RESEARCH SEMINAR

"Climate change, emerging conflicts and population movements"

Brief introduction to climate change evidence and impacts

EUPeace
European University for Peace, Justice, and Inclusive Societies

Prof. Alfonso Senatore

UNIVERSITÀ DELLA CALABRIA
DIPARTIMENTO DI INGEGNERIA DELL'AMBIENTE
CeSMMA

CeSMMA Lab and University of Calabria

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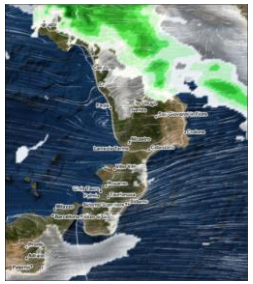
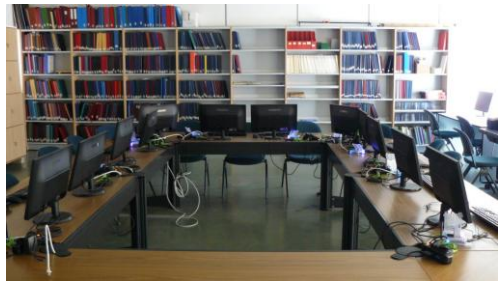
Monitoring

Modelling





Education

UNIVERSITÀ DELLA CALABRIA

CONTENTS

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- Climate change basics
- Current impacts (focus on population movements)
- Projected impacts (focus on population movements)

Trump orders USDA to take down websites referencing climate crisis

Forest service website among many sites affected as agencies scramble to comply with president's orders

The Climate Change Resource Center page on the USDA's website on Thursday. Photograph: USDA

https://www.theguardian.com/us-news/2025/jan/31/trump-order-usda-websites-climate-crisis

We (still) need to dwell on evidences

On Thursday [30.01.2025], the Trump administration ordered the US agriculture department to take down its websites documenting or referencing the climate crisis

[…]

The changes at the Forest Service website followed a directive issued by the United States Department of Agriculture's office of communications. In the memo, which was reviewed by the Guardian, officials instructed website managers across the agency to "identify and archive or unpublish any landing pages focused on climate change" . It also included a Friday deadline to list the mentions in a spreadsheet for further review

On Friday, USDA officials clarified that the content should not be deleted

Climate change basics

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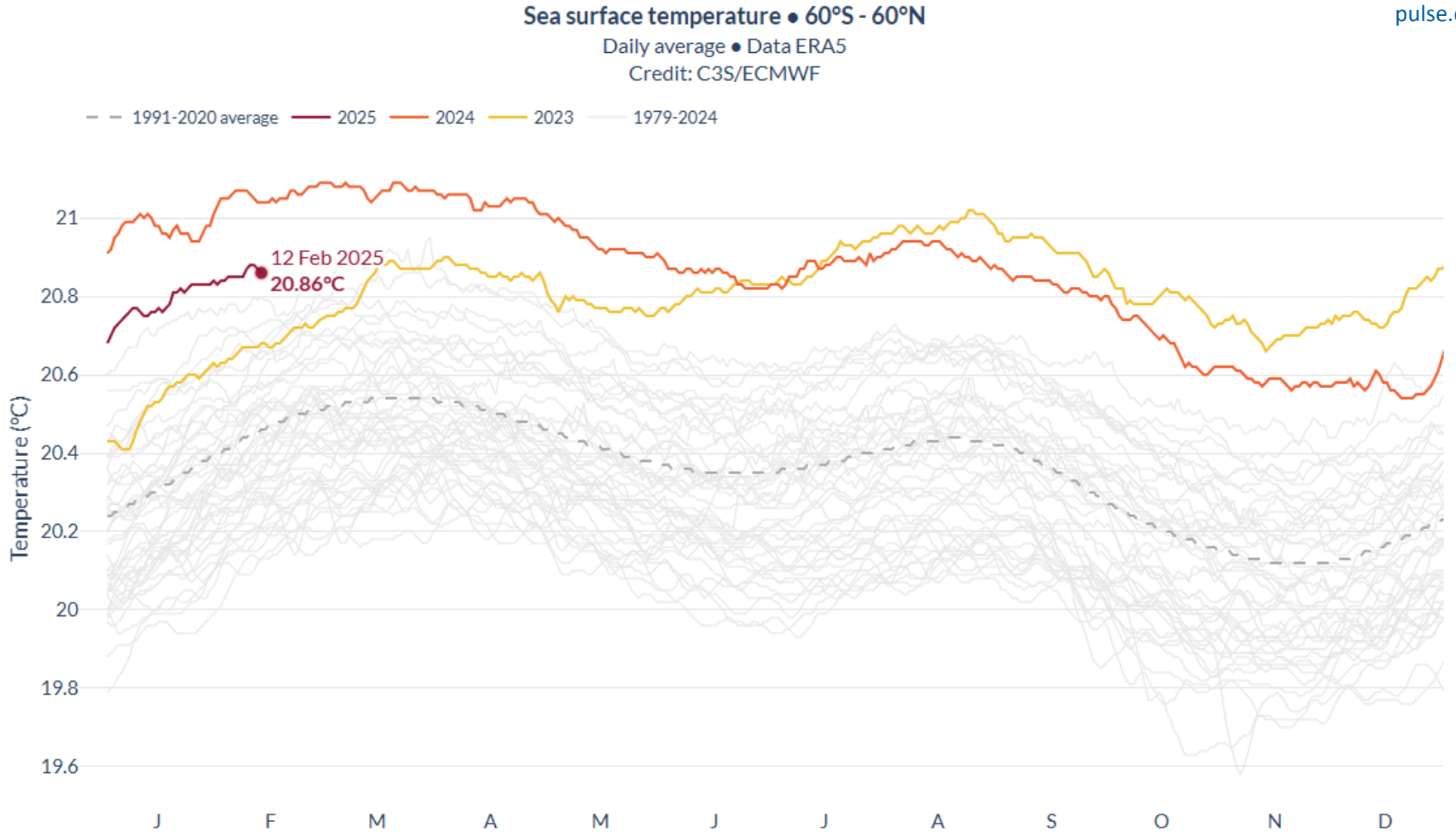
pulse.climate.copernicus.eu/



Climate change basics

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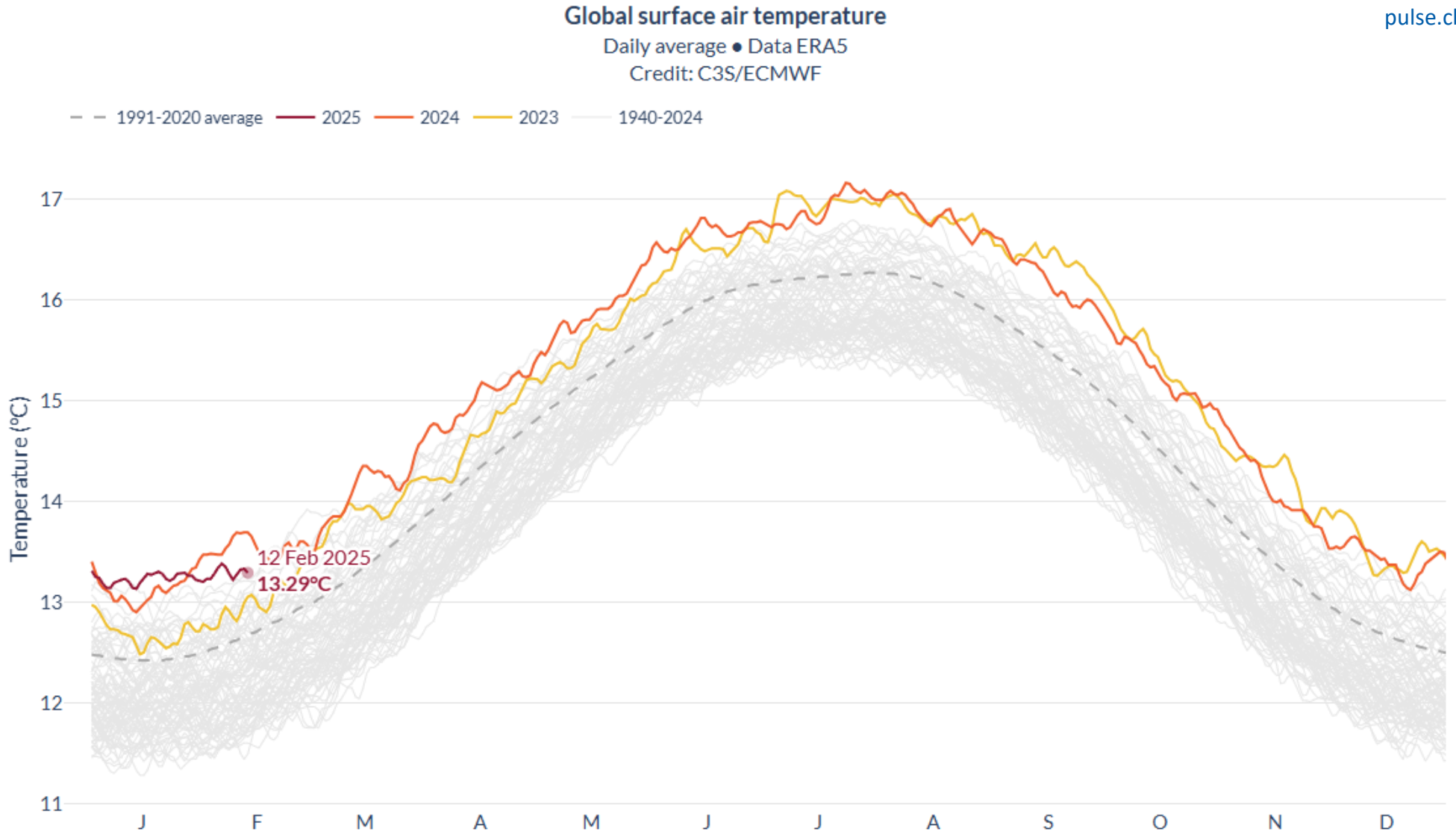
pulse.climate.copernicus.eu/



Climate change basics

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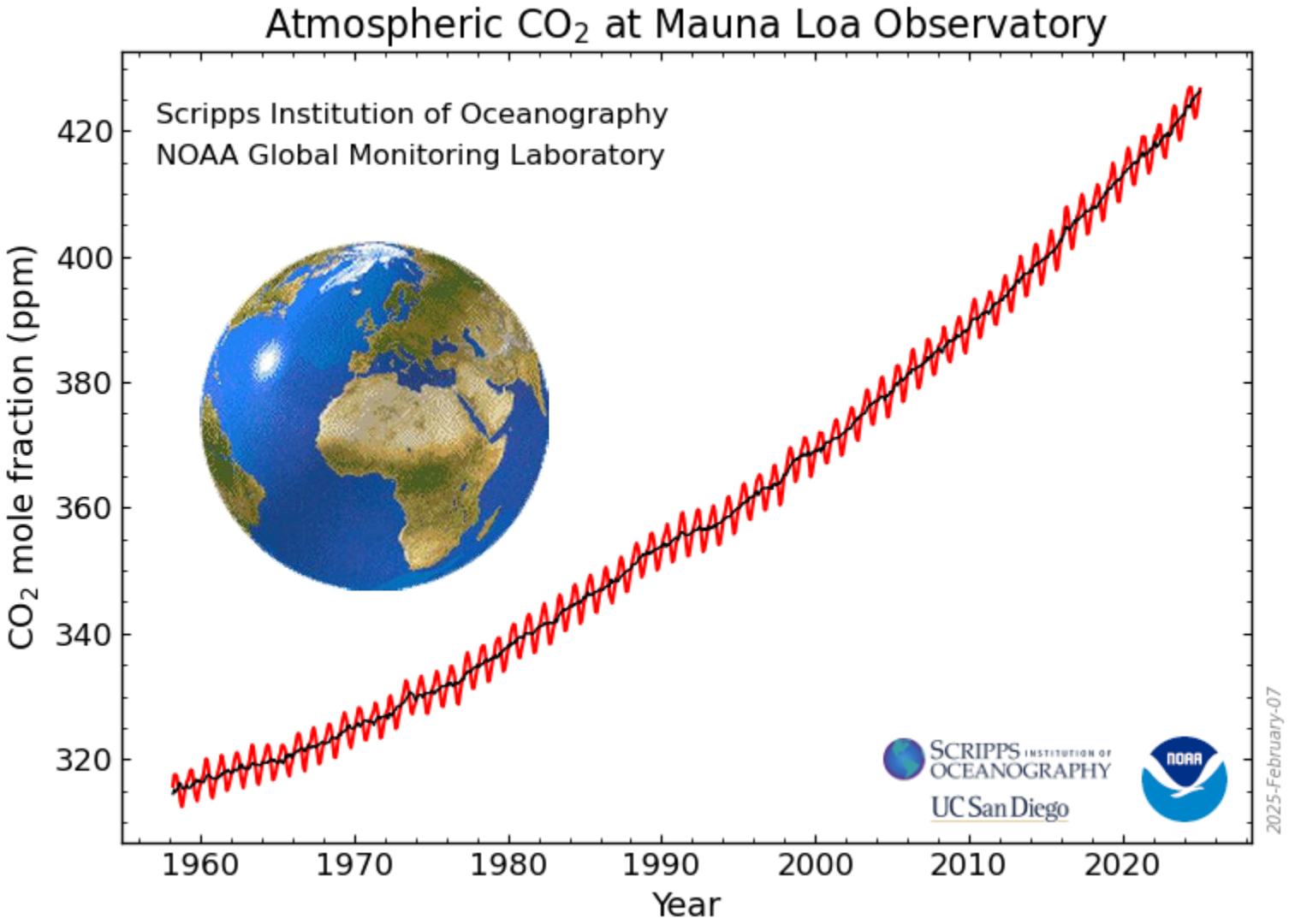
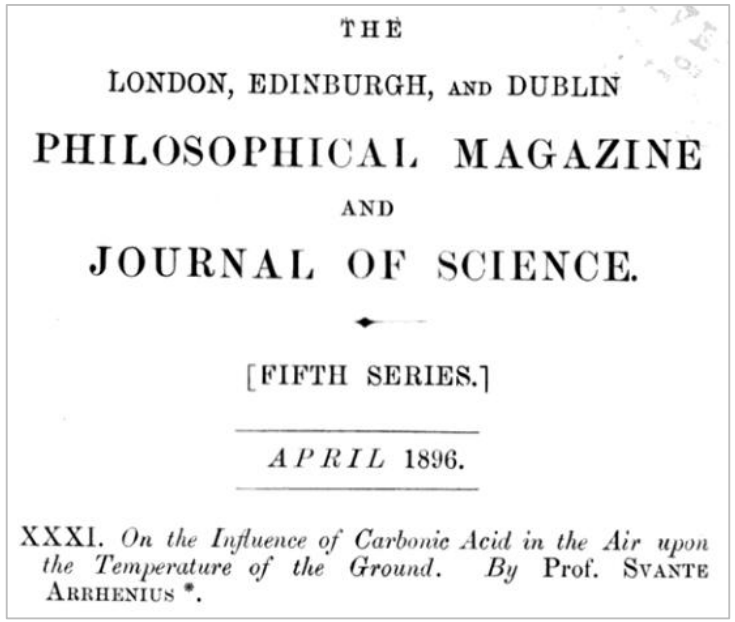
https://gml.noaa.gov/ccgg/trends/mlo.html





THE

LONDON, EDINBURGH, AND DUBLIN

PHILOSOPHICAL MAGAZINE

AND

JOURNAL OF SCIENCE.

[FIFTH SERIES.]

APRIL 1896.

XXXI. *On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground.* By Prof. SVANTE ARRHENIUS *.

if the quantity of carbonic acid increases in geometric progression, the augmentation of the temperature will increase nearly in arithmetic progression

Climate change basics

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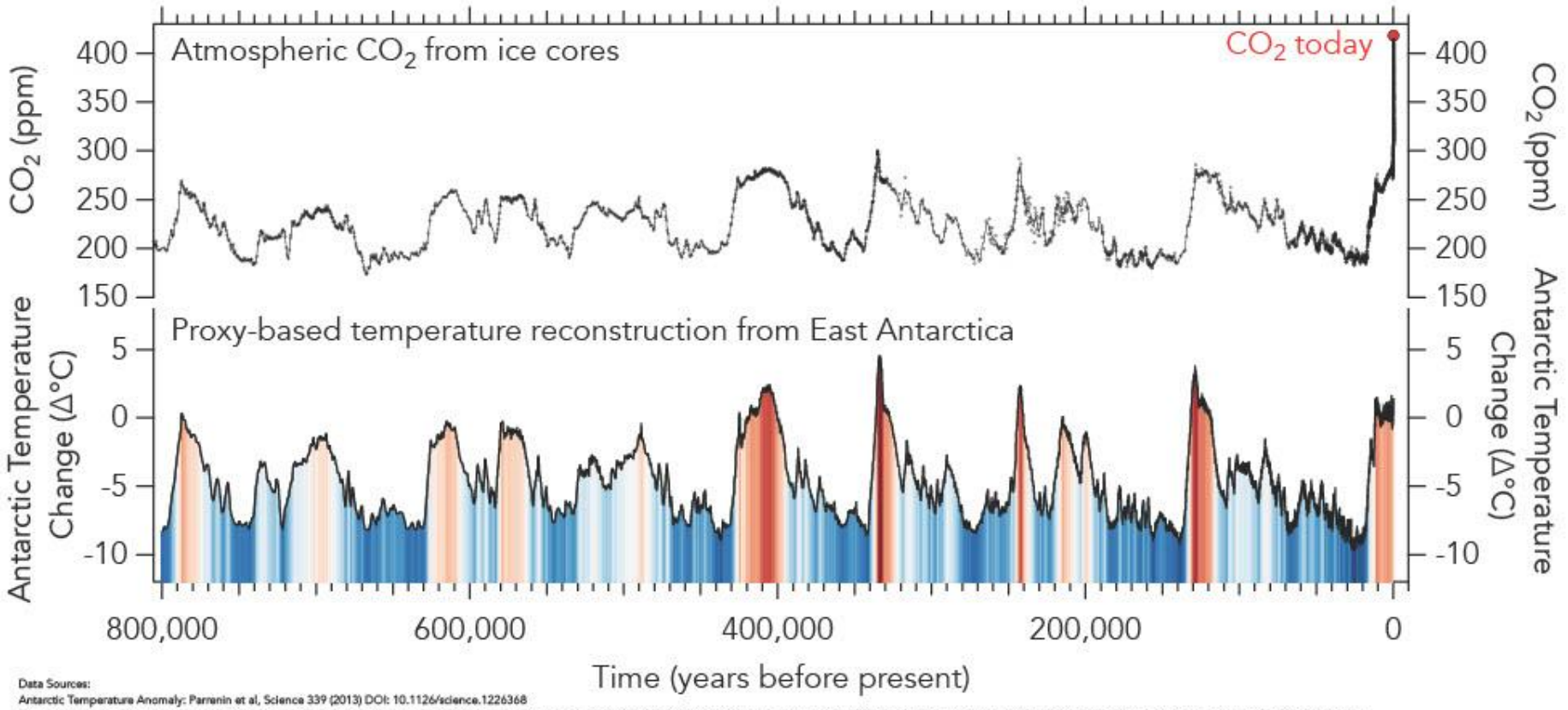
https://www.bas.ac.uk/data/our-data/publication/ice-cores-and-climate-change/

Figure 3: The oldest ice core records for atmospheric CO_2 and temperature change in Antarctica



Data Sources:
Antarctic Temperature Anomaly: Parrenin et al, Science 339 (2013) DOI: 10.1126/science.1226368
Atmospheric CO_2: Petit et al., Nature 399, 429 (1999); Fischer et al., Science 283, 1712 (1999); Monnin et al., EPSL 224 (2004); Siegenthaler et al., Science 310, 5752 (2005); Lüthi et al., Nature 453, 379–382 (2008) Loulergue et al., Nature 453, 383–386 (2008); Bereiter et al., PNAS 109, 9755–9760 (2012); Ahn et al., Global Biogeochem. Cycles, 26 (2012); Mitchell et al., Science 342, 6161 (2013); Marcott et al., Nature 514, 616–619 (2014); Bauska et al., Nature Geoscience 8, 383–387 (2015); Rubino et al., Earth Syst. Sci. Data, 11, 473–492 (2019); Nehrbass-Ahles et al., Science 369, 6506 (2020); Shin et al., Clim. Past 16, 2203–2219 (2020) Lee et al., Clim. Past 16, 1691–1713 (2020);Bauska et al., Nature Geoscience 14, 91–96 (2021); NOAA/GML (gml.noaa.gov/ccgg/trends/)
Figure made by Thomas Bauska

January 2025: 426.65 ppm
January 2024: 422.80 ppm
Last updated: Feb 07, 2025

Current impacts

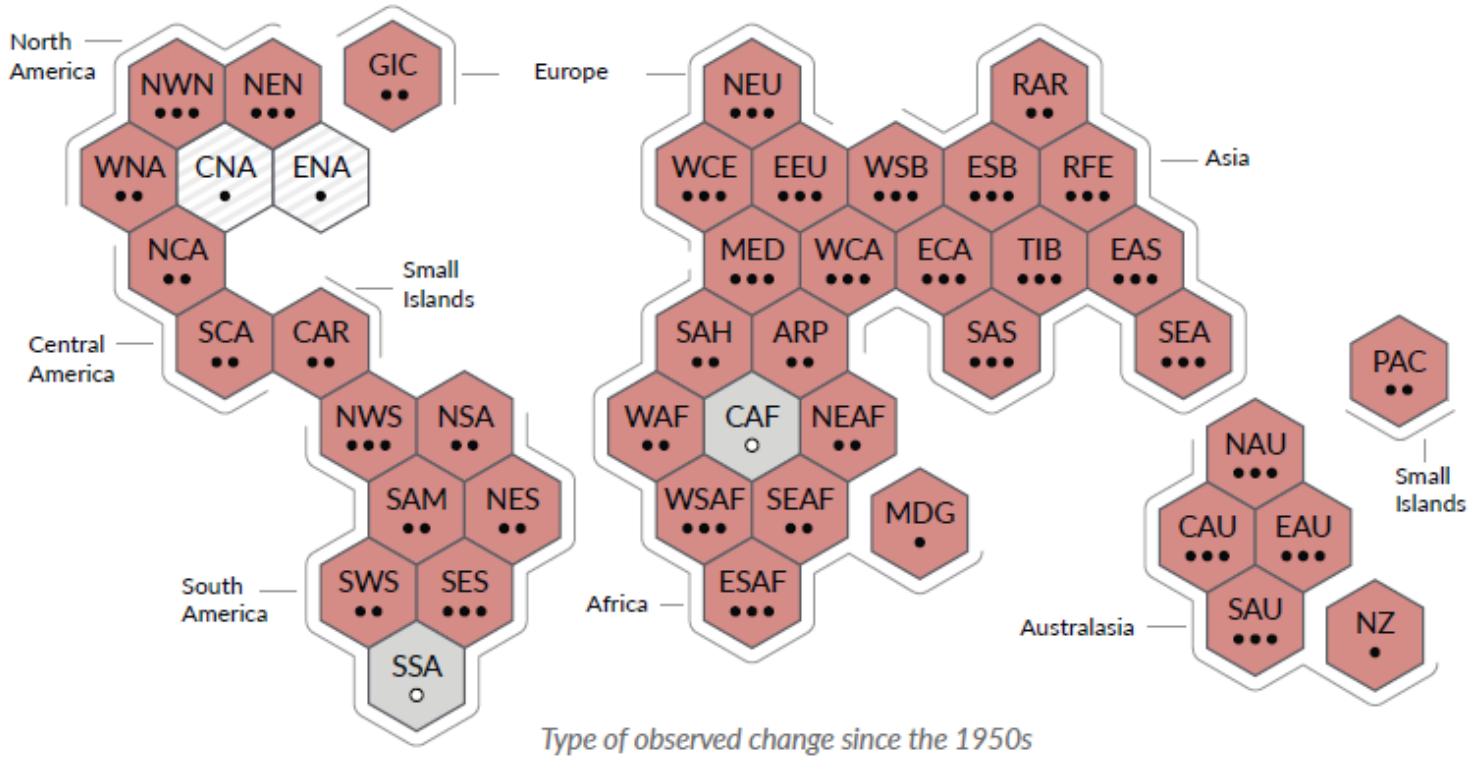
(a) Synthesis of assessment of observed change in **hot extremes** and confidence in human contribution to the observed changes in the world's regions

Type of observed change
in hot extremes

- Increase (41)
- Decrease (0)
- Low agreement in the type of change (2)
- Limited data and/or literature (2)

Confidence in human contribution
to the observed change

- ●●● High
- ●● Medium
- ● Low due to limited agreement
- ○ Low due to limited evidence



Type of observed change since the 1950s

Current impacts

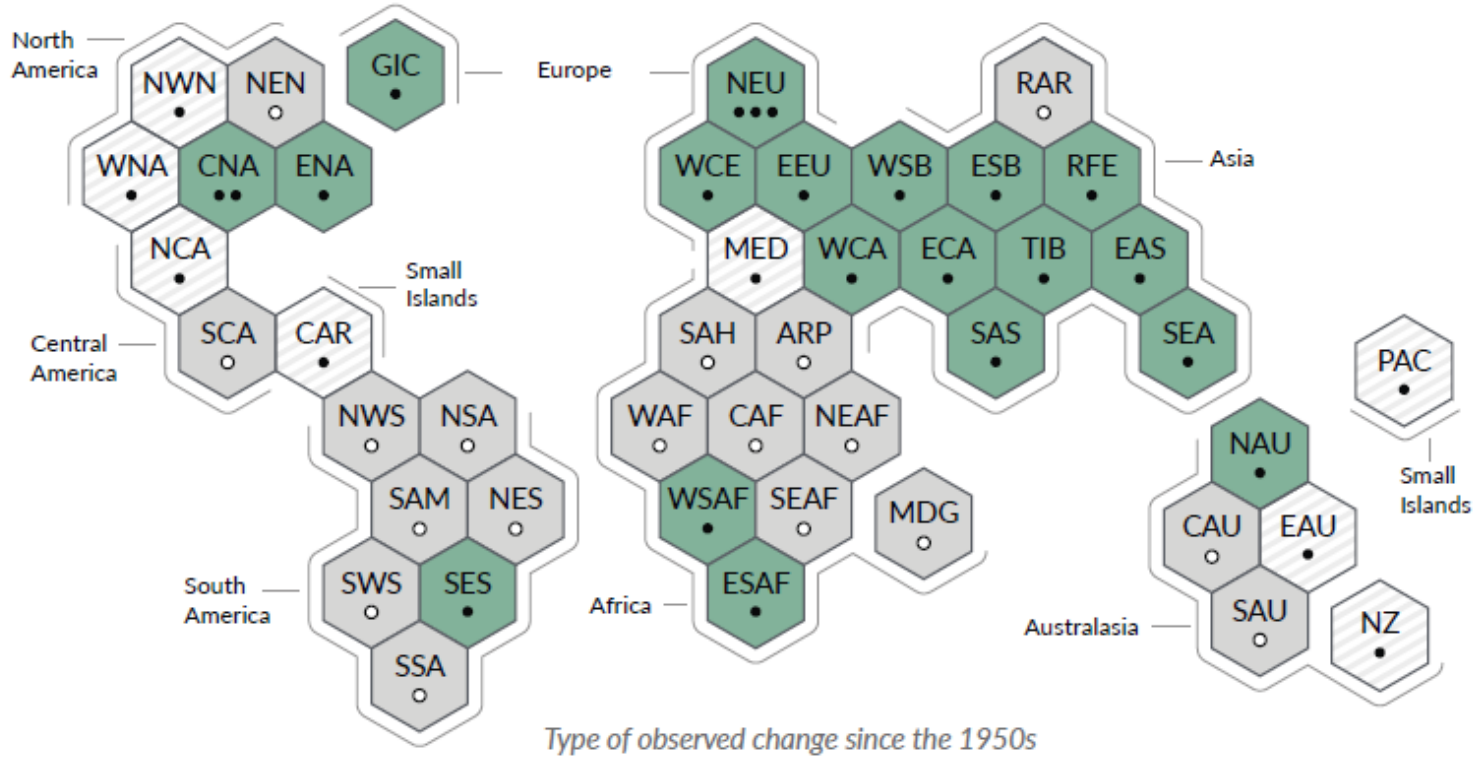
(b) Synthesis of assessment of observed change in **heavy precipitation** and confidence in human contribution to the observed changes in the world's regions

Type of observed change
in heavy precipitation

- Increase (19)
- Decrease (0)
- Low agreement in the type of change (8)
- Limited data and/or literature (18)

Confidence in human contribution
to the observed change

- ●●● High
- ●● Medium
- ● Low due to limited agreement
- ○ Low due to limited evidence



Type of observed change since the 1950s

Current impacts

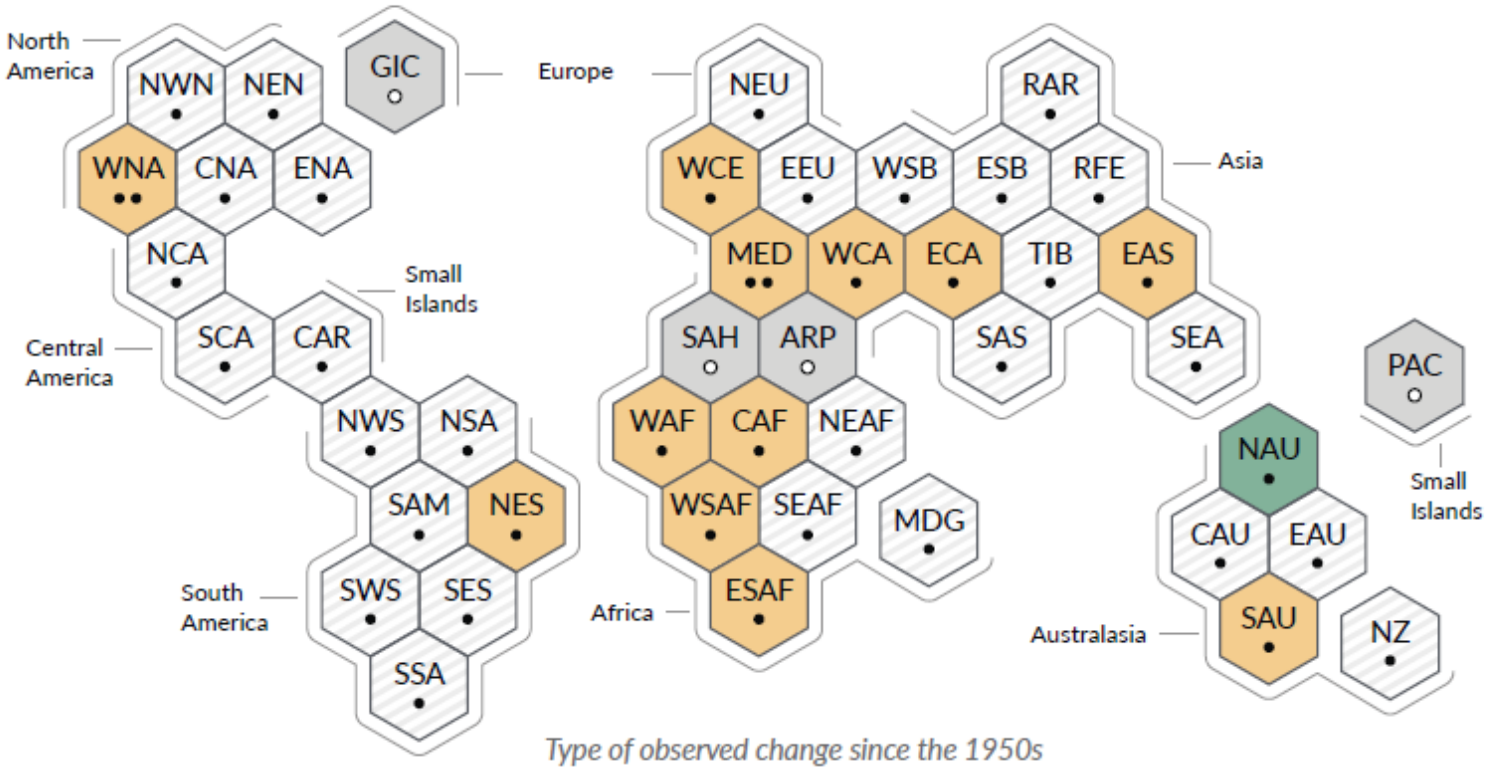
(c) Synthesis of assessment of observed change in **agricultural and ecological drought** and confidence in human contribution to the observed changes in the world's regions

Type of observed change
in agricultural and ecological drought

- Increase (12)
- Decrease (1)
- Low agreement in the type of change (28)
- Limited data and/or literature (4)

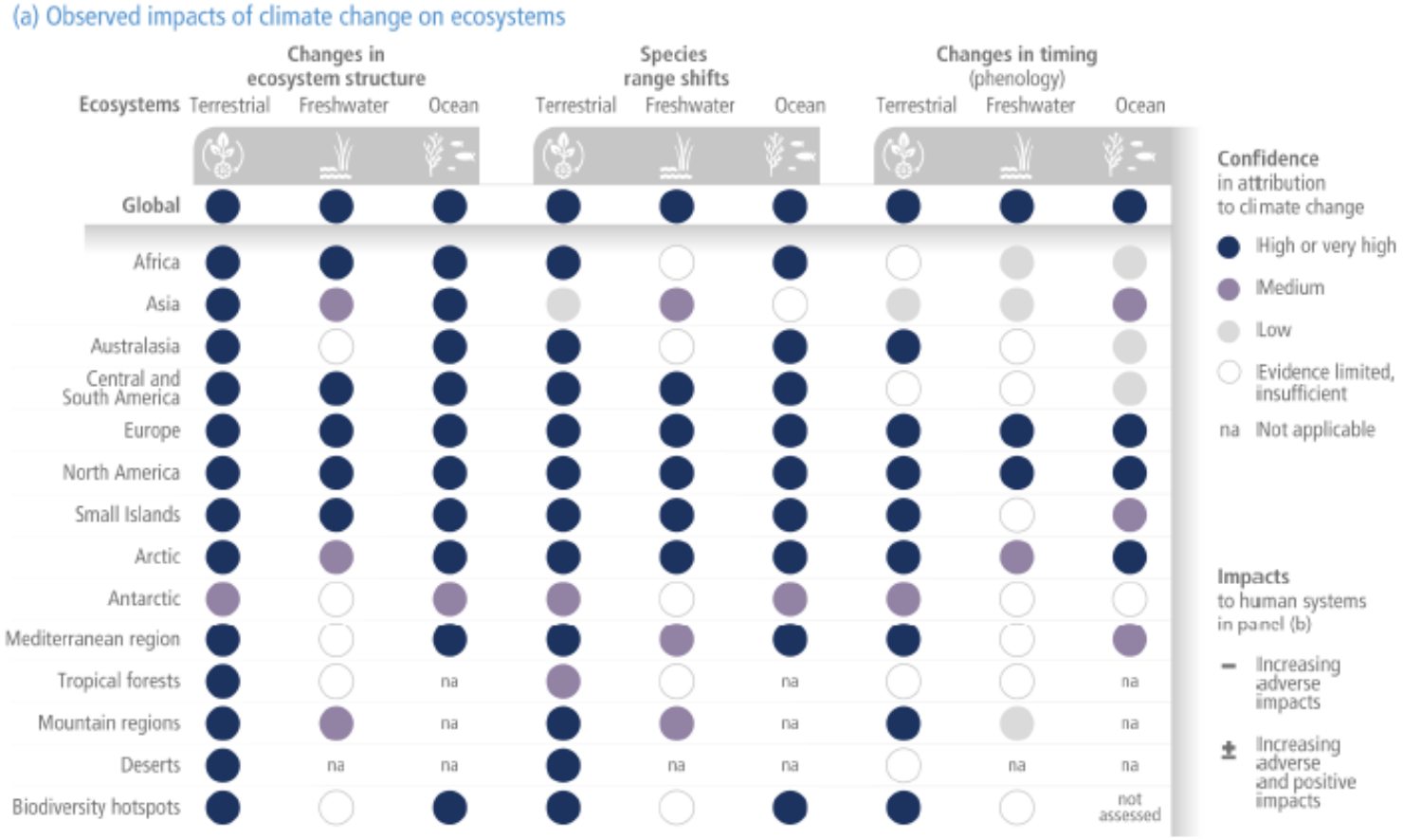
Confidence in human contribution
to the observed change

- ●●● High
- ●● Medium
- ● Low due to limited agreement
- ○ Low due to limited evidence



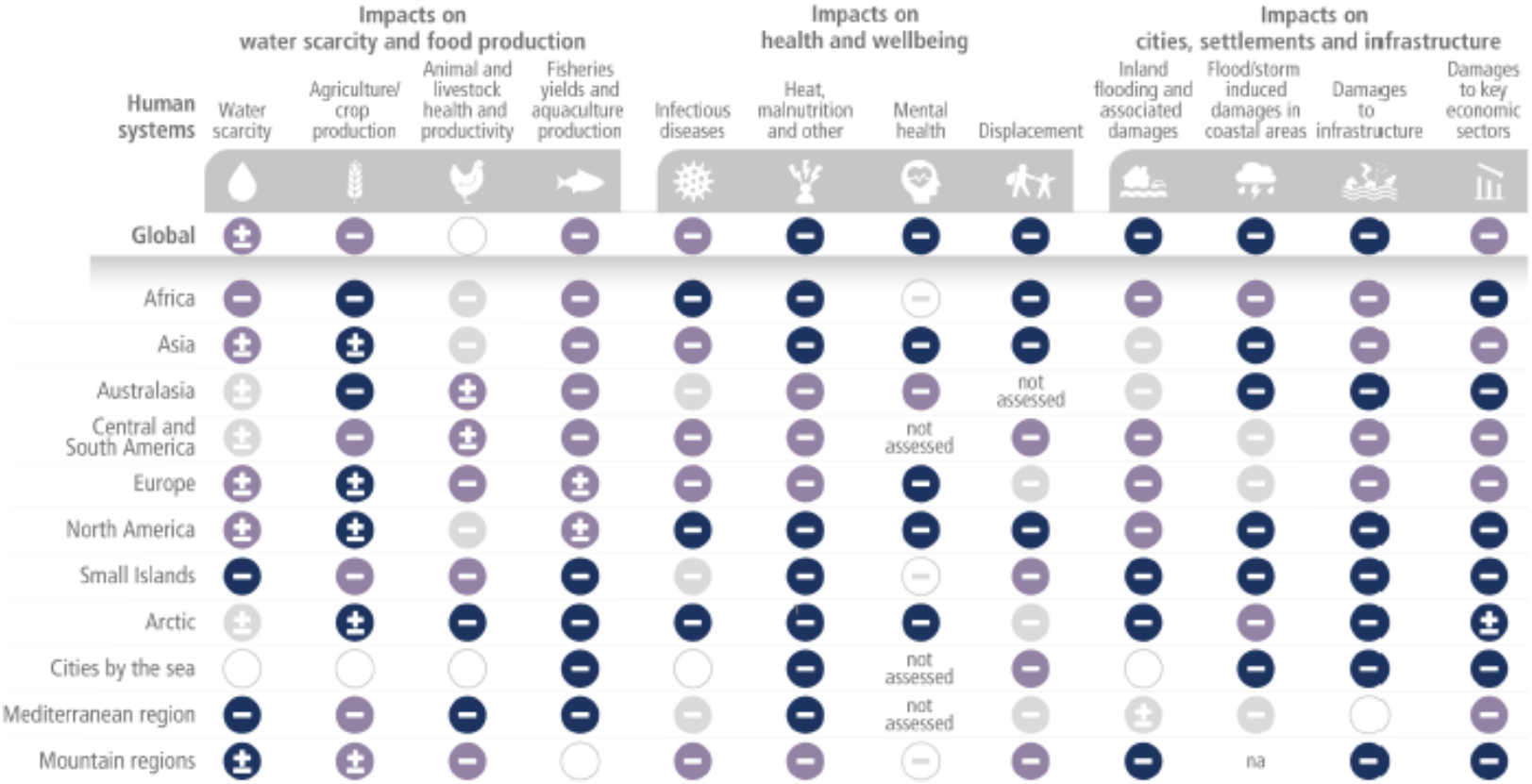
Type of observed change since the 1950s

Current impacts



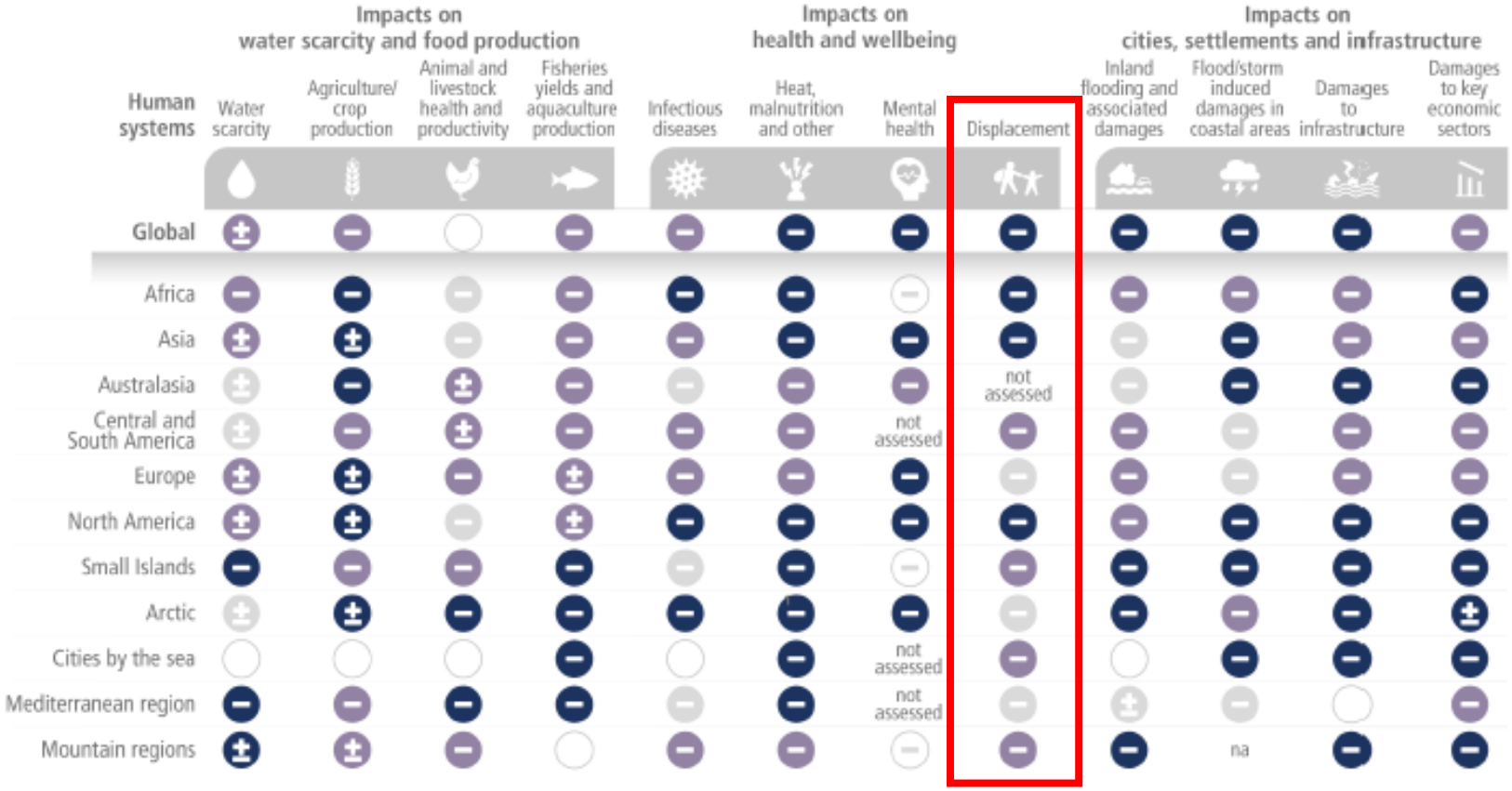
Current impacts

(b) Observed impacts of climate change on human systems



Current impacts

(b) Observed impacts of climate change on human systems



Current impacts

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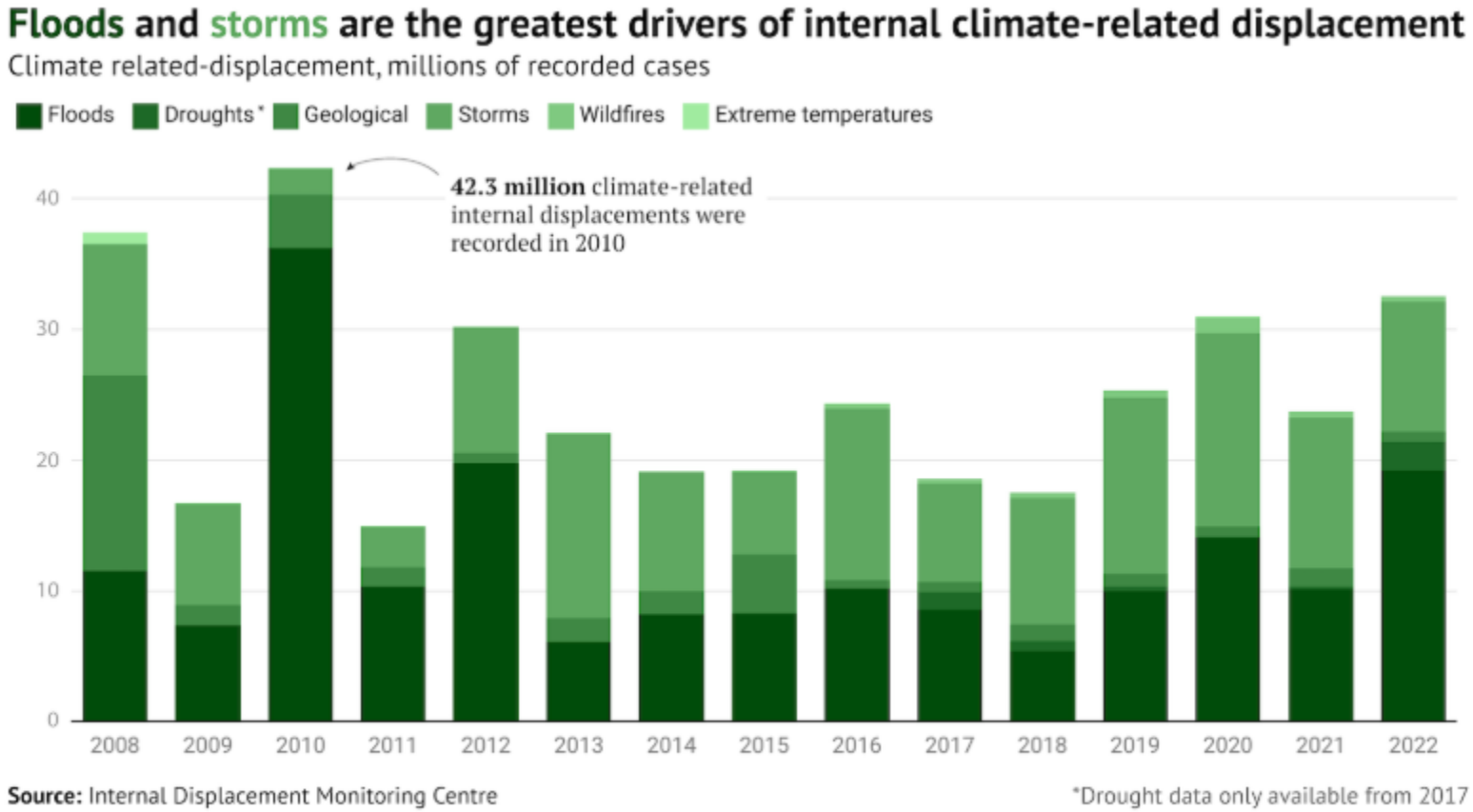
Climate change effects on population movement already occurring



Drivers of internal climate-related displacement over 2008-22. Data source: Internal Displacement Monitoring Centre.

https://interactive.carbonbrief.org/climate-migration/index.html

Current impacts - *methodology*

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Murray-Tortarolo & Martínez Salgado, 2021, Drought as a driver of Mexico-US migration, Climatic Change

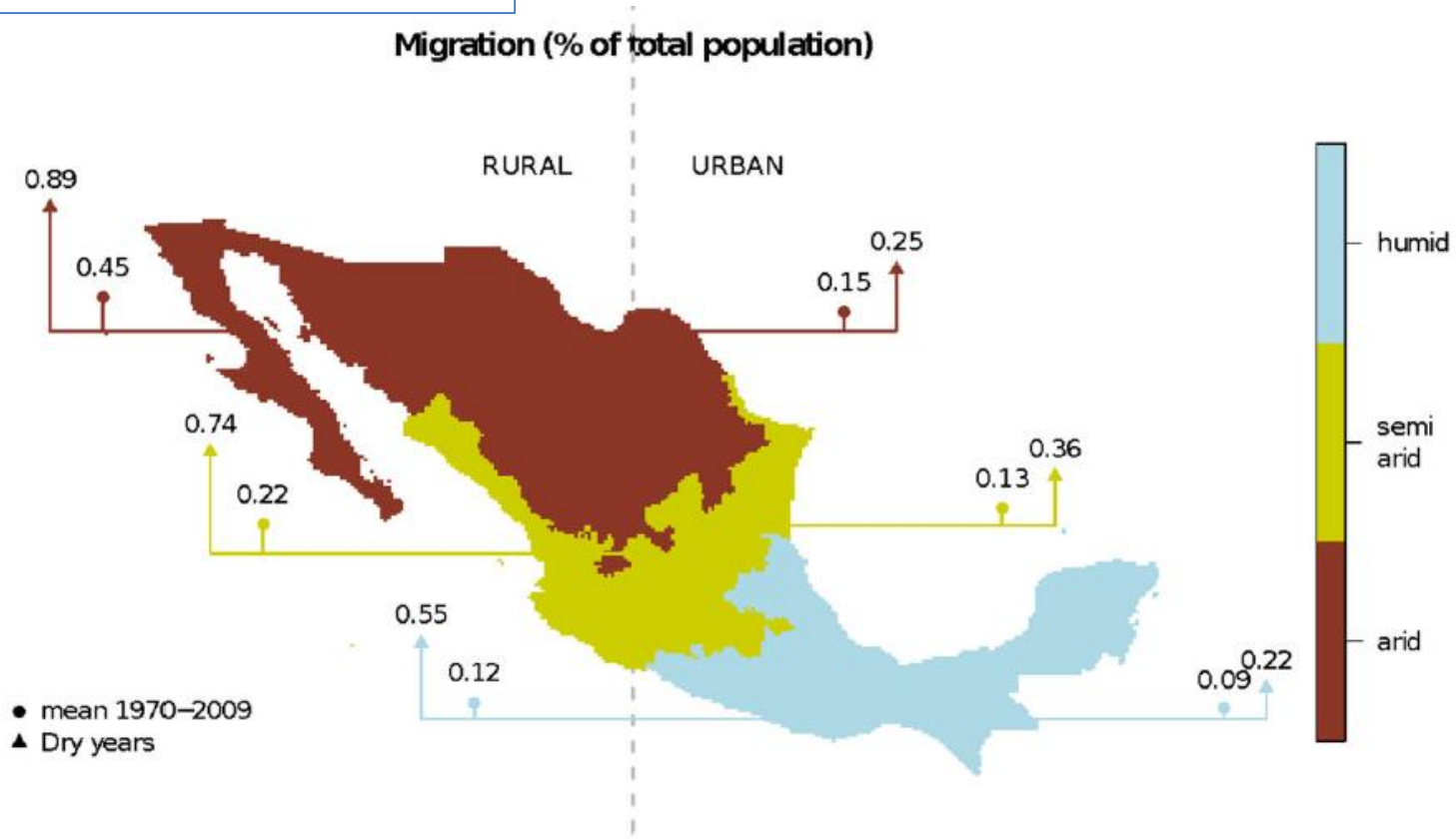

Fig. 3 Mexico-US migration by background climate for the period 1970–2009 and during dry years (1978, 1986, 1999, and 2000). Colors indicate the background climate based on precipitation (arid having less than 500 mm of annual rainfall, semi-arid having 500–1000 mm, and humid having more than 1000 mm)

PNAS RESEARCH ARTICLE | DEMOGRAPHY | OPEN ACCESS

Weather deviations linked to undocumented migration and return between Mexico and the United States

Julia Li Zhu[a], Nancy Chau[b], Amanda D. Rodewald[c], and Filiz Garip[d,1]

Affiliations are included on p. 9.

Edited by Richard Alba, City University of New York, Graduate Center, New York, NY; received January 10, 2024; accepted September 8, 2024

High-resolution (municipal-level) and long-term databases (1970–2009), which included nation-level interviews, border patrol apprehensions, and high-resolution precipitation were employed

Current impacts - *methodology*

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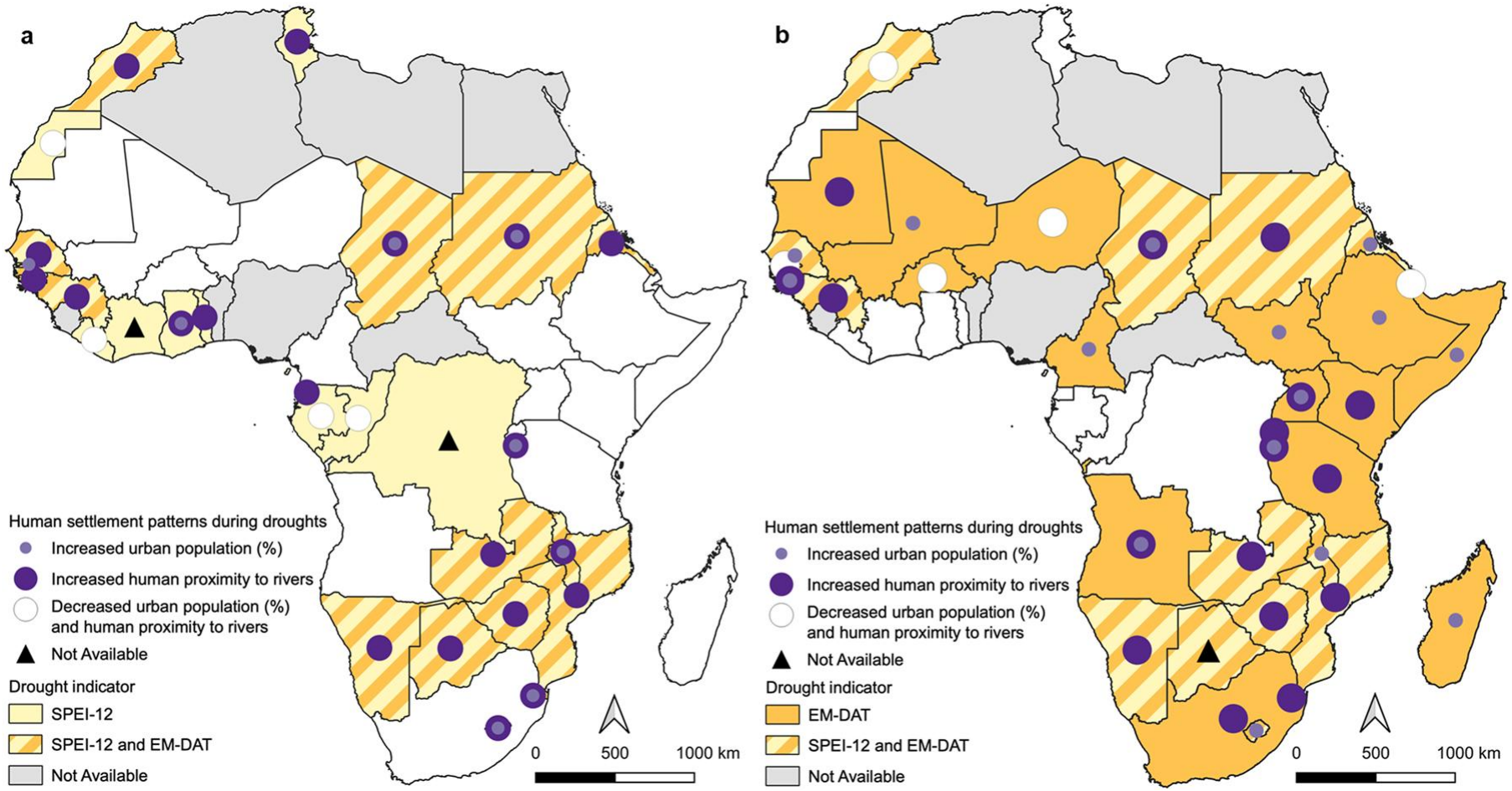
Ceola et al., 2023, Drought and Human Mobility in Africa, Earth's Future

For each country, annual drought occurrences were extracted from two indicators, the international disaster database EM-DAT and the standardized precipitation evapotranspiration index (SPEI-12) records, and human settlement patterns were evaluated by considering urban population data and human distance to rivers, as derived from **nighttime lights**



Projected impacts

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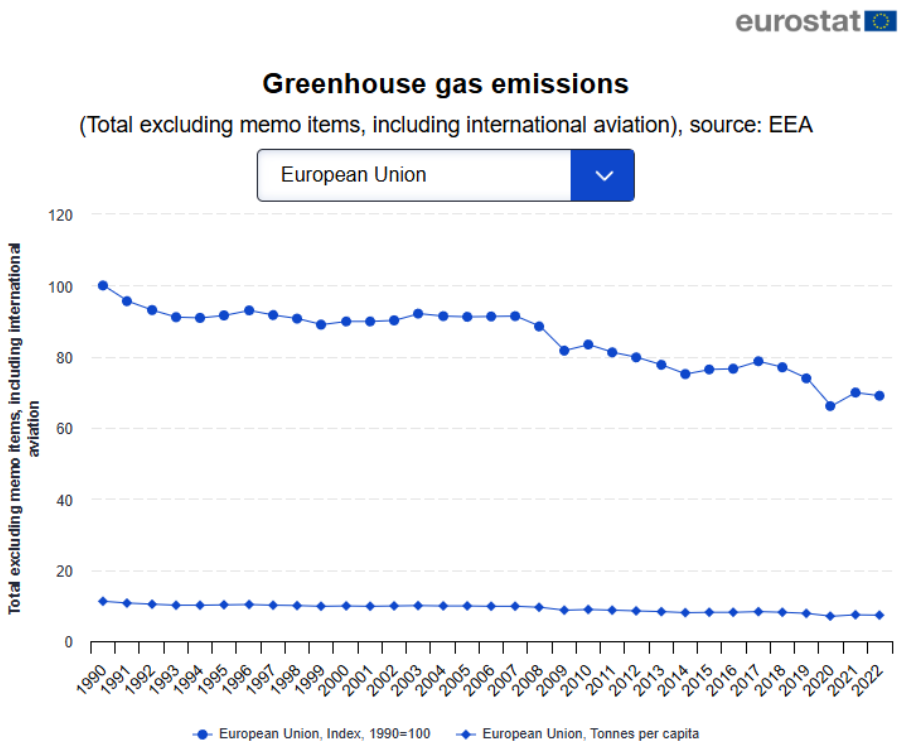
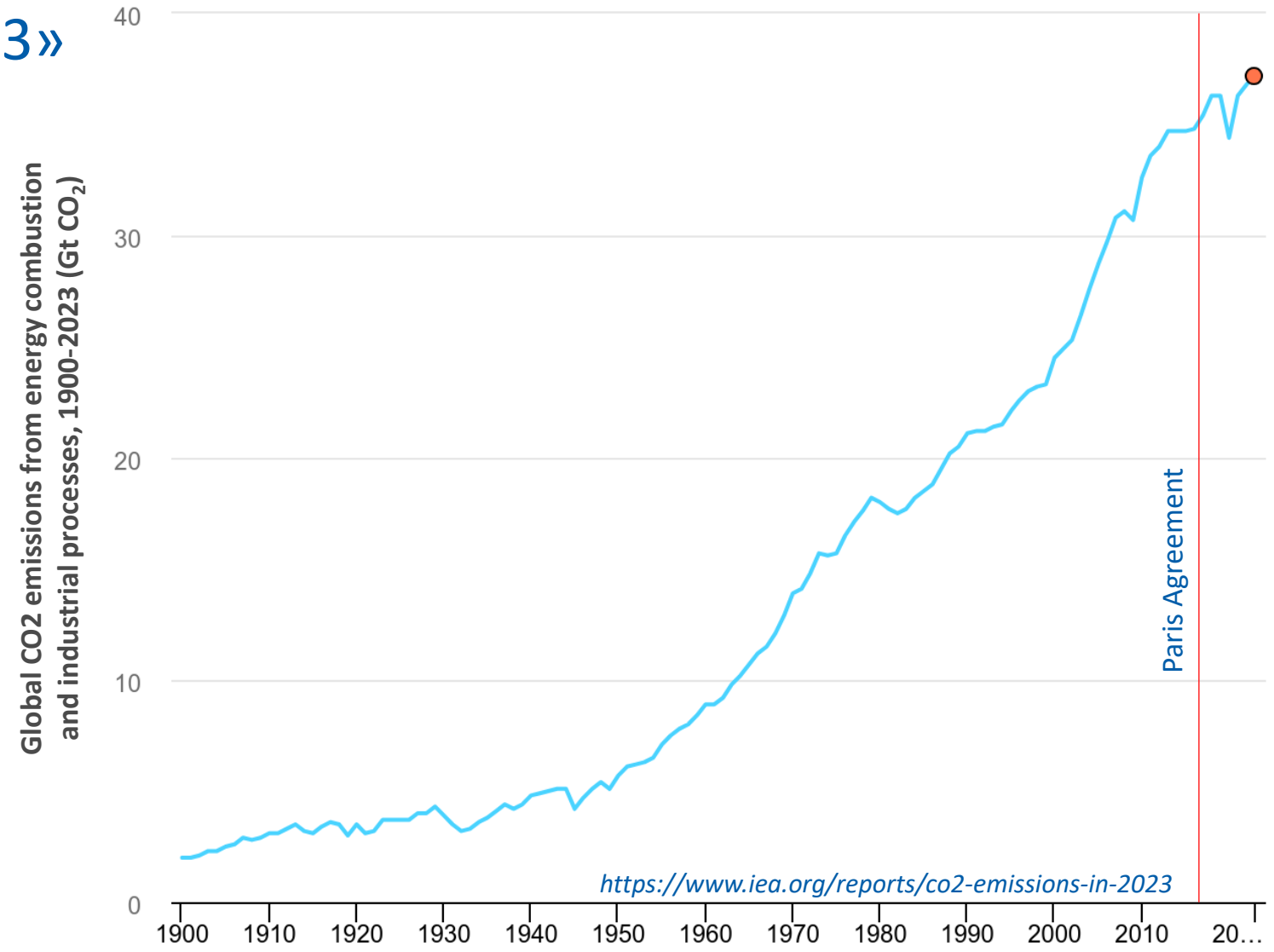
IEA report «CO_2 Emissions in 2023»



https://ec.europa.eu/eurostat/web/climate-change



https://www.iea.org/reports/co2-emissions-in-2023

Climate change background

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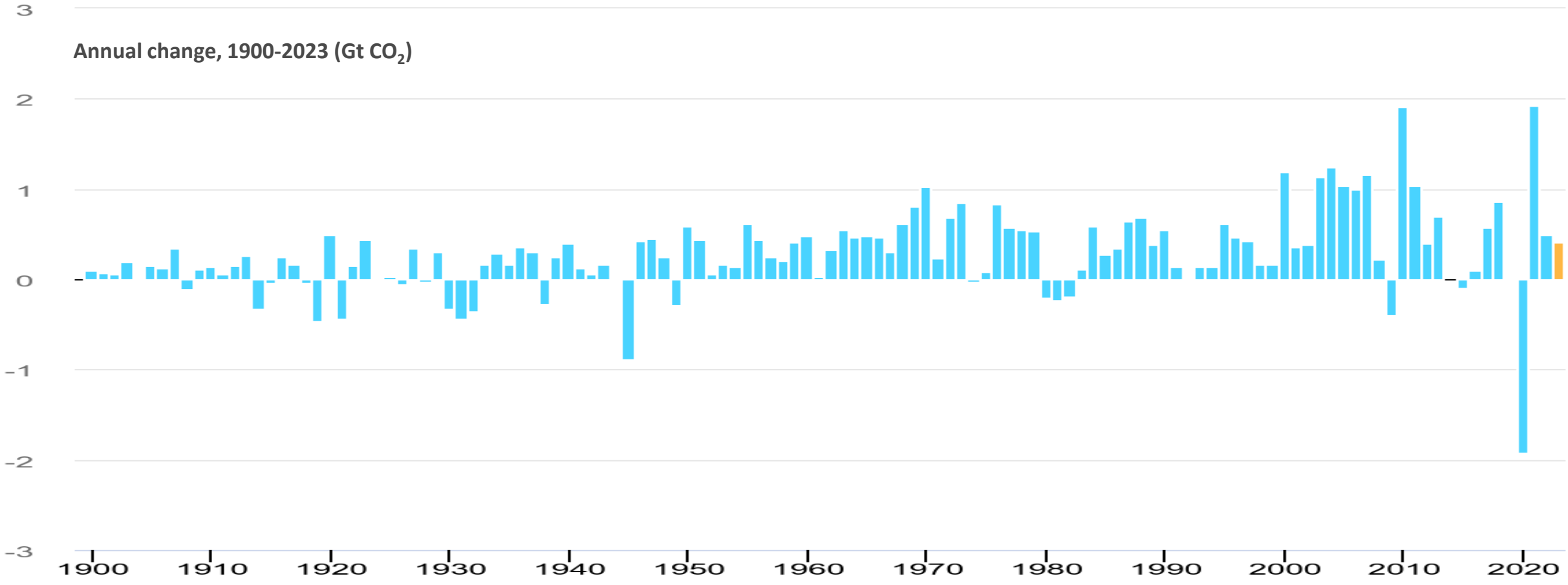
IEA report «CO_2 Emissions in 2023»



https://www.iea.org/reports/co2-emissions-in-2023

Climate change background

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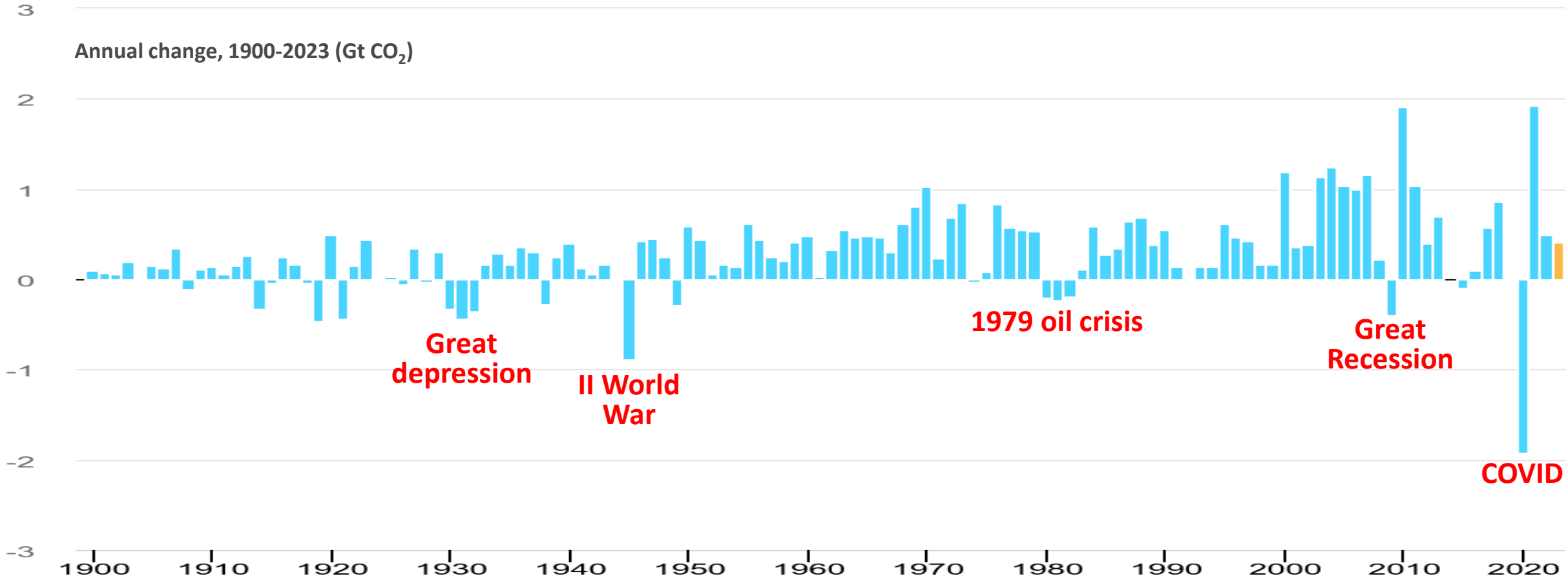
IEA report «CO_2 Emissions in 2023»



https://www.iea.org/reports/co2-emissions-in-2023

Projected impacts

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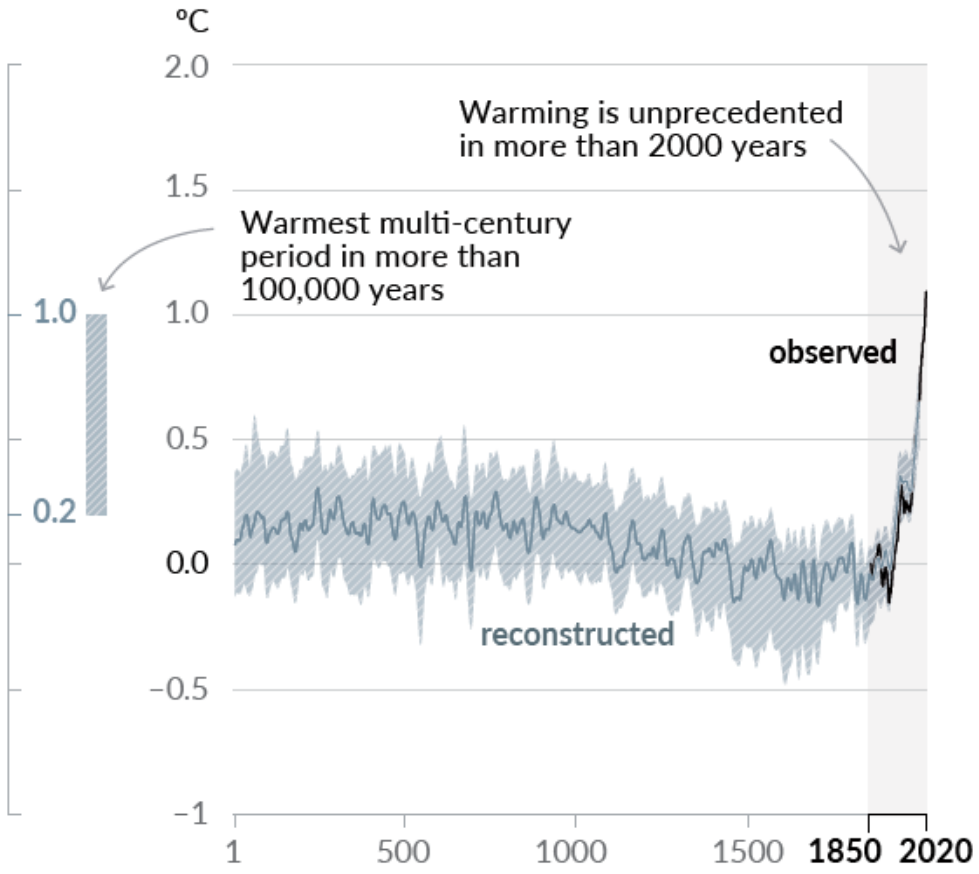
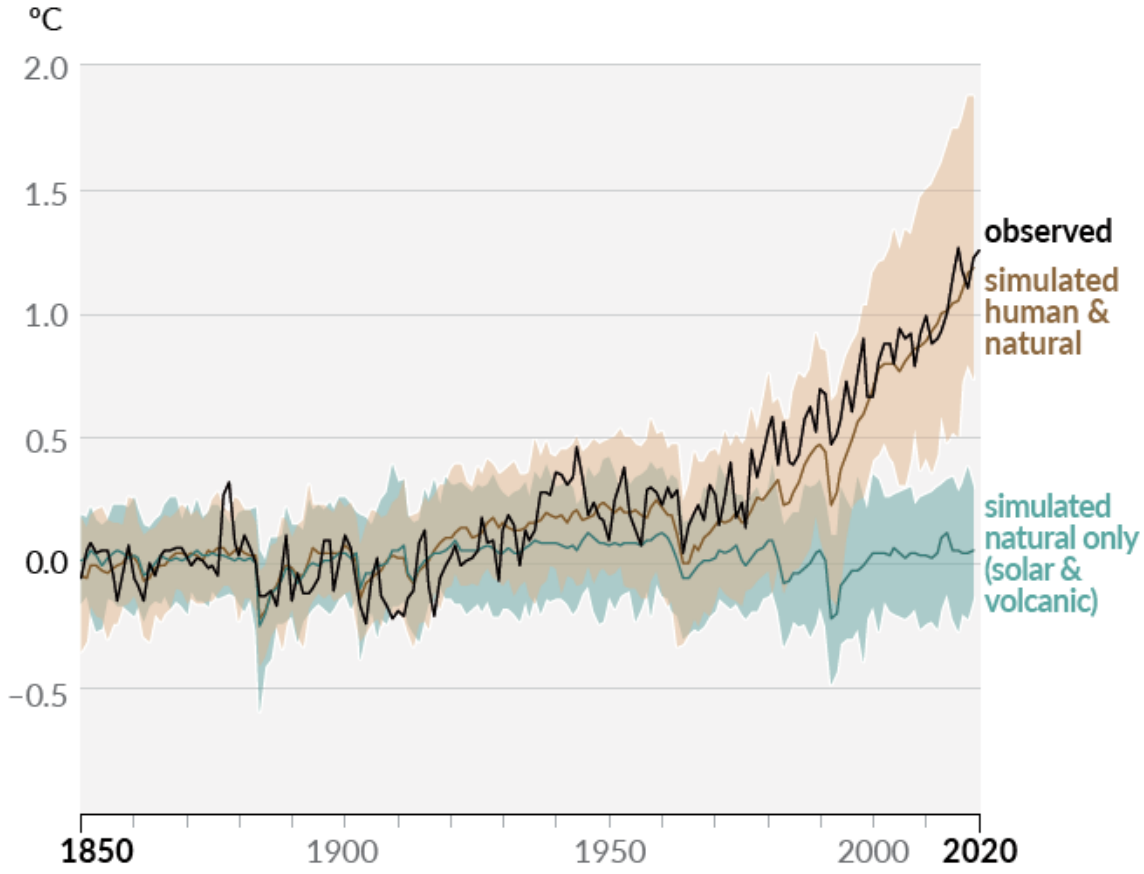
Changes in global surface temperature relative to 1850–1900

IPCC AR6 WG1 FINAL REPORT - Fig. SPM.1

(a) Change in global surface temperature (decadal average) as reconstructed (1–2000) and **observed** (1850–2020)



(b) Change in global surface temperature (annual average) as **observed** and simulated using human & natural and only natural factors (both 1850–2020)



Projected impacts

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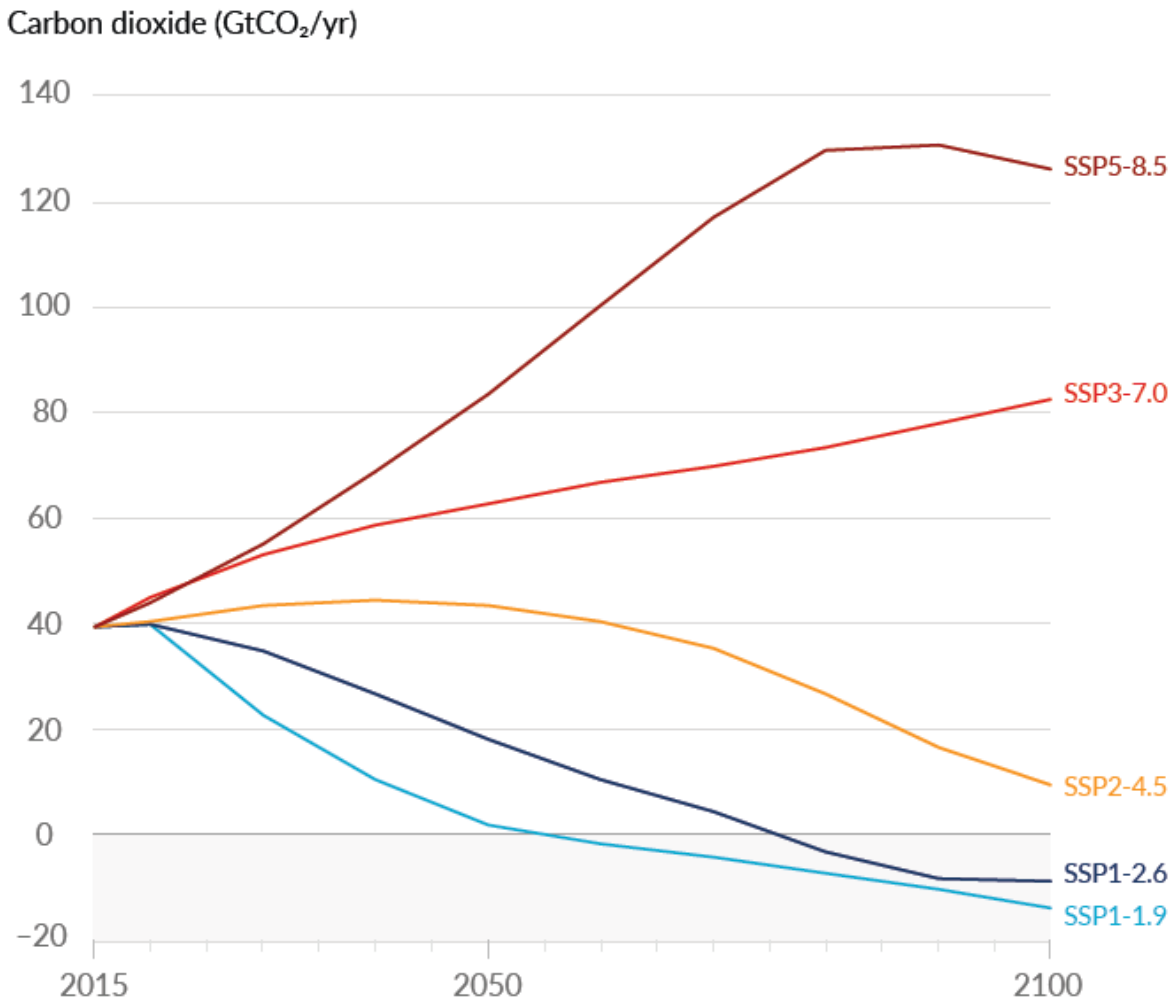
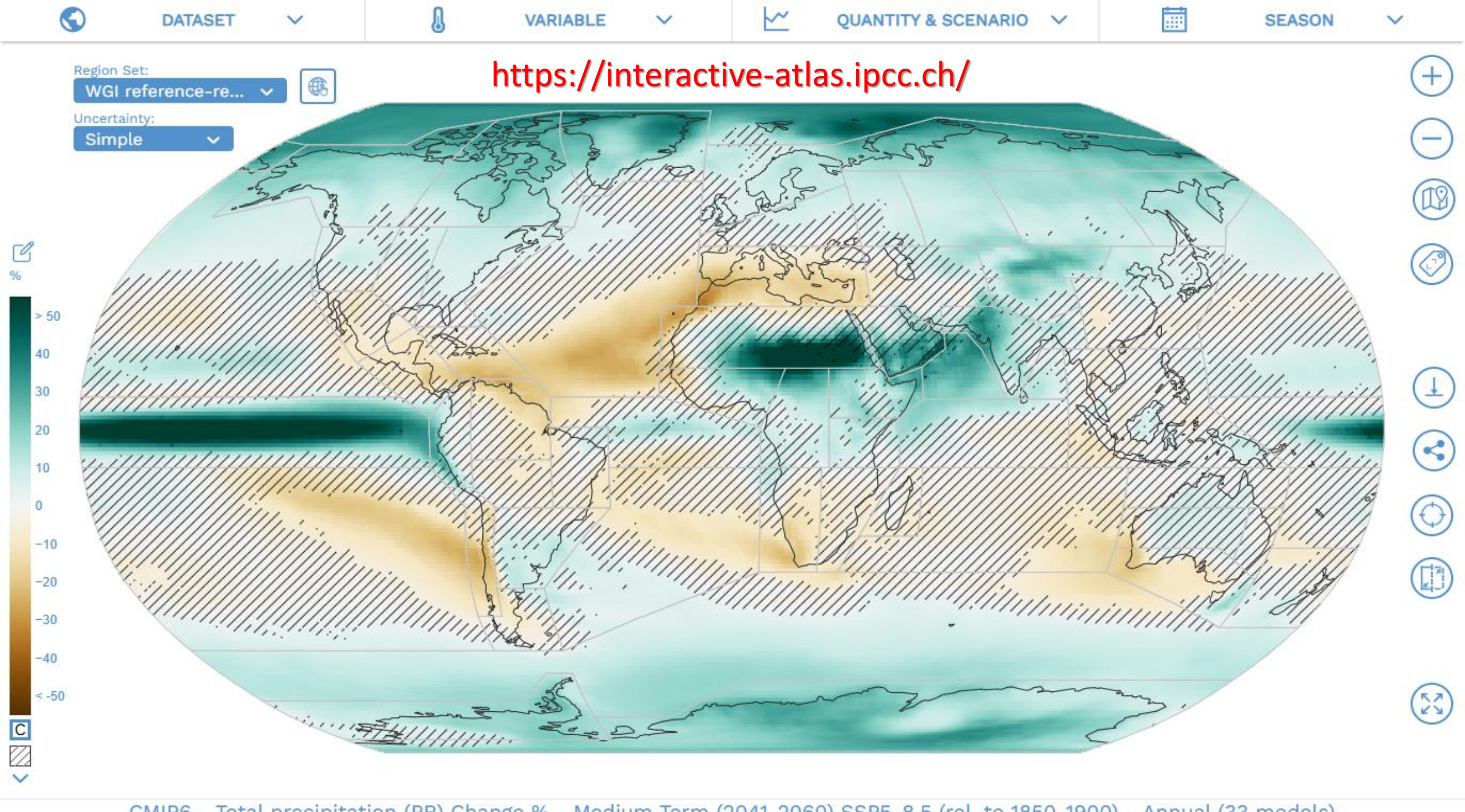
IPCC AR6 WG1 FINAL REPORT - Fig. SPM.1



- **SSP1:** Sustainability (Taking the Green Road)
- **SSP2:** Middle of the Road
- **SSP3:** Regional Rivalry (A Rocky Road)
- **SSP4:** Inequality (A Road divided)
- **SSP5:** Fossil-fueled Development (Taking the Highway)

- **SSP1-1.9** very low GHG emissions
  CO_2 emissions cut to net zero around 2050
- **SSP1-2.6** low GHG emissions
  CO_2 emissions cut to net zero around 2075
- **SSP2-4.5** intermediate GHG emissions
  CO_2 emissions around current levels until 2050, then falling but not reaching net zero by 2100
- **SSP3-7.0** high GHG emissions
  CO_2 emissions double by 2100
- **SSP5-8.5** very high GHG emissions
  CO_2 emissions triple by 2075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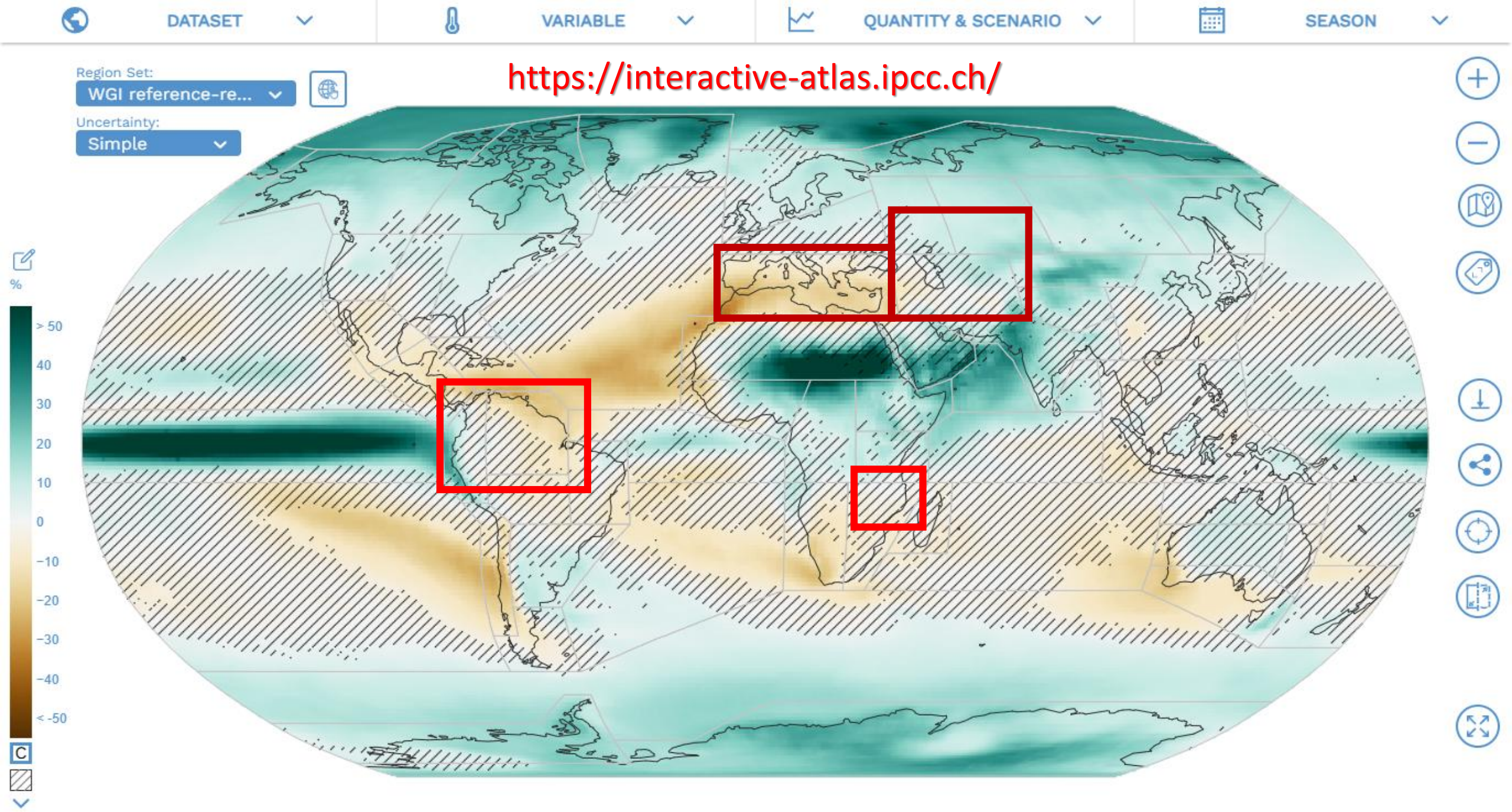
CMIP6 - Total precipitation (PR) Change % - Medium Term (2041-2060) SSP5-8.5 (rel. to 1850-1900) - Annual (33 models)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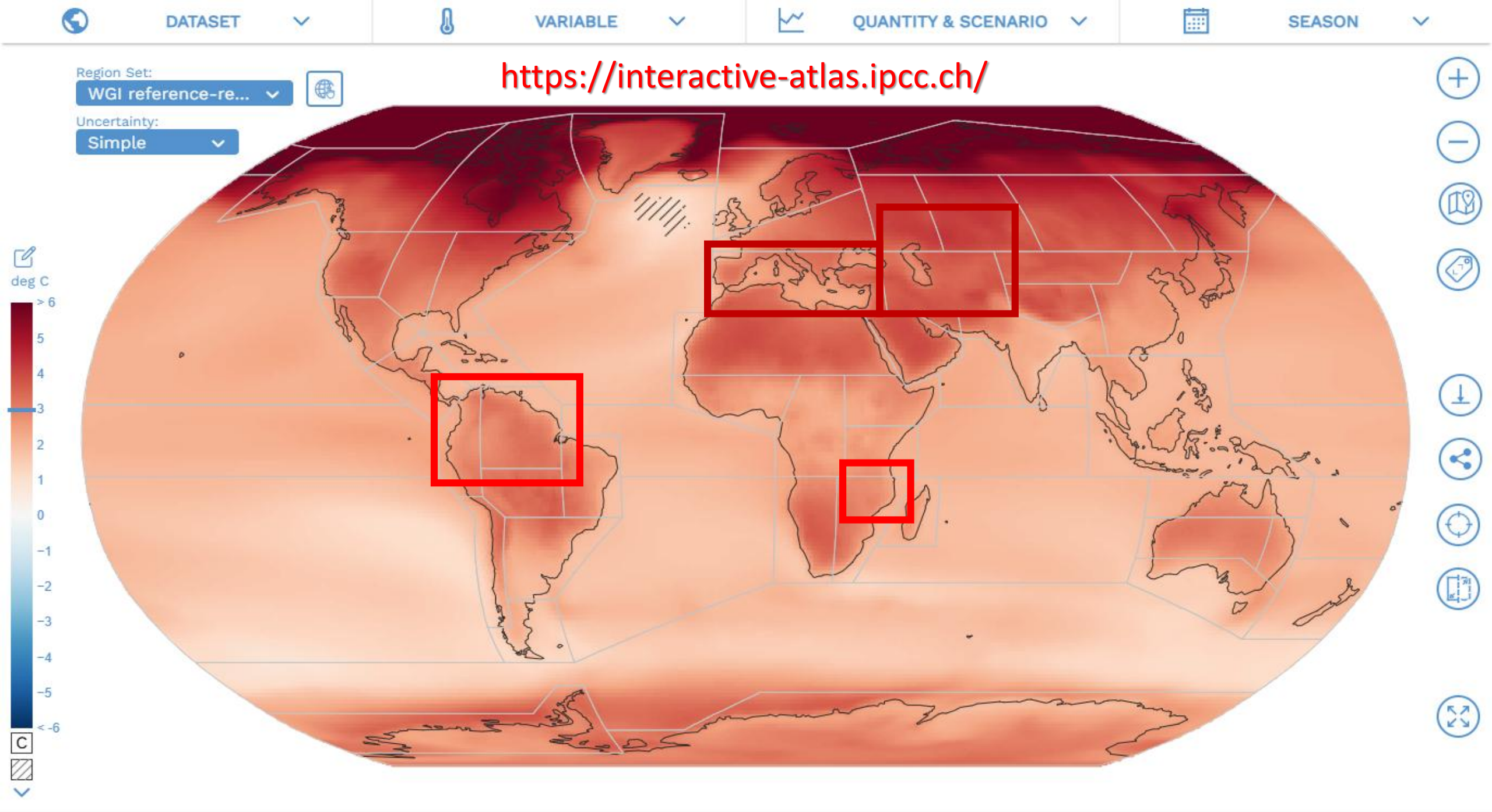
CMIP6 - Total precipitation (PR) Change % - Medium Term (2041-2060) SSP5-8.5 (rel. to 1850-1900) - Annual (33 models)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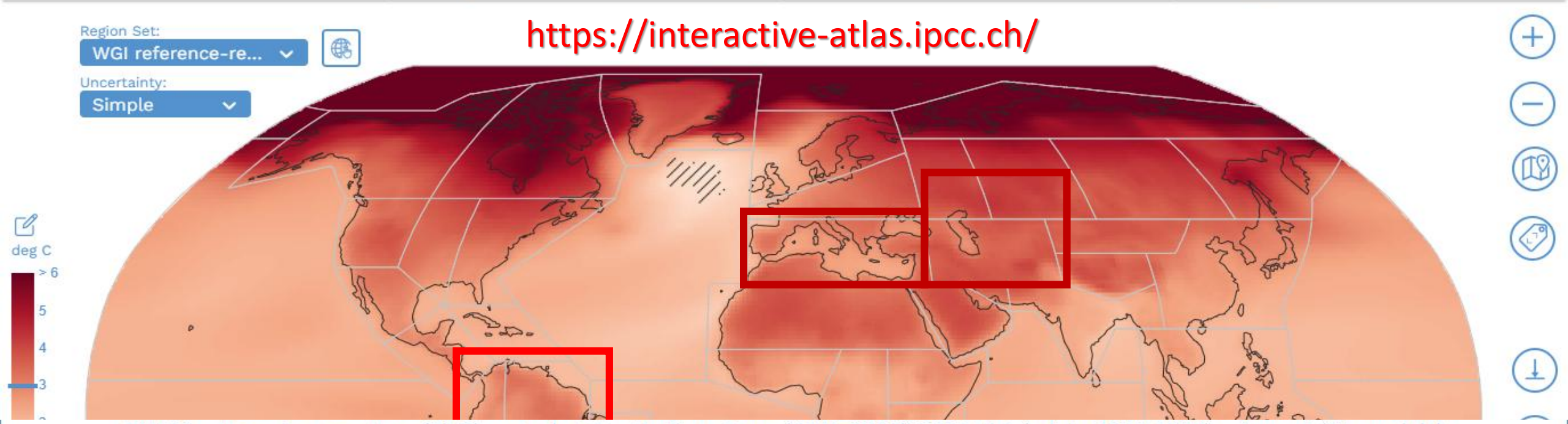
CMIP6 - Mean temperature (T) Change deg C - Medium Term (2041-2060) SSP5-8.5 (rel. to 1850-1900) - Annual (34 models)

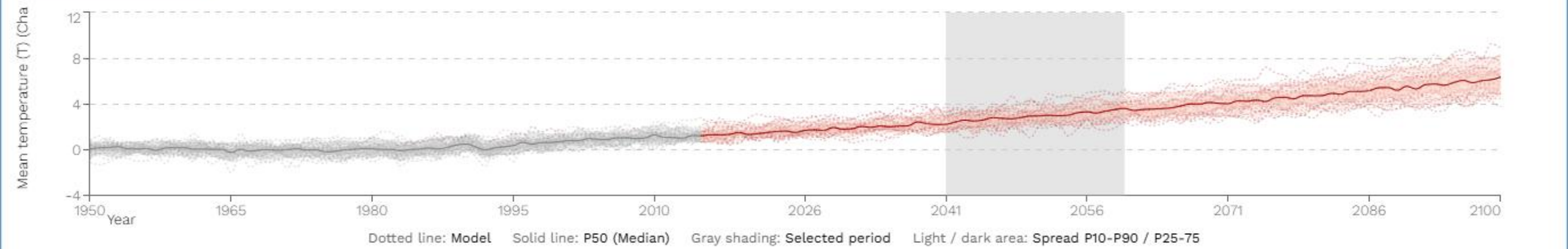
DATASET | VARIABLE | QUANTITY & SCENARIO | SEASON

https://interactive-atlas.ipcc.ch/



CMIP6 - Mean temperature (T) Change deg C - Medium Term (2041-2060) SSP5-8.5 (rel. to 1850-1900) - Annual (34 models)
Regions: Mediterranean

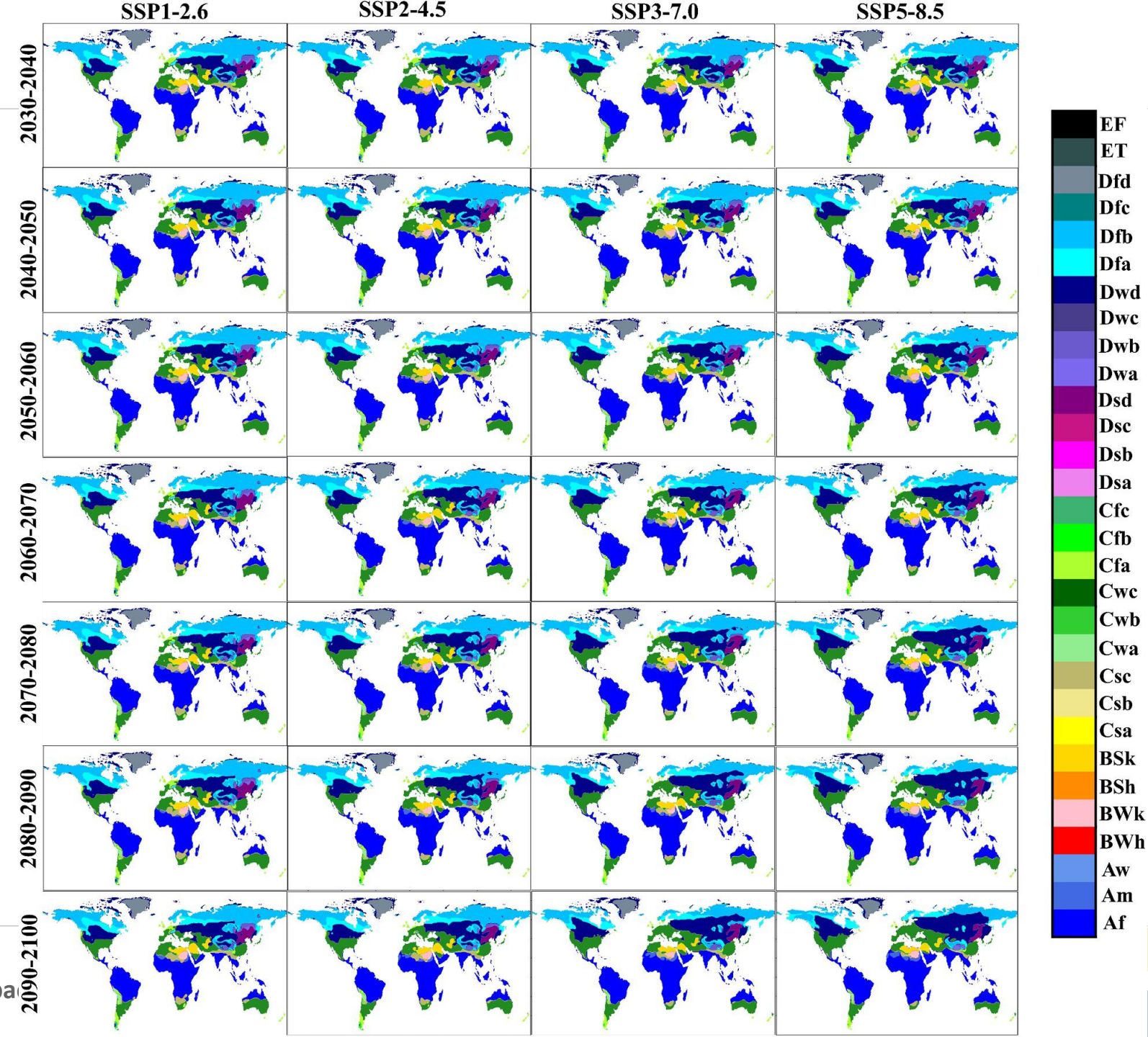
Time Series | GWL Plot | Annual Cycle | Scatter Plot | Table Summary | Stripes | Seasonal Stripes



Dotted line: **Model** Solid line: **P50 (Median)** Gray shading: **Selected period** Light / dark area: **Spread P10-P90 / P25-75**

Projected impacts

Song et al., 2025, CMIP6 GCMs Projected Future Koppen-Geiger Climate Zones on a Global Scale, Earth's Future



Spatial changes in projected climate zones estimated by multi-model ensemble for four future scenarios

Projected impacts

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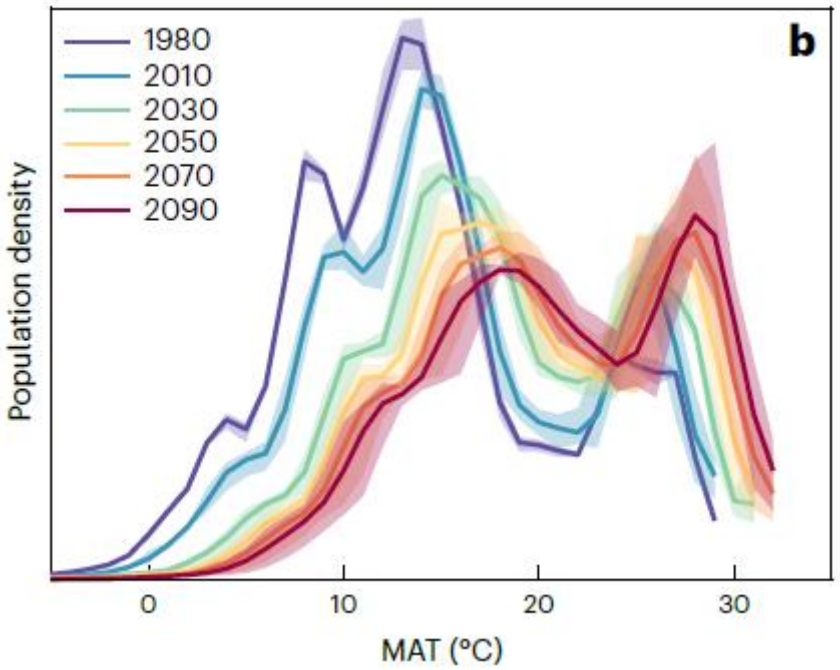
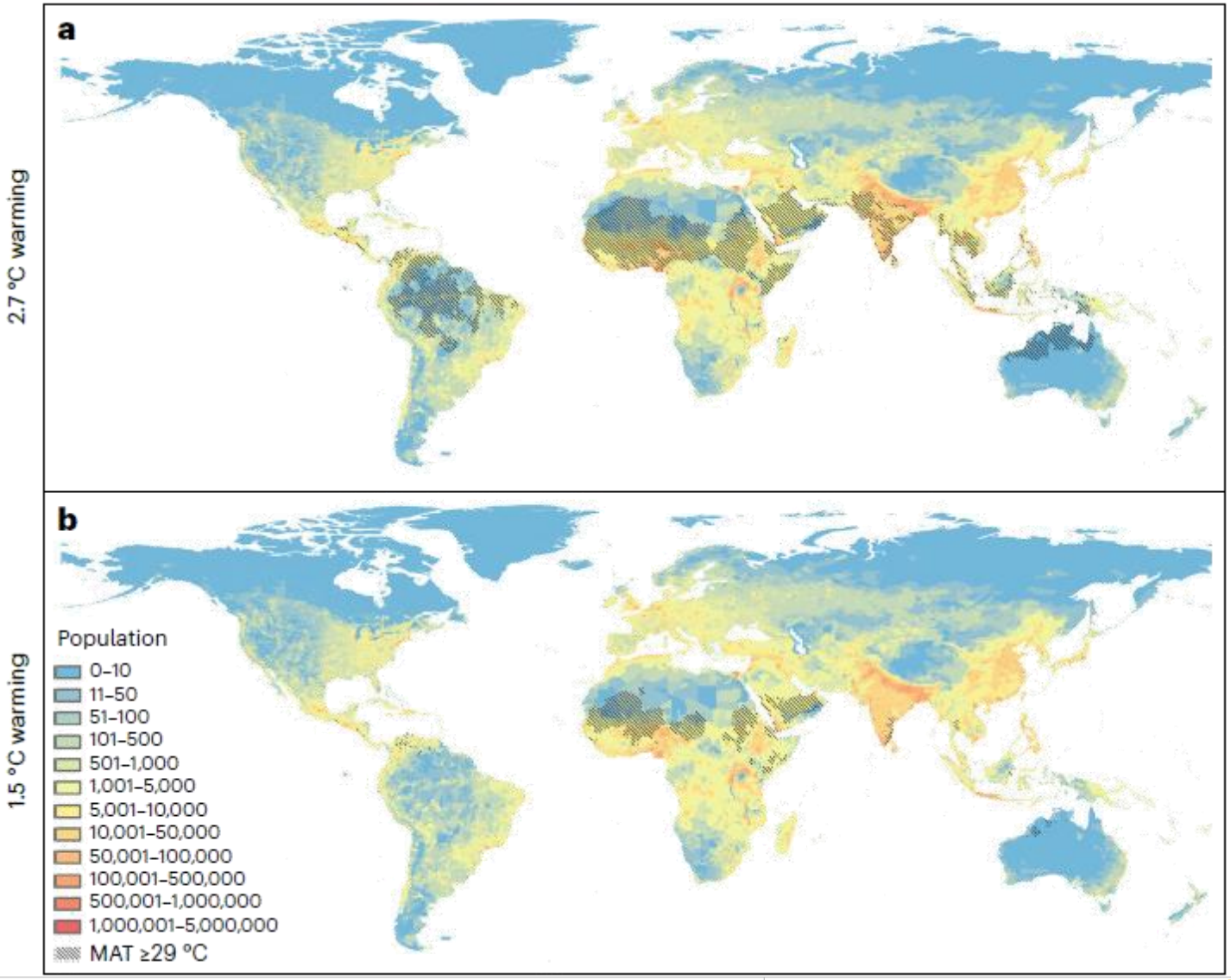
Lenton et al., 2023, Quantifying the human cost of global warming, Nature sustainability



Observed and projected future changes in population density with respect to MAT following SSP2-4.5 leading to ~2.7 °C global warming and peak population 9.5 billion

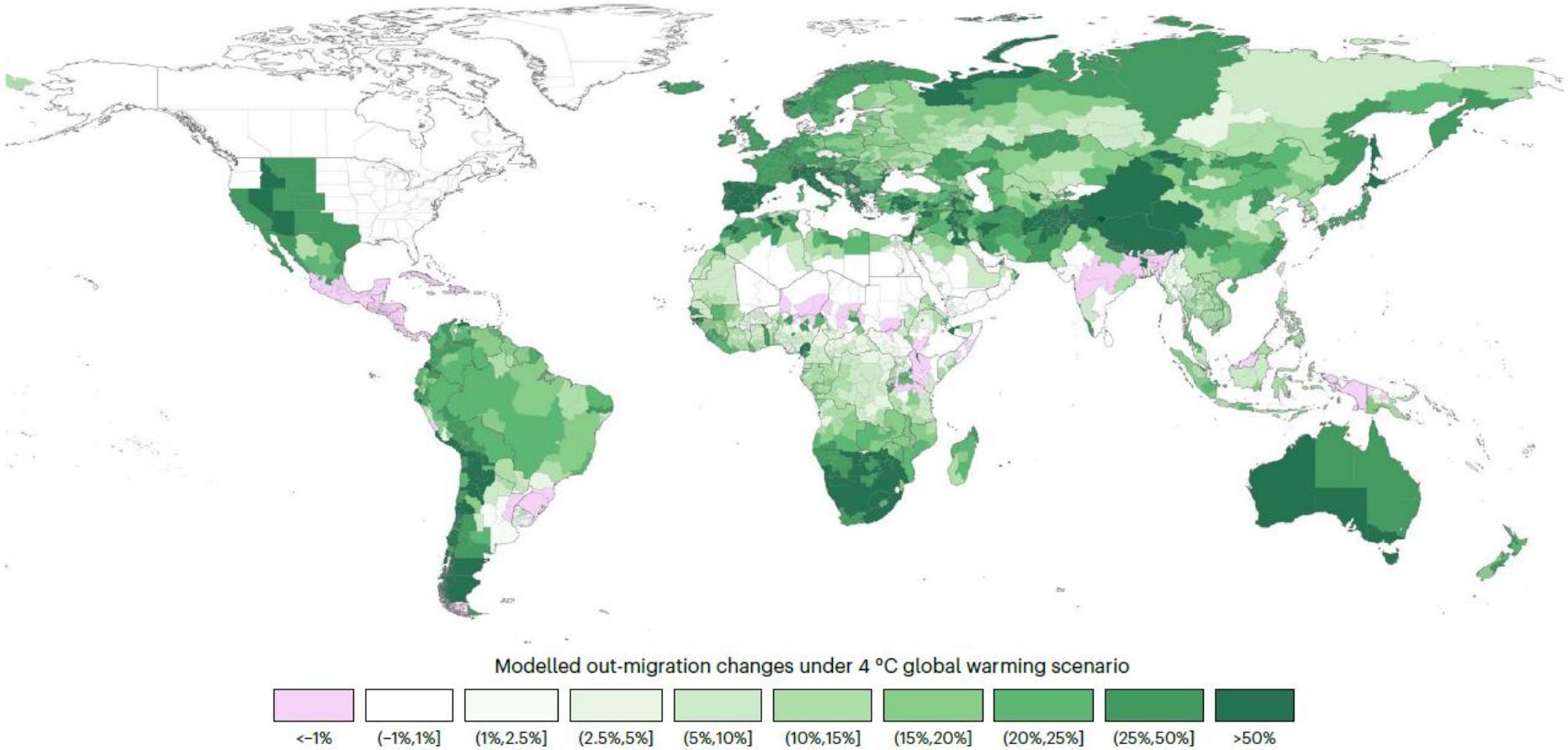


Regions and population densities exposed to unprecedented heat at different levels of global warming. a,**b**, Regions exposed to unprecedented heat (MAT ≥29 °C) overlaid on population density (number in a ~100 km2 grid cell) for a world of 9.5 billion (SSP2, 2070) under 2.7 °C global warming (**a**) and 1.5 °C global warming (**b**).

Projected impacts

EUPeace

Hoffmann et al., 2024, Drought and aridity influence internal migration worldwide, Nature Climate Change



Modelled migration changes under a 4 °C global warming scenario based on projected changes in dryness in the regions until the end of the century

Projected impacts

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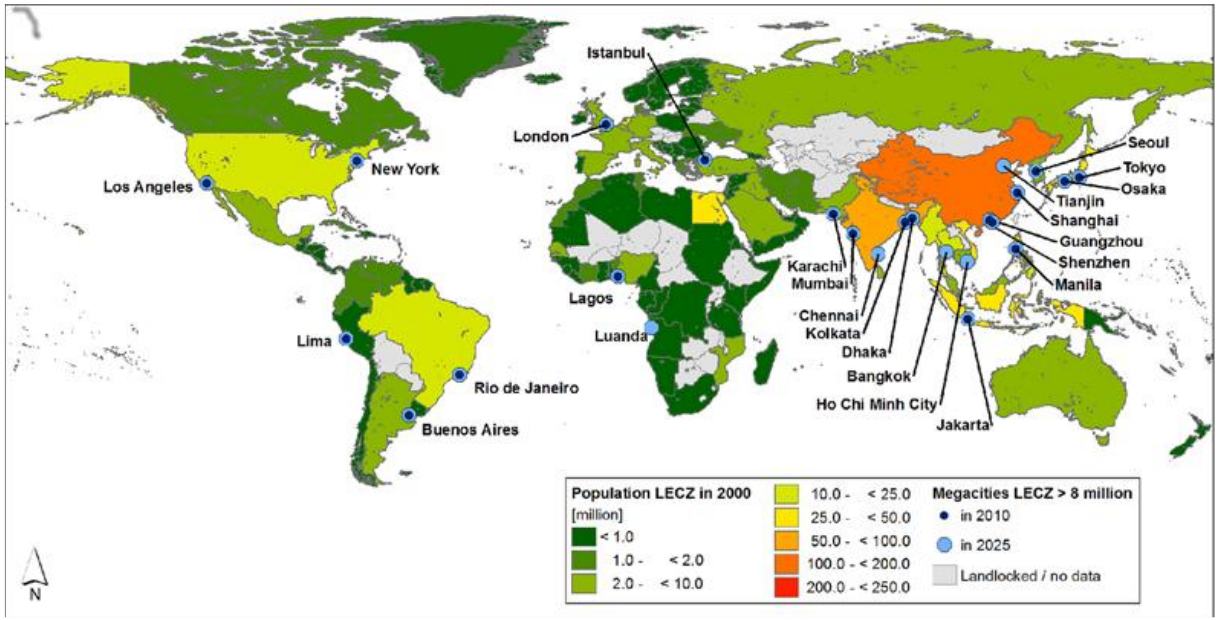
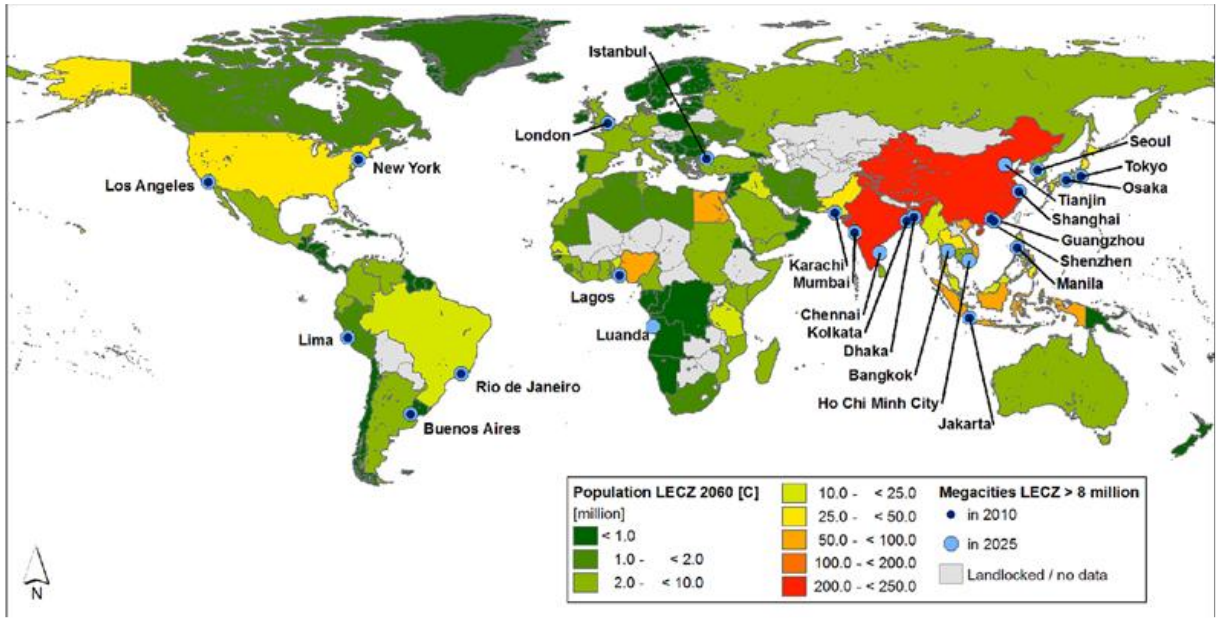
Neumann et al., 2015, Future Coastal Population Growth and Exposure to Sea-Level Rise and Coastal Flooding - A Global Assessment, Plos One





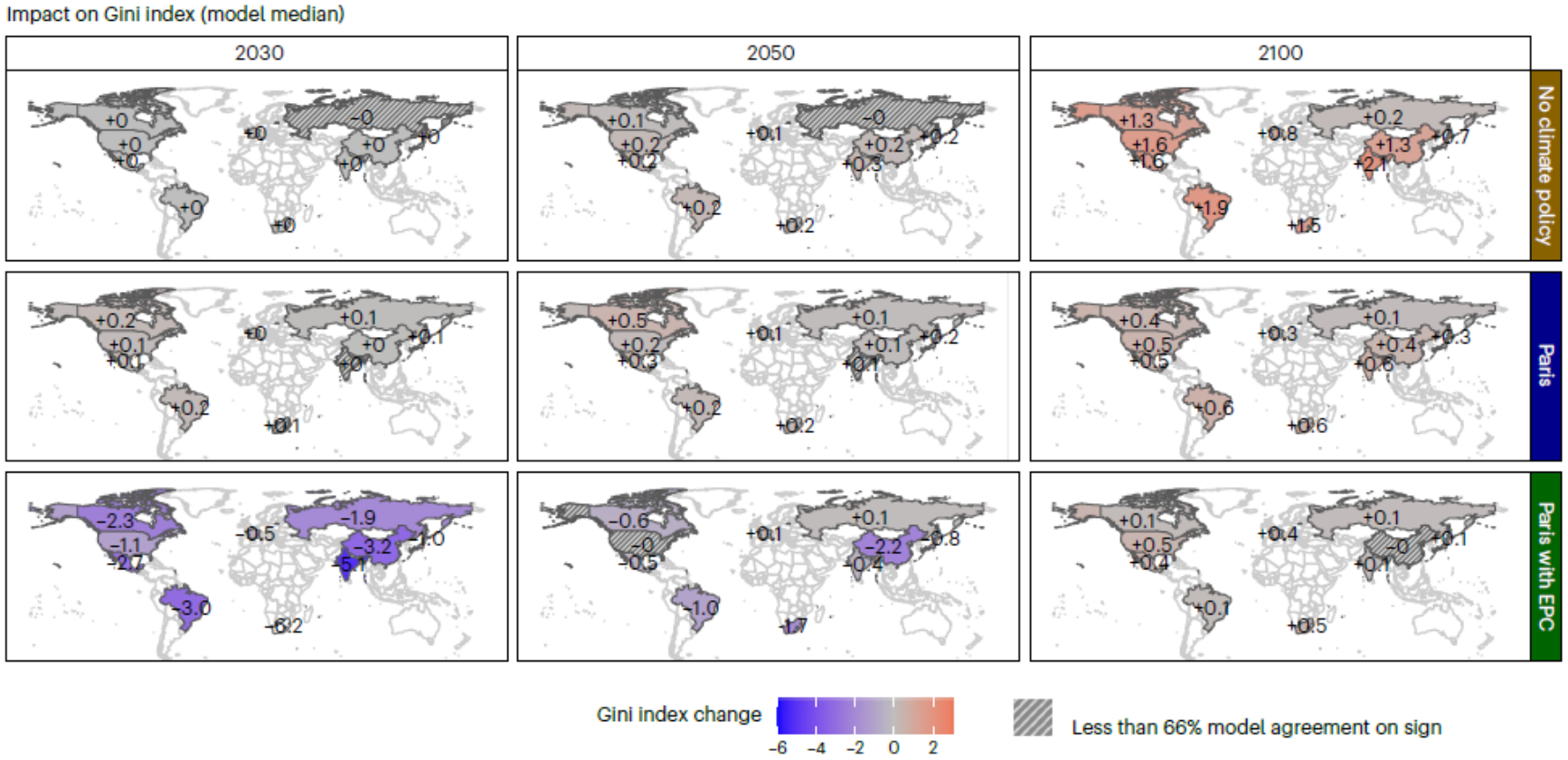
Low-elevation coastal zone population in the year 2000 and for 2030/2060 per country

Projected impacts

EUPeace

Emmerling et al., 2024, A multi-model assessment of inequality and climate change. Nat. Clim. Chang.

By 2100, climate impacts will increase inequality by 1.4 points of the Gini index on average. Maintaining global mean temperature below 1.5 °C reduces long-term inequality increase by two-thirds but increases it slightly in the short term. However, equal per-capita redistribution can offset the short-term effect, lowering the Gini index by almost two points

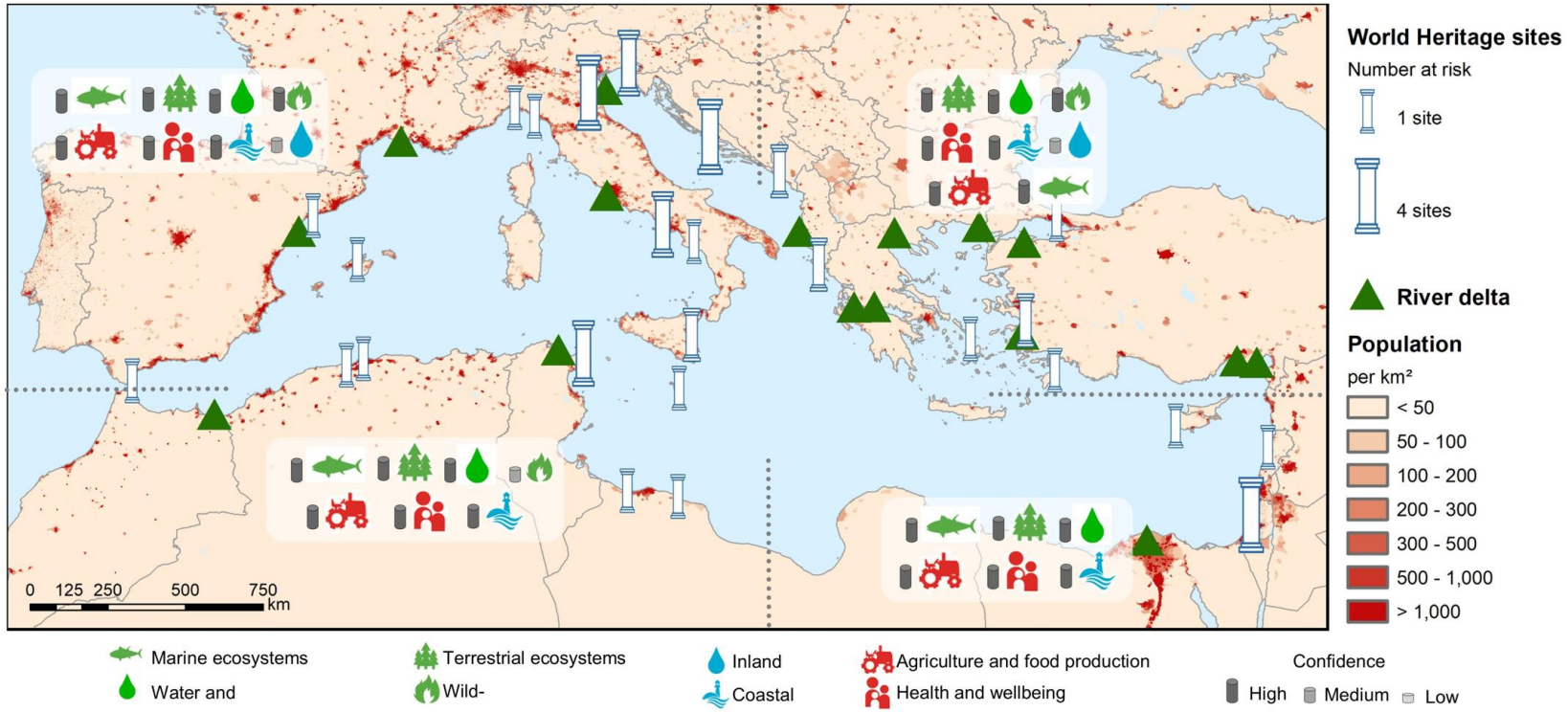


Map of the median across models showing change in Gini index with respect to the Reference scenario without climate impacts

Projected impacts - *methodology*

EUPeace

Higher spatial resolution to disclose critical details



Key risks across the Mediterranean region by 2100 (IPCC WGII AR6, Cross-Chapter Paper 4: Mediterranean Region)

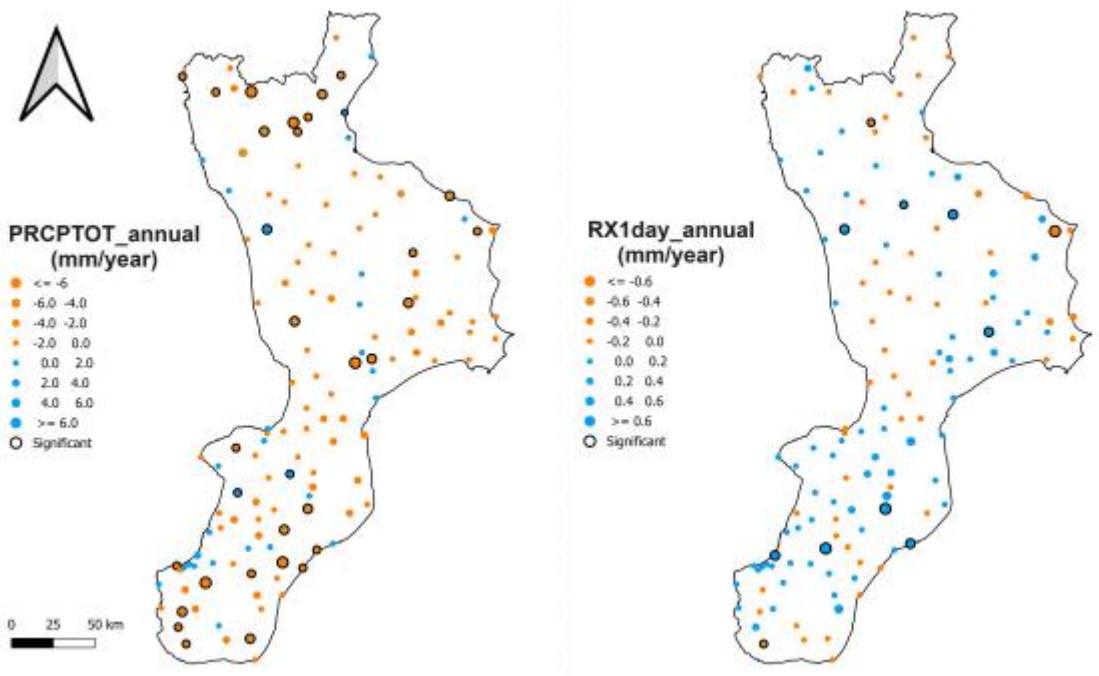
In general, increasing temperatures and more intensive heatwaves in the basin threaten human well-being, economic activities and also many ecosystems on land and in the ocean. ***Extreme rainfall events****, which despite the lower total rainfall are expected to increase in intensity and frequency in some regions, generate significant risks for infrastructure and people through flash floods*

Projected impacts - *methodology*

EUPeace

Higher spatial resolution to disclose critical details

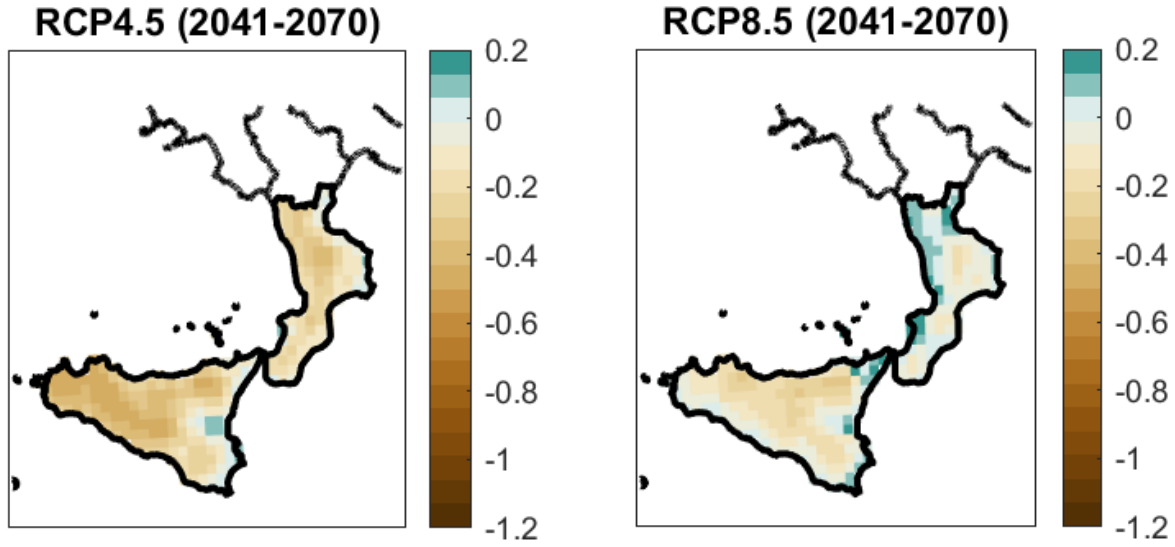
Observations



Annual precipitation (PRCPTOT) and maximum one-day precipitation (RX1day) trends

Senatore et al., 2025 (in preparation)

Projections



Standardized Precipitation Index

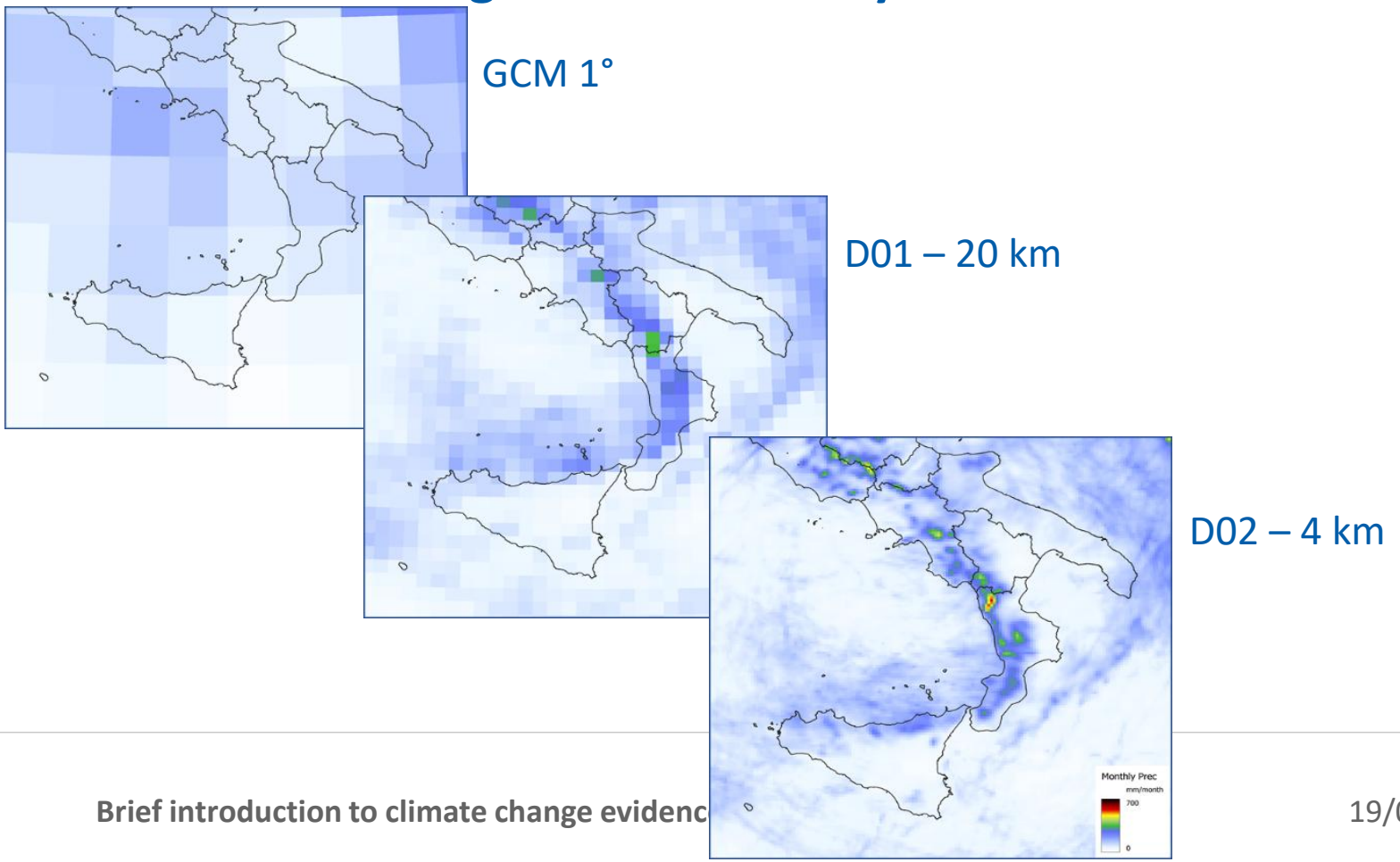
Peres et al., 2023, A dynamic approach for assessing climate change impacts on drought: an analysis in Southern Italy, Hydrological Sciences Journal.

Projected impacts - *methodology*

EUPeace

Higher spatial resolution to disclose critical details

Ongoing convection-permitting climate downscaling in southern Italy



GCM 1°

D01 – 20 km

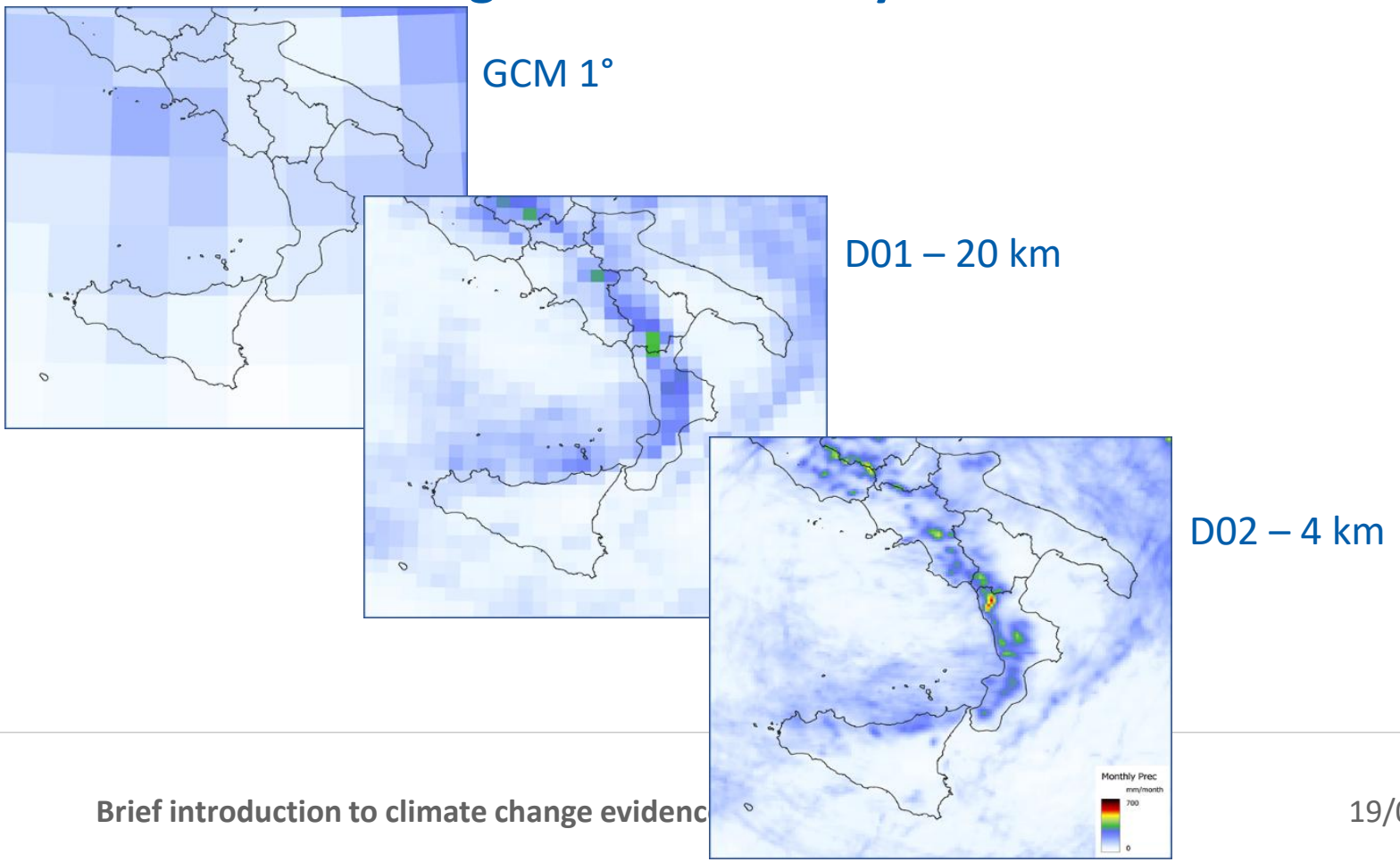
D02 – 4 km

Projected impacts - *methodology*

EUPeace

Higher spatial resolution to disclose critical details

Ongoing convection-permitting climate downscaling in southern Italy



GCM 1°

D01 – 20 km

D02 – 4 km

Footprint of climate simulations

Acosta et al., 2024, The computational and energy cost of simulation and storage for climate science: lessons from CMIP6. Geosci. Model Dev

190 different experiments that were used to simulate **40000 years** and produced around **40PB** of data in total

The estimated carbon footprint of running such big simulations within the IS-ENES3 consortium is **1692t of CO_2 equivalent**
(cryptocurrency mining, meanwhile, has emitted many millions of tons of CO_2)

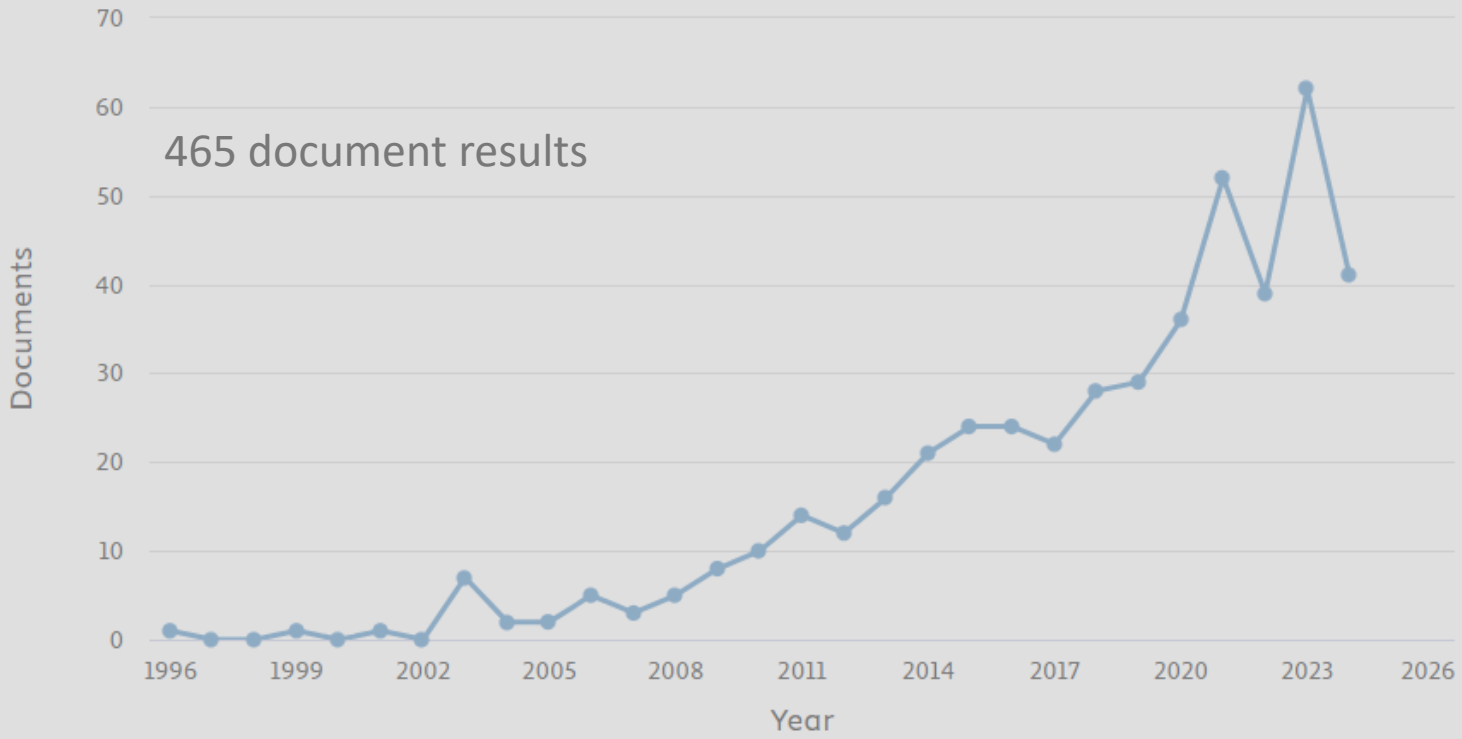
Climate change and population movement as emerging field

EUPeace

ELSEVIER Scopus

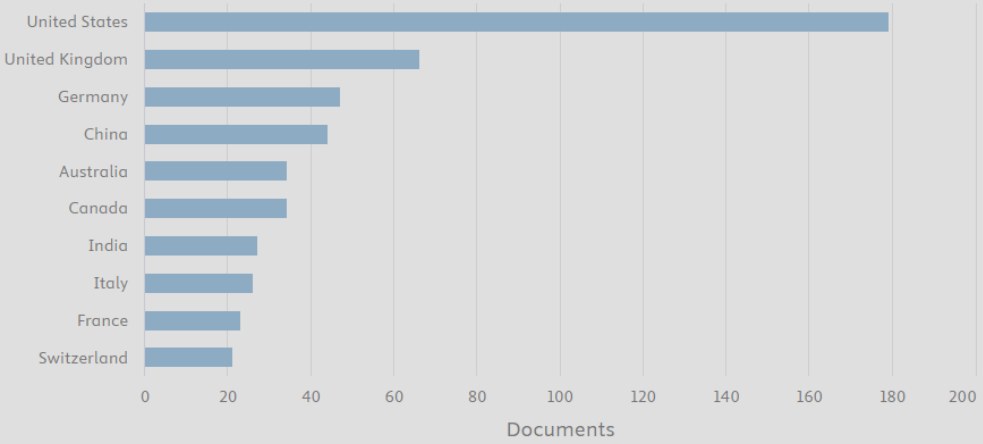
(TITLE-ABS-KEY ("climate change") AND TITLE-ABS-KEY ("human population movement*" OR "human migration"))

Documents by year

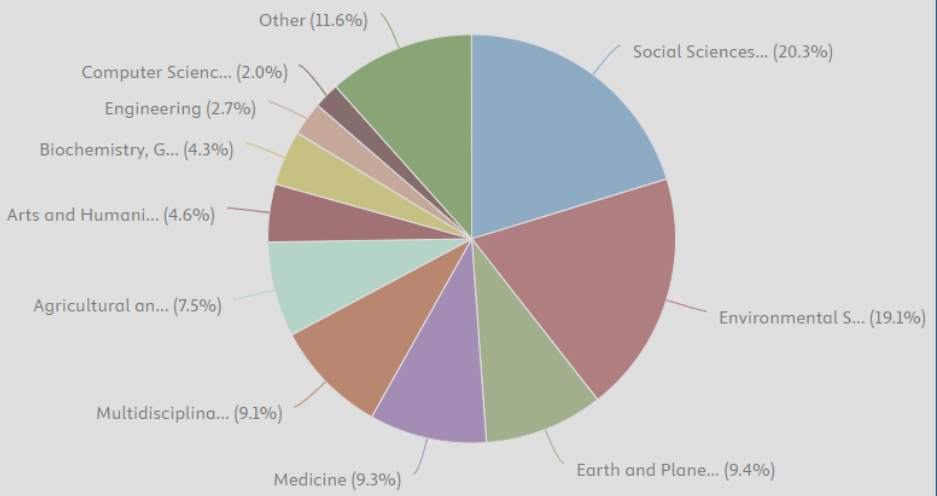


Documents by country or territory

Compare the document counts for up to 15 countries/territories.



Documents by subject area



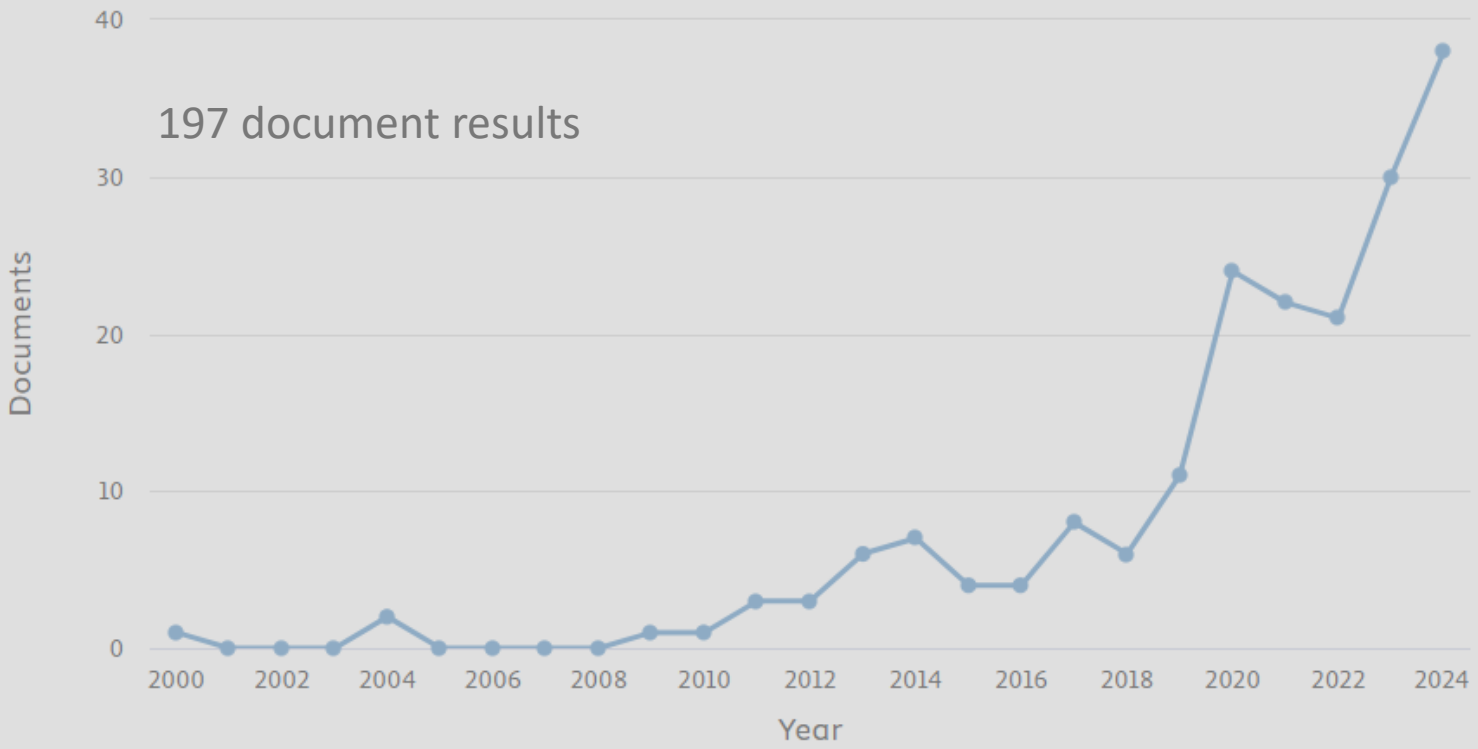
Climate change and population movement as emerging field

EUPeace

ELSEVIER Scopus

TITLE-ABS-KEY ("climate migrant*")

Documents by year



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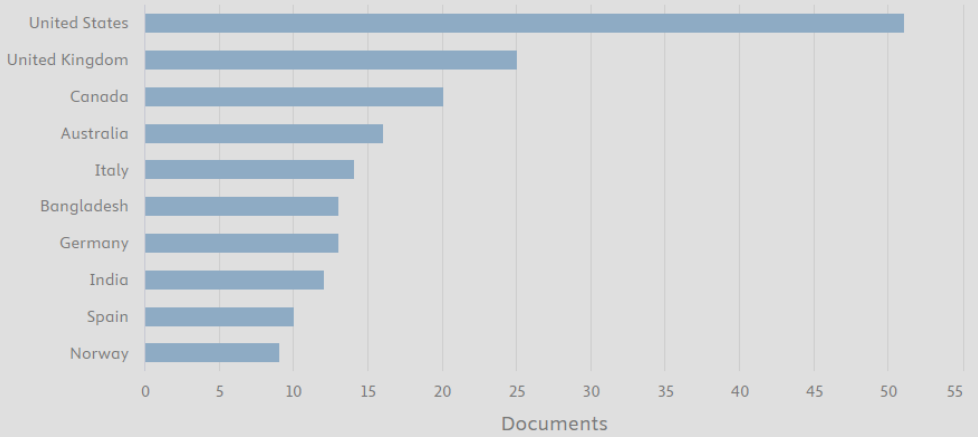

Documents by subject area