
Feeling the Heat
Understanding Earth‘s Changing Climate
Source: showyourstripes.info

Presented at
„Find your Nature“ - Erasmus Summercamp 2026
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Sebastian Schappert
M.Sc.-Meteorologist at Deutscher Wetterdienst (DWD)
Contact: S.Schappert@web.de

How much of the Earth’s atmosphere consists of Carbon Dioxide?

CO_2: O = C = O

Answer: 0.04 %
(4 molecules out of ten thousand)

CO_2: O = C = O

How can a gas that makes up just 0.04% of the atmosphere change the climate of an entire planet?

Table of Content

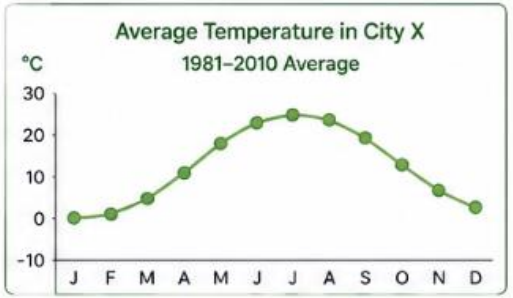
What is Climate?

Weather

- Short term changes in the atmosphere
- Hour-to-hour, day-to-day

Climate

Source: Generated with ChatGPT (OpenAI), 2026.



- Average weather conditions in a specific area over a long period of time
- Trends over 30 years and more

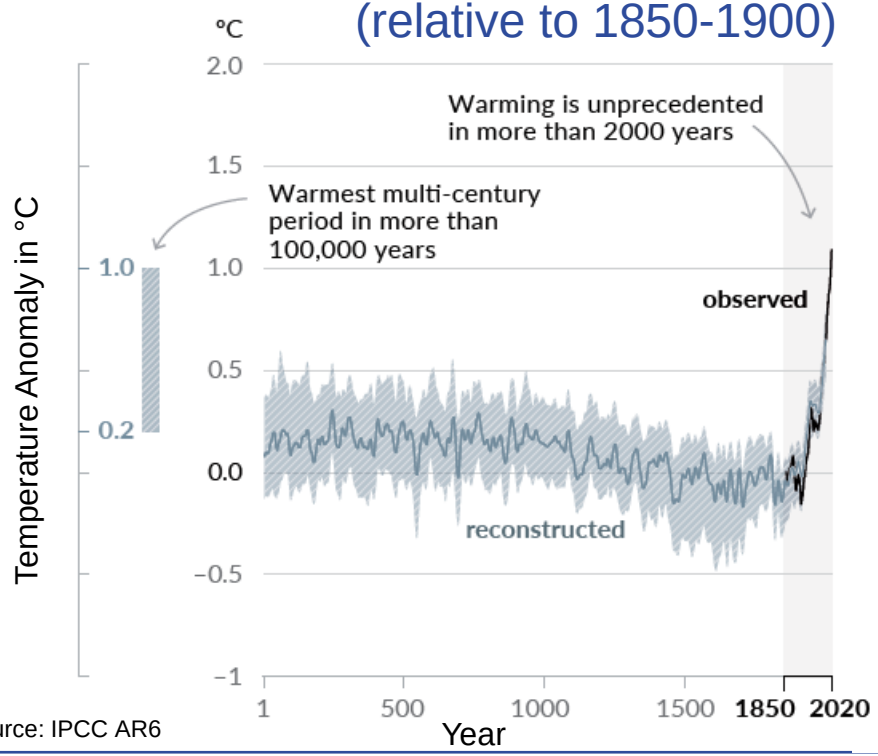
What is Climate Change?

➔ Intergovernmental Panel on Climate Change (IPCC)

Climate Change is a **persistent shift** in the state of the climate lasting **decades or longer**.
It can result from **natural processes**, **external forces** (e.g., solar cycles, volcanoes), or persistent **anthropogenic changes** that alter atmospheric composition or land use.

What We Observe

Change in global surface temperature (relative to 1850-1900)



Source: IPCC AR6

Atmospheric CO_2 Concentration from ice core records

Source: climate.nasa.gov

What We Observe

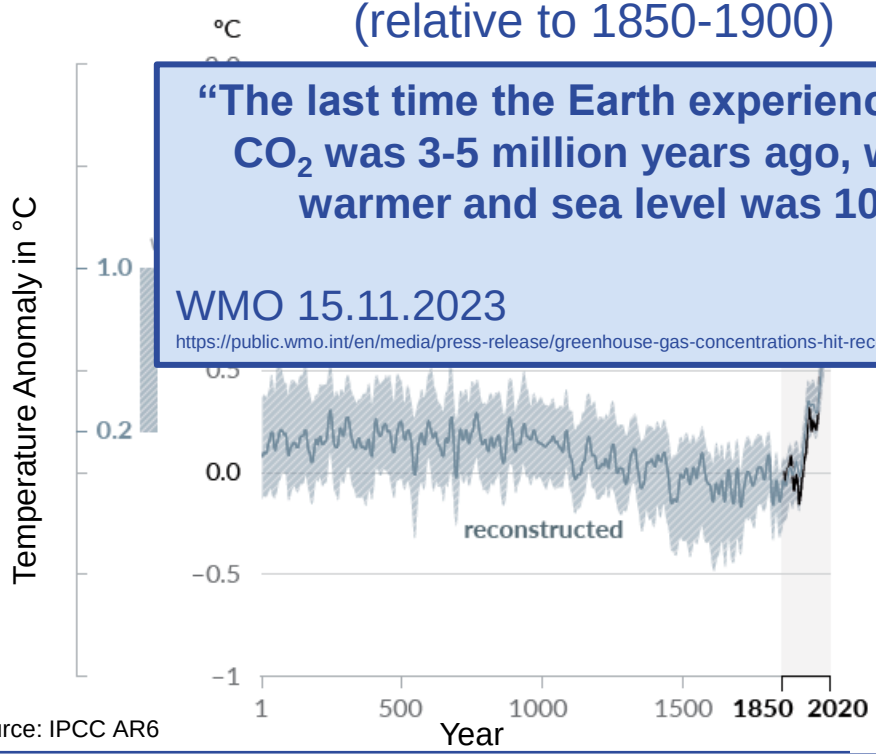
Change in global surface temperature (relative to 1850-1900)

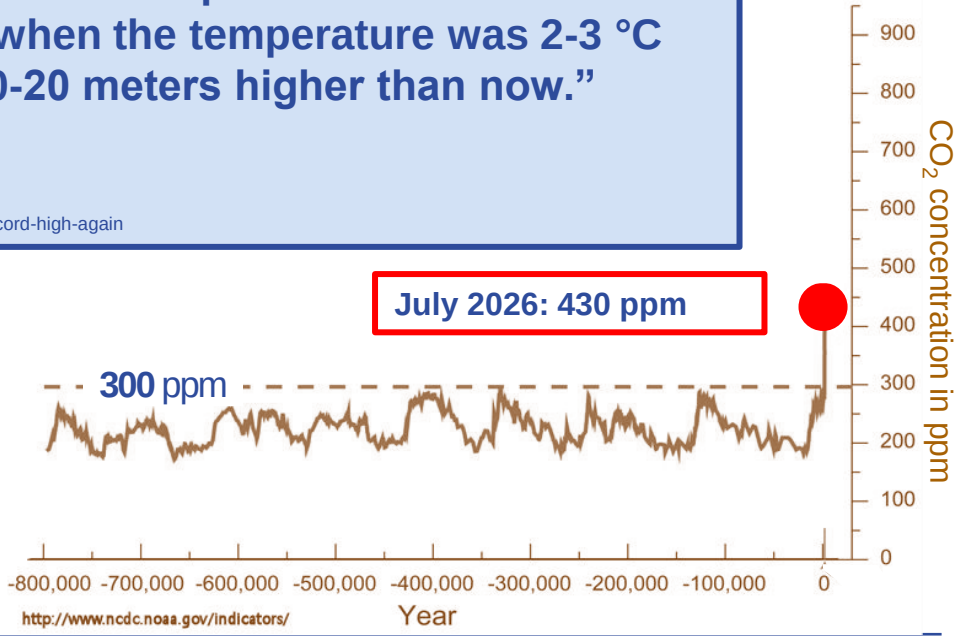
Atmospheric CO_2 Concentration from ice core records

“The last time the Earth experienced a comparable concentration of CO_2 was 3-5 million years ago, when the temperature was 2-3 °C warmer and sea level was 10-20 meters higher than now.”

WMO 15.11.2023

https://public.wmo.int/en/media/press-release/greenhouse-gas-concentrations-hit-record-high-again





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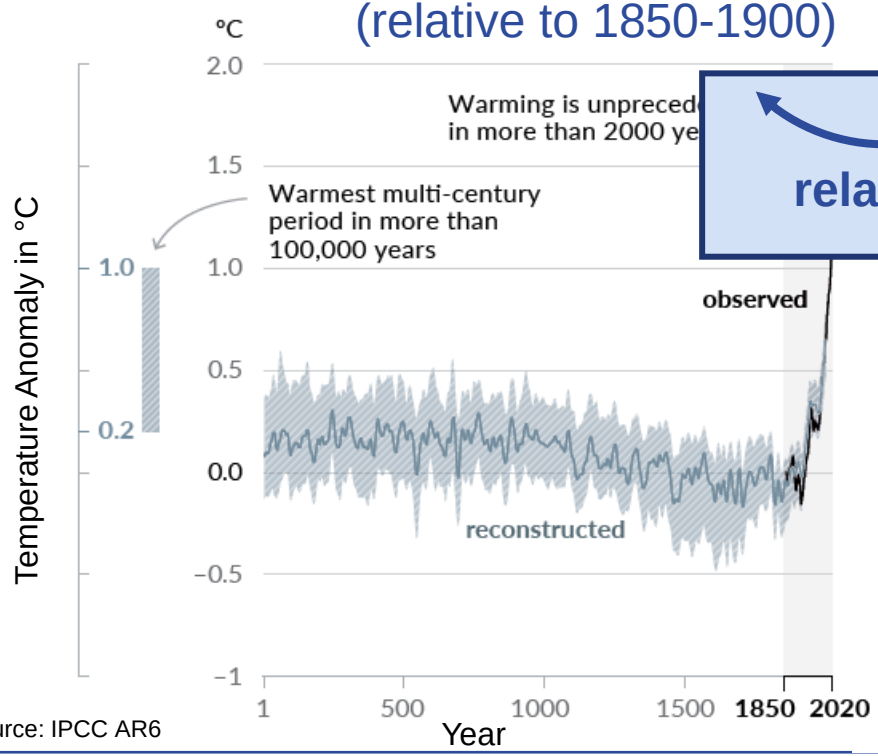

Source: IPCC AR6

related?

Atmospheric CO_2 Concentration from ice core records

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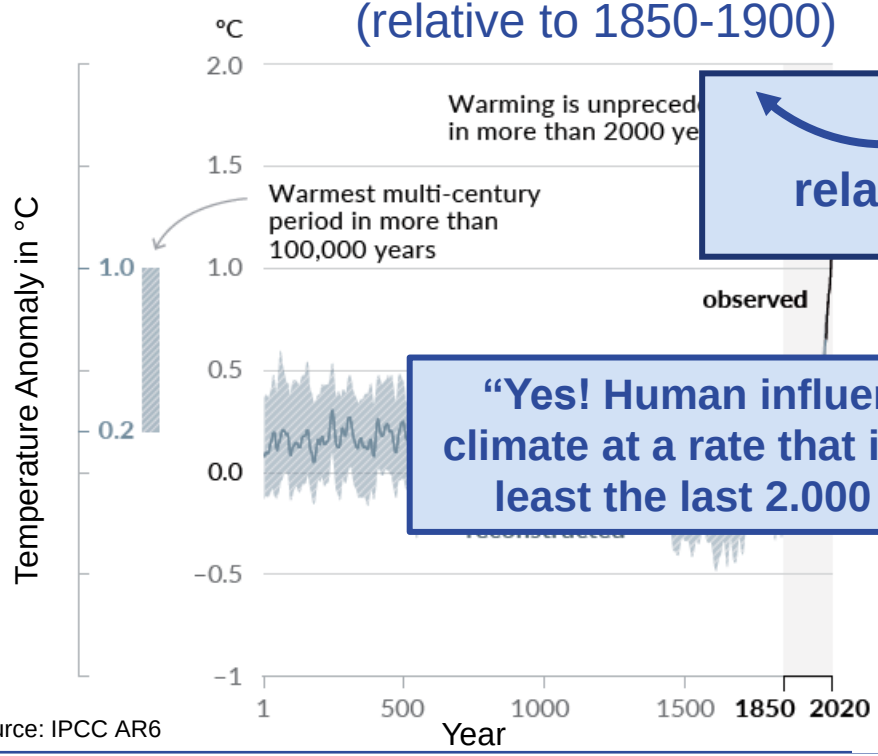


Source: IPCC AR6

related?

Atmospheric CO_2 Concentration from ice core records

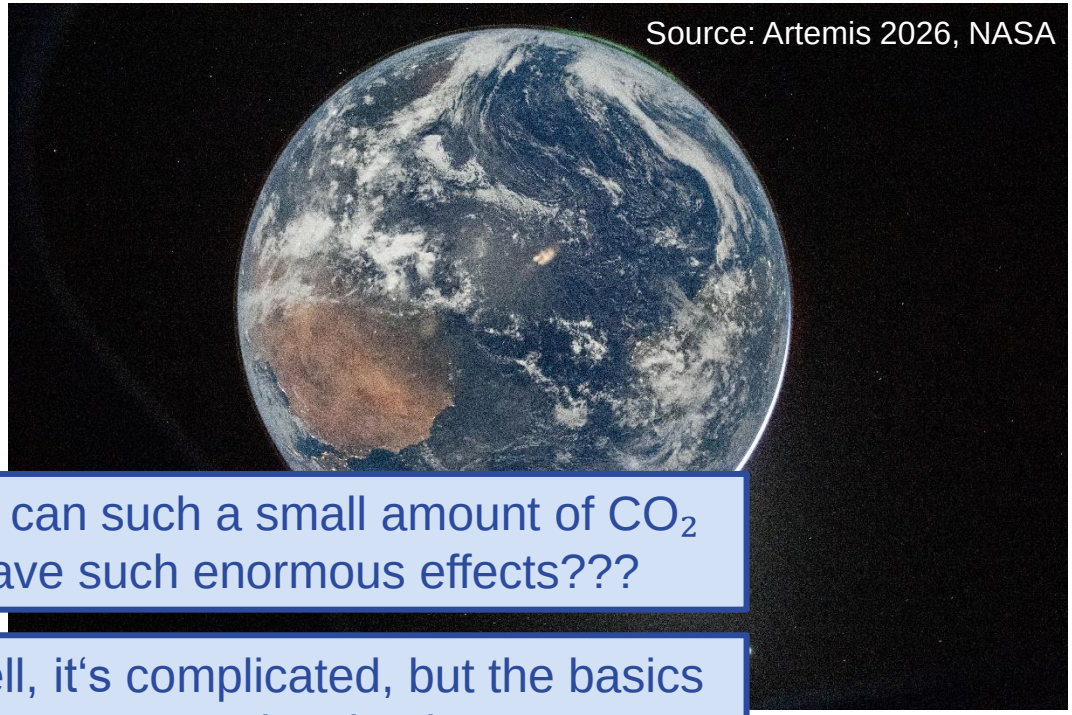
Source: climate.nasa.gov

“Yes! Human influence has warmed the climate at a rate that is unprecedented in at least the last 2.000 years.” IPCC AR6 (2021)

How do we know this?

The Earth‘s Atmosphere

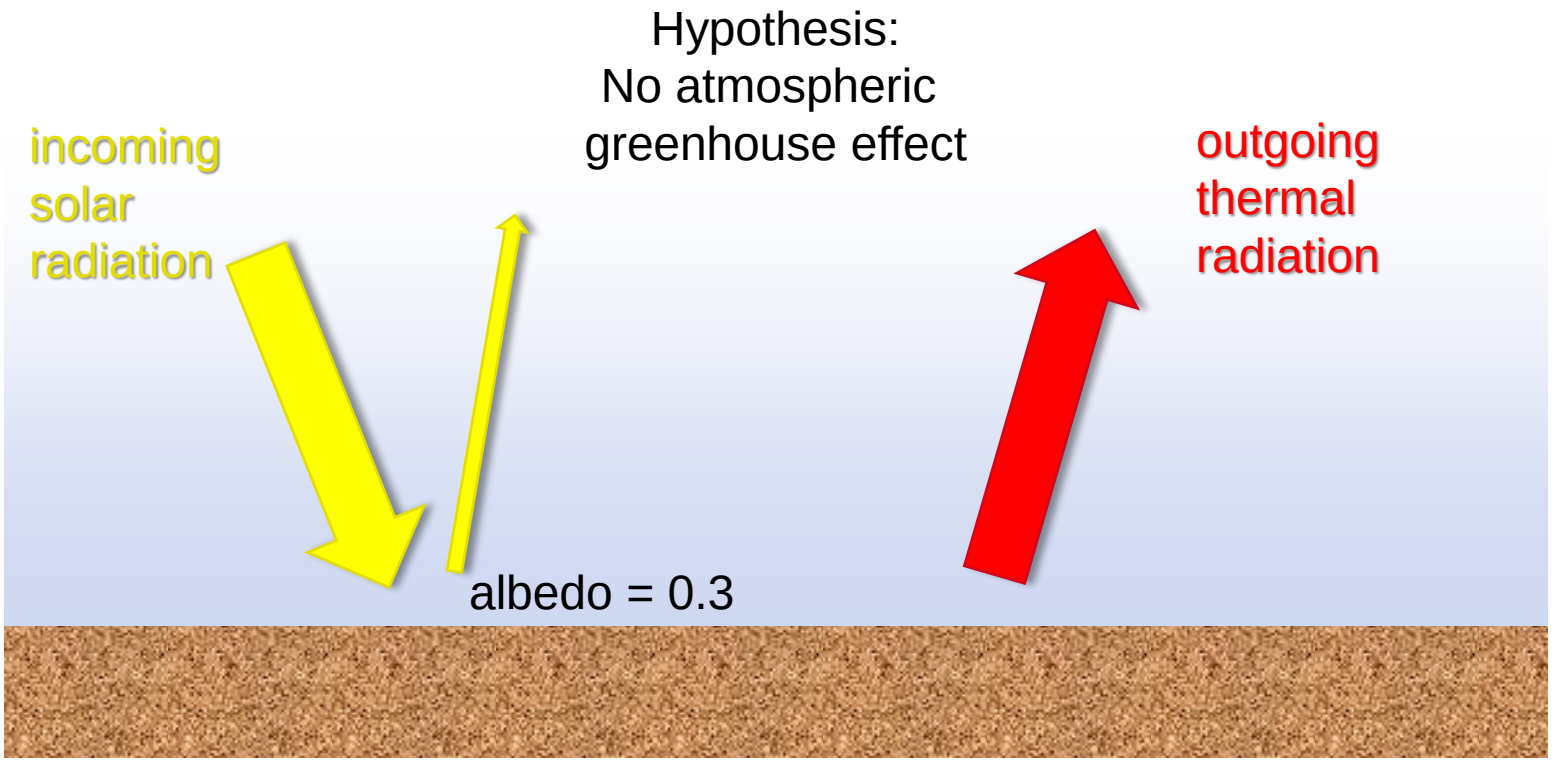
- The atmosphere is **unique**!
- Just the right gas mix for complex life forms
  - 78% Nitrogen (N_2)
  - 21% Oxygen (O_2)
  - 0.04% Carbon Dioxide (CO_2)


Source: Artemis 2026, NASA

How can such a small amount of CO_2 have such enormous effects???

…well, it‘s complicated, but the basics are quite simple.

Some Scientific Background



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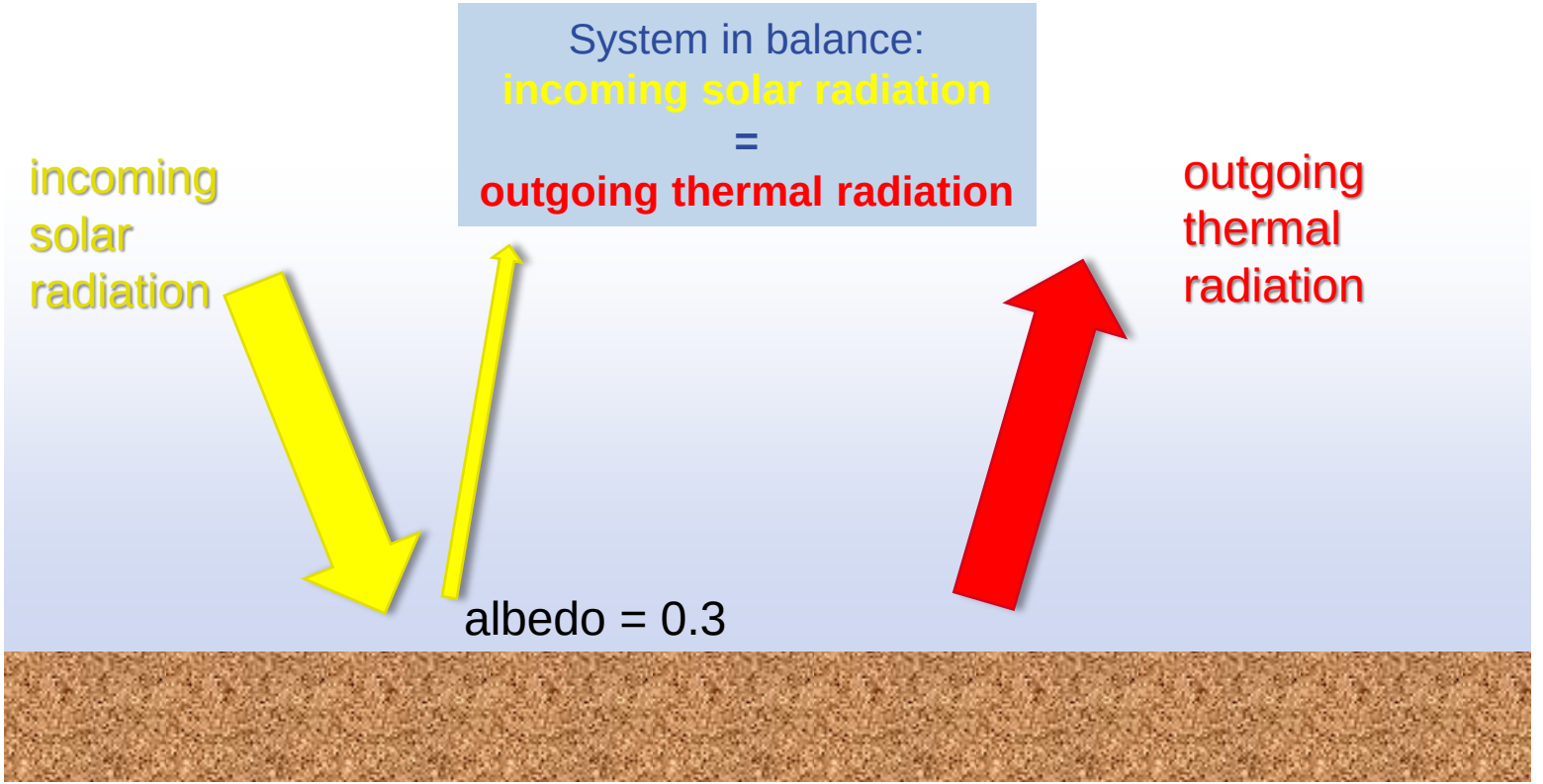

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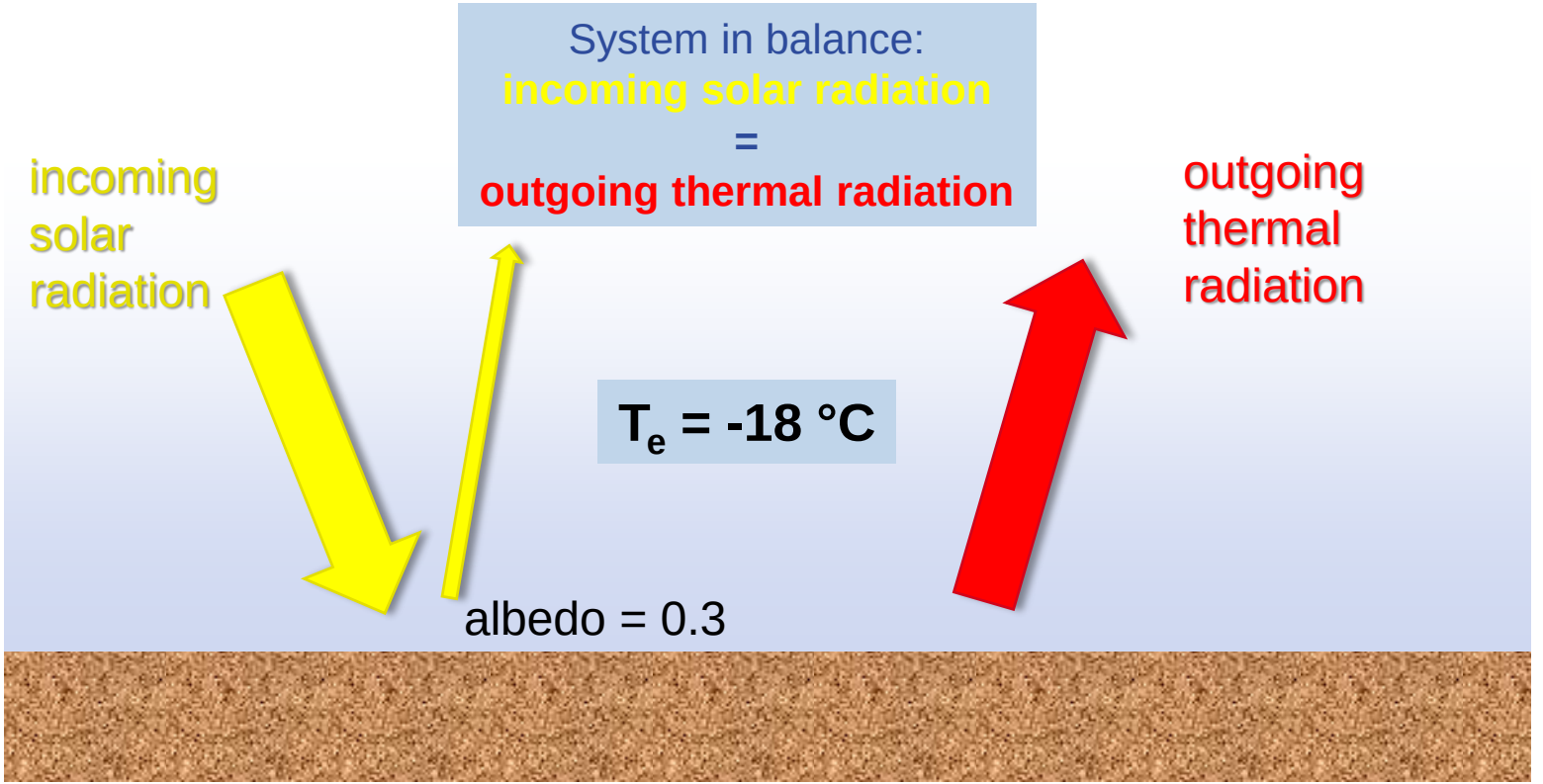

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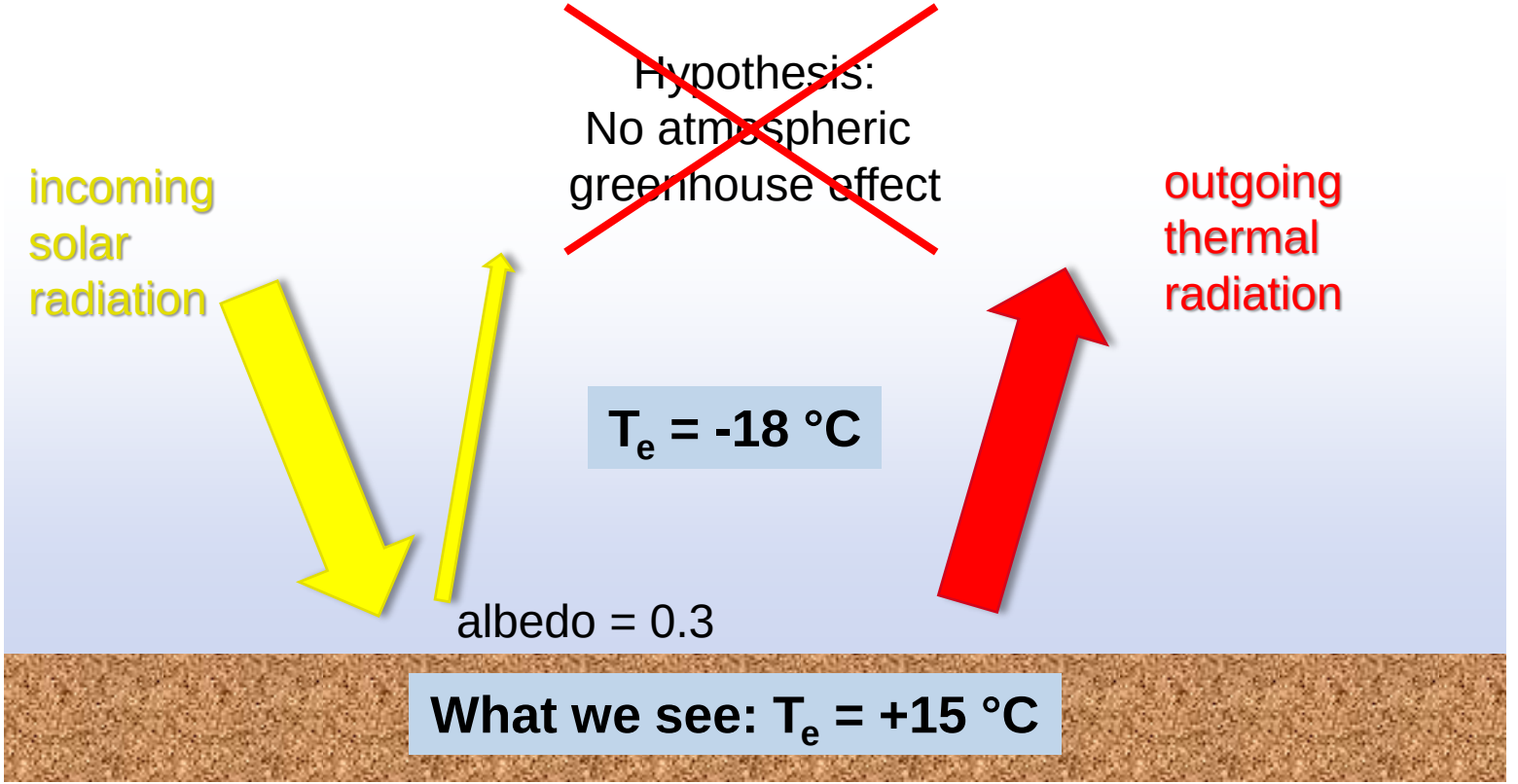

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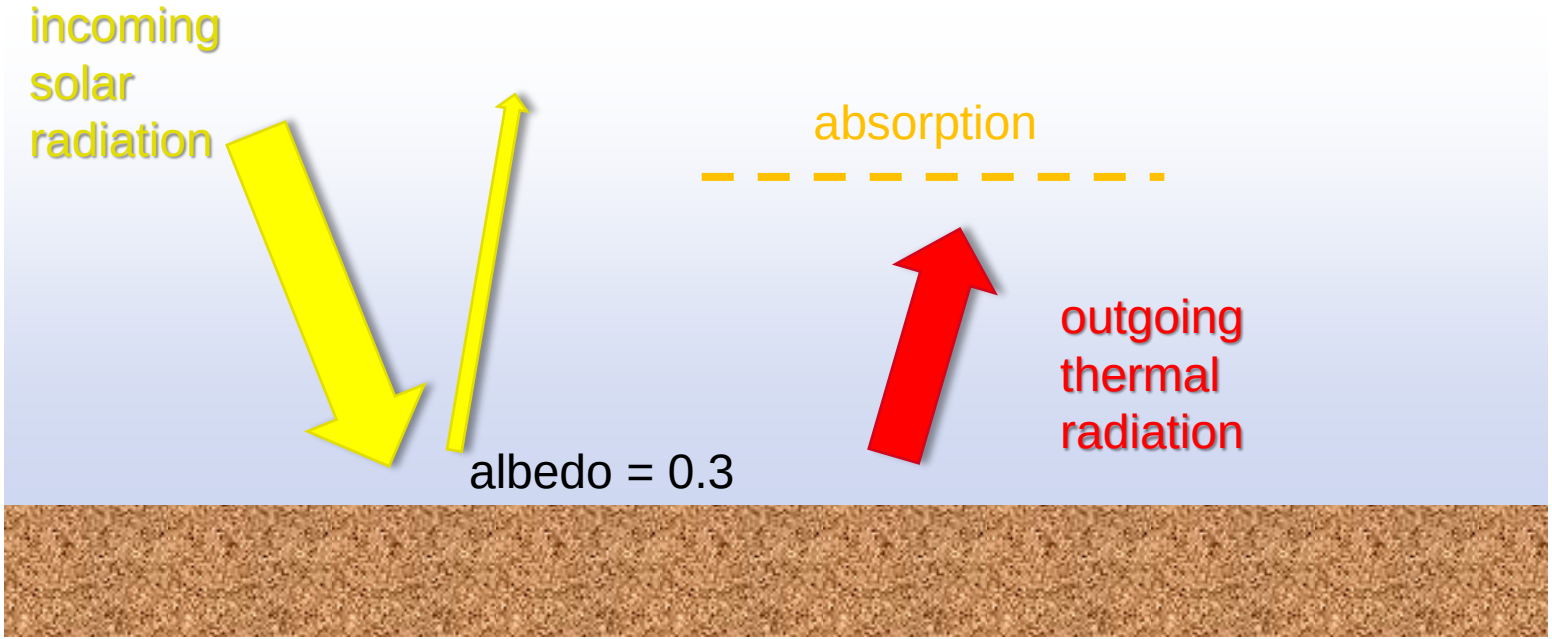

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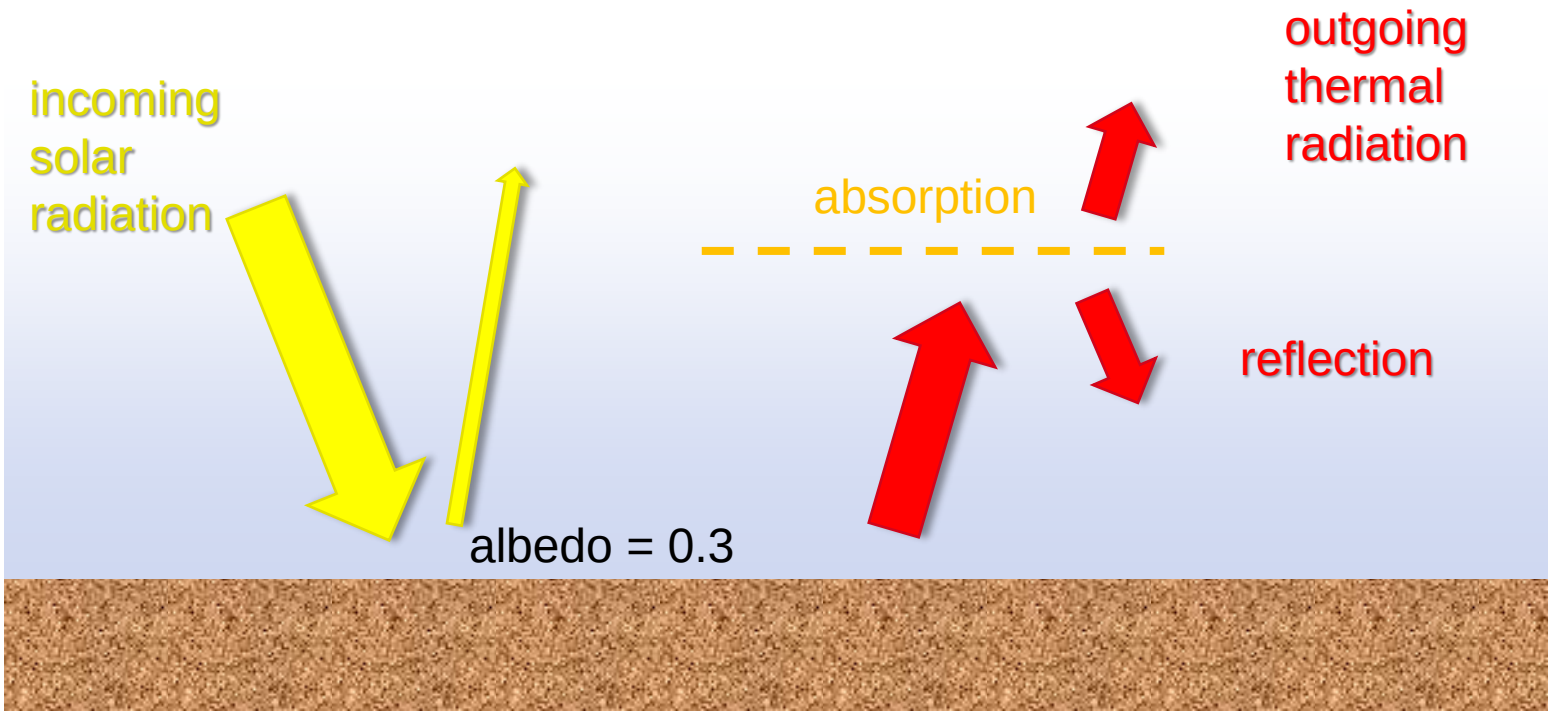

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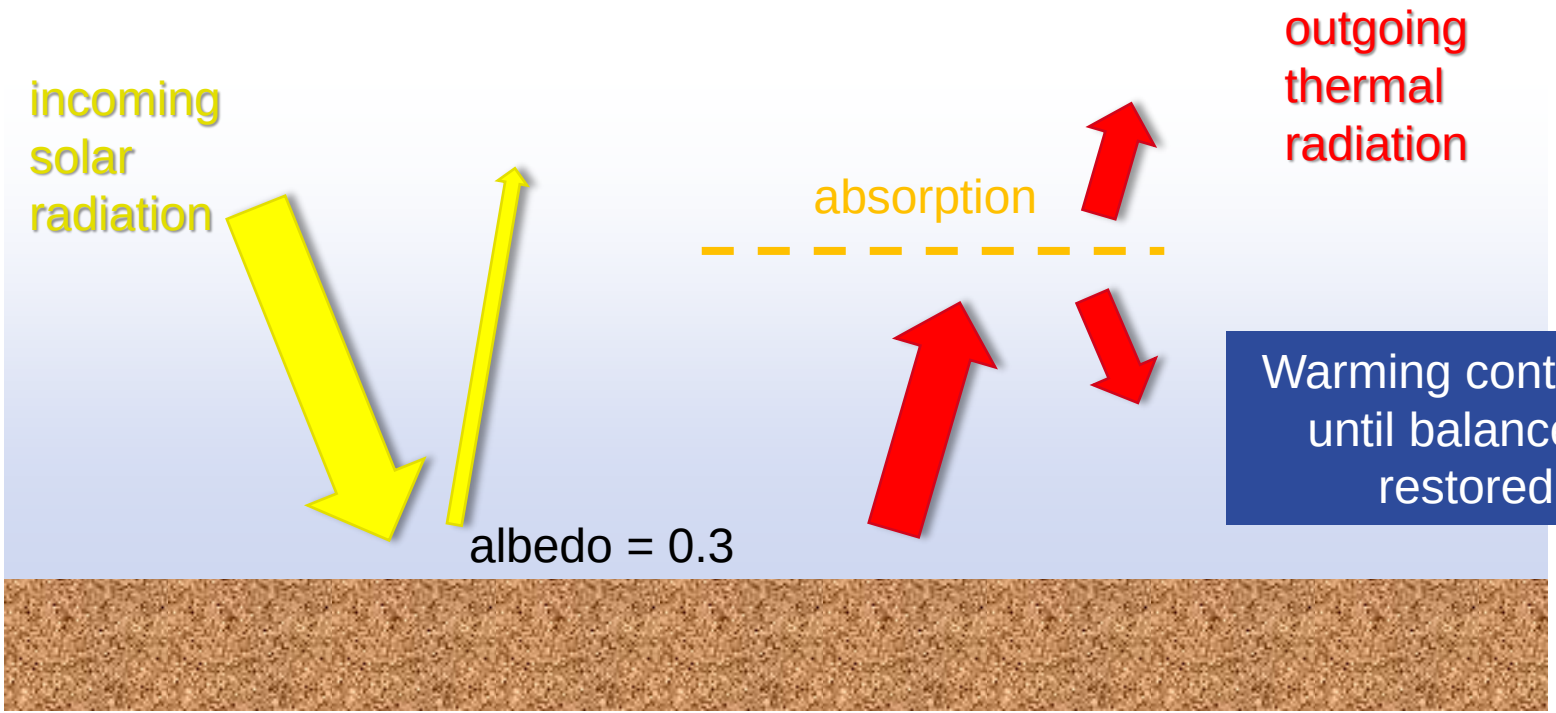

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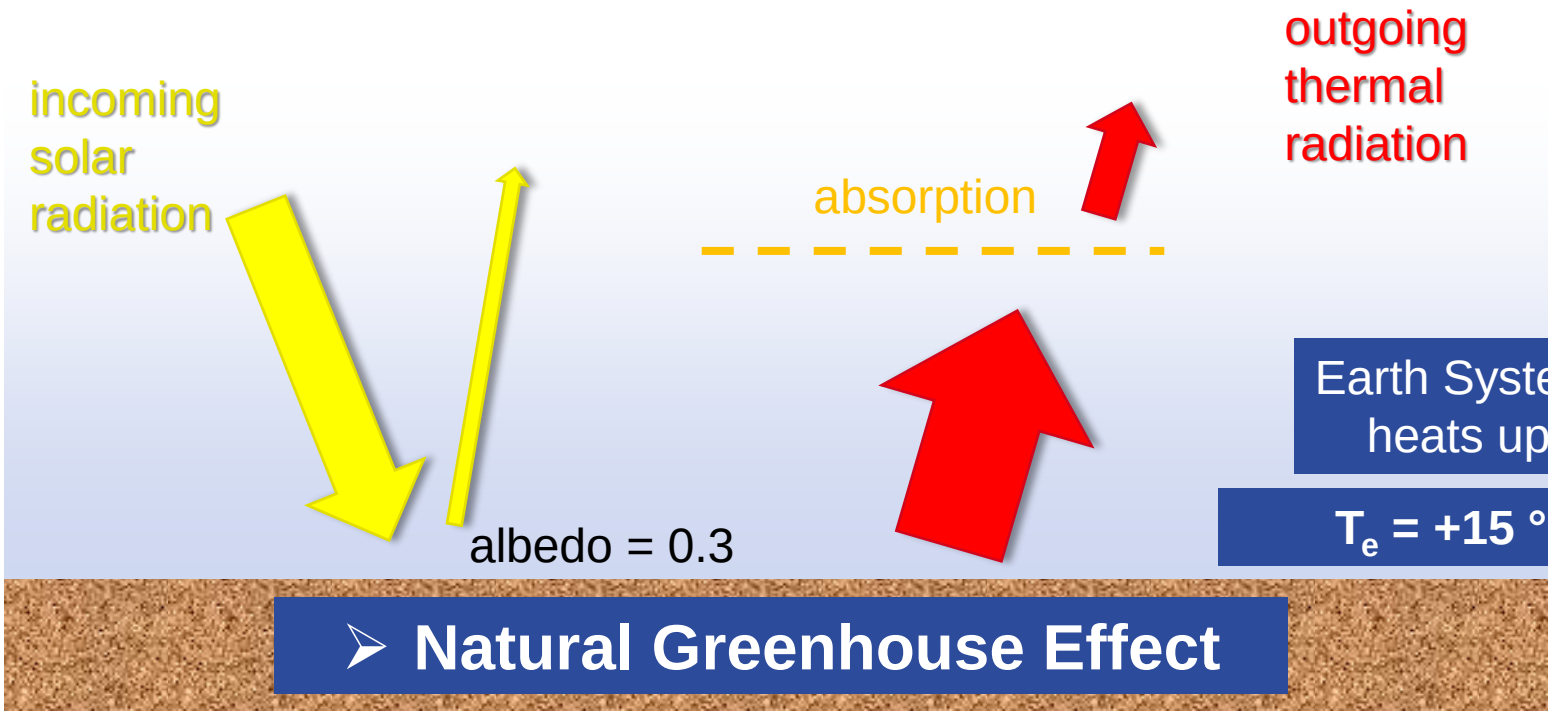


Some Scientific Background

How can just 0.04% CO_2 change the climate of an entire planet?

- ➔ Only trace gas but very efficient in interacting with thermal radiation
- ➔ A tiny change in its concentration changes the Earth‘s energy balance

Some Scientific Background

➔ We have known about the greenhouse effect for quite some time now

Source: https://www.europeana.eu

1824: Jean Baptiste Joseph Fourier (**natural greenhouse effect**)

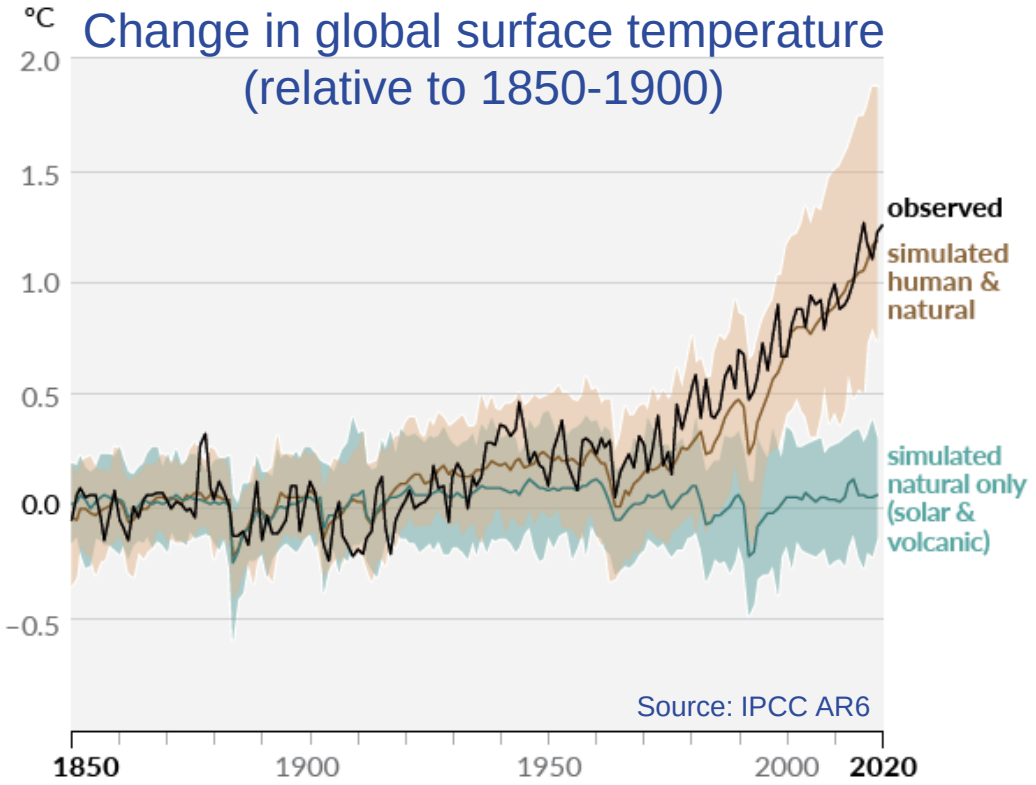
Source: Verlag von W. Engelmann - Photogravure Meisenbach Riffarth & Co., Leipzig

1896: Svante Arrhenius (**human influence on global warming**)

Some Scientific Background

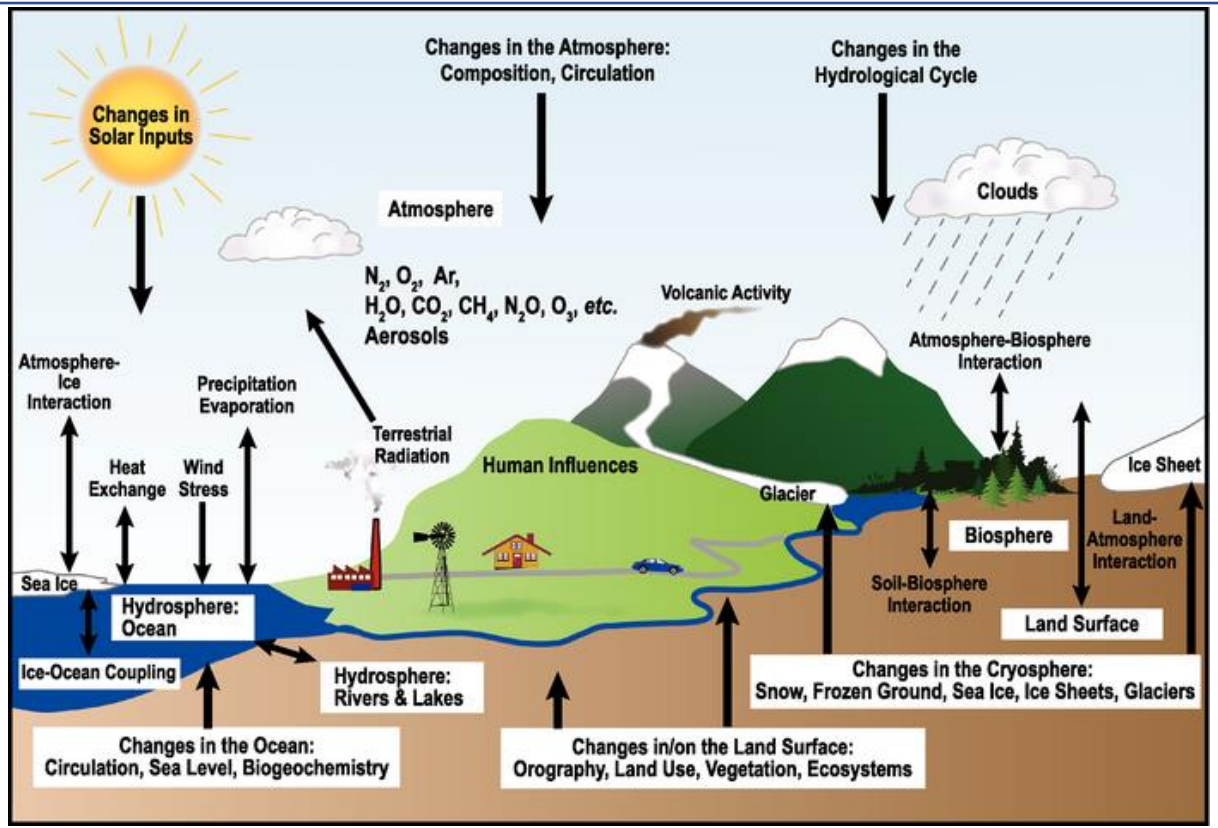
Human activities emit ***additional*** greenhouse gases into the atmosphere

…this results in a human-induced (***additional***) greenhouse effect



This wasn‘t too hard, was it?

Well,… reality is way more complex than this!

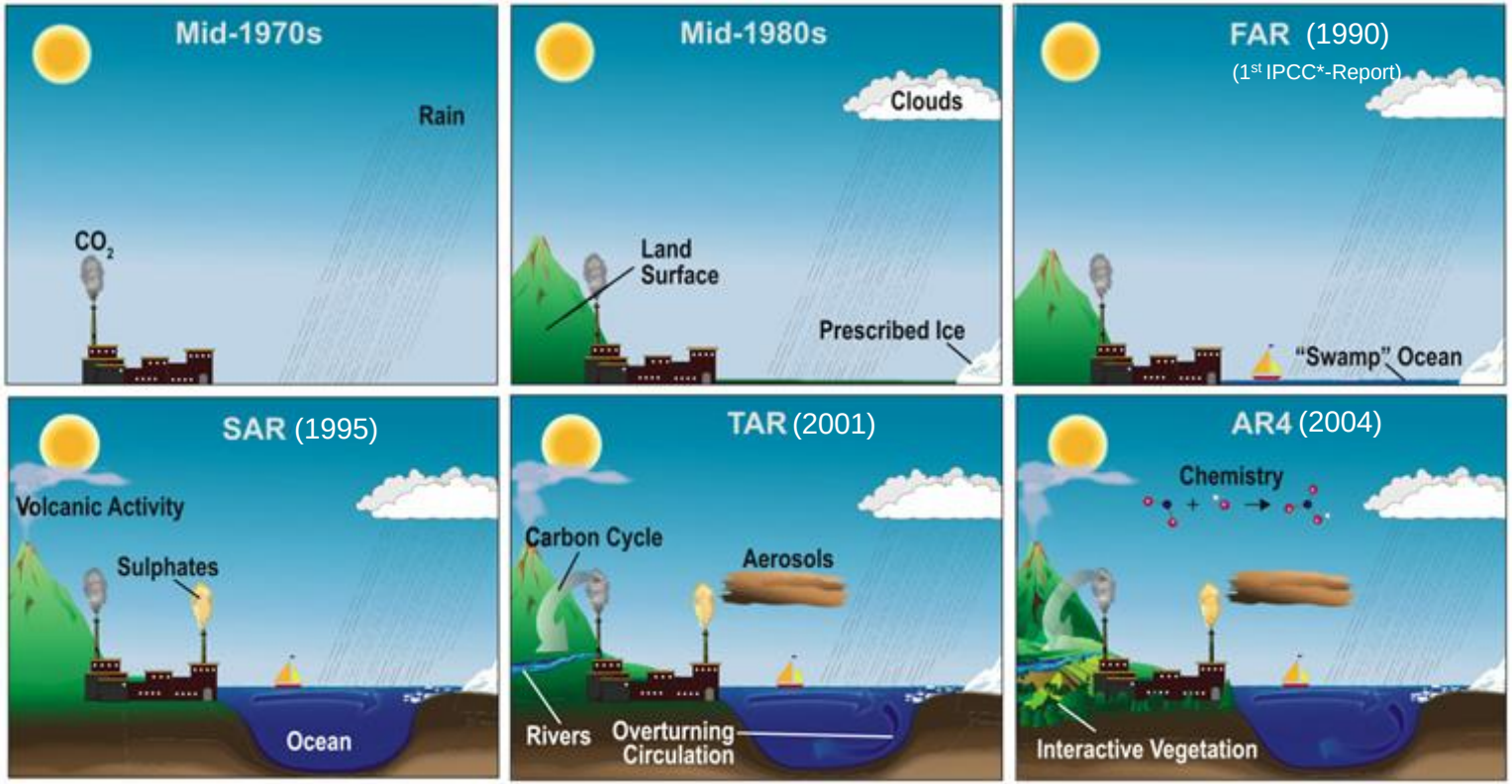


Source: IPCC AR4 (2004)

Why Do We Need Climate Models?

- The Earth‘s Climate System is a **complex system**
- Defintion of „complex system“: Interactions between components can be **non-linear**
  - Tipping elements can cause **irreversible** changes once critical thresholds are crossed.
- Objective of Climate Modelling:
  - Understanding the climate system using mathematical models
  - Put those into **numerical models**
  - Predict **future climate change**

Model Evolution



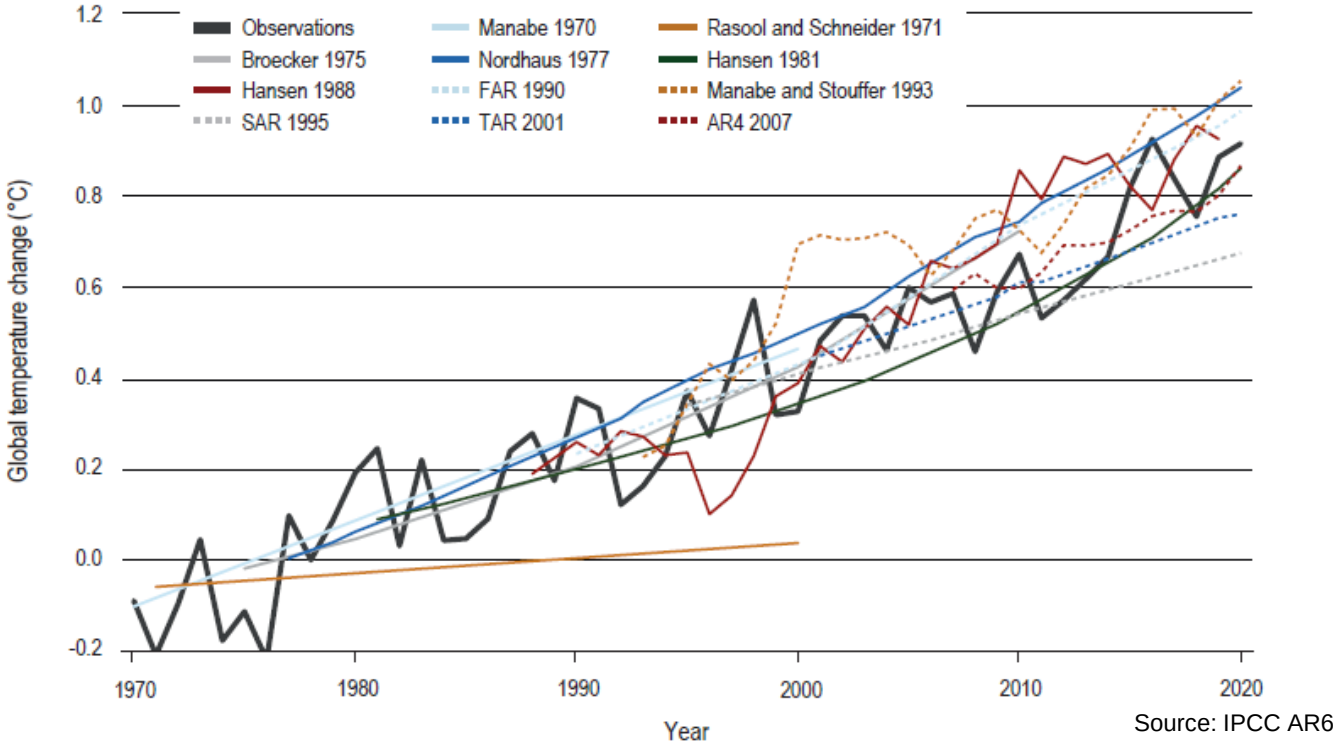
*(Intergovernmental Panel on Climate Change)

AR5: 2013
AR6: 2021

Source: IPCC AR4

Model Forecasts

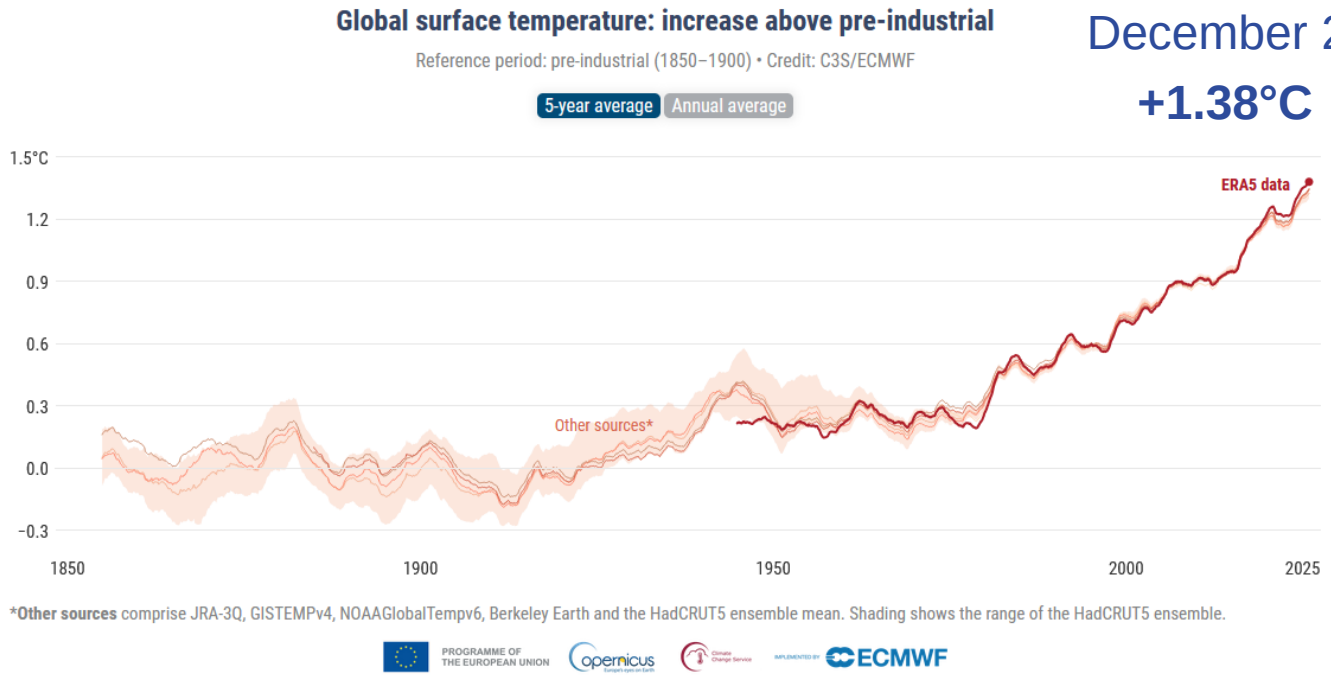
- Historical temperature projections versus observations



Source: IPCC AR6

Where Are We Today?

Global average temperature



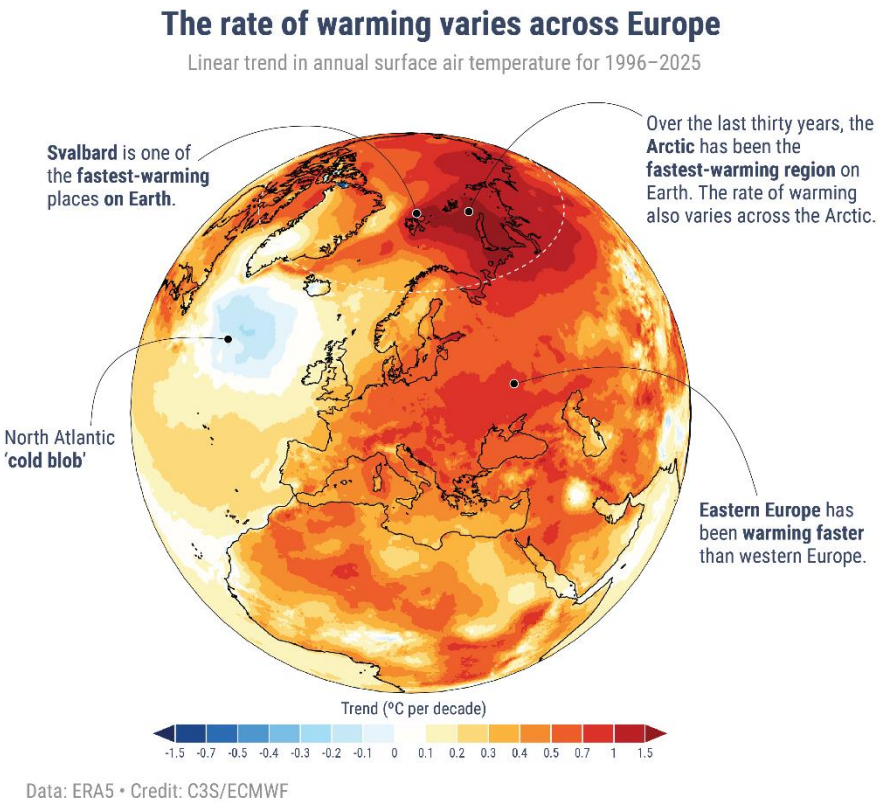
December 2025

+1.38°C

margin of uncertainty
± 0.13°C

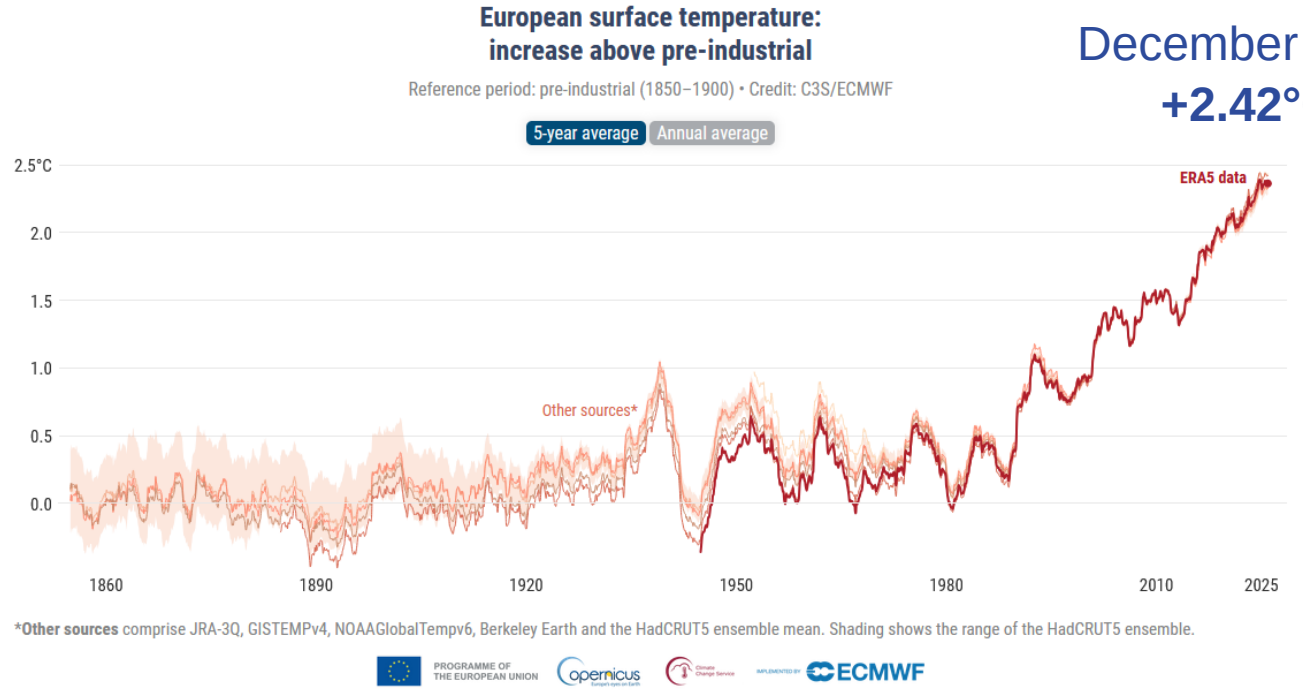
Where Are We Today?

- Warming is not evenly spread across the earth
- Arctic is the fastest-warming region on Earth
- Europe is the fastest-warming continent
- Several factors:
  - Changing weather patterns (more intense summer heat waves)
  - Reduced air pollution (less cloud cover)
  - Decreasing snow cover (decreasing albedo)
  - Geographical proximity to Arctic



Where Are We Today?

European temperature

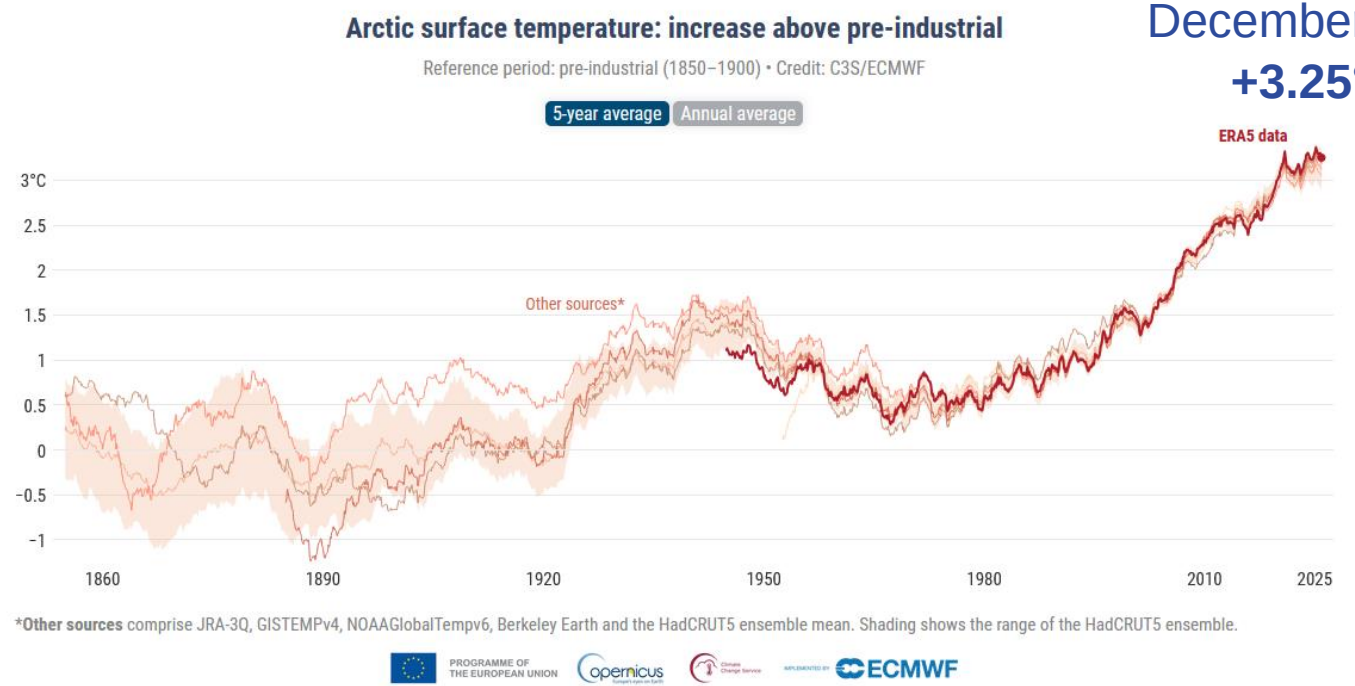


December 2025

+2.42°C

Where Are We Today?

Arctic temperature

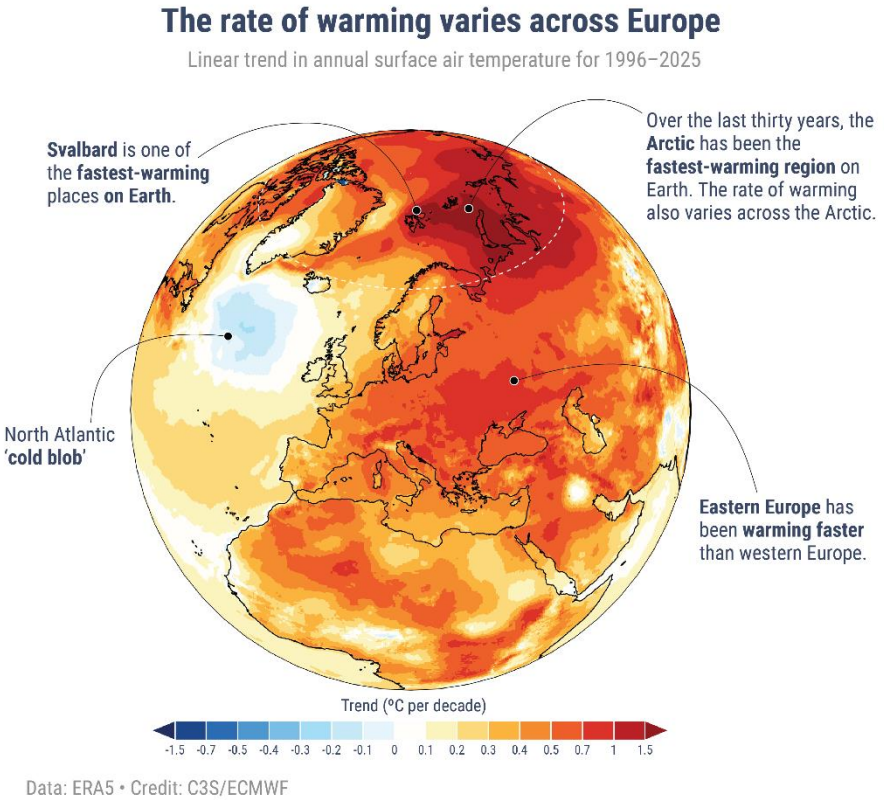


December 2025

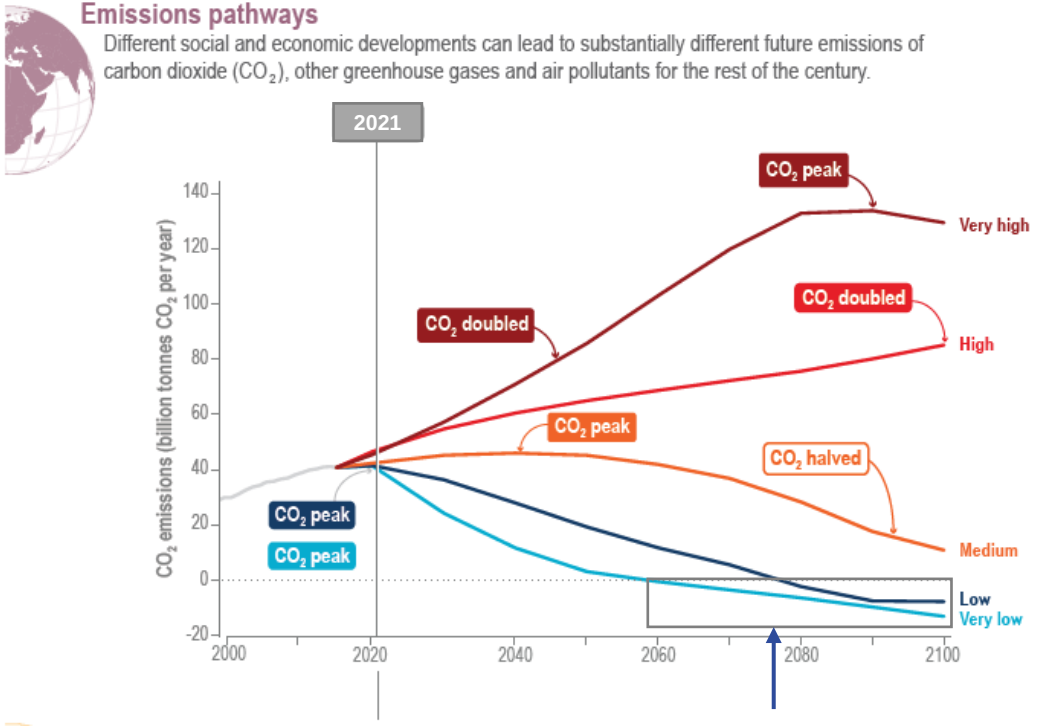
+3.25°C

Where Are We Today?

- North Atlantic „**cold blob**“
- Cooling of **0.9°C** since 1900
- Probable Reasons:
  - Clearly attributable to anthropogenic [human-caused] forcing
  - Changes in the high latitude ocean circulation
  - Cool fresh water avoids sinking creating more low-level clouds
  - One possible explanation is a weakening Atlantic Meridional Overturning Circulation

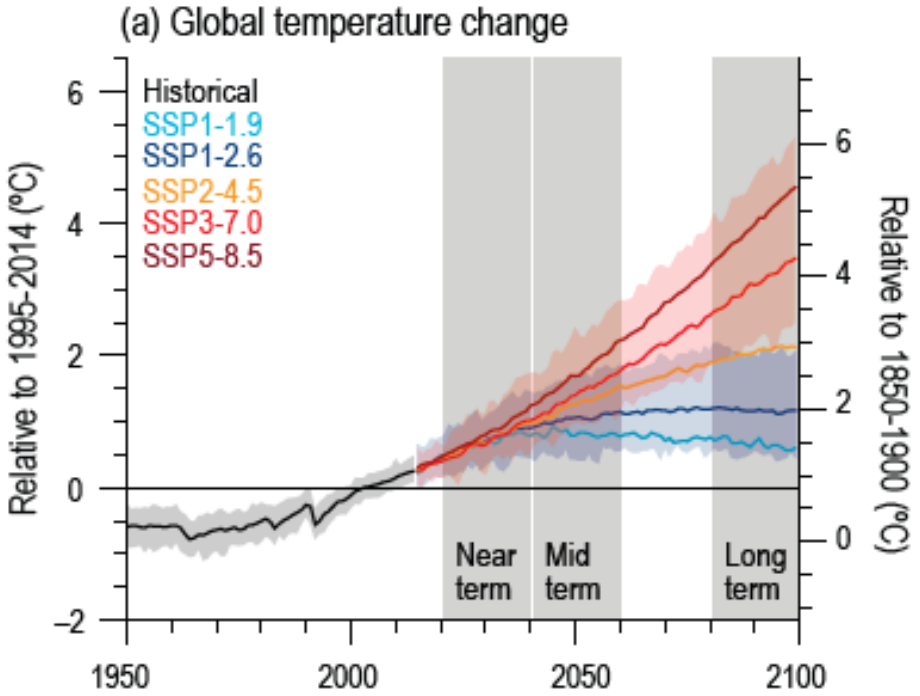


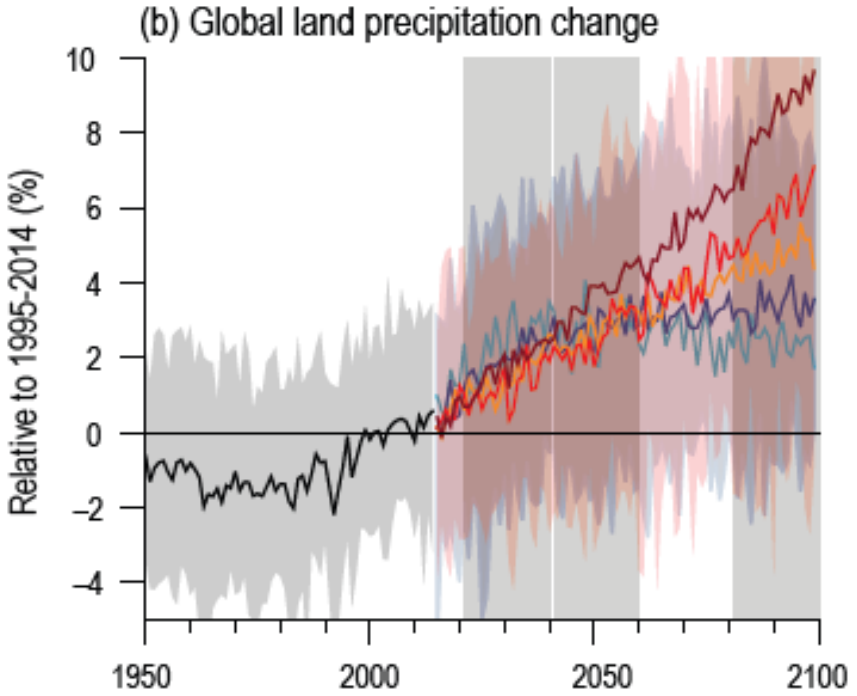
Model Projections



Source : IPCC, AR6, Technical Summary

Model Projections



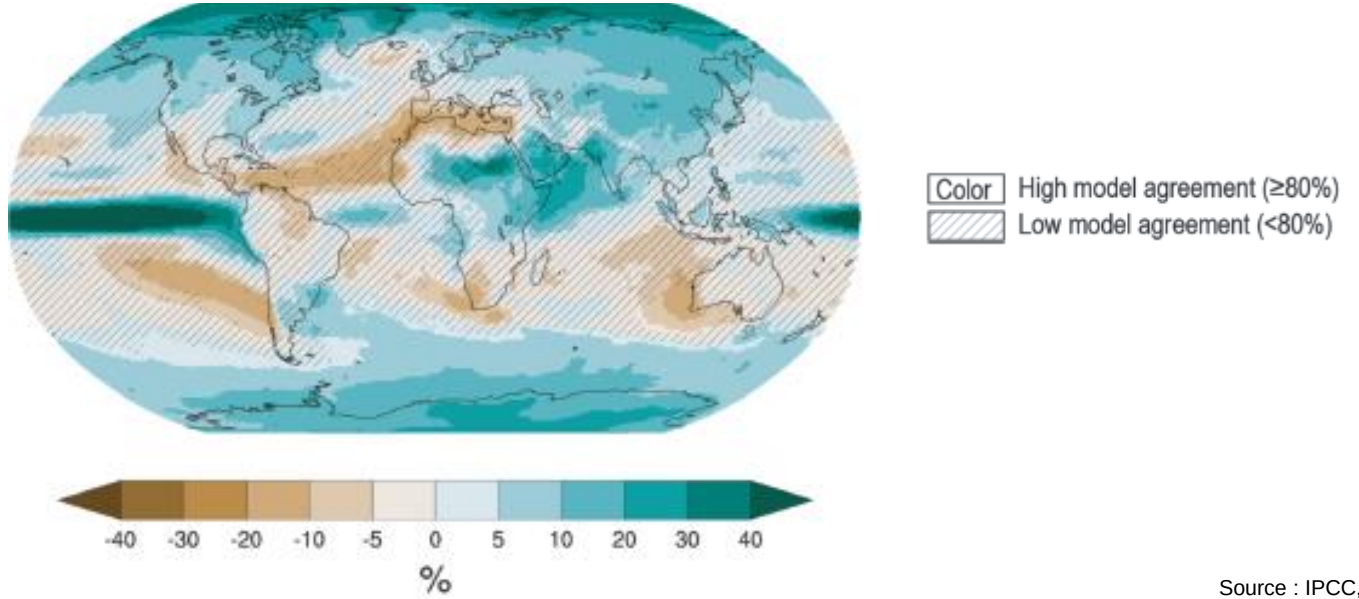


Source : IPCC, AR6

Model Projections

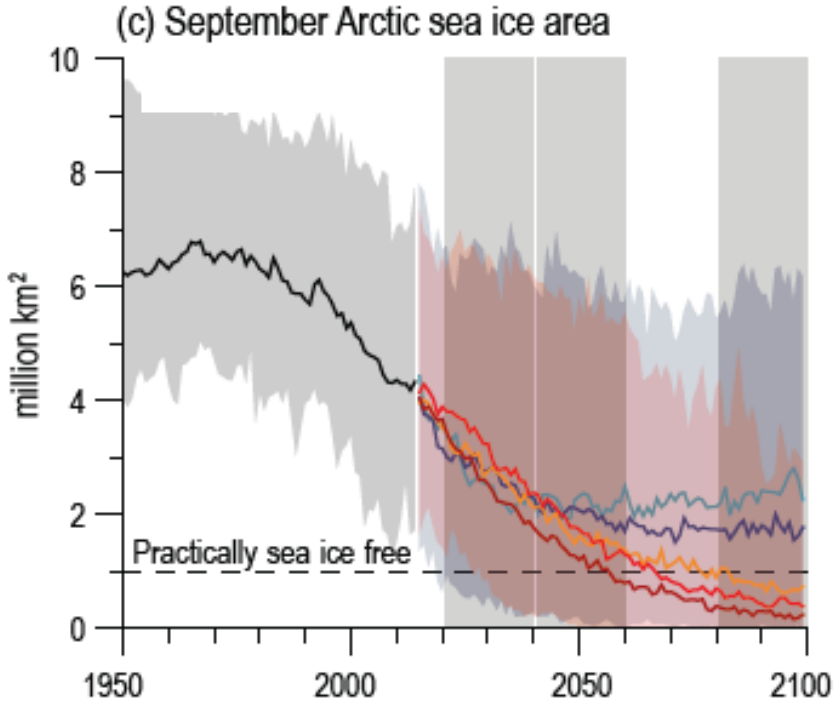
low - medium emissions scenario

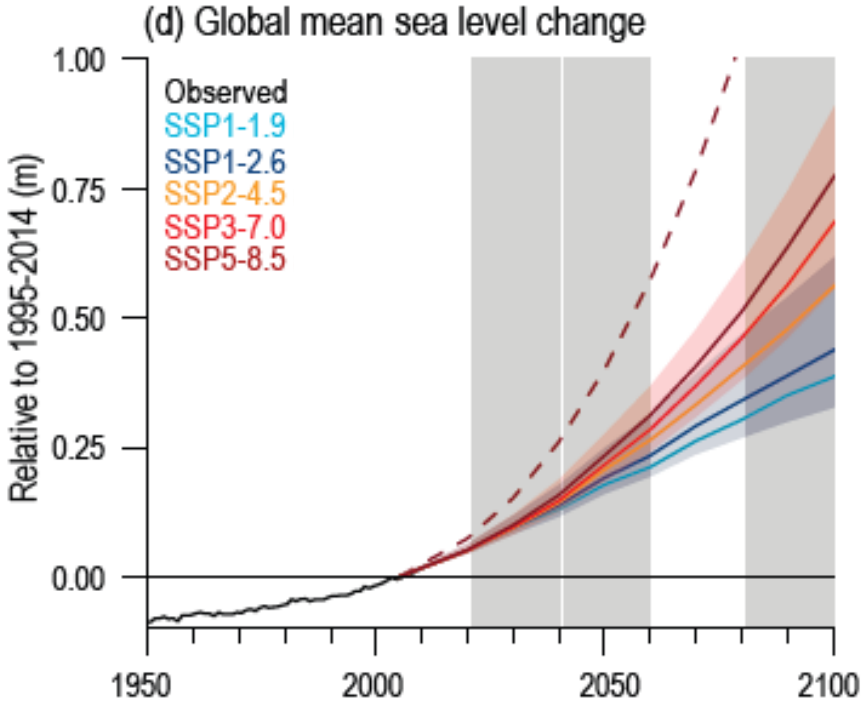
Long-term (2081–2100) projected annual mean changes (%) in precipitation relative to present-day (1995–2014)



Source : IPCC, AR6

Model Projections





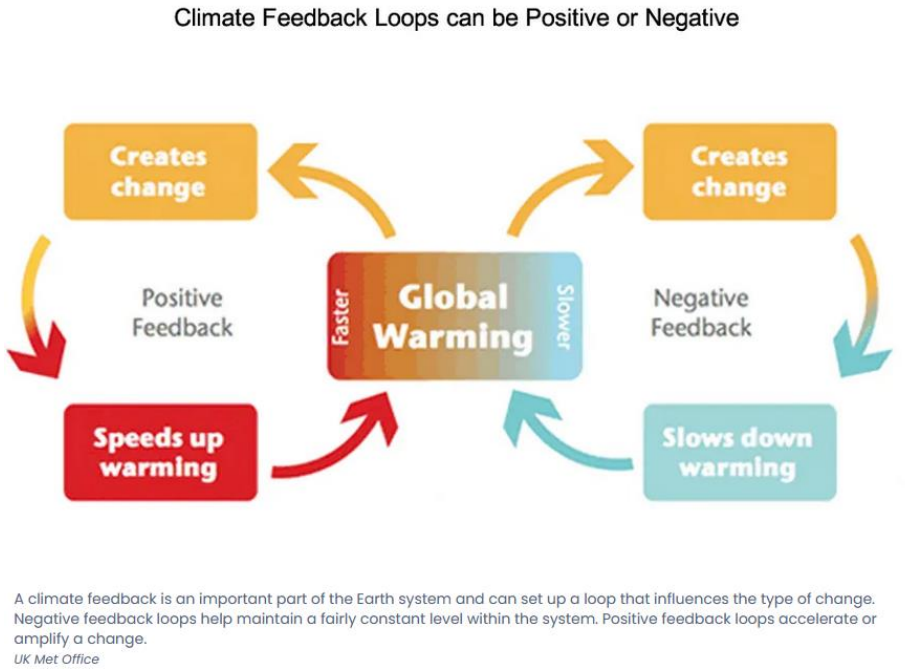
Source : IPCC, AR6

Model Projections

Why should this worry us?

Feedback Loops

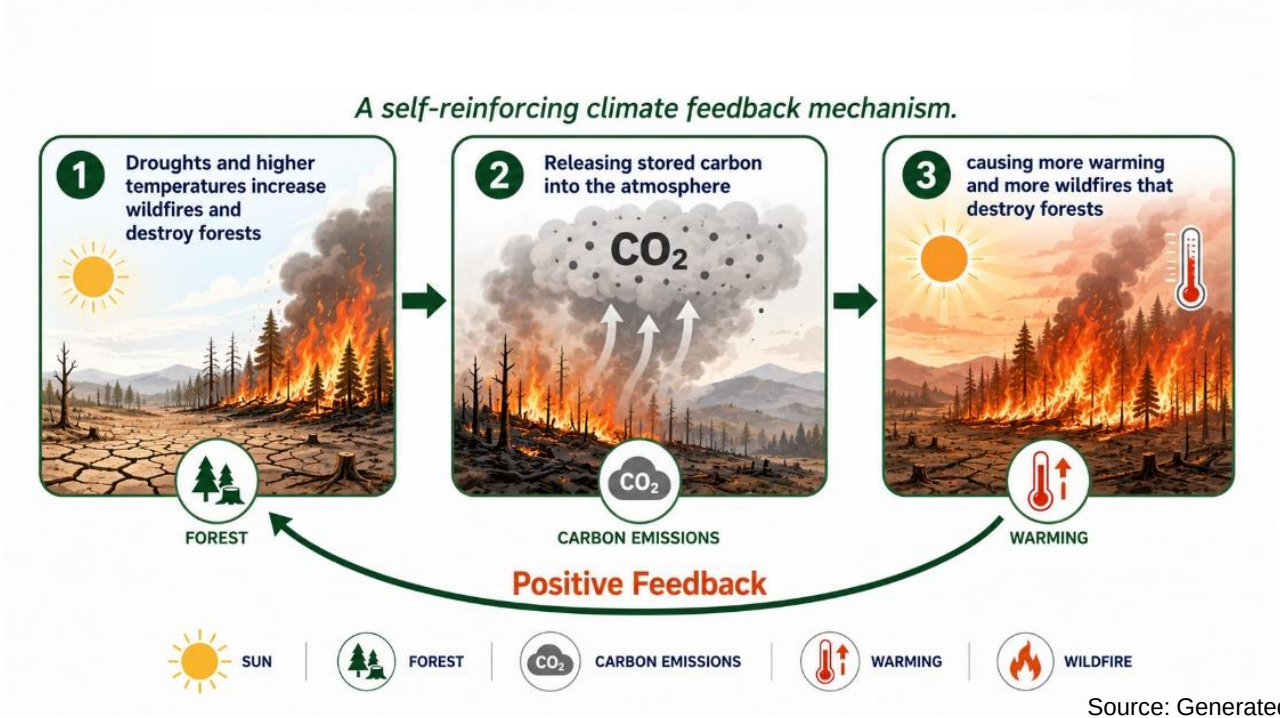
- **Complex system** with interactions like **feedback loops** and **tipping points**
- **Feedback loops** in climate change are processes that either amplify (positive) or weaken (negative) the effects of global warming, acting as self-reinforcing processes.



Source : UK Met Office

Feedback Loops - Examples

➔ **Forest Dieback (positive feedback loop):**



Source: Generated with ChatGPT (OpenAI), 2026.

Feedback Loops - Examples

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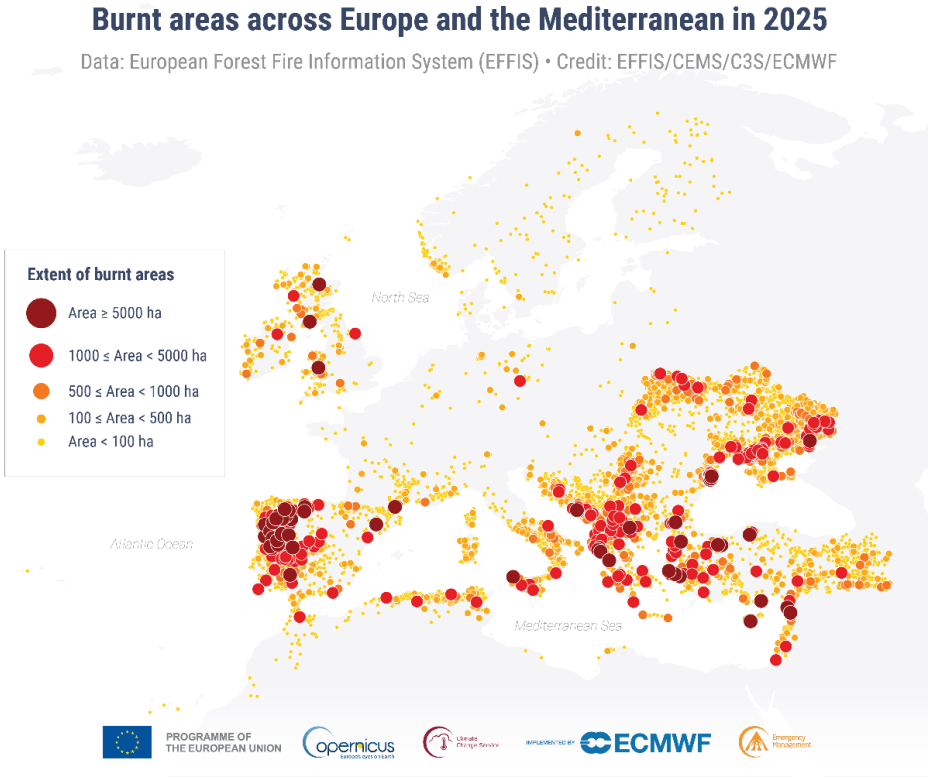
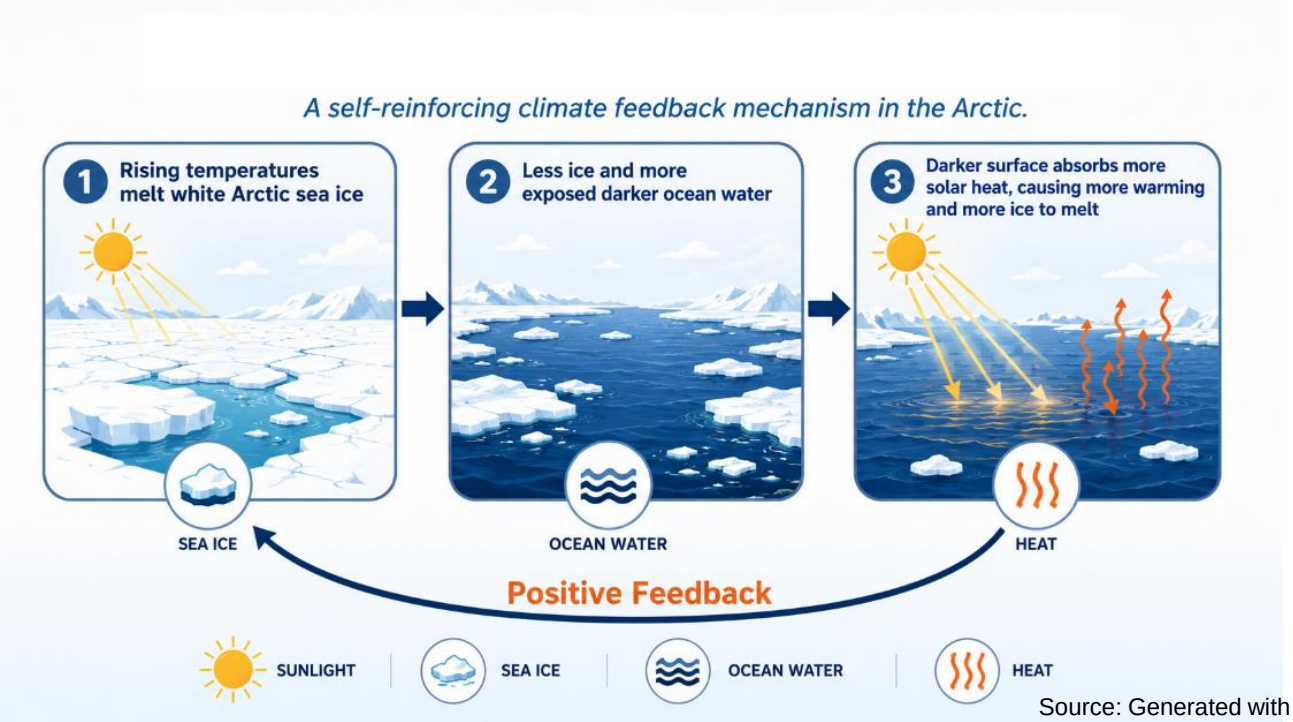
Source: anews.com



Feedback Loops - Examples

➔ **Ice-Albedo Feedback (positive loop):**



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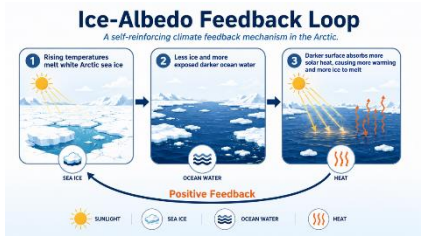

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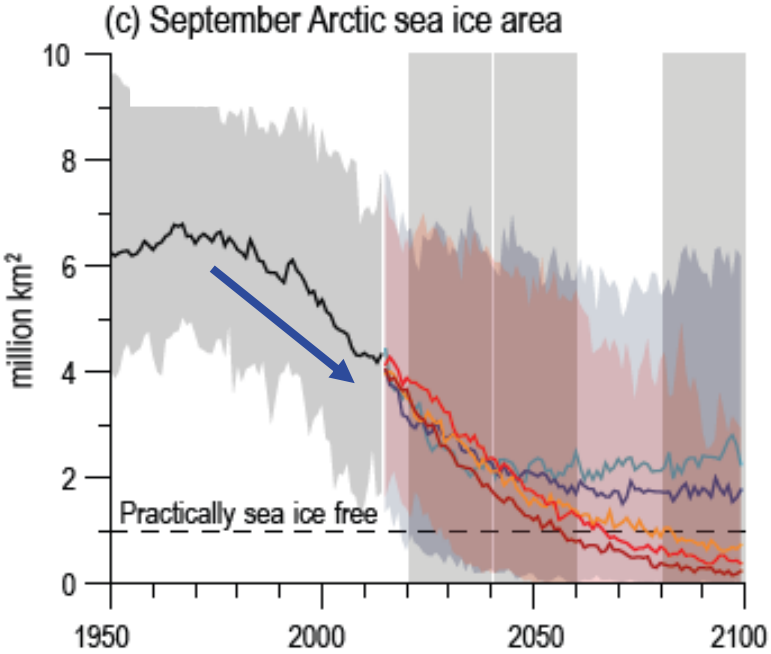
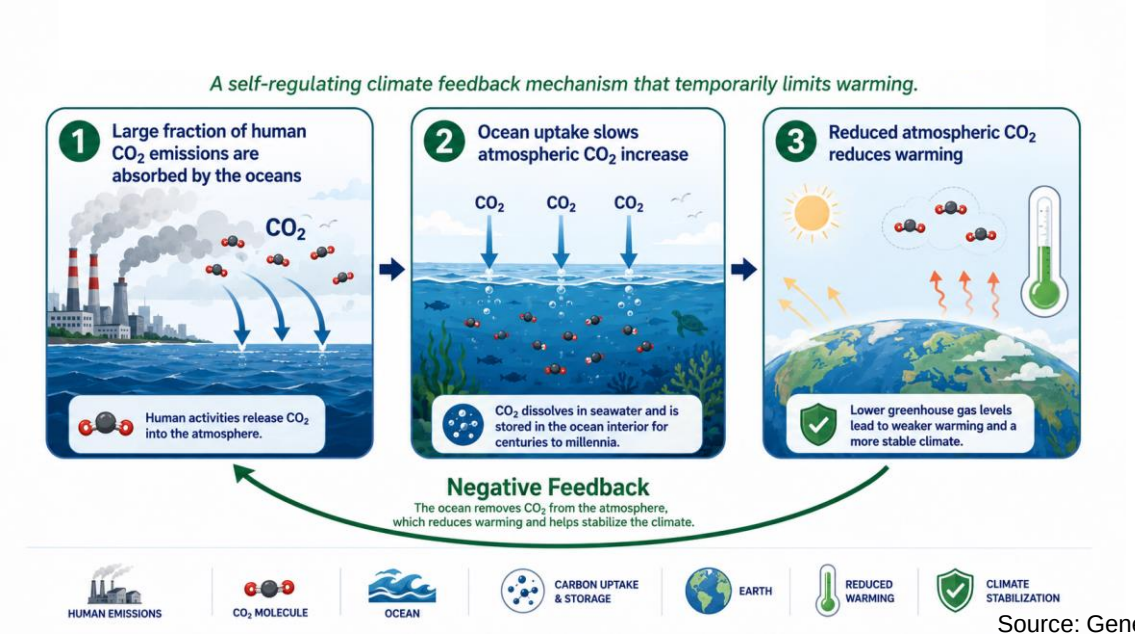


Source : IPCC, AR6

Feedback Loops - Examples

- **Negatives loops** help the Earth system to remain stable
- **Ocean uptake of CO_2 (negative loop):**



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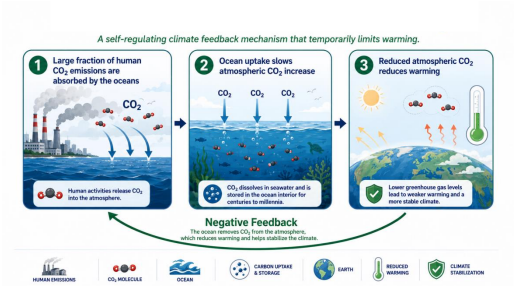


Source: Generated with ChatGPT (OpenAI), 2026.

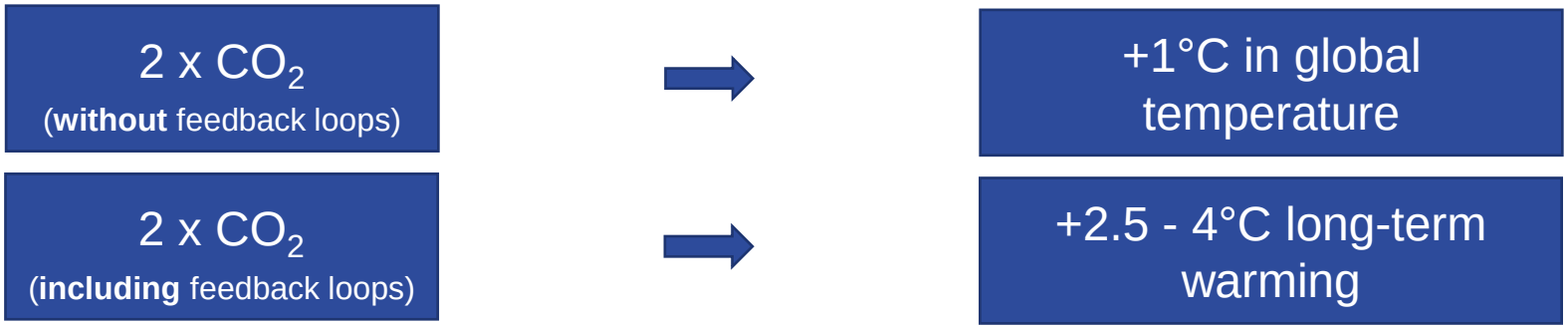
Problems:

- Warmer ocean absorbs CO_2 less efficiently
- Ocean acidification due to CO_2 uptake

➢ **The ocean is buying us time — not solving the problem.**

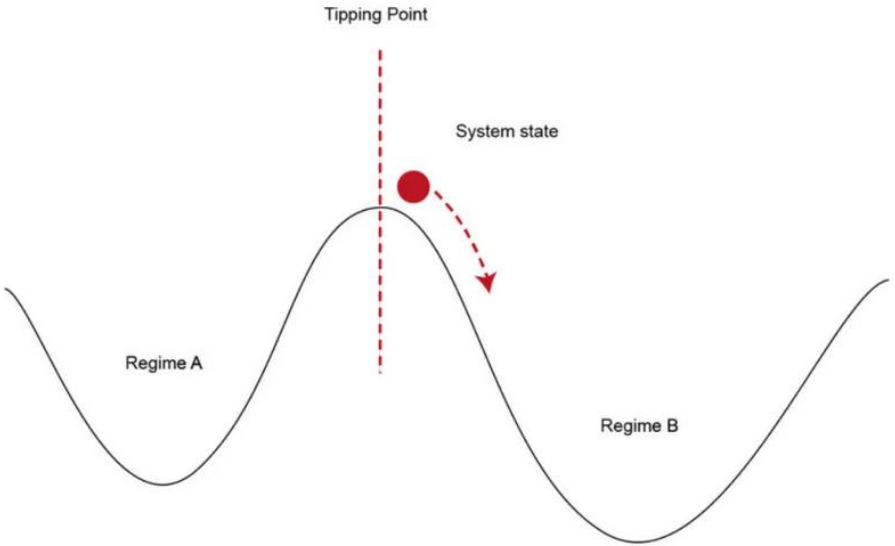
Feedback Loops

- Why are **feedback loops** important?
  - CO_2 may cause **initial** warming
  - Feedback loops can **multiply** this warming significantly
  - Especially positive loops can lead to "**tipping points**" where changes become **irreversible**



Tipping Points

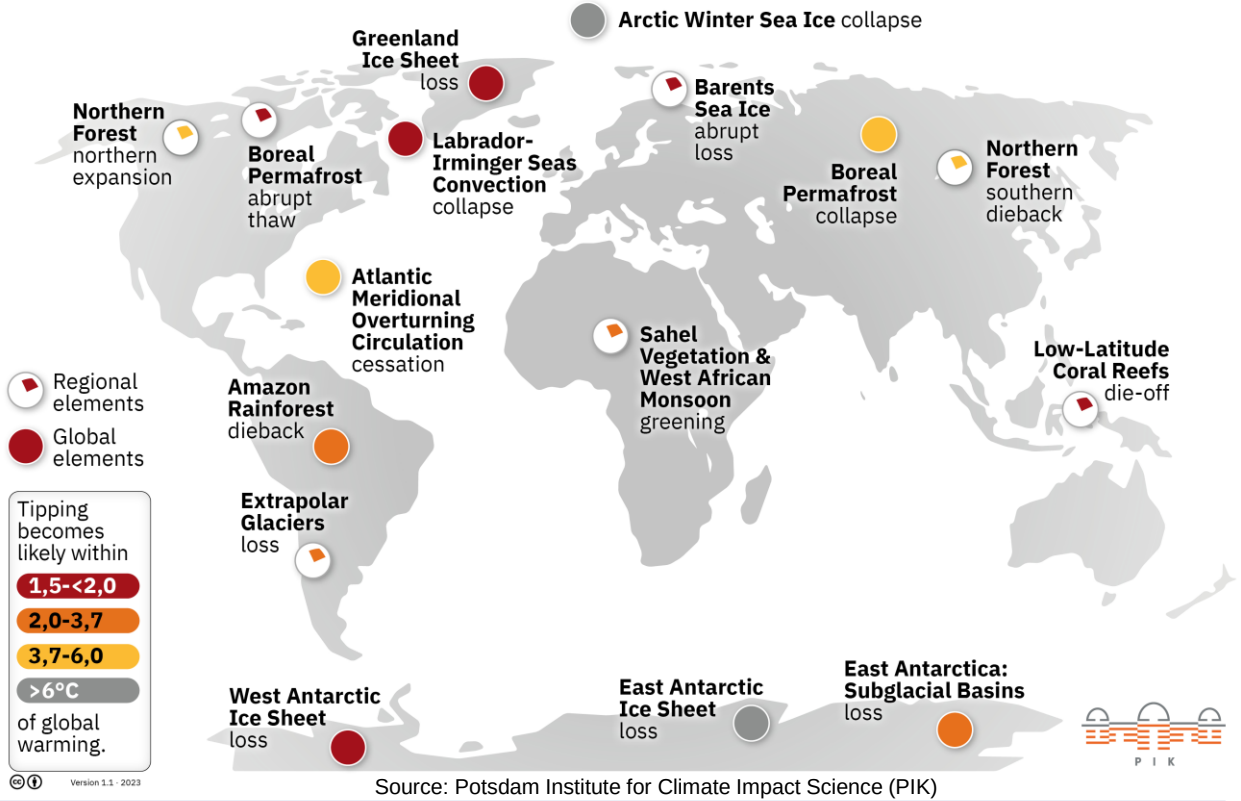
- Tipping points occur when a **positive feedback loop** crosses a **threshold**
- This leads to large changes, that often can‘t be turned around or reversed.



Tipping points within Earth's climate system mark a threshold at which positive feedback loops can 'tip' an existing, predictable system into a profoundly different pattern.
Creative Commons Rauter et al.

Tipping Points

- Exact **thresholds** for most of the tipping points are **uncertain**
- With the rise above **+1.5°C** there is a high risk of triggering tipping points
- Leads to greater risk of unexpected changes

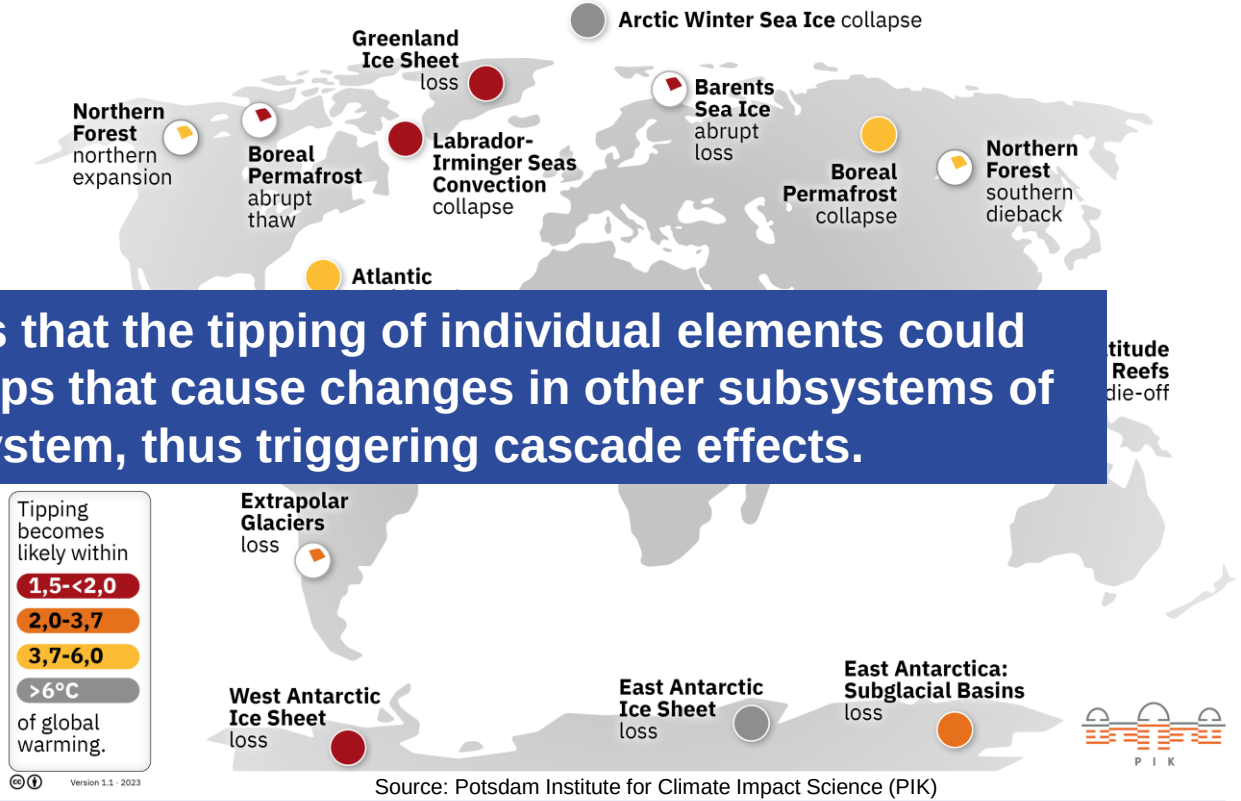


Source: Potsdam Institute for Climate Impact Science (PIK)

Tipping Points

- Exact **thresholds** for most of the tipping points are **uncertain**
- Wi… **+1**… of …
- Leads to greater risk of unexpected changes

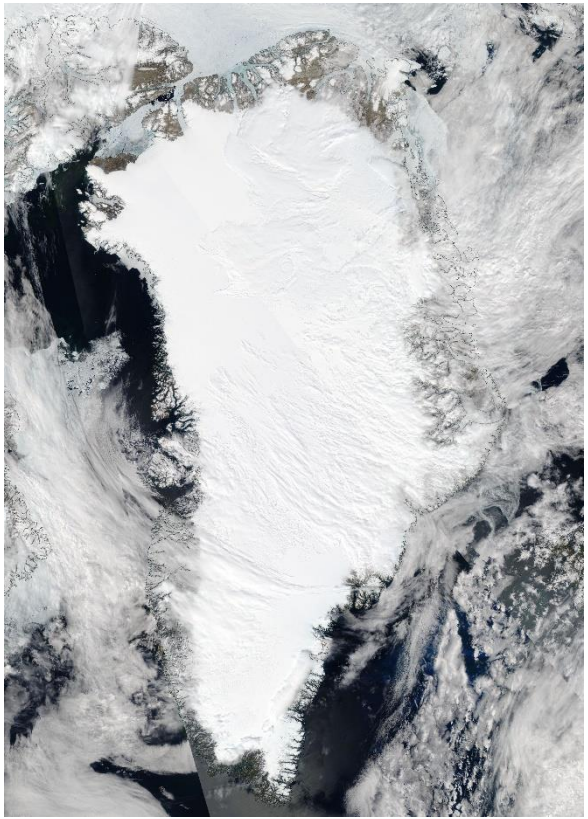
There are concerns that the tipping of individual elements could trigger feedback loops that cause changes in other subsystems of the Earth system, thus triggering cascade effects.



Source: Potsdam Institute for Climate Impact Science (PIK)

Tipping Points

- **Greenland Ice Sheet**
- Thickest point nearly 3500 m
- If the ice melts, it won‘t be able to grow back, even if temperature returns to „normal“ conditions
- Not immediate collapse but the beginning of an irreversible transition for centuries to come



Source: https://worldview.earthdata.nasa.gov

Tipping Points

- „Greenland's Ice Sheet might be close to first tipping point"

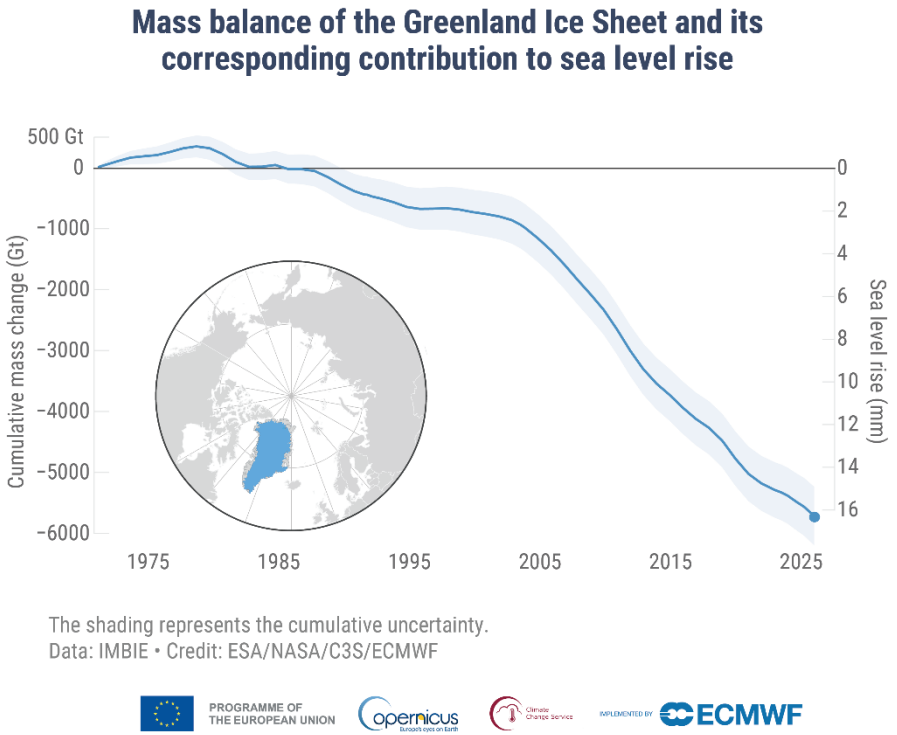
(Potsdam Institute of Climate Impact Science, May 2023)

- Long-term global sea-level rise

Höning et al., 2023:

  - Passing of +0.6°C → 26 cm (1950th)
  - Passing of +1.6°C → 2.4 m
  - Consistently passing +2°C → eventually up to 7 m rise

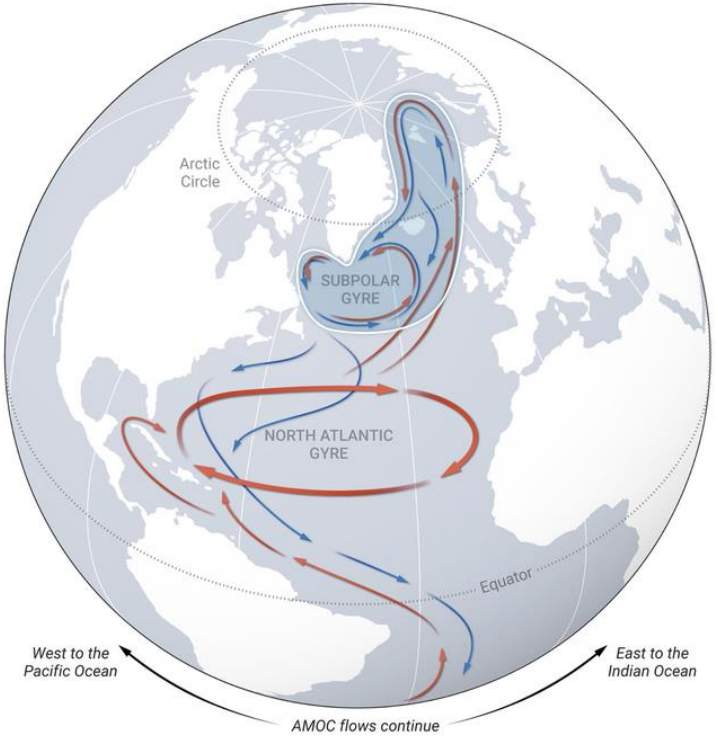
- Increased freshwater input into the North Atlantic, potentially affecting ocean circulation



Tipping Points

- **Atlantic Meridional Overturning Circulation**
- Winds and differences in salinity transport warm surface water north, heating up northwest Europe
- Deep water formation (overturning):
  - Warm surface water cools down and evaporates
  - As sea ice forms salt cannot fit into ice‘s crystal structure („brine rejection“)
  - extremly cold and dense

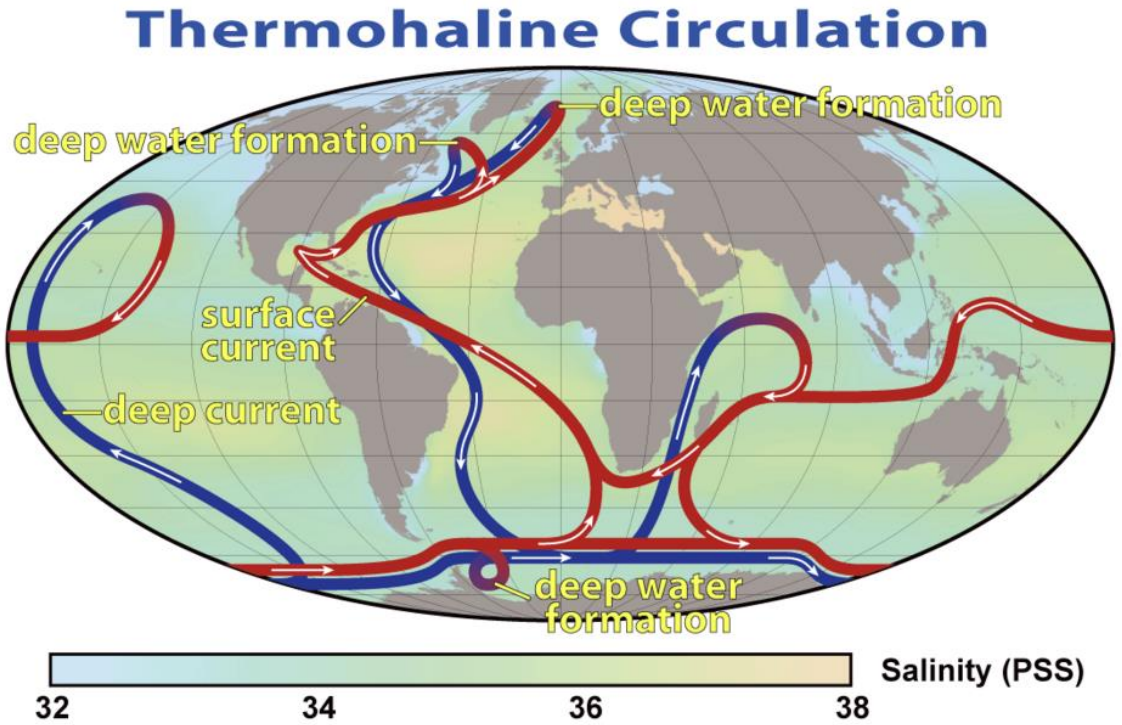
    saltwater sinks into deeper ocean
- Stabilizes climate conditions, especially in Europe



Source: https://www.science.org/content/article/ocean-current-warms-europe-may-be-more-resilient-feared

Tipping Points

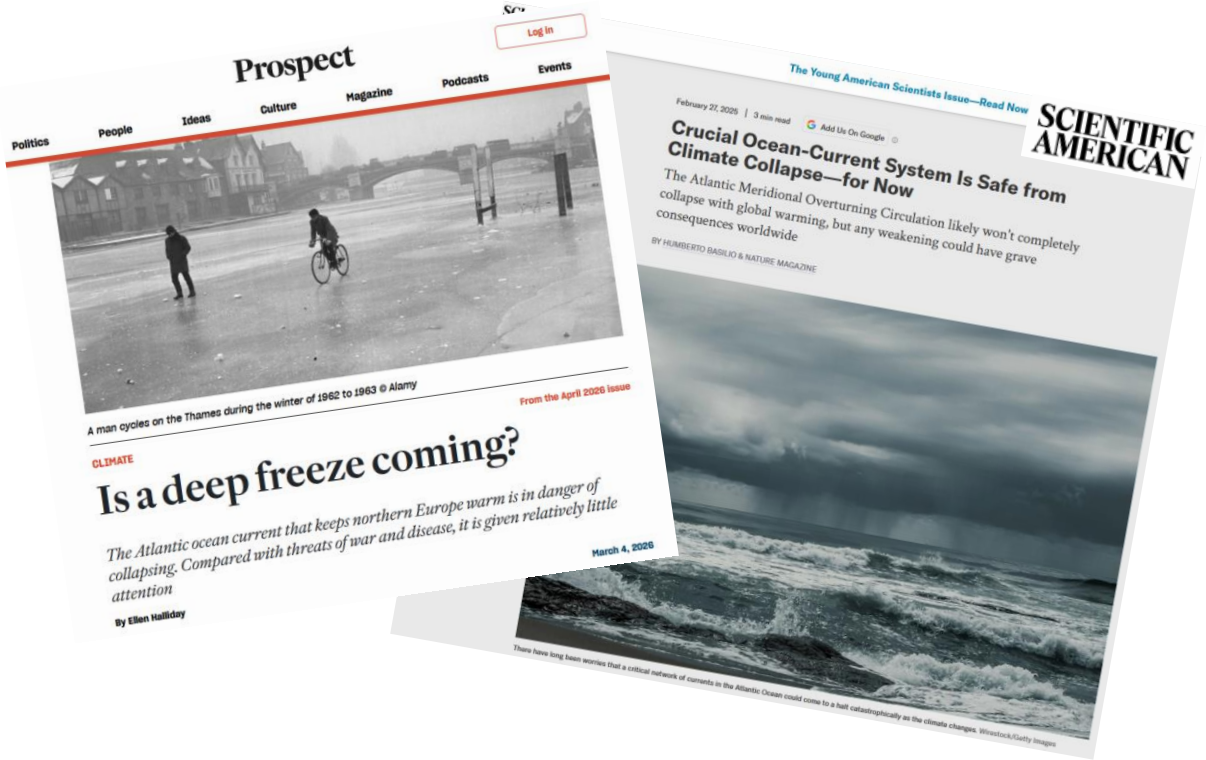
- The **Atlantic Meridional Overturning Circulation (AMOC)** is part of the global **Thermohaline Circulation**
- A weakening or collapse of the AMOC will have a global impact



Source: Robert Simmon, NASA. Wikimedia Commons

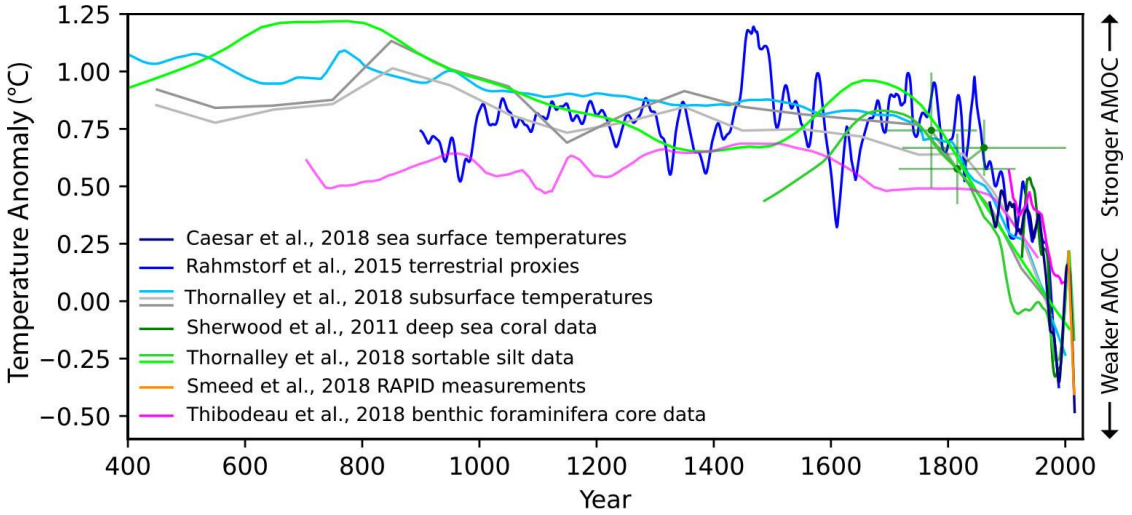
Tipping Points

- **Is the AMOC approaching a critical threshold?**



Tipping Points

- **Is the AMOC approaching a critical threshold?**
- Scarce observations suggest a weakening in recent decades

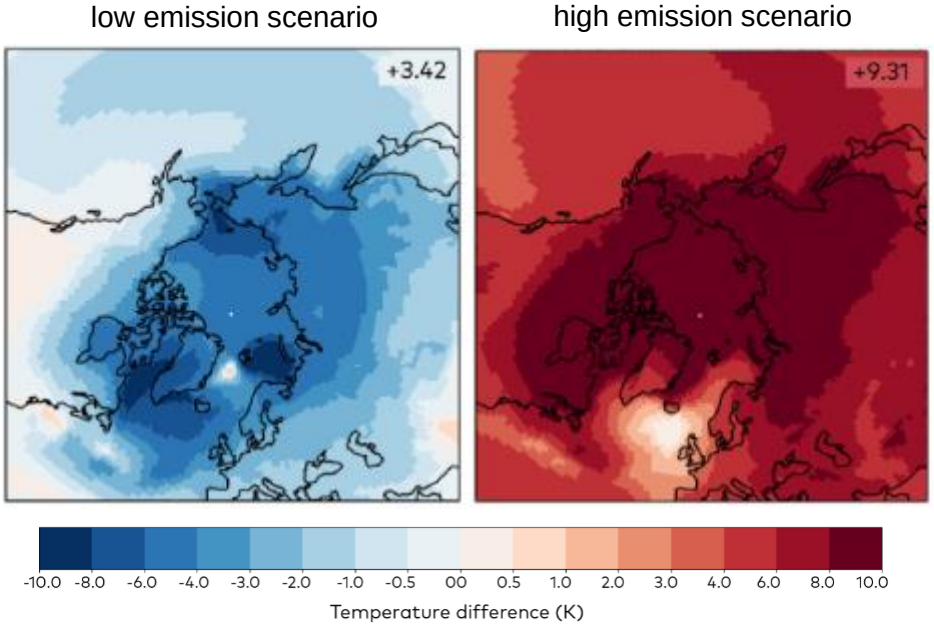


Source: Rahmstorf (Oceanography, 2024)

Tipping Points

- **Is the AMOC approaching a critical threshold?**
- Scarce observations suggest a weakening in recent decades
- large model differences (no interactive greenland ice sheet)

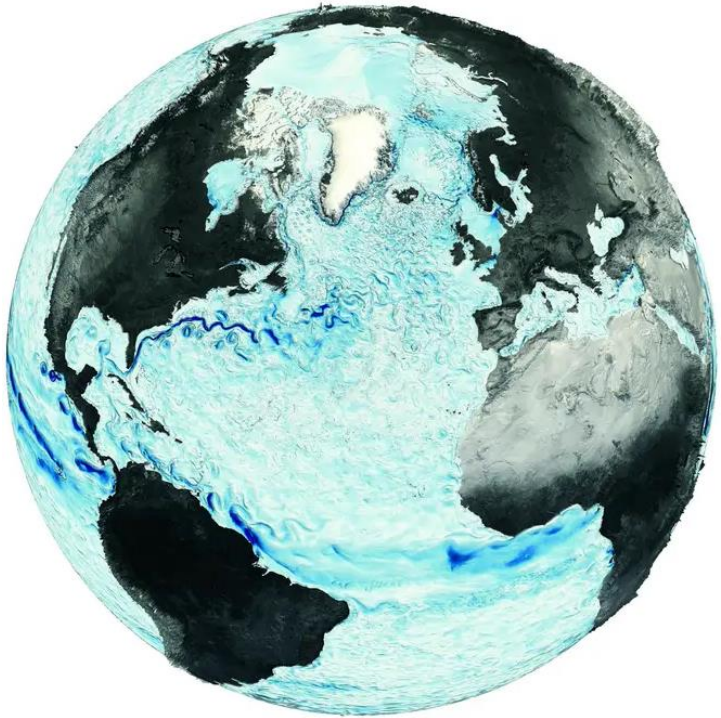
Mean winter surface temperature anomalies (2005-2025) with AMOC slow down at the end of the century



Source: A Nordic Perspective on AMOC Tipping (2025); Credit: FMI, Laura Thölix

Tipping Points

- **Is the AMOC approaching a critical threshold?**
- Scarce observations suggest a weakening in recent decades
- large model differences (no interactive greenland ice sheet)
- possible early warning signals
- but no precise prediction of timing



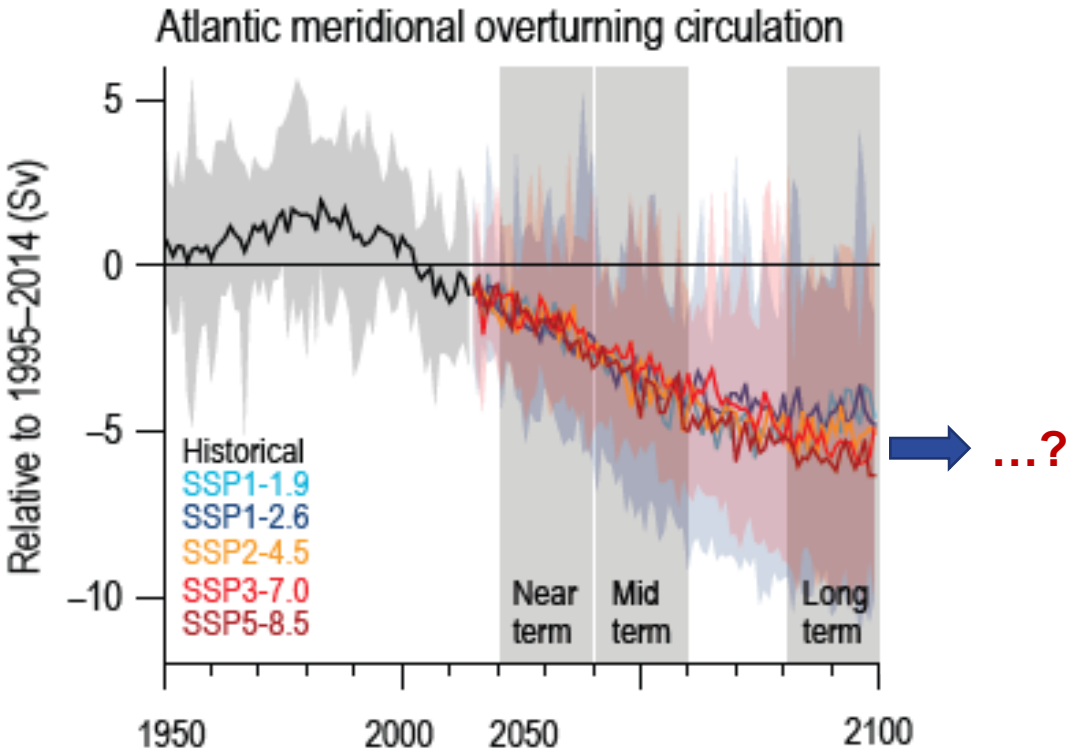
Source: Max Planck Forschung (Ausgabe 2, 2026)

Tipping Points

- IPCC AR6 (2021):

  “With medium confidence, AMOC shutdown is unlikely this century.”

- “While there is medium confidence that the projected decline in the AMOC will not involve an abrupt collapse before 2100, such a collapse might be triggered by an unexpected meltwater influx from the Greenland Ice Sheet.”



Source : IPCC, AR6

Tipping Points

Some recent studies suggest the risk may be **underestimated**,

highlighting the potential for substantial, persistent **global impacts** if tipping points were crossed.

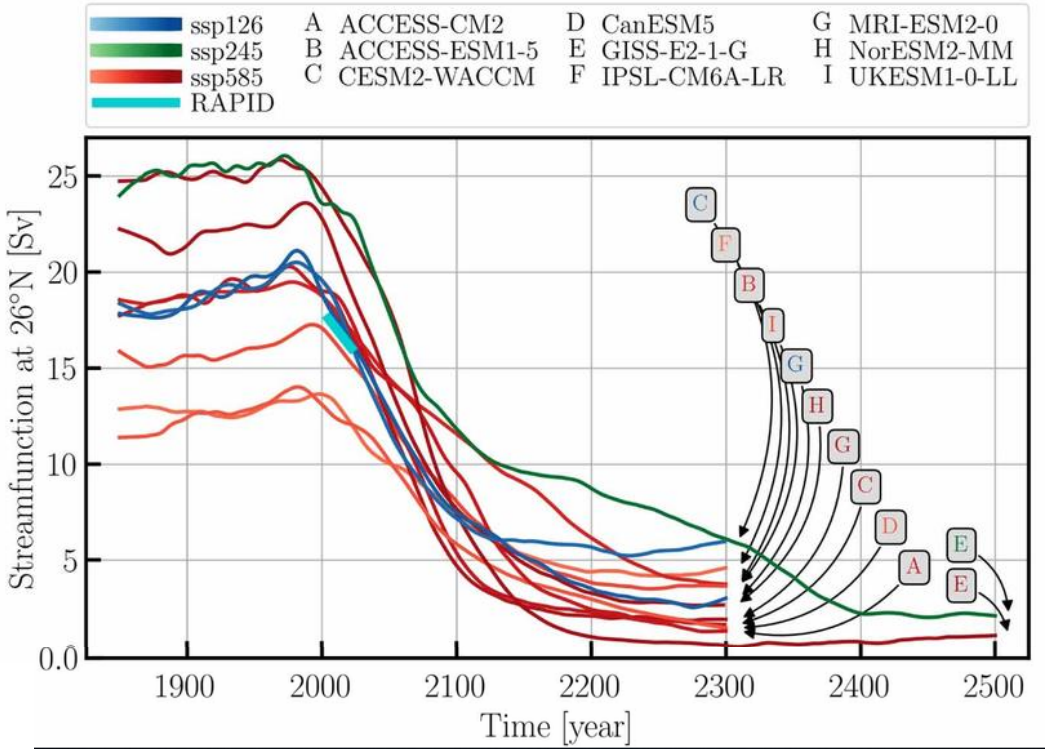
Tipping Points

➔ **Drijfhout et al. (Env. Letters, 2025):** „Shutdown of northern Atlantic overturning after 2100 following deep mixing collapse in CMIP6 projections”

Risk of collapse:

- ➔ **High** emission scenarios: 70%
- ➔ **Medium** emission scenarios: 40%
- ➔ **Low** emission scenarios: 25 %

! **Collapse might be after 2100, tipping point is probably in this century**



Source: Drijfhout et al. (Env. Letters, 2025)

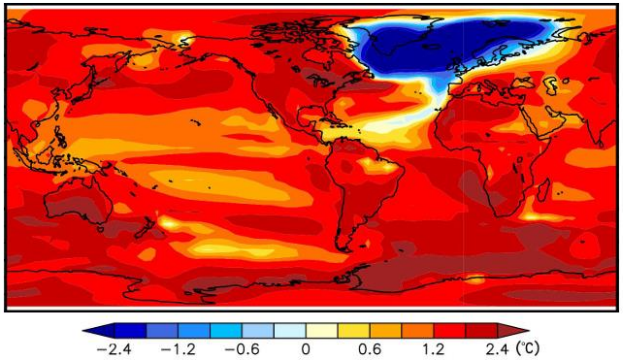
Tipping Points

- Open letter to the Nordic Council of Ministers warning of the devasting impacts of a collapsed AMOC

Open Letter by Climate Scientists to the Nordic Council of Ministers

Reykjavik, October 2024

We, the undersigned, are scientists working in the field of climate research and feel it is urgent to draw the attention of the Nordic Council of Ministers to the serious risk of a major ocean circulation change in the Atlantic. A string of scientific studies in the past few years suggests that this risk has so far been greatly underestimated. Such an ocean circulation change would have devastating and irreversible impacts especially for Nordic countries, but also for other parts of the world.



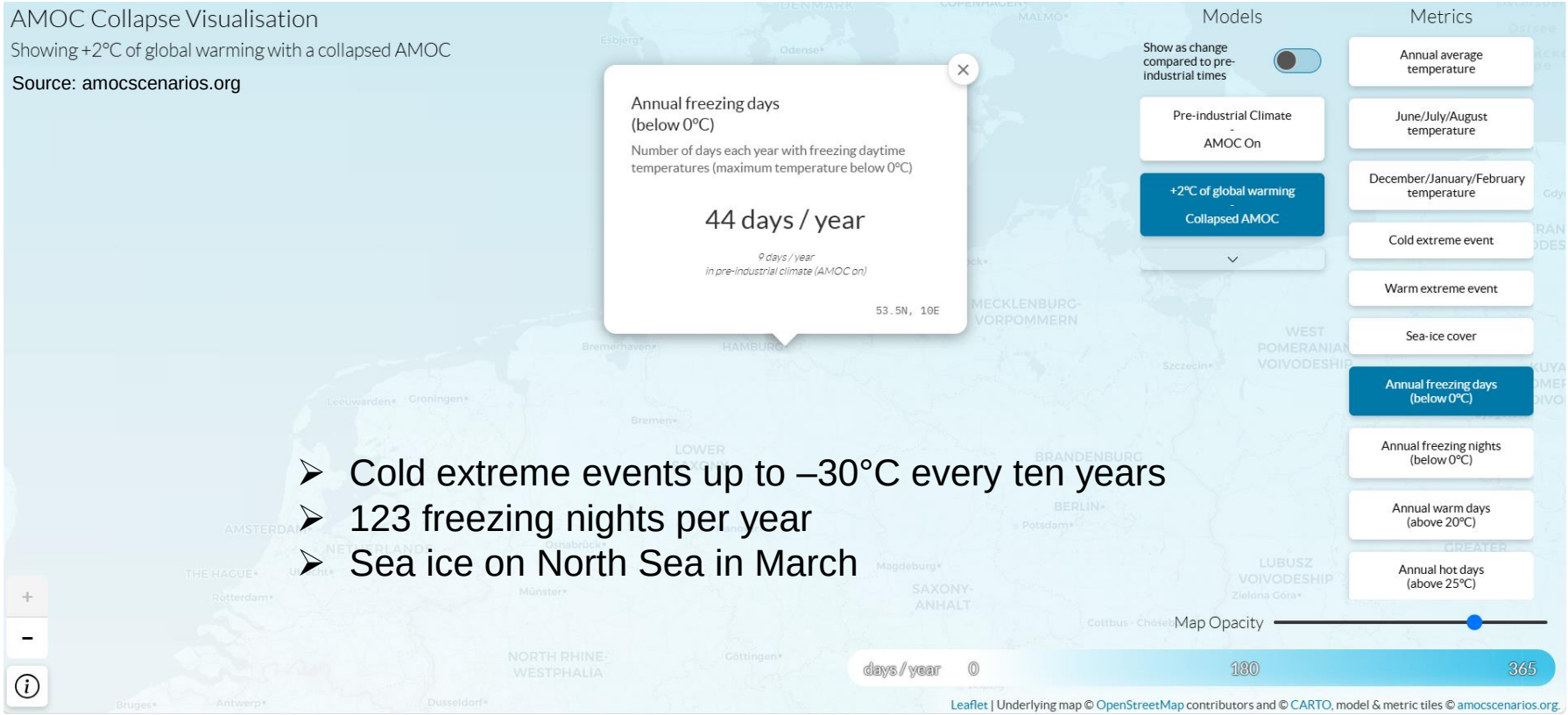
Annual mean temperature change in an idealised future CO2 doubling scenario in which the AMOC has fully collapsed. Source: Science[1].

Source: Arctic Circle Conference in Reykjavík, Iceland (2024)

Tipping Points

- **IF AMOC collapses, it reshapes global climate pattern:**
- Redistribution of heat
  - Strong cooling in the Northern Hemisphere (Arctic mean temperatures ~7°C colder)
  - Strong warming in the Southern Hemisphere (Antarctica mean temperatures ~6°C warmer)
  - Climate impacts highly regional
- **Europe:** (paleoclimate research)
  - Heatwaves and Droughts in summer due to atmospheric blocking (Schenk et al. (2018))
  - Very cold winters (van Westen et al. (2024): up to 20 °C colder)

Tipping Points



- Cold extreme events up to –30°C every ten years
- 123 freezing nights per year
- Sea ice on North Sea in March

Tipping Points

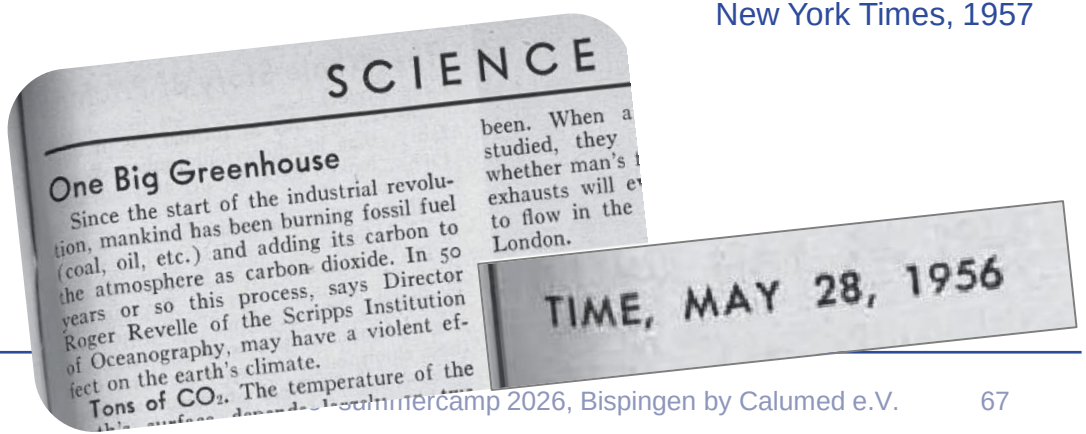
- **IF AMOC collapses, it reshapes global climate pattern:**
- AMOC collapse turns ocean from **CO_2 sink** into **CO_2 source** releasing CO_2 into the atmosphere
  - Further global warming
- Even a significant weakening of the AMOC can have dramatic impacts

Irreversibility

➔ Roger Revelle (oceanographer and climatologist):

„Human beings are now carrying out a large scale geophysical experiment of a kind that could not have happened in the past nor be reproduced in the future.”

New York Times, 1957



SCIENCE

One Big Greenhouse

Since the start of the industrial revolution, mankind has been burning fossil fuel (coal, oil, etc.) and adding its carbon to the atmosphere as carbon dioxide. In 50 years or so this process, says Director Roger Revelle of the Scripps Institution of Oceanography, may have a violent effect on the earth's climate.

Tons of CO_2. The temperature of the

been. When a studied, they whether man's exhausts will e to flow in the London.

TIME, MAY 28, 1956

How can just 0.04% CO_2 change the climate of an entire planet?

- CO_2 changes the Earth's **radiation balance**
- Feedback loops **amplify** the initial warming
- And because CO_2 remains in the atmosphere for a very long time, today's emissions determine tomorrow's climate.

All Hope Is Lost?

- International Cooperation
  - eg. Paris Agreement (2015): nearly all countrys agreed to keep global warming below 2°C and pursue efforts to limit it to 1.5°C

Is this still possible?

Remaining Carbon Budget

Greenhouse gas emission

Global warming

Historical emissions (1850 – 2025): 2770 $GtCO_2$ → ~ +1.38°C

Currently ~ 40 $GtCO_2$ per year

How much more CO_2 can we emit to stay below +2°C (+1.5°C)?

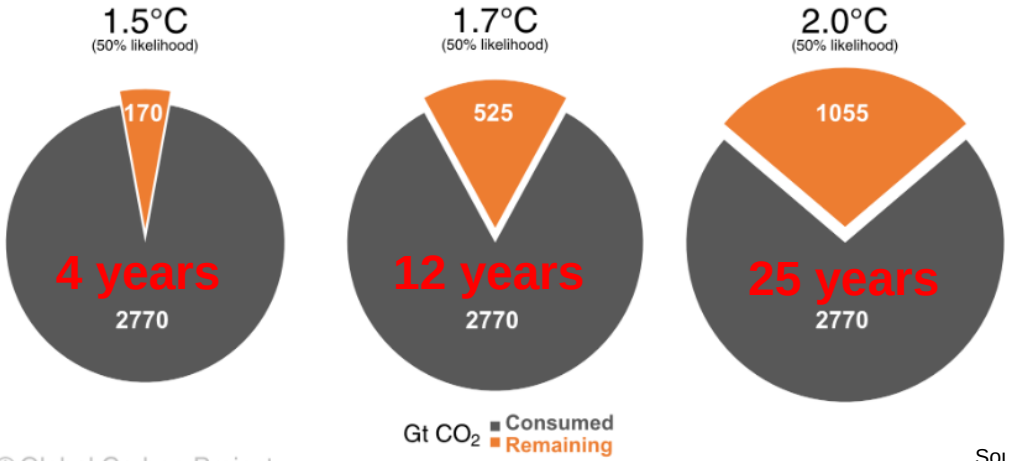
Source: Global Carbon Project, January 2026

Remaining Carbon Budget

Greenhouse gas emission

Global warming

related!

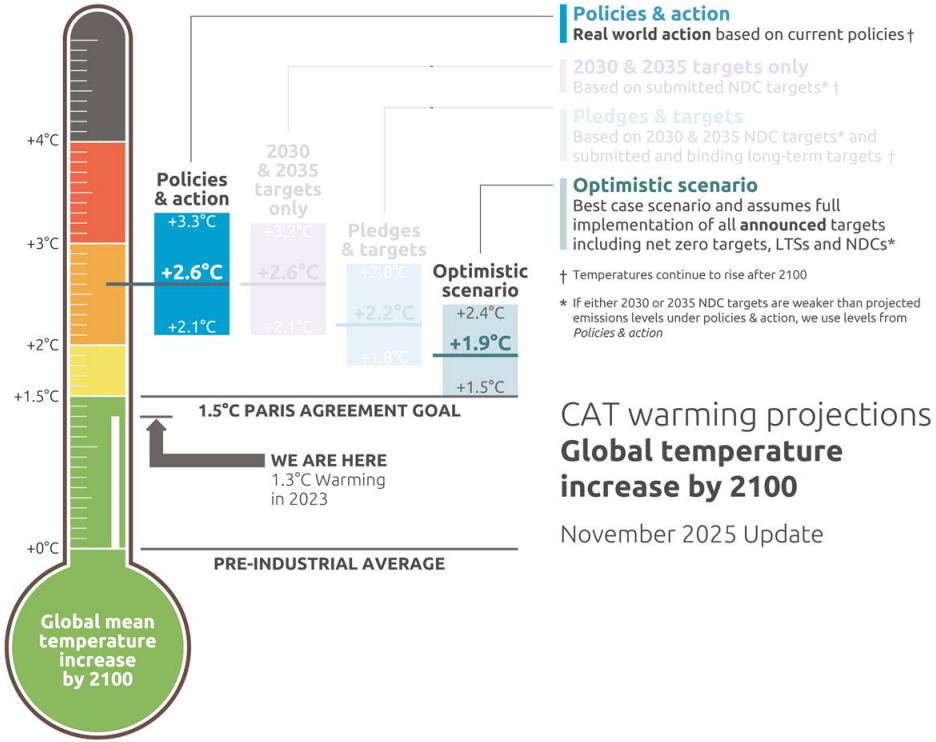


Source: Global Carbon Project, January 2026

All Hope Is Lost?

- International Cooperation
  - eg. Paris Agreement (2015): nearly all countries agreed to keep global warming below 2°C and pursue efforts to limit it to 1.5°C
  - 35 countries with declining emissions in the last decade (2015-2024)
  - German Climate Protection Program: Climate neutrality by 2045.

All Hope Is Lost?

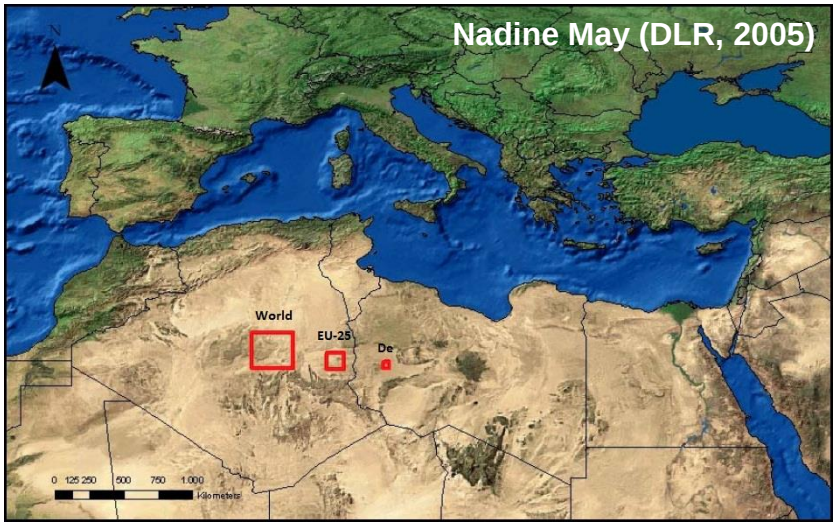


Source: Climate Action Tracker

What Can We Do?

- Energy transition and decarbonization of the economy
  - Rapid expansion of renewable energy

- Land area required for solar power plants to meet electricity demand



What Can We Do?

- Progress in science and innovations
- Protecting natural carbon sinks
  - Forest conservation and restoration
  - Protecting oceans and ecosystems
  - Improving soil and land management
- Education → „Find your nature“ summer camp in Bispingen

Understand, why change
is necessary!

What Can We Do?

- Individual choices matter
  - Each of us can contribute by making more climate-friendly choices
- Climate change is more than an individual challenge
  - It‘s a collective transformation
  - Because climate change is driven by the way our societies produce and consume,
  - Therefore meaningful solutions require changes at the societal level
- Prepare for unavoidable impacts
  - Even with ambitious climate action, some changes are already unavoidable.
- Investing in climate action today is far less costly than paying for the damages of climate change tomorrow

Key Messages – What We Know

- **Human** greenhouse gas **emissions** are **warming** the planet.
- Every **additional** tonne of **CO_2 increases future warming**.
- **Crossing tipping points** becomes **more likely** with increasing warming.
- **Too late?** No, but every fraction of a degree matters.
- Scientific uncertainties remain, **but the evidence** is already **sufficient** to **justify rapid action**.
- The core challenge is no longer **understanding** the problem, but **solving it**.

The future is not predetermined, it depends on the choices we make today.

Climate Change in Ten Words

It‘s real.

It‘s us.

It‘s bad.

Experts agree.

There‘s hope!

(Anthony Leiserowitz, 2017)


Thank You For Your Attention!
Any Questions?
Sebastian Schappert
S.Schappert@web.de
Source: showyourstripes.info