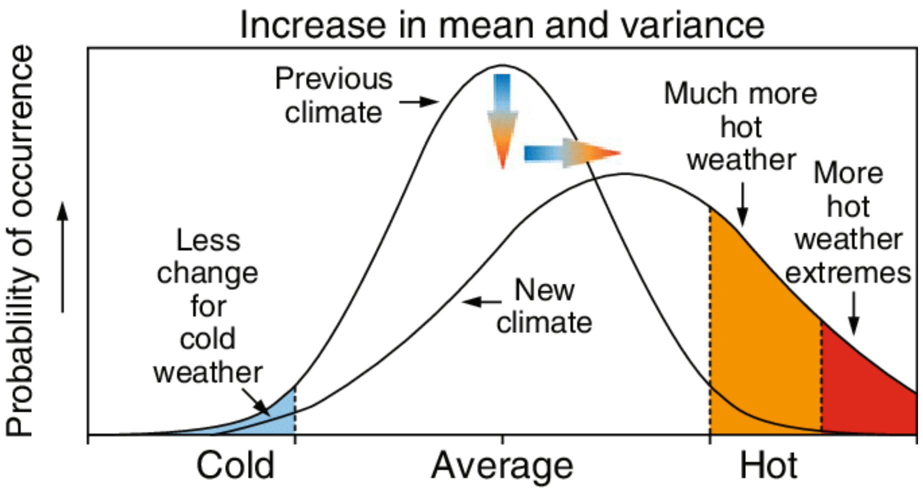
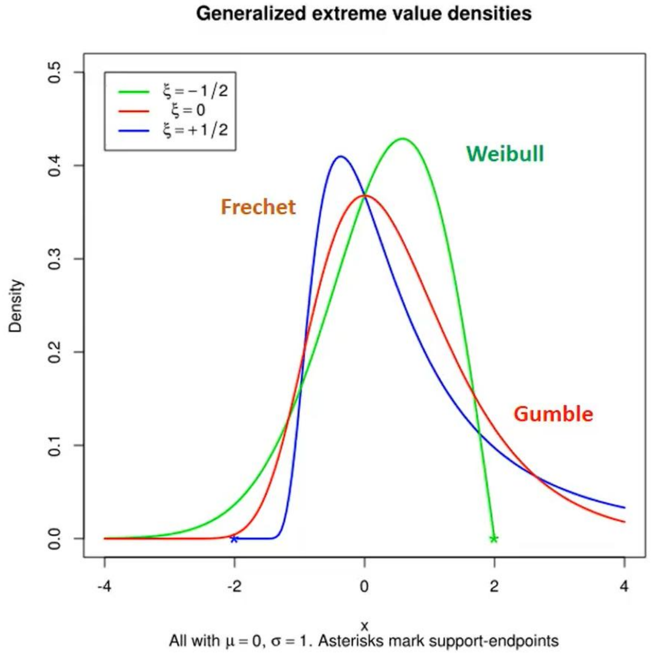
Recap of previous lecture

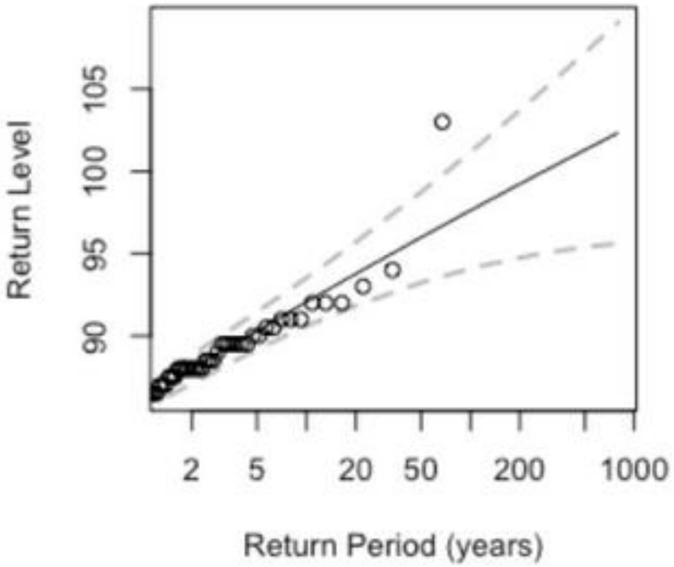


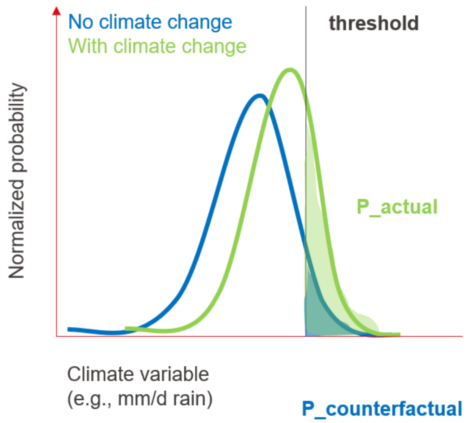
A changing climate invokes a shift in the mean and a broadening of the distribution



Extreme values can be characterized by three different types of distributions

The statistical evaluation of extremes allows to calculate return periods





- P_actual > P_counterfactual
- Probability ratio:
  P_actual/P_counterfactual > 1
- Fraction of attributable risk (FAR)=
  1- p_counterfactual/p_actual

Risk of extreme events can be attributed to climate change through comparison with counterfactual model simulations

General outline

	No.	Date	Topics	Deadlines / tentative
Basics	1.	11.09.2025	Introduction to the climate system	Questionnaire (not graded)
	2.	18.09.2025	Climate System, Radiation	
	3.	25.09.2025	Radiation, Earth's Energy balance, Greenhouse effect	launch of first assignment
	4.	02.10.2025	Aerosols & clouds, Radiative Forcing	Launch of poster project
	5.	09.10.2025	Feedback mechanisms, Climate Sensitivity	
	6.	16.10.2025	Paleoclimate	submission of Poster proposal (graded)
Present and future Climate change	7.	30.10.2025	Climate variability, Introduction to IPCC	
	8.	06.11.2025	Current state of climate, IPCC – report, Paris Agreement, Climate scenarios (RCPs, SSPs)	
	9.	13.11.2025	Emissions Gap, 1.5 vs 2.0°C vs warmer, Tipping elements, Extreme Events	submission of Poster draft (graded)
	10.	20.11.2025	COP 30, Extreme Events Attribution Studies, Carbon budget	
	11.	27.11.2025	Metrics, Carbon offsets	submission of assignment (graded)
	12.	04.12.2025	Polar climate change	
Actions	13.	11.12.2025	Mitigation measures	Poster Conference (graded)
	14.	18.12.2025	Climate engineering, questions and answers session	fill in Questionnaire in exercises (not graded)

The Pope on Extreme Events

- **“Creation is crying out in floods, droughts, storms and relentless heat",**
- "one in three people live in great vulnerability because of these climate changes".
- To them, climate change is not a distant threat, and to ignore these people is to deny our shared humanity.

- https://www.vaticannews.va/en/pope/news/2025-11/pope-leo-xiv-videomessage-cop30-amazon-global-south-bishops.html

Steps of a scientific probability attribution study

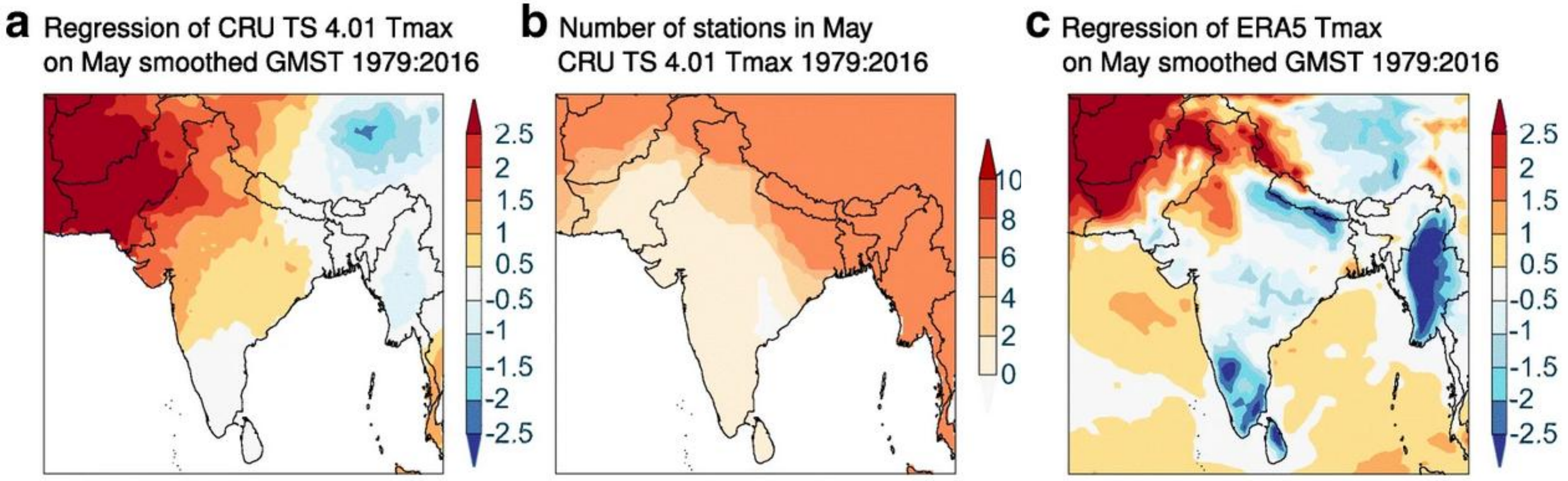
1. measuring the magnitude and frequency of a given event based on observed data,
2. running computer models that are compared to and verified with the observational data,
   1. Can the model in principle represent the extremes of interest?
   2. Are the statistics of the modeled extreme events compatible with the statistics of the observed extremes?
   3. Is the meteorology driving these extremes realistic?
      → gaining trust in the model
3. running the same validated models on the counterfactual scenario with no climate change, and
4. using statistics (see previous slide) to analyze the differences between the second and third steps, thereby measuring the direct effect of climate change on the studied event.

Pitfalls of extreme event attribution

- Need of complete data series, too big gaps will introduce biases.
- Also gridded data from observations (interpolated between stations) can invoke biases.

Gridded and interpolated data, based on a few stations only, or even no station data

Data set based on numerical model with observational data integrated → gives a much more realistic view of the situation



a Trend of May maximum temperature in South Asia 1979–2016 in the CRU TS 4.01 dataset. **b** Number of stations used to estimate the temperature at each grid point in CRU TS 4.01. **c** Trend of May maximum temperatures in the ERA5 reanalysis

Floods in India in May 2016

- https://link.springer.com/article/10.1007/s10584-021-03071-7

Current developments in extreme event attribution

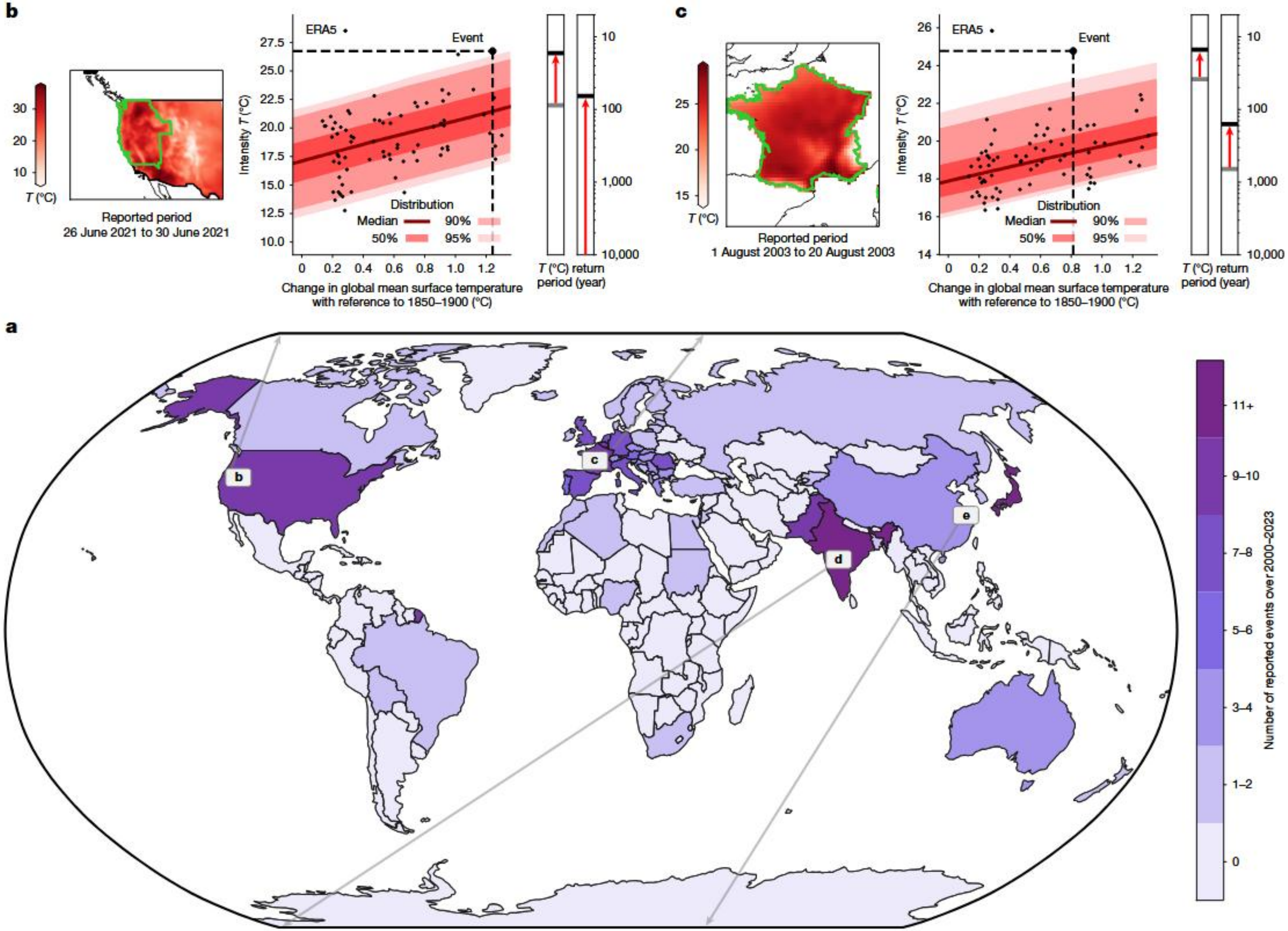
- The **World Weather Attribution (WWA)** collaboration has over the last 5 years developed a methodology to answer these questions in a scientifically rigorous way in the immediate wake of the event when the information is most in demand. → 8 Step procedure (see exercises)
- Next step: **Extreme Event Impact Attribution** (as opposed to risk or probability)
  - The methods of extreme event attribution (EEA) that quantify the extent to which climate change affected specific recent extreme weather events in the past 20 years have been combined more recently with socio-economic impact data to quantify extreme weather's impacts attributable to climate change.
  - The EEIA "algorithm" can be divided into the EEA part (the climate science component) and the impact analysis (the socio-economic component, including potentially human and environmental impacts). The EEA component is used to determine the change in the probability or the intensity of a well-defined extreme weather event (e.g., the rainfall in a particular location and period) as a consequence of climate change. The impact part then links this change to the event's observed impacts (e.g., mortality associated with the event) to attribute a fraction of the total impact of the event to anthropogenic climate change causes.
- Next step: attribution of events to specific emitters

Systematic attribution of heatwaves to the emissions of carbon majors

Yann Quilcaille, Lukas Gudmundsson, Dominik L. Schumacher, Thomas Gasser, Richard Heede, Corina Heri, Quentin Lejeune, Shruti Nath, Philippe Naveau, Wim Thiery, Carl-Friedrich Schleussner & Sonia I. Seneviratne

Nature **645**, 392–398 (2025) | Cite this article

…Here we show that **climate change made 213 historical heatwaves reported over 2000–2023 more likely and more intense**, to which each of the **180 carbon majors** (fossil fuel and cement producers) substantially contributed.
…Owing to global warming since 1850–1900, the median of the heatwaves during 2000–2009 became about **20 times more likely, and about 200 times more likely** during 2010–2019. Overall, one-quarter of these events were virtually impossible without climate change.
The emissions of the carbon majors contribute to half the increase in heatwave intensity since 1850–1900. Depending on the carbon major, **their individual contribution is high enough** to enable the occurrence of 16–53 heatwaves that would have been virtually impossible in a preindustrial climate.
We, therefore, establish that the influence of climate change on heatwaves has increased, and that all carbon majors, even the smaller ones, contributed substantially to the occurrence of heatwaves. Our results contribute to filling the evidentiary gap to establish **accountability of historical climate extremes**[7,8].



a, The number of heatwaves reported per country in EM-DAT (www.emdat.be) over 2000–2023. An EEA is performed for each of them, as shown for four examples with ERA5 (ref. [28]) data. **b**, The 2021 Pacific Northwest heat dome. **c**, The 2003 heatwave in France.

…

For each example, the average temperatures during the event are mapped, with the outlines of the reported region (lime green contours). Moreover, the intensity (average temperature *T* (°C) during the period and the region of the event) and change in GMST (°C) are represented over 1950–2023 (black dots), with their conditional distribution represented through the median (red line) and ranges of the distribution (red shading). Finally, the change in intensity and change in return period (year) compared with the preindustrial reference period are shown for each example. Uncertainties inferred using bootstrapping are not shown here for the sake of clarity. …

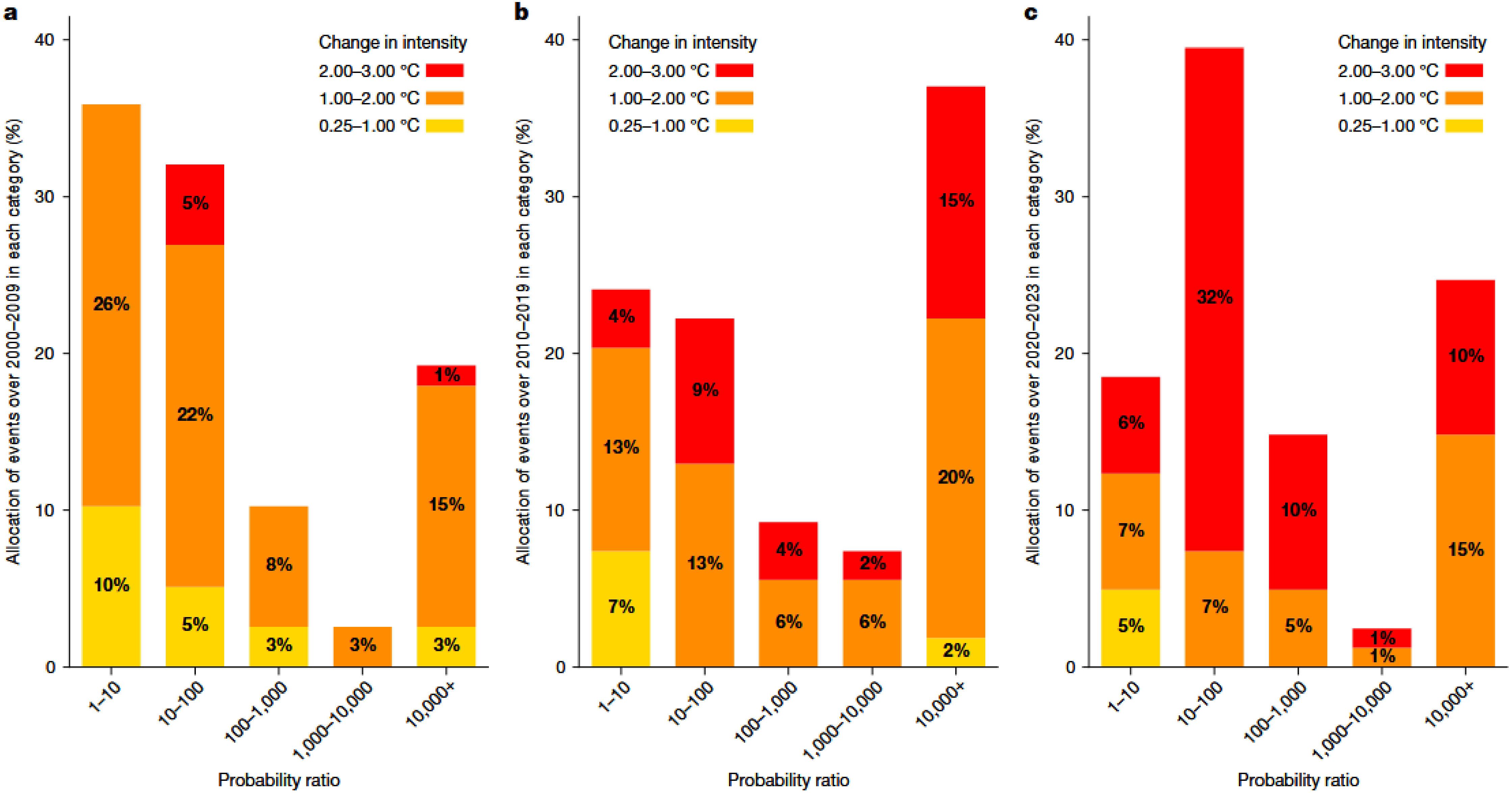
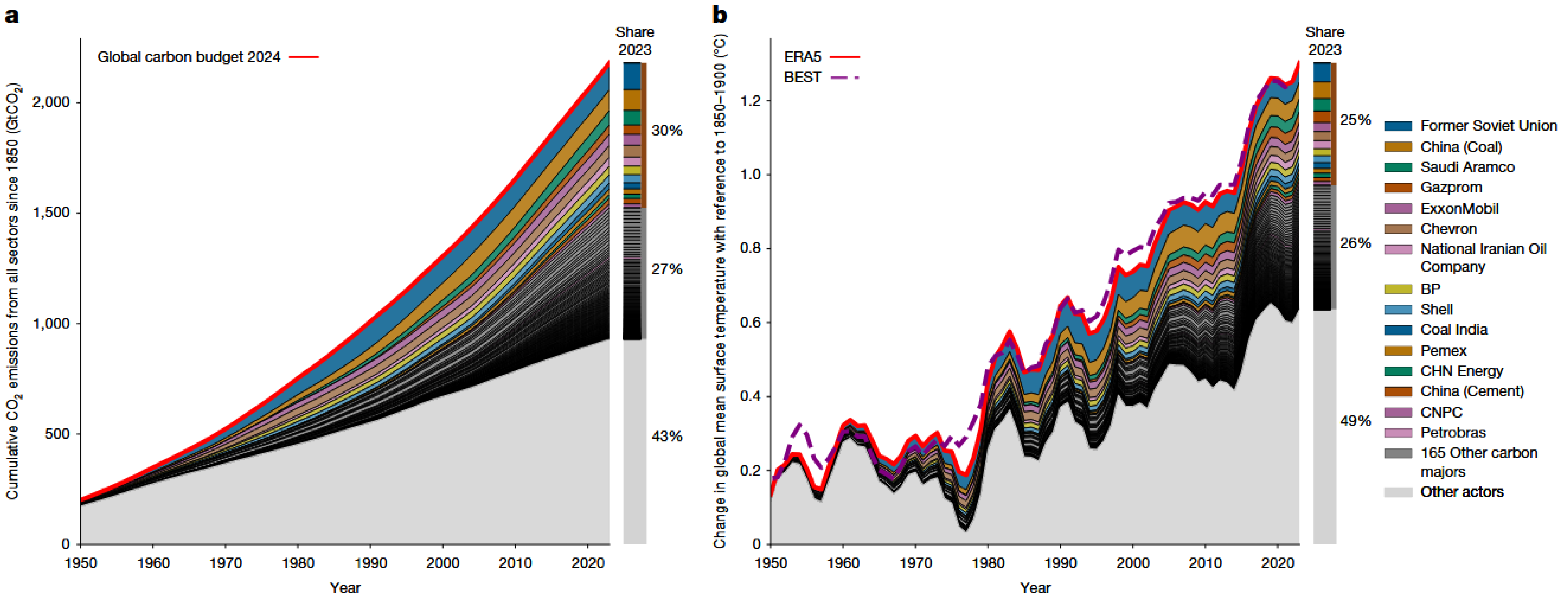
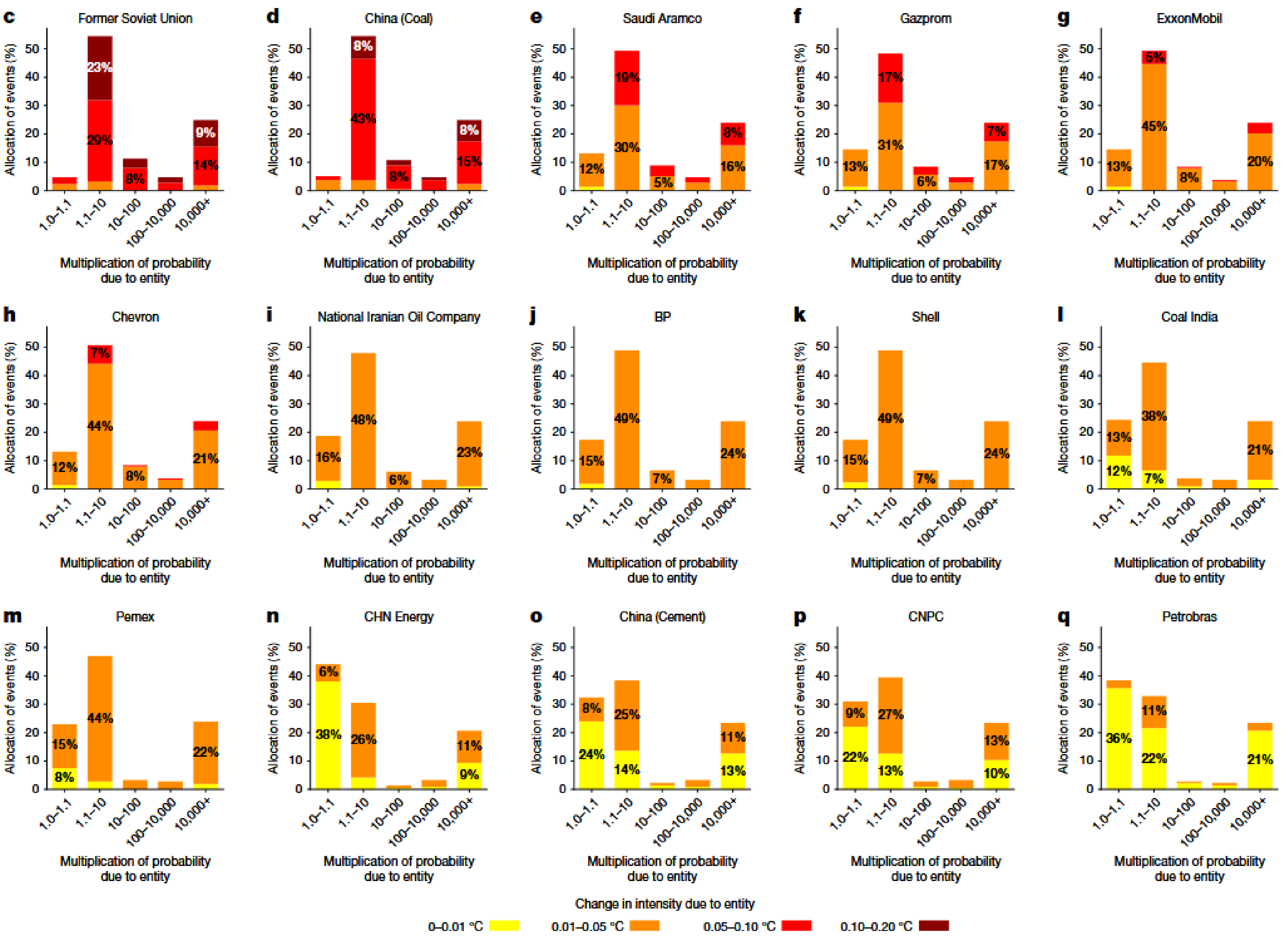


Fig. 2 | Increasing contribution of climate change to 213 heatwaves over time. Each heatwave is allocated a category depending on its change in intensity (colour) and its probability ratio (vertical bars in per cent) with reference to 1850–1900. **a**–**c**, Events are categorized based on the year of the event: 78 heatwaves attributed over 2000–2009 (**a**), 54 heatwaves attributed over 2010–2019 (**b**) and 81 heatwaves attributed over 2020–2023 (**c**). Median results are shown here. Further details on the attribution of each heatwave event are provided in the Methods, and all results are provided in the Supplementary Information.

Use of carbon budget for attribution

a,**b**, Contributions of the carbon majors to the cumulative CO_2 emission since 1850 (all sectors) (**a**) as reported in the Carbon Majors database (https://carbonmajors.org/) and compared with the Global Carbon Budget[36] and the ensuing GMST as simulated by the OSCAR model (**b**). The GMST of ERA5[28] and BEST[29] have been rebased to 1850–1900 (ref. [9]).





c–q, Attribution of historical heatwaves to the emissions of carbon majors for 15 selected carbon majors. In each of these panels, the 213 heatwaves are allocated into categories of contributions of the carbon majors to the change in intensity (colours) and how many times the carbon major increased the likelihood of the heatwave compared to 1850–1900 (*x*-axis)

Discussion

- …there are still two limitations in this work.
  - Although the EM-DAT is the most complete existing **database** for disasters, many heatwaves are still not reported, calling for a more exhaustive coverage of the events.
  - Moreover, the **contributions of the carbon majors remain incomplete**. On the one hand, not all CO_2 and CH_4 emissions are covered in this database because of underreporting[19]. For instance, this database represents only 75% of the fossil fuel and cement CO_2 emissions reported over 1850–2023 (ref. [36]). The actual contributions of the carbon majors are thus expected to be higher if all the emissions from fossil fuel and cement producers are included.
- On the other hand, the burning of fossil fuels can release **aerosols that would have a local effect on the climate**. As a whole, the aerosols emitted by the fossil fuel sector reduce their contribution by approximately 10% (ref. [38]).
  - However, attributing aerosol climate effects to individual companies would be highly challenging. The effects of aerosols on climate are local to regional, yet fossil fuels are globally traded. Furthermore, aerosol emissions from fossil fuel combustion strongly depend on the use of filter technology, which differs between regions, sectors and combustion techniques.
- If these challenges are overcome, it would pave the way for **attributing the aerosol health effects to individual emitters**. Aerosols are also harmful air pollutants, with the emissions by the use of fossil fuel causing about 5 million excess deaths per year (ref. [39]

IPCC AR6 definition of extreme events

Two sets of metrics for the frequency of hot/warm days have been used in the literature:

- One set **counts the number of days** when maximum daily temperature is **above a relative threshold** defined as the 90th or higher percentile of maximum daily temperature for the calendar day over a base period.
  - An event based on such a definition can occur at any time of the year, and the impact of such an event would differ depending on the season.
- The other set **counts the number of days** in which maximum daily temperature is **above an absolute threshold** such as 35°C, because exceeding this temperature can sometimes cause health impacts
  - These impacts may depend on location and whether ecosystems and the population are adapted to such temperatures.

The resulting meaning of “extreme” is different.

- From AR6, Ch 11.2.1

Moving targets

- When similar damage occurs once a fixed threshold is exceeded, it is more important to ask a question regarding changes in the frequency. But when the exceedance of this fixed threshold becomes a normal occurrence in the future, this can lead to a saturation in the change of probability (Harrington and Otto, 2018a).
- If the impact of an event increases with the intensity of the event, it would be more relevant to examine changes in the magnitude.
- Finally, adaptation to climate change might change the relevant thresholds over time, although such aspects are still rarely integrated in the assessment of projected changes in extremes.

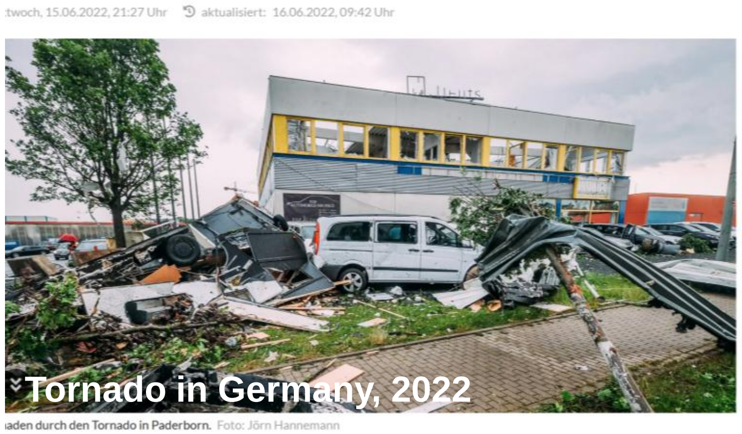
Human dimension

- AR6, Ch11

Beyond climate variables – impact and vulnerability

- «Every year, disasters related to weather, climate and water hazards cause **significant loss of life** and set back economic and social developments by years, if not decades.»

- «From 1970 to 2012, 8,835 disasters, 1.94 million deaths and US$ 2.4 trillion of **economic losses** were reported globally as a result of droughts, floods, windstorms, tropical cyclones, storm surges, extreme temperatures, landslides and wildfires, or by health epidemics and insect infestations directly linked to meteorological and hydrological conditions.»



Tornado in Germany, 2022

From WMO (2014) *Atlas Of Mortality And Economical Losses From Weather, Climate And Water Extremes (1970-2012)*


Floods in Switzerland, 2021

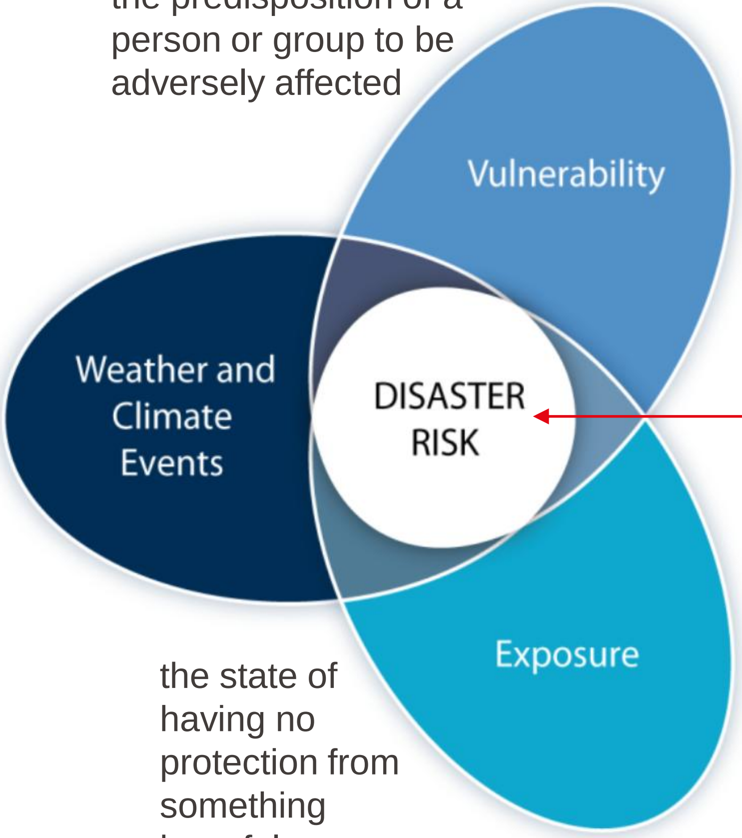

Fires in France, 2022

Beyond climate variables – impact and vulnerability

Socioeconomic development interacts with natural climate variations and human-caused climate change to influence disaster risk
- → **There is a human dimension to the definition of extreme events.**
- → **The impact counts as well.**

the predisposition of a person or group to be adversely affected

climate change-driven



the likelihood of severe alterations in the normal functioning of a community or society due to weather or climate events interacting with vulnerable social conditions

the state of having no protection from something harmful

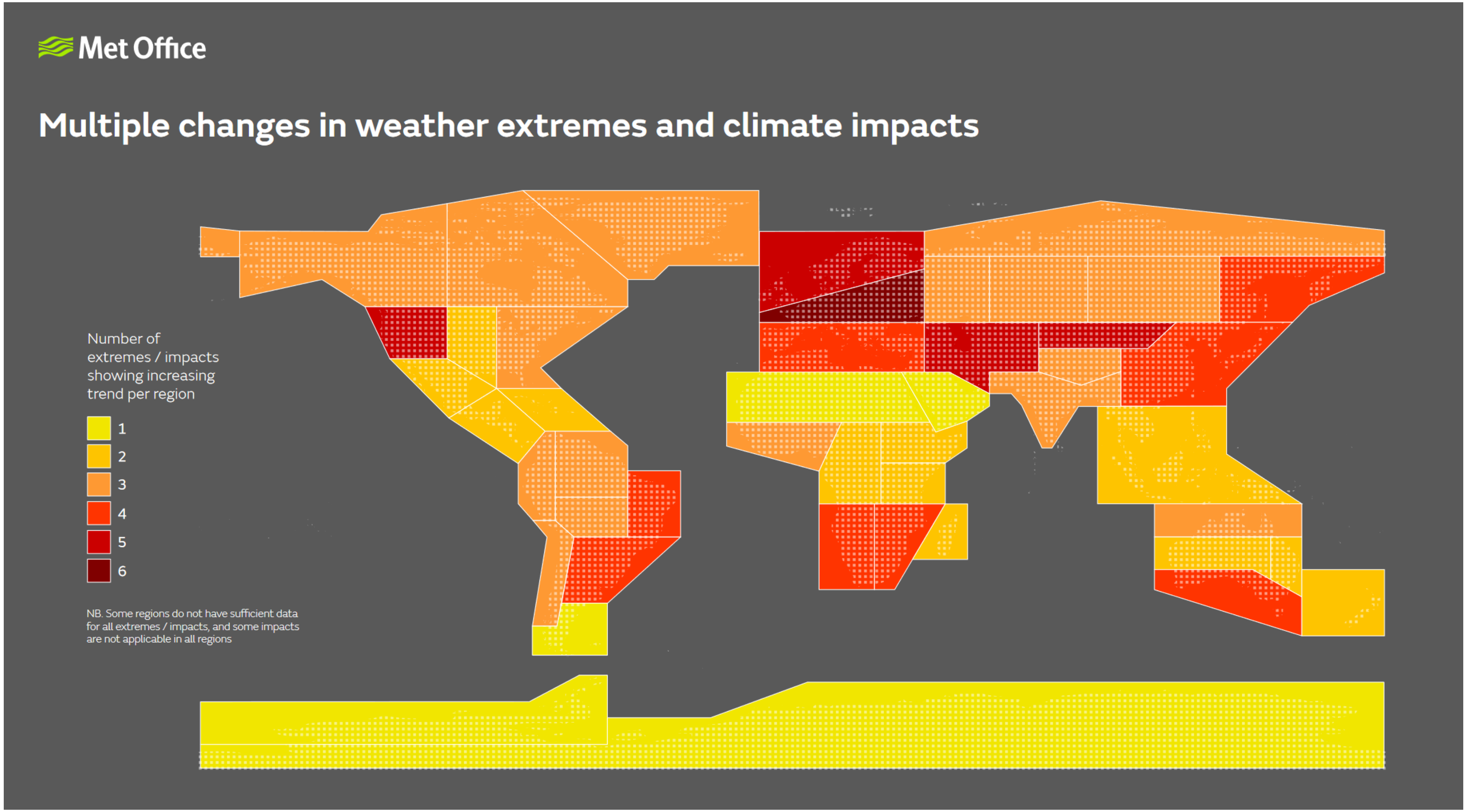
- https://www.ipcc.ch/site/assets/uploads/2018/03/IPCC_SREX_slide_deck-1.pdf, IPCC 2012

Compound Events

- Events that occur at the same time or in sequence (such as consecutive floods in the same region) and in the same geographic location or at multiple locations within a given country or around the world.
- May consist of multiple extreme events or of events that by themselves may not be extreme but together produce a multi-event occurrence.
- It is possible for the net impact of these events to be less than the sum of the individual events if their effects cancel each other out.
  - For example, increasing CO_2 concentrations and acceleration of the hydrological cycle may mitigate the future impact of extremes in gross primary productivity that currently impact the carbon cycle.
- From a risk perspective, the primary concern relates to compound extremes with additive or even multiplicative effects.
  - For instance, lack of precipitation early in the year combined with an atmospheric blocking event over western Russia in 2010 led to an extraordinary hot and dry summer, which induced widespread wildfires and air pollution ultimately causing more than 50,000 deaths and destroying 25% of Russian crops.
- Difficulty is to predict compound events to be prepared.

- https://science2017.globalchange.gov/chapter/15/; https://damocles.compoundevents.org/

Multiple extremes



The six categories covered in the study are:

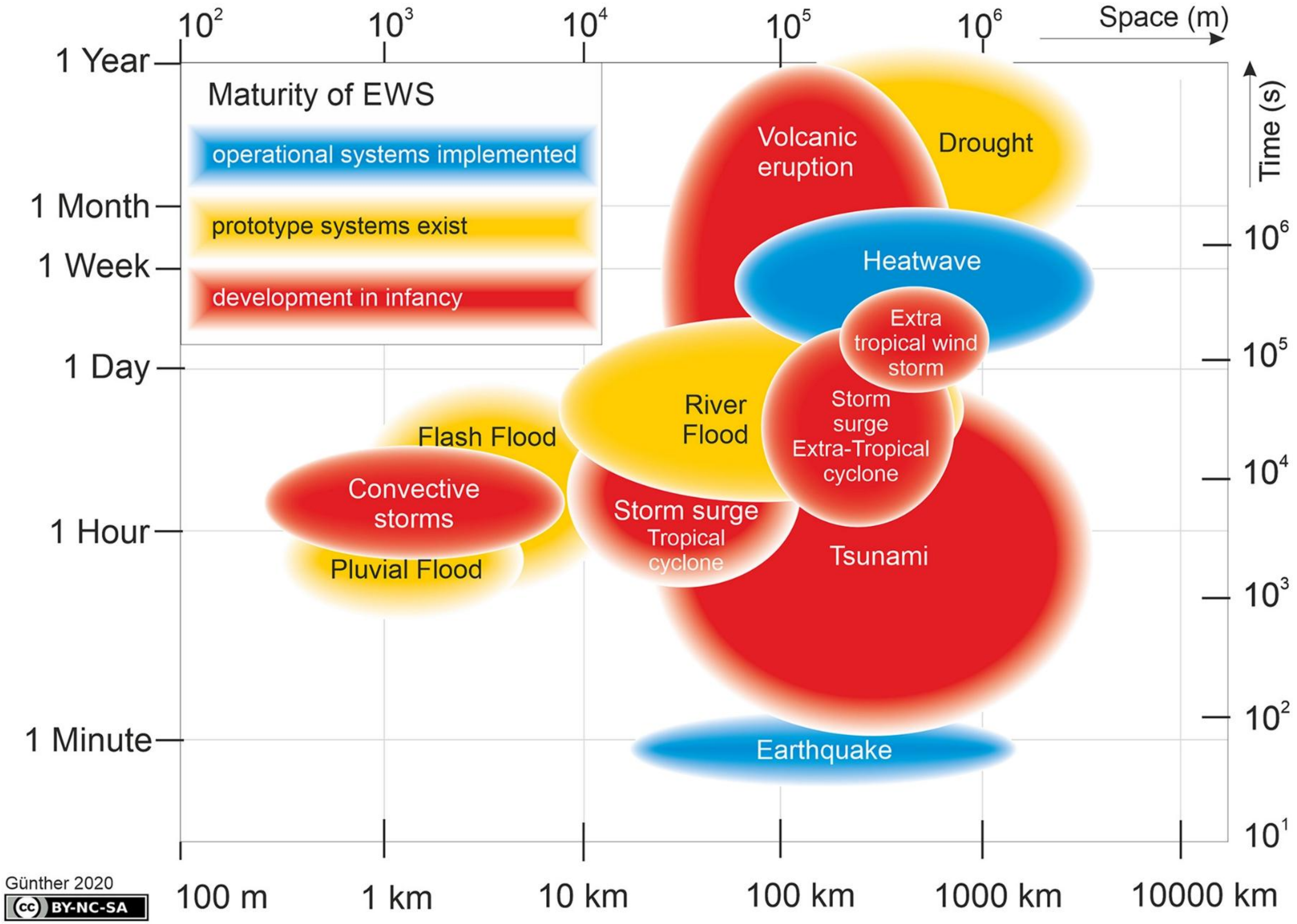
- Extreme high temperatures
- Heavy rainfall
- River flows
- Agricultural drought
- Fire weather
- Loss of ice mass from glaciers

For further indepth reading please see:
Global hotspots for the occurrence of compound events

https://www.nature.com/articles/s41467-020-19639-3

- https://www.metoffice.gov.uk/about-us/press-office/news/weather-and-climate/2022/changes-in-weather-extremes-and-climate-impacts-from-the-poles-to-the-tropics

Development of impact forecasting systems



- Opens new possibilities for coping with damaging events in the emergency phase
- Include exposure and vulnerability estimates
- Extending single-hazard to multihazard impact forecasts considering interactions between hazards and vulnerabilities is the next challenge

https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2020RG000704

GLOBAL CARBON project

GLOBAL CARBON BUDGET 2025

The GCP is a Global Research Project of futurearth Research. Innovation. Sustainability. and a Research Partner of WCRP World Climate Research Programme

Published on 13 November 2025
PowerPoint version 0.6

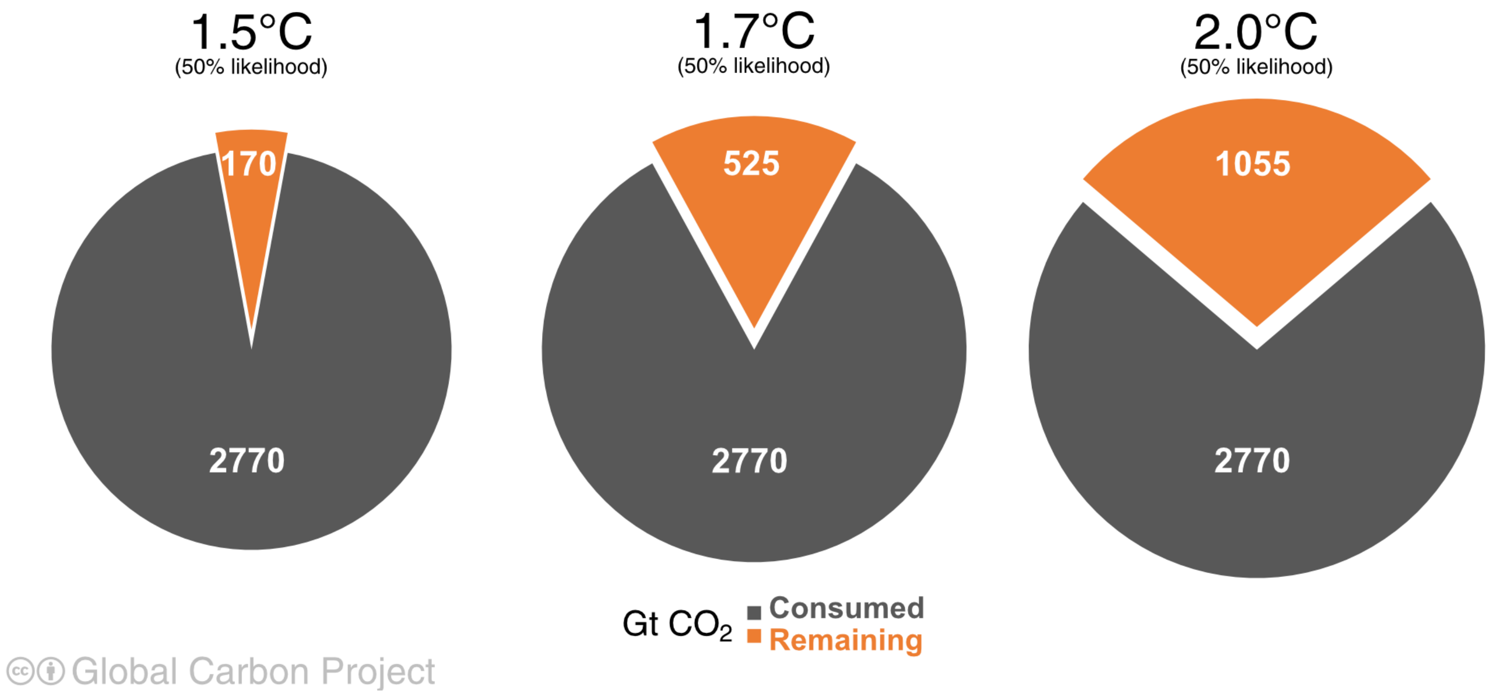
What is a carbon budget and how do we define it?

- It tells us how much more carbon we can emit until we reach a certain level of warming.
- It is the accounting the helps us get to net-zero, because the rate of emissions is directly linked to the amount of carbon in the atmosphere and corresponding warming.
- It enables us to account for mitigation measures that avoid or sequester carbon emissions.

- Which country/company may emit how much more carbon?
  - What is fair?
- And how do we define «carbon»?

Remaining carbon budget

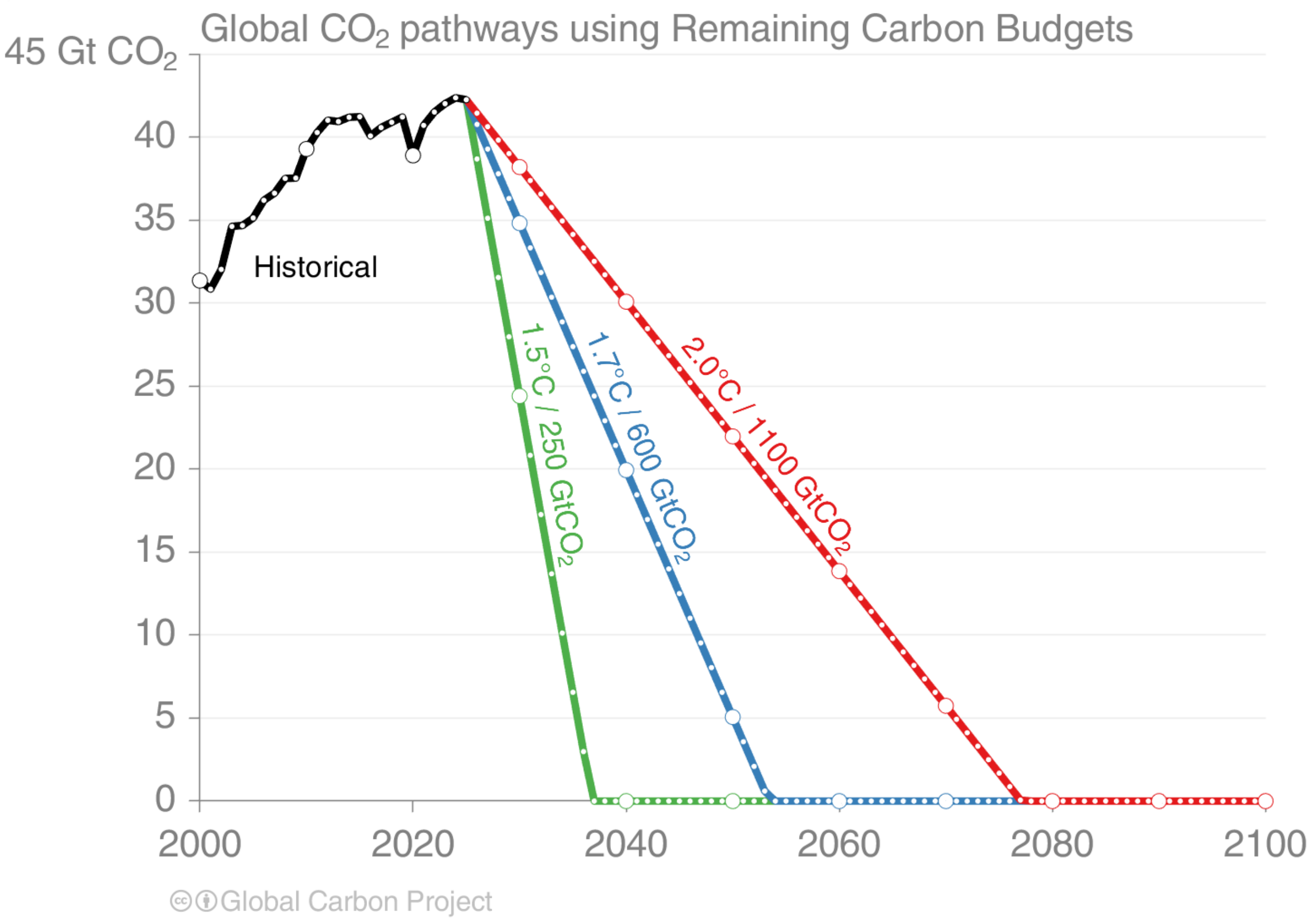
The remaining carbon budget to limit global warming to 1.5°C , 1.7°C and 2°C is
170 GtCO_2, 525 GtCO_2, and 1055 GtCO_2 respectively, equivalent to 4, 12 and 25 years from 2026.
A total of 2770 GtCO_2 has been emitted since 1850.



The remaining carbon budgets are the average of two estimates (IPCC AR6 and Forster et al., 2025), both updated by removing the most recent emissions.
Quantities are subject to additional uncertainties e.g., future mitigation choices of non-CO_2 emissions
Source: IPCC AR6 WG1; Forster et al., 2023; Friedlingstein et al 2025; Global Carbon Project 2025

Remaining carbon budget

Global CO_2 emissions must reach zero to limit global warming.
All-else-equal, the later the net zero year, the higher the warming level.



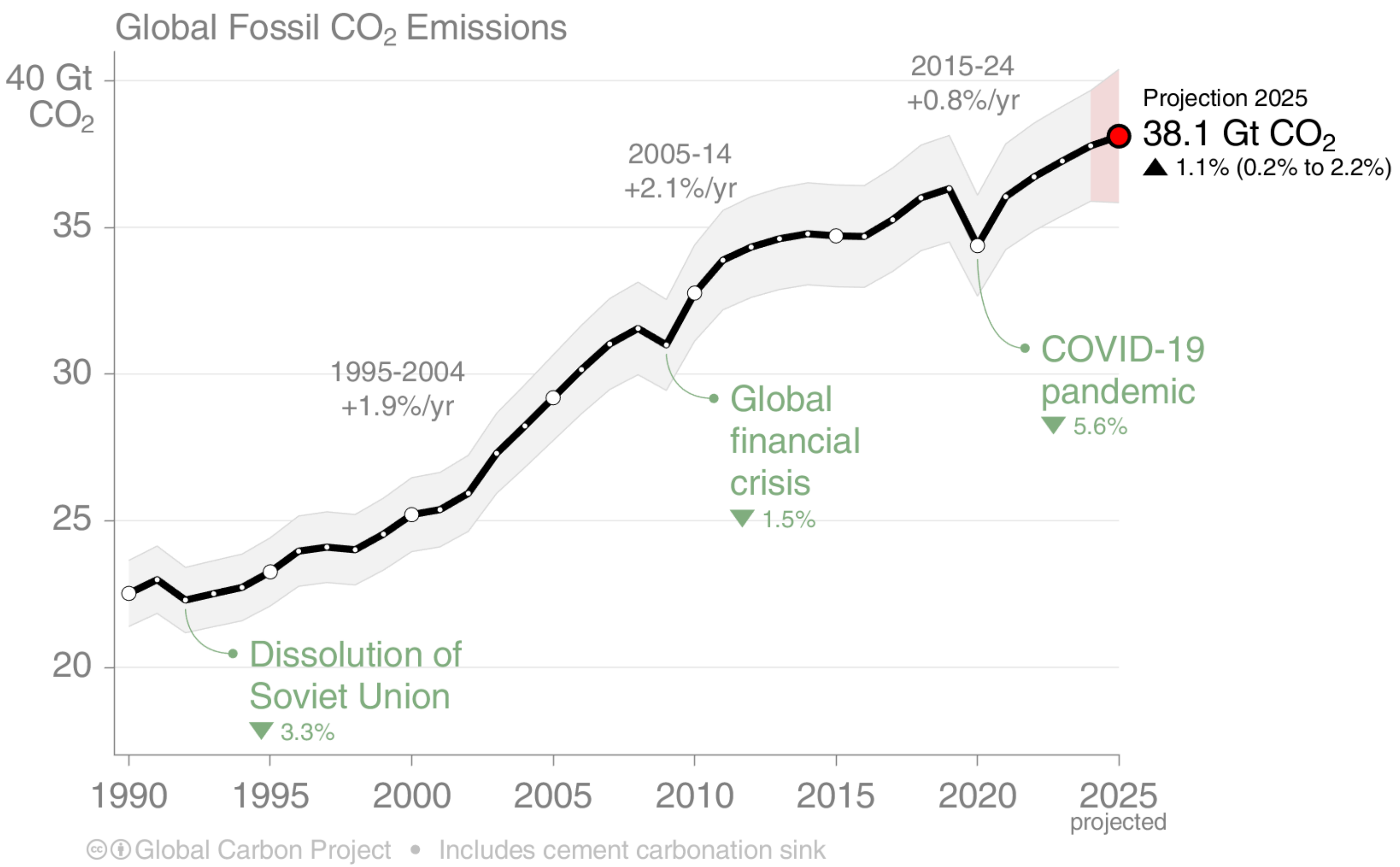
Source: Friedlingstein et al 2025; Global Carbon Project 2025

Global Fossil CO_2 Emissions

Global fossil CO_2 emissions: 37.8 ± 2 $GtCO_2$ in 2024, 69% over 1990

● Projection for 2025: 38.1 ± 2 $GtCO_2$, 1.1% [0.2% to +2.2%] higher than 2024

Covid was a tiny dent.



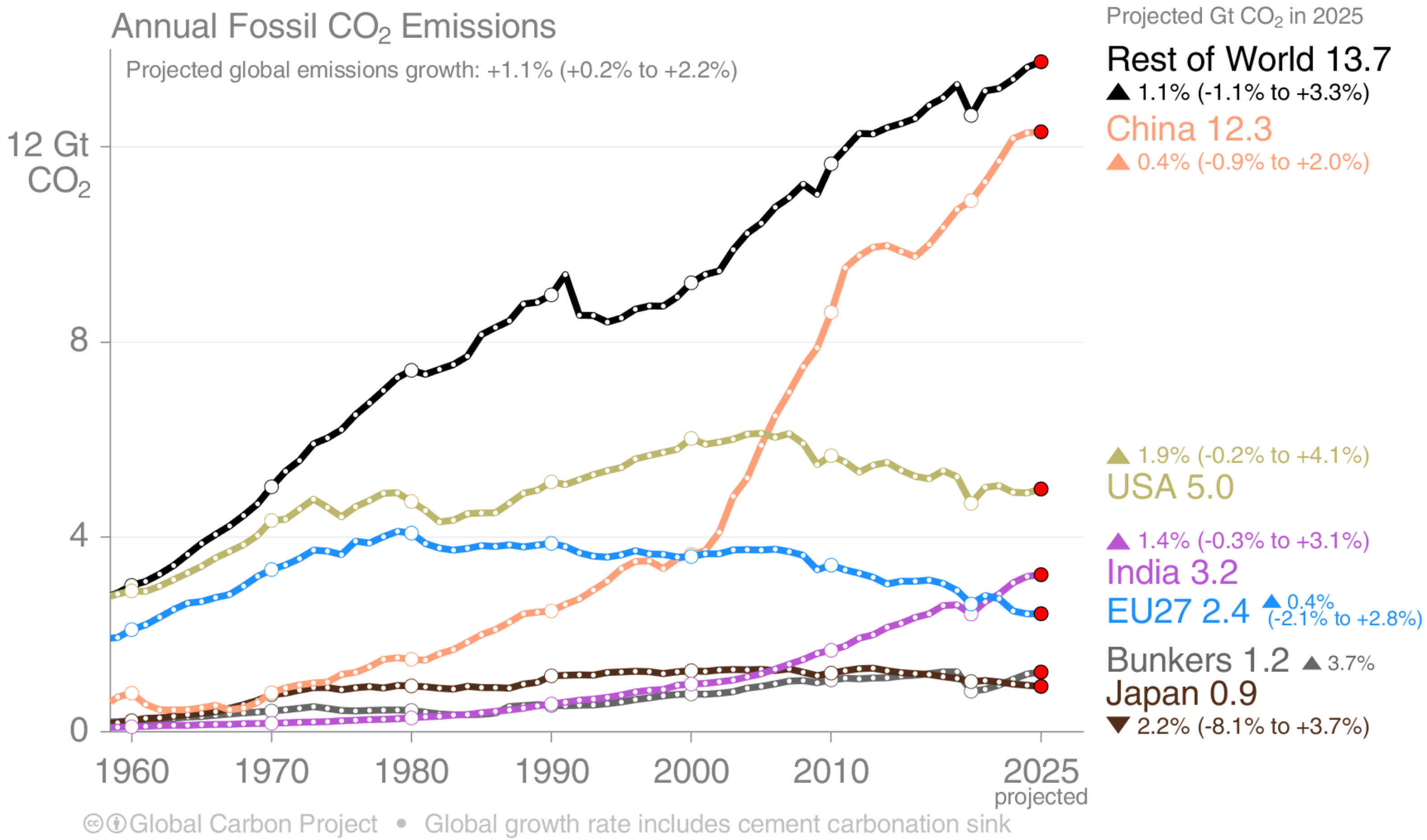
Uncertainty is ±5% for one standard deviation (IPCC "likely" range)

The 2025 projection is based on preliminary data and modelling. The global total includes a cement carbonation sink of 0.8 $GtCO_2$.

Source: Friedlingstein et al 2025; Global Carbon Project 2025

Emissions Projections for 2025

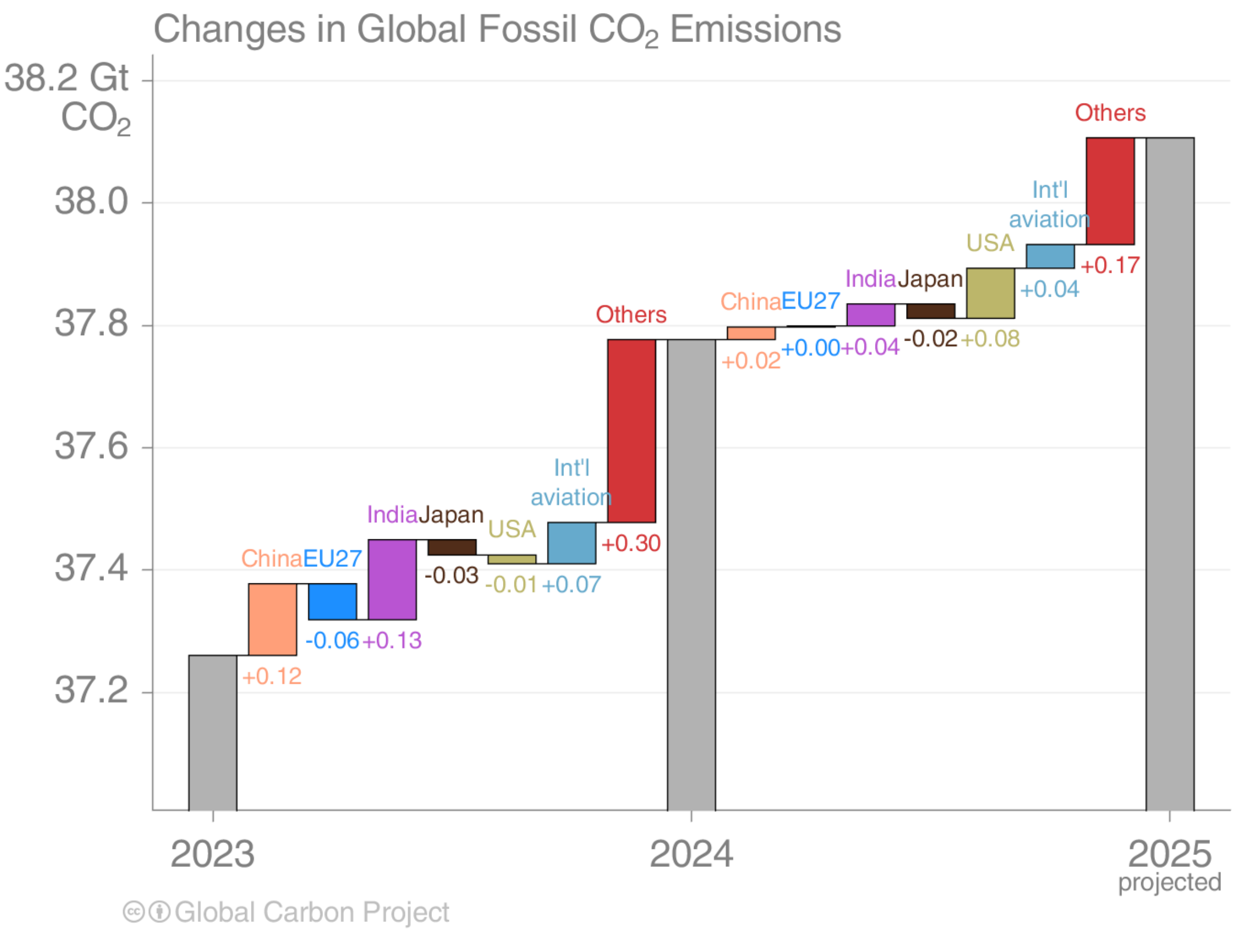
Fossil CO_2 emissions growth is from different regions in 2025 compared to 2024:
The USA rising, and EU27 flat, reversing recent declines. China flat, India low growth, contrasting recent strong growth.



The 2025 projections are based on preliminary data and modelling.
'Bunkers' are fossil fuels used for international shipping and aviation
Source: Friedlingstein et al 2025; Global Carbon Project 2025

Fossil CO_2 emissions growth: 2023–2025

Emissions are projected to increase in USA and India, be flat to slight rise in China and the EU, decline in Japan, with growth in international aviation and the combined rest of the world (Others) in 2025

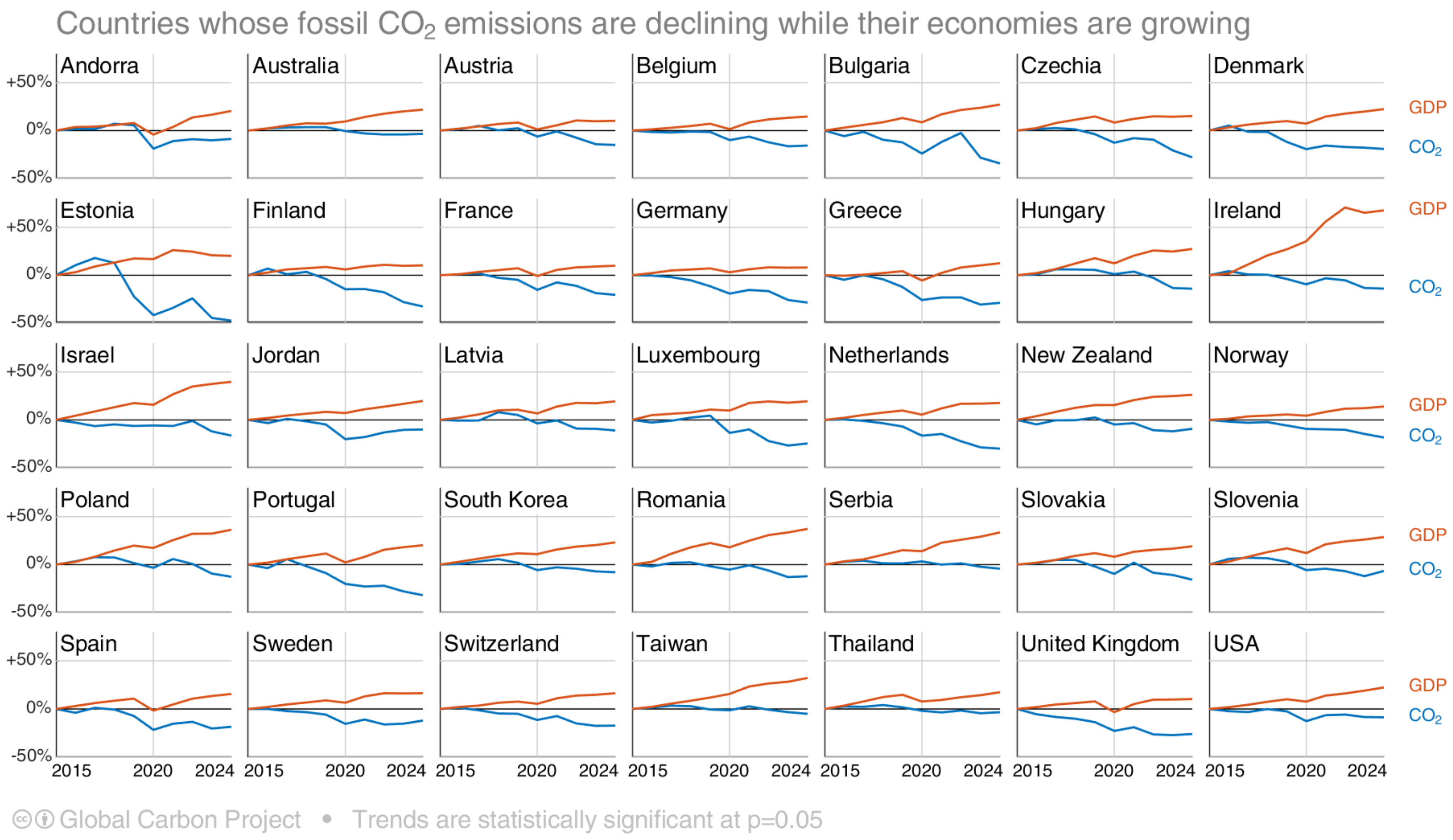


The 2025 projections are based on preliminary data and modelling.

Source: Friedlingstein et al 2025; Global Carbon Project 2025

Decarbonisation progress

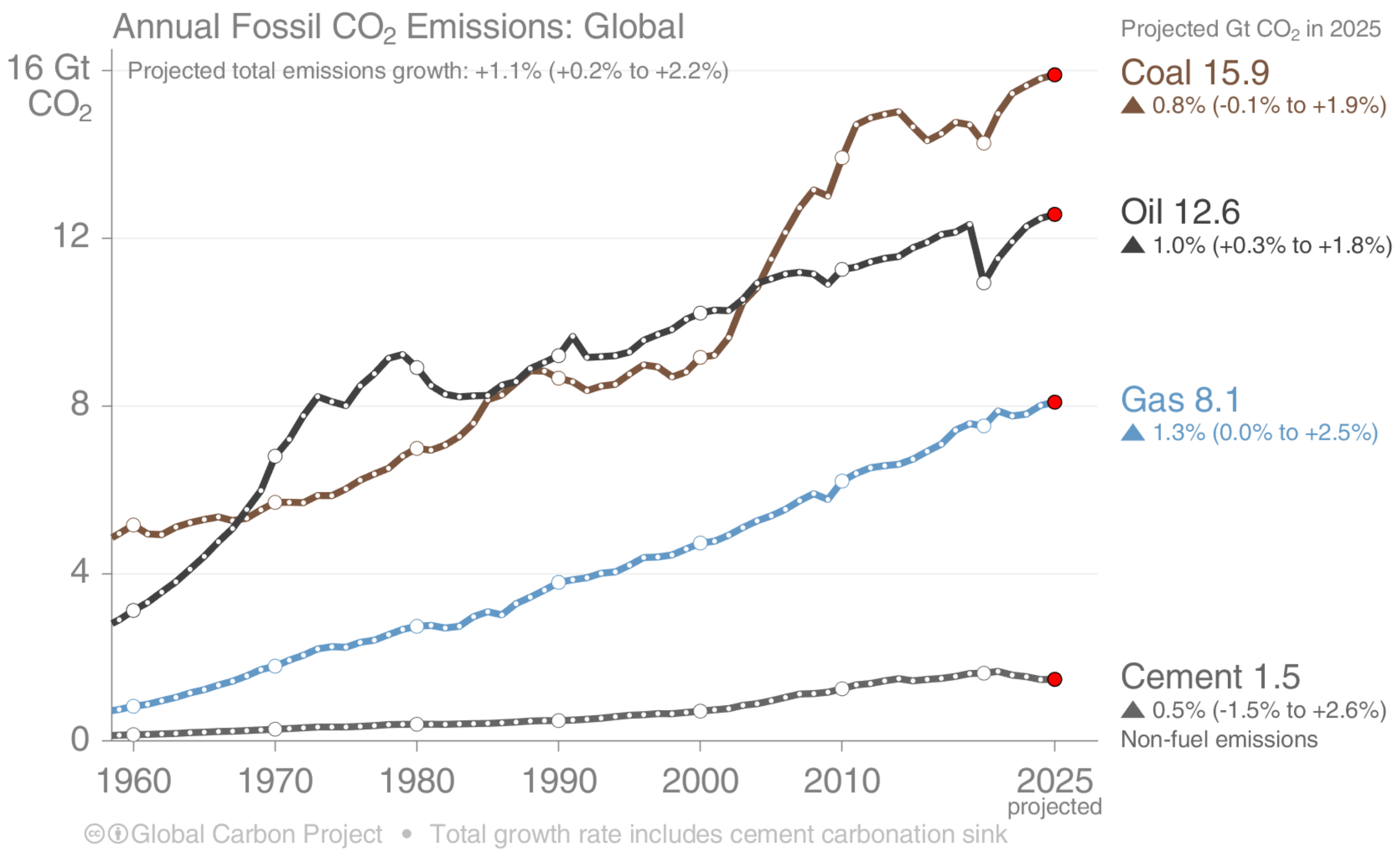
Fossil CO_2 emissions are declining in 35 countries while economic output is rising (2015–2024)



Source: Friedlingstein et al 2025; Global Carbon Project 2025

Fossil CO_2 emissions by source

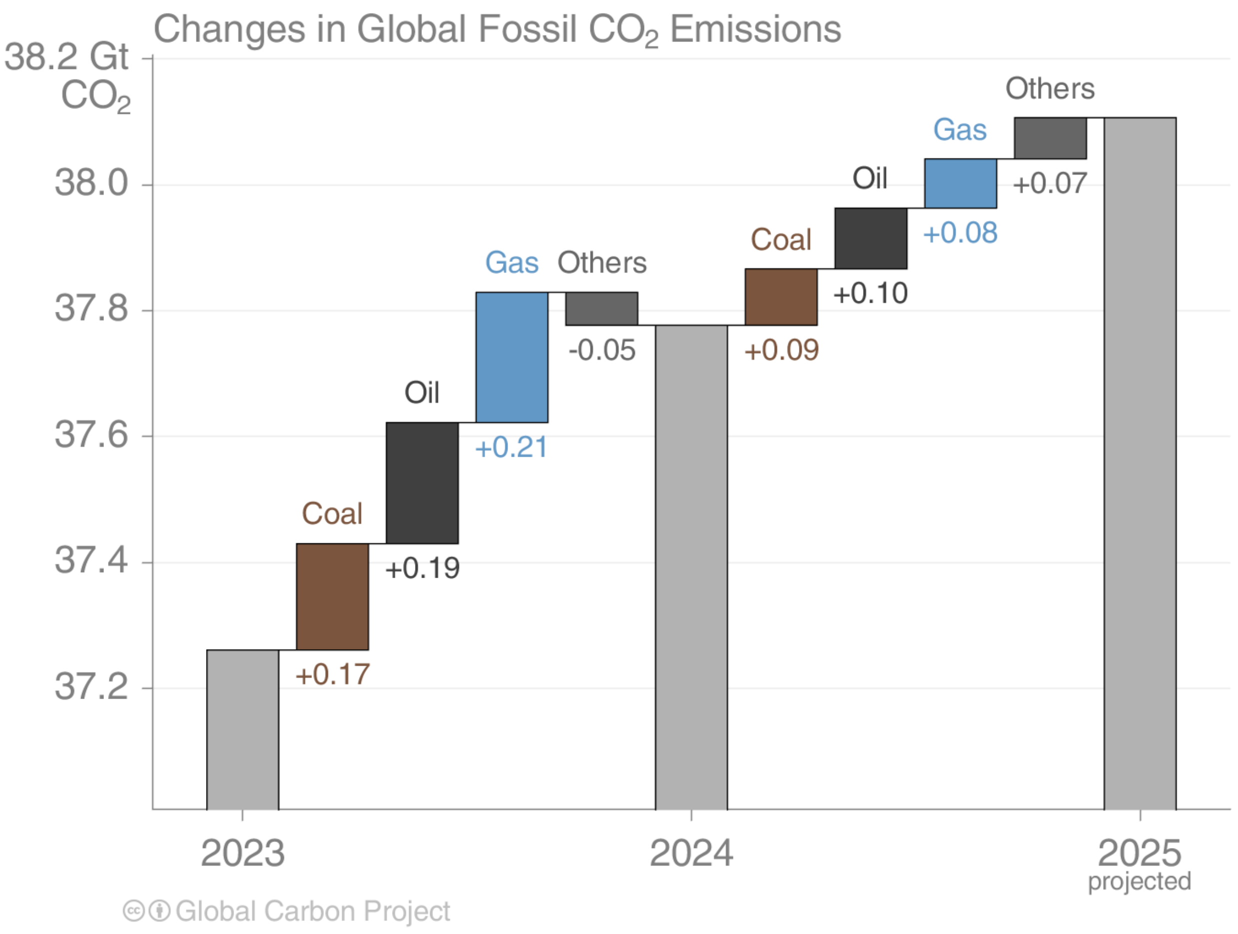
Share of global fossil CO_2 emissions in 2025: coal (41%), oil (32%), gas (21%), cement (4%), flaring and others (2%, not shown)



The 2025 projection is based on preliminary data and modelling.
Source: Friedlingstein et al 2025; Global Carbon Project 2025

Fossil CO_2 emissions growth: 2023–2025

Global emissions grow in all categories in 2025, but more slowly than in 2024 apart from the “Others” category, which includes cement, lime, and flaring.



Source: Friedlingstein et al 2025; Global Carbon Project 2025

What's going at COP regarding fossil fuels?

UNFCCC Executive Secretary Simon Stiell

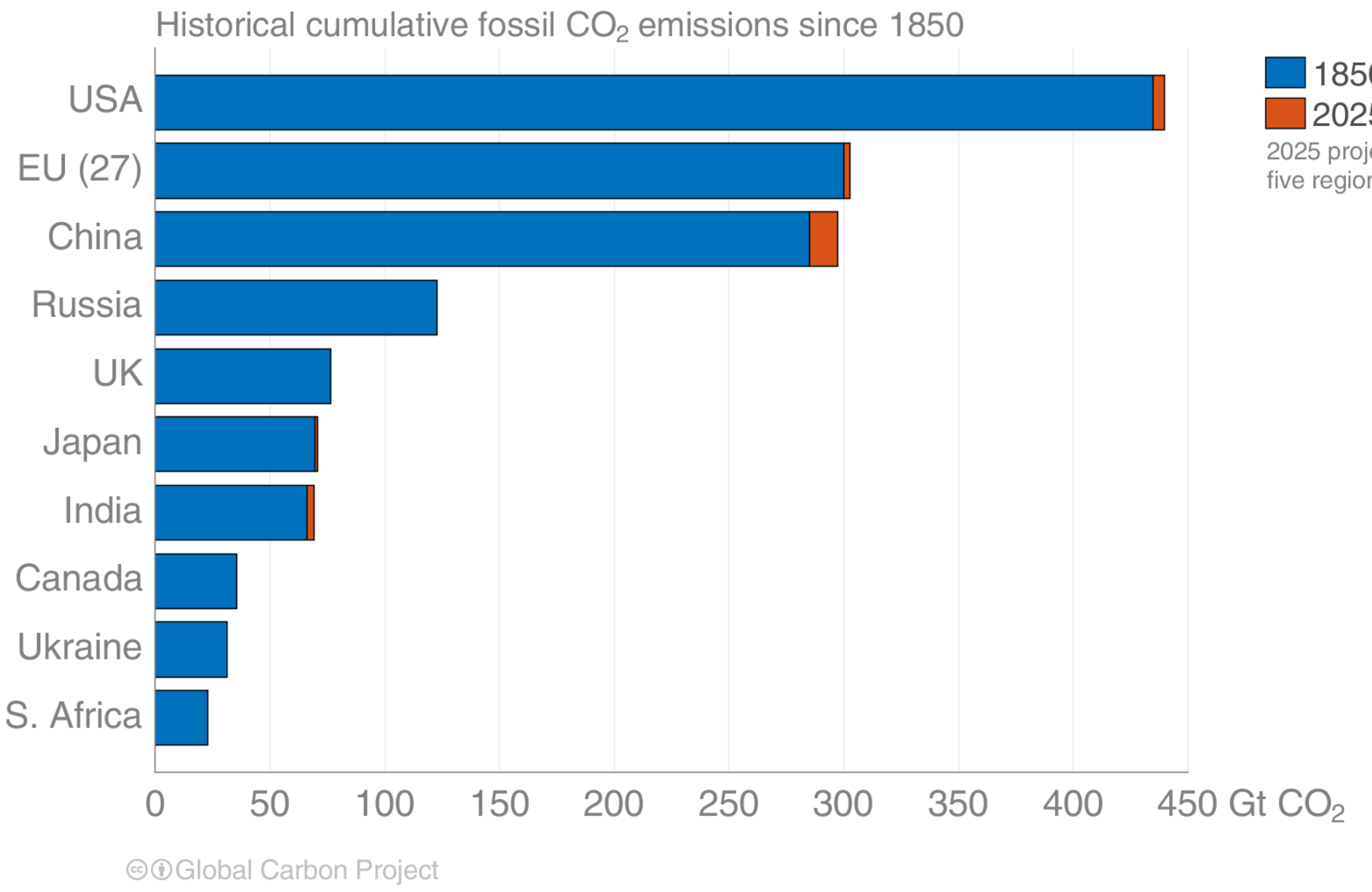
17 Nov 2025

- “The good news – last year alone, more than 2.2 trillion dollars flowed into renewable energy – that’s more than the GDP of over 180 countries.
- This real-world progress is not a nice-to-have. It is mission-critical. In this new era, much will depend on bringing our process closer to the real economy, to speed up implementation, and spread its vast benefits to billions more people, as I've been saying.
- But friends – the pace of change in the real economy has not been matched by the pace of progress in these negotiating rooms. The spirit is there, but the speed is not.
- As climate disasters wreck millions of lives and hammer every economy, pushing up prices for food and other basic needs. We all know what's at stake.
- I said we needed an acceleration in the Amazon, and that applies equally to how we all go about our collective work here. “

- https://unfccc.int/news/cop30-needs-to-show-climate-cooperation-standing-firm-in-a-fractured-world-simon-stiell-at-start-of

Historical cumulative fossil CO_2 emissions

The USA and EU have the highest accumulated fossil CO_2 emissions since 1850, but China is a close third.



Who needs to act?

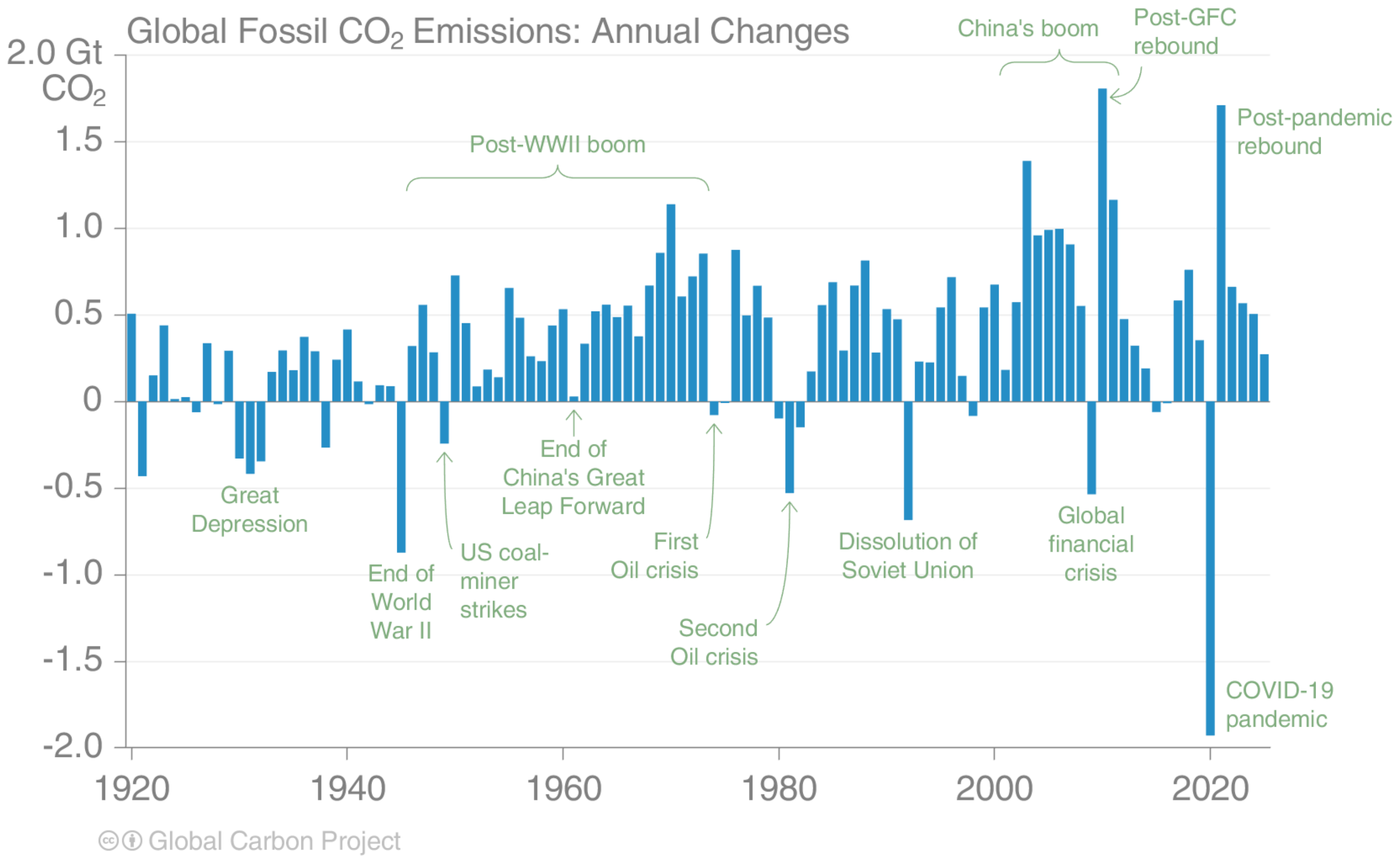
Calculated using territorial emissions.

Source: Friedlingstein et al 2025; Global Carbon Project 2025

Global fossil CO_2 emissions

For the last 100 years, it has generally taken a crisis to drive global emissions reductions.
To stabilise temperatures, intentional, planned, sustained global reductions must begin.

Humanity always needed a crisis to reduce emissions.

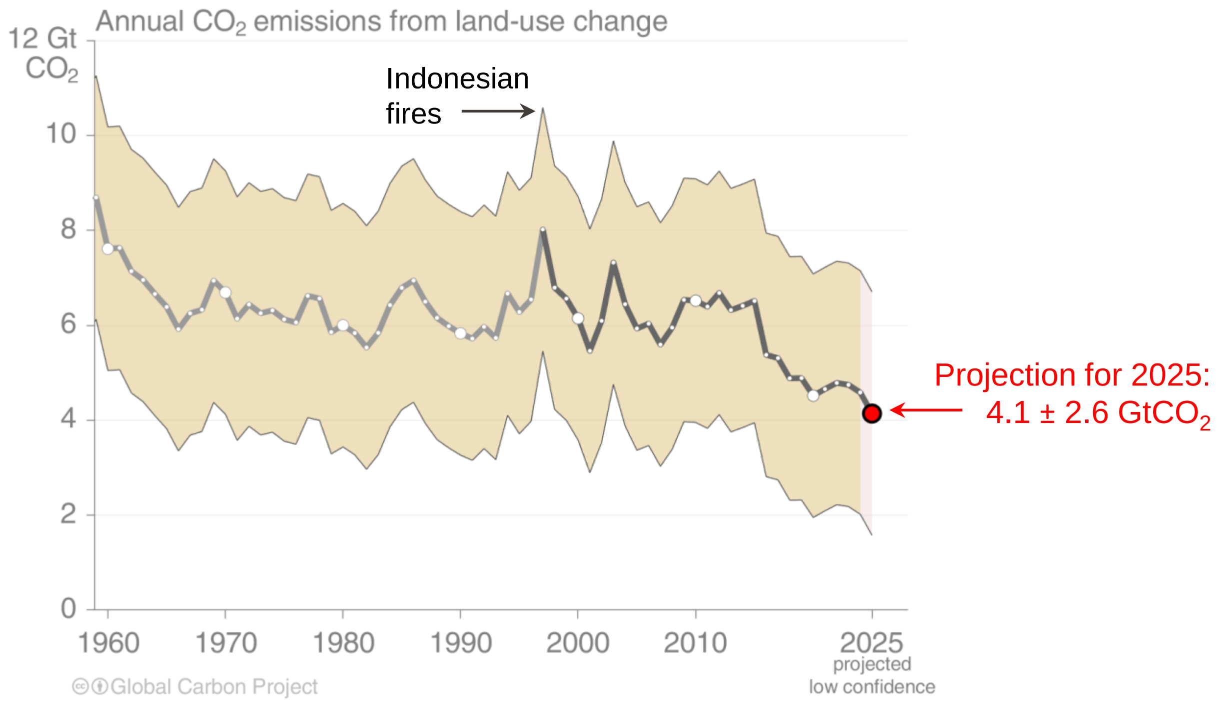


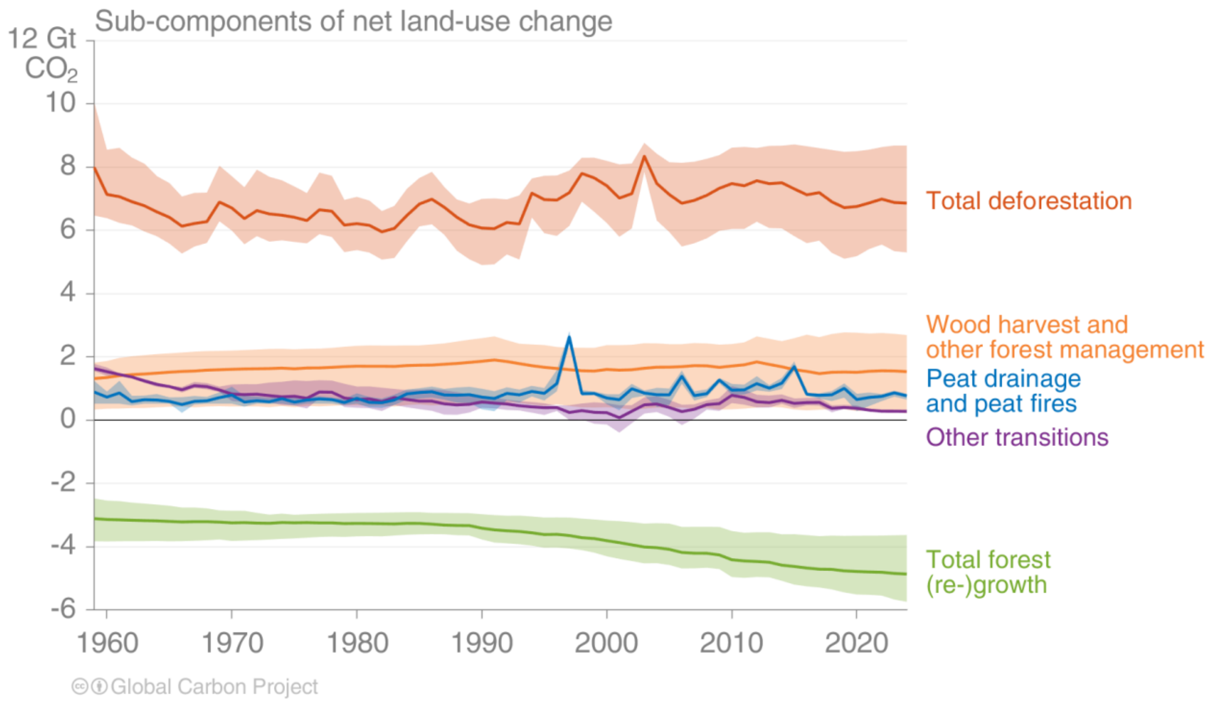
The 2025 projection is based on preliminary data and modelling.
Source: Friedlingstein et al 2025; Global Carbon Project 2025

Land-use change emissions

Land-use change emissions were 5.0 ± 2.6 $GtCO_2$ per year for 2015–2024 and show a negative trend in the last two decades, but estimates are still highly uncertain.

Net land-use emissions are the result of multiple anthropogenic activities on land that lead to CO_2 emissions or removals



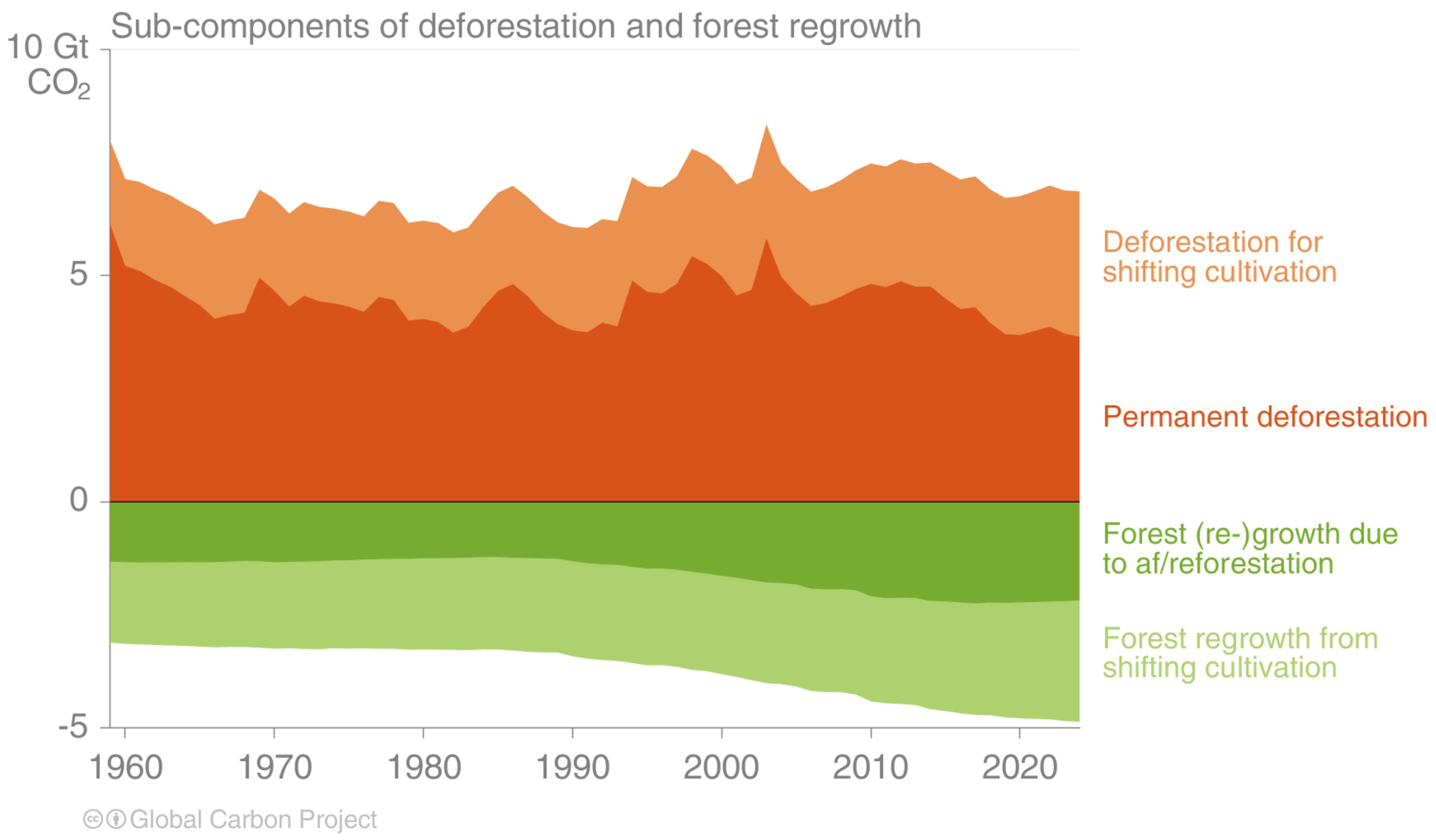


Estimates from three bookkeeping models

Source: Friedlingstein et al 2025; Global Carbon Project 2025

Land-use change emissions

Annual emissions from permanent deforestation declined over 2015–2024 but remain high at around 3.9 $GtCO_2$.
Carbon dioxide removals through permanent af/reforestation are 2.2 $GtCO_2$ per year over the same period.

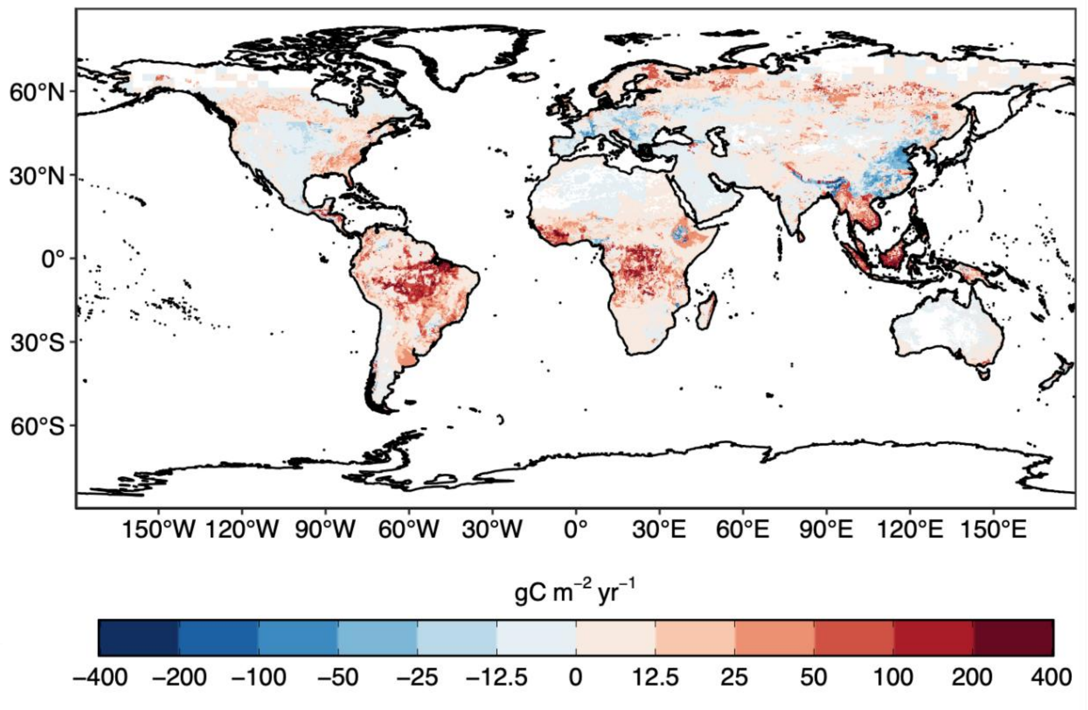


Estimates from three bookkeeping models
Source: Friedlingstein et al 2025; Global Carbon Project 2025

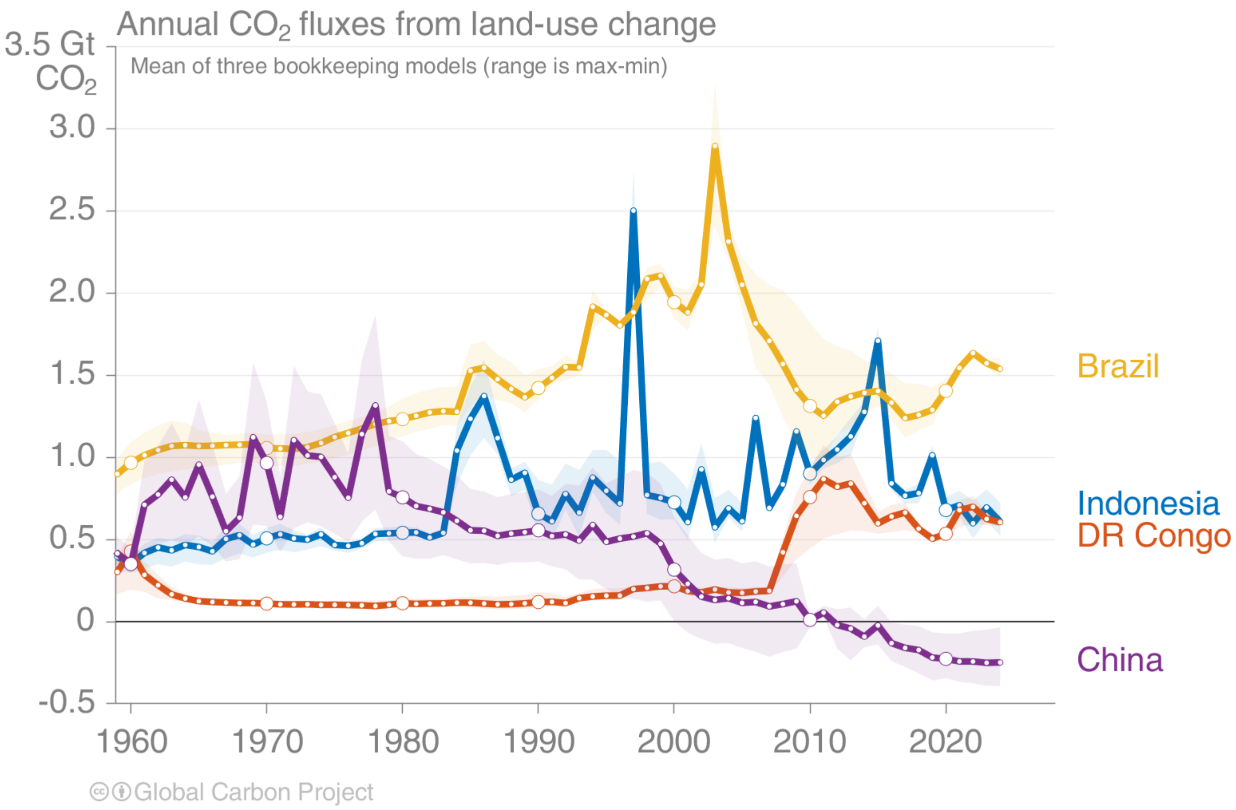
Regional patterns of land-use change emissions

Land-use emissions are high in the tropics, driven largely by deforestation. Net sinks occur in regions of re/afforestation such as parts of Europe and China.

Land-use emissions, decadal average 2015–2024



The top three emitters over 2015–2024 – Brazil, Indonesia, and the Democratic Republic of the Congo – contribute more than half of the global net land-use emissions, while China is now the largest remover.



The peak in Indonesia in 1997 was the Indonesian peat fires.

Estimates from three bookkeeping models
Source: Friedlingstein et al 2025; Global Carbon Project 2025

Carbon Dioxide Removal

Equivalent to ~5% of annual Fossil CO_2 emissions

Equivalent to ~1 millionth of annual Fossil CO_2 emissions

2.2 $GtCO_2$ per year

0.001 $MtCO_2$ per year

0.007 $MtCO_2$ per year

Vegetation-based CDR estimates from GCB2025

CDR not based on vegetation from the State of CDR report (2024)

GLOBAL CARBON project

Fate of anthropogenic CO_2 emissions (2015–2024)

Sources = Sinks

35.9 $GtCO_2$/yr
88%

12%
5.0 $GtCO_2$/yr

20.4 $GtCO_2$/yr
50%

21%
8.7 $GtCO_2$/yr

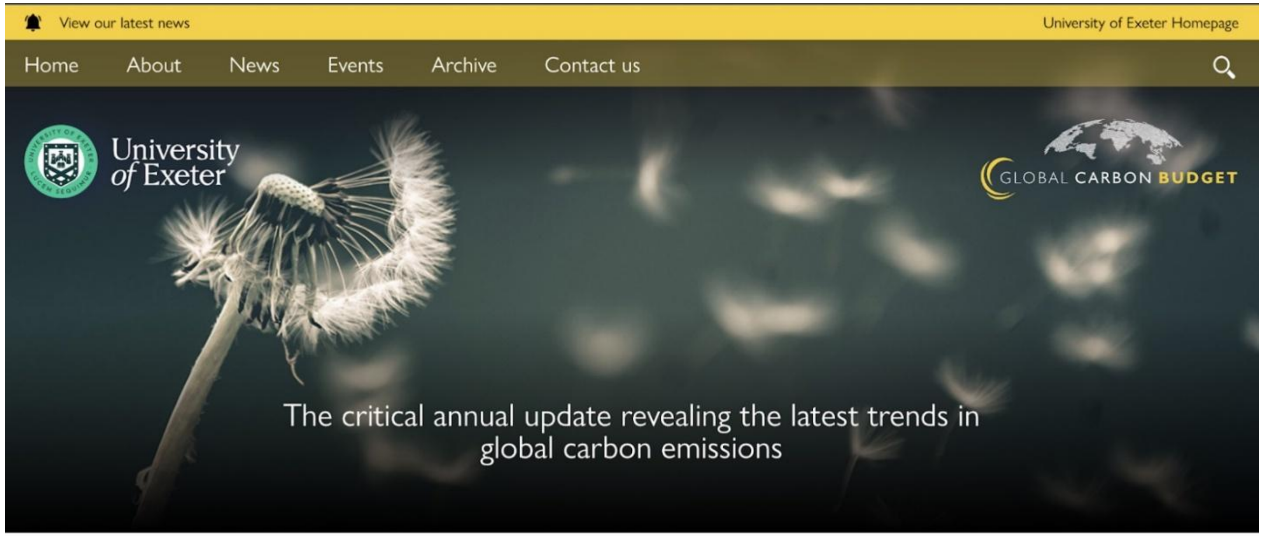
29%
11.8 $GtCO_2$/yr

Budget Imbalance:
(the difference between estimated sources & sinks)

<1%
0.1 $GtCO_2$/yr

Source: Friedlingstein et al 2025; Global Carbon Project 2025

Data Access and Additional Resources



More information, data sources and data files:
https://globalcarbonbudget.org/carbonbudget

More information, data sources and data files:
www.globalcarbonatlas.org
(co-funded in part by BNP Paribas Foundation)

Climate Litigation

German court dismisses Peruvian farmer's climate lawsuit against RWE

Court rejects argument that man's home is at risk from glacial flood but sets precedent that polluters may be held liable for costs

Saúl Luciano Lliuya in Huaraz, Peru. Photograph: Angela Ponce/Reuters

- The upper regional court in Hamm confirmed that companies could be held liable for climate damages in civil proceedings but rejected the argument by the farmer and mountain guide Saúl Luciano Lliuya that his home was at direct risk of being washed away by a glacial flood.
- However, the judge in the case ruled that companies "may be obligated to take preventive measures" to counter their emissions, according to a statement from the higher regional court in Hamm.
- "If the polluter definitively refuses to do so, it could be determined, even before actual costs are incurred, that the polluter must bear the costs in proportion to their share of the emissions," the court concluded.
- The ruling was nonetheless a milestone for climate litigation, Lliuya's lawyer Roda Verheyen said in a statement. "For the first time in history, a higher court in Europe has ruled that large emitters can be held responsible for the consequences of their greenhouse gas emissions," she said.
- The outcome of the case would "give a tailwind to climate lawsuits against fossil fuel companies, and thus to the move away from fossil fuels worldwide", she added.
- "This decision clarifies how climate science can inform judicial decision-making on corporate climate liability. It strengthens the foundation for future claims where the evidence is even more robust."

https://www.theguardian.com/world/2025/may/28/rwe-peruvian-farmer-court-germany

9 April 2024


KlimaSeniorinnen Schweiz
Aînées pour la protection du climat Suisse
CLIMATE JUSTICE
© Miriam Künzli / Ex-Press / Greenpeace

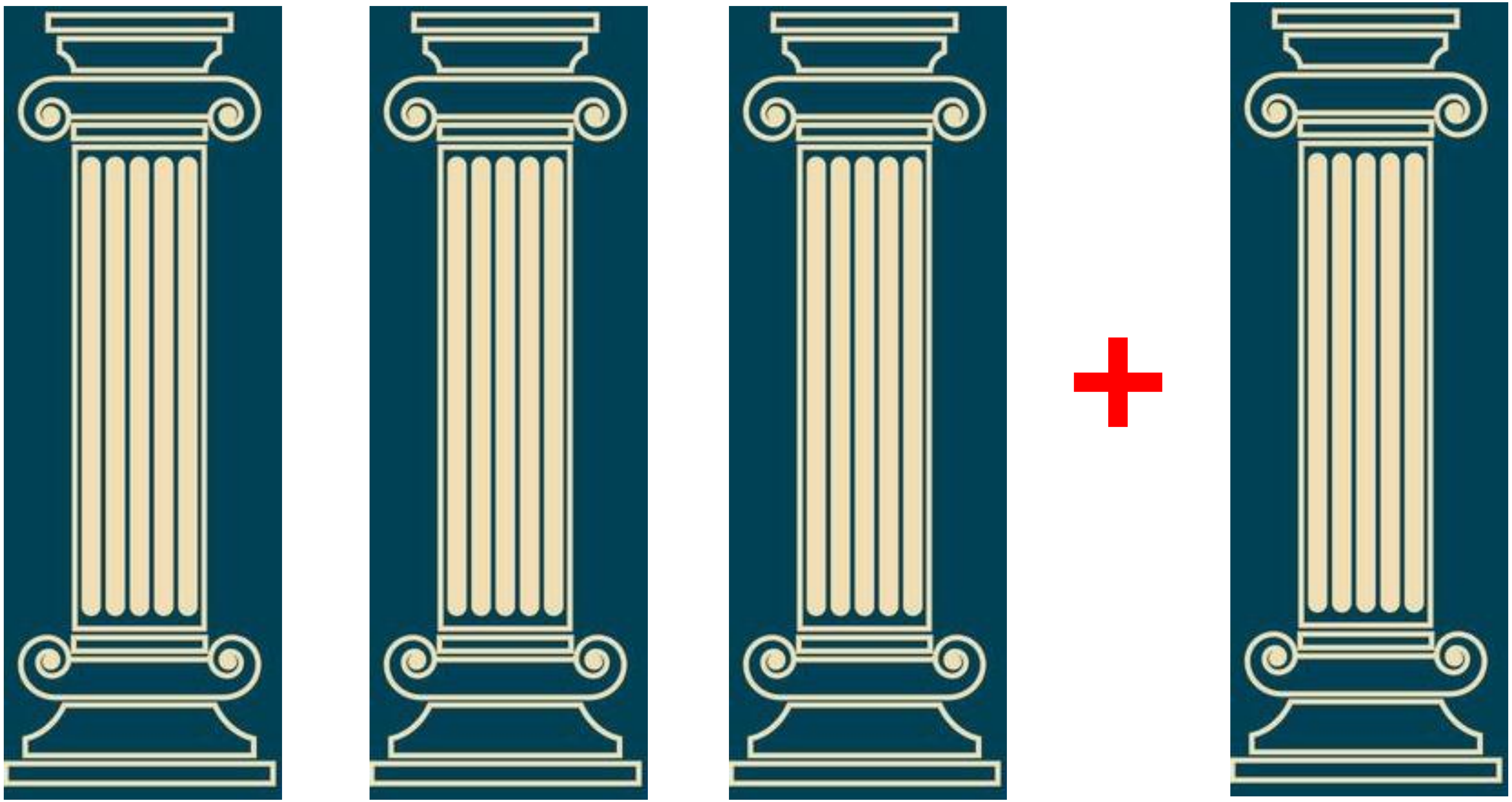
EPFL

Swiss climate verdict: carbon budgets mattered to the judges

- On April 9, 2024, Europe's top human rights court ruled in favour of a group of elderly Swiss women, the KlimaSeniorinnen, who said the government's inadequate efforts to combat climate change put them at risk of dying during heatwaves.
- The European Court of Human Rights (ECHR) recently ruled that Switzerland had failed to meet its own climate targets and to set a national **carbon budget**.
- Ruling: Switzerland "**failed to quantify, through a carbon budget or otherwise, national greenhouse gas emissions limitations**"
- **Implication of a carbon budget**: There is a hard limit and emissions need to stay within it.

https://www.swissinfo.ch/eng/science/swiss-climate-verdict-strasbourg-echr-why-carbon-budgets-mattered-to-the-judges/76347450

New Era of Accounting in Europe



revenue cost capital sustainability

Corporate Sustainability Reporting Directive (CSRD)

- In Europe, 11,700 companies, banks, and insurers will have to report their greenhouse gas emissions for the first time in 2025 because of the European Union's Corporate Sustainability Reporting Directive (CSRD). (formerly covered by the Non-Financial Reporting Directive (NFRD), imposed broader, less stringent rules on environmental, social, and governance disclosure.)
- Their 2025 reports will have to detail emissions from their 2024 fiscal years.

Exhibit 1: The early years of CSRD compliance

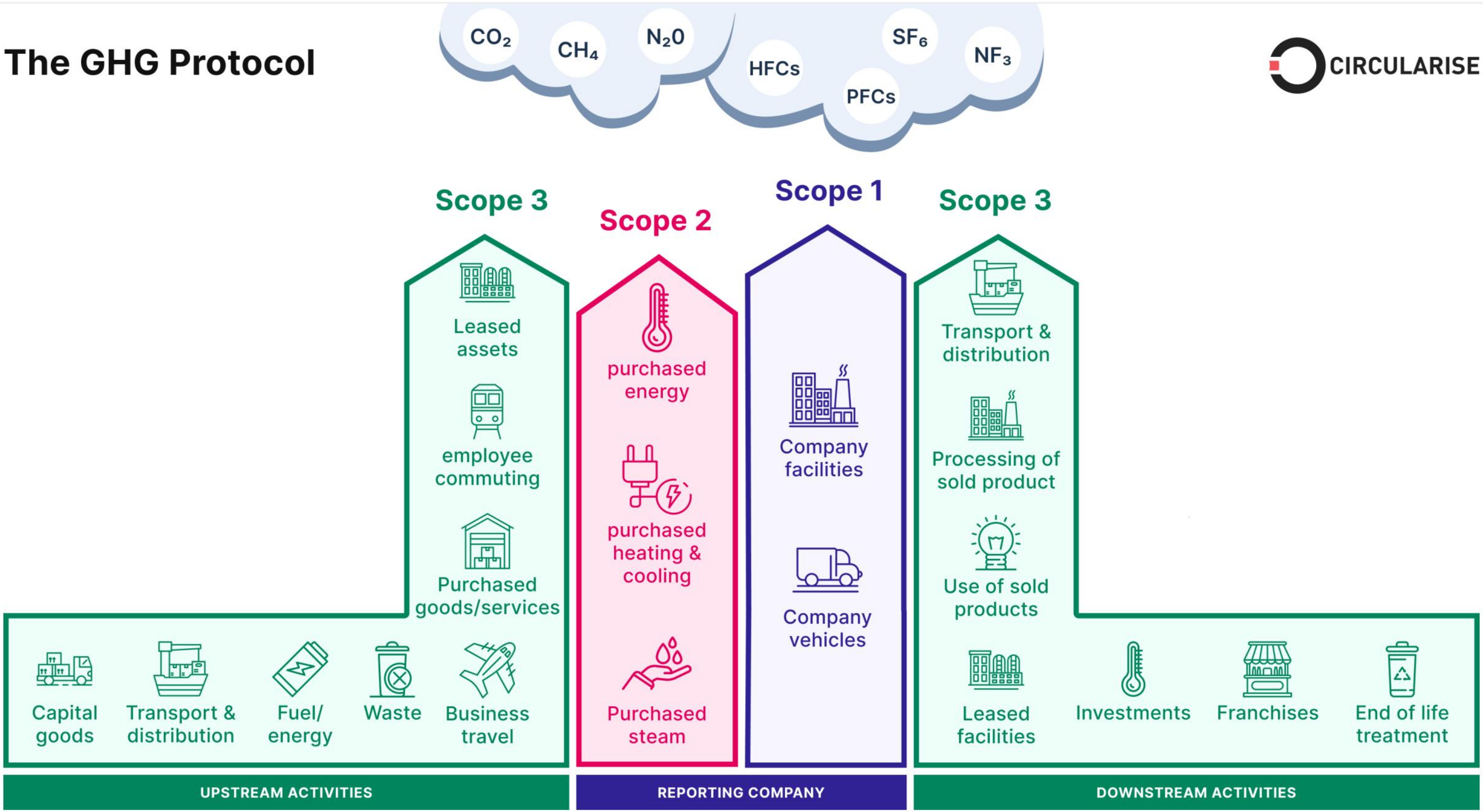
Corporate Sustainability Reporting Directive (CSRD)

- Ultimately, nearly 50,000 companies in Europe will be reporting as well as more than 10,000 non-EU companies and their European subsidiaries.
- In 2028, the CSRD takes effect for non-EU parent companies with €150 million annual revenues in the EU and at least one subsidiary or branch in the EU that conducts significant business. They must file their first report using 2028 emissions data at a consolidated group level (including non-EU activity) in 2029.

Scope 1, 2, 3 emissions

- Scope 1 encompasses direct emissions originating from sources owned or controlled by the reporting company.
- Scope 2 pertains to indirect emissions derived from the generation of purchased electricity, steam, heating, and cooling employed by the reporting company.
- Scope 3 covers indirect emissions resulting from activities involving assets beyond the reporting organization's control, but within its value chain.

The GHG Protocol



Carbon Accounting

- Carbon accounting is also set to become a major factor in defining business risk as many companies begin to calculate carbon footprints using the Greenhouse Gas Protocol's Scope 1, 2, and 3 definitions for the first time.
- CSRD disclosure is also based not just on a company's carbon dioxide (CO_2) emissions but rather on its **total greenhouse gas emissions — using CO_2 equivalents**.