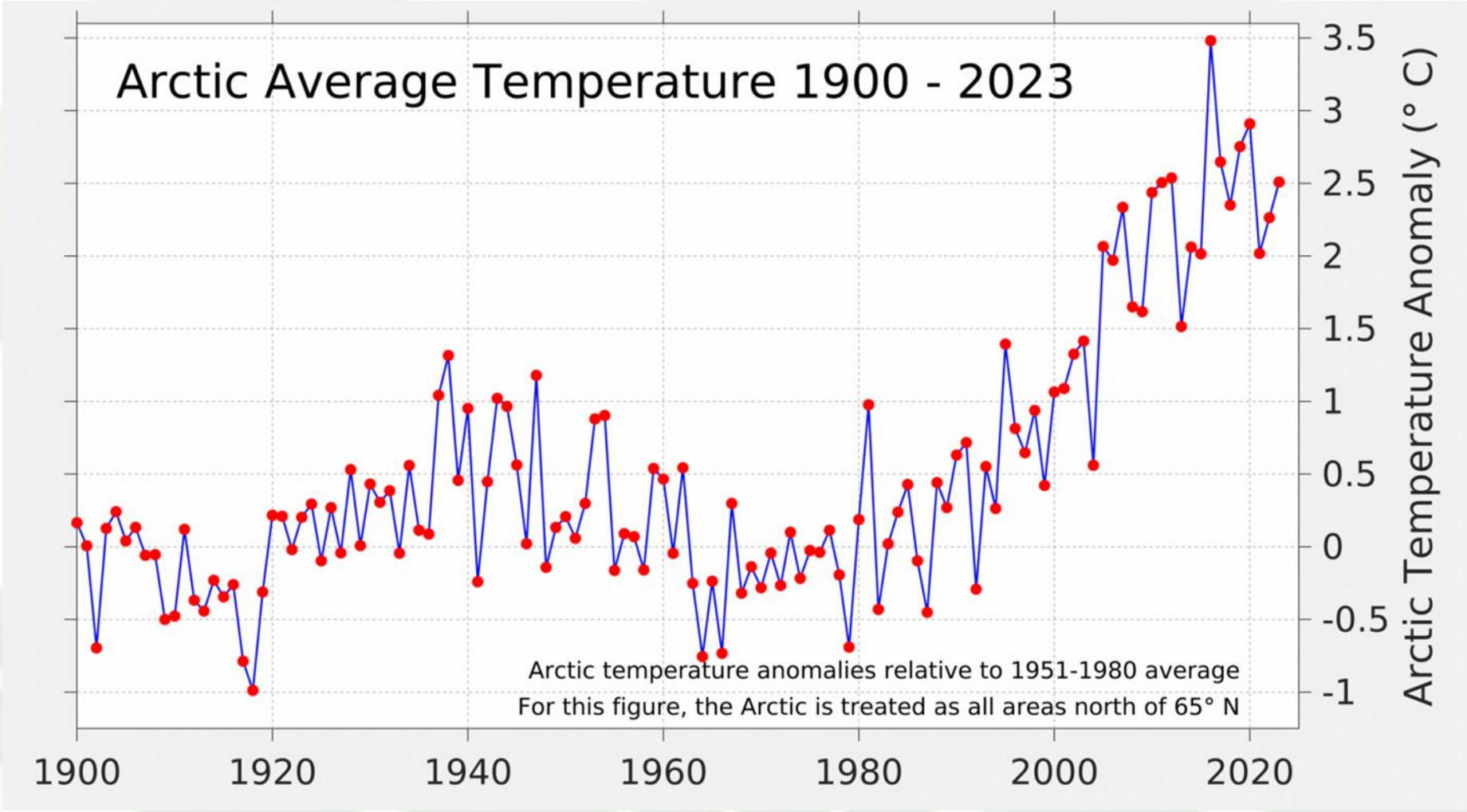

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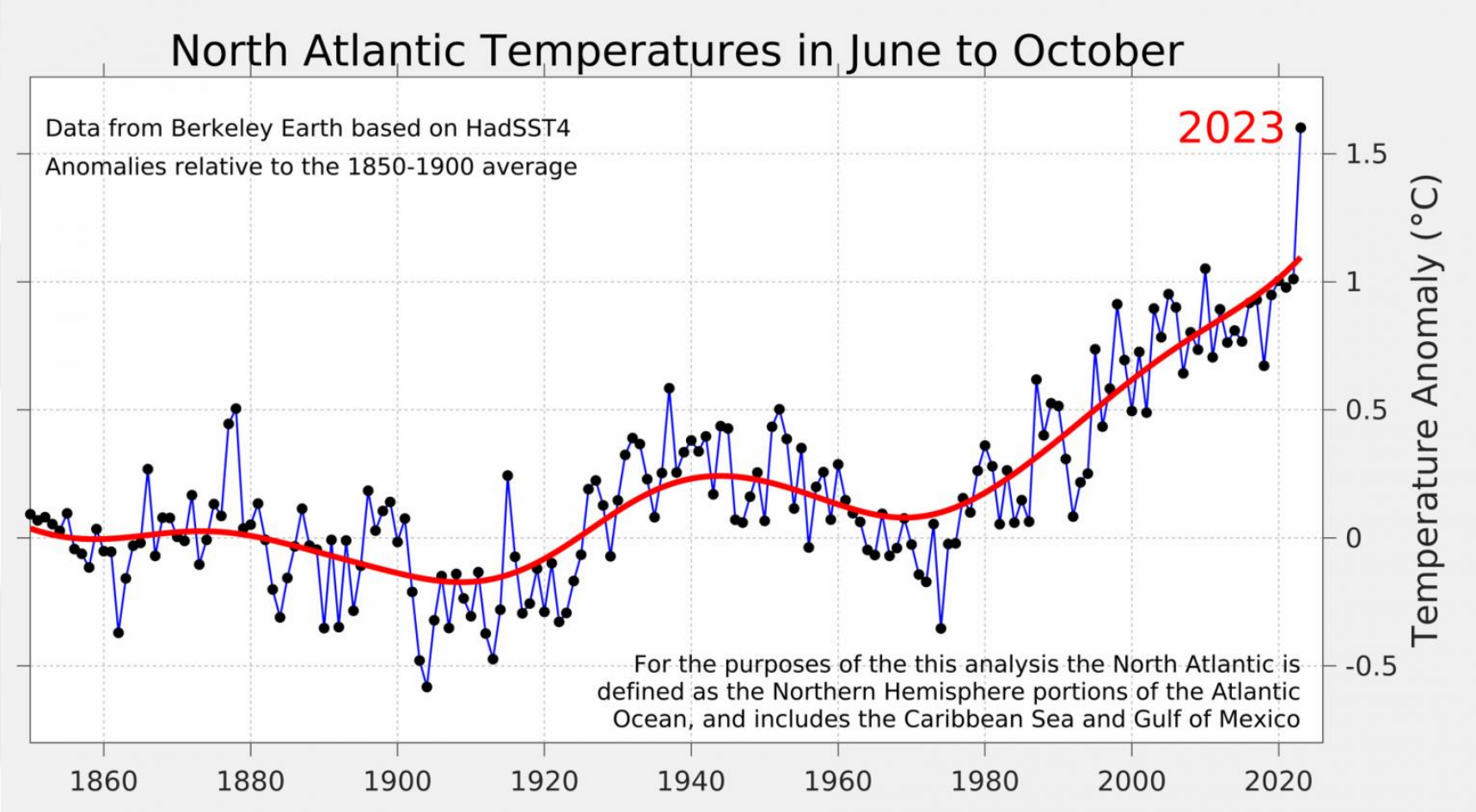

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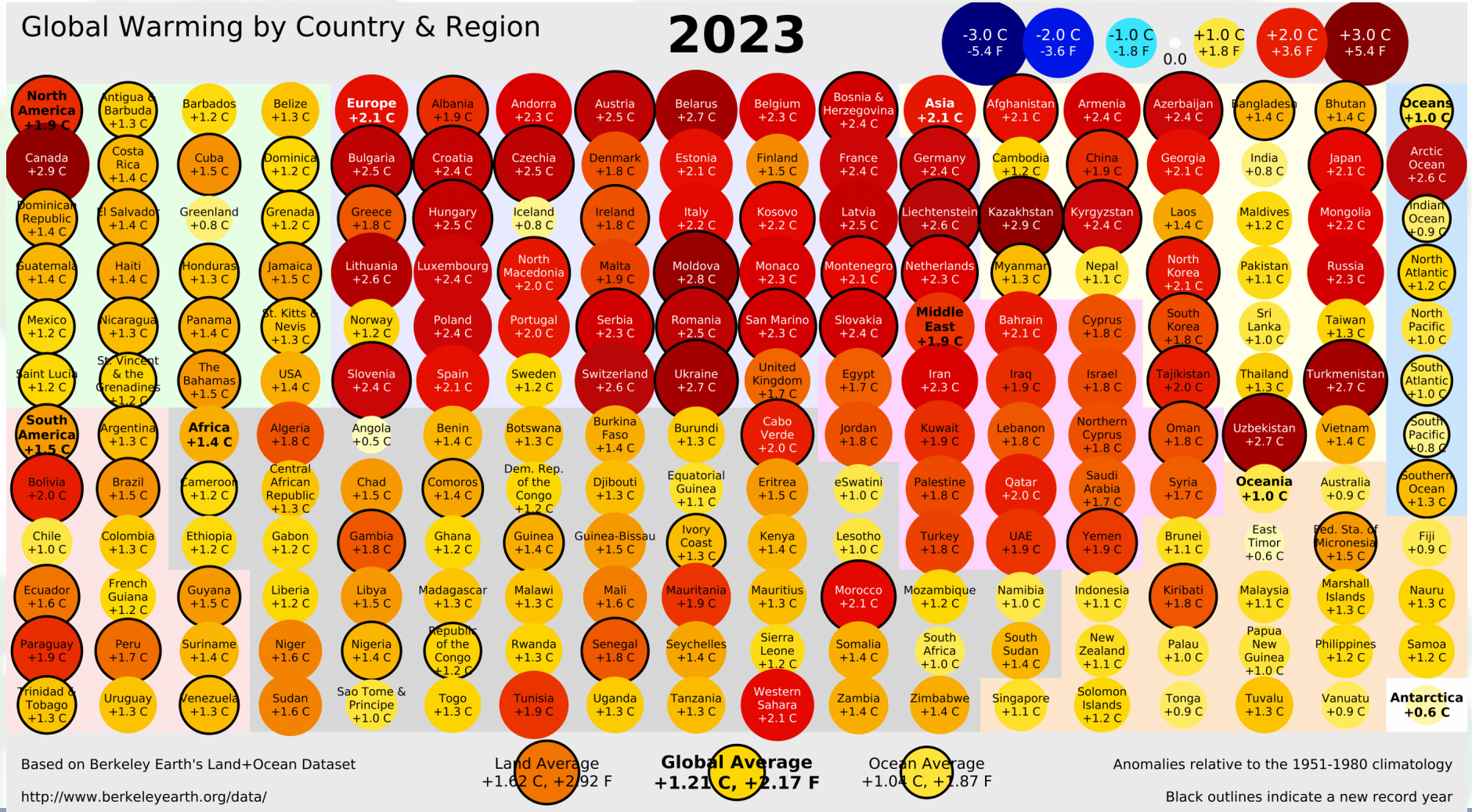

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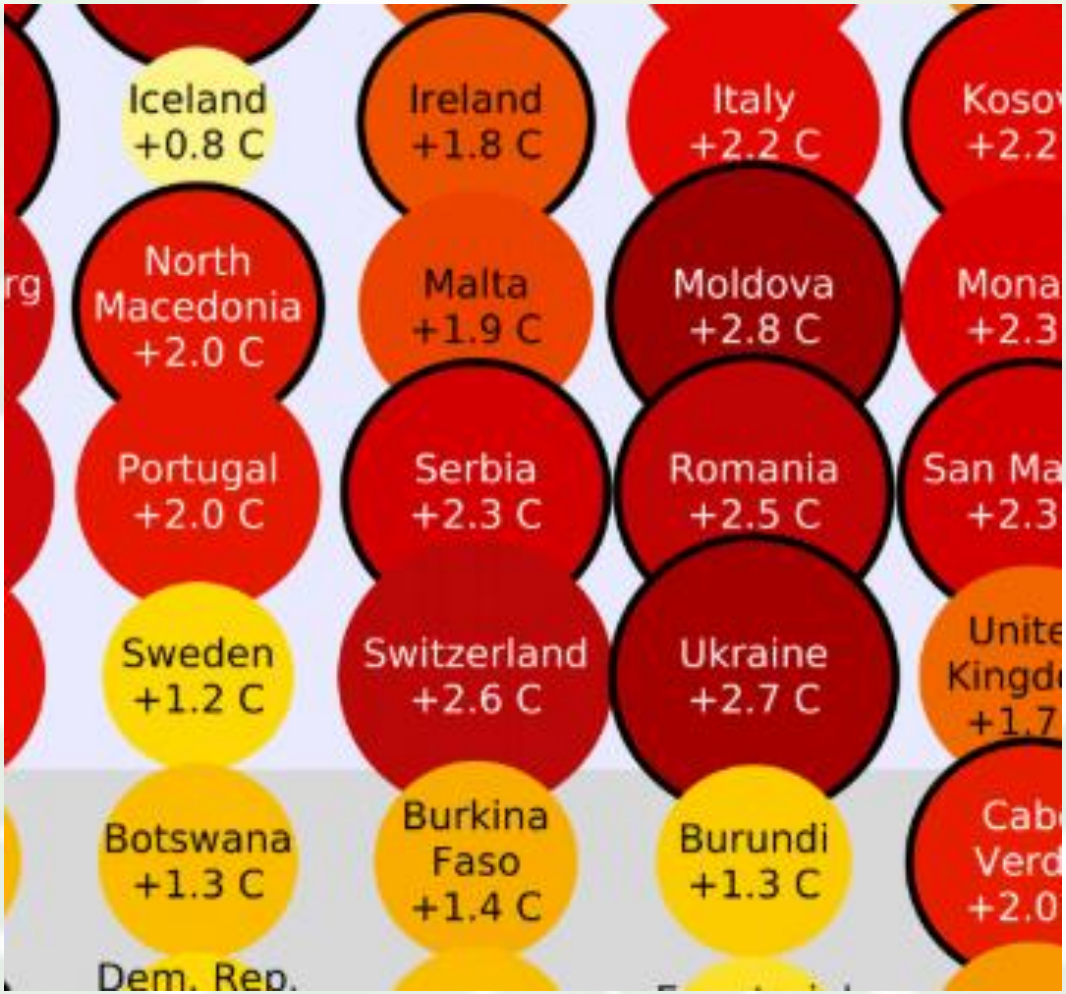



**2023**

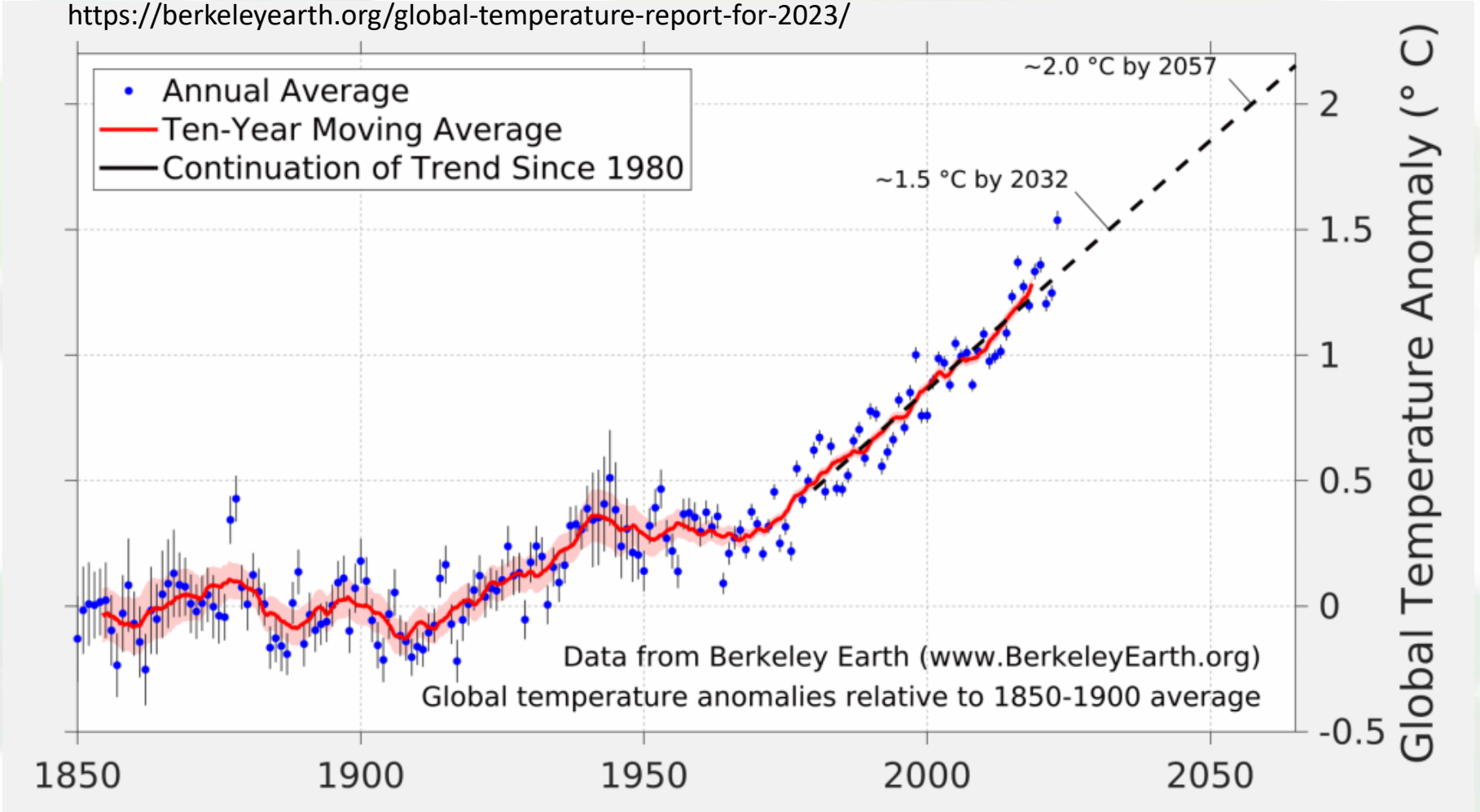
**SERBIA**
**+2.3°C**

**GLOBAL LAND AVERAGE**
**+1.62°C**

# The science background of climate change and global warming

## Evidence of Climate Change

https://berkeleyearth.org/global-temperature-report-for-2023/



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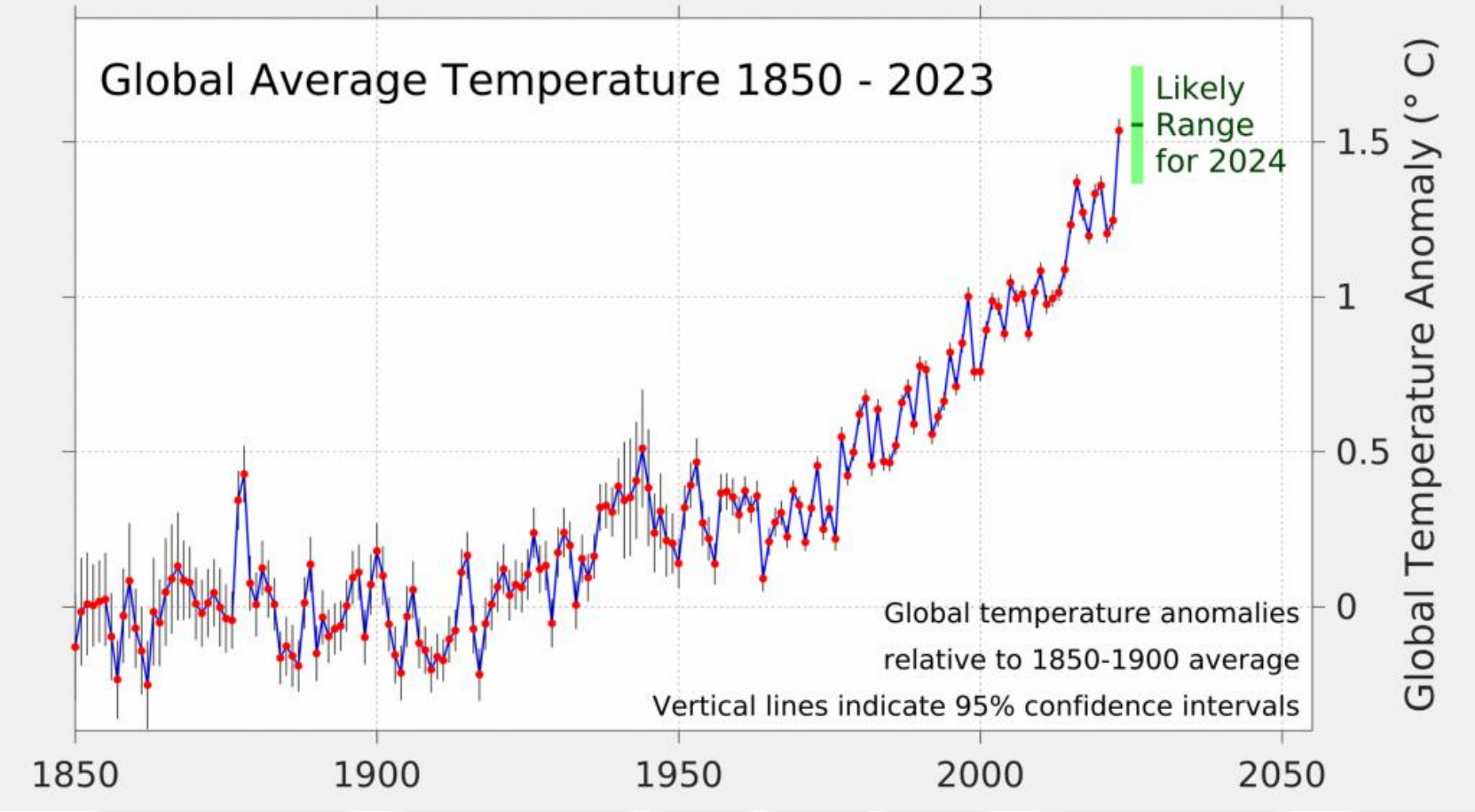

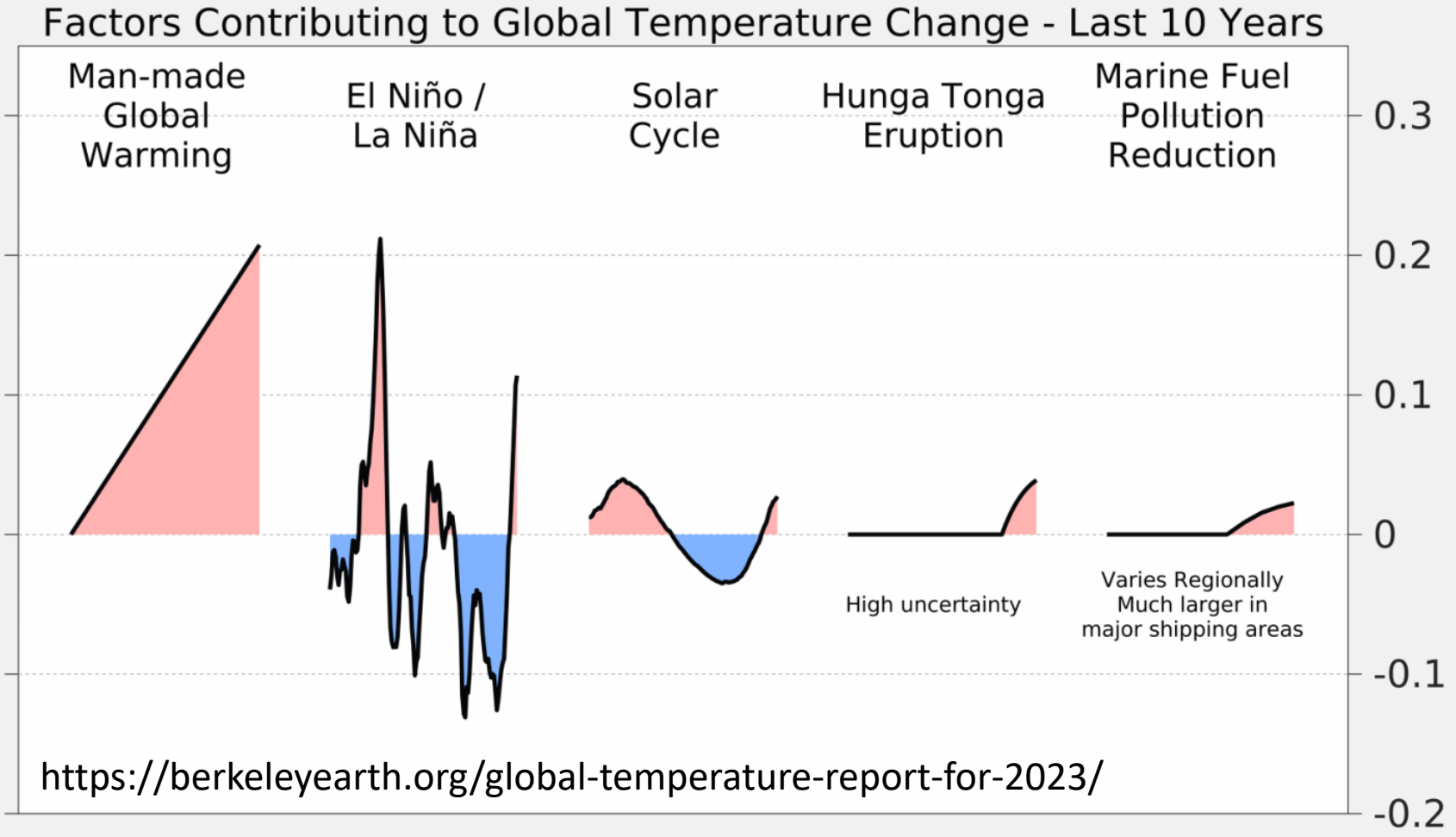
Factors Contributing to Global Temperature Change - Last 10 Years
Man-made Global Warming
El Niño / La Niña
Solar Cycle
Hunga Tonga Eruption
Marine Fuel Pollution Reduction
High uncertainty
Varies Regionally
Much larger in major shipping areas
0.3
0.2
0.1
0
-0.1
-0.2
Global Temperature Impact (° C)
https://berkeleyearth.org/global-temperature-report-for-2023/

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## The science background of climate change and global warming

## Impacts of Climate Change

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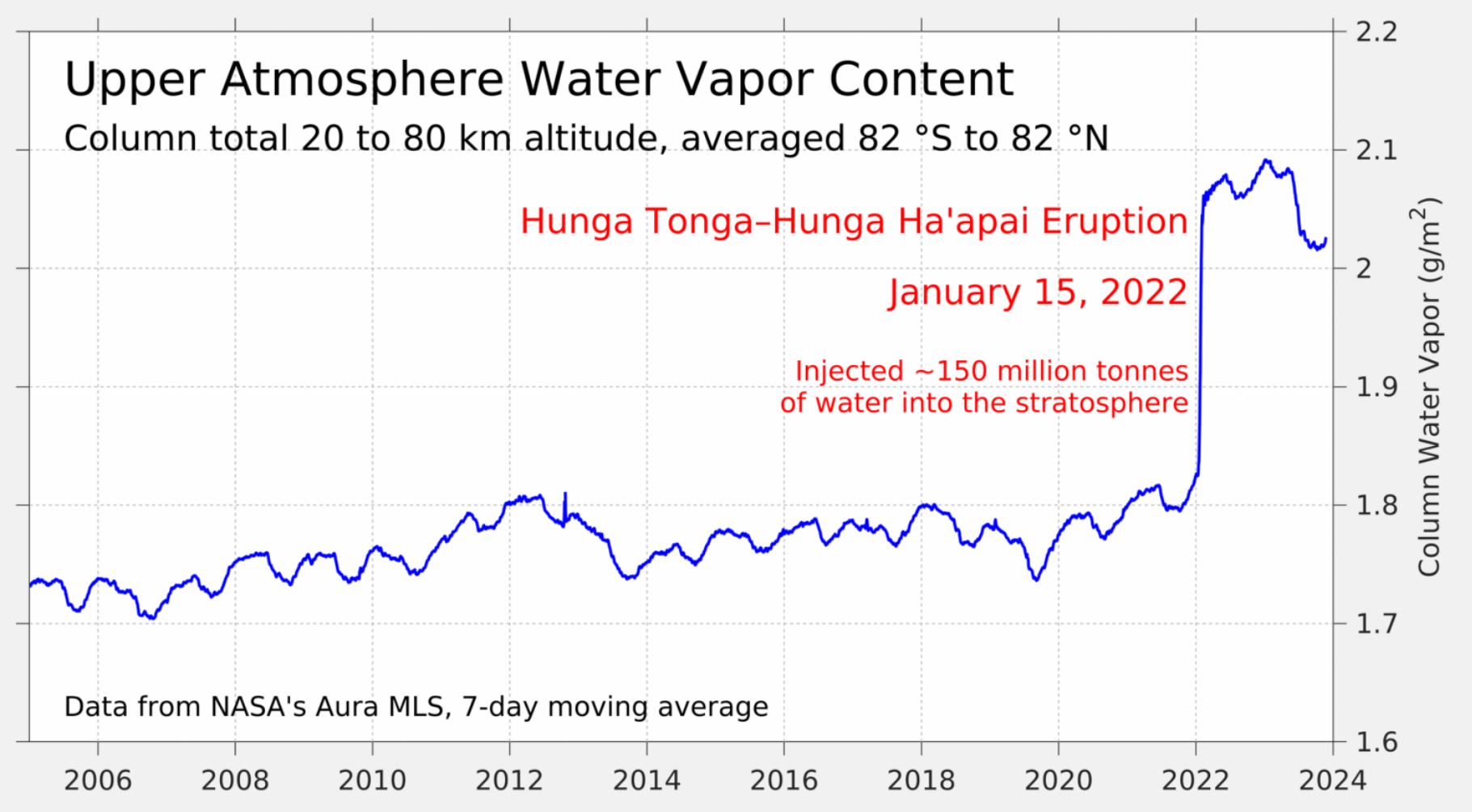

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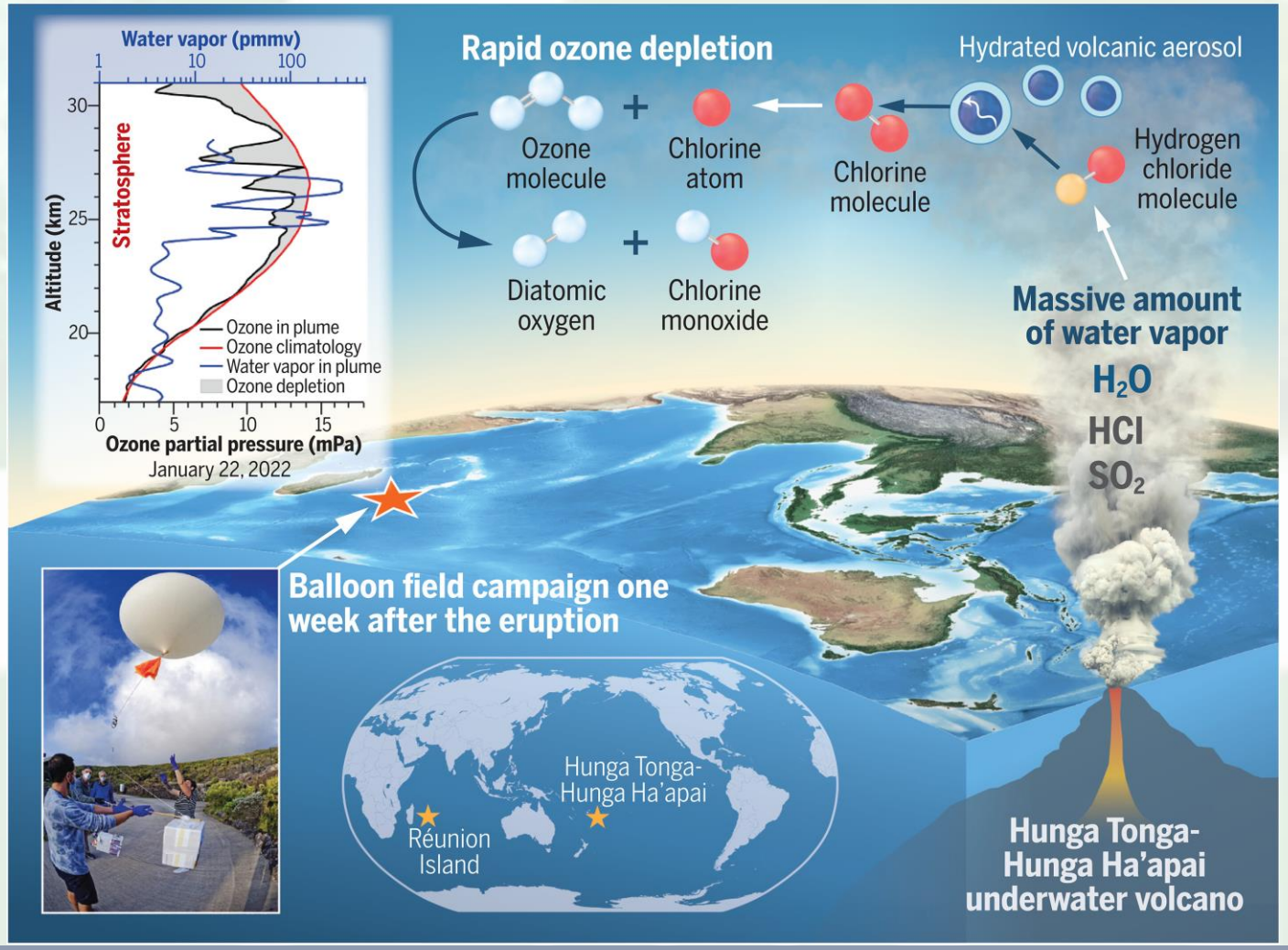

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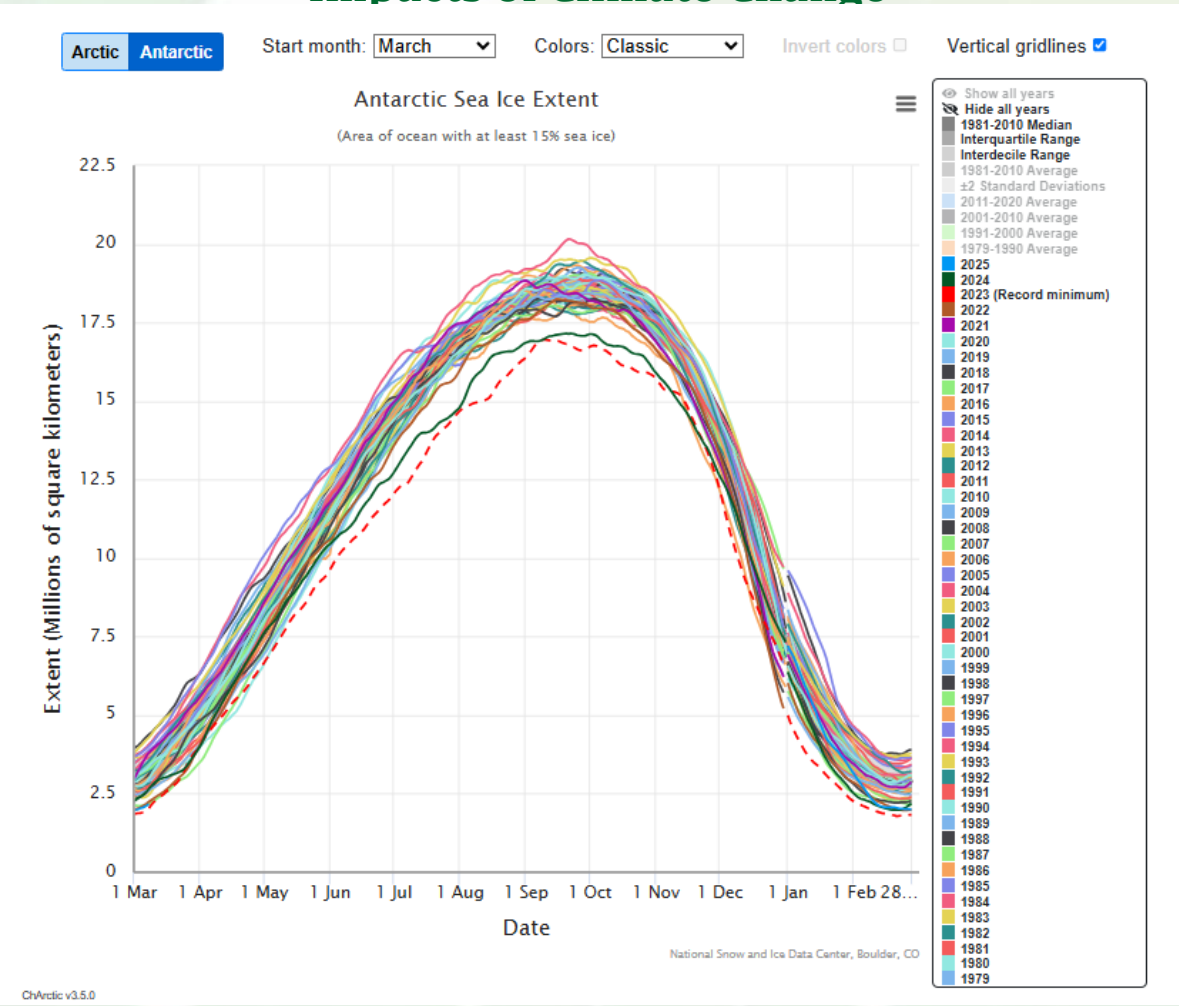


https://nsidc.org/sea-ice-today/sea-ice-tools/charctic-interactive-sea-ice-graph

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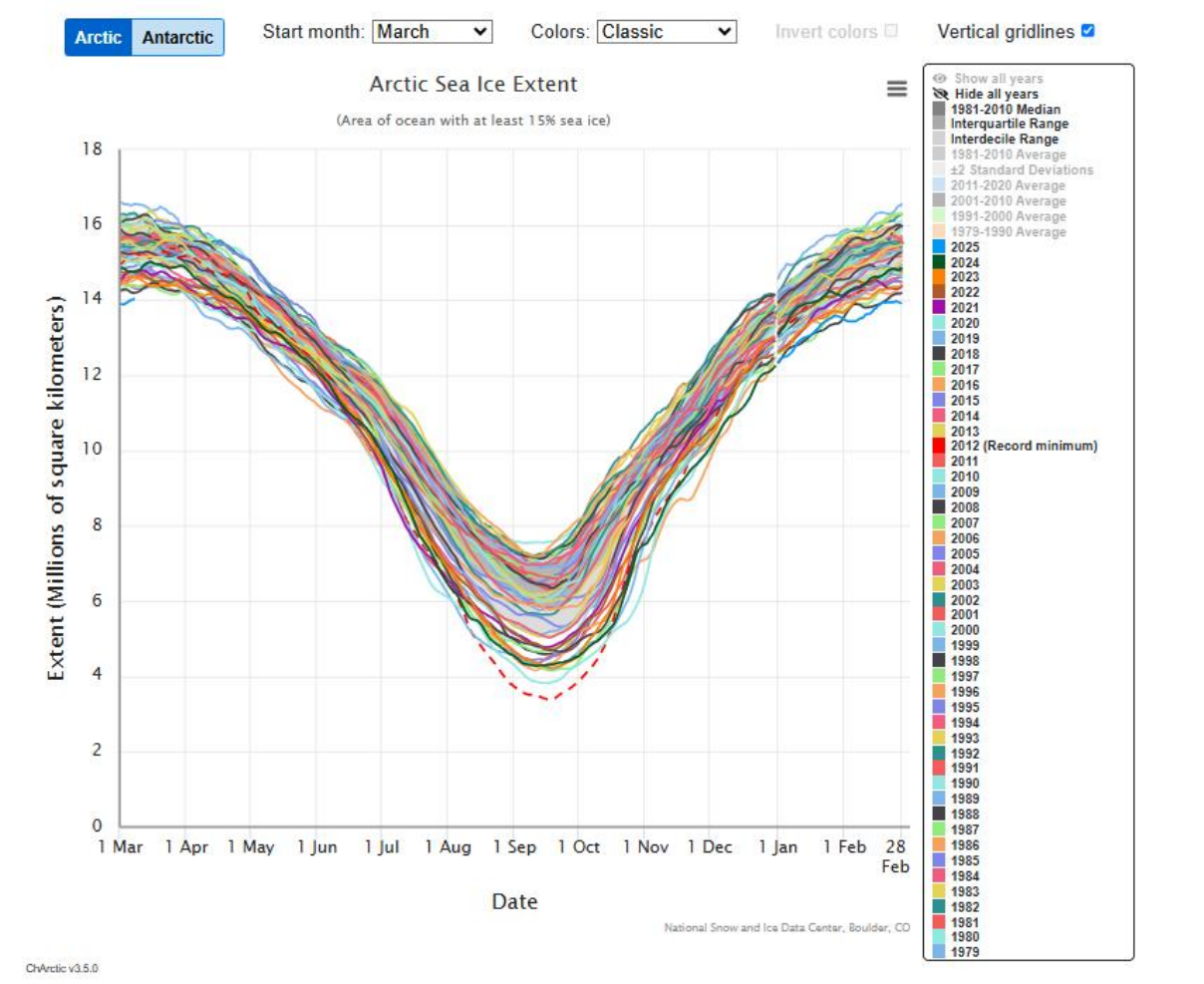


https://nsidc.org/sea-ice-today/sea-ice-tools/charctic-interactive-sea-ice-graph

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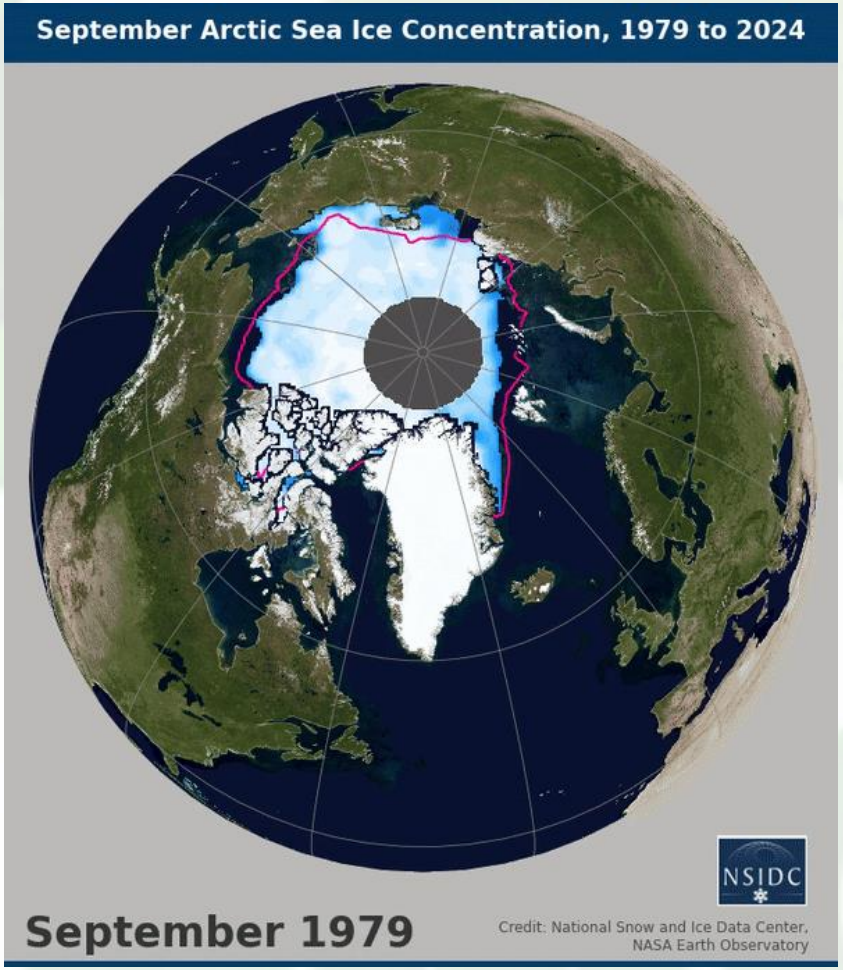


https://nsidc.org/sites/default/files/images/Data/conc-09-1979-2024-arctic.gif

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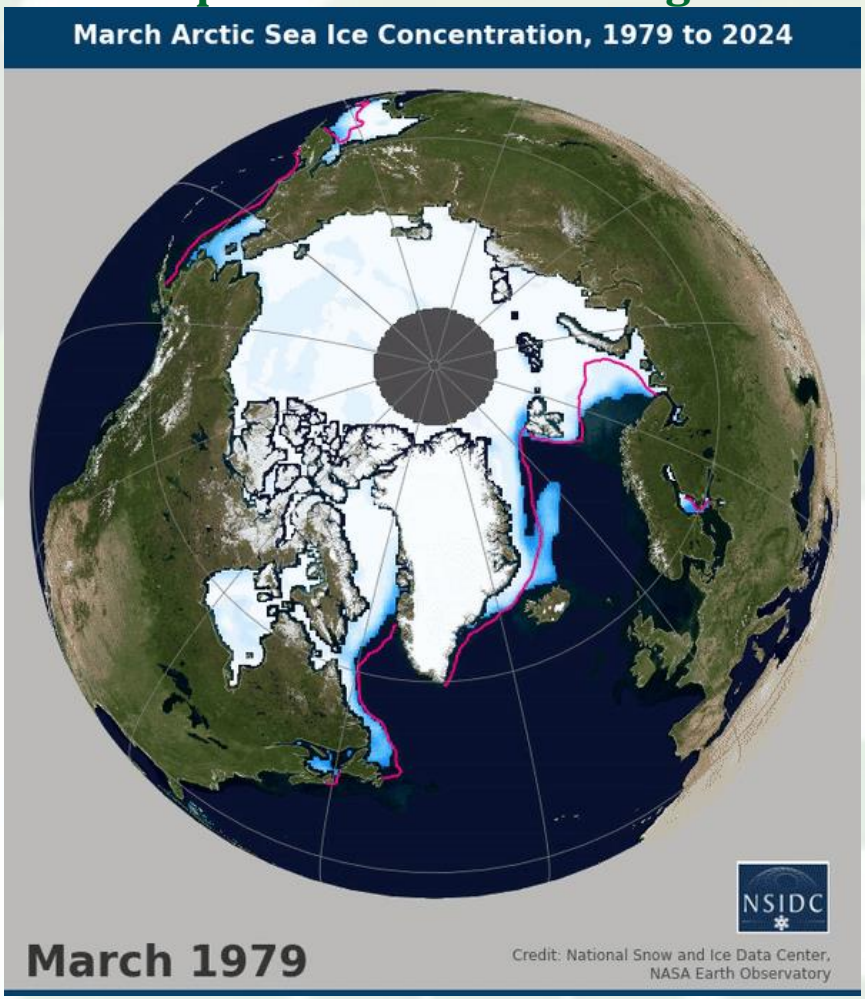


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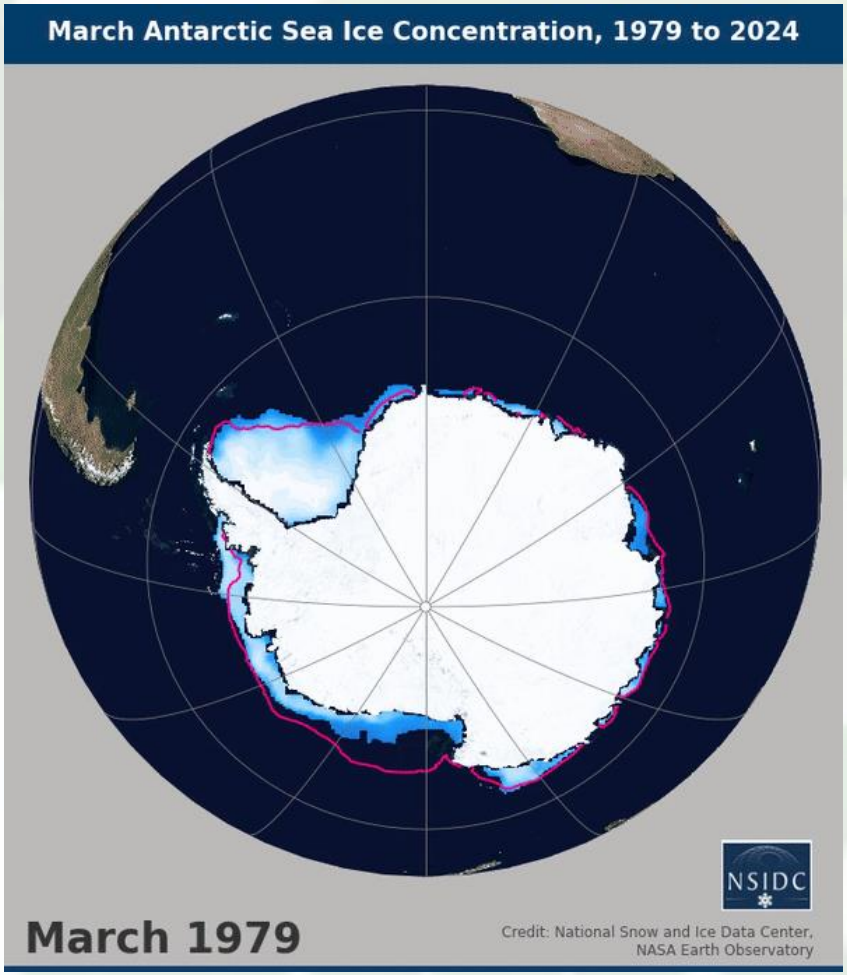


https://nsidc.org/sites/default/files/images/Data/conc-09-1979-2024-antarctic.gif

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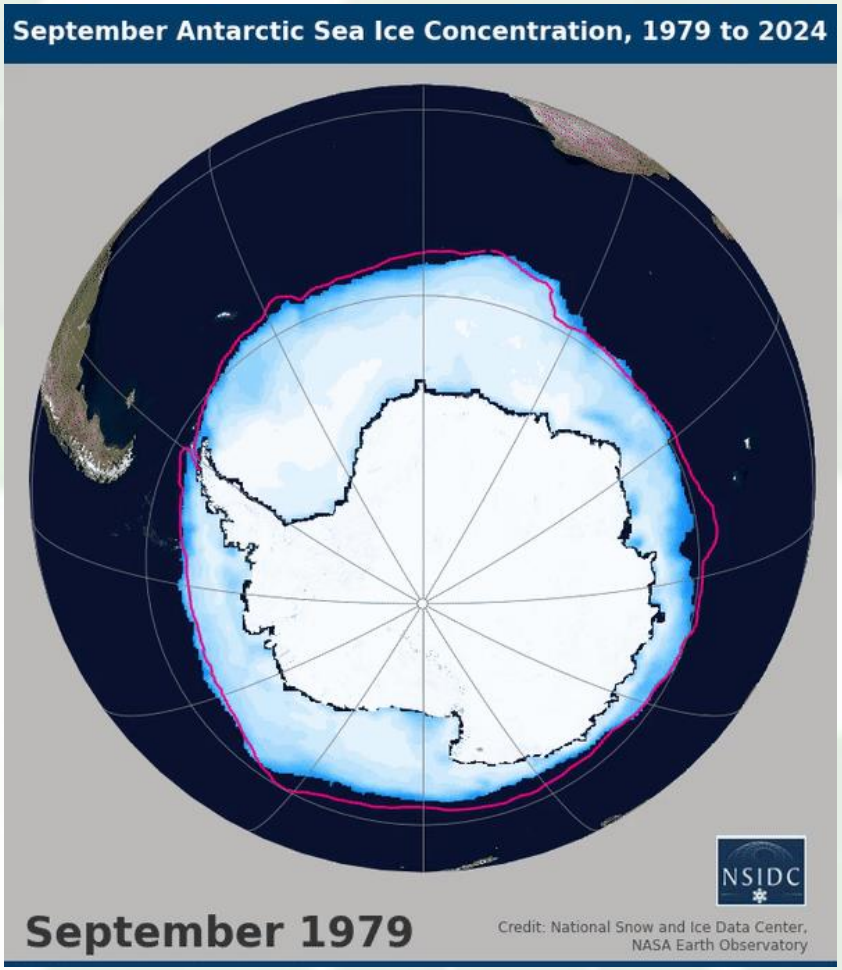


https://nsidc.org/sites/default/files/images/Data/conc-03-1979-2024-antarctic.gif

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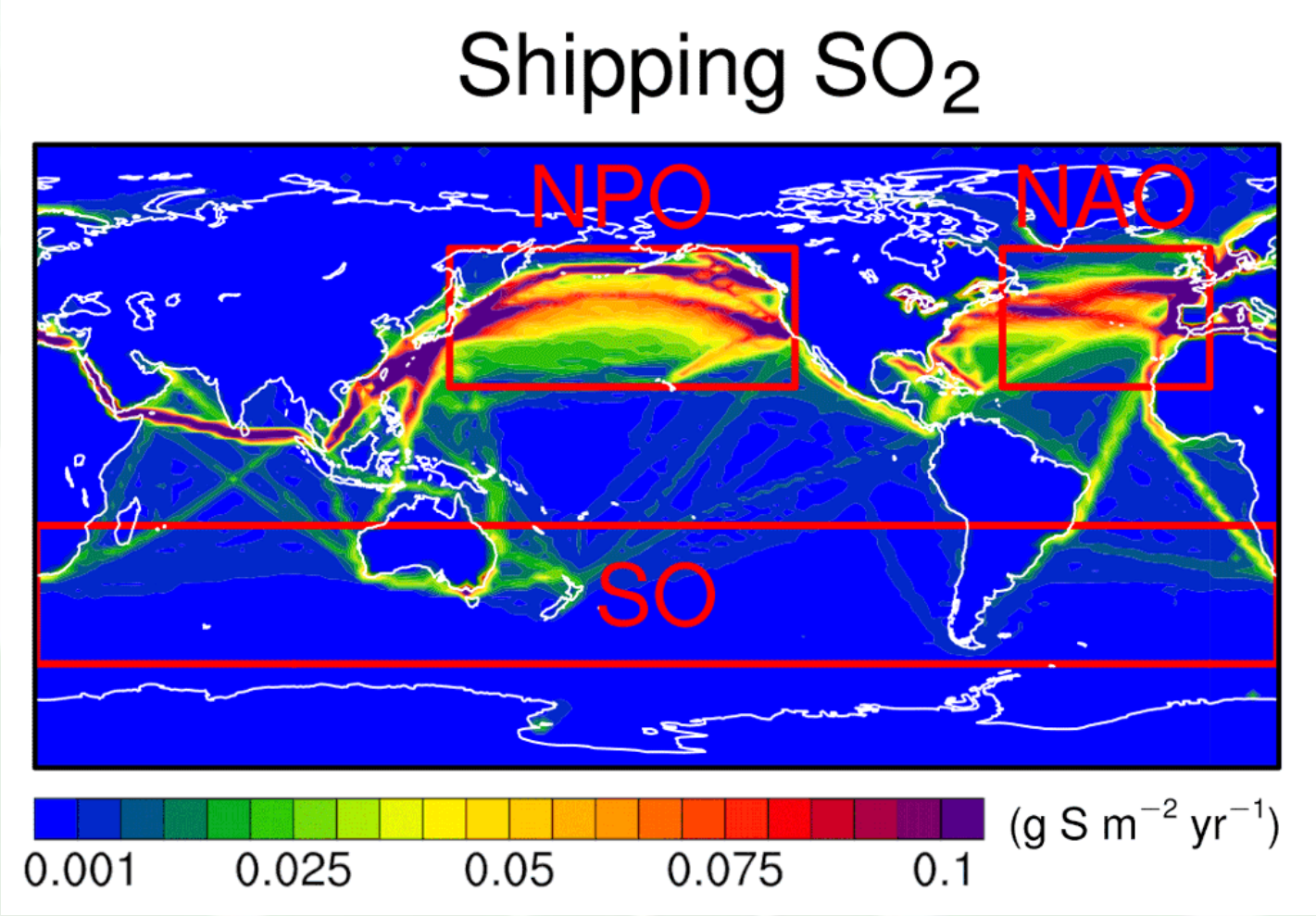

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# The science background of climate change and global warming

## Climate Models and Predictions

**Types of Climate Models:**

**Global Climate Models (GCMs)**: Simulate entire planet at coarse resolution.

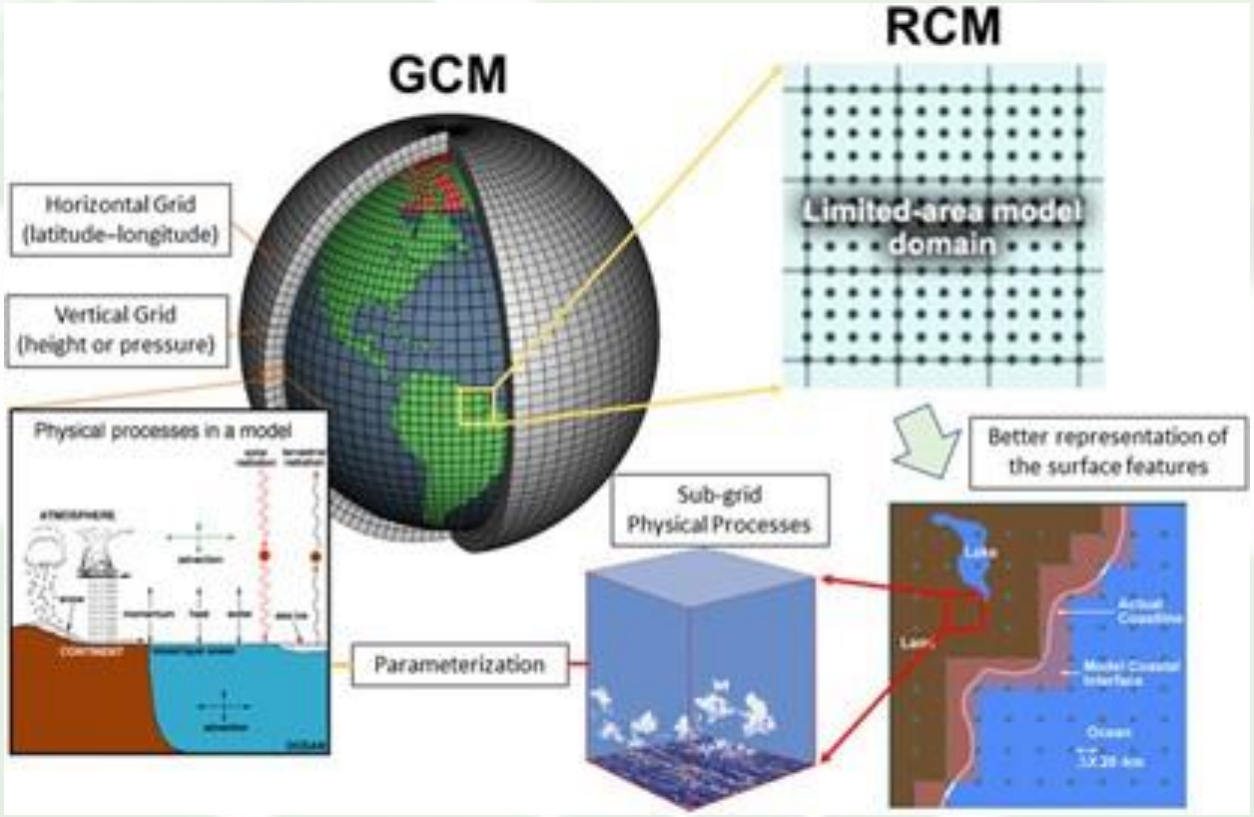
**Regional Climate Models (RCMs)**: High-resolution focus

**Earth System Models (ESMs):** Include biogeochemical cycles

https://celebrating200years.noaa.gov/breakthroughs/climate_model/modeling_schematic.html

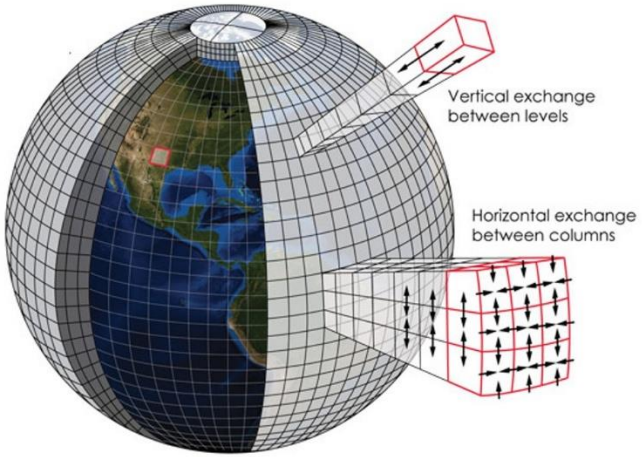
## General Circulation Models (GCMs)

General Circulation Models (GCMs) are mathematical models that attempt to simulate the Earth's climate system.



# The science background of climate change and global warming

## Climate Models and Predictions




$$\frac{d\vec{v}}{dt} = -\frac{1}{\rho}\vec{\nabla}p - \vec{g} + \vec{F}_{fric} - 2\vec{\Omega}\times\vec{v}$$

Biological/chemical principles

$$\vec{F} = M\vec{a}$$

e.g. momentum conservation

https://cml.jbnu.ac.kr/cml/11846/subview.do

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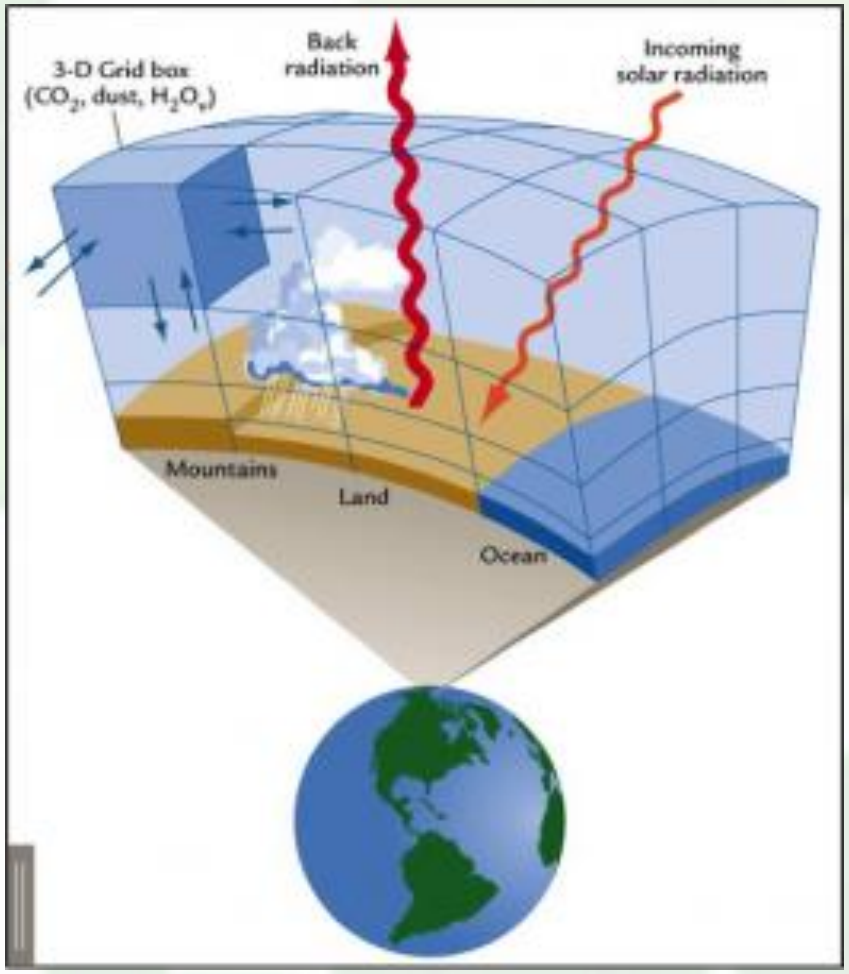
## The science background of climate change and global warming

## Climate Models and Predictions




https://news.climate.columbia.edu/2018/05/18/climate-models-accuracy/

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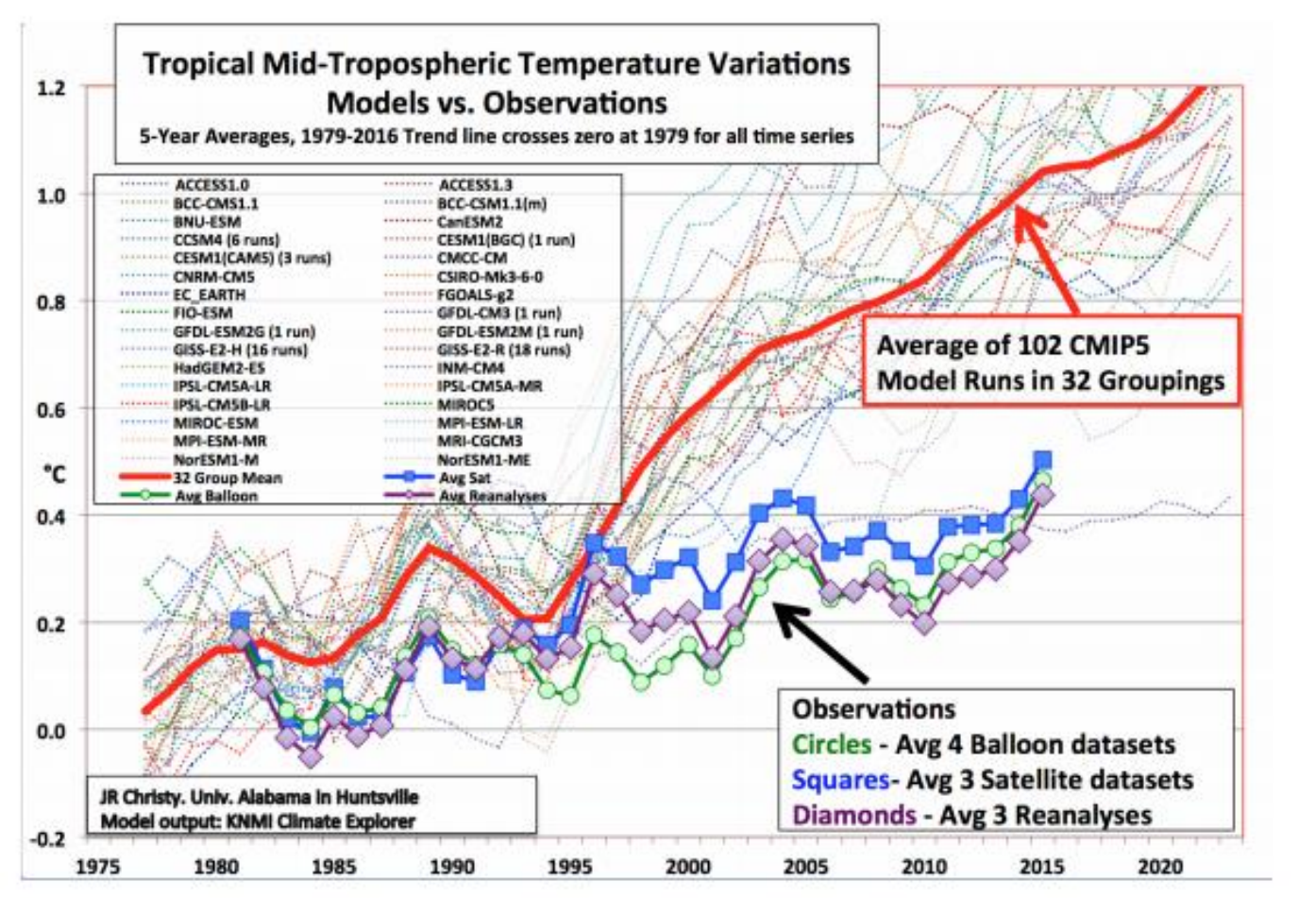

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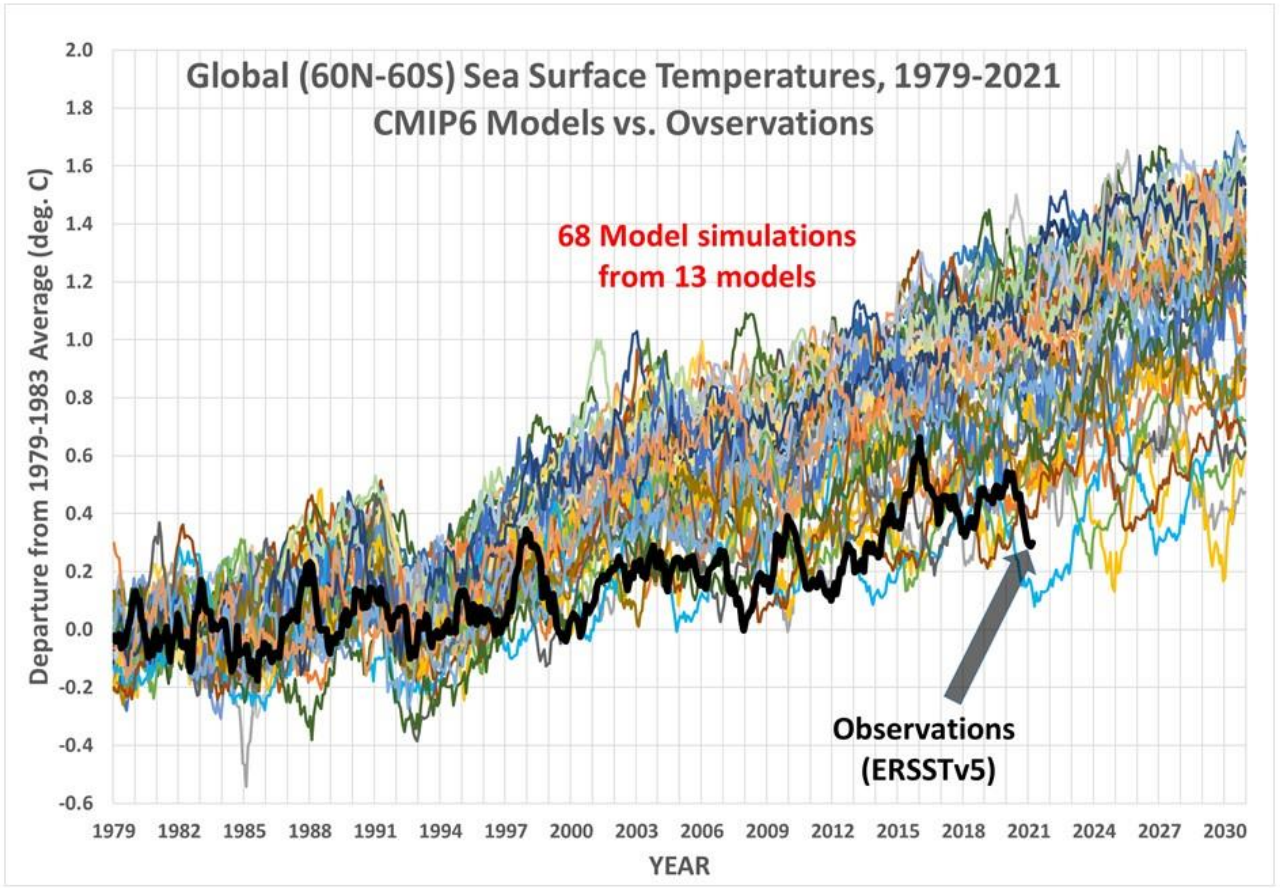
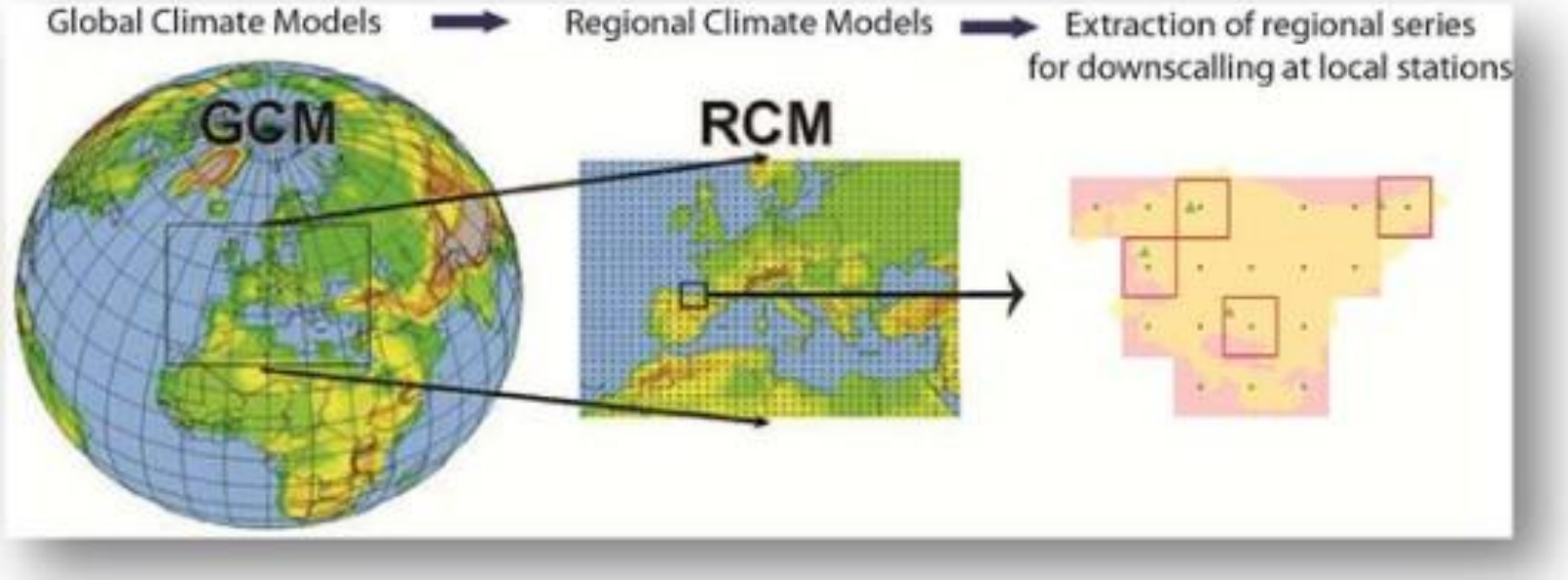
## Climate Models and Predictions

https://thefarmingforum.co.uk/index.php?threads/climate-models-v-reality.387984/



## Regional Climate Models (RCMs)

https://www.researchgate.net/publication/304526712_Meteorological_data_for_RES-E_integration_studies_-_State_of_the_art_reviewtitle/figures

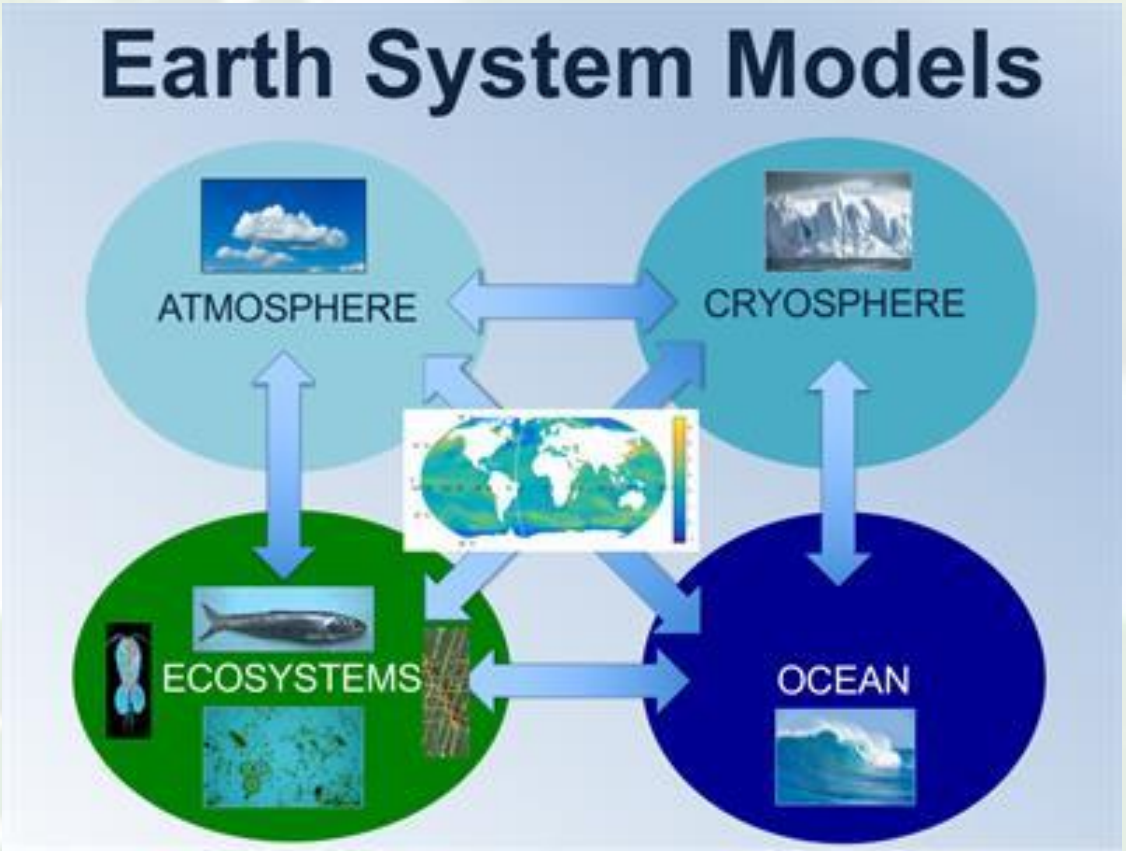



Downscaling from Global Climate Models (GCMs) to Regional Climate Models (RCMs) and extraction of the regional time series to capture the effect of the specific variable of the finer scale at specific location

# The science background of climate change and global warming

## Climate Models and Predictions

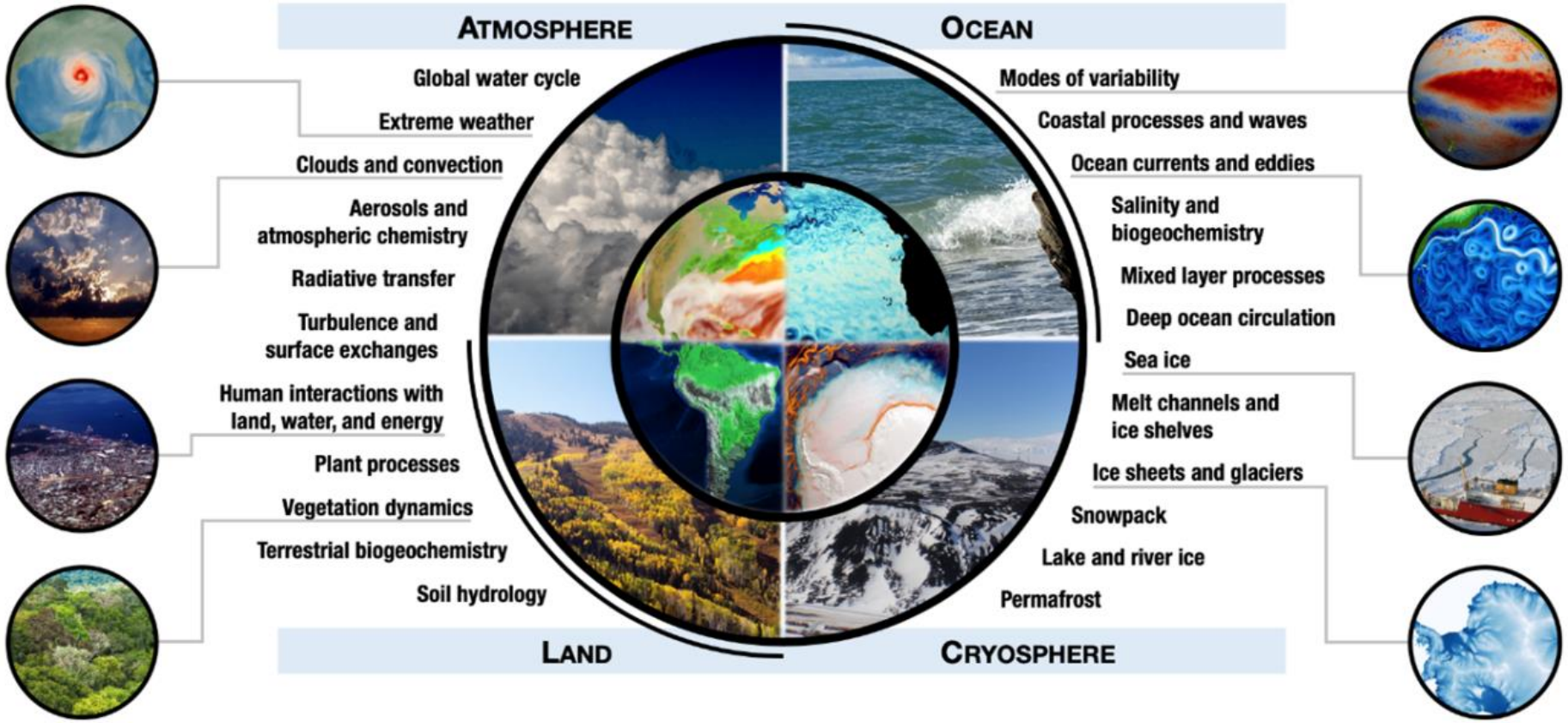
**Earth System Models (ESMs):**



# The science background of climate change and global warming

## Climate Models and Predictions

### Earth System Models (ESMs):

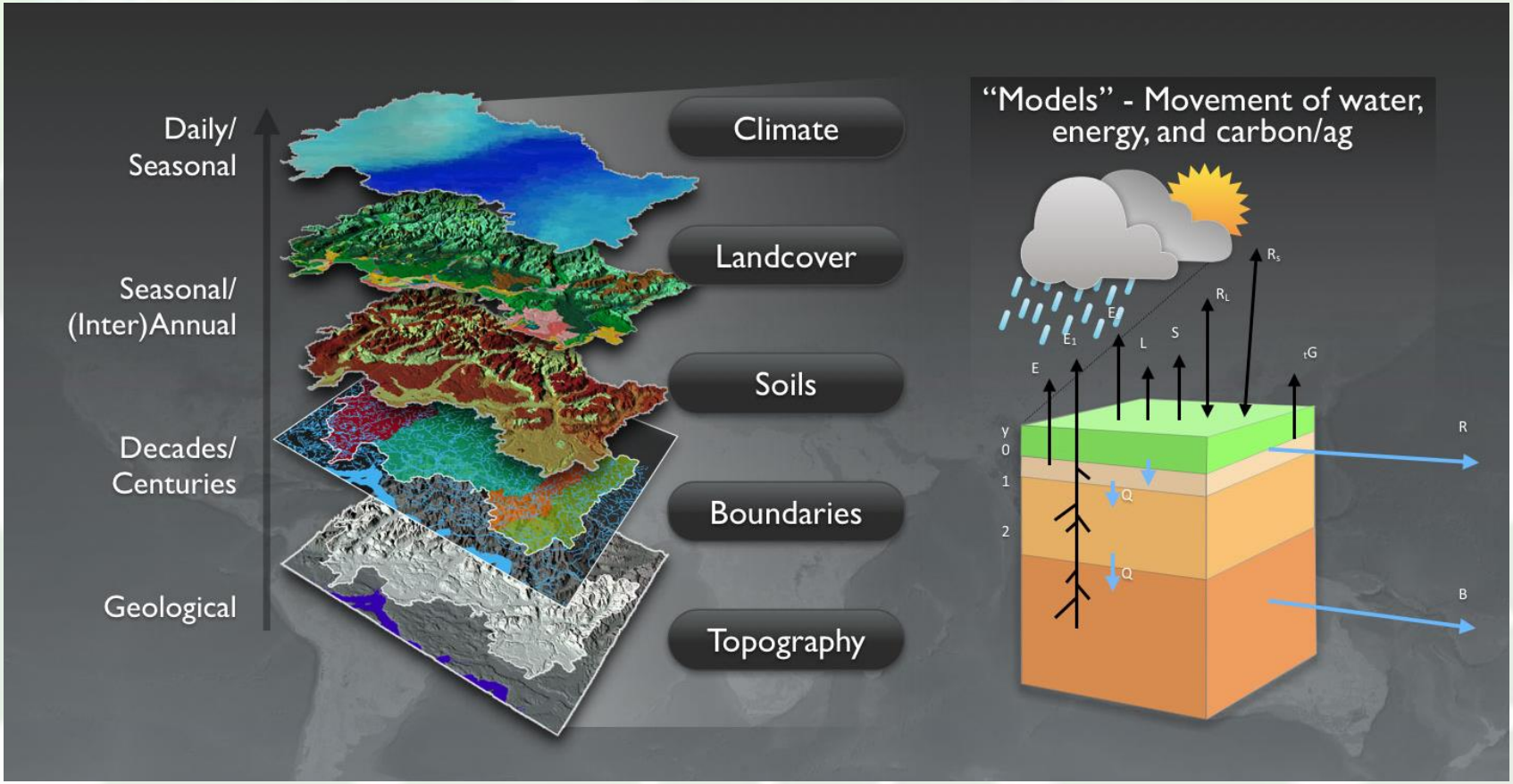


# The science background of climate change and global warming

## Climate Models and Predictions

**Earth System Models (ESMs):**

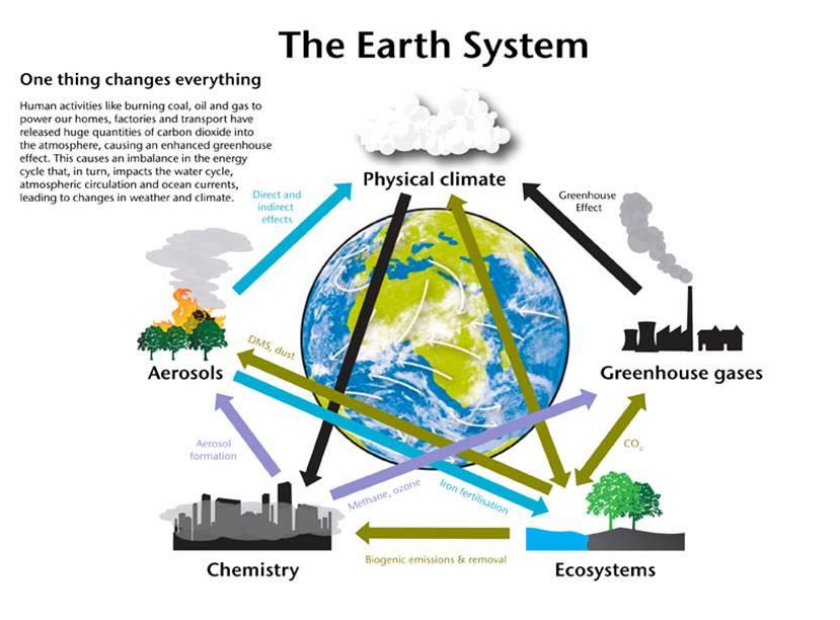
A digital representation of the physical world



# The science background of climate change and global warming

## Climate Models and Predictions

### Earth System Models (ESMs):




Earth System Models (ESMs) are advanced computational tools used to simulate and understand the complex interactions between various components of the Earth's system, including the atmosphere, oceans, land surface, and biosphere. These models help scientists analyze past climate changes, predict future climate scenarios, and assess potential impacts of human activities on the environment

ESMs are integrated models that represent the physical, chemical, and biological processes of the Earth's systems. They encompass more than just the atmosphere; they include ocean dynamics, land surface processes, and ecological interactions.

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## Earth System Models (ESMs):

Components of ESMs

- Atmosphere: Simulates weather patterns, temperature, humidity, and atmospheric circulation.
- Oceans: Models currents, temperature distributions, salinity, and biogeochemical cycles.
- Land Surface: Accounts for vegetation, soil moisture, snow cover, and land use changes.
- Biosphere: Represents the dynamics of ecosystems and carbon storage, including interactions among plants, animals, and microorganisms.

**Earth System Models (ESMs):**

Types of Earth System Models

- Energy Balance Models (EBMs): Simplified representations focusing on the balance between incoming solar radiation and outgoing thermal radiation.

- General Circulation Models (GCMs): More complex, solving mathematical equations governing atmospheric and oceanic physics, typically used for climate simulations.

- Coupled Models: Integrate multiple components (atmosphere, ocean, land) to better reflect the interconnected nature of Earth's systems.

## Earth System Models (ESMs):

Earth System Models are vital tools in climate science, providing crucial insights into the workings of our planet and the potential consequences of human activities. As we face the challenges of climate change, improving ESMs will play a key role in informing mitigation and adaptation strategies.

## International Agreements

United Nations Framework Convention on Climate Change (UNFCCC) - Adopted: 1992 in Rio de Janeiro, Brazil

Kyoto Protocol - Adopted: 1997 in Kyoto, Japan

Paris Agreement - Adopted: 2015 in Paris, France

Montreal Protocol on Substances that Deplete the Ozone Layer - Adopted: 1987

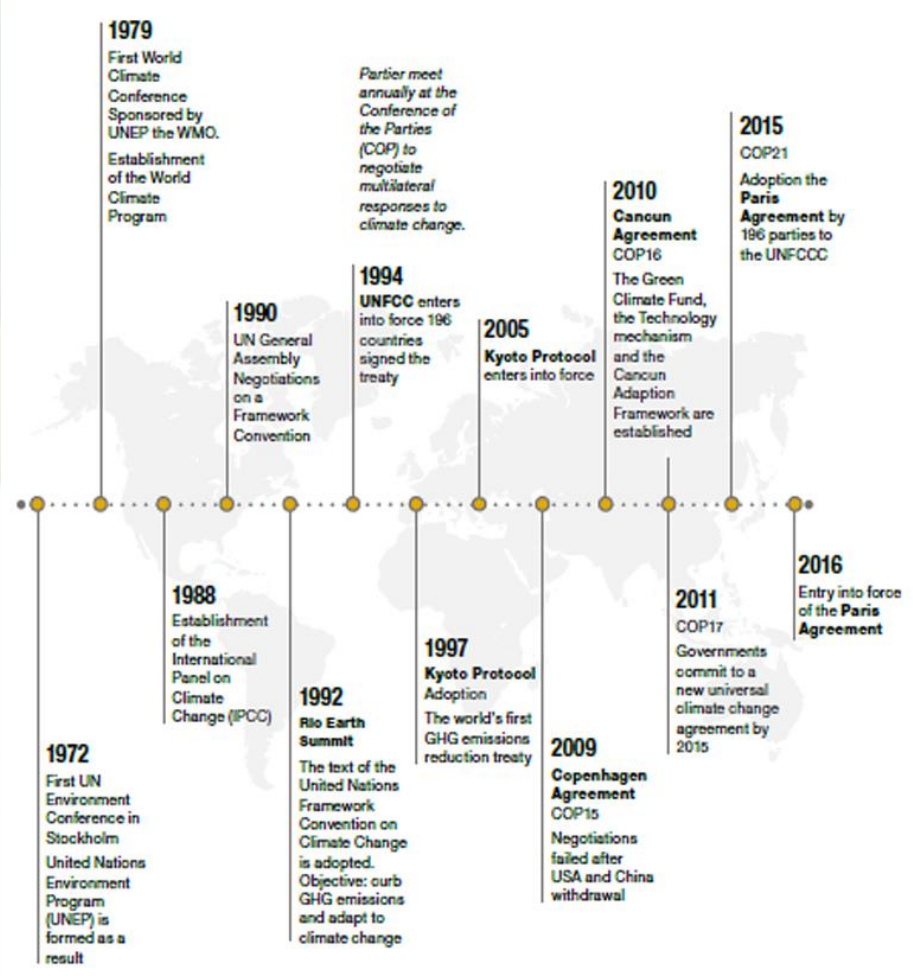
Glasgow Climate Pact - Adopted: 2021 at COP26 in Glasgow, UK

The 2030 Agenda for Sustainable Development - Adopted: 2015

# Introduction to Climate Change Management

## The science background of climate change and global warming

## International Agreements




https://www.man.com/insights/data-driven-approach-to-climate-change

# The science background of climate change and global warming

## Conclusion

Climate change represents one of the most pressing challenges of our time, threatening ecosystems, economies, and communities worldwide. The overwhelming consensus among scientists underscores the urgency to act, as rising temperatures, extreme weather events, and shifting climate patterns continue to escalate.

However, it is essential to recognize that combating climate change is not solely the responsibility of governments and international organizations. Individuals and communities play a critical role in driving change at the grassroots level. Through education, sustainable lifestyle choices, community involvement, advocacy, and support for renewable energy, everyone can contribute to creating a more sustainable future.

# The science background of climate change and global warming

## Conclusion

International agreements like the Paris Agreement provide a framework for global cooperation, but the success of these initiatives relies heavily on the commitment and actions of individuals and local entities. By working together—through small daily actions and larger collective movements—we can foster a resilient planet and ensure a healthier environment for generations to come.

Ultimately, climate change is a shared challenge that requires a unified response. Whether through policy advocacy, community engagement, or personal lifestyle changes, every effort counts. By embracing our roles as stewards of the Earth and supporting one another, we can pave the way for innovative solutions and create a legacy of environmental responsibility.

# The science background of climate change and global warming

## Data Source

**1. Intergovernmental Panel on Climate Change (IPCC) Data Distribution Centre (DDC)**

- Provides **climate, socio-economic, and environmental data** from the past and future scenarios.
- Includes projections for temperature, precipitation, and sea-level rise.
- **Website**: IPCC DDC, https://ipcc-data.org/about.html

**2. National Centers for Environmental Information (NOAA NCEI)**

- Offers **historical weather and climate data**, including temperature, precipitation, and extreme weather events.
- Hosts one of the largest archives of climate data globally.
- **Website**: NOAA NCEI, https://www.ncei.noaa.gov/

## Data Source

### 3. NASA Earth Science Data Systems

- Provides **satellite and ground-based data** on climate indicators like temperature, ice melt, and sea-level rise.
- Includes tools like **GISTEMP** (global temperature analysis) and **Worldview** (interactive satellite imagery).
- **Website**: NASA Earth Data, https://www.earthdata.nasa.gov/

### 4. World Bank Climate Change Knowledge Portal (CCKP)

- Offers **global data** on historical and future climate, vulnerabilities, and impacts.
- Includes visualizations and tools for analyzing climate risks.
- **Website**: World Bank CCKP, https://climateknowledgeportal.worldbank.org/

## Data Source

### 5. National Snow & Ice Data Center (NSIDC)

- Focuses on **cryosphere data**, including sea ice, glaciers, and ice sheets.
- Provides datasets and maps for polar and mountain regions.
- **Website**: NSIDC, https://nsidc.org/home

National Snow and Ice Data Center
a part of CIRES at the University of Colorado Boulder

### 6. Goddard Institute for Space Studies (GISS)

- Hosts **global temperature records** and climate model outputs.
- Known for its **GISTEMP dataset**, which tracks global surface temperature changes.
-

National Aeronautics and Space Administration
Goddard Institute for Space Studies

## Data Source

### 7. ClimateData.ca (Canada)

- Provides **climate data and tools** for adaptation planning in Canada.
- Includes projections for temperature, precipitation, and extreme weather.
- **Website**: ClimateData.ca, https://climatedata.ca/

### 8. IRI/LDEO Climate Data Library

- Offers **global climate datasets** and analysis tools.
- Includes data on temperature, precipitation, and ocean-atmosphere interactions.
- **Website**: IRI Data Library, https://iridl.ldeo.columbia.edu/

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## Data Source

**9. UNdata (United Nations)**

- Provides **environmental and energy statistics**, including greenhouse gas emissions
- Includes datasets from the **Energy Statistics Database** and **Environment Statistics Database**.
- /data.un.org/


**10. Emission Factor Database (EFDB)**

- Hosted by the IPCC, it provides **emission factors** for estimating greenhouse gas emissions.
- Useful for researchers and policymakers.
- **Website**: IPCC EFDB, https://www.ipcc-nggip.iges.or.jp/EFDB/main.php

# The science background of climate change and global warming

## Data Source

- Climate Change Data Portal (CCDP) Developed by Xander Wang, University of Regina. It provides dynamically-downscaled climate projections over Canada and China.


The Best Data Viz and Infographics on Climate Change Facts

https://visme.co/blog/climate-change-facts/

visme

https://climatevisuals.org/

## Scientific journals

### 1. Nature Climate Change

- **Focus**: Publishes cutting-edge research on climate change, including its causes, impacts, and mitigation strategies.
- **Key Topics**: Range shifts in ecosystems, carbon balance, renewable energy, and socio-economic impacts of climate change.
- **Recent Highlights**: Articles on rooftop photovoltaic systems, Arctic carbon uptake, and gender inequality in climate assessments.
- **Website**: Nature Climate Change, https://www.nature.com/nclimate/

Citation Impact 2023
Journal Impact Factor: 30.3
5-year Journal Impact Factor: 31.4
Immediacy Index: 4.5
Eigenfactor® Score: 0.06679
Article Influence Score: 11.6

**2. Climate (MDPI)**

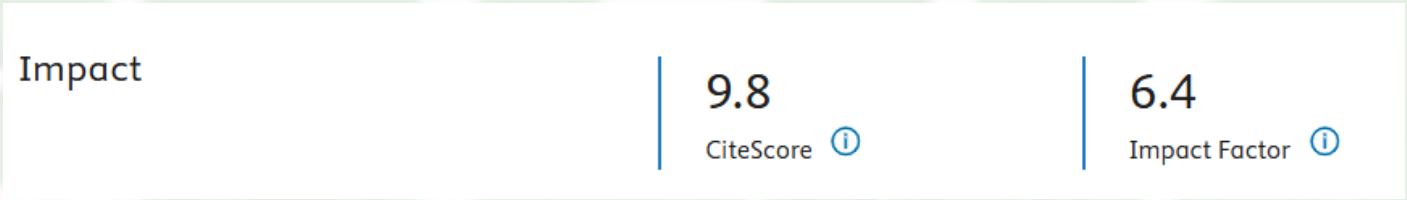
- **Focus**: An open-access journal covering climate science, adaptation, and mitigation.
- **Key Topics**: Climate impacts on natural resources, rural livelihoods, and communication strategies for climate resilience.
- **Recent Highlights**: Studies on gendered climate impacts in Kyrgyzstan and the role of renewable energy communities.
- **Website**: Climate Journal. https://www.mdpi.com/journal/climate

**Impact Factor:** 3.0 (2023); 5-Year Impact Factor: 3.3 (2023)

### 3. Advances in Climate Change Research

- **Focus**: Interdisciplinary research on climate change, including policy, socio-economic impacts, and mitigation.
- **Key Topics**: Changes in climate systems, greenhouse gas emissions, and global climate governance.
- **Recent Highlights**: Special issues on Arctic permafrost and global mitigation strategies.
- **Website**: Advances in Climate Change Research.

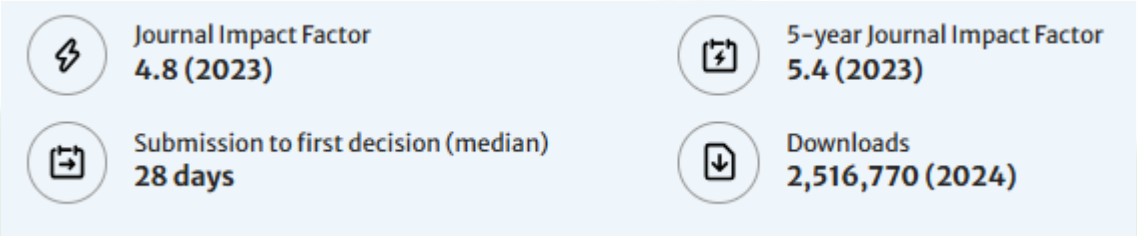
https://www.sciencedirect.com/journal/advances-in-climate-change-research/about/insights



## 4. Climatic Change

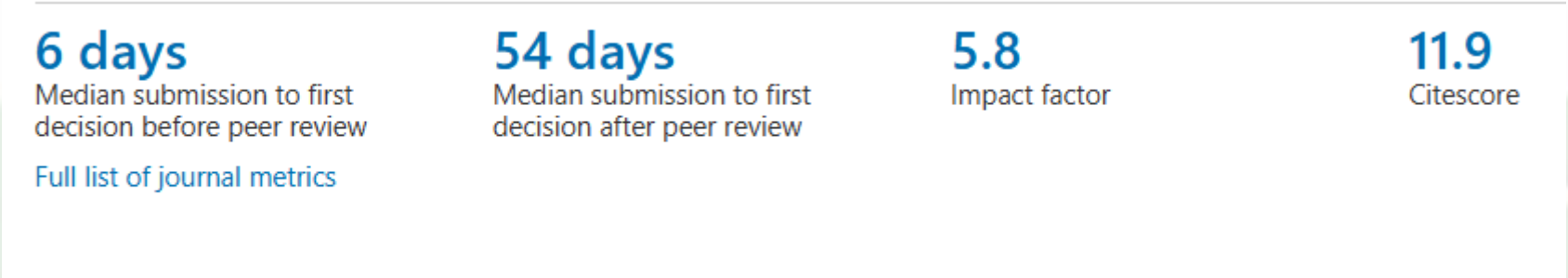
- **Focus**: Examines climatic variability and change, including its causes and implications.
- **Key Topics**: Climate policy, adaptation, and mitigation.
- **Recent Highlights**: Research on climate change impacts on health, ecosystems, and socio-economic systems.
- **Website**: Climatic Change.

https://link.springer.com/journal/10584



## 5. Environmental Research Letters

- **Focus**: Covers all areas of environmental science, including climate change.
- **Key Topics**: Climate impacts, adaptation, and mitigation strategies.
- **Recent Highlights**: Studies on extreme weather events, carbon sequestration, and renewable energy.
- **Website**: Environmental Research Letters, https://iopscience.iop.org/journal/1748-9326



## 6. WIREs Climate Change

- **Focus**: Promotes cross-disciplinary discussions on climate change and its societal implications.
- **Key Topics**: Climate science, policy, and adaptation.
- **Recent Highlights**: Reviews on climate change impacts on health, ecosystems, and global governance.
- **Website**: WIREs Climate Change.

https://wires.onlinelibrary.wiley.com/journal/17577799

### Citation Impact

| | | |
|---|---|---|
| 2023 | **CiteScore** (Scopus): | 20 |
| 2023 | **Journal Citation Indicator** (Clarivate): | 1.34 |
| 2023 | **Journal Impact Factor** (Clarivate): | 9.4 |

## 7. Climate Policy

- **Focus**: A leading journal on climate change policy, including adaptation and mitigation.
- **Key Topics**: Policy design, implementation, and socio-political issues related to climate change.
- **Recent Highlights**: Research on climate governance, negotiations, and policy impacts.
- **Website**: Climate Policy.

Journal metrics

| Usage | Citation metrics | Speed/acceptance |
|---|---|---|
| • **783K** annual downloads/views | • **5.3 (2023)** Impact Factor<br>• **Q1** Impact Factor Best Quartile<br>• **6.5 (2023)** 5 year IF<br>• **12.9 (2023)** CiteScore (Scopus)<br>• **Q1** CiteScore Best Quartile<br>• **1.987 (2023)** SNIP<br>• **2.245 (2023)** SJR | • **0** days avg. from submission to first decision<br>• **110** days avg. from submission to first post-review decision<br>• **11** days avg. from acceptance to online publication<br>• **12%** acceptance rate |

## 8. Climate Change Ecology

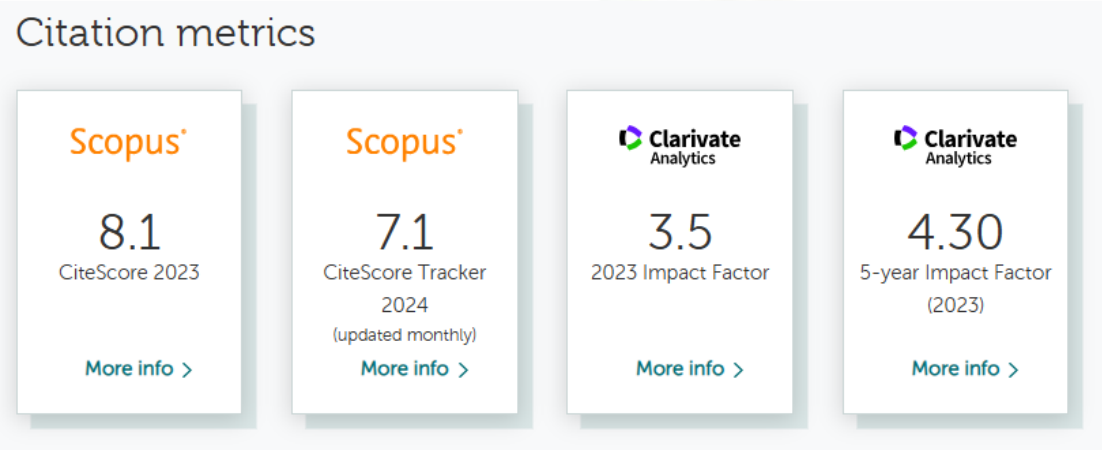
- **Focus**: Examines the ecological impacts of climate change.
- **Key Topics**: Ecosystem responses to climate change, biodiversity loss, and adaptation strategies.
- **Recent Highlights**: Studies on species distribution shifts and ecosystem resilience.
- **Website**: Climate Change Ecology.

https://www.sciencedirect.com/journal/climate-change-ecology

## 9. International Journal of Climate Change Strategies and Management

- **Focus**: Explores strategies for managing climate change impacts.
- **Key Topics**: Climate adaptation, mitigation, and policy frameworks.
- **Recent Highlights**: Research on climate risk management and sustainable development.
- **Website**: IJCCSM.

https://www.emerald.com/insight/publication/issn/1756-8692



## 10. Global Environmental Change

- **Focus**: Addresses the interactions between global environmental change and human systems.
- **Key Topics**: Climate impacts, adaptation, and socio-economic responses.
- **Recent Highlights**: Studies on climate-induced migration, food security, and ecosystem services7.
- **Website**: Global Environmental Change.

https://www.sciencedirect.com/journal/global-environmental-change