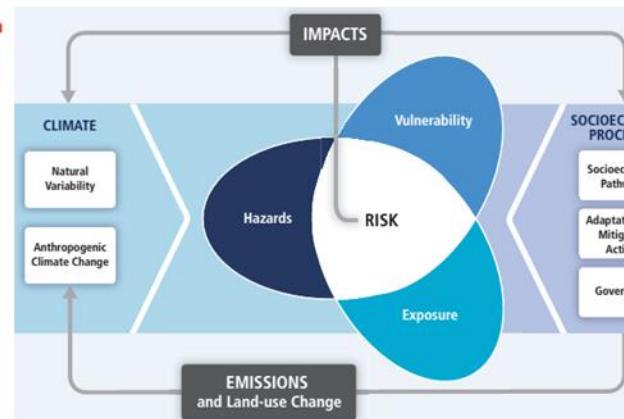
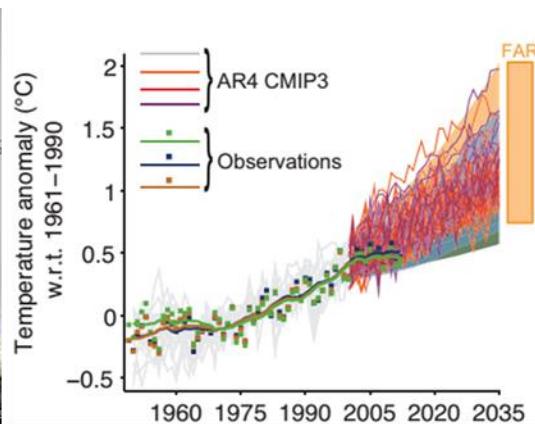




Energy Systems & Climate Change



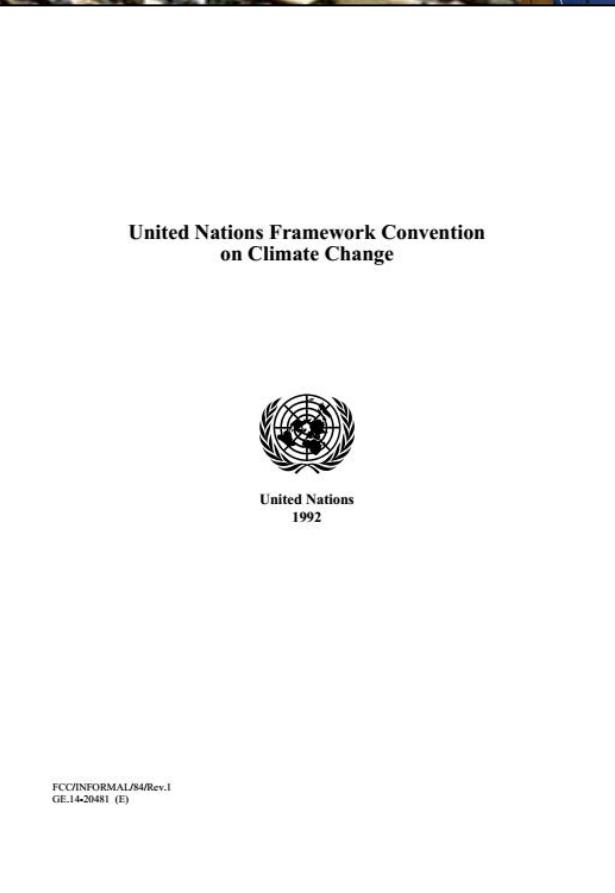
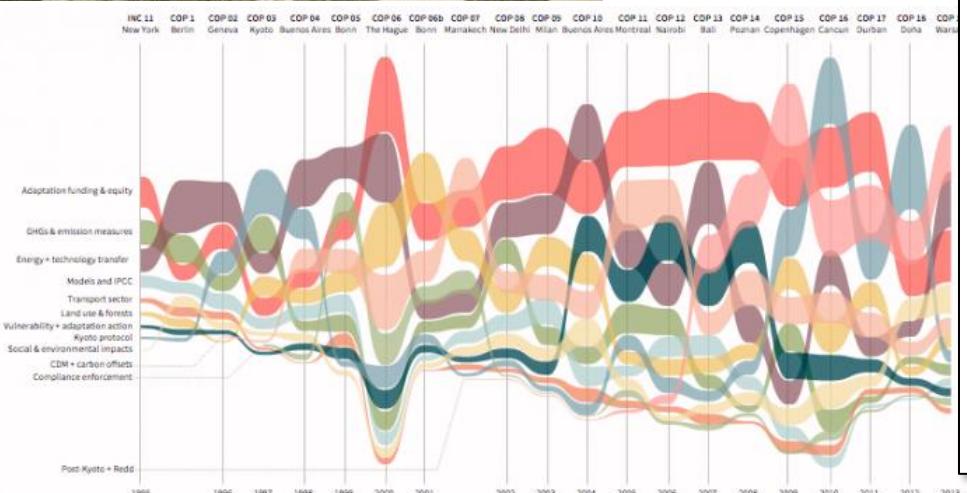
4c: The Global Response

In this section:

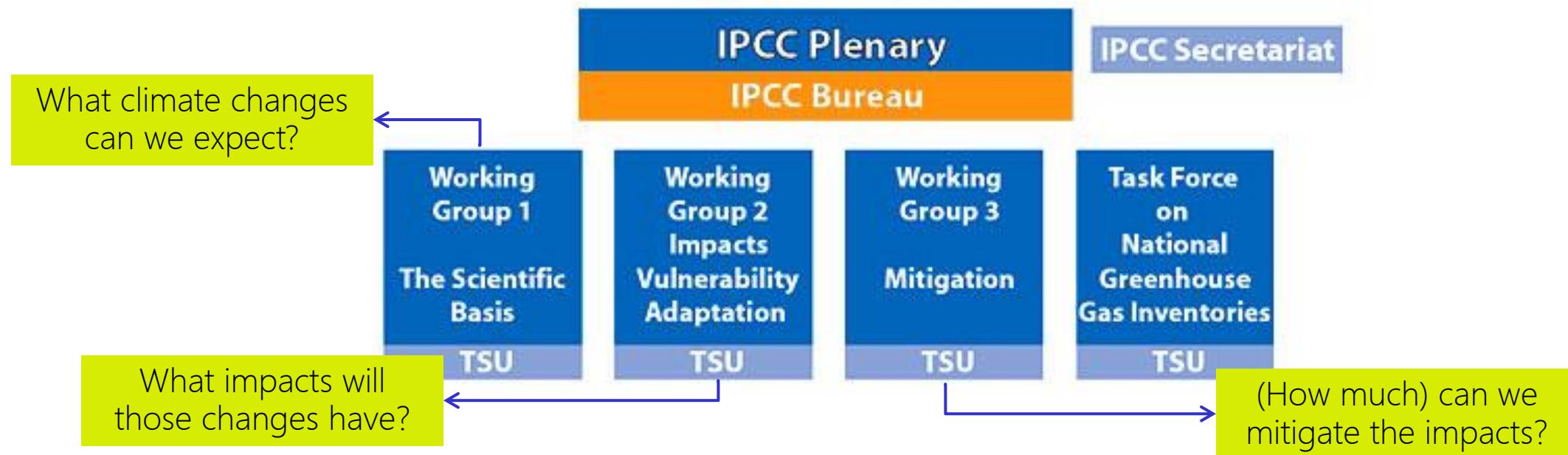
- The IPCC and UNFCCC
- Negotiating a global treaty
- Implementing the Paris Agreement
- Establishing priorities
- Assessing risks
- Assessing impacts



Climate negotiations



Intergovernmental Panel on Climate Change (established 1998)



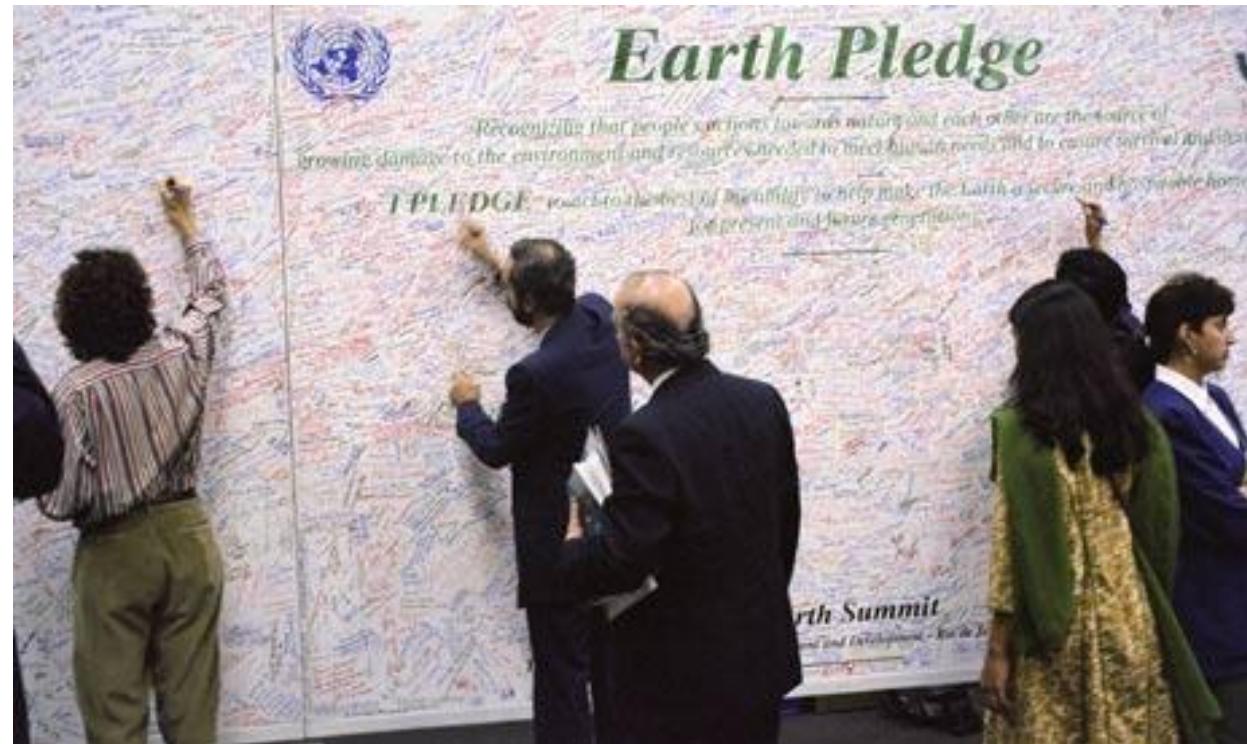
- Governments require information on climate change for negotiations
- Function of IPCC is to provide assessments of the science of climate change
- Scientific community contributes widely and on a voluntary basis

1988: UNEP and WMO establish IPCC

1992: Rio Earth Summit



1994: UNFCCC enters into force



UNFCCC – key text



United Nations
1992

FCCC/INFORMAL/84/Rev.1
GE.14-20481 (E)

The Parties to this Convention

Acknowledging that change in the Earth's climate and its adverse effects are a common concern of humankind,

Concerned that human activities have been substantially increasing the atmospheric concentrations of greenhouse gases, that these increases enhance the natural greenhouse effect, and that this will result on average in an additional warming of the Earth's surface and atmosphere and may adversely affect natural ecosystems and humankind,

Noting that...the share of global emissions originating in developing countries will grow to meet their social and development needs,

Noting that there are many uncertainties in predictions of climate change, particularly with regard to the timing, magnitude and regional patterns thereof,

UNFCCC – key text



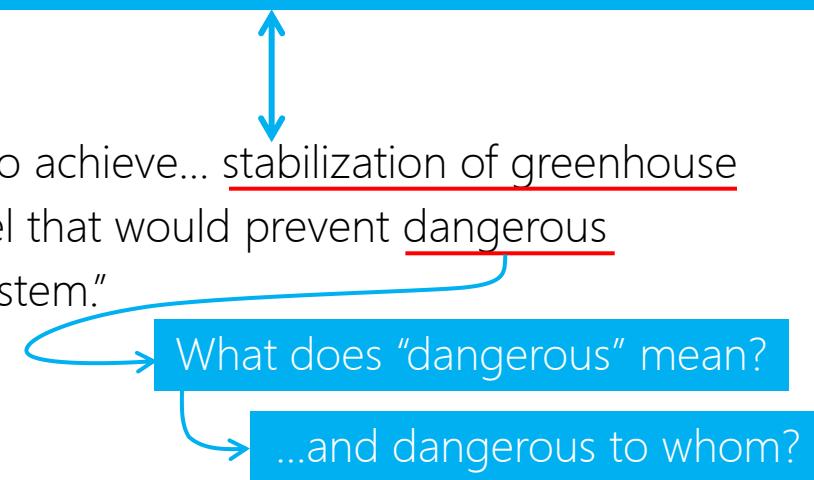
United Nations
1992

FCCC/INFORMAL/84/Rev.1
GE.14-20481 (E)

Article 2: Objective

"The ultimate objective of this Convention...is to achieve... stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."

ppm_{CO_2} – a simple, unambiguous, quantifiable goal



"Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner."

What does "sustainable" mean?

UNFCCC – key text



Precautionary Principle

FCCC/INFORMAL/84/Rev.1
GE.14-20481 (E)

Article 3: Principles

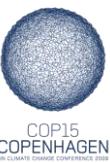
1. "The Parties should protect the climate system... on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities."

"Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof"

3. "The Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects."

"Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures..."

"...taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost"



1988: UNEP and WMO establish IPCC

1992: Rio Earth Summit



1994: UNFCCC enters into force



1995: COP-1, Berlin

1997: COP-3, Kyoto
Kyoto Protocol adopted (to 2012)



2007: G8 Summit, Germany
"aim to at least halve global CO₂ emissions by 2050"

2009: COP-15, Copenhagen
Failed to replace Kyoto Protocol
Copenhagen Accord established (non-binding)
2020 targets

2011: COP-17, Durban

Agreement to agree in the future:
*"...to develop a protocol...or an agreed outcome with legal force... applicable to all Parties...to be completed no later than 2015...and ...to be implemented from 2020."*¹

2013: COP-19, Warsaw
Agreement to prepare INDCs

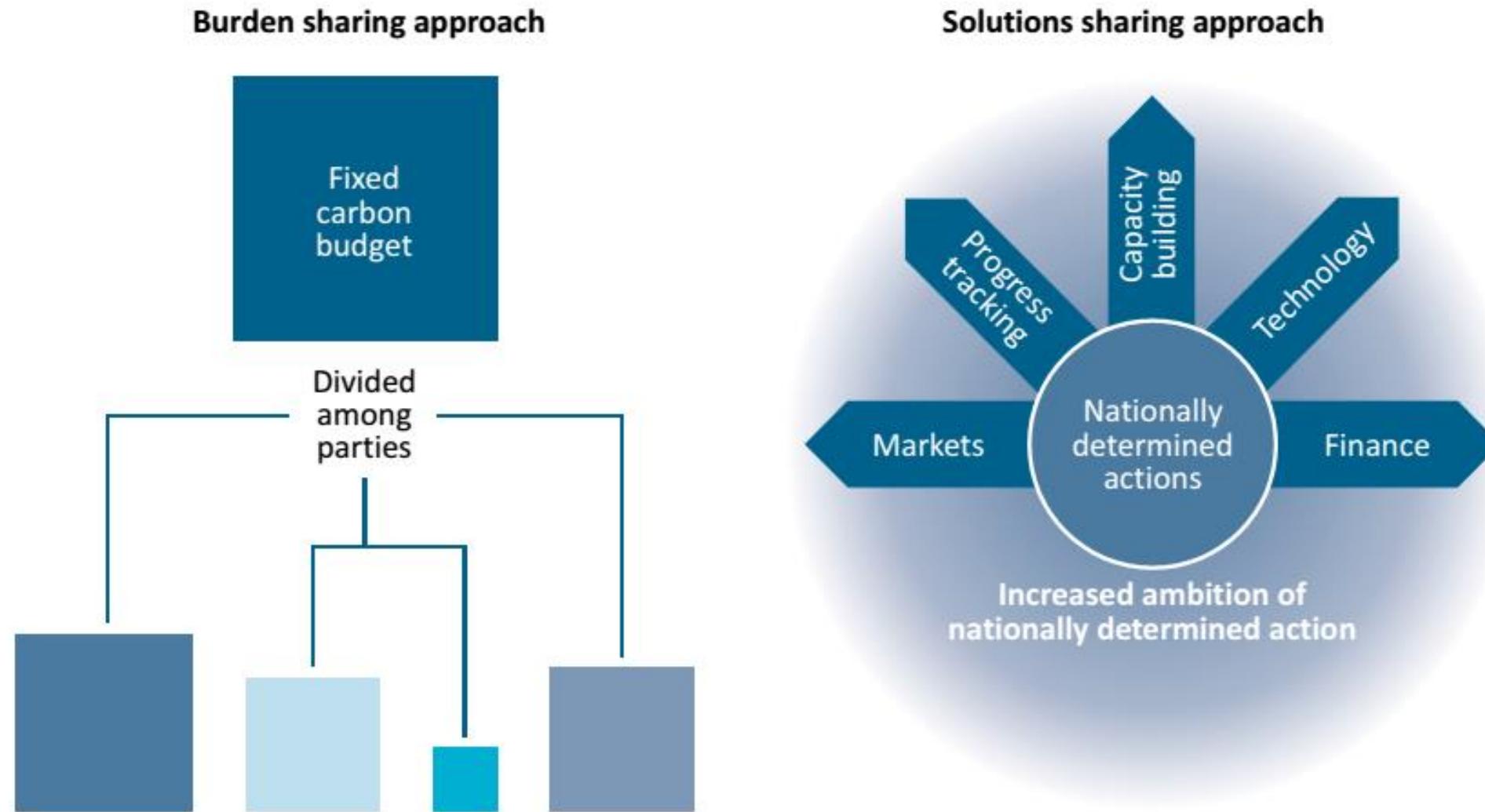
2015: COP-21, Paris



PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

¹ <http://unfccc.int/bodies/body/6645.php>



Figure 5.1 ▷ Approaches to international climate negotiations

Source: Energy and Climate Change, WEO 2015, Fig. 5.1. IEA/OECD (2015)

Nationally-Determined Contributions (NDCs) :

- should comprise a mitigation goal which eventually can be transformed into a legally binding mitigation commitment;
- must be transparent, quantifiable, comparable, verifiable and ambitious;
- shall reflect equity according to the [Common but Differentiated Responsibilities](#) and [Respective Capacities](#) principles;
- shall reflect national circumstances, and are expected to be of many different types.

<http://climateobserver.org/open-and-shut/indc/>

<https://www4.unfccc.int/sites/NDCStaging/Pages/All.aspx>

www.climateactiontracker.org



Article 15

1. A mechanism to facilitate implementation of and promote compliance with the provisions of this Agreement is hereby established.

2. The mechanism referred to in paragraph 1 of this Article shall consist of a committee that shall be expert-based and facilitative in nature and function in a manner that is transparent, non-adversarial and non-punitive. The committee shall pay particular attention to the respective national capabilities and circumstances of Parties.

<http://unfccc.int/resource/docs/2015/adp2/eng/8infnot.pdf>

Source: ADP.2015.8.Informal Note, Ad hoc Working Group on the Durban Platform for enhanced action (Oct 2015)



Article 2

1. This Agreement, in enhancing the implementation of the Convention, including its objective, aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including by:

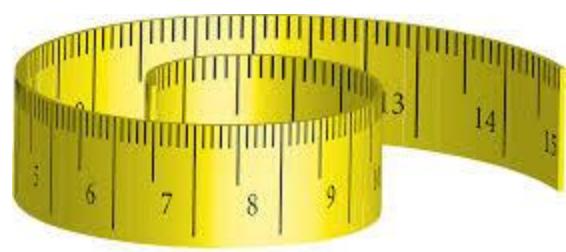
(a) Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change;

- Is a change in "temperature" a sensible metric?
- How were these threshold values chosen?



Article 2

1. This Agreement, in enhancing the implementation of the Convention, including its objective, aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including by:
 - (a) Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change;
 - (b) Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production; and
 - (c) Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.



Article 14

1. The Conference of the Parties...shall periodically take stock of the implementation of this Agreement to assess the collective progress towards achieving the purpose of this Agreement and its long-term goals (referred to as the "global stocktake").
2. The Conference of the Parties...shall undertake its first global stocktake in 2023 and every five years thereafter unless otherwise decided...
3. The outcome of the global stocktake shall inform Parties in updating and enhancing, in a nationally determined manner, their actions and support in accordance with the relevant provisions of this Agreement, as well as in enhancing international cooperation for climate action.



Implementation

Is the “bottom up” (NDC-based) approach working?

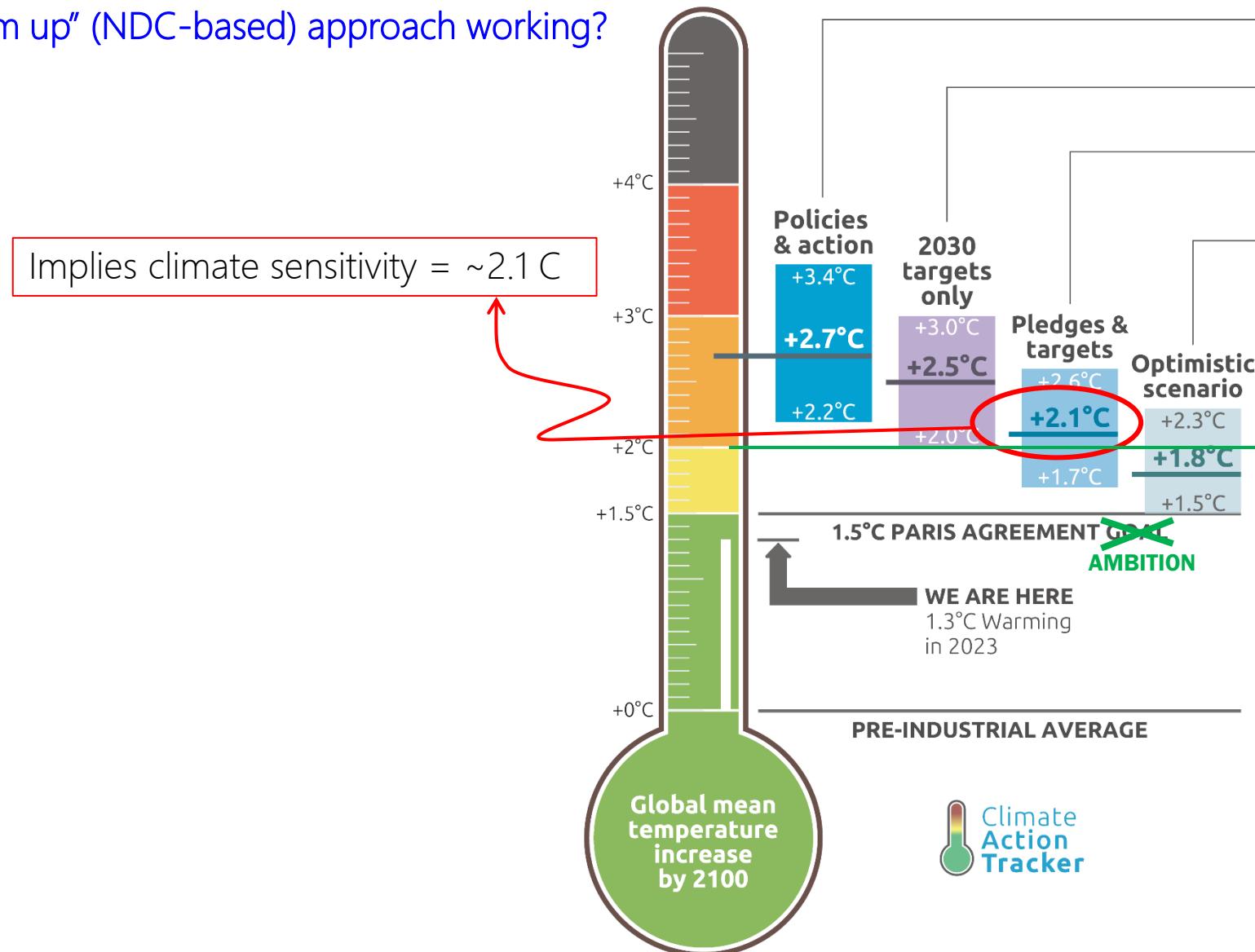
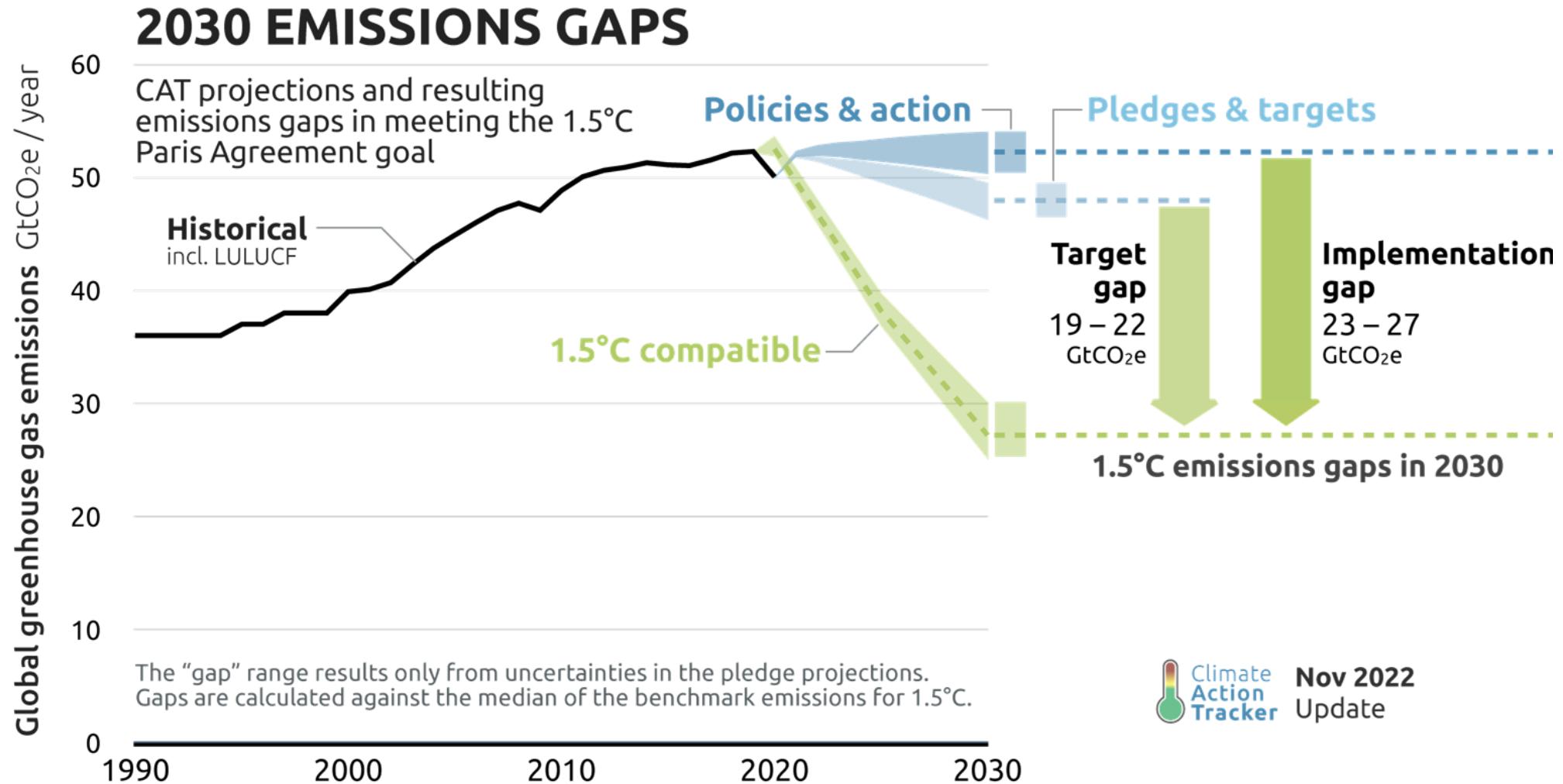
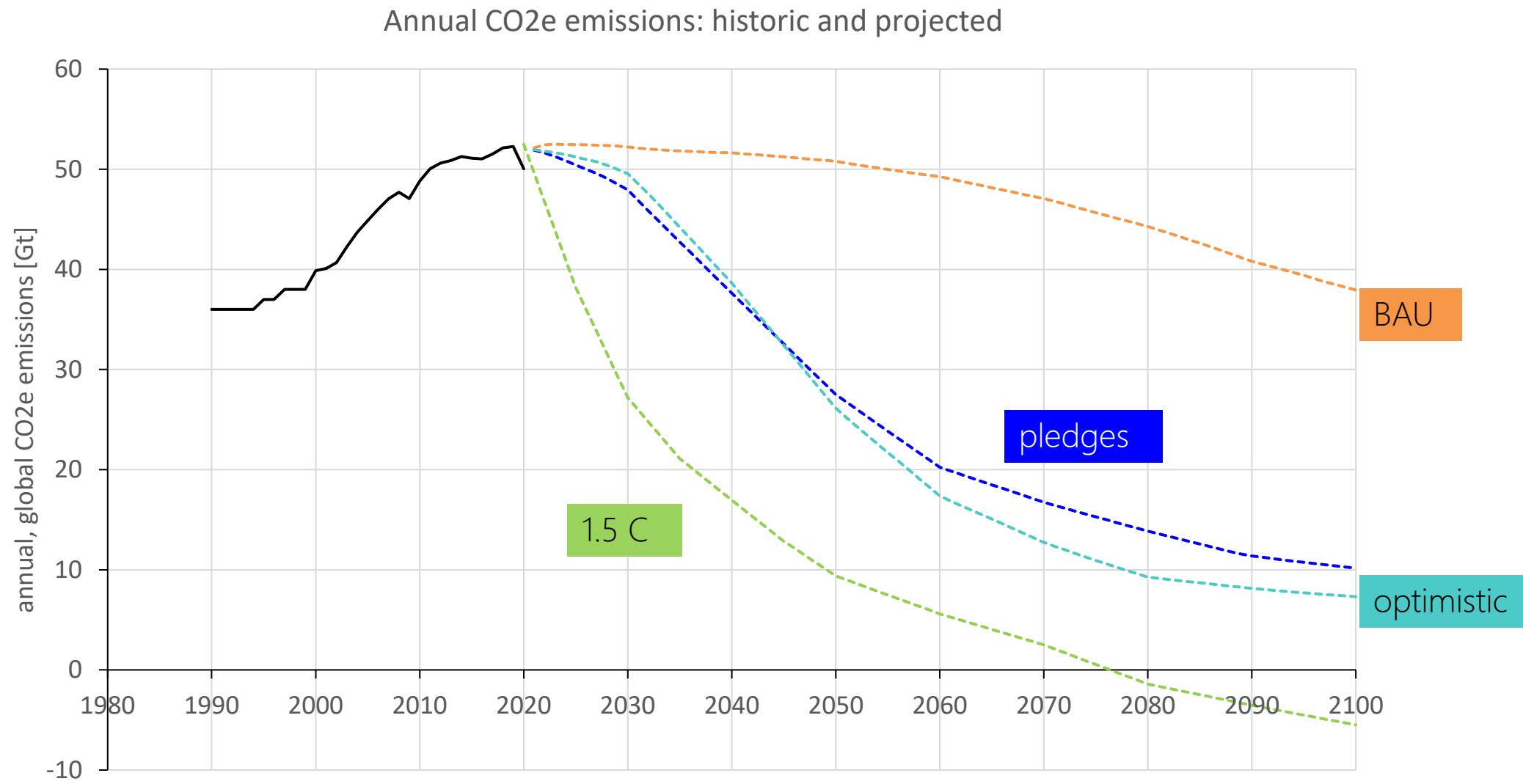


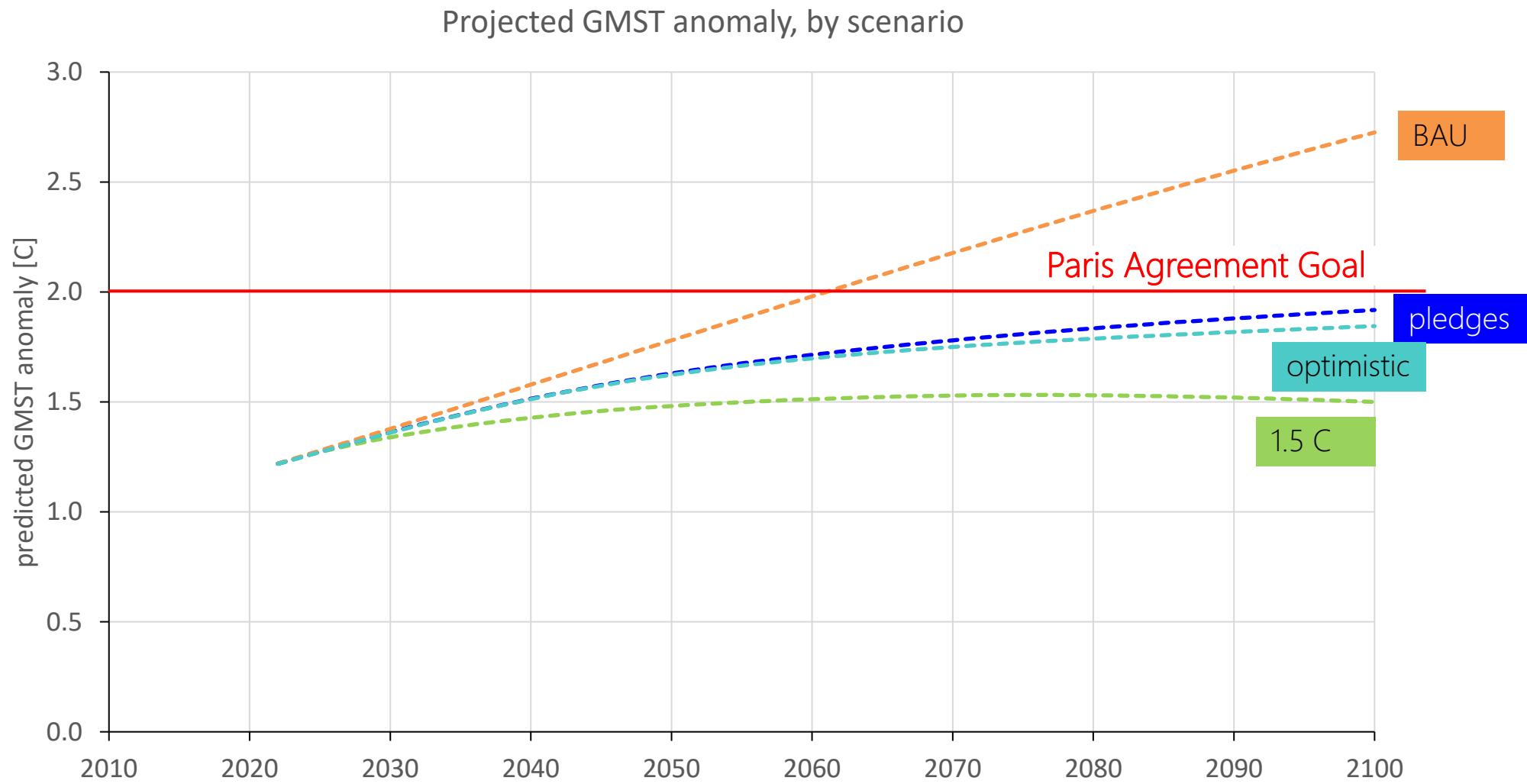
Figure source: <https://climateactiontracker.org/publications/no-change-to-warming-as-fossil-fuel-endgame-brings-focus-onto-false-solutions/>



Figures: <http://climateactiontracker.org/global.html>

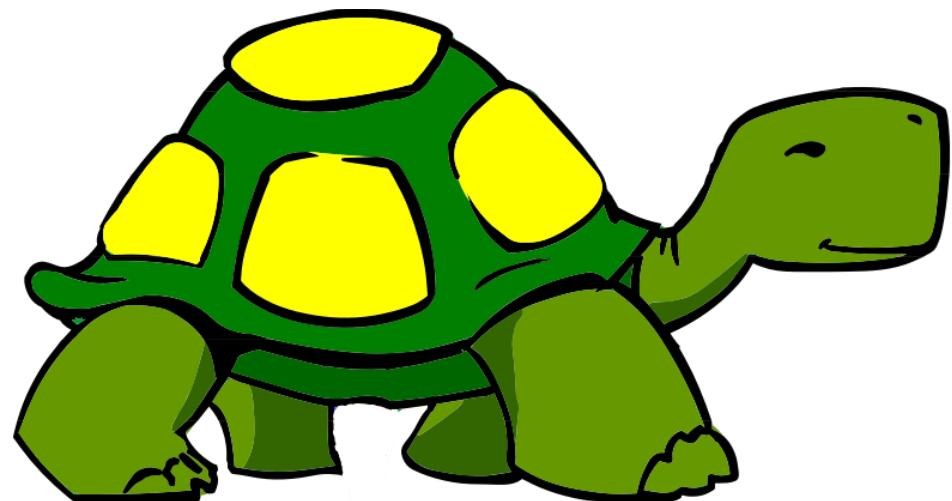


Raw data: <http://climateactiontracker.org/global.html>



Raw data: <http://climateactiontracker.org/global.html>

Who are the leaders...



...and who are the laggards?

Donald Trump: Washington formally tells UN of Paris agreement withdrawal

Posted Sat 5 Aug 2017 at 1:49am

China pledges to become carbon neutral before 2060

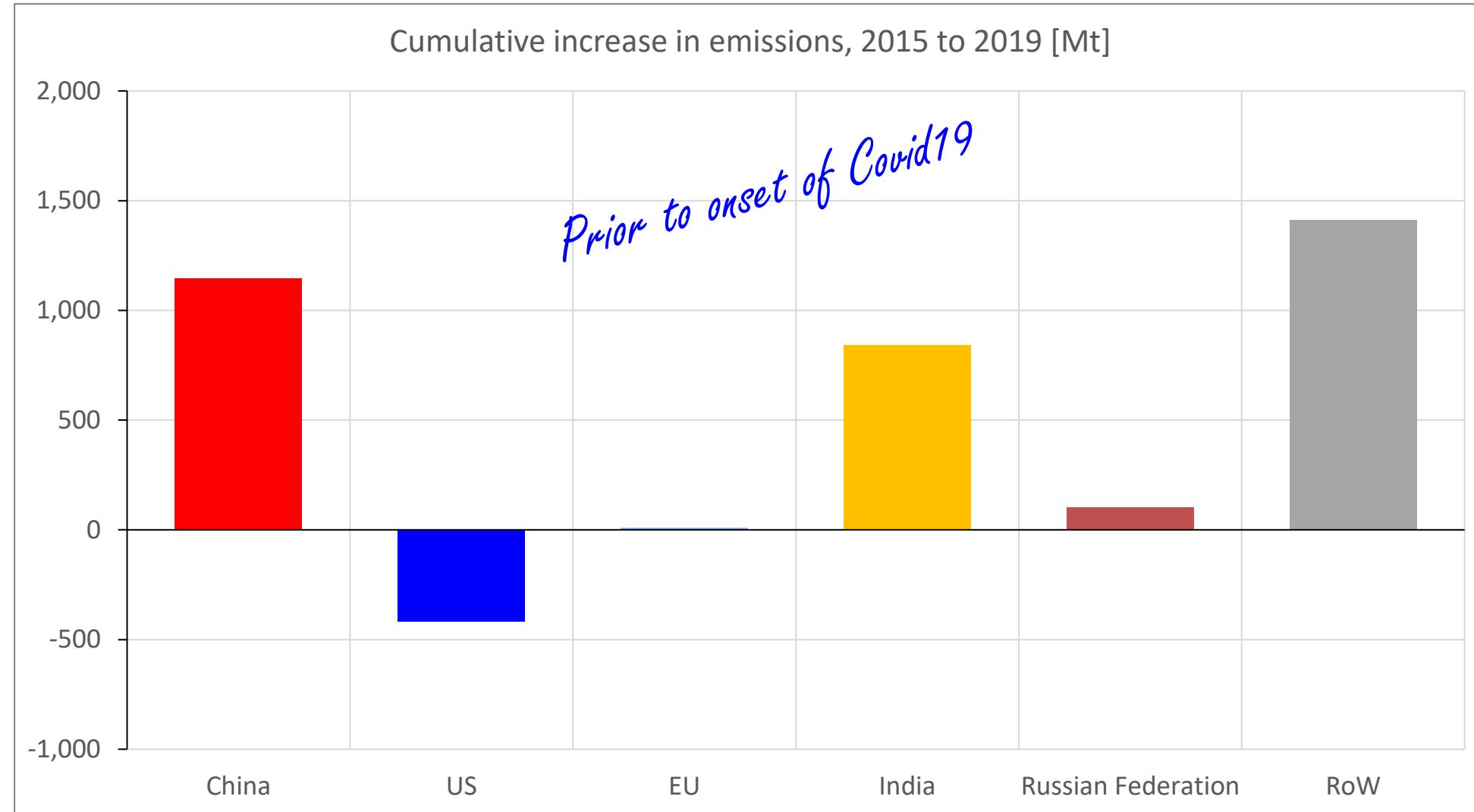
Unexpectedly forthright pledge will boost UN efforts to galvanise action on climate crisis

The screenshot shows a news article from EURACTIV.com. The top navigation bar includes links for 'The Capitals', 'Newsletters', social media icons, 'Login / Register', 'Events', 'EURACTIV Net', 'Global Europe', 'Health', 'Agrifood', 'Digital', 'Economy & Jobs', 'Energy & Environment', and 'epaa15'. The main headline reads 'EU leaders to decide tougher climate goal in December' with a sub-headline 'EU leaders to decide tougher climate goal in December'. Below the headline is a photo of a tree with the text '#EPAA15'. The bottom of the page has a footer with the UCD Dublin logo and the text 'EURACTIV.com with AFP and Reuters'.

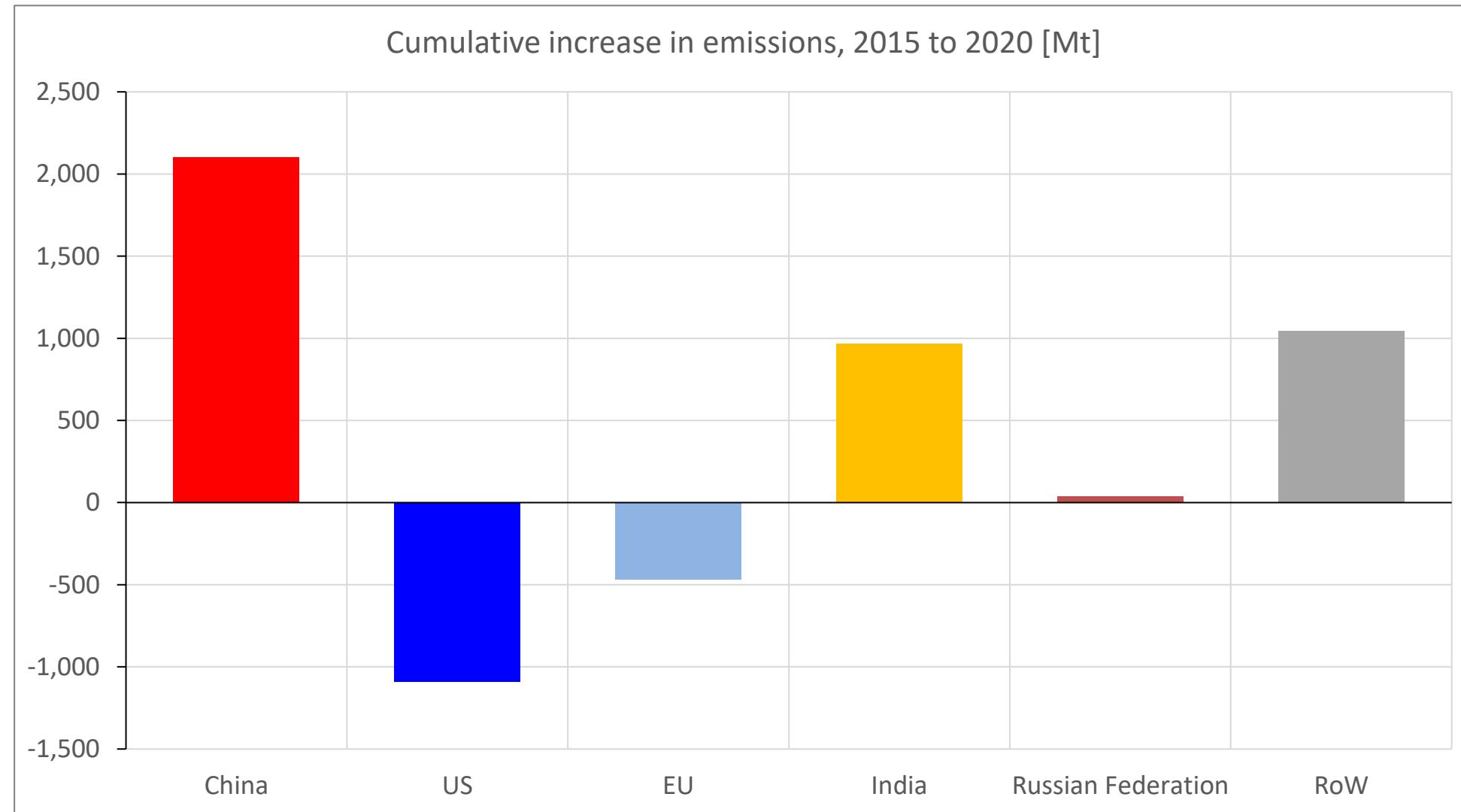
The screenshot shows the BBC News homepage. The top navigation bar includes 'BBC', 'Sign in', 'Home', 'News', 'Sport', 'Reel', and 'Worklife'. Below the navigation is a red banner with the word 'NEWS'. Underneath the banner, there are links for 'Home', 'US Election', 'Coronavirus', 'Video', 'World', 'UK', 'Business', 'Tech', 'Science', 'Stories', and 'Entertain'. A 'Science' section is highlighted with a red underline. To the right, there is a promotional box for 'Cosmetics: protecting the planet' with the text 'Essentials For Daily Life'.

US election 2020: What the results will mean for climate change

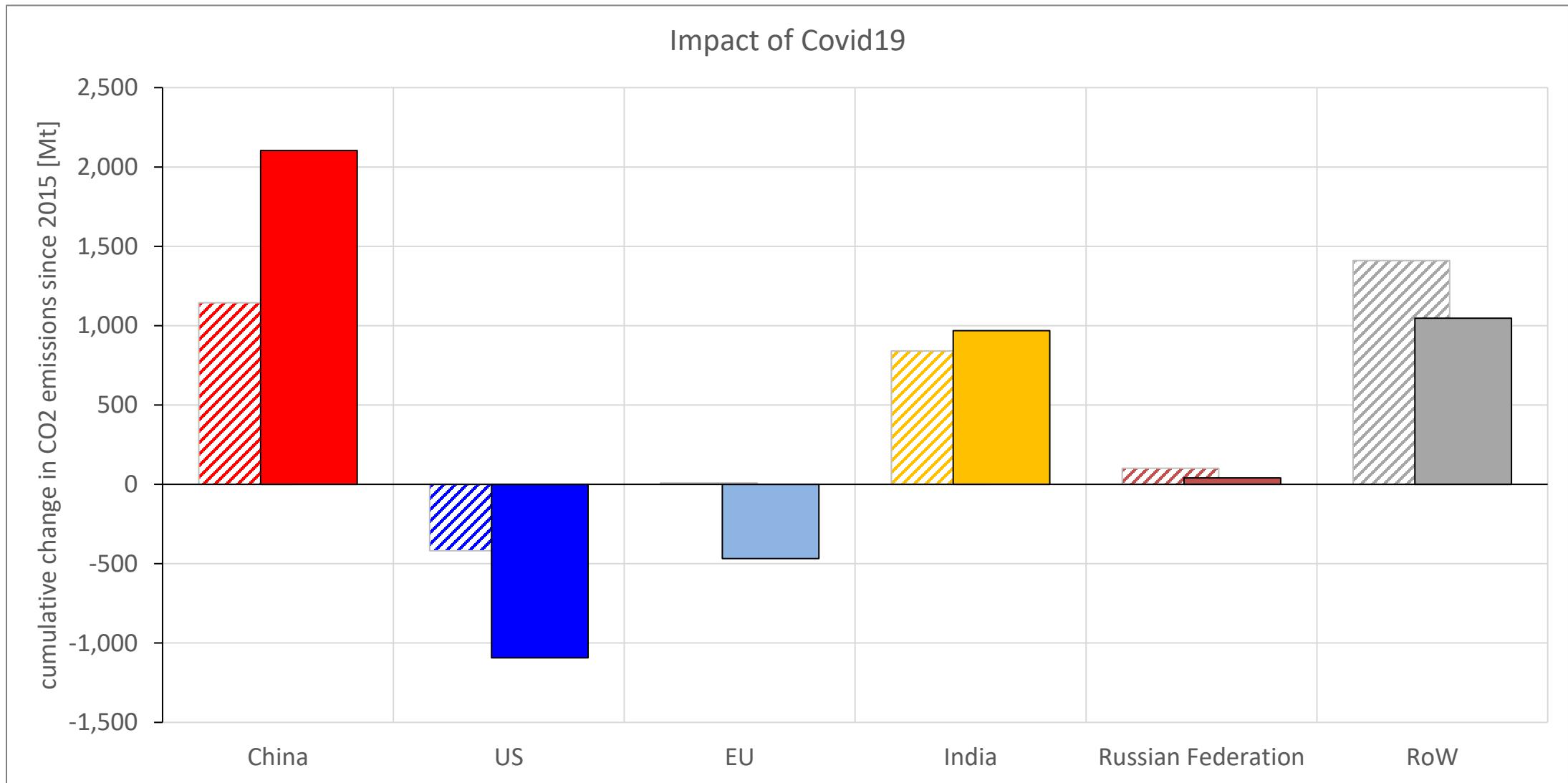
The screenshot shows a news article from Climate Home News. The top navigation bar includes 'Home', 'Politics', 'Finance', 'Energy', 'Land', 'Tech', 'Science', and 'Comment'. Below the navigation is a large headline 'CLIMATE HOME NEWS' with a sub-headline 'China hits out at US climate record, in pointed message ahead of election'. The article is by Matt McGrath, Environment correspondent, published on 19/10/2020, 4:43pm. The bottom of the page has a footer with the UCD Dublin logo and the text 'Published on 19/10/2020, 4:43pm'.



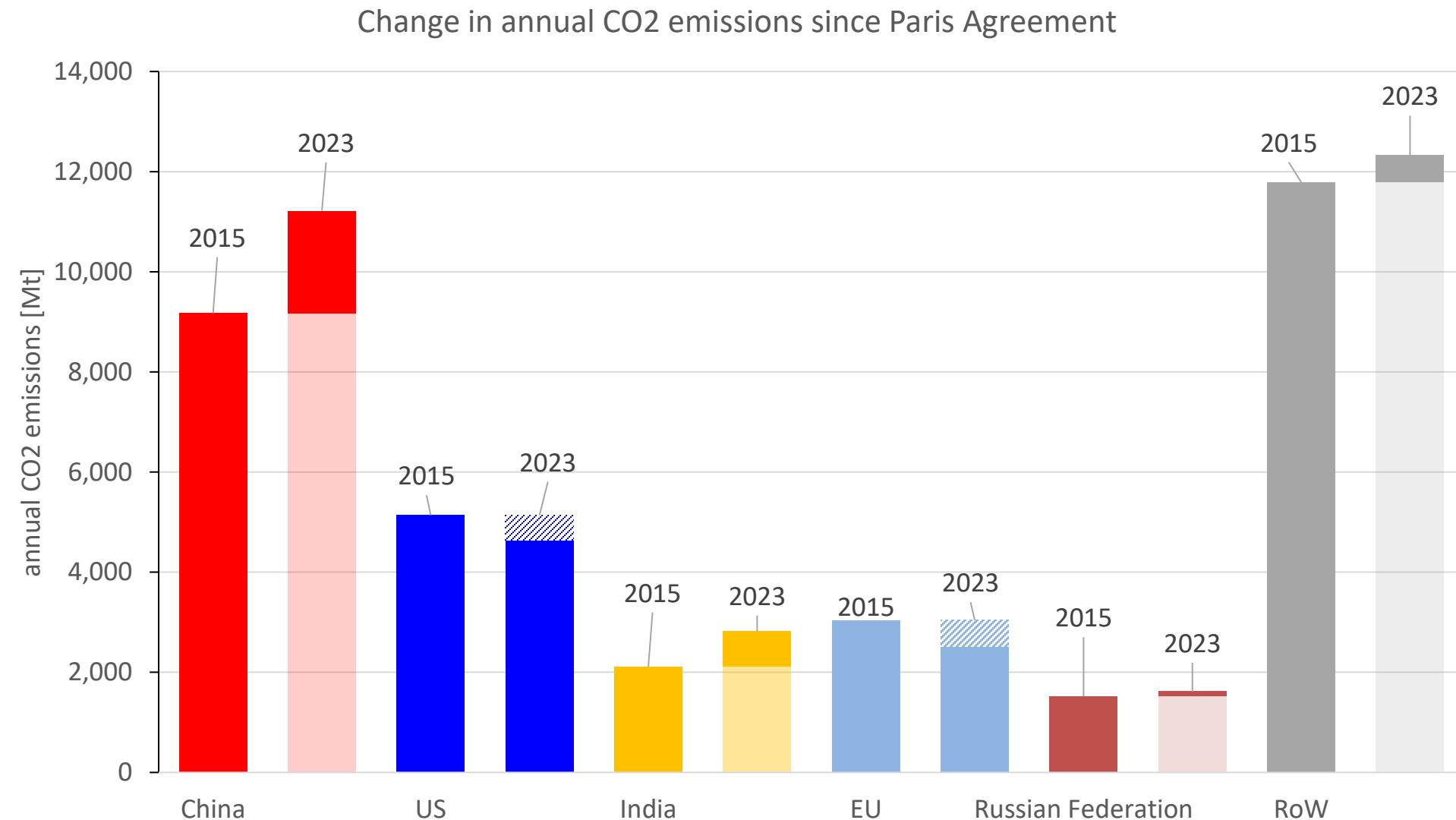
Raw data: Statistical Review of World Energy



Raw data: Statistical Review of World Energy



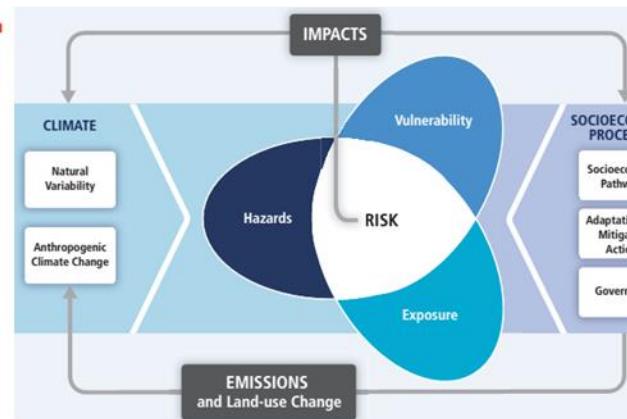
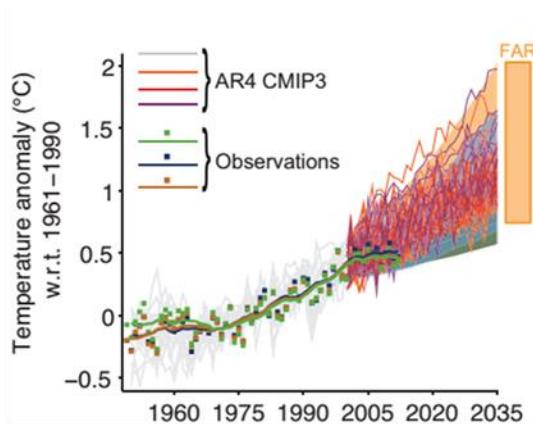
Raw data: Statistical Review of World Energy



Raw data: Statistical Review of World Energy



Energy Systems & Climate Change



Establishing priorities

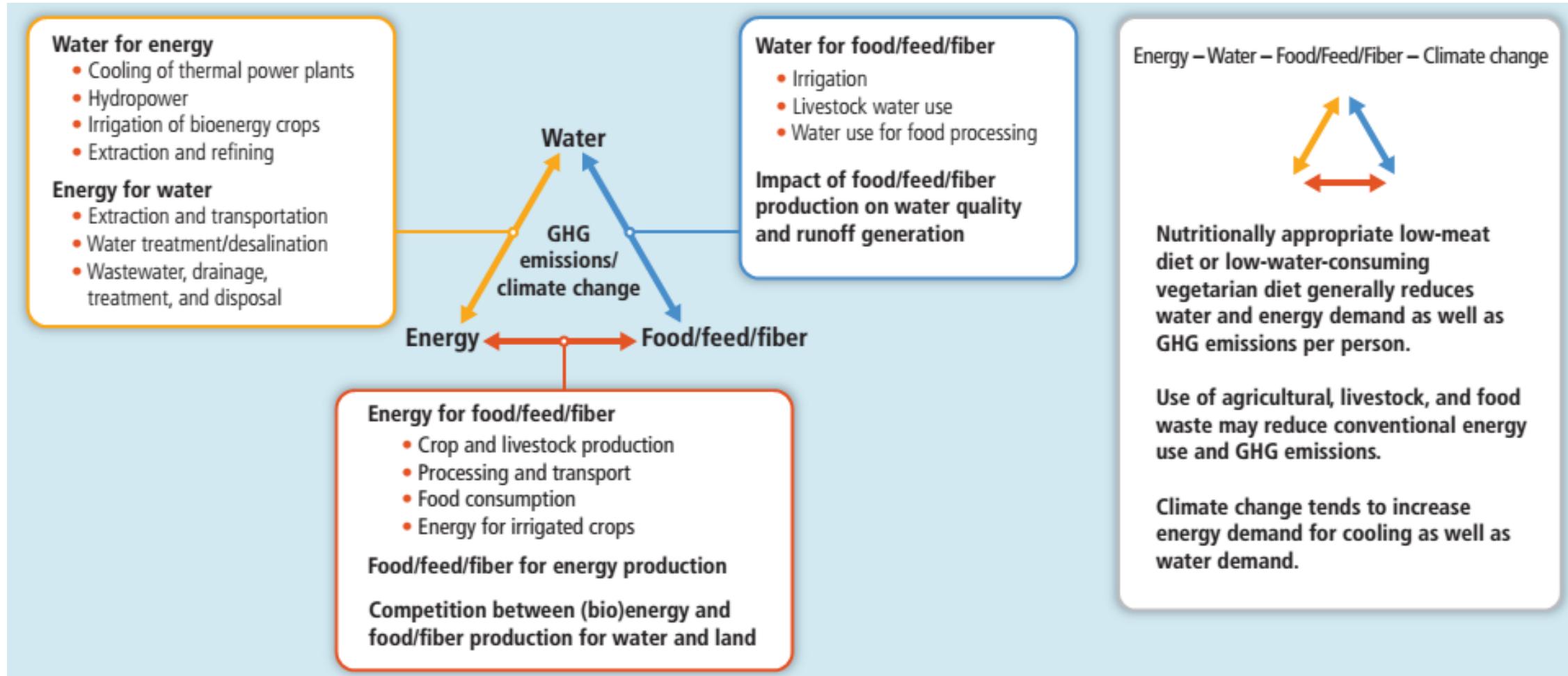
A close-up photograph of a person's hand holding a black marker, writing on a white surface. The hand is positioned in the lower center of the frame. The writing consists of four lines of text: "now" in an oval at the top, followed by "later", "tomorrow", and "next week" stacked vertically below it. Each word is crossed out with a large, hand-drawn style X.

now

later

tomorrow

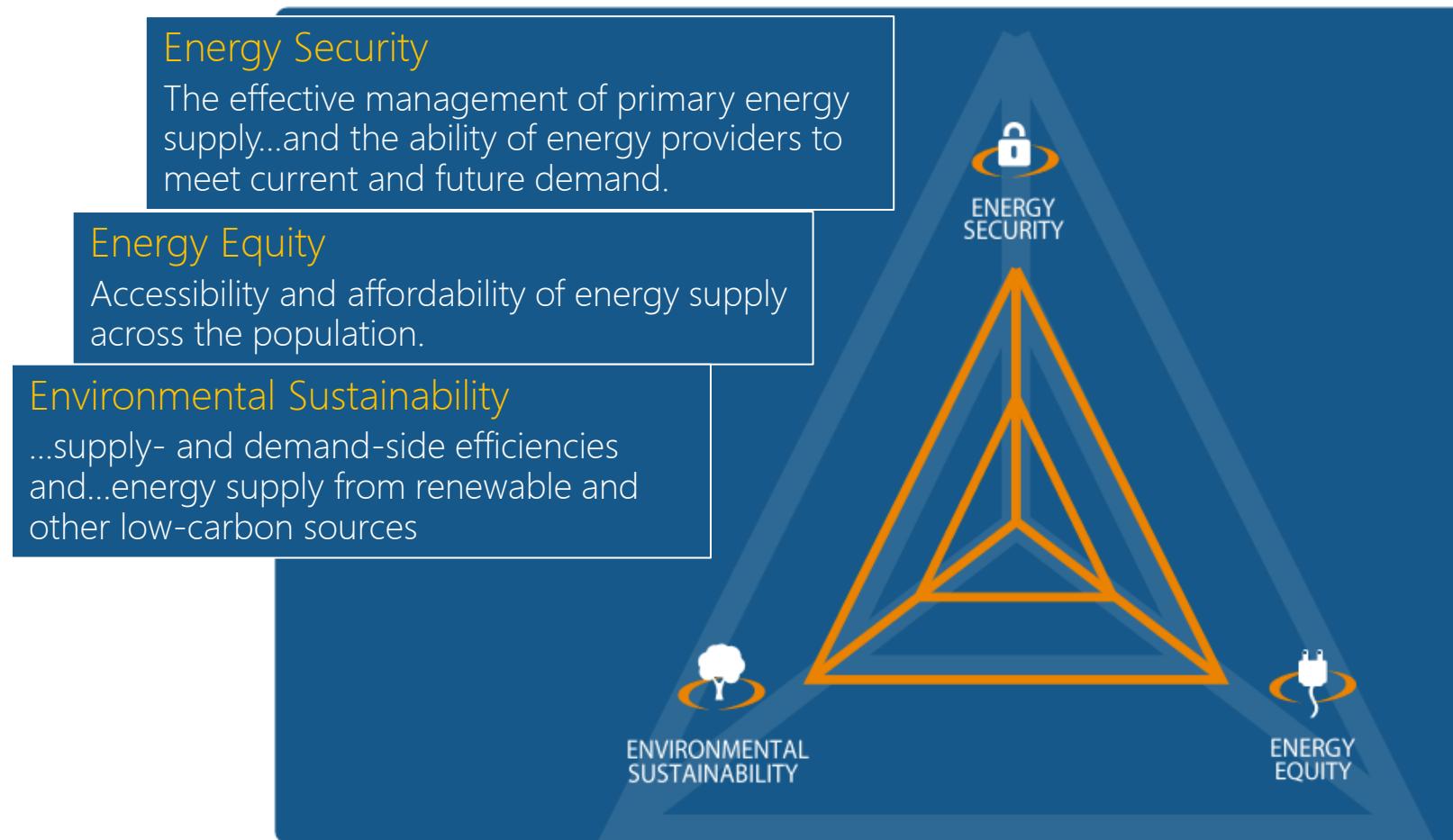
next week



Box TS.9 Figure 1 | The water–energy–food nexus as related to climate change, with implications for both adaptation and mitigation strategies. [Figure WE-1, Box CC-WE]

Source: IPCC AR5, WG2 Impacts & Adaptation, Box TS.9, Fig. 1

Figure 2
The World Energy Trilemma
Source: World Energy Council/Oliver Wyman, 2013



Source: *World Energy Trilemma: Priority actions on climate change*. World Energy Council (2015)

U.N. Sustainable Development Goals vs UNFCCC: squaring the circle



"For SDGs 1 (poverty), 2 (hunger), 6 (water), and 7 (energy), there is a risk of trade-offs or negative side-effects from stringent mitigation actions compatible with 1.5°C (medium evidence, high agreement)."

Special Report on Global Warming of 1.5 C (IPCC, 2018)

Image: <https://sustainabledevelopment.un.org/sdgs>



Risks...

The global reponse

What is risk? A subjective, vague, and emotionally-laden attribute. Product of (perceived) susceptibility and severity.

Susceptibility:

Is the climate changing? (yes, but...)

Are extreme weather events (e.g. heat waves) becoming more frequent?

Are extreme weather events (e.g. heat waves) becoming more severe?

Severity (impacts):

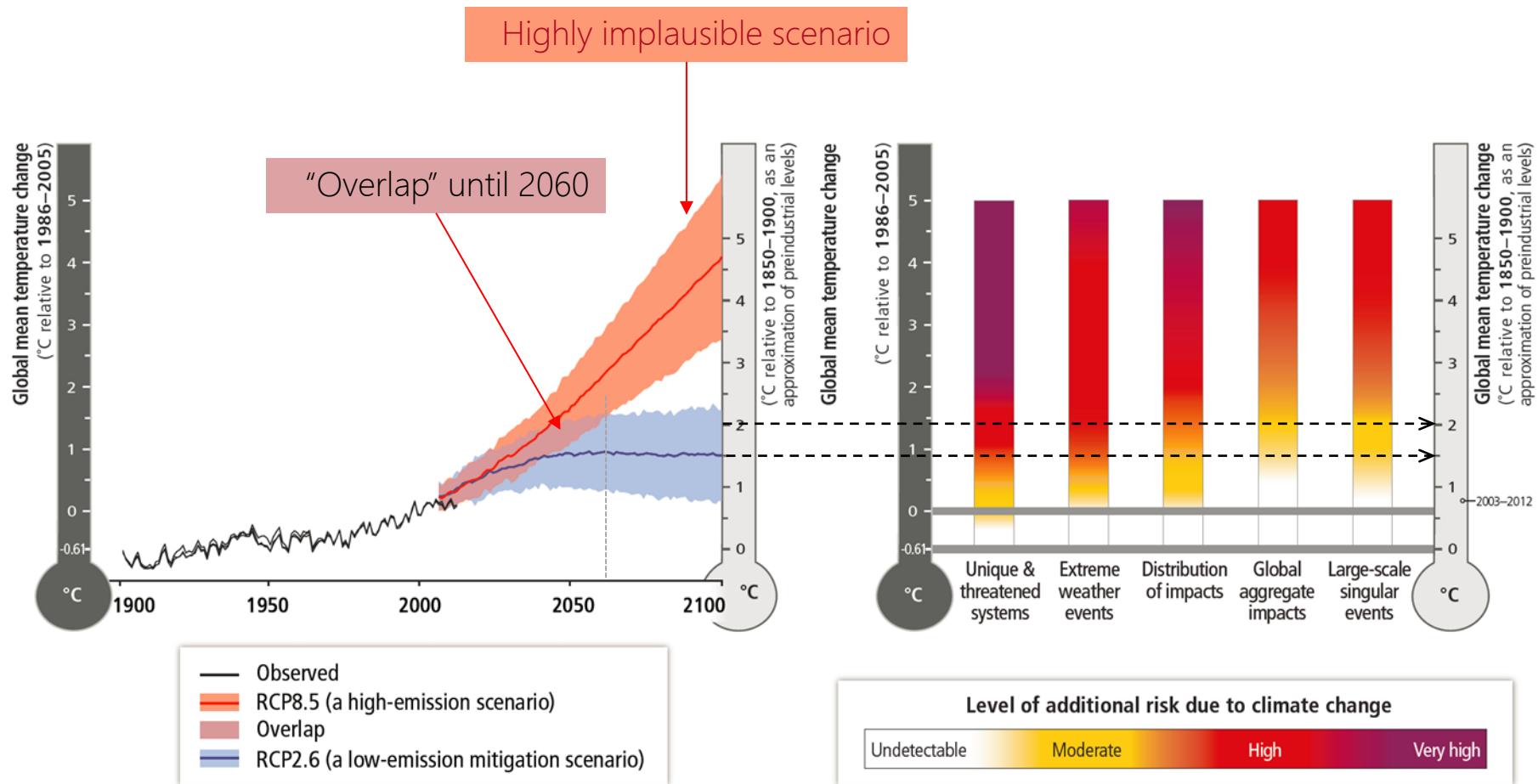
How do we define the impacts?

Where can we find relevant, objective, "impacts" data?

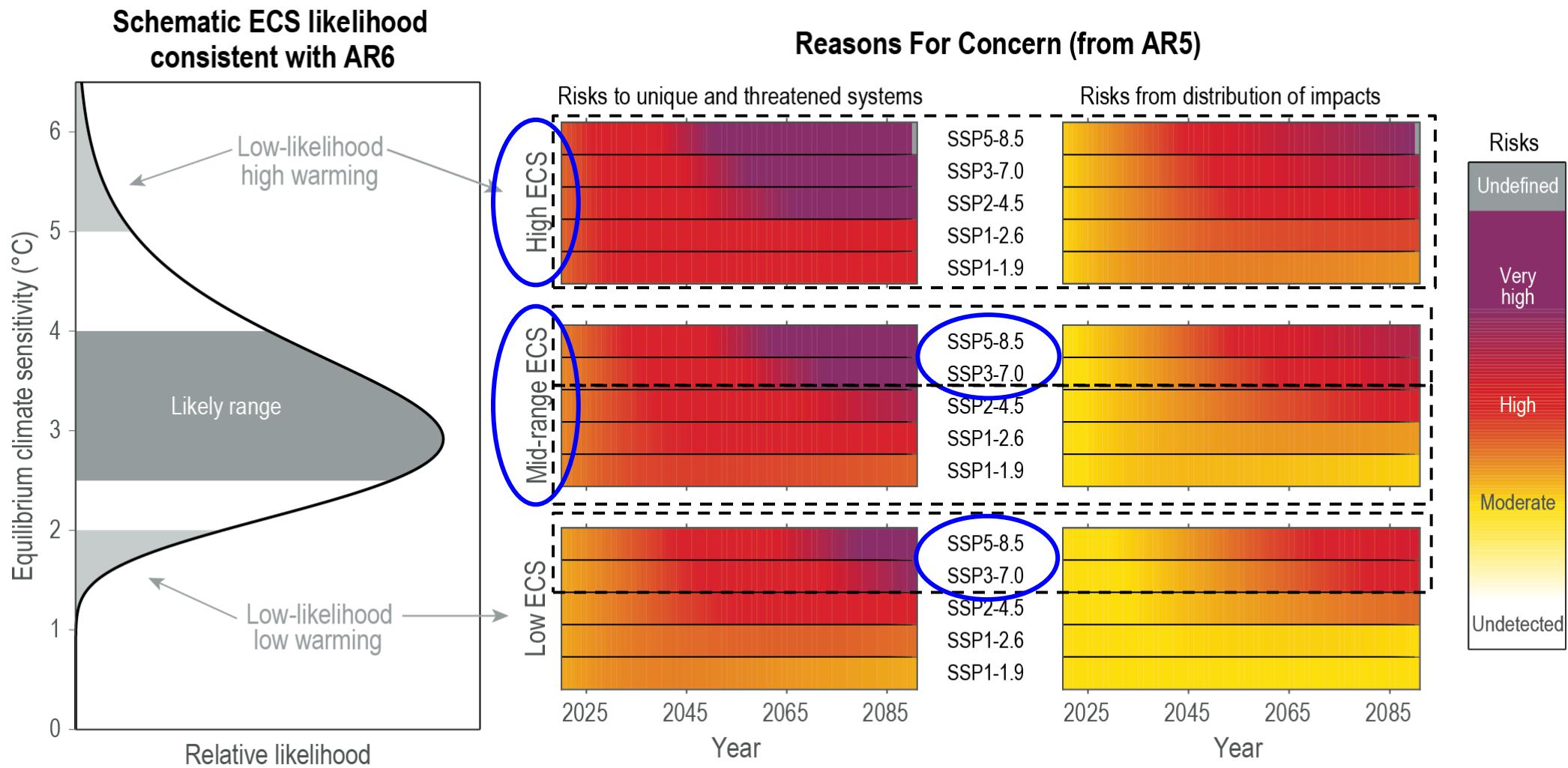
What does the data say about the 100-year trends in "climate-related" impacts?

Is warmer worse (or better) than colder / no change?

Can we control the impacts?



Source: IPCC AR5, WG2 Impacts & Adaptation, Assessment Box SPM.1 Fig. 1



Source: IPCC AR6, WG1 The Physical Science Basis Fig. 1.16

☒ Brazil: Dramatic drought in the Amazon

The Amazon rainforest is experiencing a severe drought: River levels dropped significantly, fish are dying and the human population is suffering as well. The weather phenomenon El Nino and climate change are to blame.

Image: MICHAEL DANTAS/AFP/Getty Images

Forecasters warned Ireland must prepare for increased likelihood of 'extreme weather events'

IRELAND



Climate crisis costing \$16m an hour in extreme weather damage, study estimates

Analysis shows at least \$2.8tn in damage from 2000 to 2019 through worsened storms, floods and heatwaves

Climate Crisis

Dramatic climate action needed to curtail extreme weather

This year's heatwaves, wildfires and floods are just 'tip of the iceberg'

TECH NATURE KNMI MAARTEN VAN AALST SEA LEVEL RISE HEAT » MORE TAGS

MONDAY, 9 OCTOBER 2023 - 12:05

Netherlands will soon face more extreme weather & high heat, experts say

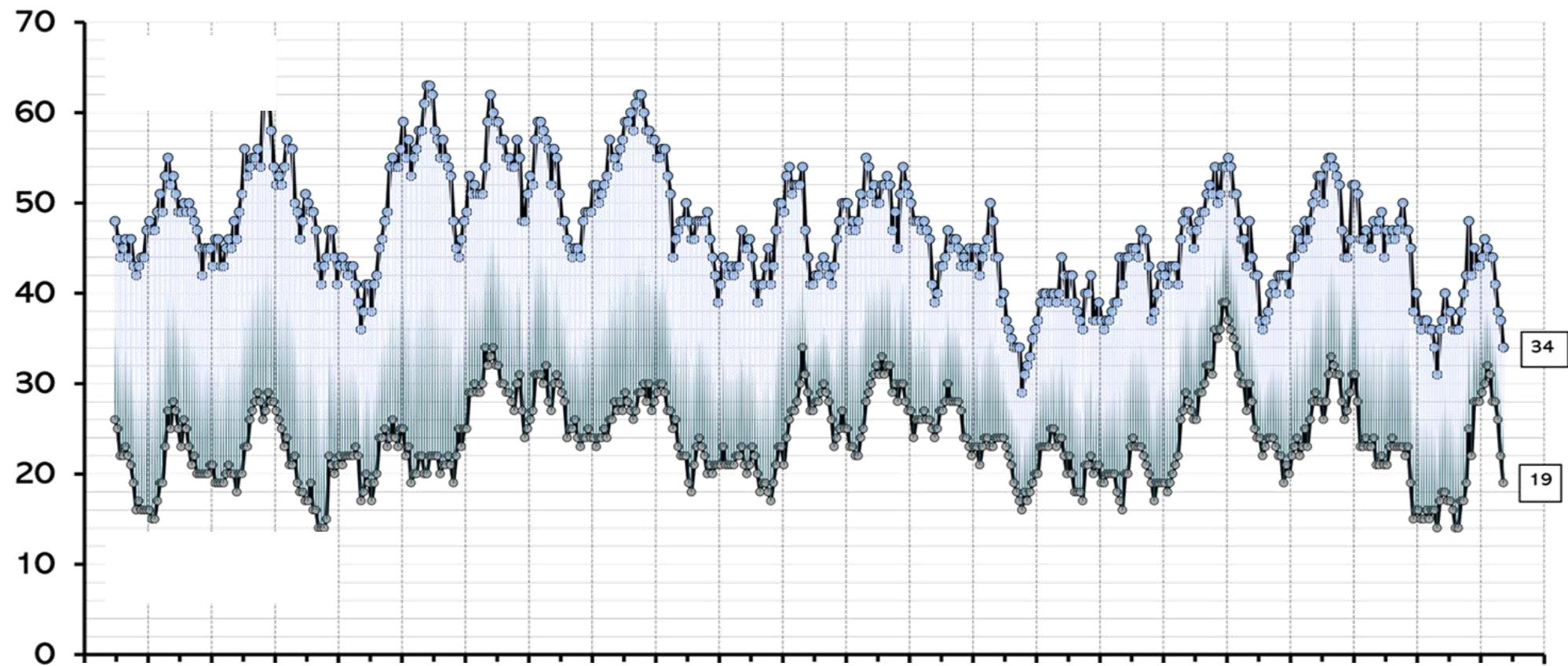
SHARE THIS:



2019-09-16 20:01:14 UTC



1. Storms



1. Storms

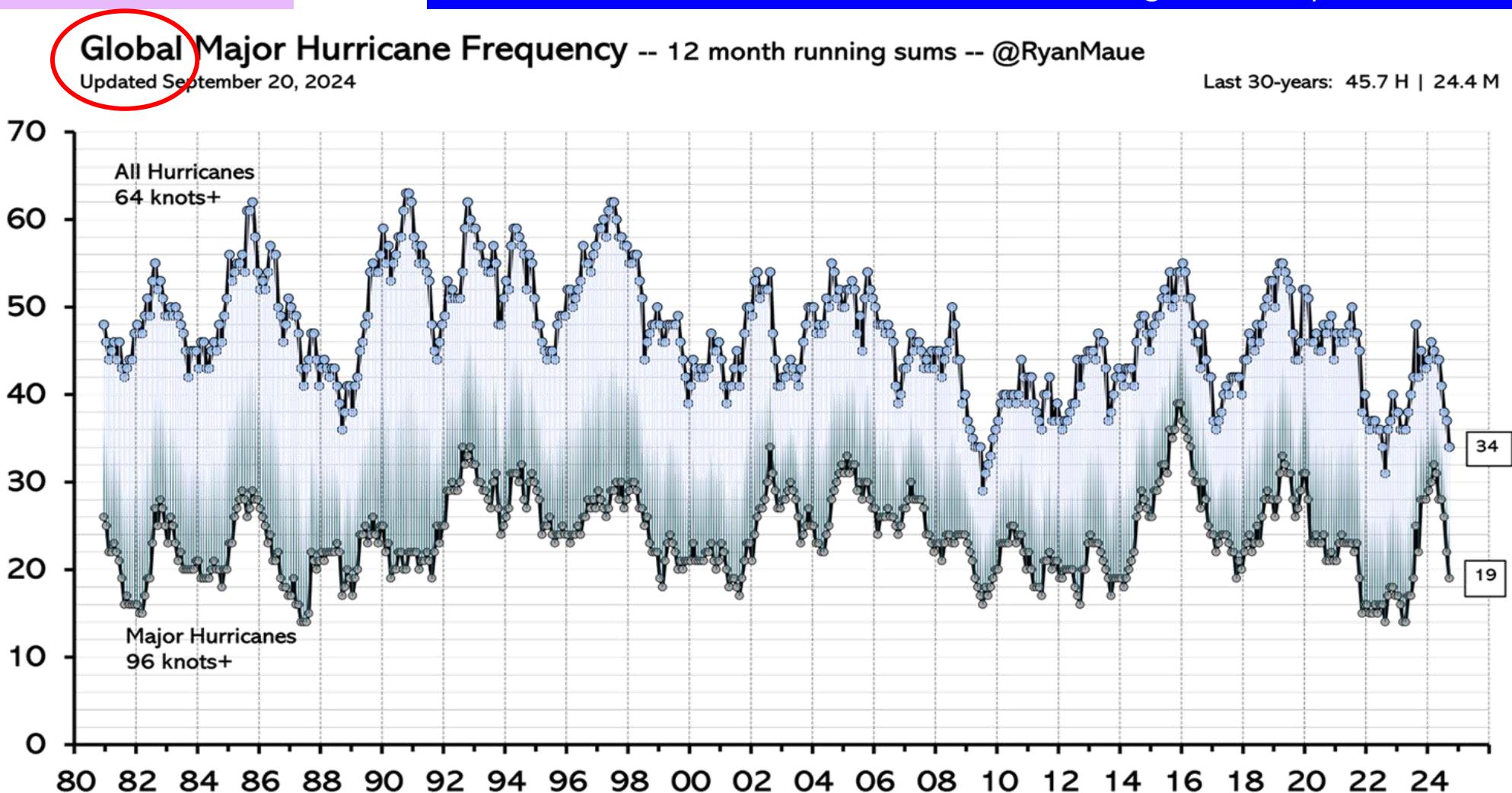


Figure: Global Hurricane Frequency (all & major) - 12-month running sums.

The top time series is the number of global tropical cyclones that reached at least hurricane-force (maximum lifetime wind speed exceeds 64-knots). The bottom time series is the number of global tropical cyclones that reached major hurricane strength (96-knots+).

1. Storms

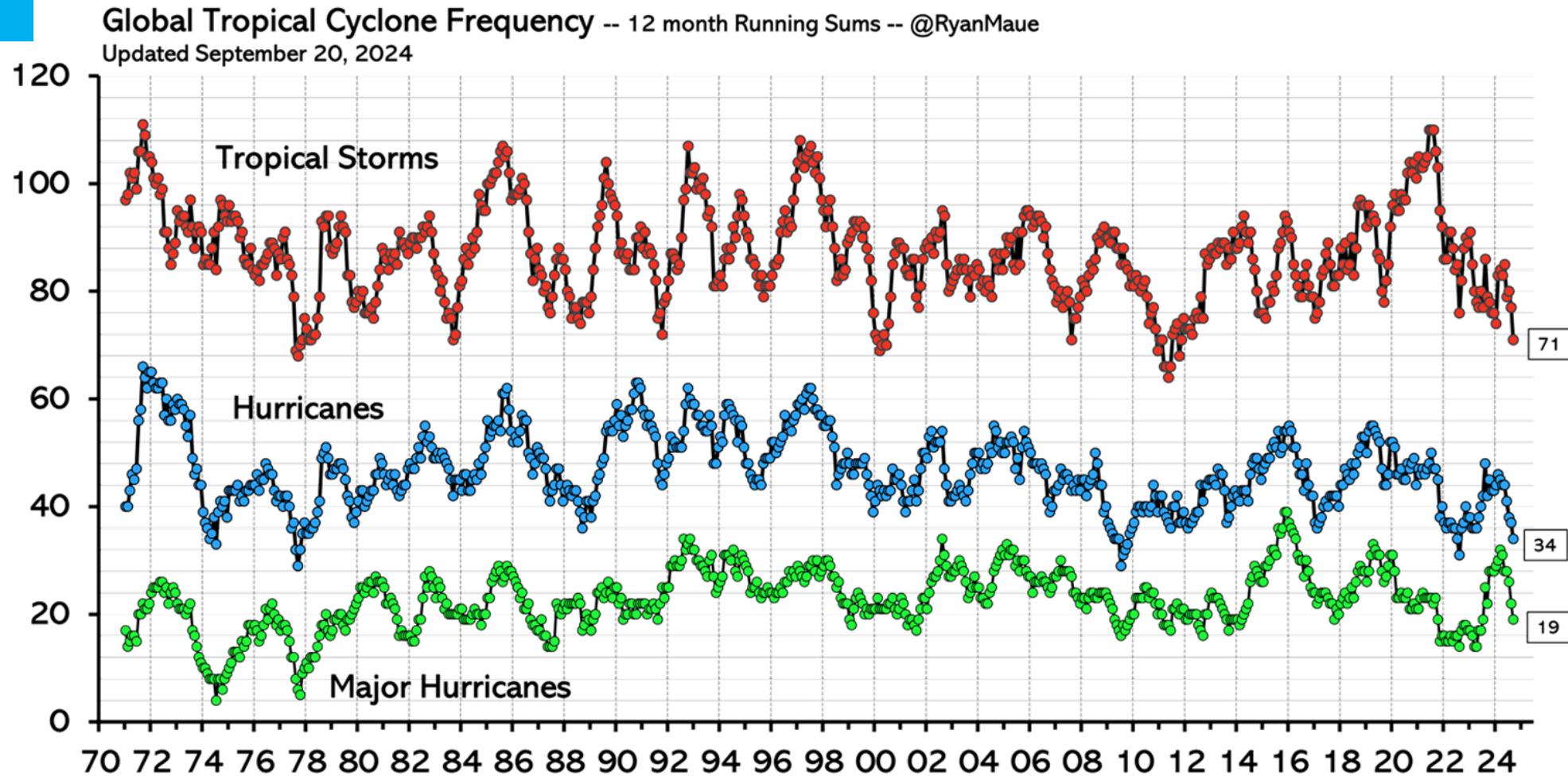


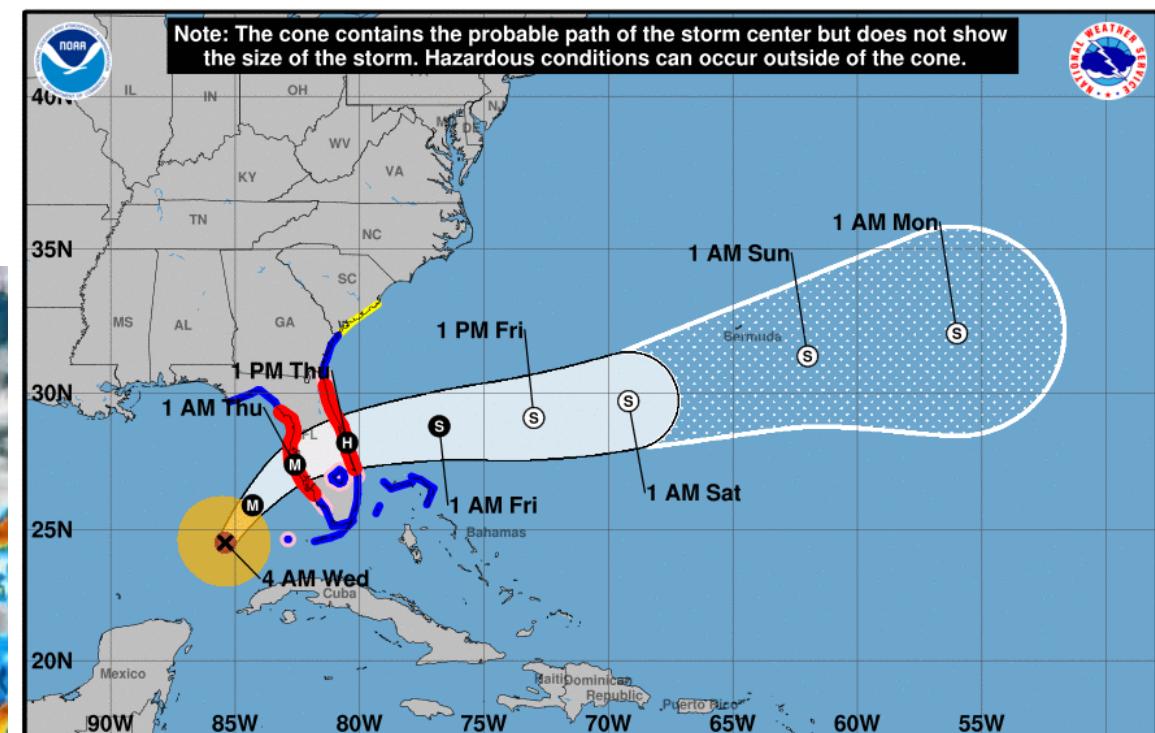
Figure: Last 50-years+ of Global Tropical Storm and Hurricane frequency - 12-month running sums.
The top time series is the number of TCs that reach at least tropical storm strength (maximum lifetime wind speed exceeds 34-knots).
The bottom time series is the number of hurricane strength (64-knots+) TCs.

Image source: https://climatlas.com/tropical/frequency_12months.png



Hurricane Milton

Floridians warned 'you are going to die' if they don't evacuate as Milton nears



Hurricane Milton Wednesday October 09, 2024 4 AM CDT Advisory 17 NWS National Hurricane Center	Current information: Center location 24.5 N 85.4 W Maximum sustained wind 160 mph Movement NE at 14 mph	Forecast positions: ● Tropical Cyclone ○ Post/Potential TC Sustained winds: D < 39 mph S 39-73 mph H 74-110 mph M > 110 mph
Potential track area: Day 1-3 Day 4-5	Watches: Hurricane Trop Stm	Warnings: Hurricane Trop Stm



1. Storms

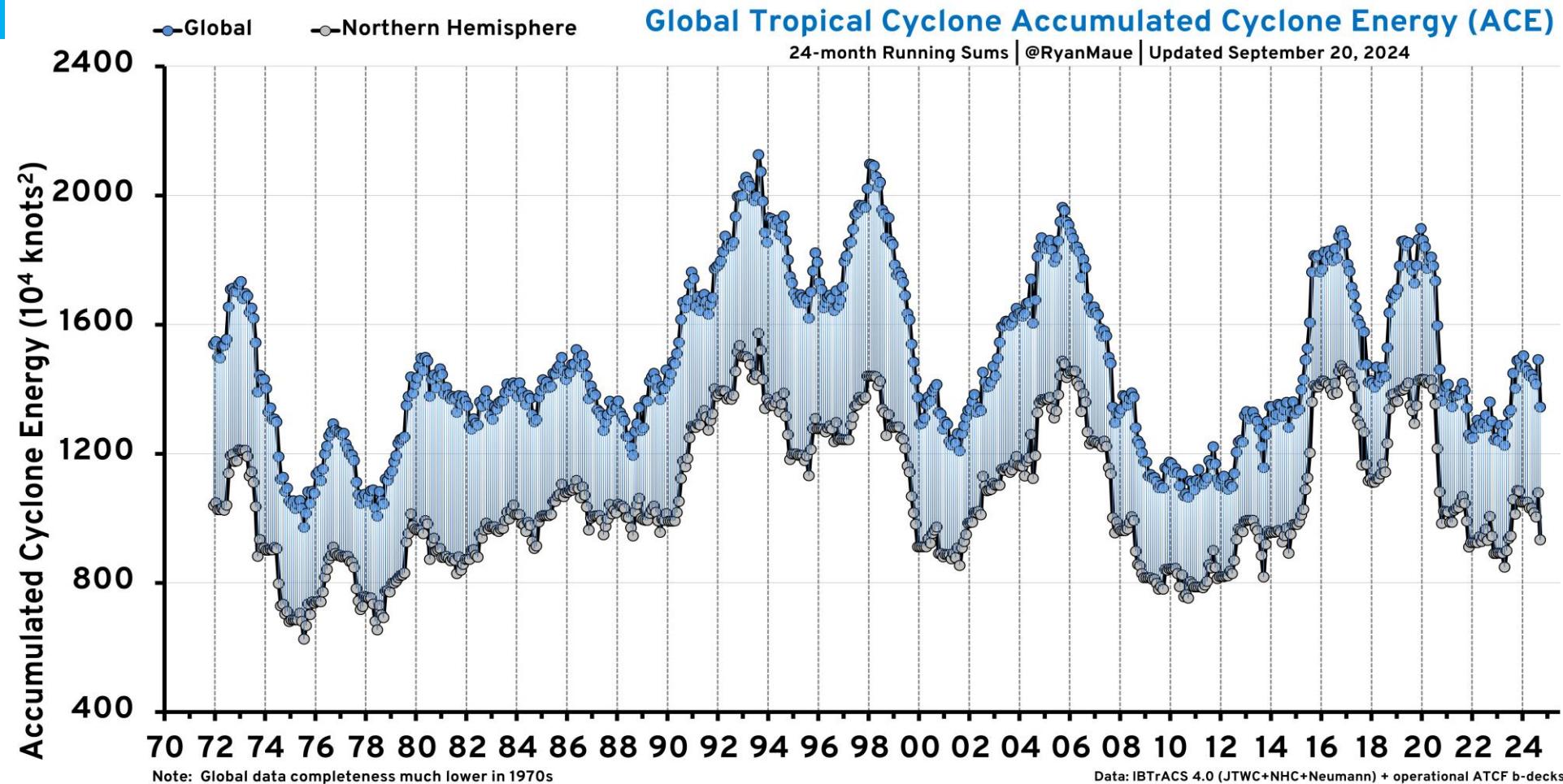


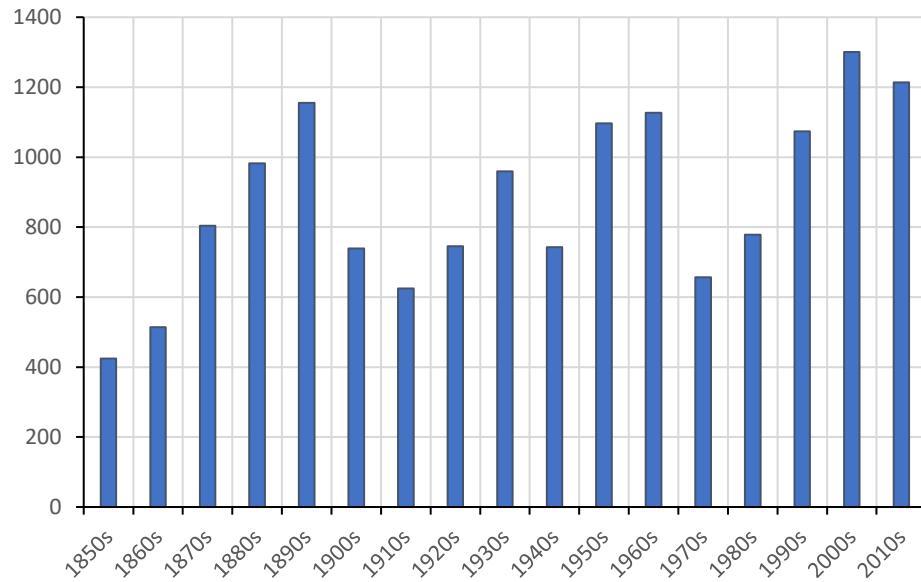
Figure: Last 50-years+ of Global and Northern Hemisphere Accumulated Cyclone Energy: 24 month running sums.

Note that the year indicated represents the value of ACE through the previous 24-months for the Northern Hemisphere (bottom line/gray boxes) and the entire global (top line/blue boxes). The area in between represents the Southern Hemisphere total ACE.

Image source: https://climatlas.com/tropical/global_running_ace.png

1. Storms

ACE – North Atlantic

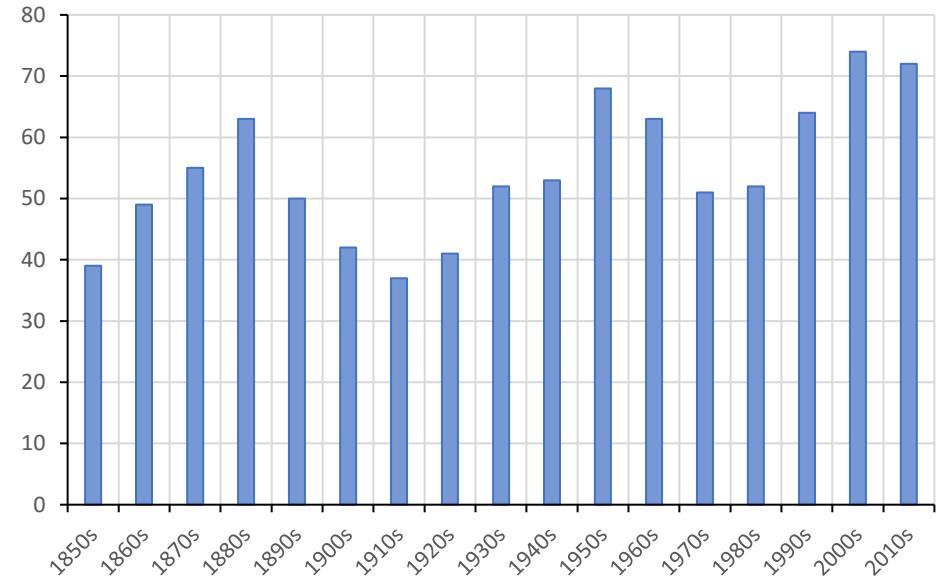


Note: Regional trends may differ significantly from the global average.

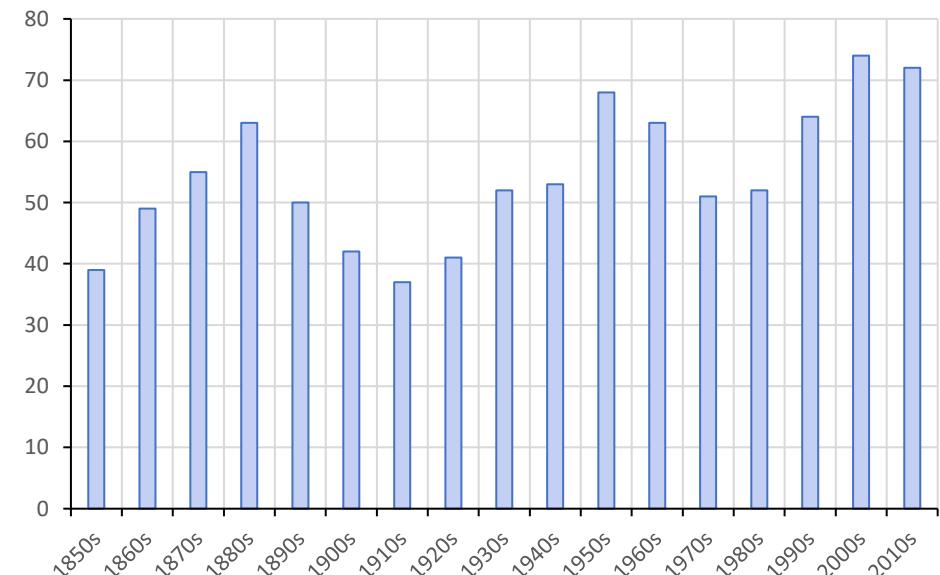
The data presented here, for the North Atlantic basin, suggest a mild upward trend for all three data sets, albeit with very substantial fluctuations from decade to decade.

There may also be some hint of a longer-term (50 – 70 year) cycle.

Major hurricanes – North Atlantic



Number of hurricanes – North Atlantic



Raw data: https://www.aoml.noaa.gov/hrd/hurdat/comparison_table.html



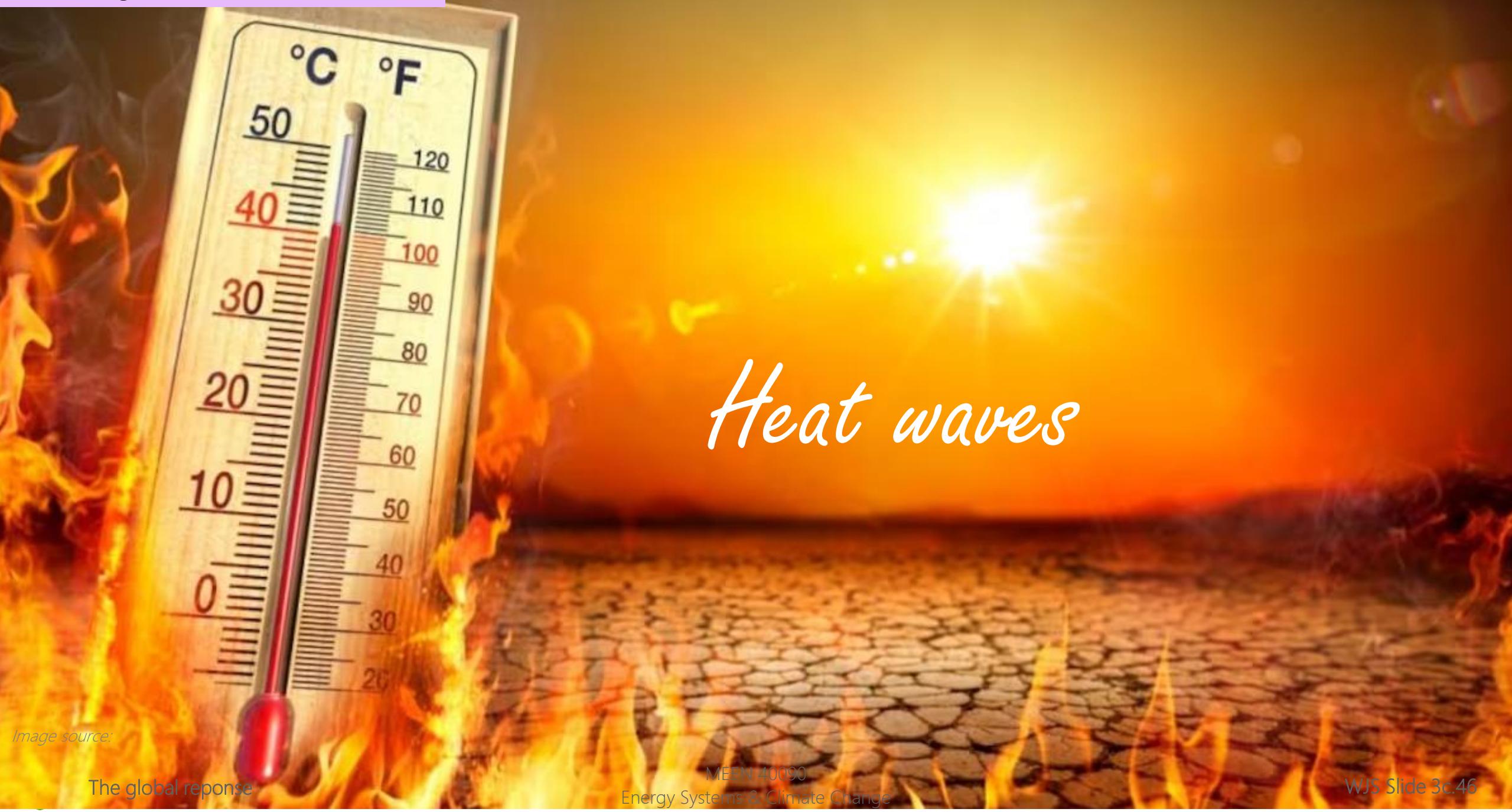
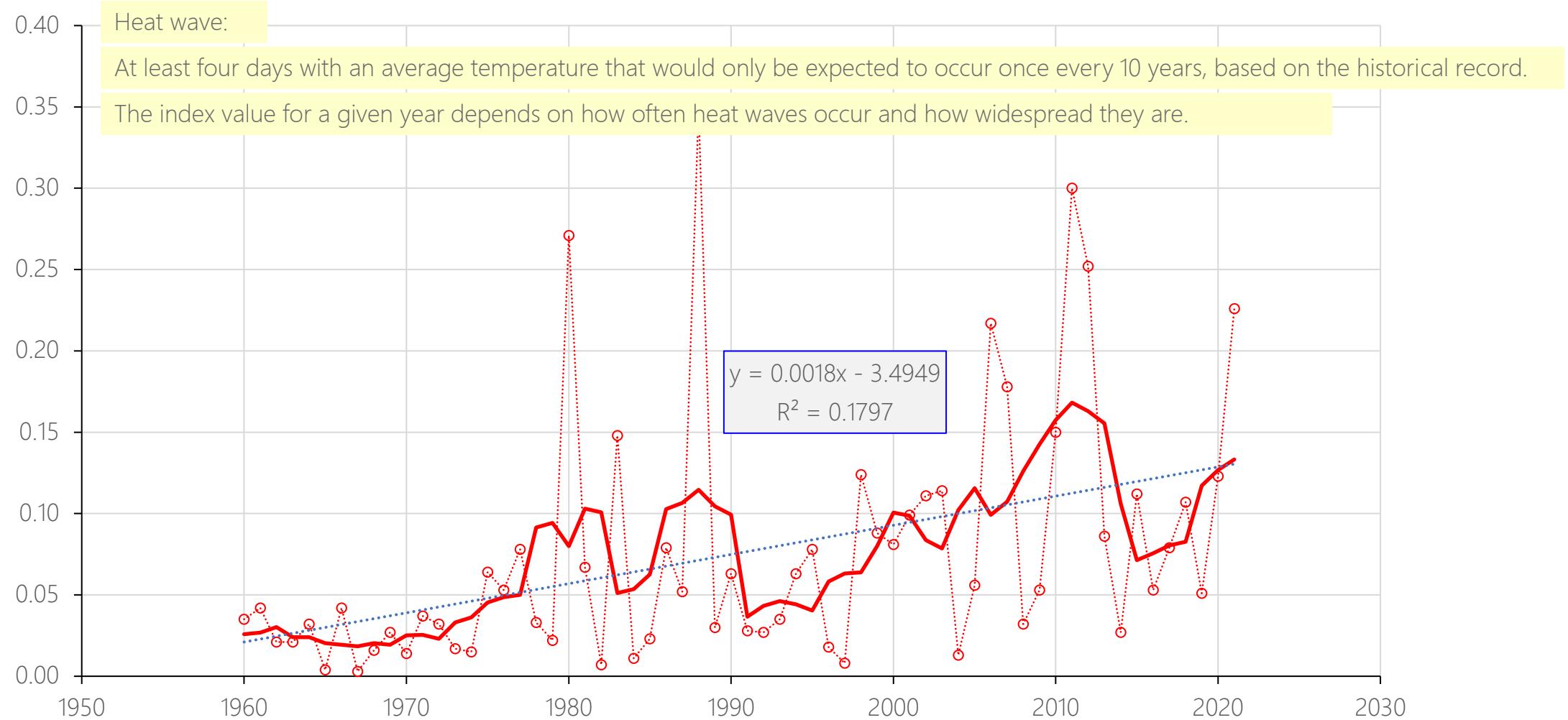


Image source:

The global reponse

2. Heat waves

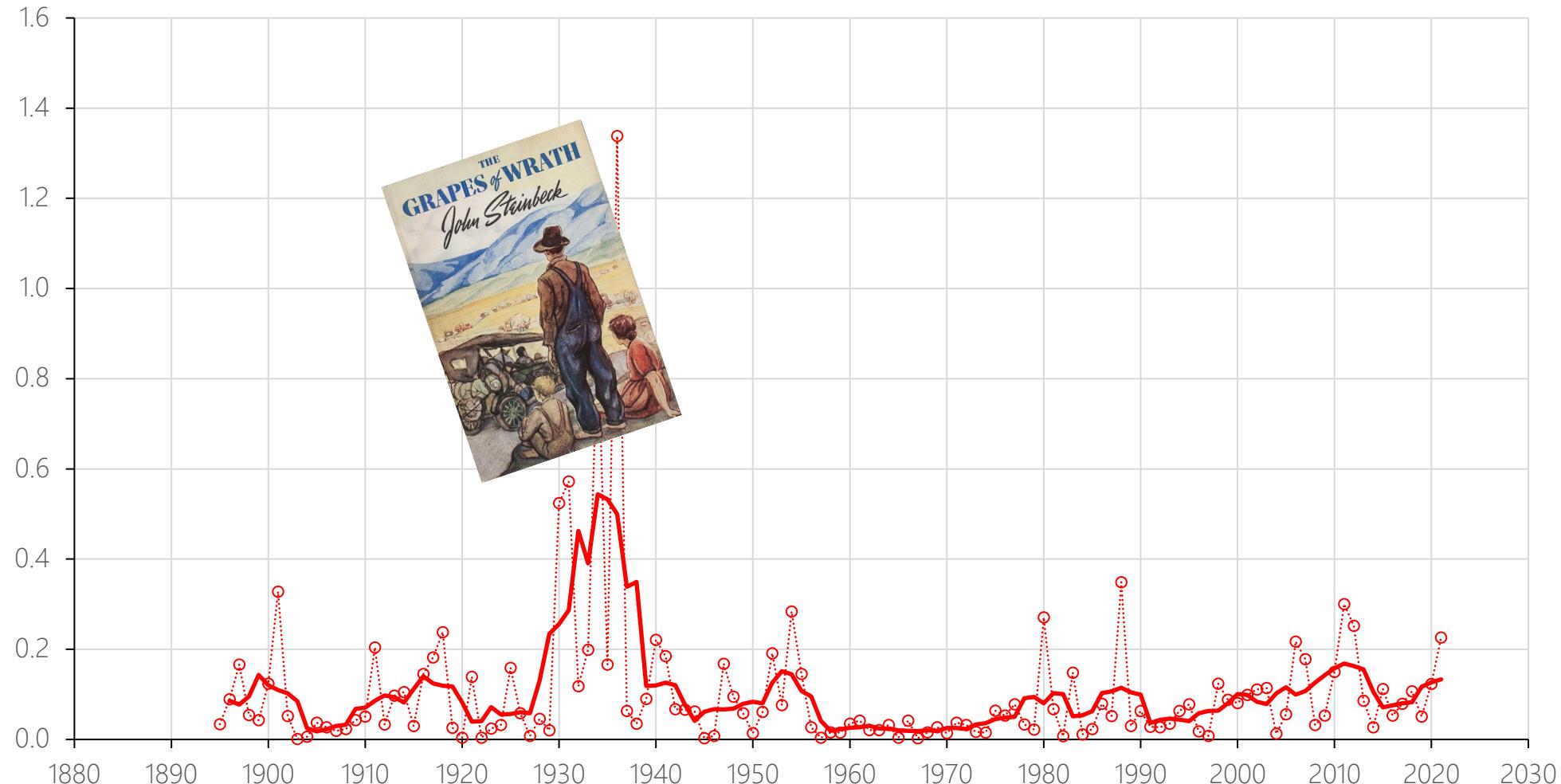
US annual heat-wave index, 1960-2021



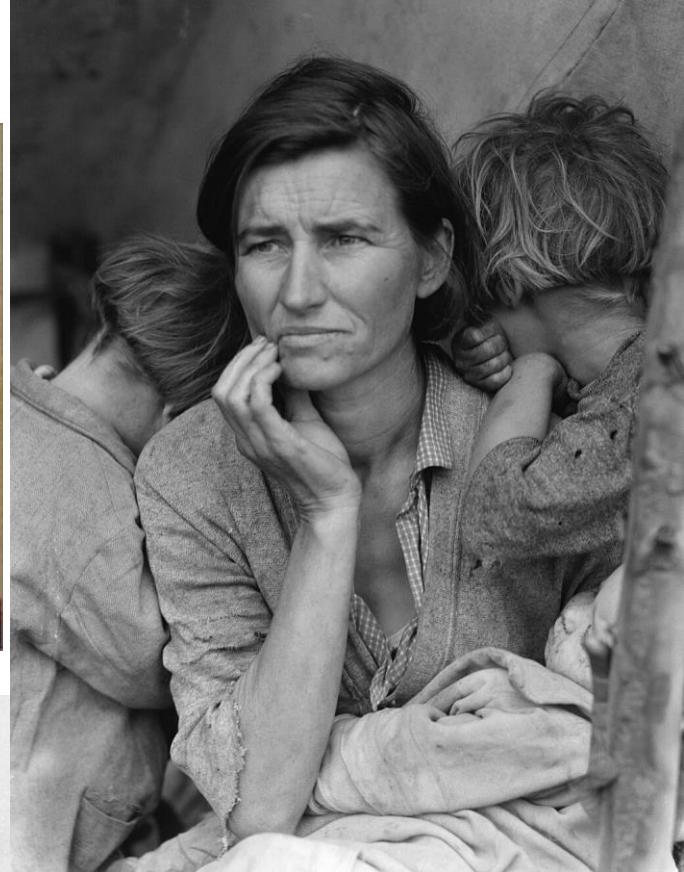
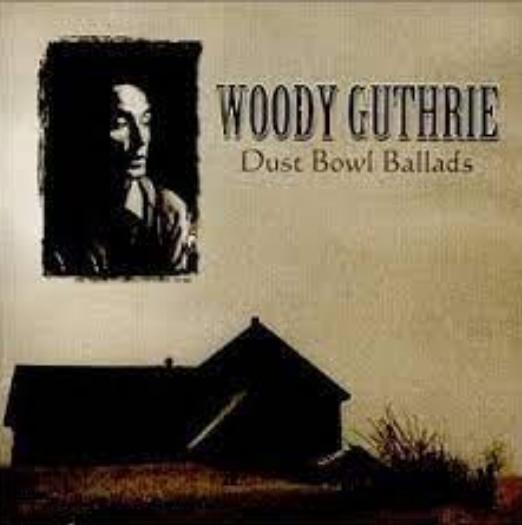
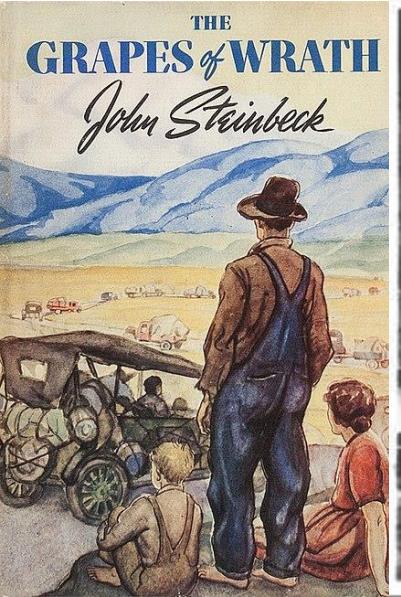
Raw data: <https://ourworldindata.org/grapher/heat-wave-index-usa?time=earliest..latest>

2. Heat waves

US annual heat-wave index, 1895 - 2021



Raw data: <https://ourworldindata.org/grapher/heat-wave-index-usa?time=earliest..latest>



"Migrant Mother"
Dorothea Lange's iconic 1936
photograph of Florence Owens
Thompson

...and Impacts



How do we define (measure) the impacts?



- Mortality / excess deaths?
- Injuries / displacements?
- Financial cost?
- % of GDP?

Image source: World Disasters Report 2022, Data Annex.

https://www.ifrc.org/sites/default/files/2023-01/20230130_2022_WDR_DataAnnex.pdf

Where can we find relevant, objective, "impacts" data?



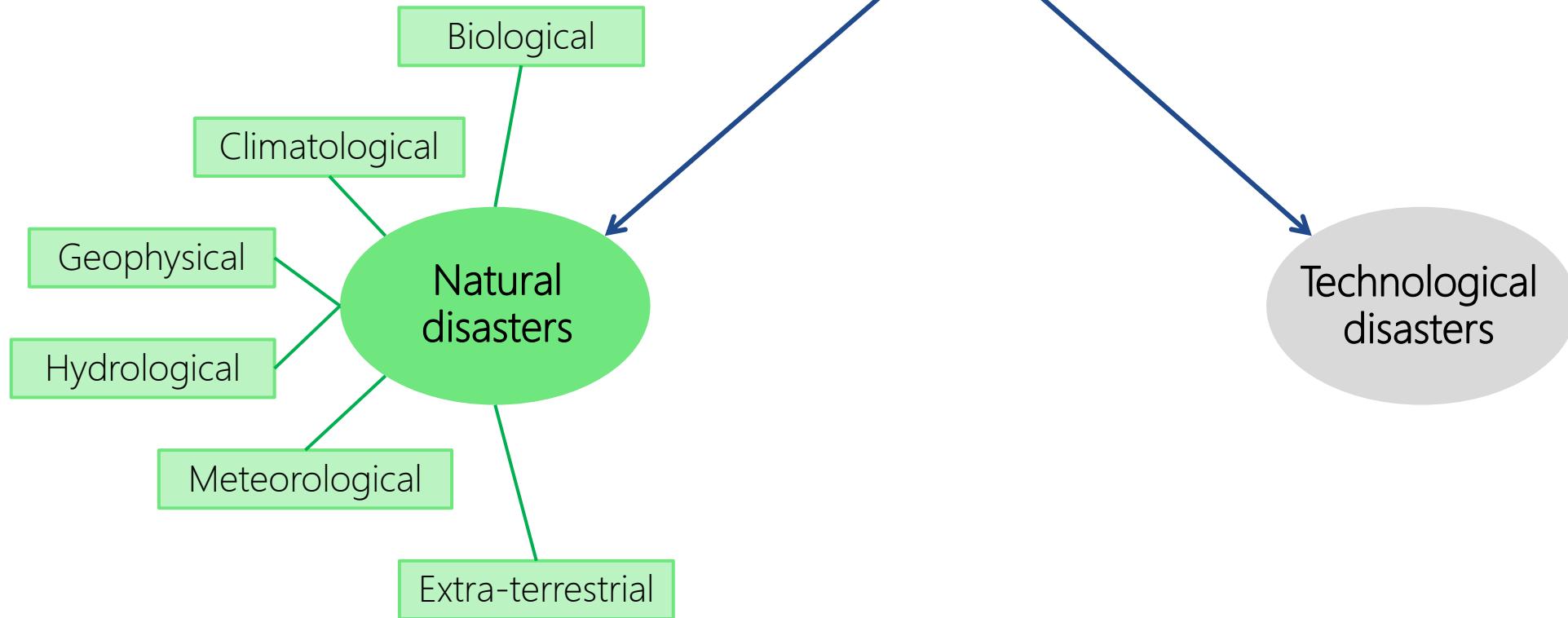
- Created in 1988 with support of the World Health Organization (WHO), and the Belgian Government.
- Main objective is to support humanitarian actions at national and international levels.



- At least one of the following criteria must be fulfilled before a new event can be added to the database:
 - 10 or more deaths.
 - 100 or more people affected/injured/homeless.
 - declaration of a state of emergency and/or an appeal for international assistance.
- Data sources include UN, governmental and non-governmental agencies, insurance companies, research institutes and press agencies.
- A disaster will only be entered if **at least two sources** report the occurrence of a disaster in terms of deaths and/or affected people.

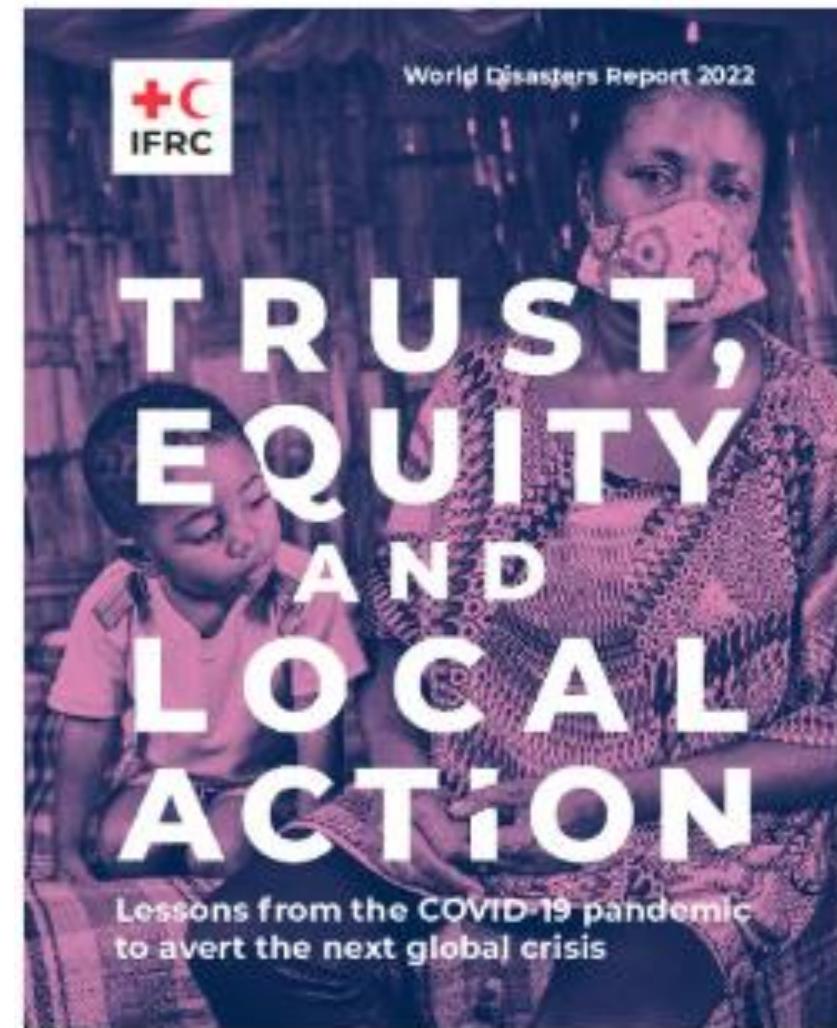


You can download this data for yourself, free, from public.emdat.be.



You can download this data for yourself, free, from public.emdat.be.

World Disasters Report



EM-DAT is the primary data source for the "World Disasters Report" published each year by the IFRC.

The International Federation of Red Cross and Red Crescent Societies (IFRC) is the world's largest humanitarian network.

Image source: World Disasters Report 2022, Data Annex.

https://www.ifrc.org/sites/default/files/2023-01/20230130_2022_WDR_DataAnnex.pdf

What does the data tell us about the 100-year trends in “climate-related” impacts?

Figure 8.11: Total deaths from disasters recorded globally per decade, split by disaster type

Note:

"climate-related" is not the same as "climate change-related".

- In the EM-DAT categorisation, "climate-related" deaths include those due to climatological, meteorological, and hydrological disasters.
- Deaths from climate-related disasters have **decreased dramatically** over the past 60 years:

1962-1971: 1.95 million

2012-2021: 0.11 million

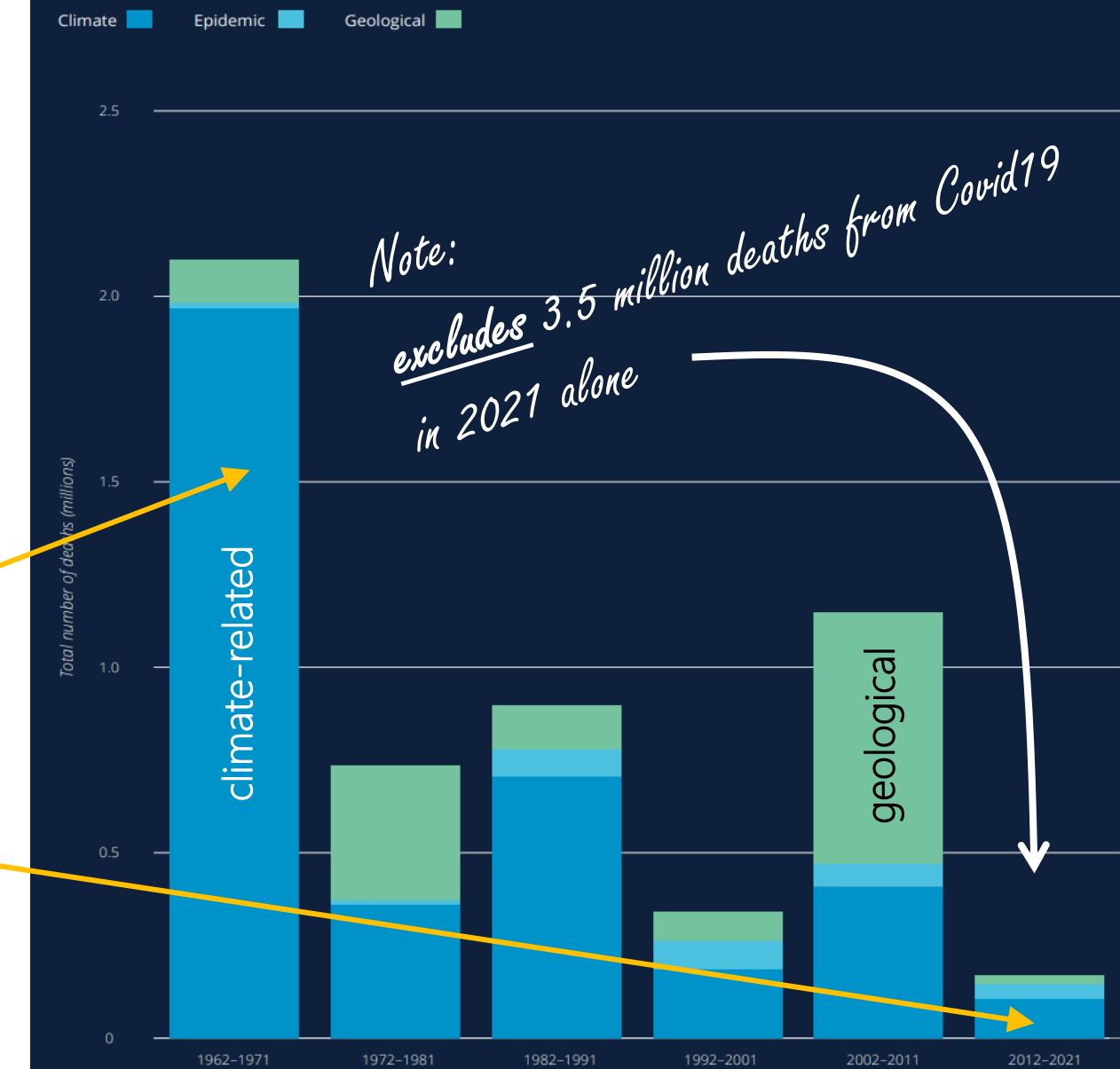


Image source: World Disasters Report 2022, Data Annex.

https://www.ifrc.org/sites/default/files/2023-01/20230130_2022_WDR_DataAnnex.pdf

- Deaths due to “Biological” disasters (epidemics – not including Covid19) have, apparently, plummeted
- Deaths due to “Geophysical” disasters (earthquakes and volcanoes) seem fairly consistent.



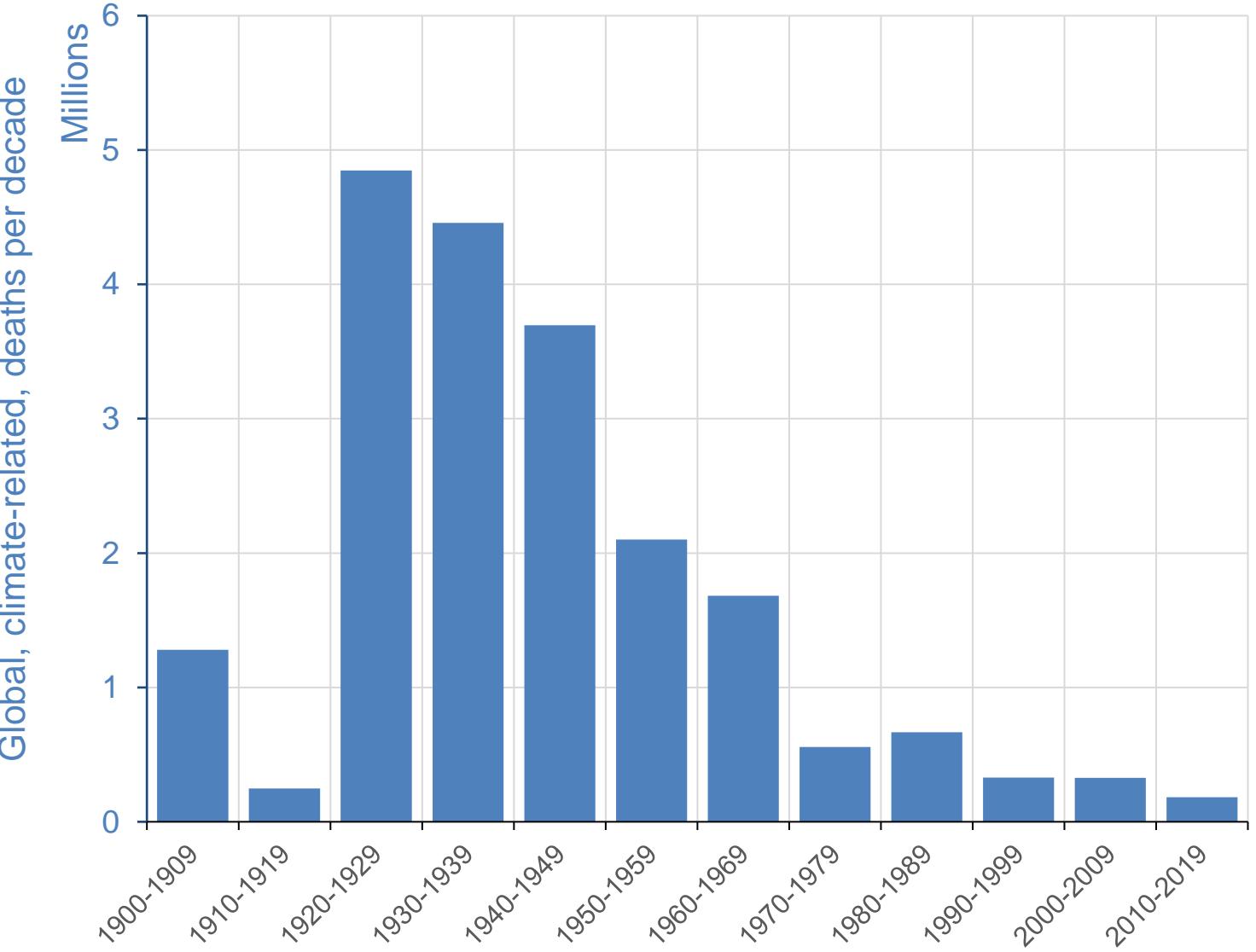
Raw data: <https://public.emdat.be/data>

Considered over the past century, the decline in “climate-related” deaths has been dramatic.

Bear in mind that:

- Global population increased by a factor of ~4, between 1920 and 2010.
- Data from earlier decades is likely incomplete, of variable quality, and probably under-estimated.
- You can download this data for yourself, free, from public.emdat.be.

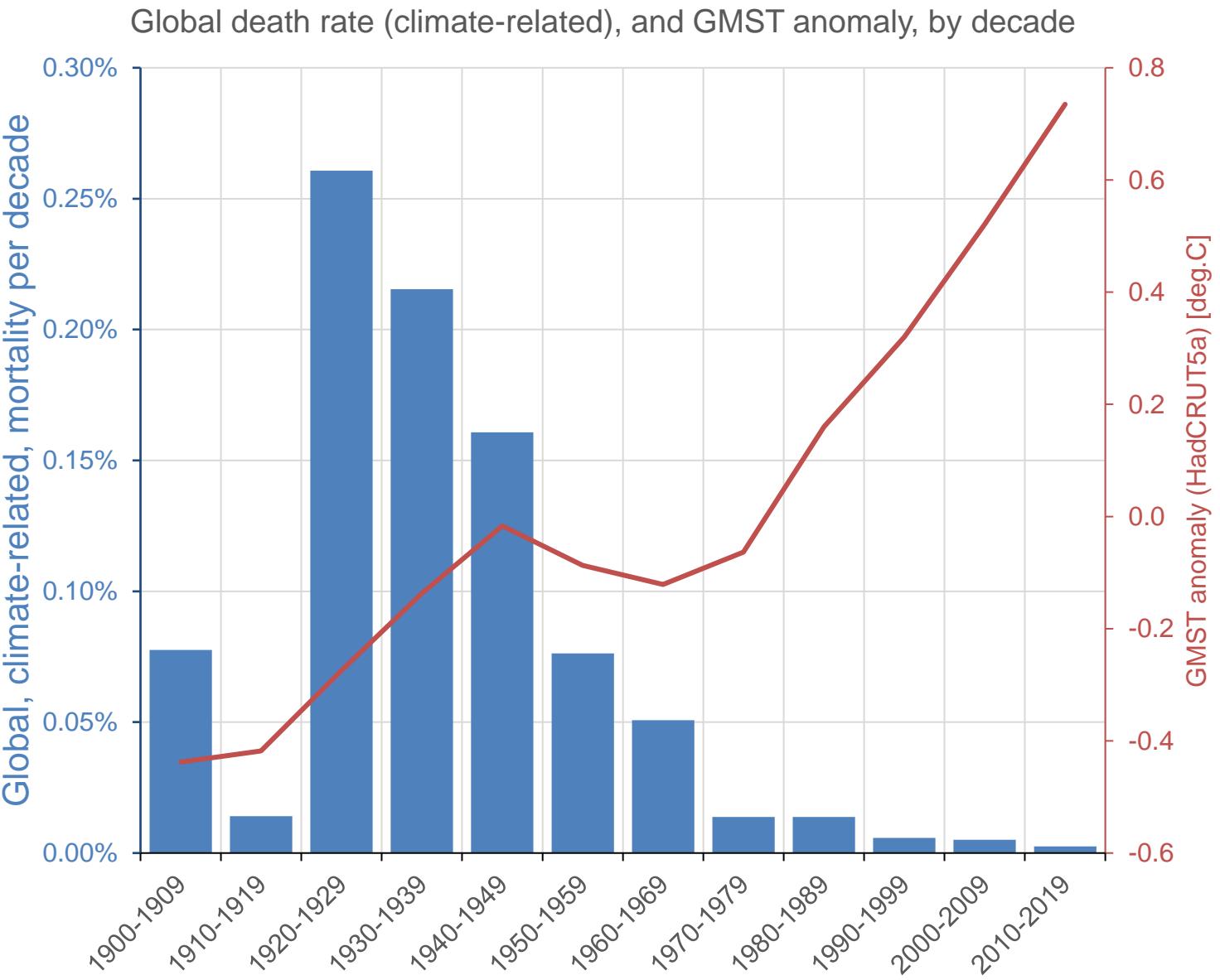
Global deaths (climate-related), by decade



Raw data: <https://public.emdat.be/data>

Considering mortality rate, the reduction in climate-related impact is stronger still.

Despite increasing surface temperatures, climate-related mortality rates decreased by a factor of 17 between the 1960s and the 2010s.

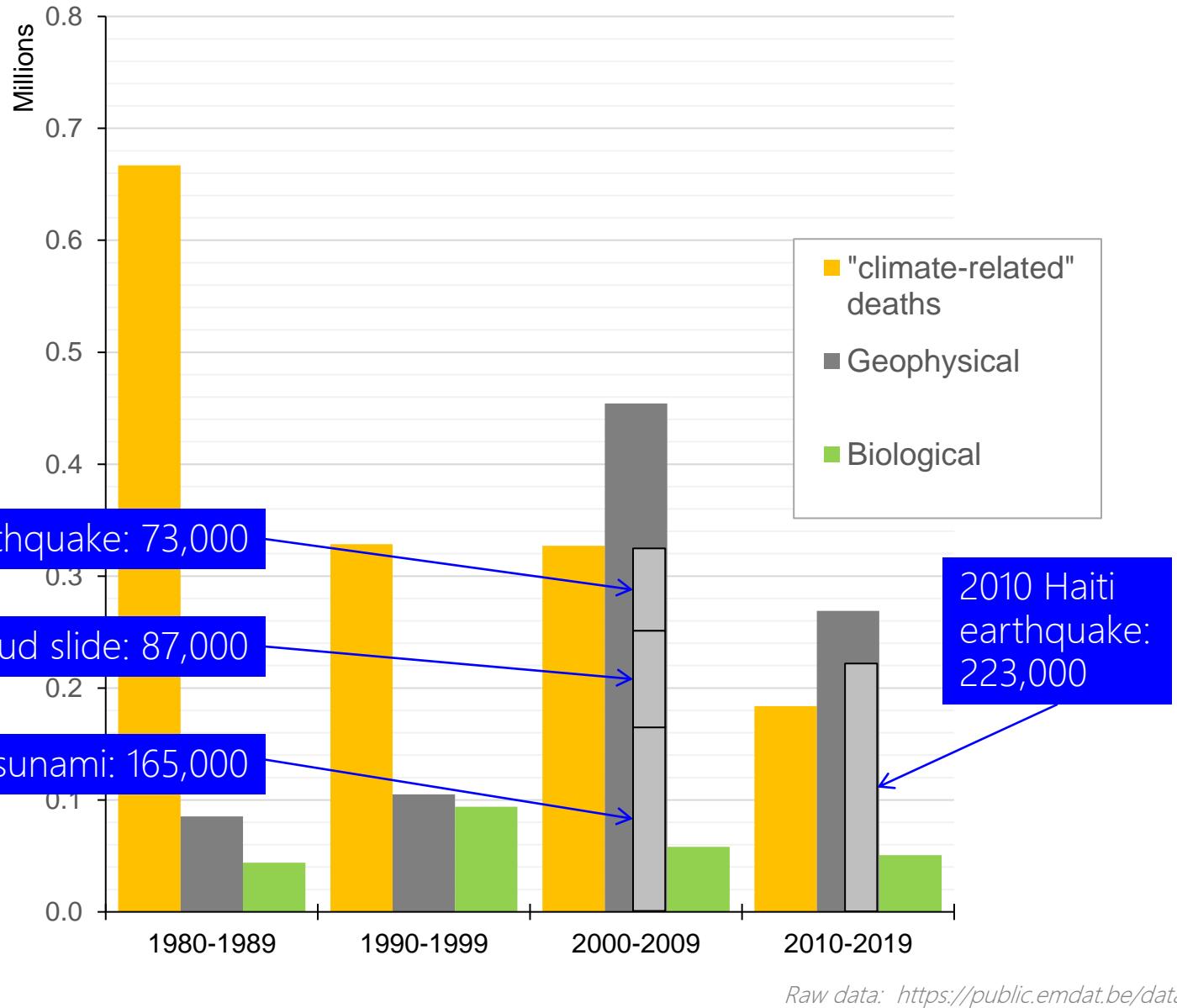


Raw data: <https://public.emdat.be/data>.

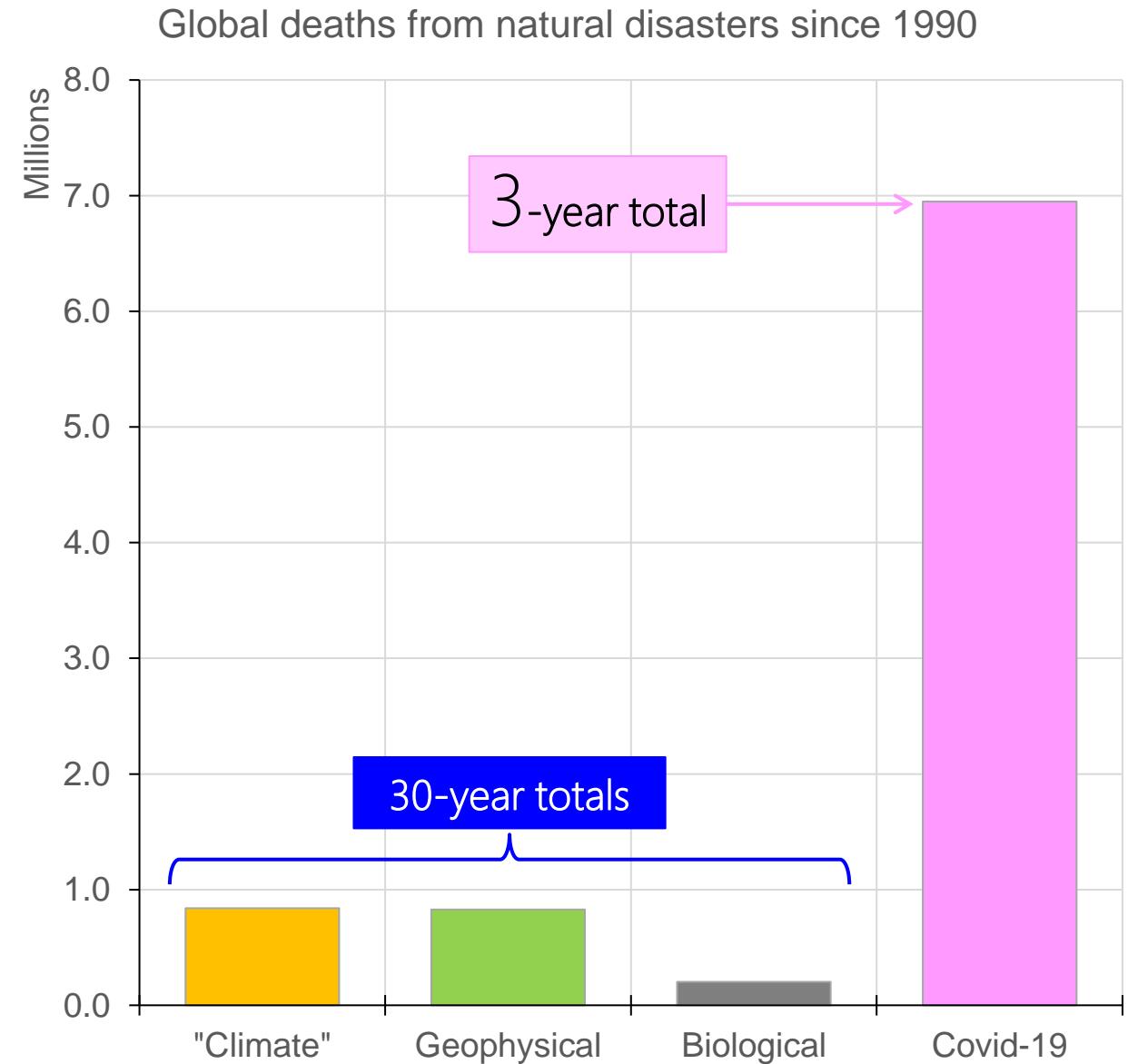
Compare "climate-related" with "geological"

- The four seismic events highlighted here accounted for more than two decade's worth of climate-related deaths.

Global deaths from natural disasters, by decade



Compare "climate-related" with Covid-19



Raw data: <https://public.emdat.be/data>.

Compare "climate-related" with Covid-19

In 2021, the death toll from Covid-19 was **>240 times higher** than from all natural disasters combined...

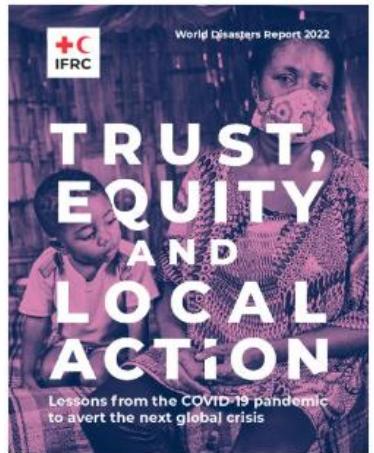


Image source: World Disasters Report 2022.

https://www.ifrc.org/sites/default/files/2023-01/20230130_2022_WDR_DataAnnex.pdf

14,577 deaths
by disaster in 2021

3,529,949 deaths

by COVID-19 in 2021

COVID-19

83.0 million cases in 2020
1.9 million deaths in 2020

204.7 million cases in 2021
3.5 million deaths in 2021

Disasters

99.0 million people affected in 2020
15,396 deaths in 2020

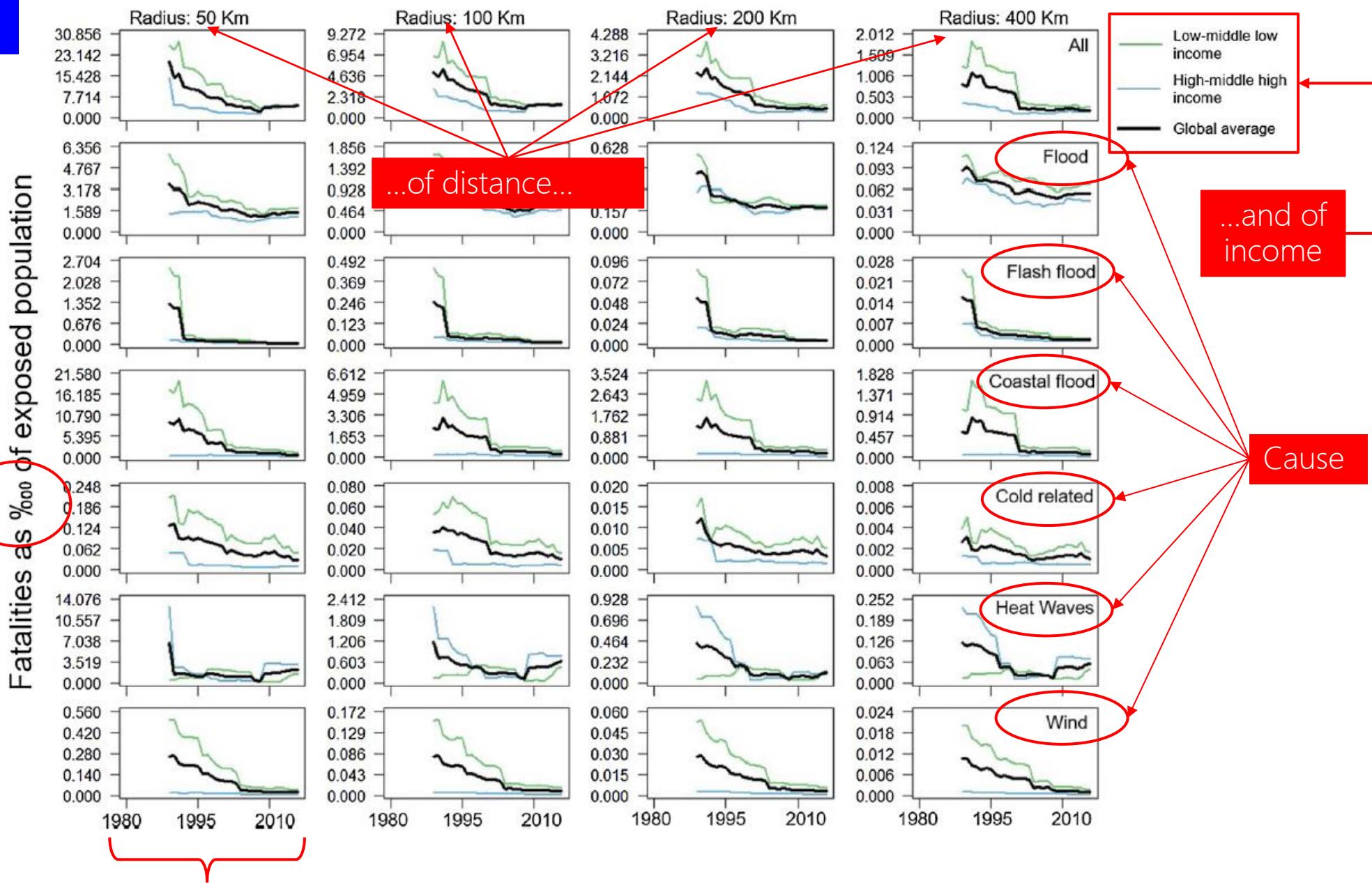
121.3 million people affected in 2021
14,577 deaths in 2021

Assessing impacts

Figure source:

"Empirical evidence of declining global vulnerability to climate-related hazards", Formetta and Feyen, Global Environmental Change 57 (2019) 101920

Fatalities per
10,000 people
exposed.

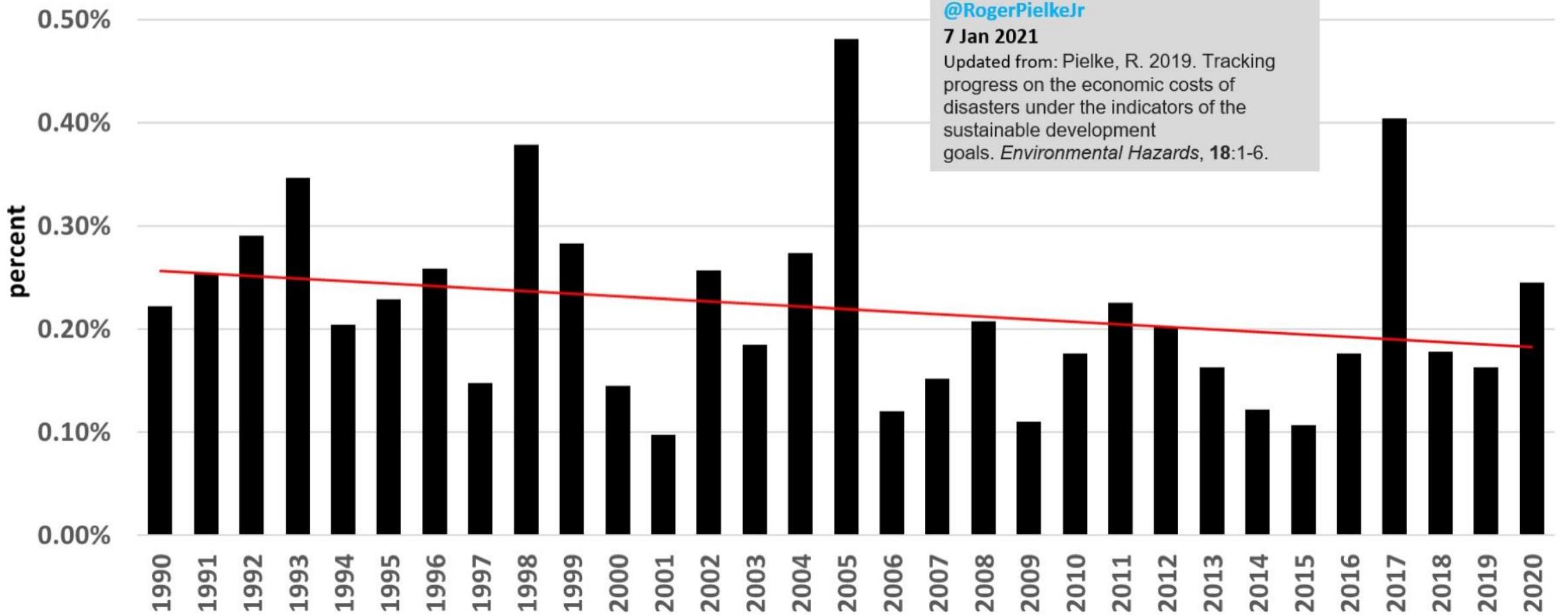


...as a function of time



Global Weather Losses as Percent of Global GDP: 1990-2020

(Sources: Munich Re, World Bank)



@RogerPielkeJr

7 Jan 2021

Updated from: Pielke, R. 2019. Tracking progress on the economic costs of disasters under the indicators of the sustainable development goals. *Environmental Hazards*, 18:1-6.

Is warmer worse (or better) than colder / no change?

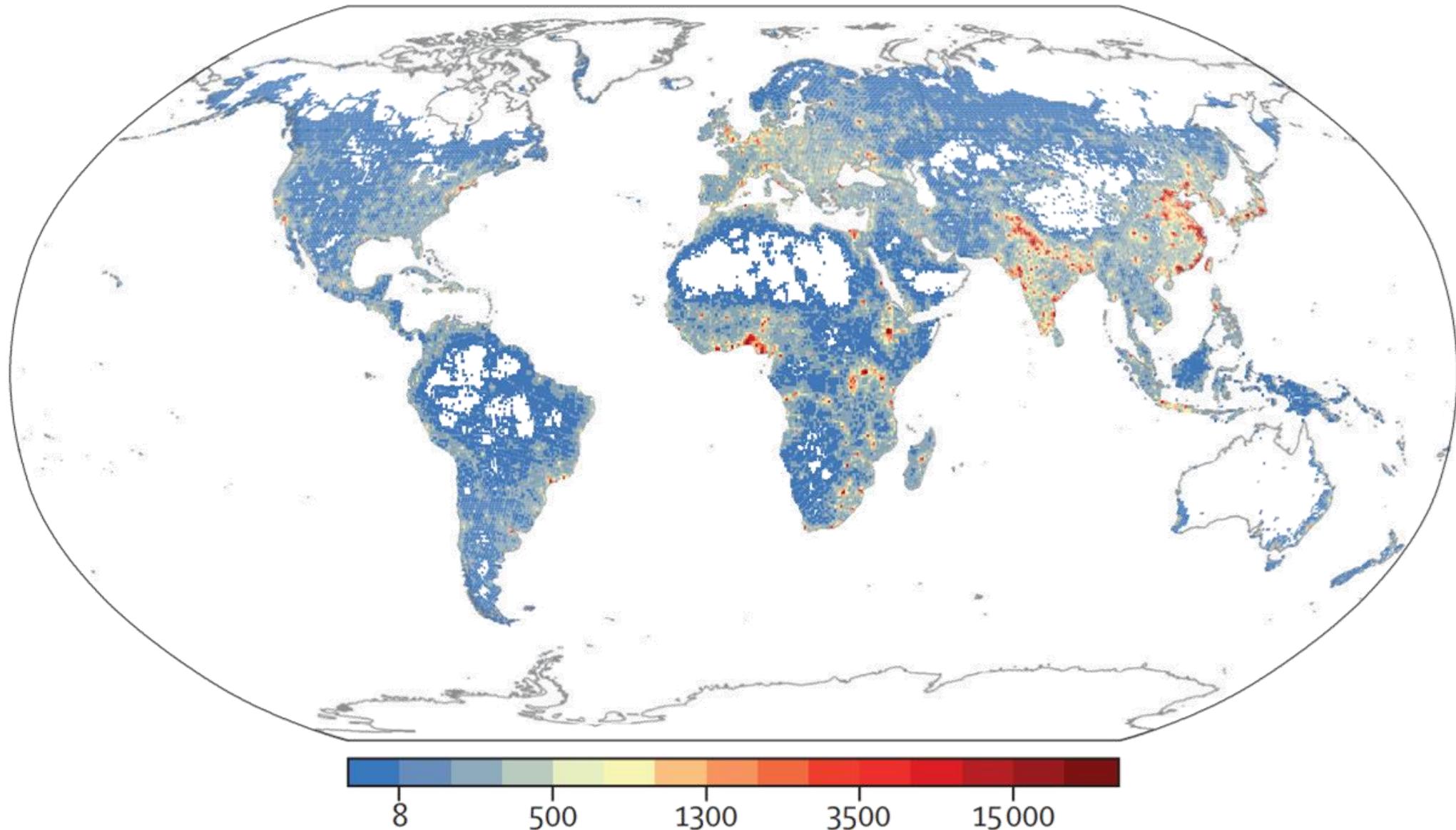


Image source: "Global, regional, and national burden of mortality associated with non-optimal ambient temperatures from 2000 to 2019: a three-stage modelling study".
Zhao et al., www.thelancet.com/planetary-health Vol 5 July 2021

Mortality associated with non-optimal temperatures, 2000-2019

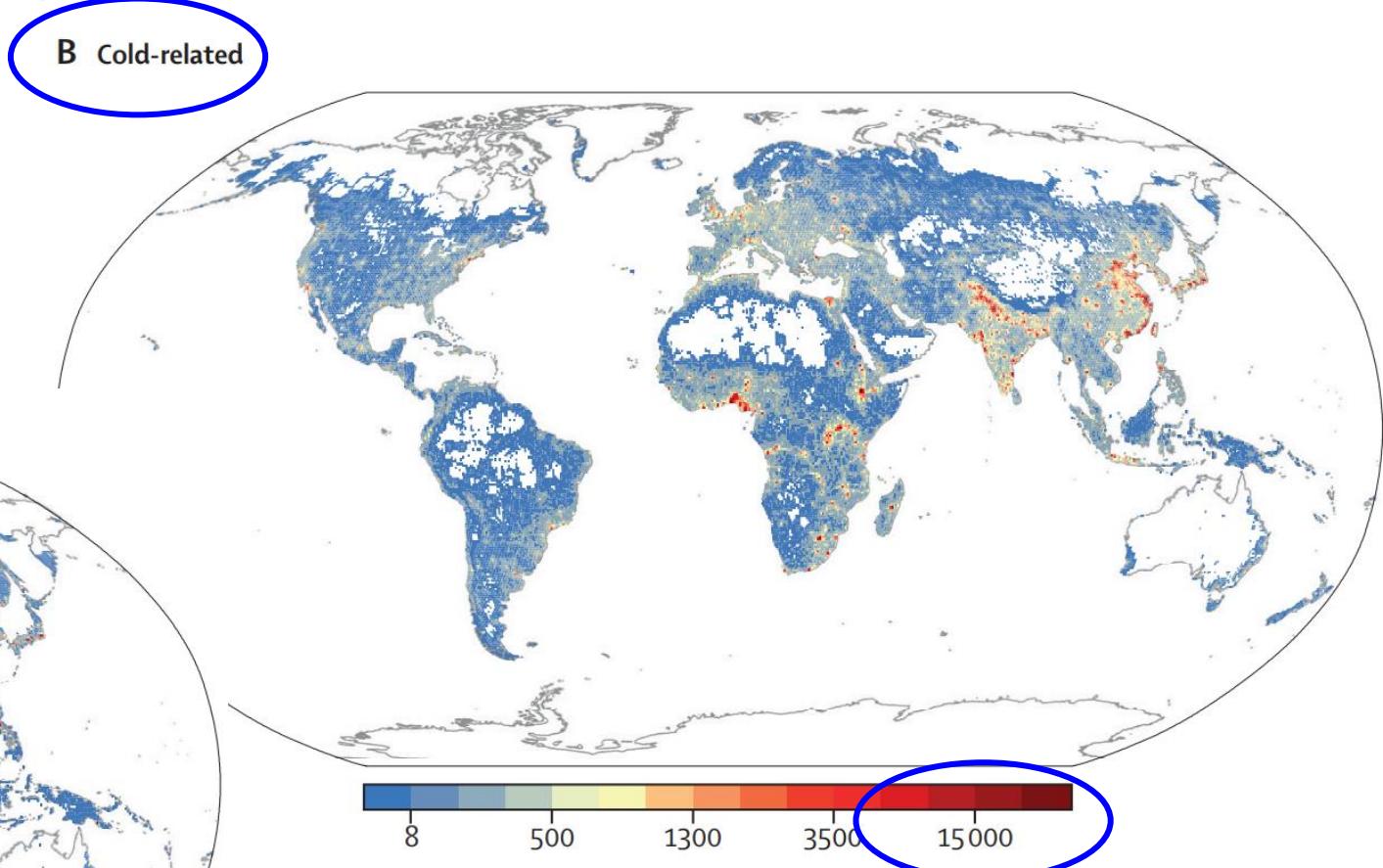
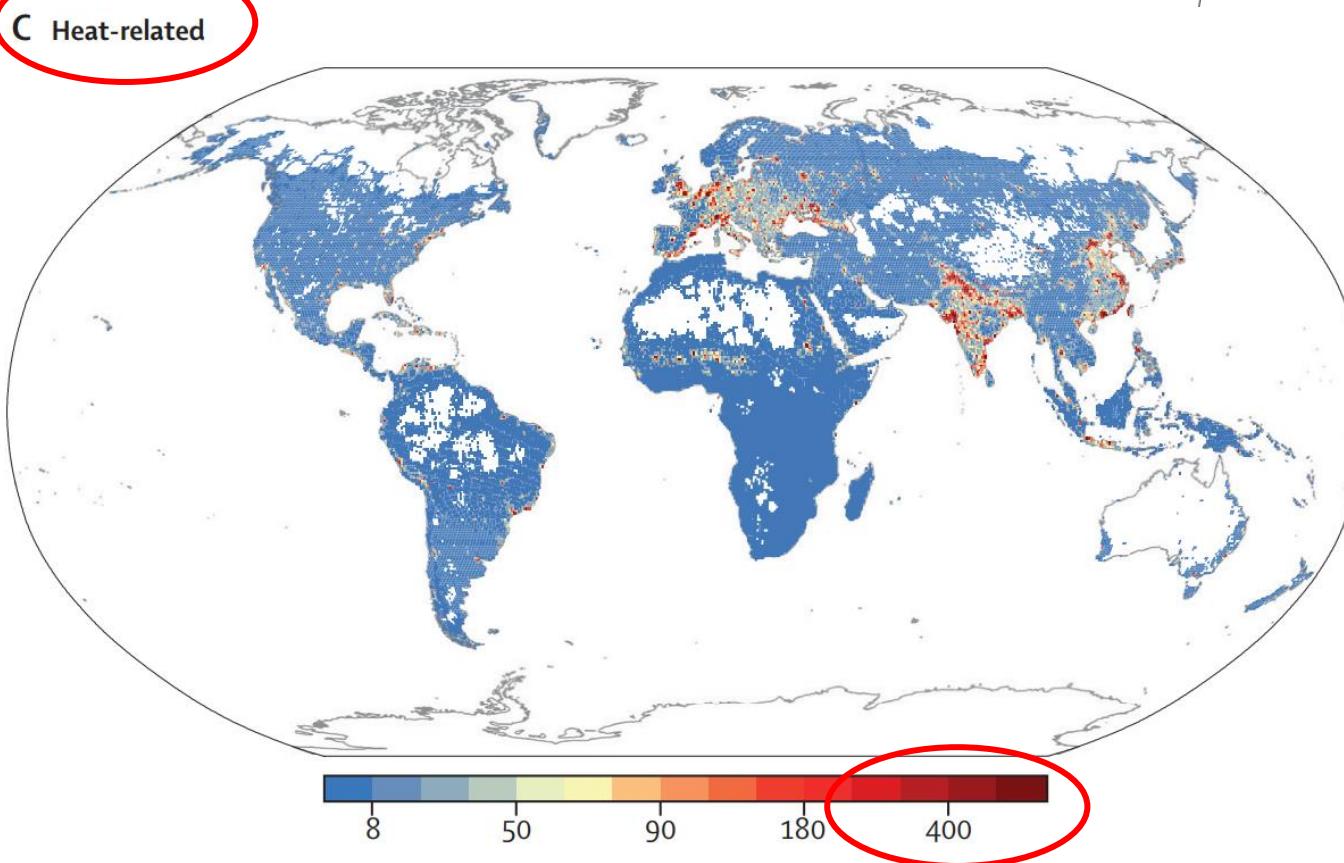


Figure 2

Average annual excess deaths due to non-optimal temperatures in 2000–19 at a spatial resolution of $0.5^\circ \times 0.5^\circ$

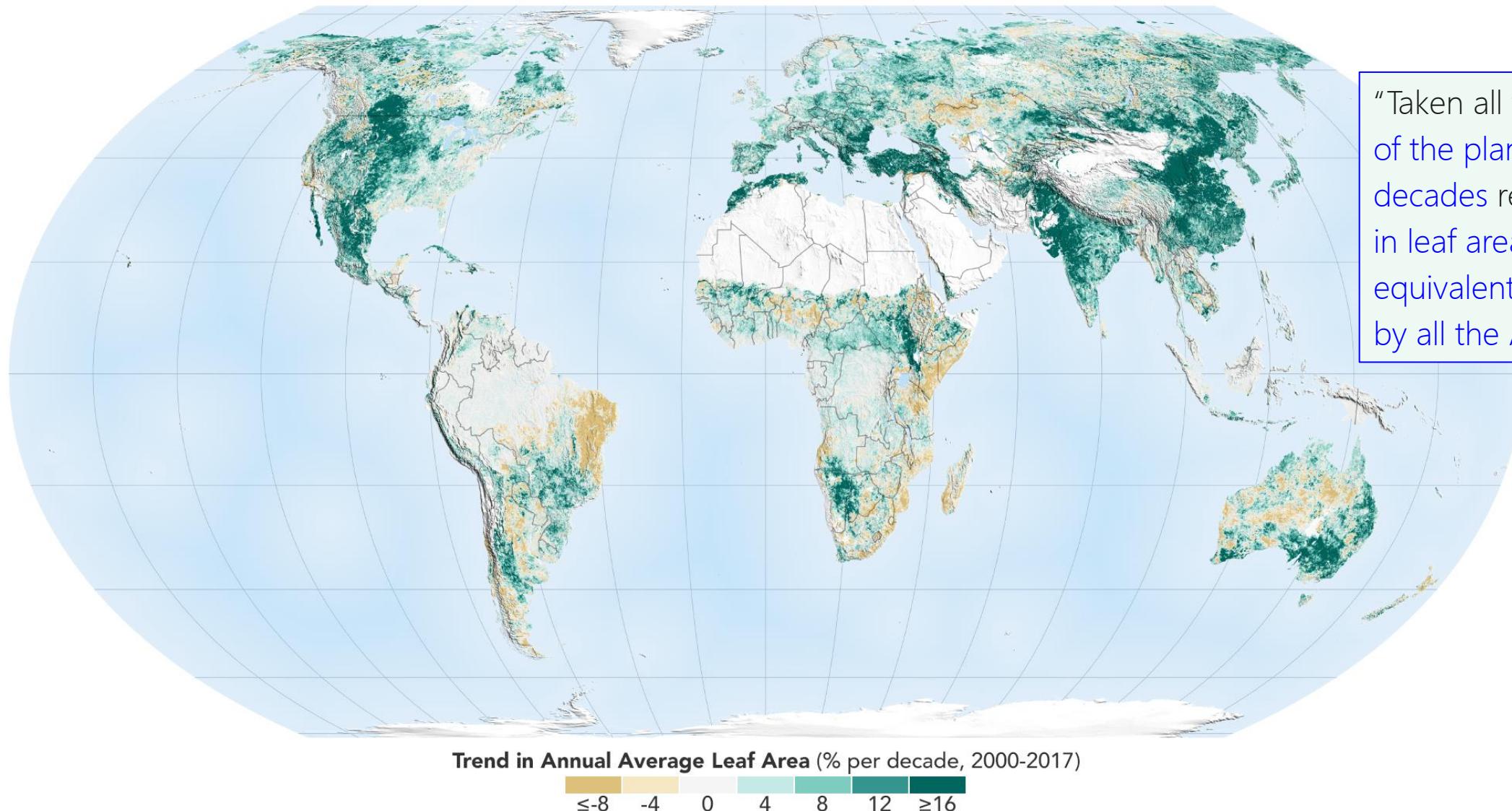
(A) Overall annual excess deaths. (B) Cold-related annual excess deaths. (C) Heat-related annual excess deaths. Only grids with at least one annual death were included.

A provocative perspective...



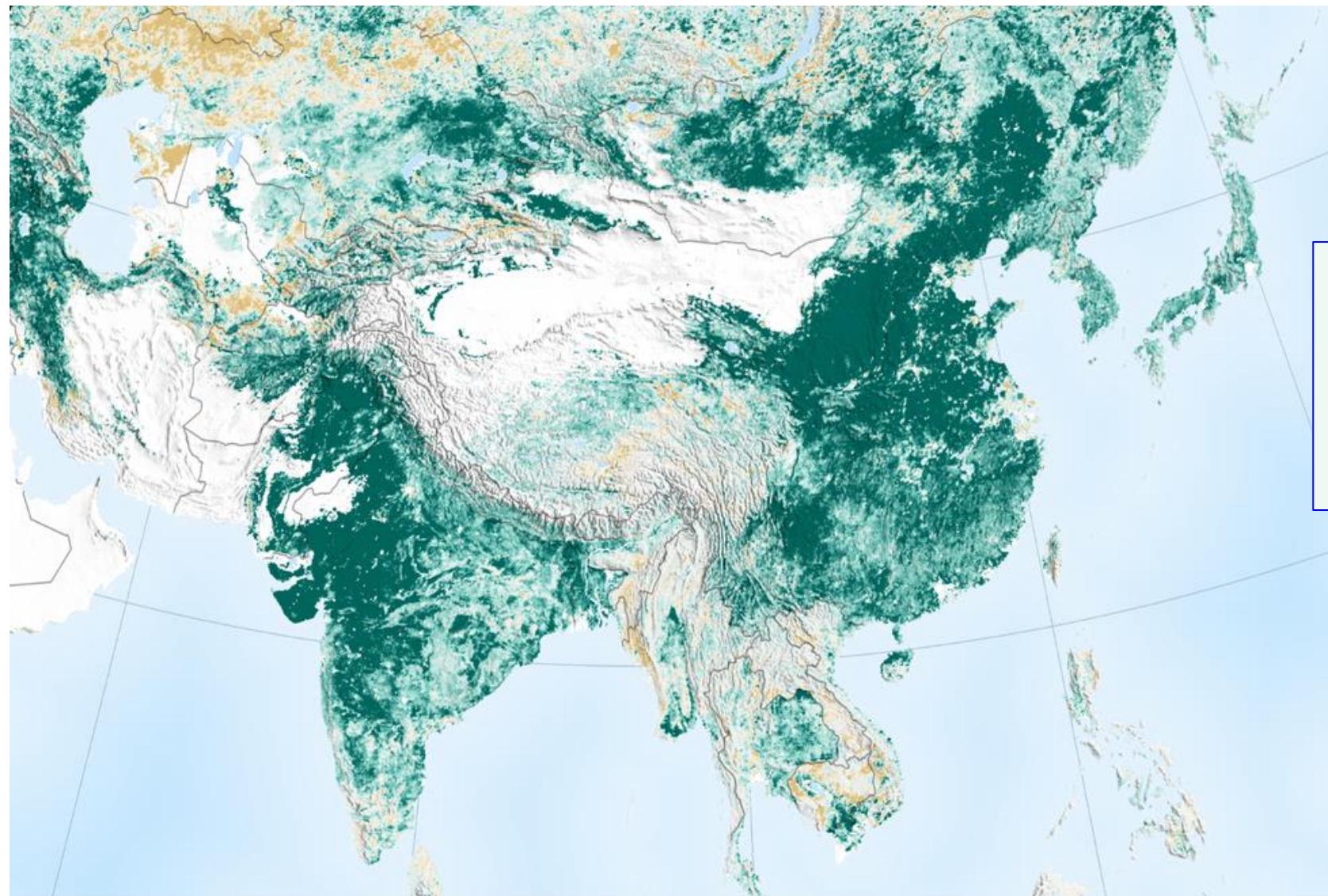
Human activities are “greening” the planet.





"Taken all together, the greening of the planet over the last two decades represents an increase in leaf area on plants and trees equivalent to the area covered by all the Amazon rainforests."

<https://www.nasa.gov/feature/ames/human-activity-in-china-and-india-dominates-the-greening-of-earth-nasa-study-shows>



"China and India account for one-third of the greening... a surprising finding, considering the general notion of land degradation in populous countries from overexploitation."

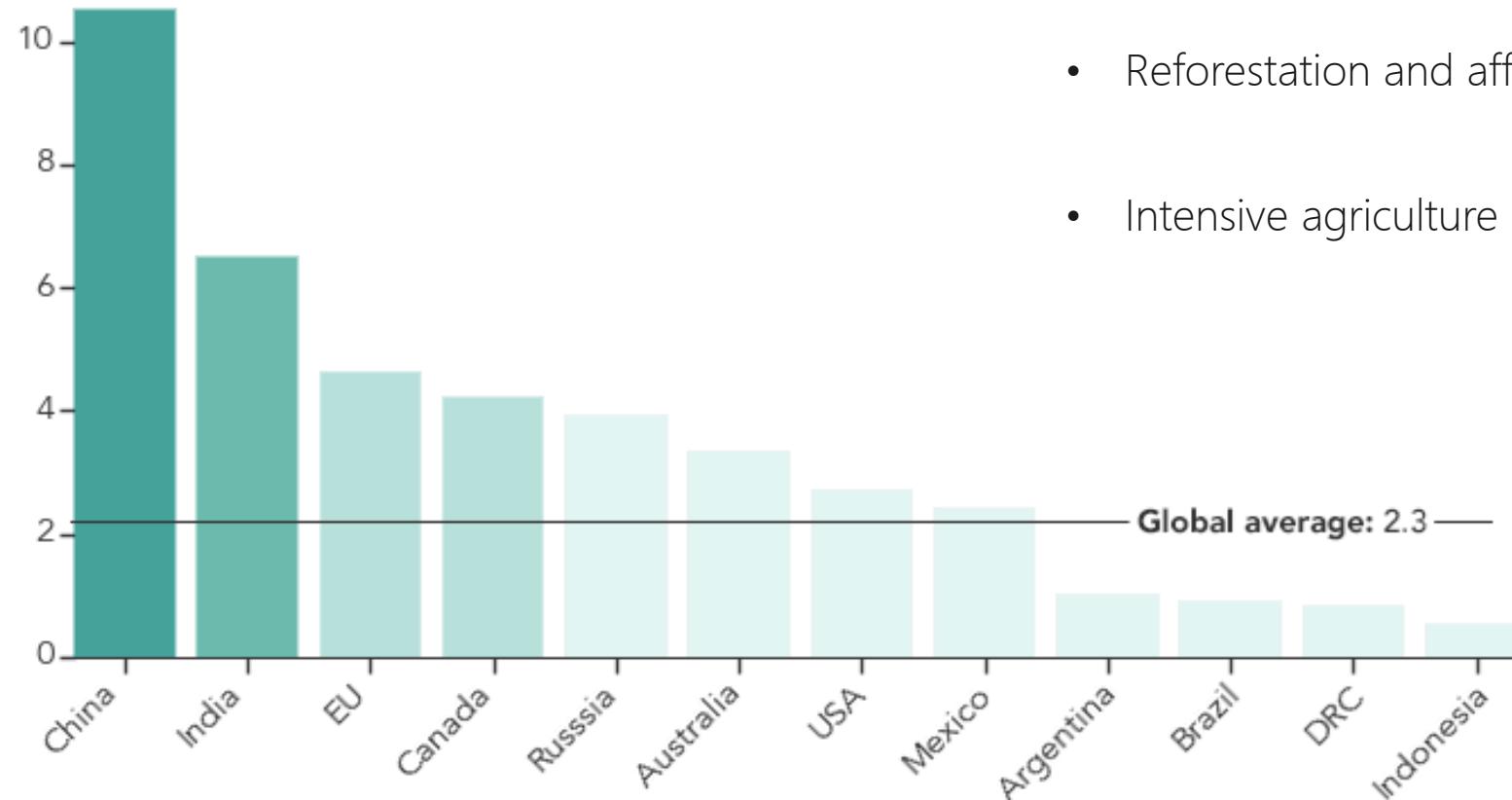
Trend in Annual Average Leaf Area (% per decade, 2000-2017)

≤ -8 -4 0 4 8 12 ≥16

<https://www.nasa.gov/feature/ames/human-activity-in-china-and-india-dominates-the-greening-of-earth-nasa-study-shows>

Causes of greening¹:**China and India Lead in Greening Due to Human Activity**

Change in Leaf Area (% per decade)



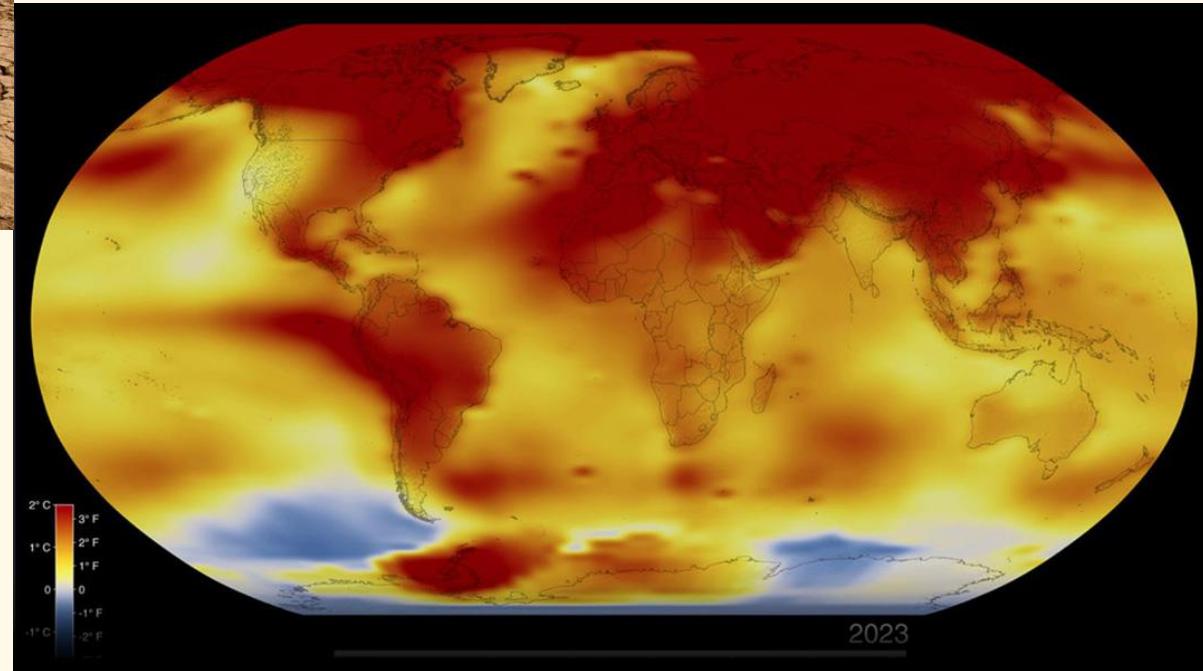
- Climate change: warmer, wetter, higher CO₂
- Reforestation and afforestation
- Intensive agriculture

~65%**Land-use change
(LUC, or AFOLU)****~35%**

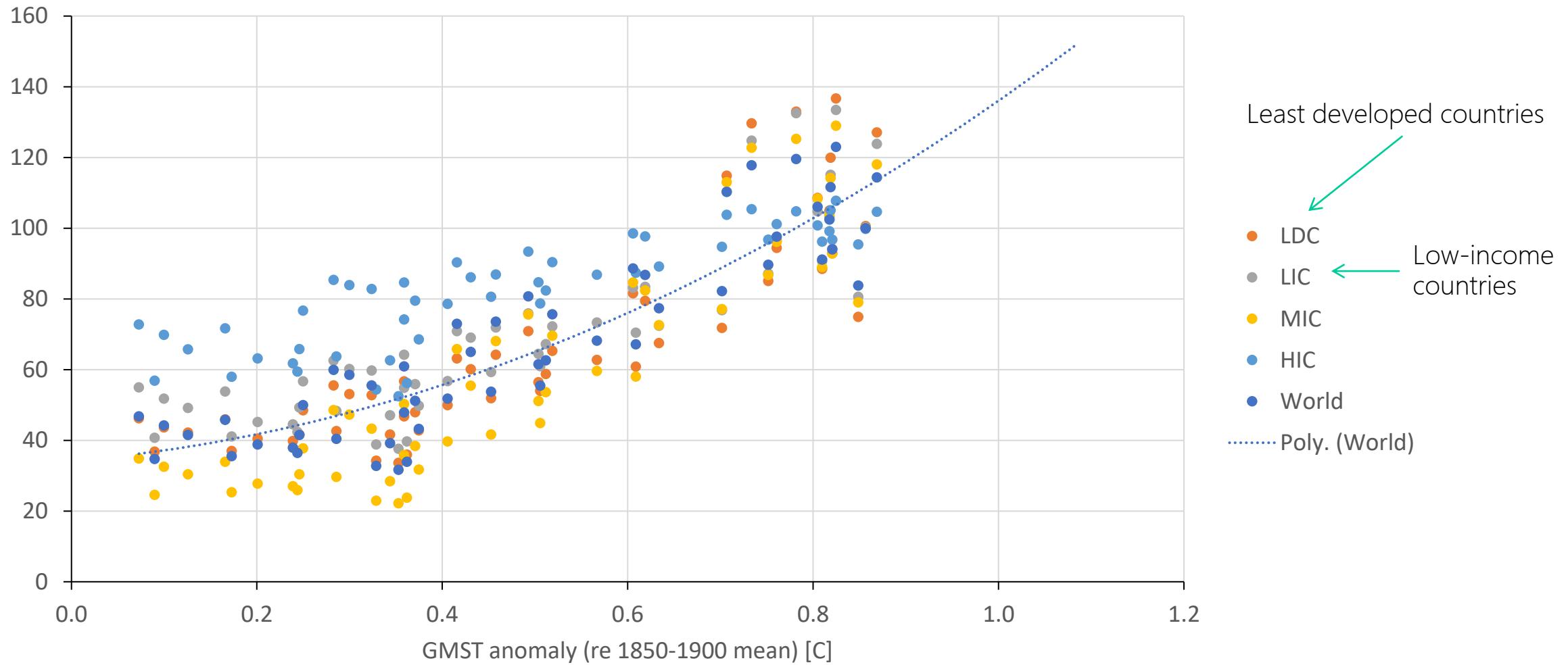
¹ Chen *et al*: *Nature Sustainability*, vol. 2, February 2019, 122–129

Figure: <https://www.nasa.gov/feature/ames/human-activity-in-china-and-india-dominates-the-greening-of-earth-nasa-study-shows>

A warmer planet is better for humans...?



Food production index (2004-2006 = 100)



Least developed countries

LDC

LIC

MIC

HIC

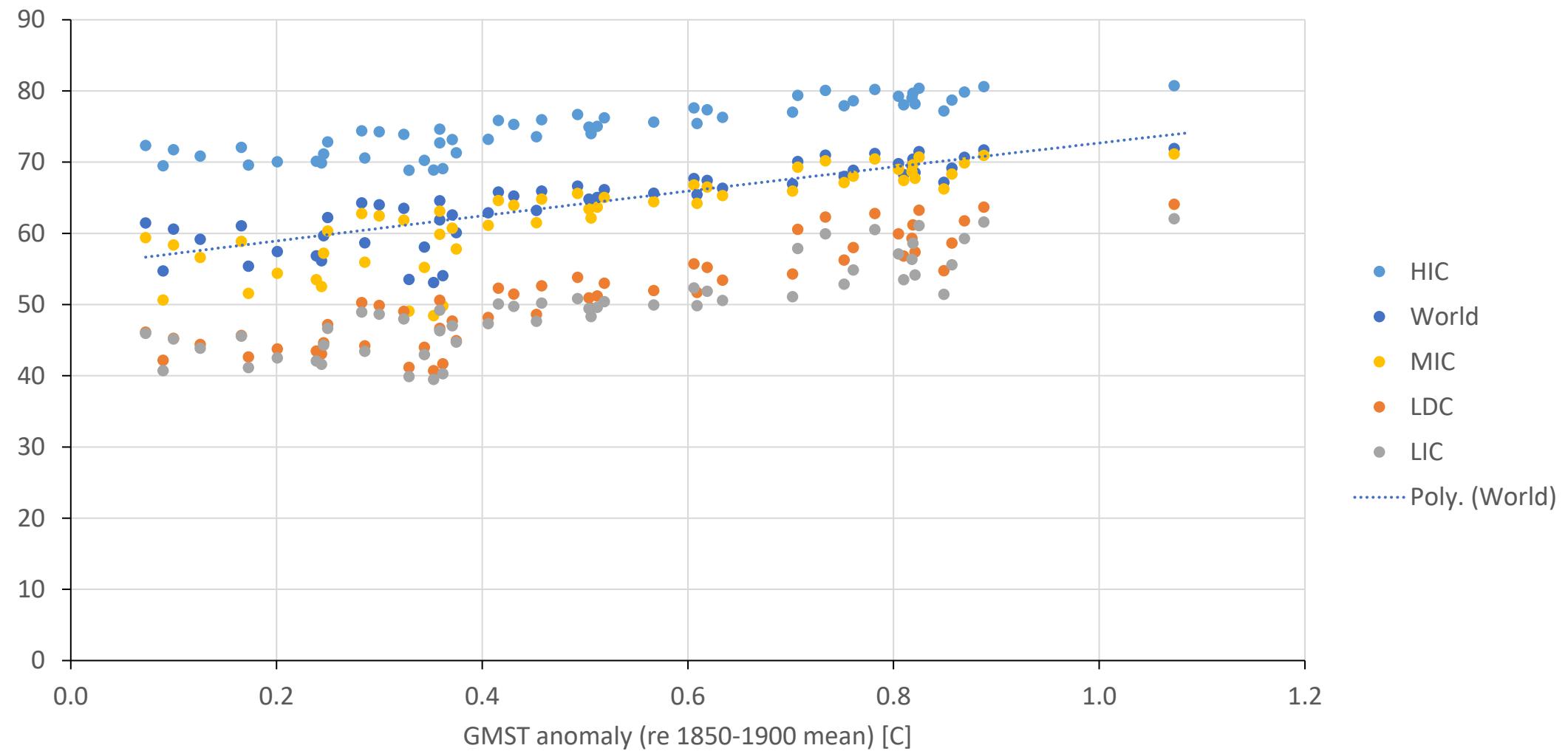
World

Poly. (World)

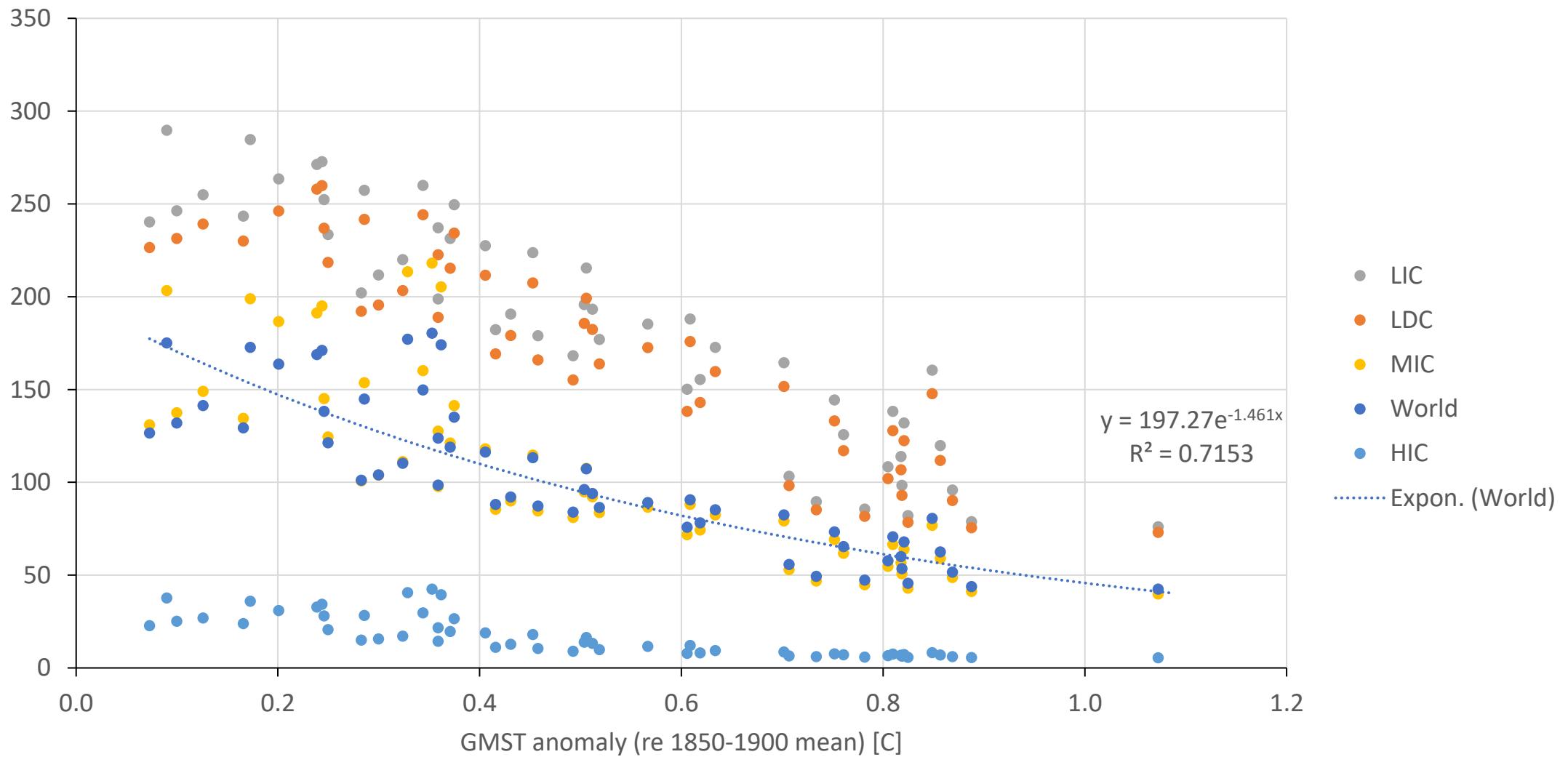
Low-income countries

Raw data: <https://data.worldbank.org/data-catalog/world-development-indicators>

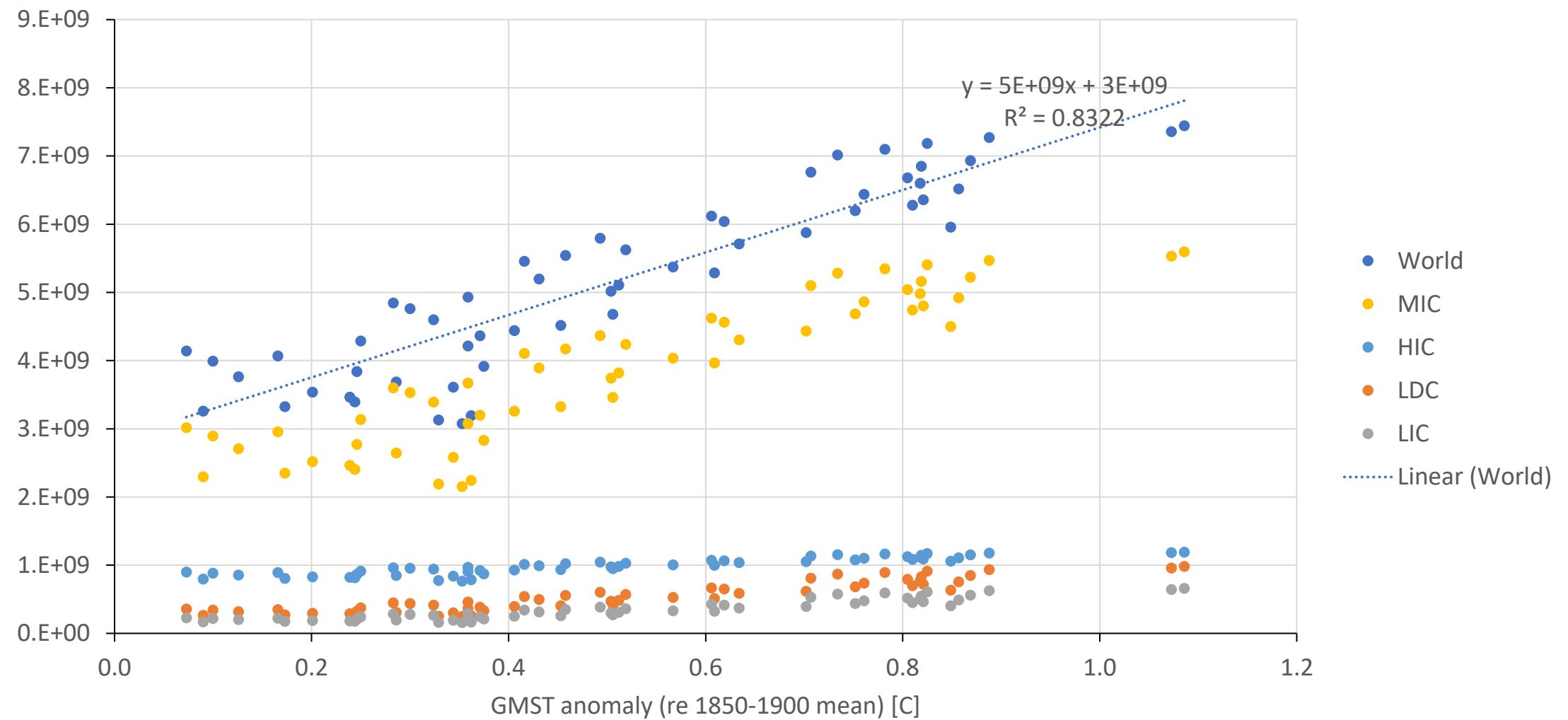
Life expectancy at birth, total (years)

Raw data: <https://data.worldbank.org/data-catalog/world-development-indicators>

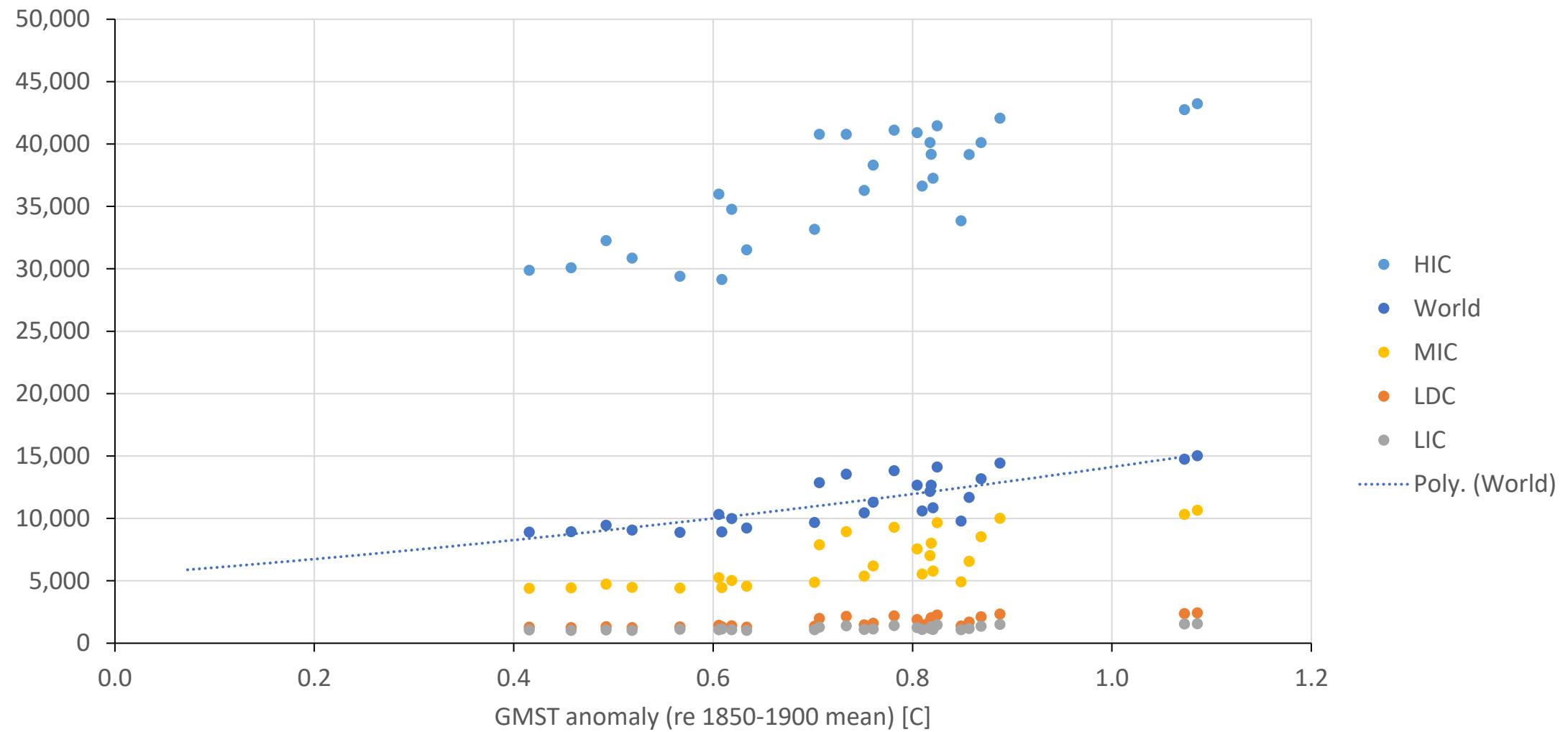
Mortality rate, under-5 (per 1,000 live births)

Raw data: <https://data.worldbank.org/data-catalog/world-development-indicators>

Population, total

Raw data: <https://data.worldbank.org/data-catalog/world-development-indicators>

GDP per capita, PPP (constant 2011 international \$)

Raw data: <https://data.worldbank.org/data-catalog/world-development-indicators>



Energy Systems & Climate Change

