



SVENSKA ARALSJÖSÄLLSKAPET

Swedish Aral Sea Society



4. Climate Change

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Uppsala University

**Master Course on Sustainable Development and Sustainability Science
For Uzbekistan by SASS and Karakalpak State University Spring 2023**

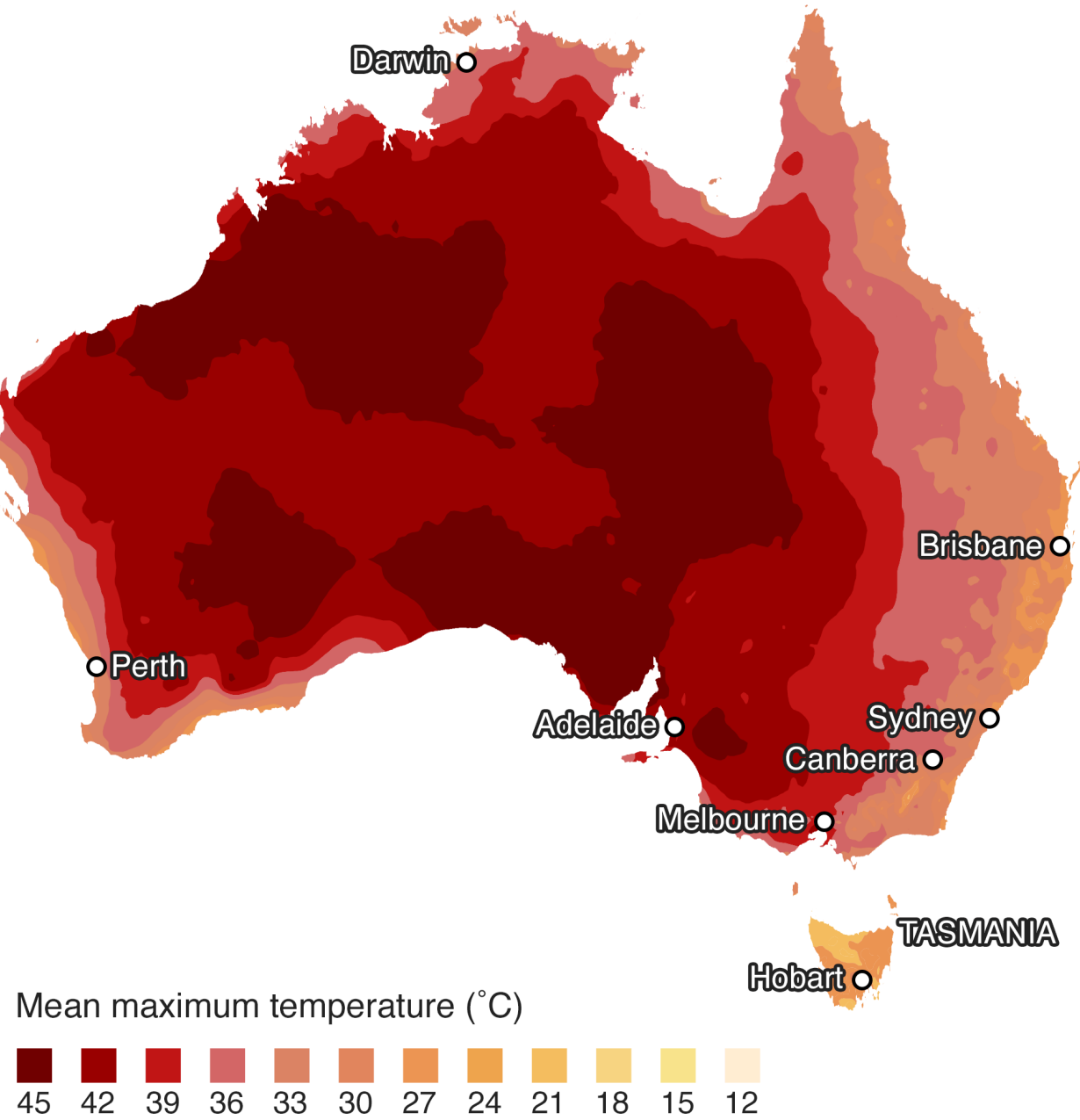
Global warming is perceived in many ways

- Extreme hot weather – heat stress
- Melting glaciers
- Forest damages – increase forest fires, decreased biodiversity
- Water shortages in many countries
- Draught and desertification
- Extreme weather events and floods
- More often and more serious tornadoes and storms
- Tropical diseases come further north
- Sea level rise – coastal inundation
- Etc.....

1. Heat waves and droughts

- Fires
- Excess mortality
- Drought and reduced harvests
- Water scarcity

Mean maximum temperature, 19 Dec



The heat wave in Australia 2019

<https://www.bbc.com/news/world-australia-50837025>



<https://www.bbc.com/news/world-australia-50837025>



<https://qz.com/1776230/australian-heat-waves-are-a-warning-sign-of-climate-change-trends/>

Megafires

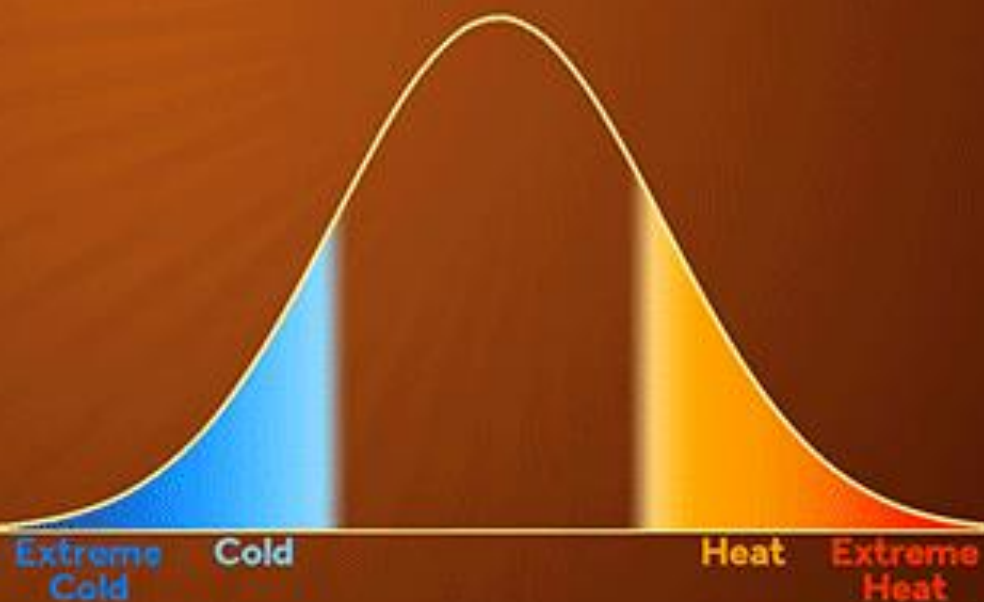
- A **megafire** is an extraordinary fire that devastates a large area. They are characterized by their intensity, size, duration, and uncontrollable dimension.
- A megafire can be caused by **high temperatures**, drought, human activities, and poor health of forests. 96% of the most disastrous 500 megafires have occurred during periods of unusual heat and/or drought (NASA).
- The number of uncontrollable megafires is **increasing** (NASA).



© Getty Images/AFP/A. Sank

<https://www.dw.com/en/deadly-heat-waves-set-to-surge-due-to-climate-change/a-39326267>

SMALL CHANGE IN AVERAGE BIG CHANGE IN EXTREMES



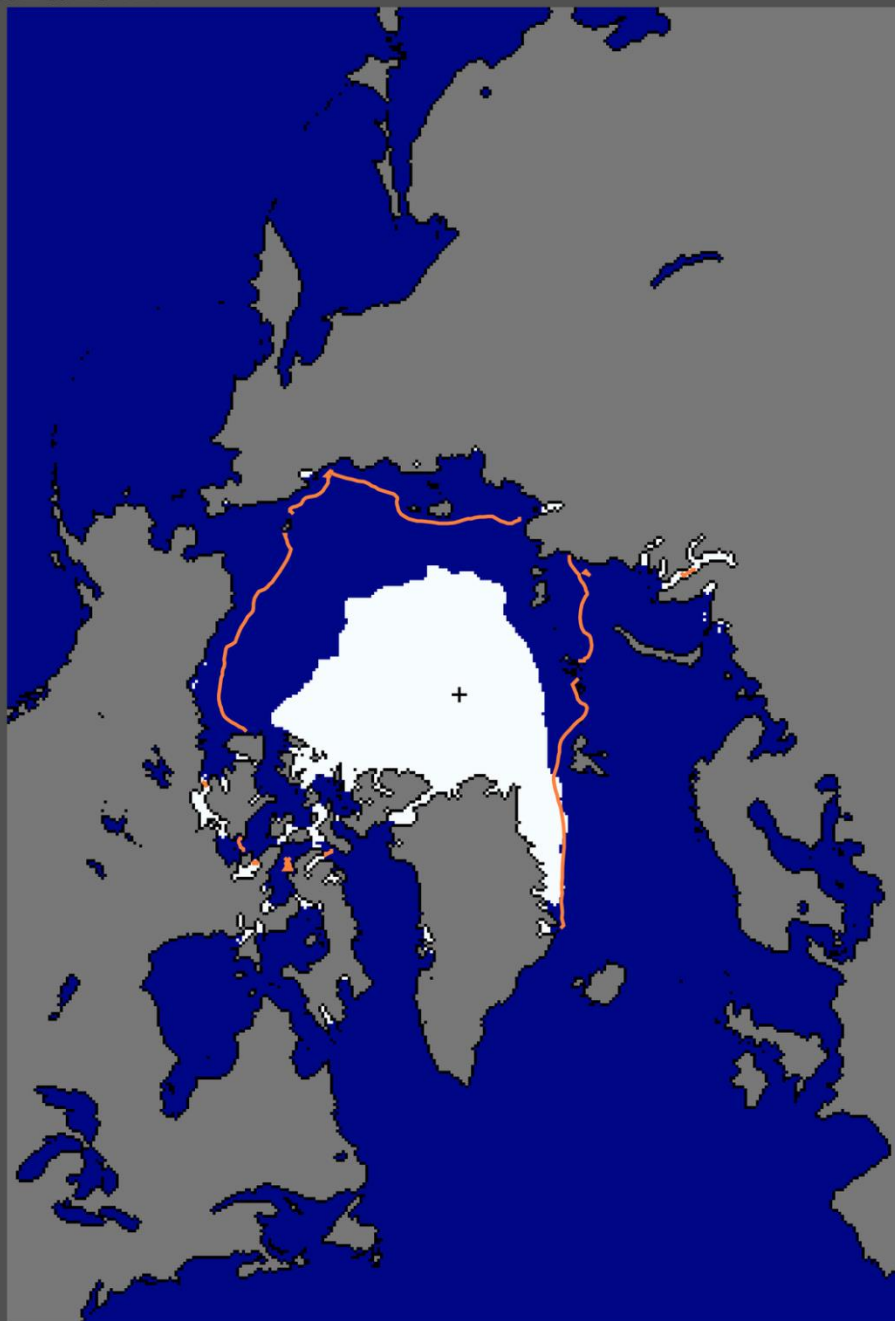
CLIMATE  CENTRAL

2. Melting Ice of the world

- Melting glaciers
- Reduced polar and Greenland ice
- Less water to the rivers
- Effects on the global ocean currents



The Upsala Glacier, Patagonia, Argentina. Original photograph taken in 1928, ©Archivo Museo Salesiano / De Agostini. Comparison image taken in 2004, © Greenpeace/Daniel Beltrá 02/06/2004. Courtesy Greenpeace Argentina.



National Snow and Ice Data Center, Boulder, CO

median
1979–2000

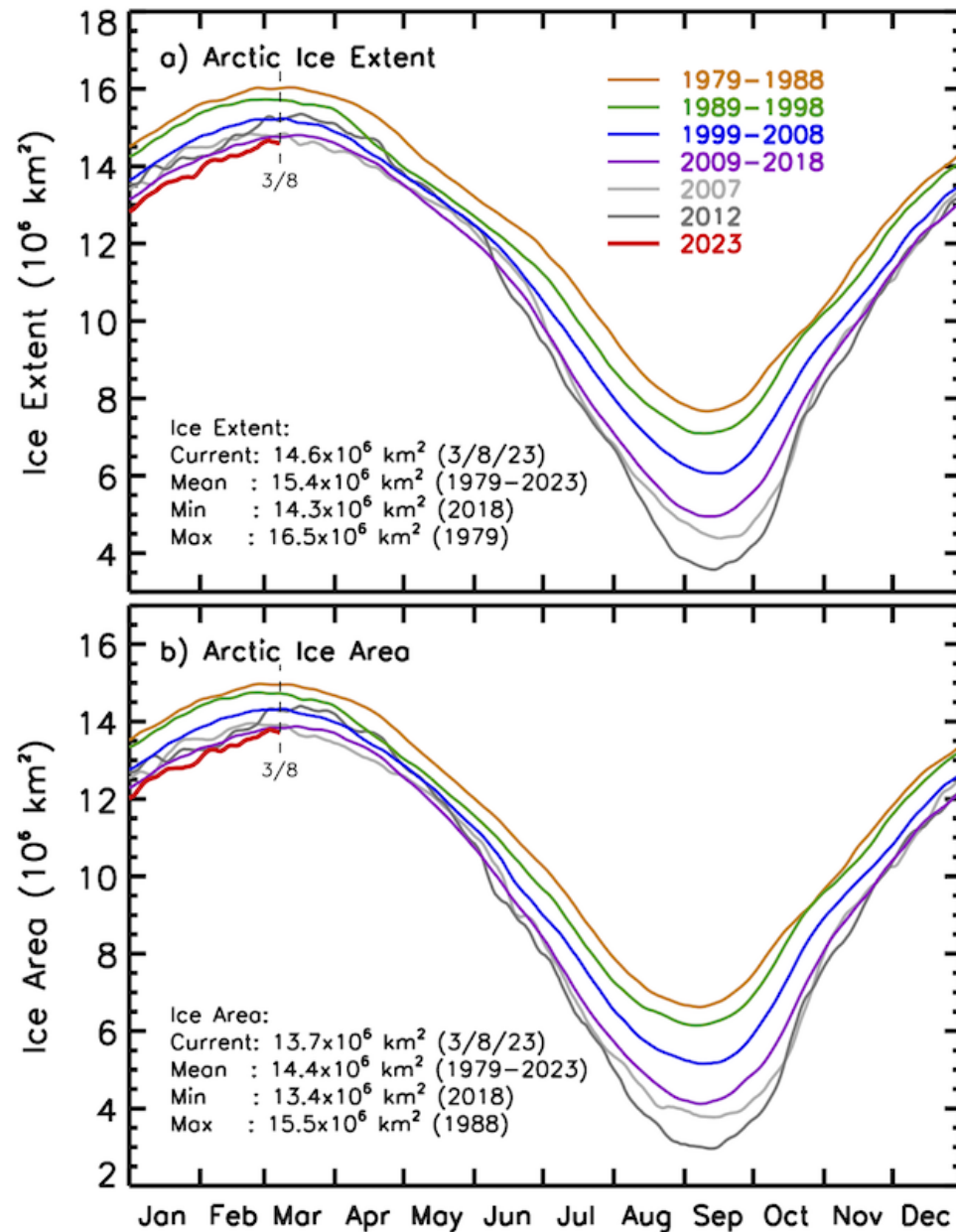
The 2012 minimum was 760,000 square kilometers (293,000 square miles) below the previous record minimum extent in the satellite record, which occurred on September 18, 2007. This is an area about the size of Germany and Poland together.

The September 2012 minimum was in turn 3.29 million square kilometers (1.27 million square miles) below the 1979 to 2000 average minimum, representing an area nearly twice the size of the state of Alaska.

This year's minimum is 18% below 2007 and 49% below the 1979 to 2000 average

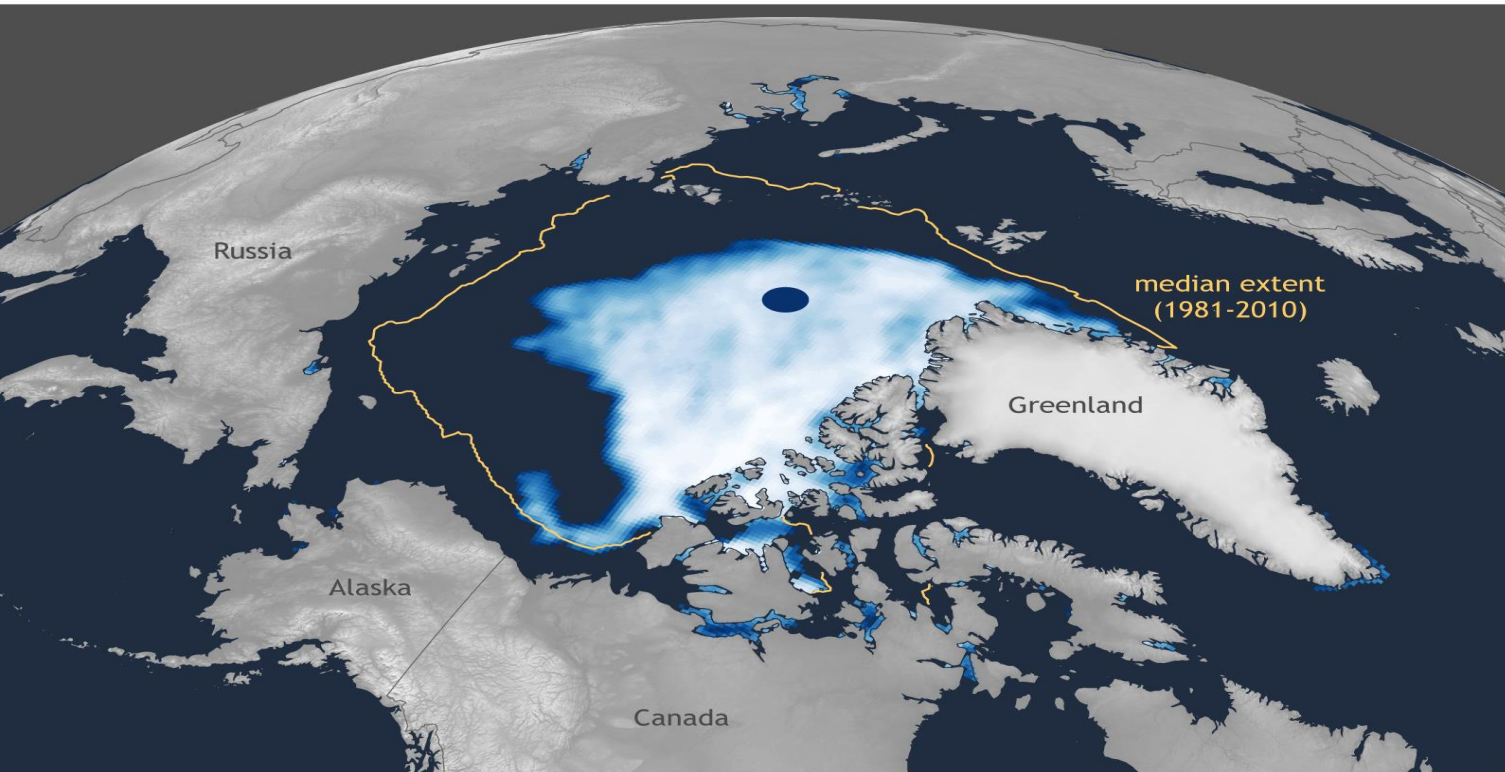
National Aeronautics and Space Administration, NASA

Current State of Sea Ice Cover



<https://earth.gsfc.nasa.gov/cryo/data/current-state-sea-ice-cover>

Arctic sea ice summer minimum 2020



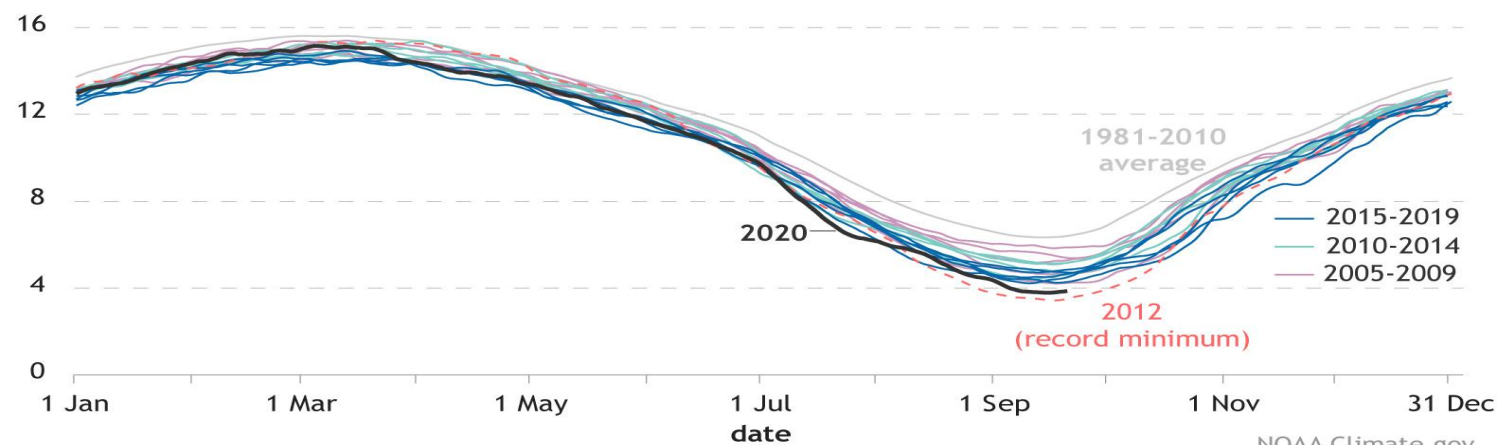
September 15, 2020

Sea ice concentration (percent)

Data: NSIDC



Daily Arctic sea ice extent (millions of square kilometers)



NOAA Climate.gov
Data: NSIDC Charctic

https://www.climate.gov/sites/default/files/Arctic-sea-ice_map_graph_202009_large.jpg

West Antarctic Ice Sheet Has Begun to Collapse

<http://news.discovery.com/earth/global-warming/west-antarctic-ice-sheet-has-begun-to-collapse-140514.htm>



3. Increased storms, cyclones and floods

- Flooding of coastal areas
- Destructive storms and tornadoes
- Destroyed harvests



*Flooding in Jakarta, Indonesia, February 2017. Source: [World Meteorological Organization / Flickr](https://www.climatecentral.org/news/report-flooded-future-global-vulnerability-to-sea-level-rise-worse-than-previously-understood)
<https://www.climatecentral.org/news/report-flooded-future-global-vulnerability-to-sea-level-rise-worse-than-previously-understood>*



Pakistan 2022

<https://zeenews.india.com/video/world/pakistan-flood-2022-more-than-1000-people-died-in-the-devastating-floods-in-pakistan-2503959.html>.



18 March 2019. The destruction unleashed by Cyclone Idai on Mozambique, Malawi and Zimbabwe, continues to claim lives and displace thousands. <https://news.un.org/en/story/2019/03/1034881>

4. Oceans of the world are changing

- Sea level rise
- Increased temperatures, destroyed coral reefs
- Decreased salinity
- Acidification
- Destroyed marine ecosystems

SATELLITE DATA: 1993-PRESENT

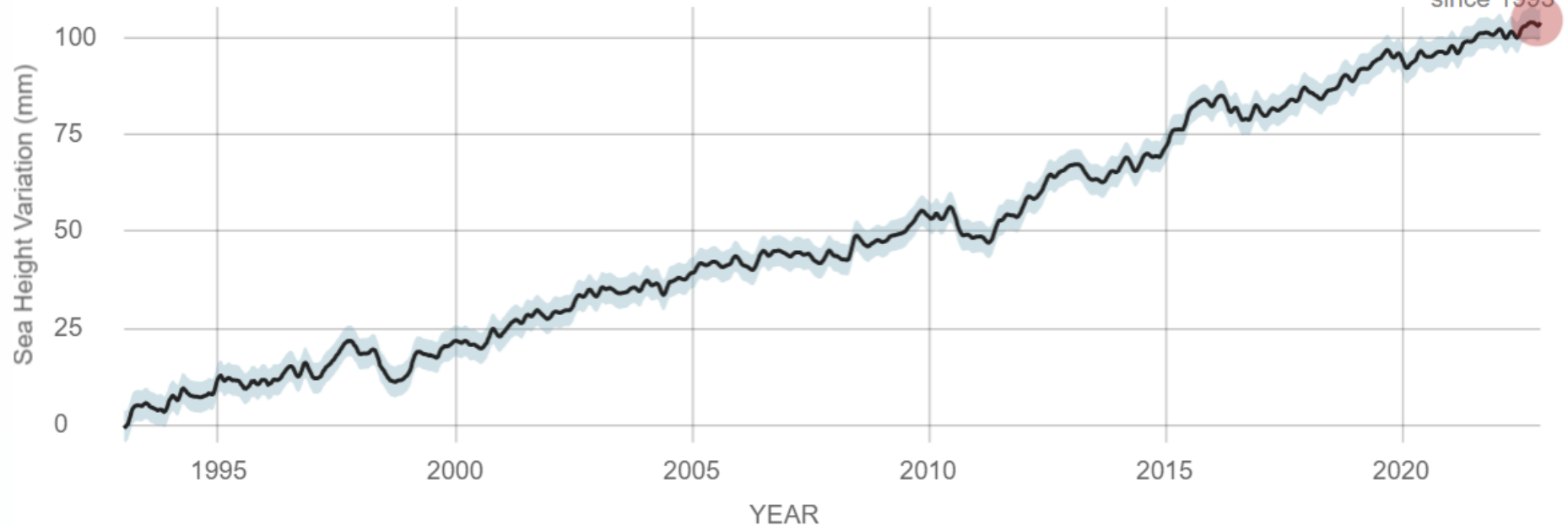
RISE SINCE 1993

Data source: Satellite sea level observations.

Credit: NASA's Goddard Space Flight Center

↑ 3.4

millimeters per year
since 1993



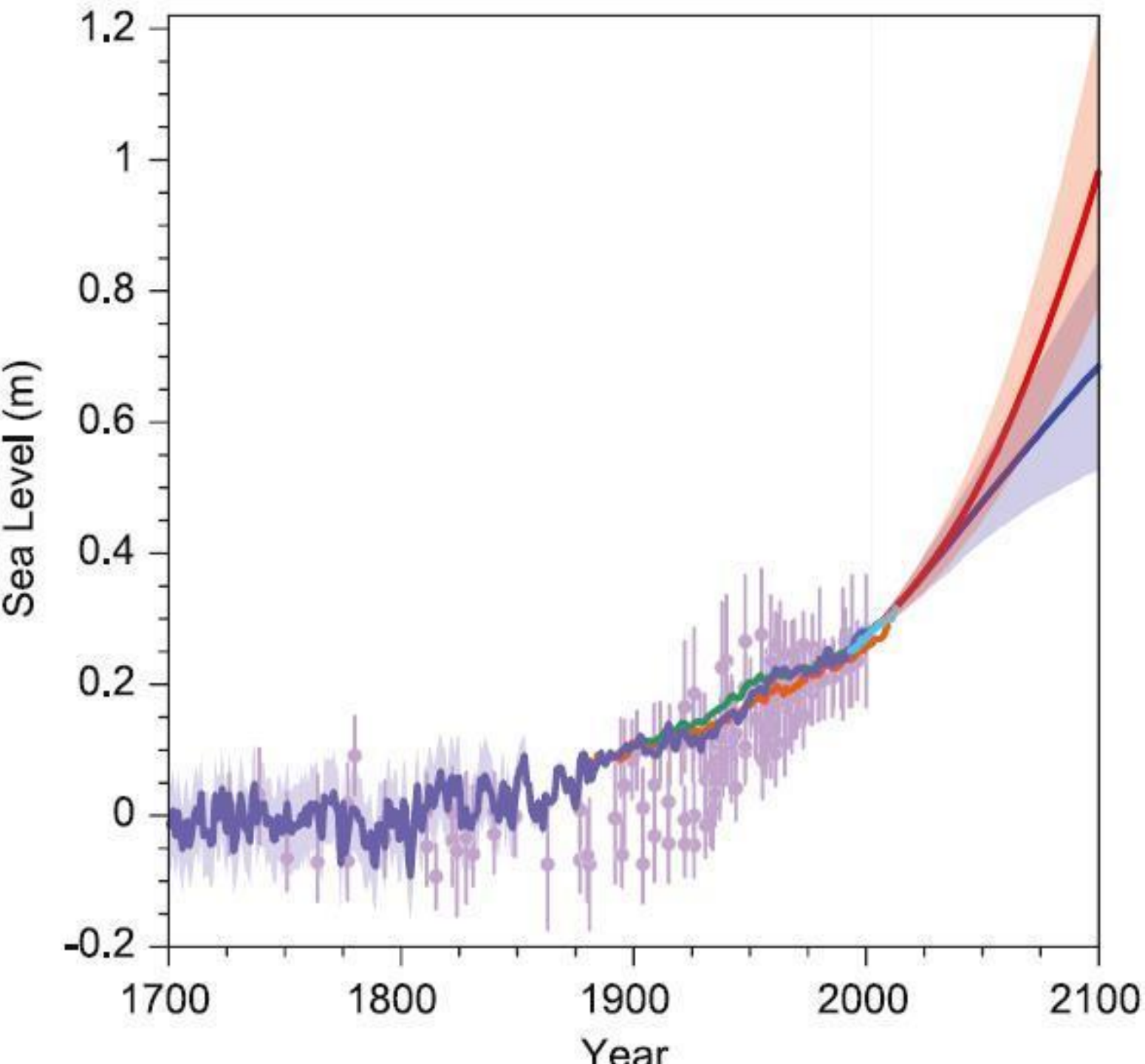
Click+drag to
zoom

RESET

Get Data: [HTTP](#) | Snapshot: [PNG](#)

Sea Level Rise

<https://www.nasa.gov/specials/sea-level-rise-2020/>



<https://wordsinm-ocean.com/2016/01/06/how-far-will-sea-levels-rise-in-the-next-100-years/>



Millions of people will be affected in cities such as [Miami](#), [Rio de Janeiro](#), [Osaka](#) and [Shanghai](#). Island nations will be submerged.

<https://climate.nasa.gov/blog/3002/sea-level-101-part-two-all-sea-level-is-local/>



<https://www.amazon.com/Under-Sea-Great-Barrier-Reef/dp/B07F6VXJRC>



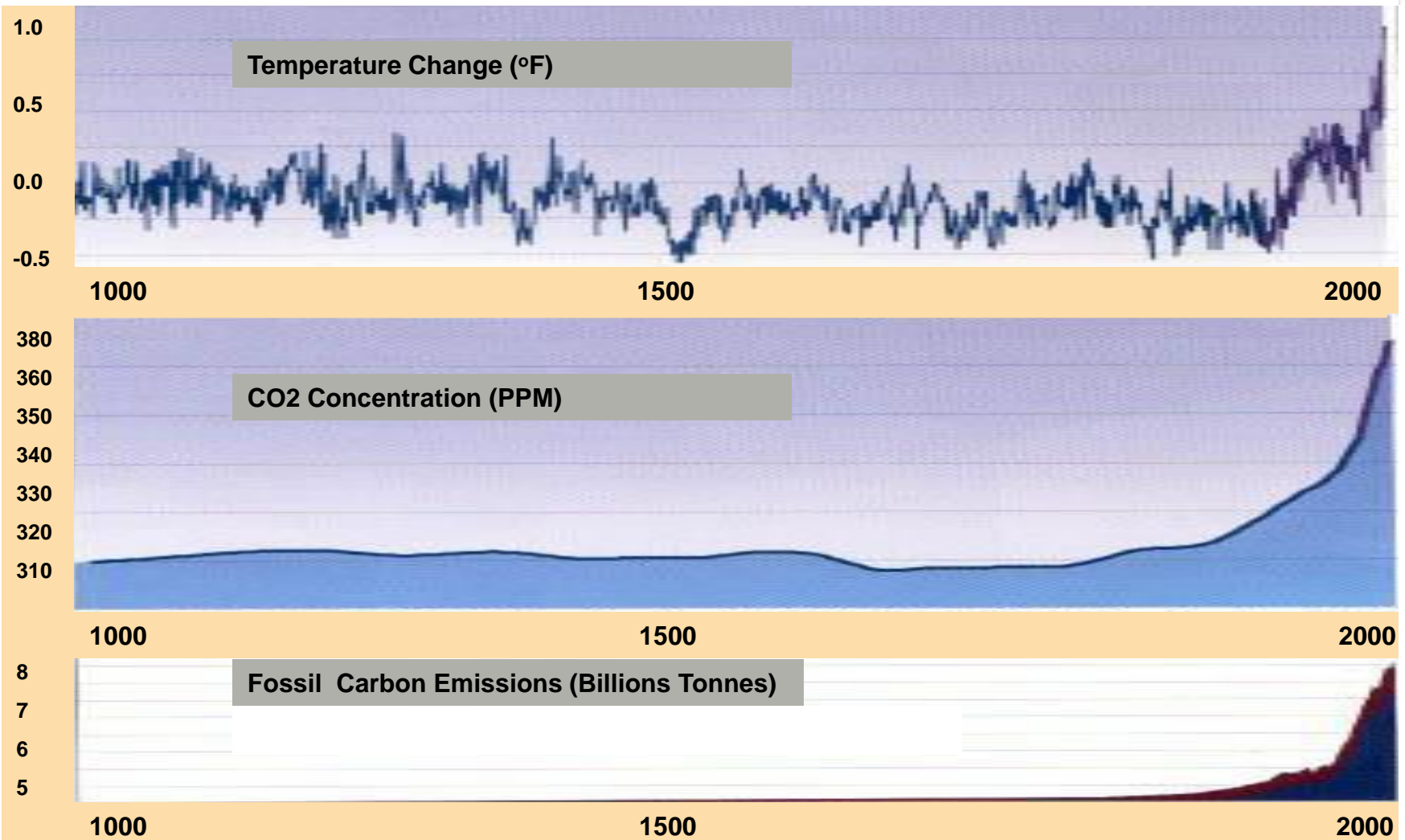
5. Terrestrial ecosystems of the world are changing

- Species move further north (about 5 km/year)
- Ecosystems depending on migration are unbalanced
- Tree limit of high mountains are pressed upwards
- Arctic species are threatened
- Biodiversity decreases





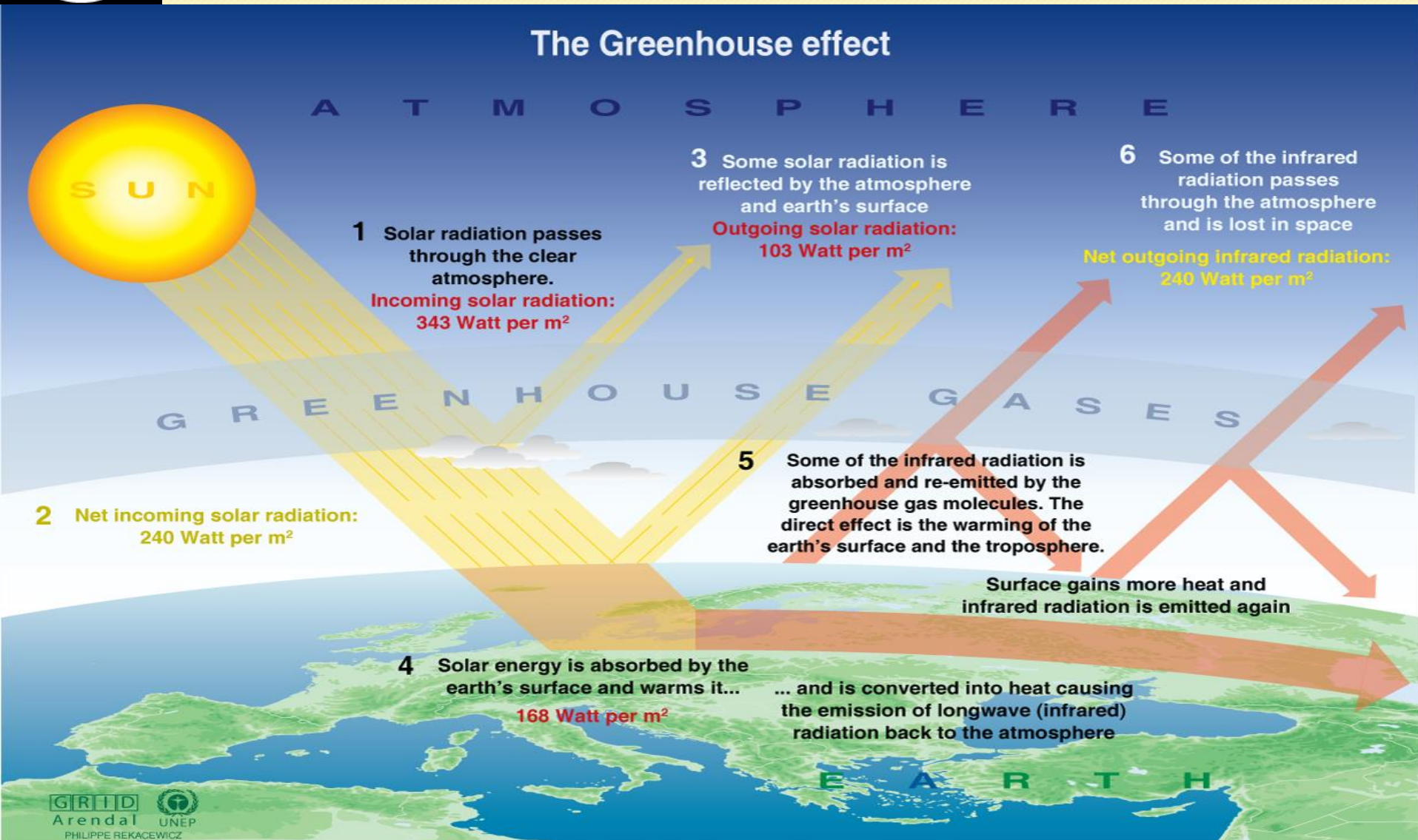
The causes of global warming



SVEBIO

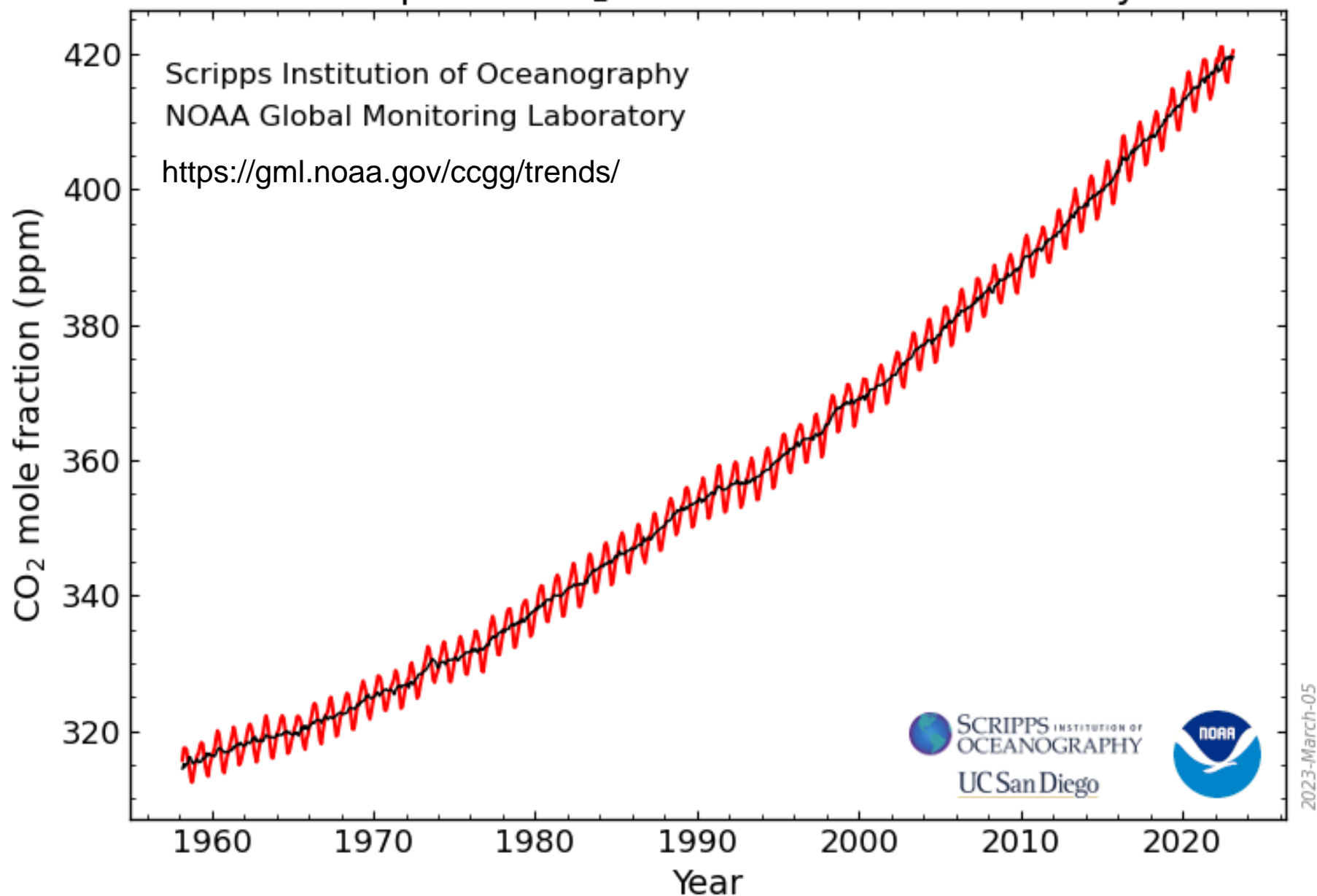


The greenhouse effect



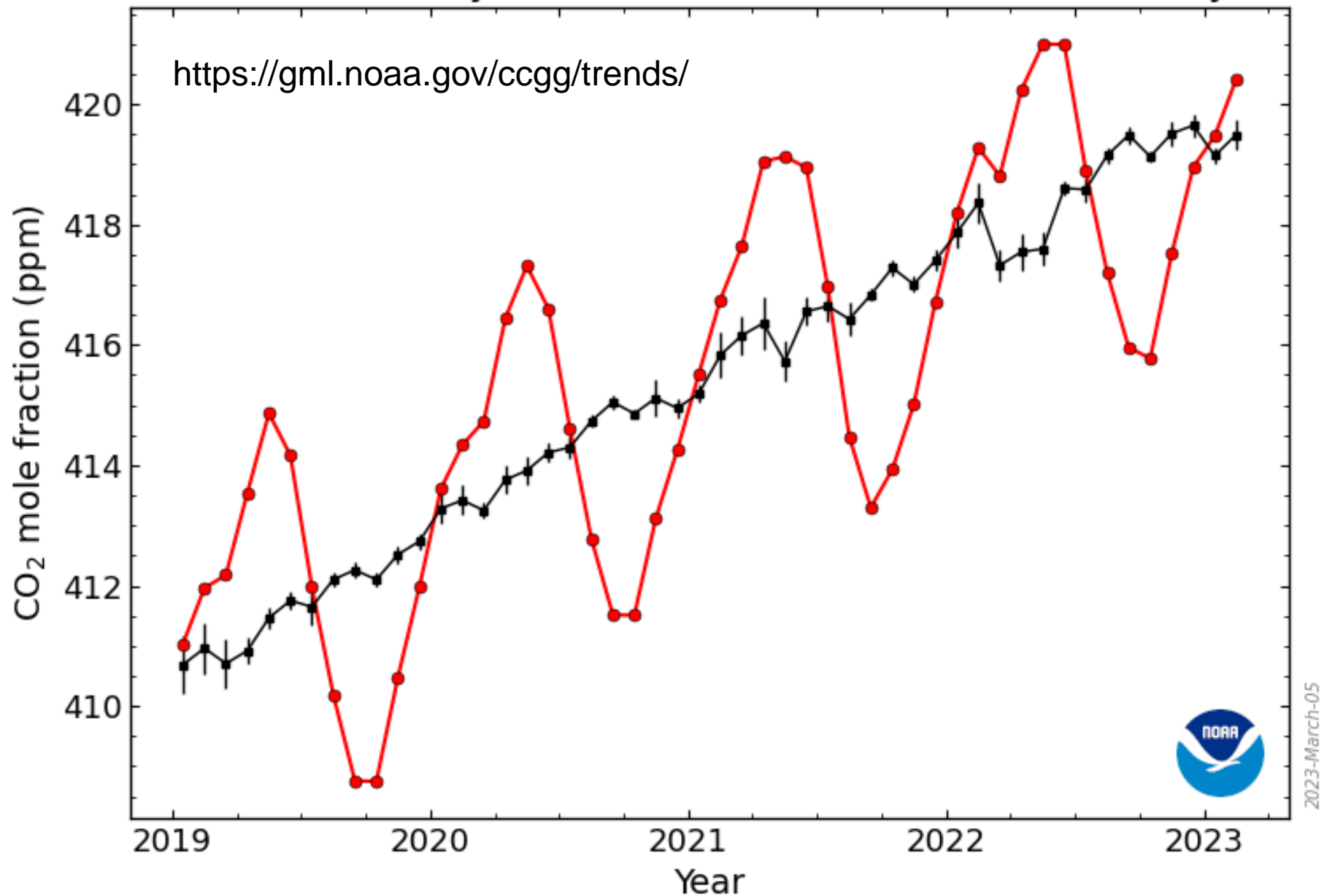
Sources: Okanagan university college in Canada, Department of geography, University of Oxford, school of geography; United States Environmental Protection Agency (EPA), Washington; Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1996.

Atmospheric CO₂ at Mauna Loa Observatory

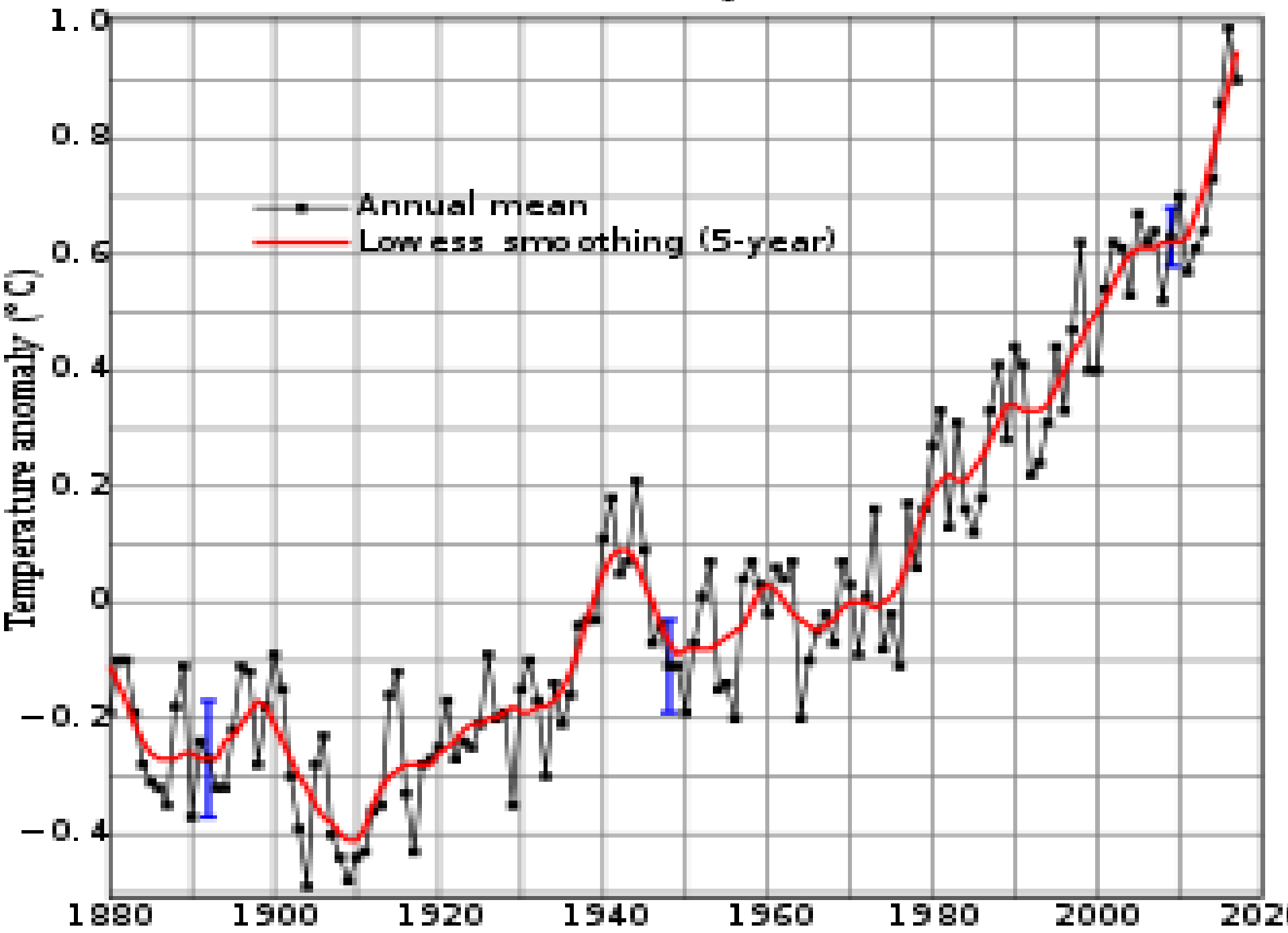


Recent Monthly Mean CO₂ at Mauna Loa Observatory

<https://gml.noaa.gov/ccgg/trends/>



Global land-ocean temperature index

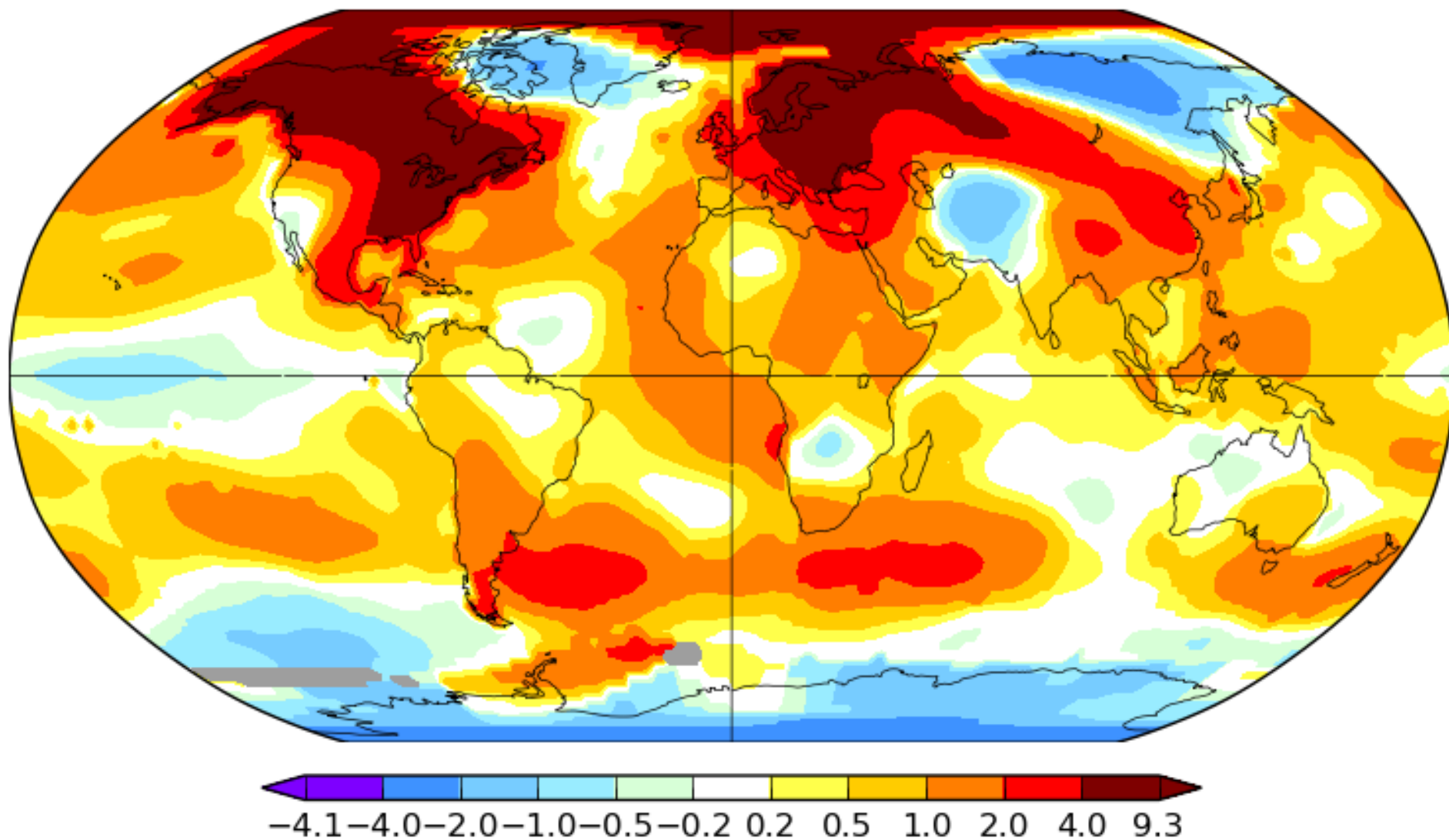


https://data.giss.nasa.gov/gistemp/animations/TEMPANOMALY_05_2022_pdiff.mp4

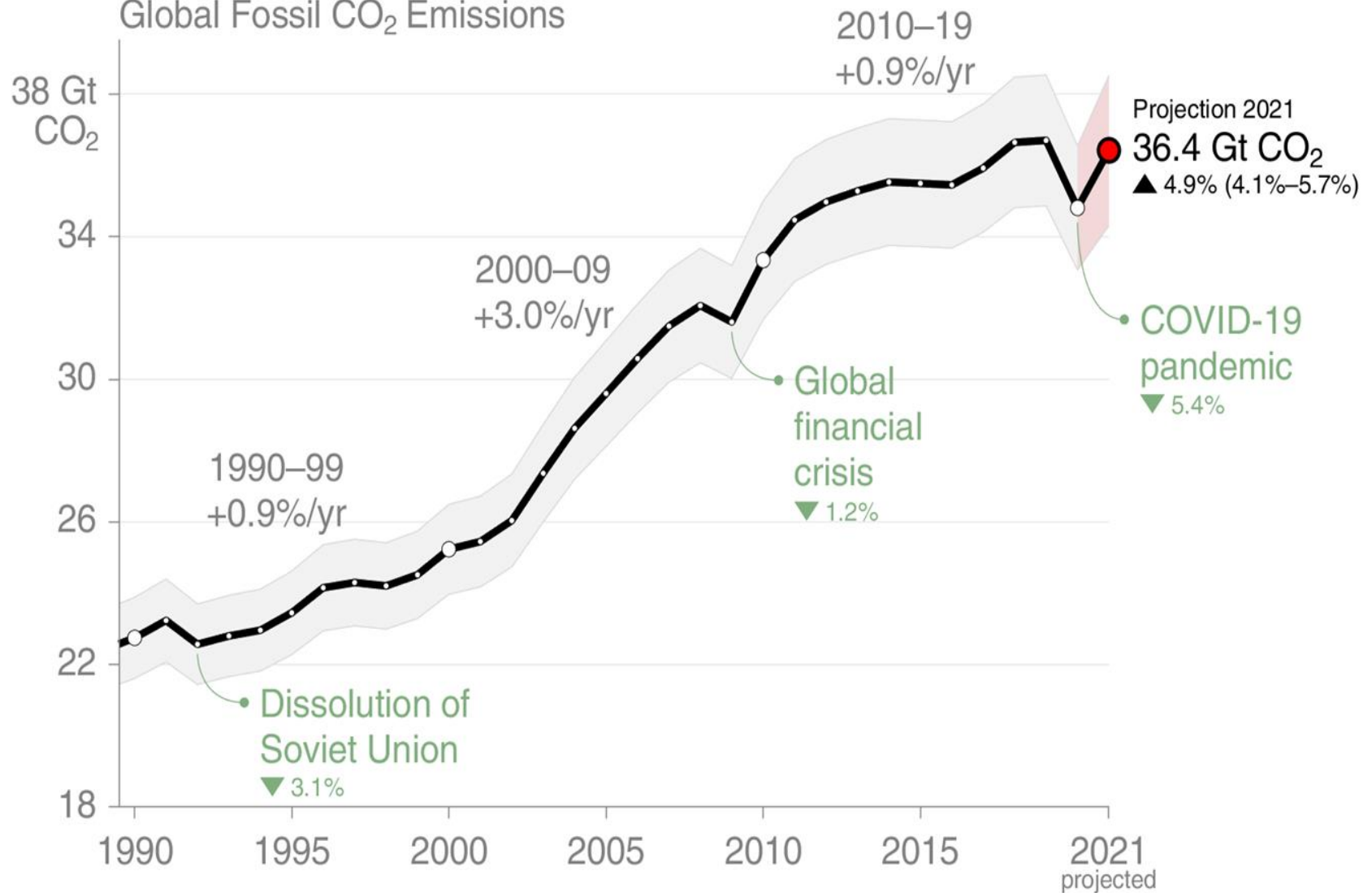
January 2023

L-OTI(°C) Anomaly vs 1951-1980

0.86

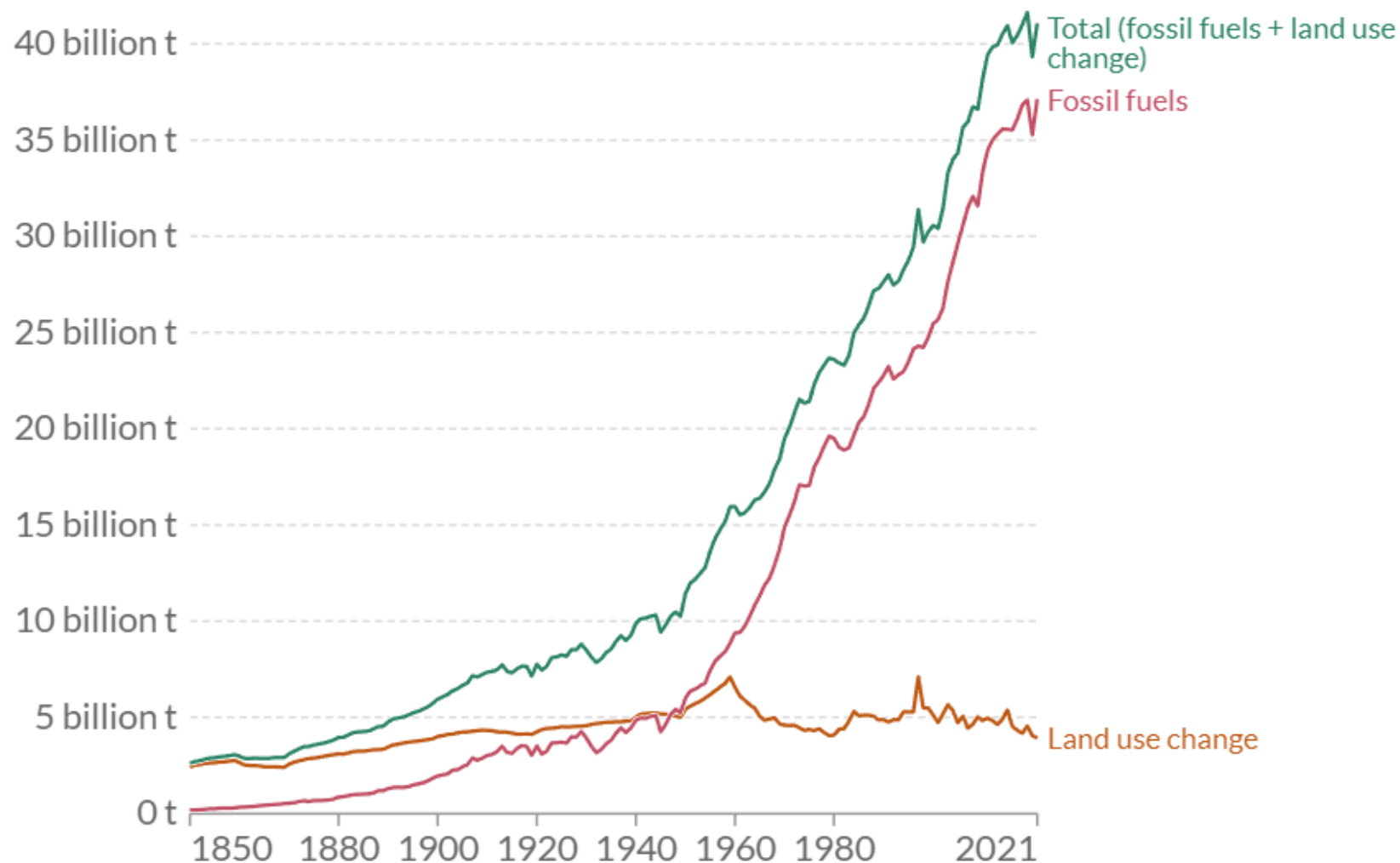


Global Fossil CO₂ Emissions

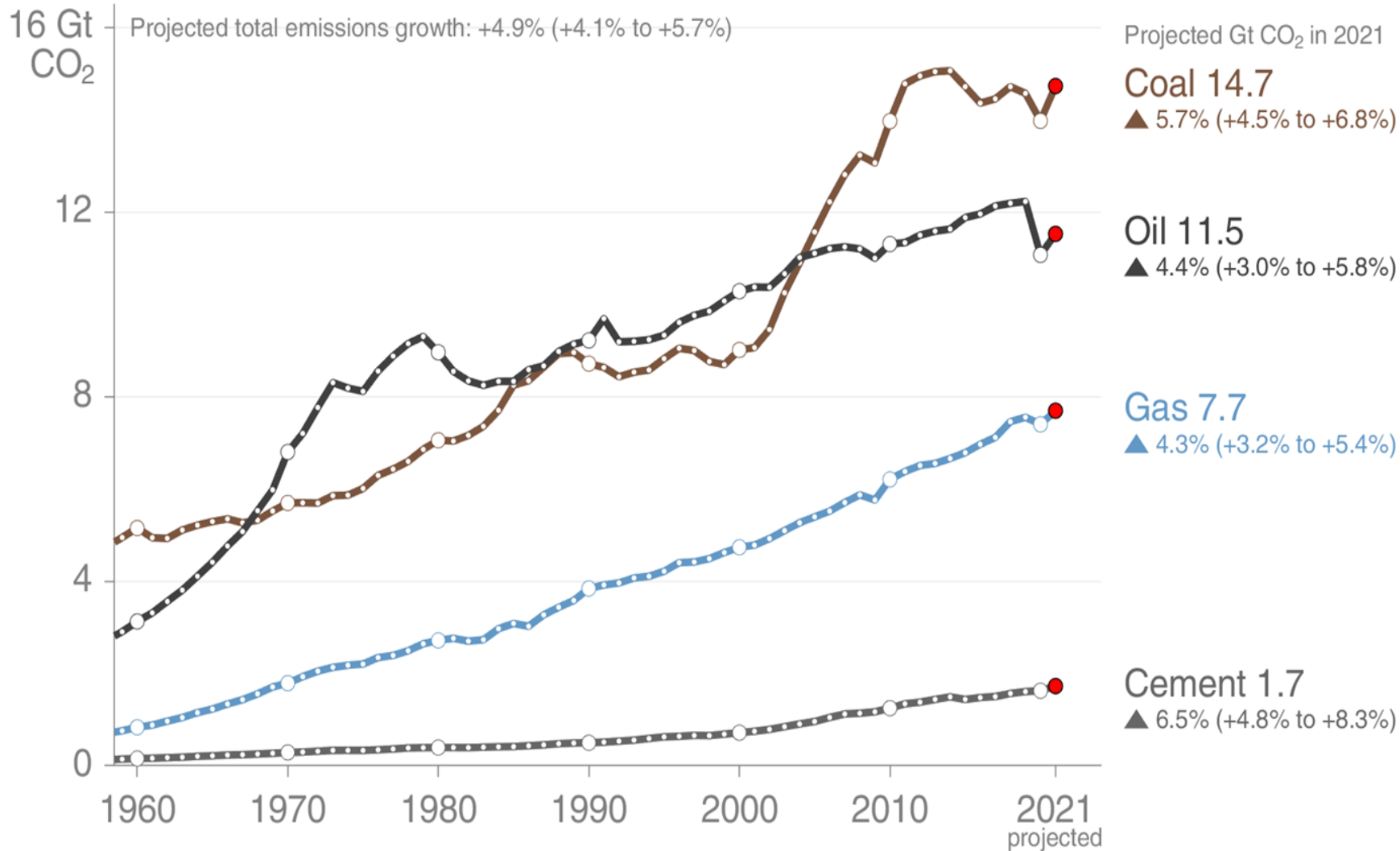


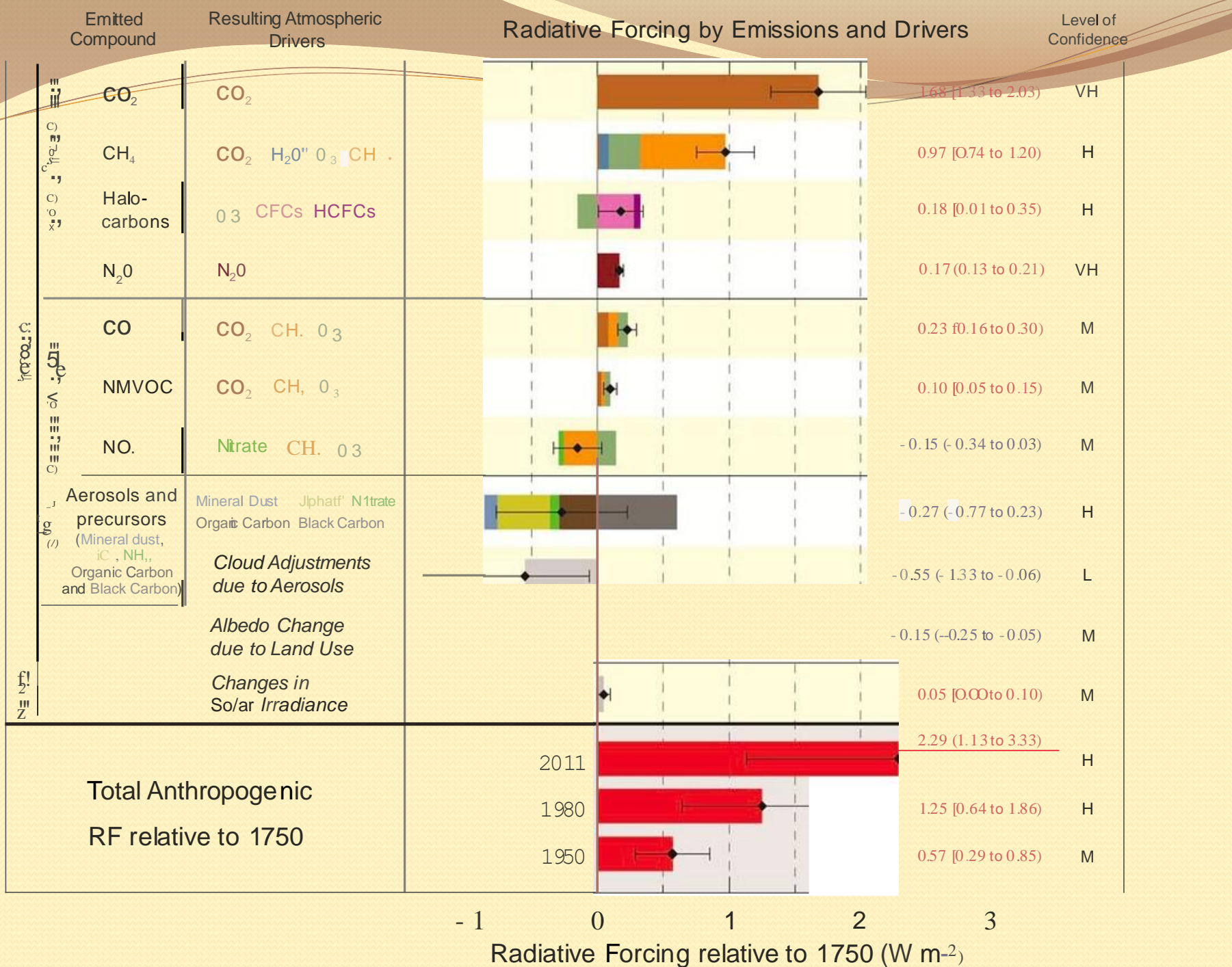
Global CO₂ emissions from fossil fuels and land use change, World

↔ Change country



Annual Fossil CO₂ Emissions: Global

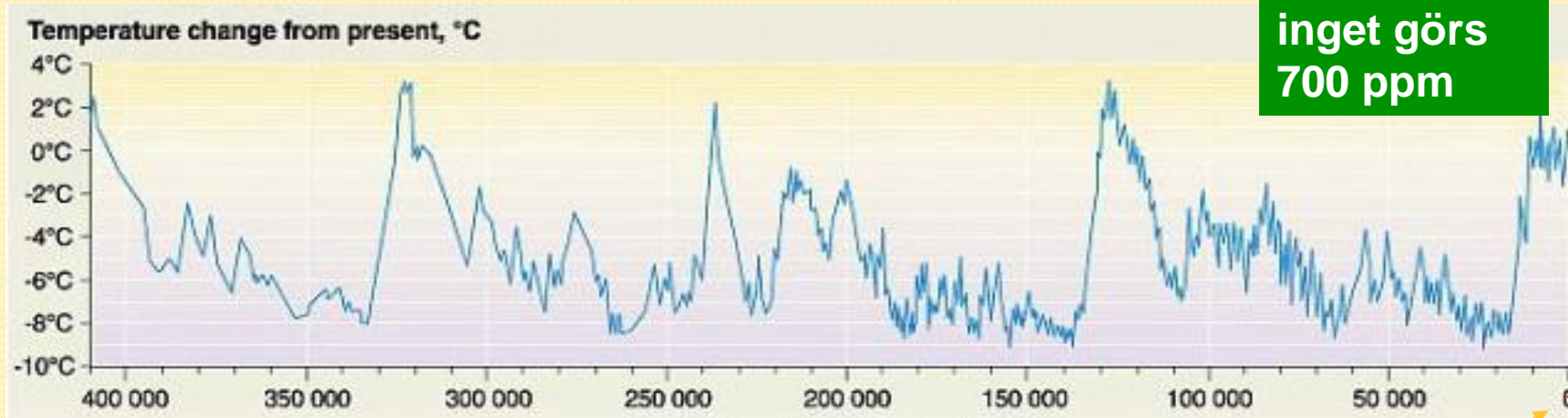




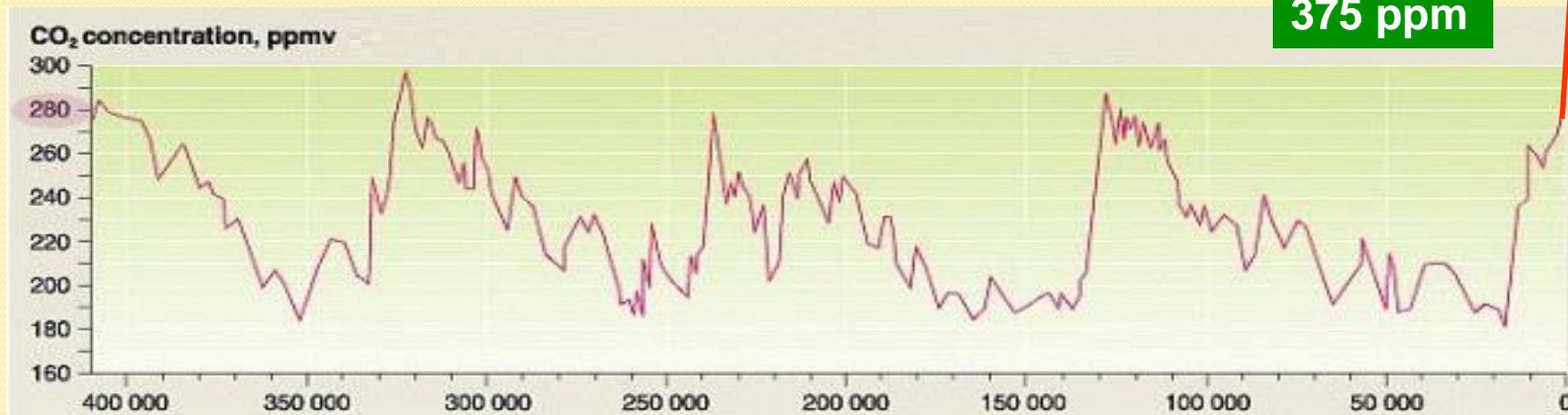
**The main cause of climate change
is the large use of fossil fuels -
*coal, oil and gas.***

Global temperatur och CO2 concentration

400 000 år data från "Vostok iskärnan"

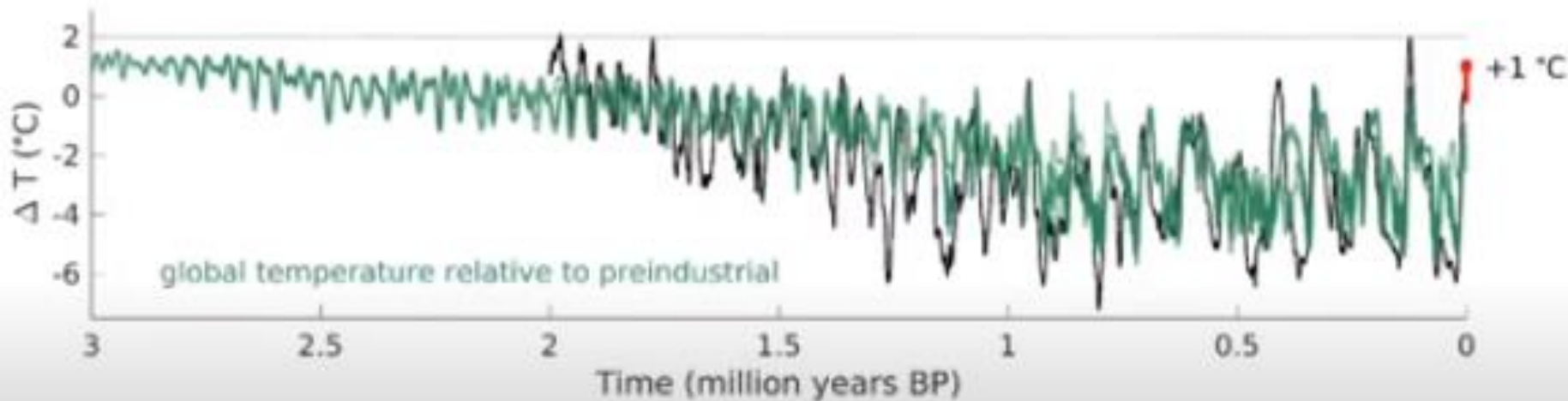


År 2100 om
inget görs
700 ppm



2004
375 ppm

We have never exceeded 2 C in the last Three Million Years



Results of model simulations: Observations shown in black, model results in colour.



Climate variability is increasing. 2010 was warm in Russia, 2012 in North America; Winter was strong in Europe, etc

Present warming is very fast: 0.16 $^{\circ}\text{C}$ per decade. The warming after the last ice age was 0.1 $^{\circ}\text{C}$ per century.

Climate sensitivity according to IPCC is around 3.7 watts per m^2 . This leads to 3 $^{\circ}\text{C}$ increase for a doubling of CO_2 levels.

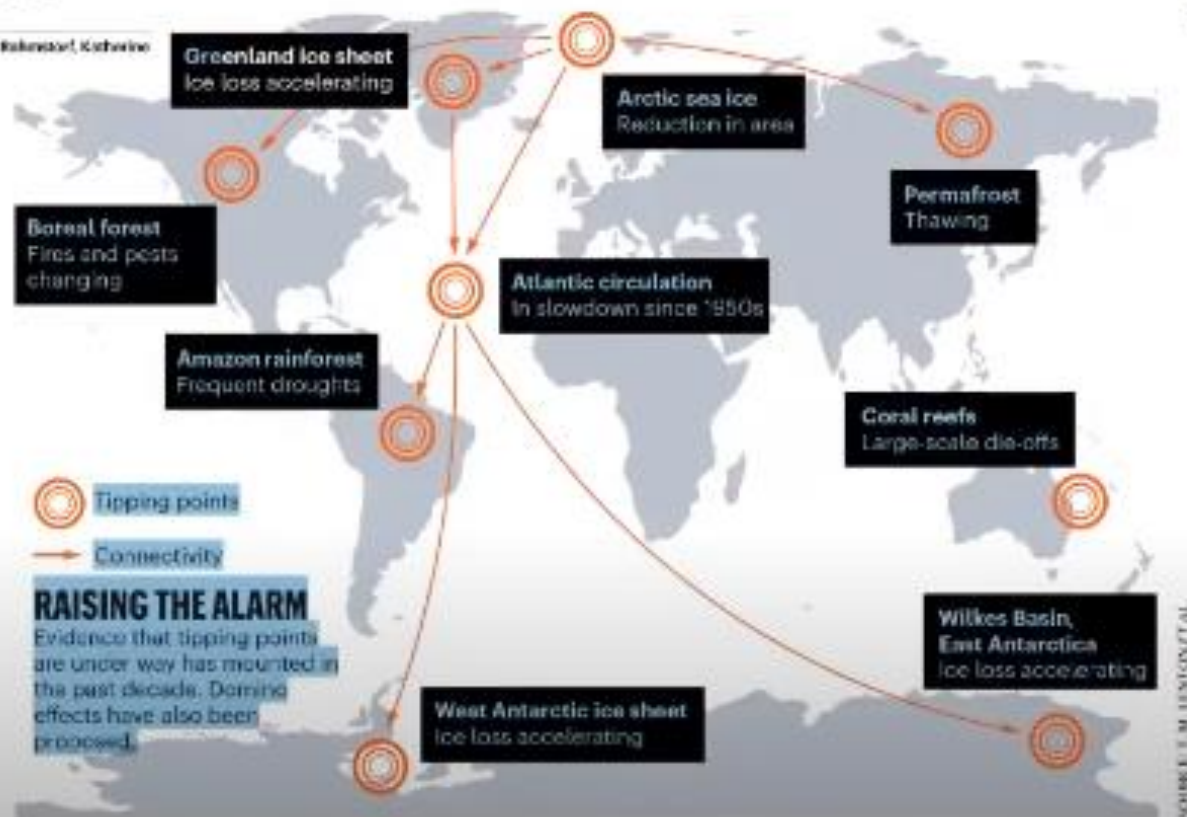
During previous warming events CO_2 levels started to increase followed by increased temperature. Now it is the opposite. We do not know what it will lead to.

Feedbacks and tipping points

- Arctic Sea summer ice melts –
feedback: decreased albedo
- Arctic permafrost is melting
feedback: increased methane emissions
- Amazon rainforest cut down and becomes savanna
feedback: decreased evapotranspiration
- Atlantic circulation decreases
feedback: ocean desalting

Climate tipping points – too risky to bet against

Timothy M. Lenton, Johan Rockström, Owen Gaffney, Stefan Rahmstorf, Katherine Richardson, Will Steffen & Hans Joachim Schellnhuber



30 minutes

- 10 minutes to think on your comments;
- 20 minute discussion.

Discuss for example

- How much are you depending on fossil fuels today?
- Do you see ways to reduce this?

II. Climate practises and policies

Climate terminology

Carbon (as CO₂) flows between the atmosphere, the above ground biosphere, the ground and the sea.

All these flows have increased considerably since *coal, oil and gas*, stored as *fossil carbon*, has started to be used as a source of energy.

We talk about *carbon sinks* and *carbon sources*.

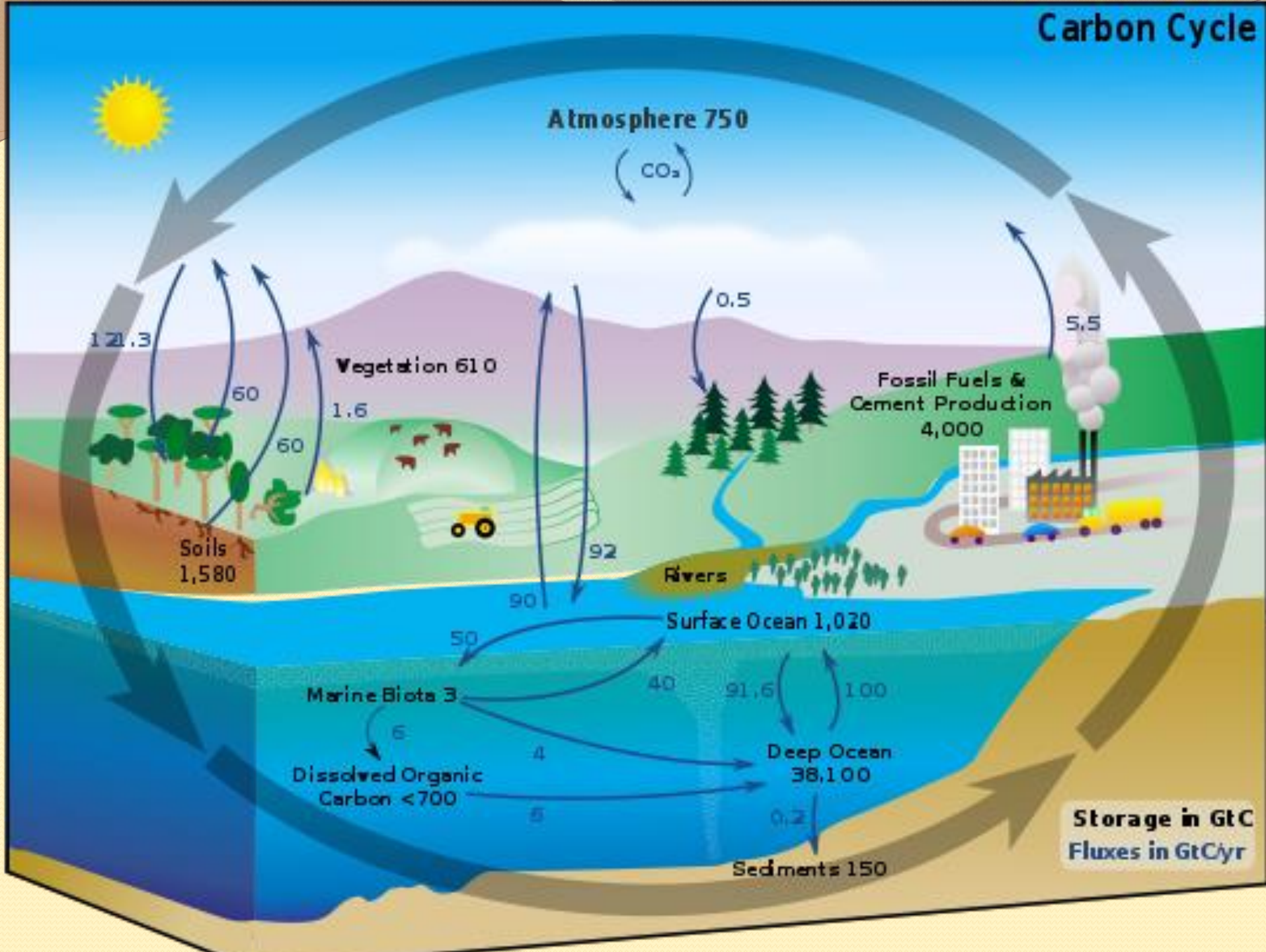
A growing forest is a carbon *sink*.

An overused soil is a carbon *source*.

When carbon is stored in a sink it is called *sequestration*.

When carbon is released from a source it is called *emission*.

Carbon Cycle



Intergovernmental Panel on Climate Change (IPCC)

- In 1988 the Intergovernmental Panel on Climate Change (IPCC) was formed by the World Meteorological Association (WMO) and UN Environmental Programme (UNEP). IPCC is reporting research on climate change by thousands of scientists.
- The assessment reports, the most recent no 6 from 2021-2022, summarizes the collective understanding of climate change and its consequences as well as projections into the future.

Global GHG emissions for 2008 by type and source

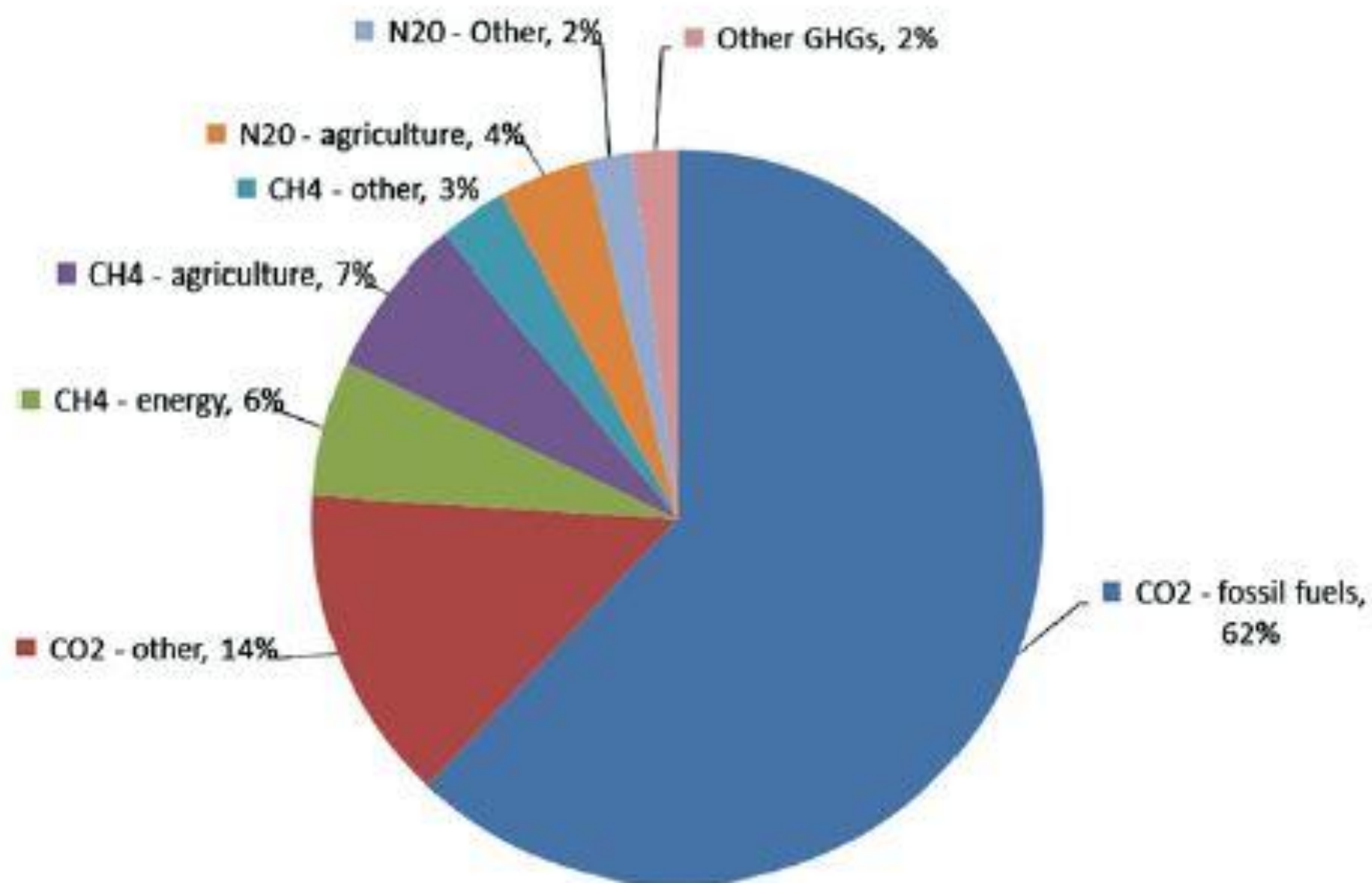


Fig. 3. Global anthropogenic GHG emissions by type and source. Data taken from IEA (2010).

Adaptation

- Not building in coastal areas
- Building flood defences
- Protecting cities for extreme heat waves
- Develop crops which can grow in higher temperatures
- Switching to drought-resistant crops
- Etc

https://en.wikipedia.org/wiki/Green_roof#/media/File:20080708_Chicago_City_Hall_Green_Roof.JPG





<https://www.pri.org/stories/2016-06-20/sea-levels-rise-rotterdam-floats-top-example-how-live-water>

Mitigation

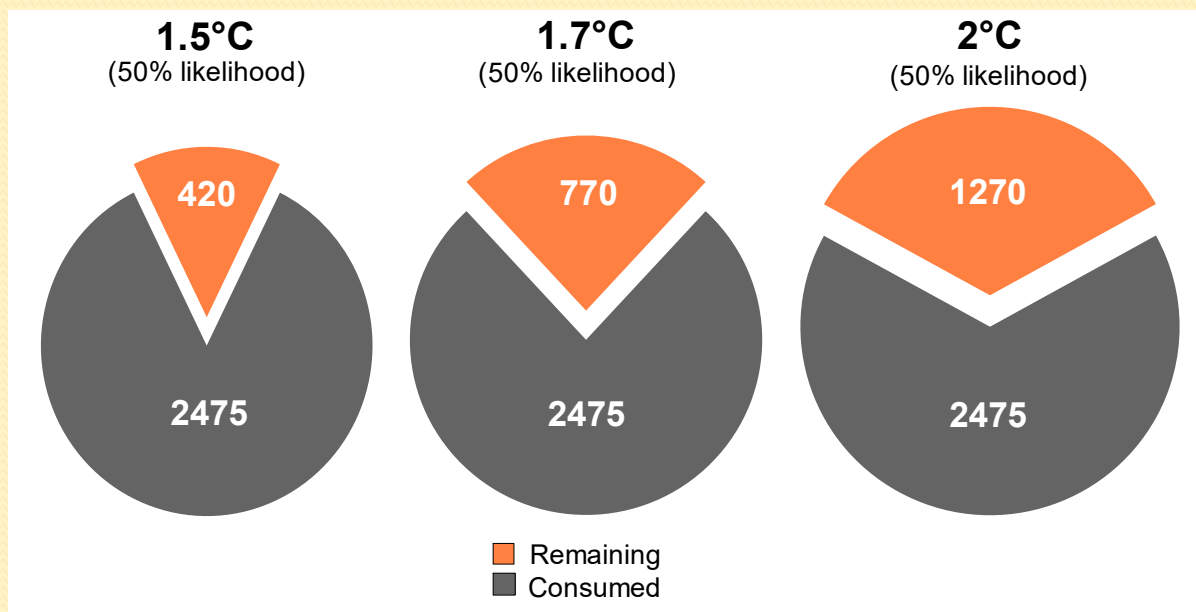
- Changing to renewable energy
- Stop using fossil fuels in power plants
- Stop using fossil fuels for heating
- Stop using fossils for driving cars, drive car less
- Reduce flying, take train for long distance travel
- Developing forestry
- Building in wood, not concrete
- And much more

The CO₂ budget of the world

- The remaining budget for the world is about 500 billion tonnes of CO₂. (500 Gtons) for the 1.5 °C targets.
- It can be divided between the countries. Then developing countries get more.
- Sweden gets 300 million tons.
- Today Sweden emits about 50 million tons per year.
- We thus need to be carbon free in 8 years, and reduce CO₂ emission by 17 % per year.

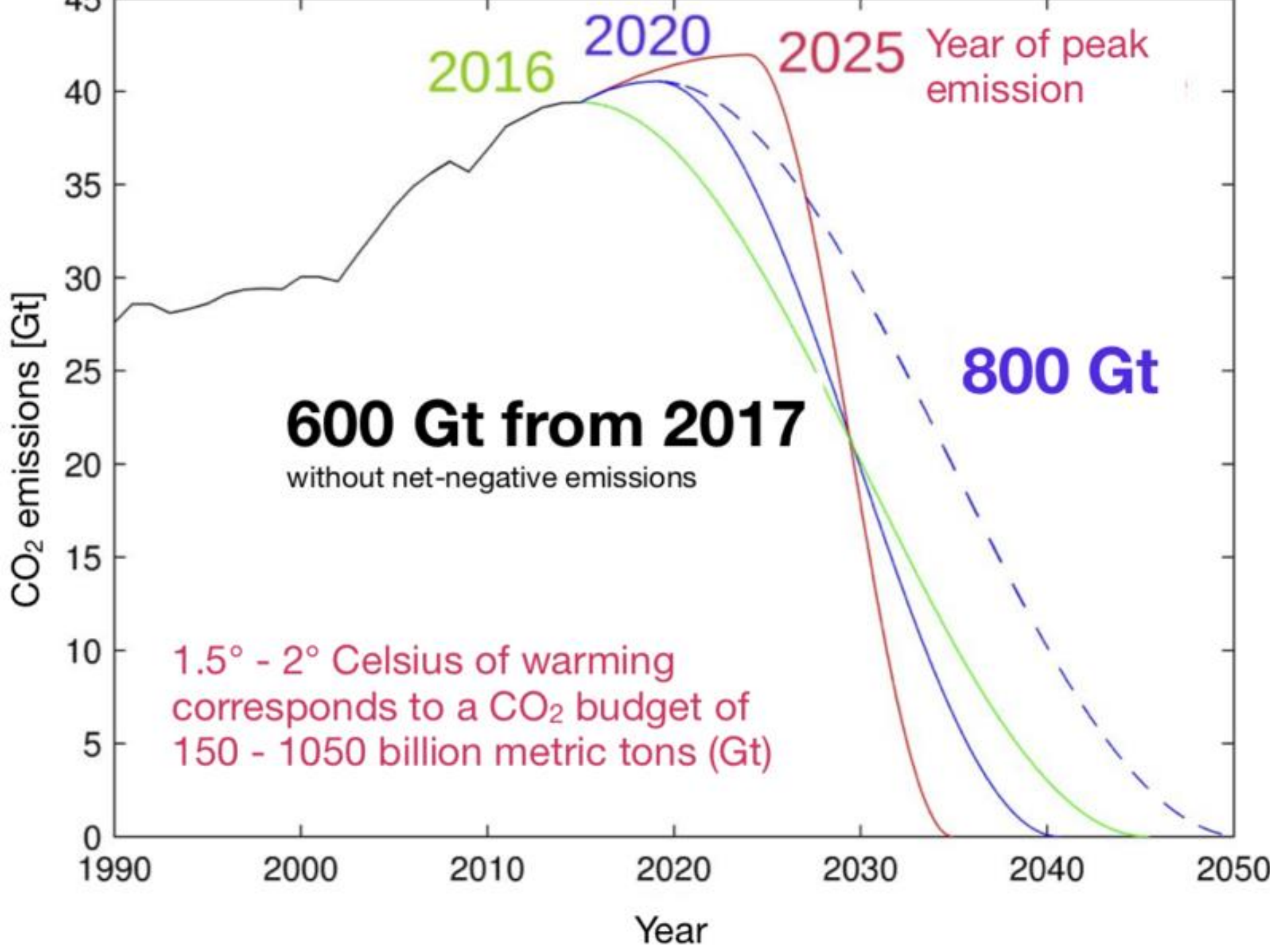
Remaining carbon budget

The remaining carbon budget to limit global warming to 1.5°C, 1.7°C and 2°C is 420 GtCO₂, 770 GtCO₂, and 1270 GtCO₂ respectively, equivalent to 11, 20 and 32 years from 2022. 2475 GtCO₂ have been emitted since 1750



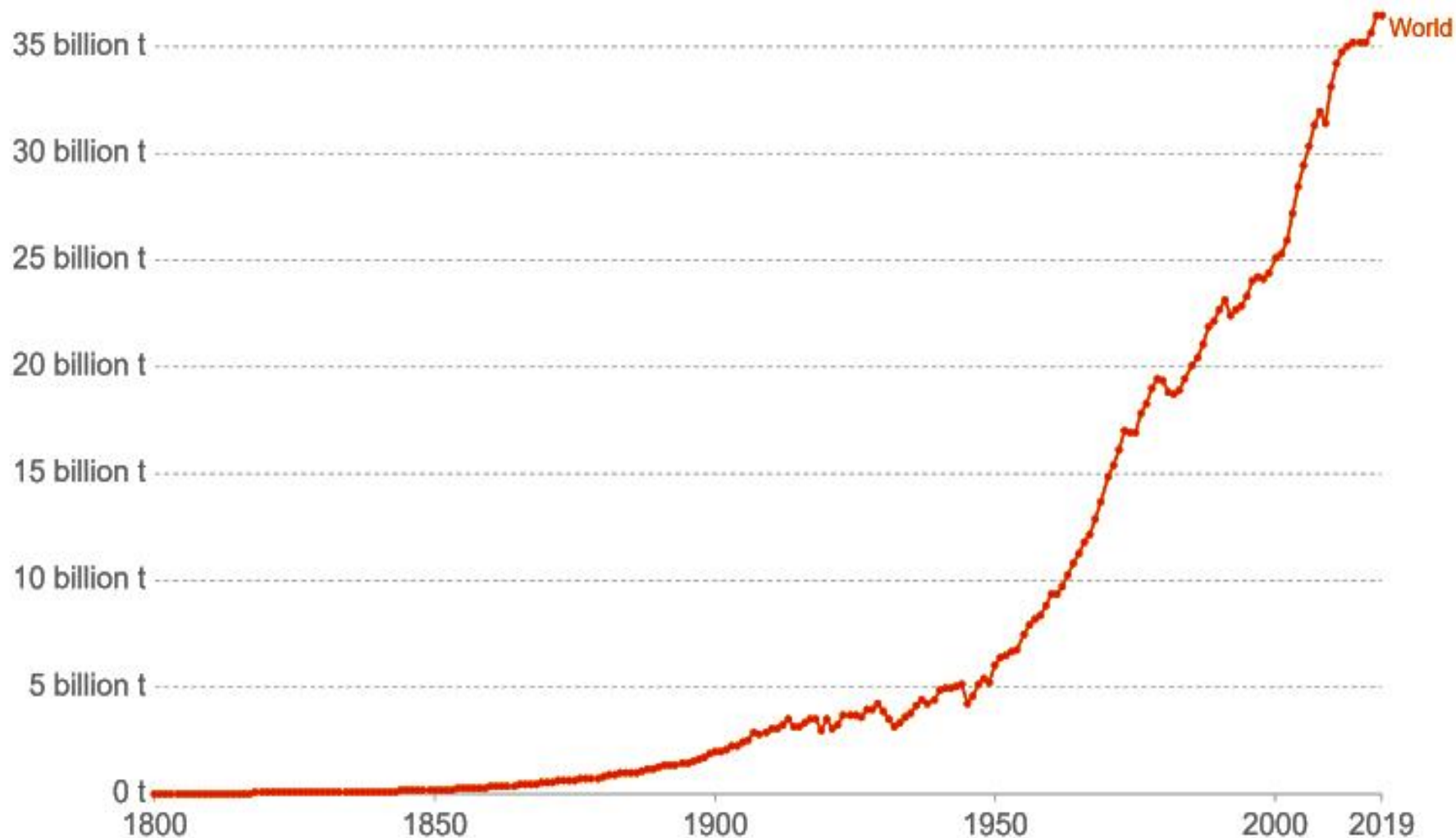
Quantities are subject to [additional] uncertainties e.g., future mitigation choices of non-CO₂ emissions

Source: IPCC AR6 WG1; [Friedlingstein et al 2021](#); [Global Carbon Budget 2021](#)



Annual CO₂ emissions

Carbon dioxide (CO₂) emissions from the burning of fossil fuels for energy and cement production. Land use change is not included.

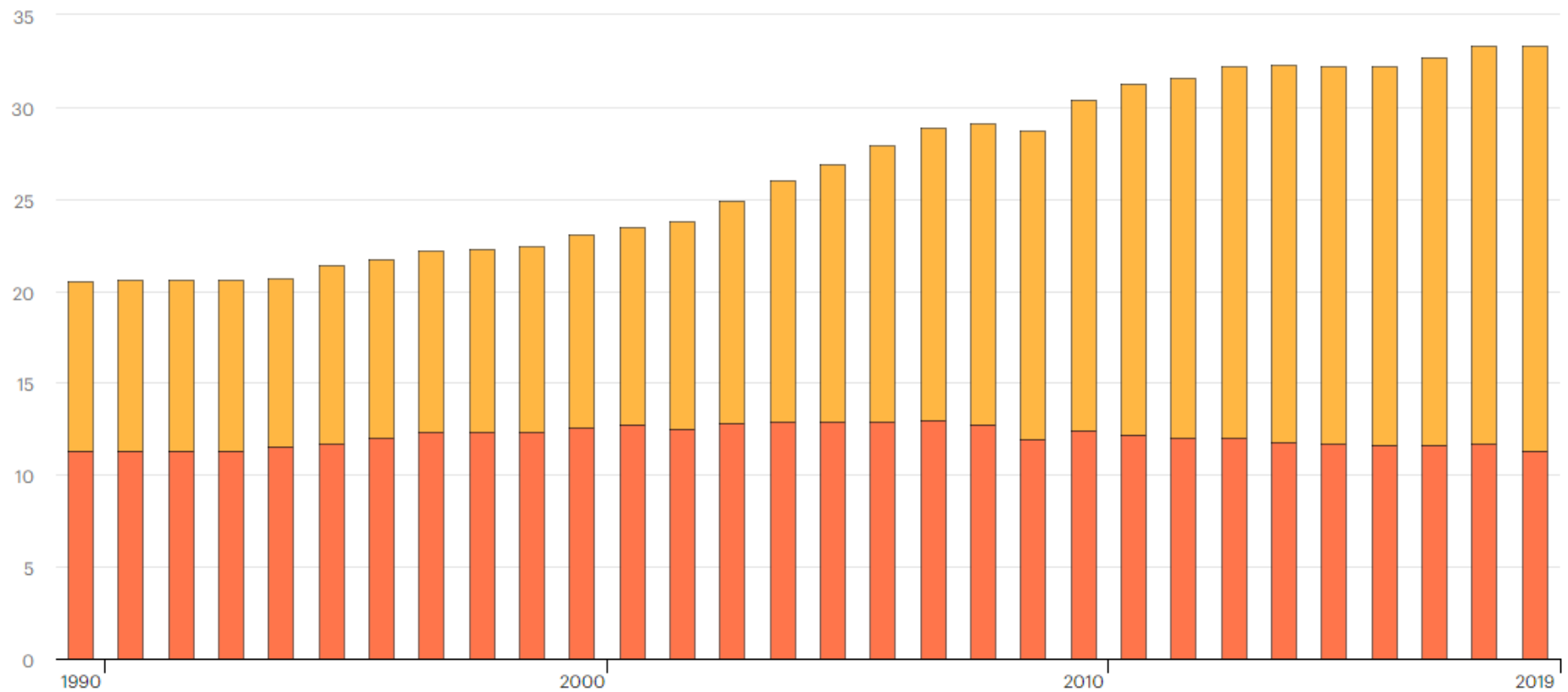


Source: Global Carbon Project; Carbon Dioxide Information Analysis Centre (CDIAC)

Note: CO₂ emissions are measured on a production basis, meaning they do not correct for emissions embedded in traded goods.

OurWorldInData.org/co2-and-other-greenhouse-gas-emissions/ • CC BY

Gt CO₂

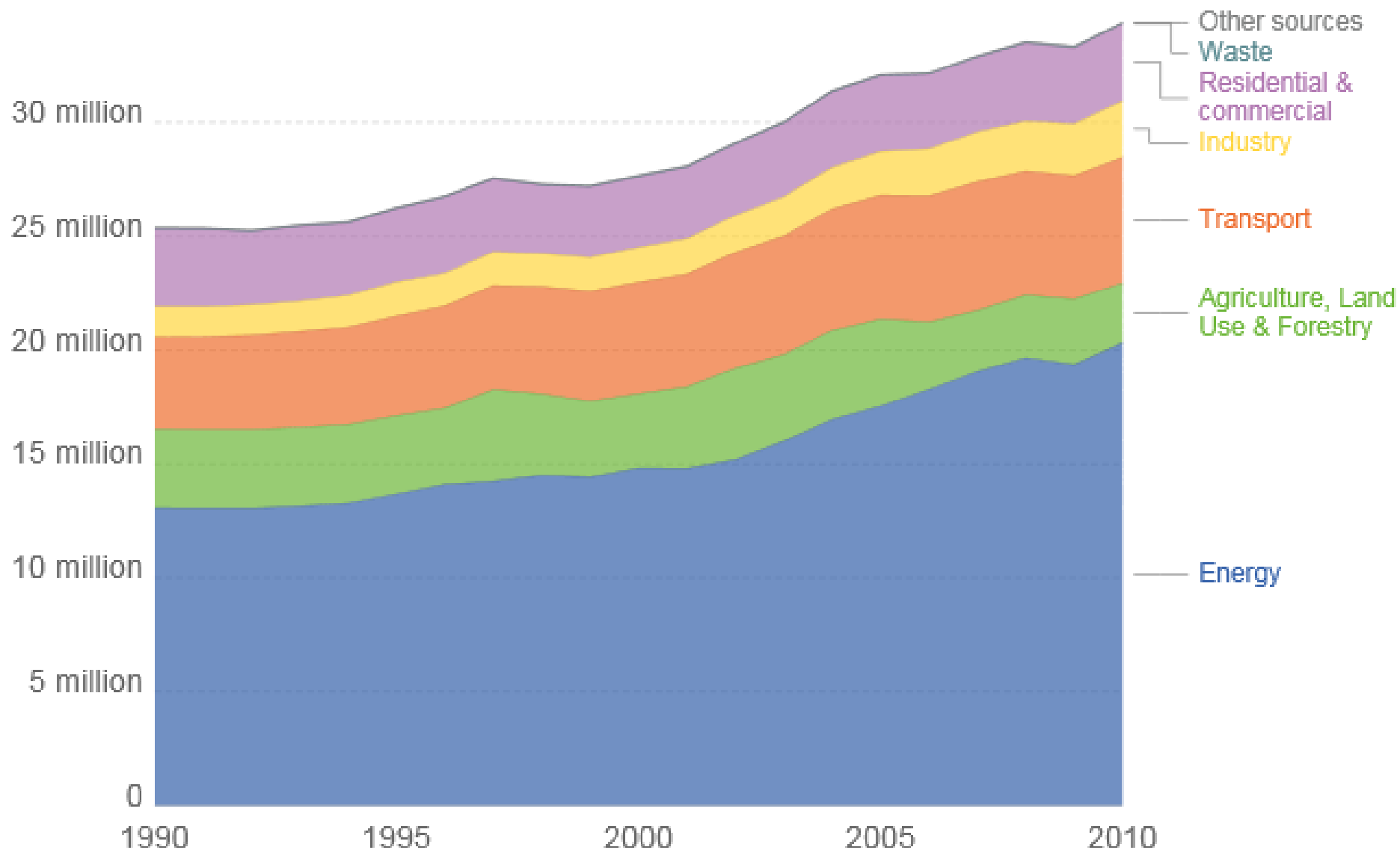


Carbon dioxide emissions per year, developed and developing countries up to 2019

<https://www.iea.org/data-and-statistics/charts/energy-related-co2-emissions-1990-2019>

Global carbon dioxide emissions by sector (Gg CO₂)

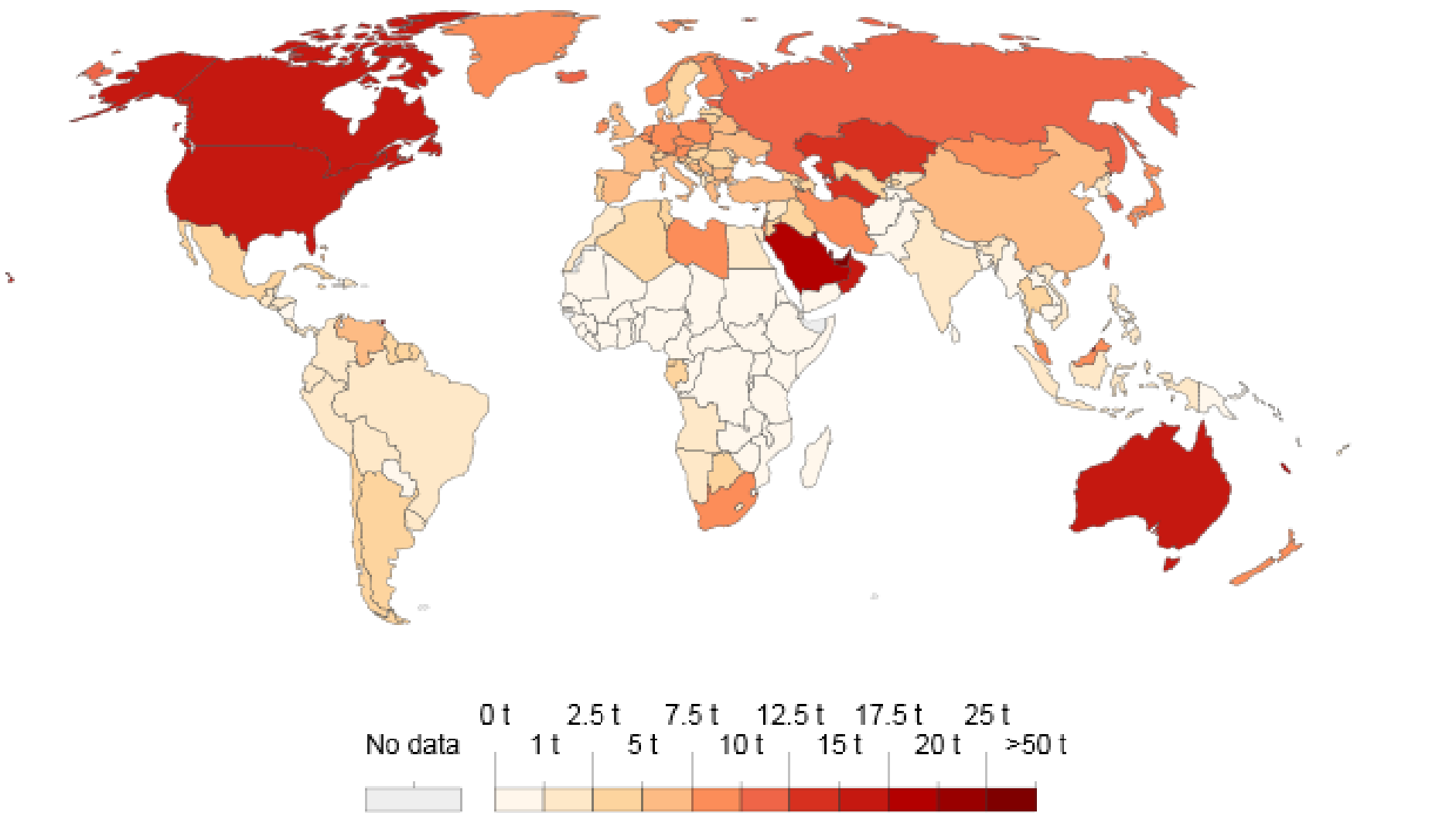
Global carbon dioxide (CO₂) emissions, measured in gigagrams of CO₂ per year.



Source: UN Food and Agricultural Organization (FAO)

CO₂ emissions per capita, 2016

Average carbon dioxide (CO₂) emissions per capita measured in tonnes per year.



Source: OWID based on Global Carbon Project, Gapminder & UN

- <https://ourworldindata.org/grapher/co-emissions-per-capita?time=2020>

United Nations Framework Convention on Climate Change (UNFCCC)

- The 1992 UN conference in Rio de Janeiro (UNCED) negotiated and signed a United Nations Framework Convention on Climate Change (UNFCCC).
- The convention went into force in 1994 when 50 states had ratified. Today 194 states are parties to the convention, that is, all states on Earth take part.
- The objective of the Convention is to stabilize greenhouse gas concentrations “at a level that would prevent dangerous anthropogenic (human induced) interference with the climate system.”
- The convention asks for mitigation (reduction) of climate change, but there is also adaptation to climate change mentioned.

Conferences of the Parties (COPs)

- The activities under the convention are negotiated at **Conferences of the Parties** (COPs), mostly organized yearly.
- At the 1997 COP₃ in Kyoto, Japan, a Protocol, a detailed plan of the actions required by each party of the convention, was signed. **The Kyoto Protocol** contains binding targets for 37 industrialized states and the European Community (so called Annex 1 countries) to reduce GHG emissions by 5% compared to the 1990 levels for the five-year period 2008-2012.
- The Protocol entered into force in 2005 after Russia had signed. Of the major emitters USA has not entered the Protocol while Australia with a new government joined in 2008 and Canada left in 2012.



The 2009 COP15 in Copenhagen was set up to reach an agreement but failed.

European Trading System, ETS

- The European Union states divided the Kyoto obligations of reduction of emissions between themselves unequally, depending on economy and level of emissions.
- Based on the COP₃ in Kyoto EU established a cap and trade system for CO₂, called European Trading System, ETS. In this system a number of major European industries, presently about 11 000, have been given allowances (rights) to emit specified amounts of CO₂. Those emitting more have to buy additional rights and those, which can reduce their emissions may finance the costs of the investments needed by selling emission rights.
- The third trading period, 2013-2020, include more GHGs, especially methane and nitrous oxide, more sectors especially air traffic, and reduced allowances of emission rights, but emission rights are too cheap for ETS to be effective.
- Since 2020 the price has raised and is today 78 Euro/tonne and will increase systematically. The fourth trading period started. It is 2020-2030.

People's Climate March New York September 21, 2014



Nations Unies

Conférence sur les Changements Climatiques 2015

COP21/CMP11

Paris France



#ParisAgreement

"Long live the planet.

Long live Humanity. Long live life itself."

Intended Nationally Determined Contributions (INDCs)

<http://www.c2es.org/international/2015-agreement/indcs>

<http://climateactiontracker.org/indcs.html>

123 INDCs from 150 countries, 87 % of global emissions

Nationally Determined Contributions will give 3.6 °C.

To really stay below 2 °C we need rapid decarbonisation of our economies right now.



Commitments of the nations of the world 2021

- **USA** **Net Zero Emissions By 2050**
- **EU** **Carbon neutral by 2050**
- **China** **Carbon neutral by 2060**
- **Sweden** **Net Zero Emissions By 2045**
- **India** **Net Zero Emissions By 2070 (Glasgow)**

- **Uppsala** **Net Zero Emissions By 2030**

Some municipalities have net zero emission today

COP 26 in Glasgow 2021

- 153 countries new or updated emissions targets (NDCs) covering 80% of the world's greenhouse gas emissions.
- Status of NDCs shall be reported every year according to agreed rules.
- Financing poor countries shall reach \$100 billion/year by 2023 and increase to \$200 billion/year. It shall include mitigation, adaptation, loss and damage.
- The text includes “accelerating the phasedown of coal power and subsidies for fossil fuels”.

COP 26 in Glasgow

- **Glasgow Leaders' Declaration on Forest and Land Use** halving and reversing forest loss and land degradation by 2030 signed by 133 nations covering over 90% of the world's forests.
- **Global Methane Pledge** limit methane emissions by 30% by 2030 compared to 2020 levels, signed by more than 100 nations.
- **Beyond Oil and Gas Alliance** (BOGA) to phase-out of oil and gas production signed by 11 National and Subnational Governments.

The Carbon Law

- A “carbon law”, halving CO₂ emissions every decade would give the world a 75% chance of keeping Earth below 2 °C.
- Fossil-fuel emissions should peak by 2020 at the latest and fall to around zero by 2050.
- The “carbon law”, is based on Moore’s Law in the computer industry, which states that computer processors double in power about every two years. This rule of thumb has held for 50 years and still drives disruptive innovation

Proposed and researched by Potsdam Climate Institute

**Fossils should remain
in the ground!**



**Greta Thunberg, 15 years of age,
in front of the Swedish Parliament 2018**



natürlicher
et nicht
s dein
fertigist

WE NEED A
GREEN
WORLD

GREEN

Climate NOW
Homework later!

Zukunft
GRÜN
DER
ARNICH

THERE'S
NO
PLANET
B

WAS DIT LUTE
KANNST BISSCHEN
FRÜHER NICHT
AUF 2038!

ZE
KIM
ETH
VERAN


Das KLIMA
aussichtsloser,
als unser
MATHE-ABI



Fridays for future

What can you do yourself?

- **Transport:** Bike, (el bike) walk, public transport, carpool, go by car together, biogas, biodiesel, electric, etc. work from home, video conferencing.
- **Food:** avoid food waste, less meat or meat from free ranging, food from local producers, buy from nearby, eco-food.
- **Housing:** insulate your house, use green electricity, energy efficient equipment, turn off stand-by, sun heat, solar cells.



**The least you can do is as
much as possible**

Lecture 4 Climate

To read

Climate change and climate science - A basic reader.

Chapter 1 *The Climate system* pp. 4-17.

Climate change and climate science - A basic reader.

Chapter 2 *Climate Change – causes and consequences* pp. 18-34 .

Climate change and climate science - A basic reader.

Chapter 4 *Mitigating and adaptation of climate change*. pp 45-48.